Swedish status and trend monitoring programme

Chemical contamination in offshore sediments 2003–2014

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Cover photo: Anoxic conditions are commonly prevailing in the depressions of the Baltic Sea. No living organisms thrive here except for the sulfur reducing bacteria *Beggiatoa* which are spreading like white thin carpets over the seafloor.
Photo: SGU.

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SWEDISH ENVIRONMENTAL PROTECTION AGENCY

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Summary
The national Swedish status and trend monitoring programme (SSTMP) for contaminants in marine sediment was launched with the objective to investigate the status and long-term trends of contaminants in the open sea within Swedish territorial water and Exclusive Economic Zone (EEZ). The programme includes sampling and analyses of surface sediments in 16 offshore stations located in the largest depressions along the Swedish coast. Sampling surveys are planned to take place every 5–6 years and have until now been completed in 2003, 2008 and 2014. The compiled results from 2003, 2008 and 2014 reveal that there is no general declining trend of the levels of elements and organic micropollutants in surface sediments around the Swedish coast. The different monitored offshore areas are still supplied with heavy metals and organic substances in volumes significant enough to elevate the concentrations of some analytes. The levels of metals varies between the different basins. For example, arsenic shows high concentrations in the Bothnian Bay and Bothnian Sea, while cadmium shows the most elevated levels in the Baltic Proper. The concentrations of most of the presented organic substances have declined since 2008. The levels of hexachlorobenzene (HCB), on the other hand, increase at almost all of the offshore stations, whilst the PAHs decrease in most sea basins. However, no statistical analyses have been carried out to establish the statistical significance of the variations between years. This will be done when more SSMTP sampling surveys have been carried out.

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SAMMANFATTNING

År 2003 lanserades det nationella svenska övervaknings- och trendprogrammet för föroreningar i sediment (SSTMP). Programmet finansieras av Naturvårdsverket och har syftet att undersöka belastning och långtidstrender av miljögifter i utsjösediment inom svenskt territorialvatten och ekonomisk zon (EEZ). Programmet omfattar provtagning och analys av ytsediment med ett tidsintervall på fem till sex år vid 16 utvalda utsjöstationer. Tidsintervallet är anpassat efter längden på havsmiljöförvaltningens sexåriga förvaltningscykel. Övervakningsstationerna är utsatta i de djupaste havsbassängerna längs Sveriges kust. Den insamlade informationen från dessa ska användas inom en rad olika områden såsom uppföljning av tre av Sveriges 16 miljömål: *En giftfri miljö, Hav i balans samt levande kust och skärgård* och *Ingen övergödning*. Programmet har sedan starten utförts i samarbete med Strålsäkerhetsmyndigheten (SSM) som analyserar radionuklider i ytsediment i syfte att följa upp miljömålet *Säker strålmiljö*. I utformningen av SSTMP har rekommendationer från de två konventioner som skyddar de marina miljöerna i Östersjön (HELCOM) och norra Atlanten (OSPAR) tagits i beaktande.

16 utsjöstationer har valts ut för övervakning av förekomsten av miljögifter i utsjösediment längs Sveriges kust. Övervakningsstationerna definieras av en cirkel med en radie på 50 m inom vilken sju platser slumpmässigt provtas vid varje övervakningstillfälle. Dessa sedimentprover analyseras senare med avseende på metaller, organiska ämnen samt näringsämnen. På detta sätt kan de senaste årens belastning av miljöstörande ämnen bestämmas. Förutom kemiska analysdata samlas även information om geologisk beskaffenhet, undervattensfotografier och hydrografiska data in vid de provtagningsstationer där bottenförhållandena tillåter. Kemiska data med tillhörande information finns tillgängliga via datavärdskapet för miljögifter i sjö- och havssediment på SGUs webbplats www.sgu.se. Data rapporteras också till ICES (www.ices.dk).

Sammanställningen av resultaten från 2003, 2008 och 2014 års miljöövervakningsomgångar visar ingen generell minskning av halter av metaller eller organiska miljögifter i ytsedimenten i utsjön längs Sveriges kust. Miljöstörande ämnen av olika sort tillförs fortfarande havet och påverkar koncentrationerna i sedimenten. Halterna av metaller varierar mellan de olika havsbassängerna. Till exempel uppvisar arsenik höga halter i Bottenviken och Bottenhavet, medan kadmium förekommer i höga halter i Egentliga Östersjön. Många av de presenterade organiska föreningarna har minskat i koncentration sedan 2008. Det finns dock ämnen som fortfarande ökar i mängd i ytsedimenten på vissa platser. Dit hör substansen hexaklorbensen (HCB). Den kemiska gruppen polycykliska aromatiska kolväten (PAH) är den ämnesgrupp som minskar avsevärt i koncentration i de flesta övervakade havsområdena. Det är dock viktigt att understryka att inga statistiska analyser har gjorts för att undersöka om variationerna i koncentrationerna mellan de 3 åren är statistiskt signifikanta. Samtliga beskrivningar är grundade på totalhalterna av respektive ämne. För ett flertal metaller och organiska ämnen finns statistiska bedömningsgrunder utarbetade av Naturvårdsverket. Om koncentrationerna av de ämnen som presenteras i denna rapport klassificeras enligt dessa bedömningsgrunder, framgår att många av de organiska ämnena förekommer i höga till mycket höga halter än idag. Detta är förvånande då åtgärder har satts in, t.ex. förbjöds de flesta av de övervakade bekämpningsmedlen i Sverige på 1970-talet. Enligt de ekotoxokologiska bedömningsgrunderna sammanställda av Havs- och vattenmyndigheten, överskrider ämnet TBT vid många provtagningsplatser den halt som bedöms vara skadlig för bottenlevande organismer. Antalet stationer där det överskrids har dock minskat sedan 2003.

SUMMARY

In 2003, a national Swedish status and monitoring programme for contaminants in marine sediment (SSTMP) was launched. The programme is funded by the Swedish Environmental Protection Agency (Swedish EPA) with the objective to investigate the status and long-term

trends of contaminants in the open sea within Swedish territorial water and Exclusive Economic Zone (EEZ). The programme includes sampling and analyses of surface sediments in 16 offshore stations every 5–6 years in order to fit the water management cycle in EU marine legislation. The monitoring stations are placed in the largest depressions along the Swedish coast and the obtained data can be used for a number of purposes such as following up on three of Sweden's 16 environmental objectives: *A non-toxic environment, A balanced marine environment, flourishing coastal areas and archipelagos* and *Zero eutrophication*. From the start the SSTMP has been carried out in cooperation with the Swedish Radiation Safety Authority (SSM) to meet the requirements of radioactivity monitoring in sediments. Data of radionuclides in sediment are used to follow-up on the national environmental objective *A safe radiation environment*. The framework of the SSTMP has been designed in accordance with recommendations from both the governing bodies for the protection of the marine environments in the Baltic Sea (HELCOM) and the North-East Atlantic (OSPAR).

16 offshore sample stations have been chosen to monitor pollutant levels in Swedish offshore sediments. Each sample station is defined as a circle with a 50 m radius in which seven sites for surface sediment sampling are randomly chosen at every monitoring occasion. The collected sediment is then analysed for heavy metals, organic substances and nutrients. By doing this, the accumulation of contaminants during recent years can be monitored. In addition to chemical data, geological information, underwater photographs and CTD data have been obtained at every station with the right conditions. All chemical data with additional information are available through the public database for sediment monitoring data at SGU's web site: www.sgu.se. Data is also reported to ICES (www.ices.dk).

The compiled results from 2003, 2008 and 2014 reveal that there is no general declining trend of the levels of elements and organic micropollutants in surface sediments around the Swedish coast. The different monitored offshore areas are still supplied with heavy metals and organic substances in volumes significant enough to increase the concentrations of some analytes. The levels of metals varies between the different basins. For example, arsenic shows high concentrations in the Bothnian Bay and Bothnian Sea, while cadmium shows the most elevated levels in the Baltic Proper. The concentrations of most of the presented organic substances have declined since 2008. The levels of hexachlorobenzene (HCB) on the other hand increase at almost all of the offshore stations, whilst the PAHs decrease in most sea basins. However, it is important to stress that no statistical analyses have been carried out to establish the statistical significance of the variations between years. Instead, only the concentration of each pollutant has been used to compare between years. For a selection of elements and organic pollutants there are available statistical assessment criteria developed and published by the Swedish EPA. If concentrations of the presented elements and organic substances are classified according to these criteria, it is shown that many of them occur in high to very high levels in the surface sediments. This is surprising since measures have been taken to decrease use and releases to the environment, for example most of the monitored pesticides were banned in Sweden in the 1970s. According to the ecotoxicological assessment criteria set by the Swedish Agency for Marine and Water Management (SwAM) TBT levels exceed the levels that are thought to cause negative effects to benthic organisms.

BACKGROUND

Sediment is an essential part of aquatic environments. Seas, oceans and lakes accumulate it over time and the dynamic sediment cycle plays a key role in each ecosystem. Therefore, sediment management is an important factor in water quality contexts. Sediments act as a potential sink for many contaminants released into the environment. Since the industrial revolution, man-

made chemicals and heavy metals have been emitted to surface waters all around Sweden. Due to their high affinity for particles, many of these chemicals and elements stick to particles in the water and sink to the seafloor where they settle and become integrated in the sediments. The seafloor sediments can act as an environmental archive of historical contamination in a specific area. By documenting the seafloor sediments we can become aware of possible disturbances and monitor changes in the environment.

In 2003, a national Swedish status and monitoring programme for contaminants in marine sediment (SSTMP) was launched. The project is funded by the Swedish Environmental Protection Agency with the objective to investigate the status and long-term trends of contaminants in the open sea within Swedish territorial water and Exclusive Economic Zone (EEZ). The programme should be considered as a complement to coastal monitoring programmes and recipient controlling programmes. It describes national rather than local distributions and trends of contaminants within the Baltic Sea and the sea regions on the Swedish west coast. Environmental issues within the Baltic Sea area are governed by the body of the Convention on the Protection of the Marine Environment of the Baltic Sea Area, known as the Helsinki Convention (HELCOM). The sampling stations on the west coast of Sweden, in Kattegatt and Skagerrak, belong to the sea region regulated by the Convention for the Protection of the Marine Environment of the North-East Atlantic, the OSPAR Convention. The framework of the SSTMP has been designed in accordance with both conventions. The programme has also been carried out in cooperation with the Swedish Radiation Safety Authority (SSM) from the start to meet the requirements of radioactivity monitoring in sediments. The monitoring of radionuclides in sediment is the foundation for SSM's reporting of indicators to the follow-up on the national environmental objective *A Safe Radiation Environment* (Andersson 2007). The first SSTMP monitoring survey was completed in 2003 and the subsequent two surveys were carried out in 2008 and 2014. Future surveys are planned every sixth year in order to follow the water management cycle in EU marine legislation.

The first SSTMP report was published in 2005 (Cato & Kjellin 2005). This report was revised in 2008 (Cato & Kjellin 2008). Both reports present data from the first monitoring survey in 2003. This report will summarise and present data from all three completed surveys.

Programme design and objectives

Monitoring data from SSTMP primarily reflect the environmental status and trends of chemical load in the larger offshore basins in the Bothnian Bay, Bothnian Sea, Åland Sea, Baltic Proper, Kattegat and Skagerrak. The main aims of the programme are:

- to assess levels and natural variation of heavy metals and organic substances in marine and brackish sediments at 16 representative offshore stations unaffected by local sources of pollution.
- to monitor long term trends of contaminant levels in the environment.
- to follow up on effects of restrictions of use and discharge of pollutants in the environment.
- to build an archive with sediment samples for future retrospective analyses.

The obtained data are thought to apply to a variety of purposes such as

- to follow up on three of Sweden's 16 environmental objectives:
  A Non-Toxic Environment,
  A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos,
  Zero Eutrophication.

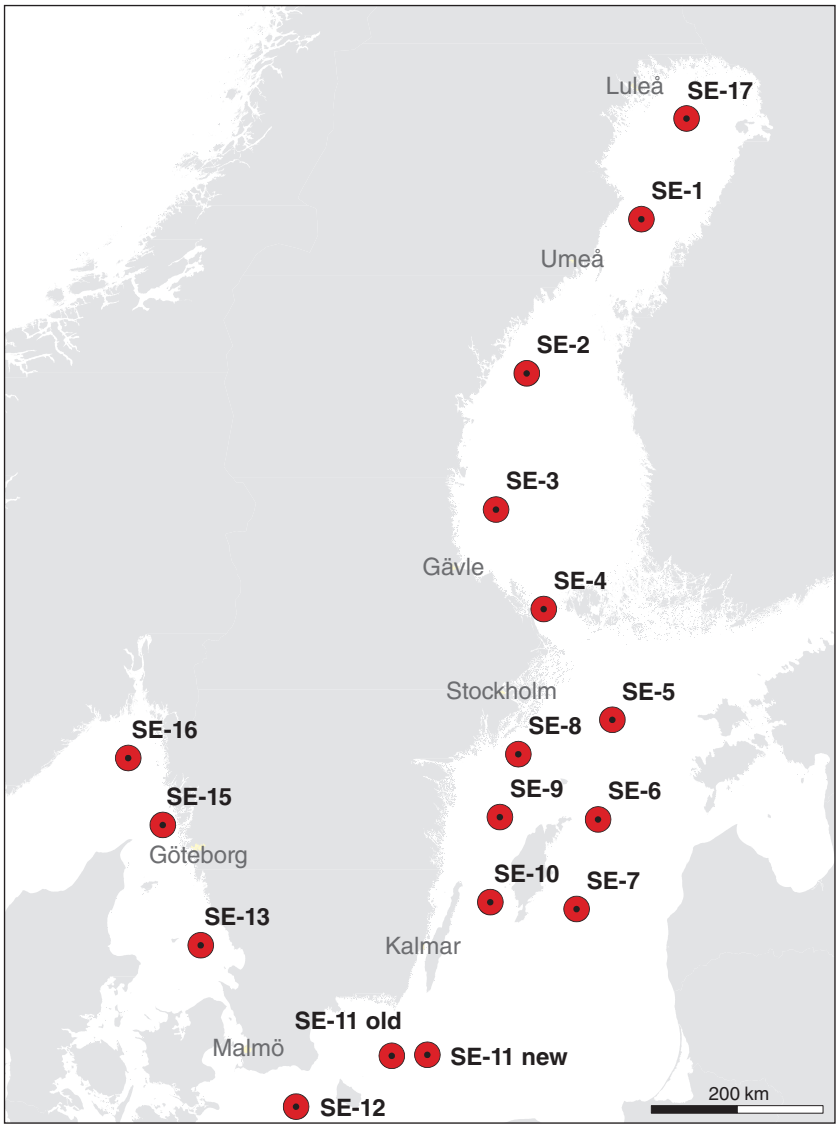

Figure 1. There are 16 stations for offshore sediment monitoring covering the largest depressions on Swedish territorial seafloors. There are two stations north of the Bornholm basin named SE-11. Due to disturbances from the laying of the gas pipeline Nord stream in 2011 the old station, SE-11 old, was displaced by SE-11 new.

- serve as reference data for local and governmental authorities and county administrative boards working with marine issues.
- support research on contaminants in the marine environment.
- act as a data foundation for assessment of good environmental status of marine waters.

16 offshore stations were placed to monitor sediment pollutant levels in the largest depressions along the Swedish coast (Fig. 1 and Table 1.) The sampling areas were chosen after surveys using hydro-acoustic methods such as sediment sub-bottom profiler, echo-sounder and side-scan sonar. Based on the interpretations of the obtained hydro-acoustic data the most suitable areas were selected (Cato & Kjellin 2008, Cato & Kjellin 2005). All stations fulfil two important criteria:

1. They are located offshore far from coastal contamination associated with urban areas.
2. The sea floor areas possess undisturbed, continuous and recent deposition of fine-grained sediments (<63 µm).

Table 1. The 16 offshore monitoring stations are located in the larger sea basins on Swedish territorial and economic zone seafloors.

Station id	Sea basin	Sea area	N SWEREF 99TM	E SWEREF 99TM	Water depth (m)
SE-1	S Bothnian Bay	Bothnian Bay	7137579	839033	113
SE-2	Härnösand Deep	Bothnian Sea	6956651	704410	200
SE-3	S Bothnian Sea	Bothnian Sea	6796706	668233	79
SE-4	Åland Deep	Åland Sea	6679643	724318	230
SE-5	NE Gotska Sandön	Baltic Sea	6549635	804899	175
SE-6	Fårö Deep	Baltic Sea	6432633	788137	195
SE-7	SE Gotland Basin	Baltic Sea	6327222	763118	173
SE-8	E Landsort Deep	Baltic Sea	6509084	694601	403
SE-9	Norrköping Deep	Baltic Sea	6435238	672991	178
SE-10	Karlsö Deep	Baltic Sea	6335390	661492	111
SE-11 new	N Bornholm Basin	Baltic Sea	6156130	587700	70
SE-11 old	N Bornholm Basin	Baltic Sea	6155024	545712	75
SE-12	Arkona Basin	Baltic Sea	6095142	433358	47
SE-13	S Rödebank	Kattegat	6284719	321401	47
SE-15	Deep Trench	Skagerrak	6426119	276793	94
SE-16	E Skagerrak	Skagerrak	6504578	236241	197
SE-17	N Bothnian Bay	Bothnian Bay	7255864	892219	87

From sampling and analyses of caesium-137 activity in the sediments on all 16 stations during the monitoring survey in 2003, the sediment accumulation rates have been estimated to between 3 and 14 mm/years (Cato & Kjellin 2008). Fresh surface sediments (0–1 cm) can be sampled approximately every five years at the stations with the lowest accumulation rates. The set time interval of six years between monitoring survey occasions within SSTMP is supported by these estimations.

Each sample station is defined as a circle with a 50 m radius with the master core site placed in the centre. Within the area of the circle, altogether seven samplings are done, one at the master site and six at randomly chosen sites (satellite sites) around the master site (Fig. 2). At every site surface sediments (0–1 cm) are taken for analyses of elements and total organic carbon (TOC) content (Table 2). Surface sediments are also collected at every site for a mixed sample for analysis of organic substances (Table 3). Hence, the sediment samples for analysis of organic pollutants are a mixture of sediments from all seven sediment sampling sites within the station. In total, 112 different sites are sampled during every monitoring survey.

METHODS

Sampling of offshore sediments has been carried out on the survey vessel S/V Ocean Surveyor, owned by the Geological survey of Sweden, during the surveys in 2003, 2008 and 2014. Sediment sampling and data collection were carried out by the same procedure at 15 out of 16 stations. Station SE-8 is located in the Landsort deep which has a depth of over 400 m which rules out the possibility to use some instruments sensible to depths over 300 m and hence, some data are not available from this station (see section *Underwater camera and sensors*).

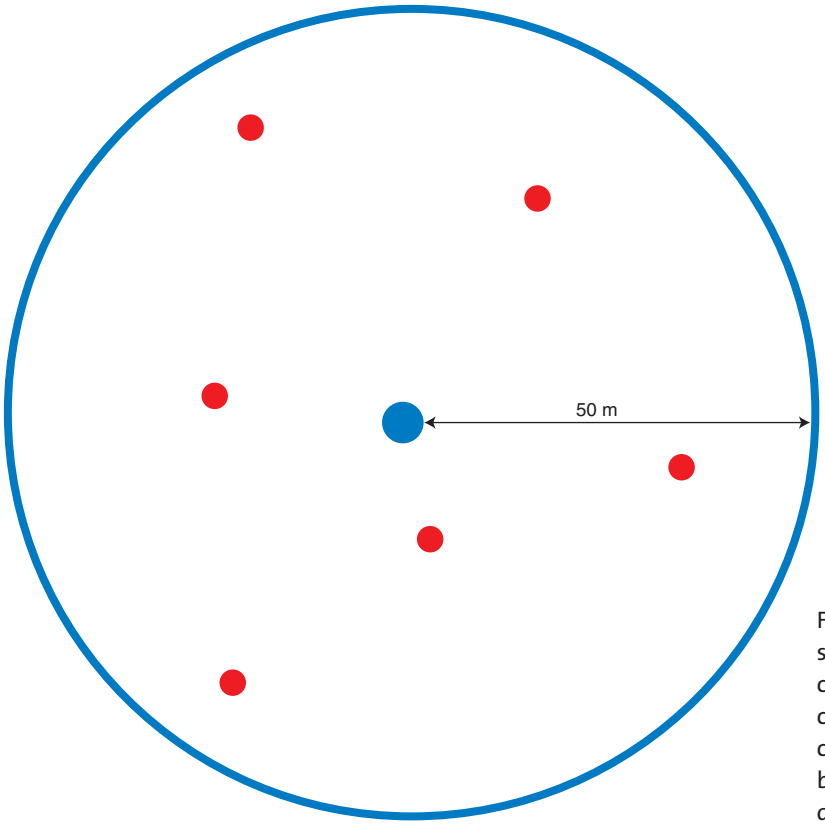

Figure 2. The monitoring stations are defined by a circle with a 50 m radius. The centre coordinate is the master core site and it is surrounded by six satellite sites randomly distributed within the circle.

Positioning

Every sampling site is positioned with a DGPS and has been given a coordinate in Sweref 99TM. Since the vessel Ocean Surveyor is equipped with dynamic positioning (DP), an accuracy of less than a meter is obtained. The DP also enables the ship to maintain an exact position during sampling.

Underwater camera and sensors

Prior to sediment sampling, a cage with an attached underwater camera (2003, 2008 and 2014), a CTD-sensor (2014), an oxygen sensor (2014) and a recording Doppler current profiler (RDCP, 2014) is lowered. The camera takes *in-situ* photographs of the seafloor surface. The photographs give a first overview of the seabed and make it possible to identify any disturbances at the surface of the sediment. Flora and fauna or other features are documented if present. The CTD-sensor measures salinity and temperature in the water column during deployment of the cage from the water surface to the seafloor. This information is used to estimate depths of thermo- and haloclines in the sea basins. The oxygen sensor gives an estimation of the concentration of dissolved oxygen in the bottom water. This instrument indicates whether there are oxic or anoxic conditions prevailing in the bottom water which is an important factor to take into consideration when assessing metal and nutrient fluxes from the sediment. The RDCP measures direction and velocity of any bottom currents. In summary, the camera cage deployment gives a first view of the state of the aquatic environment at every station. Station SE-8 located in the Landsort deep is situated at a depth of over 400 m. At this depth the underwater camera with attached sensors cannot operate properly. Therefore there are no underwater photographs or water column data available from this station.

Table 2. Geological parameters documented at every station during sampling.

Geological variables			
Sediment type	Calcareousity	Content of shells or shell fragments	Gyttja content
Detritus content	Clay content	Nodule content	Objects
Structure	Consistency	Consolidation	Age
Colour	Depositional environment	Genesis	

Table 3. Elements, carbon and nitrogen species were analysed during the three different monitoring years.

Element/parameter	2003	2008	2014
tot-C	x	x	x
tot-N	x	x	x
TOC	x	x	x
Si	x	x	x
Al	x	x	x
Ca	x	x	x
Fe	x	x	x
K	x	x	x
Mg	x	x	x
Mn	x	x	x
Na	x	x	x
P	x	x	x
Ti	x	x	x
Sum oxides	x	x	
LOI	x	x	x
Ag	x	x	x
As	x	x	x
Ba	x	x	x
Be	x	x	x
Bi	x	x	
Cd	x	x	x
Co	x	x	x
Cr	x	x	x
Cs	x	x	
Cu	x	x	x
Ga	x	x	
Ge	x	x	
Hf	x	x	
Hg	x	x	x
Li	x	x	
Mo	x	x	x
Nb	x	x	x
Ni	x	x	x

Element/parameter	2003	2008	2014
Pb	x	x	x
Rb	x	x	
Re	x	x	
Ru	x	x	
S	x	x	x
Se	x	x	
Sb	x	x	x
Sc	x	x	
Sn	x	x	x
Sr	x	x	
Ta	x	x	
Th	x	x	
Tl	x	x	
U	x	x	
V	x	x	x
W	x	x	x
Y	x	x	x
Zn	x	x	x
Zr	x	x	x
La	x	x	
Ce	x	x	
Pr	x	x	
Nd	x	x	
Sm	x	x	
Eu	x	x	
Gd	x	x	
Tb	x	x	
Dy	x	x	
Ho	x	x	
Er	x	x	
Tm	x	x	
Yb	x	x	
Lu	x	x	

Sediment sampling

The sediment sampling starts at the centre coordinate at every station. In order to obtain undisturbed sediment surface samples, a twin barrel corer is used. In 2003 and 2008 a gemini corer was used and in 2014 an improved version, a gemax corer, replaced the gemini. In 2003 and 2008, sediment samples were taken in a specially designed liner for digital x-ray scanning (Cato et al. 2000). The sediment was x-rayed in an upright position and the obtained radiographs were used in the interpretation of the degree of sediment disturbance in the core. If the radiographs showed evidence of strongly bioturbated sediments, another sampling site was chosen.

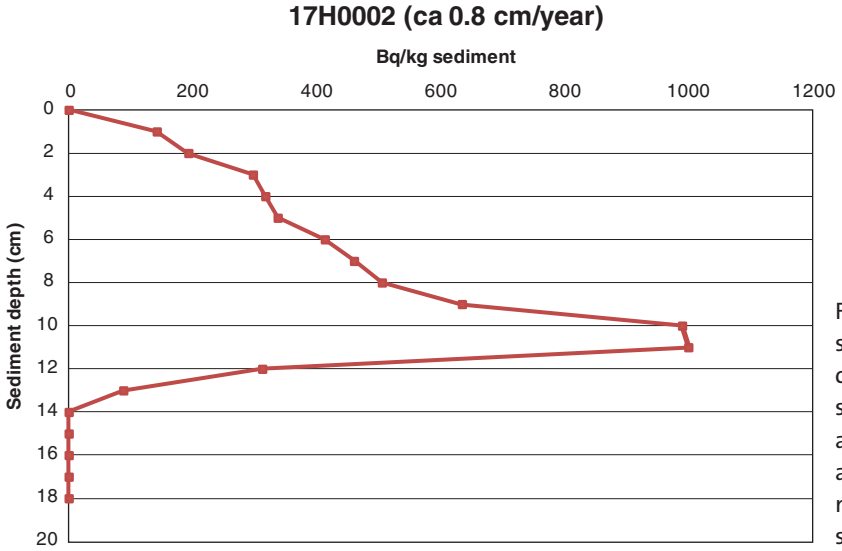

Figure 3. The graph illustrates the activity of the caesium-137 isotope versus sediment depth. Where the activity starts to increase at around 14 cm the approximate time mark for 1986 is set.

When the sampling site is approved from the underwater photographs and radiographs the sediment sampling begins with a core for visual inspection and geological description of a number of variables (Table 4). The core is also photographed and the information is logged in a database. From 2008 and onwards, the observations are documented in observation documents (Appendix 1).

In 2003 and 2008, one core at every centre coordinate was sectioned into 1 cm intervals and put into plastic jars. The samples were then run through a gamma spectrometer to analyse caesium-137 for an estimate of the annual sediment accumulation rate at every station. This was done by identifying at which depth in the sediment the caesium activity is raised. This point coincides with the Chernobyl accident in April 1986. Accumulation rates are then calculated from the ratio between the depth in the sediment core and the number of years since 1986 (Fig. 3). Since 2008 the dating of the sediments has been carried out by the Swedish Radiation Safety Authority with more sophisticated methods. Data from these measurements give more accurate estimations of sediment accumulation rates.

Following this, several gemini or gemax cores were recovered at all seven sites within each station. The surface sediments (0–1 cm) were collected and placed in plastic jars for the analysis of elements, organic carbon and nitrogen, and in glass jars for the analysis of organic substances. Elements, organic carbon and nitrogen were analysed at every site within a station in order to clarify the chemical variability within each station area. This information might help to separate between natural variations in concentrations and variations caused by changes in emissions over time. Consequently, seven samples were taken within every station for analysis of elements and organic carbon and nitrogen. For the analysis of organic substances surface sediments were collected at every sampling site for a mixed sample representing the whole station.

ANALYSES

A large number of elements and organic substances are analysed within the programme. The number of elements and organic substances has varied between the different survey years (Tables 2 and 3) as a result of updates of the Directive 2008/105/EC on Environmental Quality Standards. Resource utilisation lies behind the reduction in the number of elements analysed during the latest survey in 2014. The selection of analytes was done in cooperation with the Swedish Environmental Protection Agency.

Table 4. Organic substances analysed during the three different monitoring years. The third column indicates if there is a standard analytical method described in the OSPAR JAMP guidelines.

CAS nr	Substance	JAMP recommendation	2003	2008	2014
	Pesticides:				
1912-24-9	Atrazine		X	X	
2921-88-2	Chlorpyrifos		X	X	
34123-59-6	Isoproturon		X		
330-54-1	Diuron		X	X	X
122-34-9	Simazine		X	X	X
1582-09-8	Trifluralin		X	X	
470-90-6	Chlorfenvinfos		X	X	
15972-60-8	Alachlor		X	X	
64359-81-5	DCOIT			X	
404-86-4	Capsaicin			X	
28159-98-0	Cybutryn (Irgarol)			X	X
319-84-6	a-HCH		X	X	X
319-85-7	b-HCH		X	X	X
58-89-9	g-HCH		X	X	X
50-29-3	p,p-DDT		X	X	X
789-02-6	o,p-DDT		X	X	X
72-55-9	p,p-DDE		X	X	X
72-54-8	p,p-DDD		X	X	X
	Polycyclic aromatic hydrocarbons (PAHs):	x			
120-12-7	Anthracene		X	X	X
206-44-0	Fluoranthene		X	X	X
91-20-3	Naphtalene		X	X	X
208-96-8	Acenaphtylene		X	X	X
129-00-0	Pyrene		X	X	X
85-01-8	Phenanthrene		X	X	X
83-32-9	Acenaphtene		X	X	X
53-70-3	Dibenz(a,h)anthracene		X	X	X
218-01-9	Chrysene		X	X	X
56-55-3	Benzo(a)anthracene		X	X	X
86-73-7	Fluorene		X	X	X
50-32-8	Benzo(a)pyrene		X	X	X
205-99-2	Benzo(b)fluoranthene		X	X	X
191-24-2	Benzo(ghi)perylene		X	X	X
207-08-9	Benzo(k)fluoranthene		X	X	X
193-39-5	Indeno(1,2,3-cd)pyrene		X	X	X
	Dioxins, furans and dioxin-like PCBs:	x			
1746-01-6	2,3,7,8-T4CDD				X
40321-76-4	1,2,3,7,8-P5CDD				X
39227-28-6	1,2,3,4,7,8- H6CDD				X
57653-85-7	1,2,3,6,7,8-H6CDD				X
19408-74-3	1,2,3,7,8,9-H6CDD				X
35822-46-9	1,2,3,4,6,7,8-H7CDD				X

CAS nr	Substance	JAMP recommendation	2003	2008	2014
3268-87-9	1,2,3,4,6,7,8,9-O8CDD				X
51207-31-9	2,3,7,8-T4CDF				X
57117-41-6	1,2,3,7,8-P5CDF				X
57117-31-4	2,3,4,7,8-P5CDF				X
70648-26-9	1,2,3,4,7,8-H6CDF				X
not applicable	1,2,3,6,7,8-H6CDF				X
not applicable	1,2,3,7,8,9-H6CDF				X
60851-34-5	2,3,4,6,7,8-H6CDF				X
67562-39-4	1,2,3,4,6,7,8-H7CDF				X
not applicable	1,2,3,4,7,8,9-H7CDF				X
39001-02-0	1,2,3,4,6,7,8,9-O8CDF				X
32598-13-3	3,3',4,4'-T4CB (PCB 77),				X
70362-50-4	3,3',4',5-T4CB (PCB 81),				X
32598-14-4	2,3,3',4,4'-P5CB (PCB 105),				X
74472-37-0	2,3,4,4',5-P5CB (PCB 114),				X
65510-44-3	2,3',4,4',5'-P5CB (PCB 123)				X
57465-28-8	3,3',4,4',5-P5CB (PCB 126)				X
38380-08-4	2,3,3',4,4',5-H6CB (PCB 156)				X
69782-90-7	2,3,3',4,4',5'-H6CB (PCB 157)				X
52663-72-6	2,3',4,4',5,5'-H6CB (PCB 167)				X
32774-16-6	3,3',4,4',5,5'-H6CB (PCB 169)				X
39635-31-9	2,3,3',4,4',5,5'-H7CB (PCB 189)				X
					X
	Polychlorinated Biphenyls (PCBs):	x			
7012-37-5	PCB 28 (dutch 7)		X	X	X
35693-99-3	PCB 52 (dutch 7)		X	X	X
37680-73-2	PCB 101 (dutch 7)		X	X	X
31508-00-6	PCB 118 (dutch 7)		X	X	X
35065-28-2	PCB 138 (dutch 7)		X	X	X
35065-27-1	PCB 153 (dutch 7)		X	X	X
35065-29-3	PCB180 (dutch 7)		X	X	X
	Other chlorinated substances:				
118-74-1	Hexachlorobenzene (HCB)		X	X	X
87-68-3	Hexachlorobutadiene (HCBD)	x			X
not applicable	C10-13-Chloroalkanes + C14-C17-Chloroalkanes				X
39765-80-5	Trans-Nonachlor		X	X	X
5103-71-9	alpha-Chlordane		X	X	X
5566-34-7	gamma-Chlordane		X	X	X
87-61-6	1,2,3-Trichlorobenzene			X	X
120-82-1	1,2,4-Trichlorobenzene			X	X
108-70-3	1,3,5- Trichlorobenzene			X	X
67-66-3	Trichloromethane (Chloroform)			X	X
71-55-6	1,1,1-Trichloroethane			X	
107-06-2	1,2-Dichloroethane			X	
75-09-2	Dichloromethane			X	

CAS nr	Substance	JAMP recommendation	2003	2008	2014
56-23-5	Carbon tetrachloride			X	
127-18-4	Tetrachloroethylene			X	
79-01-6	Trichloroethylene			X	
608-93-5	Pentachlorobenzene			X	
87-86-5	Pentachlorophenol		X	X	
	Brominated Diphenyl Ethers (BDEs):	x			
not applicable	PBDE 28				X
5436-43-1	PBDE 47			X	X
not applicable	PBDE 66				X
not applicable	PBDE-85				X
60348-60-9	PBDE-99			X	X
not applicable	PBDE-100			X	X
68631-49-2	PBDE 153			X	X
not applicable	PBDE 154			X	X
not applicable	PBDE 183				X
1163-19-5	PBDE 209			X	X
	Organotin compounds:	x			
not applicable	Tributyltin (TBT)		X	X	X
15231-44-4	Dioctyltin (DOcT)		X	X	X
78763-54-9	Monobutyltin (MBT)		X	X	X
2406-68-0	Monophenyltin (MphT)		X	X	X
15231-57-9	Monooctyltin (MOcT)		X	X	X
6056-50-4	Tricyclohexyltin (TricyHexT)		X	X	X
892-20-6	Triphenyltin (TphT)		X	X	X
1461-25-2	Tetrabutyltin (TeMT)		X	X	
1002-53-5	Dibutyltin (DBT)			X	X
1011-95-6	Diphenyltin (DPhT)			X	X
	Perfluorinated compounds:	x			
2795-39-3	Perfluorooctane sulfonate (PFOS)				X
335-67-1	Perfluorooctanoic acid (PFOA)				X
29420-49-3	Perfluorobutane sulfonate (PFBS)				X
432-50-7	Perfluorohexane sulfonate (PFHxS)				X
67906-42-7	Perfluorodecanesulphonate (PFDS)				X
754-91-6	Perfluorooctane sulfonamide (PFOSA)				X
307-24-4	Perfluorohexanoic acid (PFHxA)				X
375-85-9	Perfluoroheptanoic acid (PFHpA)				X
375-95-1	Perfluorononanoic acid (PFNA)				X
335-76-2	Perfluorodecanoic acid (PFDA)				X
2058-94-8	Perfluoroundecanoic acid (PFUnDA)				X
2795-39-3	Perfluorooctane sulfonate (PFOS)				X
	Other polluting substances:				
not applicable	Nonylphenols		X	X	X
not applicable	Octylphenols		X	X	X
117-81-7	Bis(2-ethylhexyl) phthalate (DEHP)		X	X	X

CAS nr	Substance	JAMP recommendation	2003	2008	2014
84-66-2	Diethyl phthalate (DEP)				X
84-74-2	Dibethyl phthalate (DBP)				X
84-69-5	Diisobuthyl phthalate (DIBP)				X
85-68-7	Benzyl Buthyl phthalate (BBP)				X
28553-12-0 68515-48-2	Diisonyl phthalate (DINP)				X
26761-40-0	Diisodecyl phthalate (DIDP)				X
not applicable	Hexabromocyclododecane (HBCDD)				X
959-98-8	Alpha-Endosulfan			X	X
33213-65-9	Beta-Endosulfan			X	X
not applicable	Endosulfan sulfate			X	X

Geological parameters

Geology is a key factor when working with sediment monitoring. The surrounding conditions are reflected in the sediments that act as environmental and climate archives. Gyttja contents are reflected by the TOC concentrations which, in turn, affect the amount of adsorbed contaminants in the sediments since most metals and organic substances show high affinity for organic particles. Therefore, sampling of accumulation bottoms consisting of gyttja clay or clay gyttja is ideal. Consolidation, structure and consistency are also factors that determine whether an area is suitable for environmental monitoring or not. These variables are examined by marine geologists onboard Ocean Surveyor during sampling.

Elements

Most elements are natural components of the mineral particles in sediments. Therefore the total concentration of elements in the sediment was chosen as analytical standard for most elements during the first two survey years, in 2003 and 2008. This analysis procedure involves total dissolution of the sediment sample in hydrofluoric acid prior to analysis and the method was recommended from the International Council for the Exploration of the Sea (ICES) at the time when the programme was launched. The elements arsenic (As), cadmium (Cd), mercury (Hg), sulphur (S) and selenium (Se) were analysed after partial digestion with strong acid (7 M HNO_3). In 2014, the number of elements was reduced to cover the ones listed as priority substances in Annex 11 of the Directive 2008/105/EC on Environmental Quality Standards as well as a few other elements of relevance. Prior to analyses in 2014, As, Cd, Co, Hg, Ni, Pb, B, Sb, S, Se and Zn were partially digested while the rest of the elements were totally digested. However, the guidelines for environmental monitoring in sediments published by OSPAR (JAMP guidelines) (OSPAR 2002) state that similar results have been obtained using both total and strong partial methods (Smedes et al. 2000). Since comparability between the different survey occasions are of great importance, the same digestion method as in 2014 will be used in the future unless something else is agreed on or recommended by environmental monitoring working groups working for ICES, HELCOM or OSPAR. Analysed elements from the different survey years are presented in Table 3. After digestion the concentrations were measured using ICP-AES (EPA 200.7 standard) and ICP-MS (EPA 200.8 standard) techniques. Element analyses have been carried out at ALS Scandinavia AB (in 2003 and 2008 known as Analytica AB). Element concentrations are presented by station in the results section. Data from analyses of all elements are available in the public environmental monitoring database accessible at SGU's web site (www.sgu.se).

Organic substances

A large number of organic substances has been analysed within the programme. The list of substances has been changed between the different survey years for better conformity with the list of priority substances according to Annex 11 of the Directive 2008/105/EC on Environmental Quality Standards. In Table 3 all organic substances analysed from the three survey years are listed. In total 47 substances have been analysed all three years. For these substances, data from three time series are available which may be enough to detect a trend in concentrations.

Analyses of organic substances were performed at Analytica AB (today ALS Scandinavia AB) in 2003. In 2008 and 2014 the analyses were carried out by the Swedish Environmental Research Institute, IVL, with subcontracting laboratories for dioxins, furans and dioxin-like PCBs (Umeå university) and chloroalkanes (ALS Scandinavia AB) in 2014. The change of laboratory between 2003 and 2008 was made to meet the requirements of very low quantification limits due to low concentrations of some organic substances in offshore sediments. The same analytical methods have been used in 2008 and 2014. In the technical annexes of OSPAR JAMP guidelines (OSPAR 2002) analytical methods for a number of substances are described. These methods have been adopted by IVL for the specified substances analysed in 2008 and 2014.

A list of organic substances from the different survey years are presented in Table 4. Concentrations of a selection of organic substances are presented by station in the results section. In Appendix 2 maximum and minimum levels for the organic substances analysed in 2014 are presented. Data from analyses of all organic substances are available in the public environmental monitoring database accessible at SGU's web site (www.sgu.se).

Carbon and nitrogen

Organic carbon (TOC), total carbon (TC) and total nitrogen (TN) have been analysed at every station (Table 3). Sediment concentrations of carbon and nitrogen have been analysed at different laboratories in order to use the same analytical method. In 2003 analyses of carbon and nitrogen species were made at MikroKemi in Uppsala, in 2008 at the department of Earth Sciences at the University of Gothenburg, and in 2014 at the Swedish Meteorological and Hydrological Institute in Gothenburg. Sediment concentrations of carbon and nitrogen species are presented along with element data by station in the result section. Data from all carbon and nitrogen analyses are found in the public environmental monitoring database available at SGU's web site (www.sgu.se).

Assessment of chemical data

The results of the chemical analyses are presented as total concentrations and the variation between samples is presented when replicates are available (for metals 2008 and 2014). No further statistical analyses have been carried out since datasets are only available from three years, and due to the change of laboratories and methods throughout the programme which make the datasets less comparable. The statistical significance of concentration changes between years has not been evaluated, that is, the standard deviation of each parameter is not taken into consideration. When a longer time series is available, statistical analyses will be performed to evaluate increasing or decreasing trends.

Chemical data are assessed according to two different systems. The most extensive classification system used for marine sediments is developed by the Swedish EPA (Swedish EPA 1999). This system groups the assessed elements and organic substances into classes or criteria based on the statistical distribution of concentrations from surface sediment samplings done by SGU along the Swedish coast. In this scale of five groups, class 1 represents a comparison value. For elements this value is represented by the national background for the specific element. For organic substances class 1 is equal to zero. Subsequent classes describe a successively larger degree

of deviation from the natural environmental state. Class 5 means a clear influence from pollution sources. Environmental assessment criteria are available for the elements arsenic, cadmium, cobalt, chromium, copper, mercury, nickel, lead and zinc. Depending on the digestion method used (total or partial), two separate classification tables are available for metals. For organic substances there are available assessment criteria for polycyclic hydrocarbons (PAHs), hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs), hexachlorocyclohexanes (HCHs), dichlorodiphenyltrichloroethane (DDT) and related substances (DDD and DDE) and chlordanes. Concentrations of all organic pollutants except HCB are presented as a sum of congeners or substances within each substance group:

- Sum PAH (phenanthrene, anthracene, fluoranthene, pyrene, benzo(ah)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene)
- PCB7 (PCB 28, PCB 52, PCB 101, PCB 118, PCB 153, PCB 138, PCB 180)
- Sum HCH (a-HCH, b-HCH, g-HCH)
- Sum DDT (p,p'-DDT, p,p'-DDD, p,p'-DDE)
- Sum chlordane (a-chlordane, g-chlordane, trans-nonachlor)

Concentrations below the limit of quantification (LOQ) are estimated as <value/2 in the calculations of the sum parameters.

Since 2013 there are also environmental assessment criteria based on toxicological studies on benthic organisms available for water management. These criteria are set by the Swedish Agency for Marine and Water Management (SwAM) and are presented in the regulation on classification and environmental quality standards regarding surface water (HVMFS 2013:19). These criteria were developed for the participating countries within EU to facilitate their adaptation of the environmental monitoring to local conditions. The effect-based criteria are supposed to be used along with the criteria set in the EU directive 2008/105/EG when classifying surface waters within water management. In this report the criteria are used as a tool to assess whether the substance or element concentrations are present at a level that may cause harm to bottom living organisms within every monitoring station rather than the assessment of water quality. The substances and elements with available ecotoxicological effect-based criteria are: anthracene, fluoroanthene, tributyltin (TBT), cadmium and lead. Concentration data from these substances will be presented in separate tables by station in this report. The ecotoxicological effect-based assessment values for anthracene and fluoranthene pertains to sediments with a TOC level of 5%. Therefore every assessment value must be corrected to fit the TOC concentration at every specific station. This is done by multiplying the assessment value with [station mean TOC level %/5] before the comparison. The adjusted assessment values are presented in the same table as concentration data.

For metal concentration data, error bars showing the standard deviation from the seven analysed samples in 2008 and 2014 (and 2010 at station SE-11) within every station are added to the bar charts. There was no multiple sampling conducted in 2003 and therefore no standard deviations for these analyses are available. Concentrations of organic pollutants from 2008 and 2014 (and 2010 at station SE-11) are presented in diagrams with error bars declaring the measurement uncertainty for each substance group. Since the congeners included in PCB7 have uncertainties varying between 20% and 30% a mean value of 23% is presented. The PAH group consists of different substances with measurement uncertainties that vary more and therefore no error bars are added to the PAH charts. There is no documentation of measurement uncertainty from organic analyses from 2003 and therefore no error bars are added to the data from this

year. It is important to bear in mind that no further statistical analyses have been carried out to evaluate time trends. This will be done in the future when data from more monitoring surveys are available. The results of the chemical analyses are presented as total concentrations and the variation within these in this report. No statistical analyses have been carried out since only three datasets are available today and due to the change of laboratories and methods throughout the programme which make the datasets less comparable. In the descriptions of concentration variation, the standard deviation of each parameter is not taken into consideration.

RESULTS

Data collected during the three different monitoring occasions are presented for each station starting from the Bothnian Bay and moving southwards. Since the amount of data and measured parameters is extensive, only the most important pollutants will be presented at each station. For metals this includes all elements with available environmental criteria. From the group of organic micropollutants the substances and substance groups PAHs, HCB, PCBs, HCHs, DDTs and chlordanes are presented along with their assessment criteria. The substances diuron, simazine, tributyltin (TBT), bis(2-ethylhexyl) phthalate (DEHP) and nonylphenol have not yet been assigned any threshold values but are presented in this report by station along with the previously mentioned micropollutants since they have been monitored all three survey years. Some organic substances occur in levels below the limit of quantification (LOQ) on a few occasions. These concentrations are presented as <values. In this report these measurements are presented in the diagrams as half the LOQ-value, that is value/2. When a substance occurs below the LOQ in two out of three survey years at a station, the concentration is not presented in a diagram.

In 2008 and 2014, elements were analysed in surface sediments at all seven sampling sites within a station in order to estimate the variation (using relative standard deviation) within every station circle. Therefore there are seven measured concentrations available for every element at every station from these two years. To simplify data presentation, average element concentrations are presented for 2008 and 2014. In 2003, only one sample was analysed from each station.

It is important to keep in mind that changes in the analytical methods have occurred throughout the years. For this reason, data between the different survey years may be difficult to compare. For example, both methods and laboratory were changed for organic substances between 2003 and the two following monitoring campaigns. For element evaluation, the changes in digestion methods for some species are not as significant in terms of comparability since partial and total digestion methods have shown similar results in fine sediments (Smedes et al. 2000). Total organic carbon, total carbon and total nitrogen have been analysed at different laboratories on all three occasions but the same analytical method has been used.

Geological descriptions are presented separately in Appendix 1 in this report. Concentrations, maximum and minimum values of micropollutants analysed in 2014 are presented in Appendix 2.

Station SE-17, northern Bothnian Bay

Station SE-17 is located in the Bothnian Bay approximately 60 km east-south-east of Luleå at an accumulation bottom at 87 m depth (Fig. 1). In this part of the Baltic Sea, temperature is the dominating factor for stratification of the water column since the salinity is quite low in both bottom and surface waters (Fig. 4).

The seabed at station SE-17 consists of reduced postglacial gyttja clay with an oxic layer at the surface. The bottom water is oxygenated with a measured concentration of dissolved oxygen of around 8 mL/L. There is evidence of benthic life with crawling tracks on the seabed surface (Fig. 5).

The average TOC content was around 3.9% of dry weight (DW) in 2008 and around 4.4% DW in 2014 (Table 5). The average concentrations of a number of elements and parameters are also presented in Table 5. The calculated relative standard deviation in percent (%RSD) indicates that the variation in concentrations between sampling points within the station is highest for mercury (Hg) and cadmium (Cd) from 2008. TOC levels show low variation within the station for both 2008 and 2014.

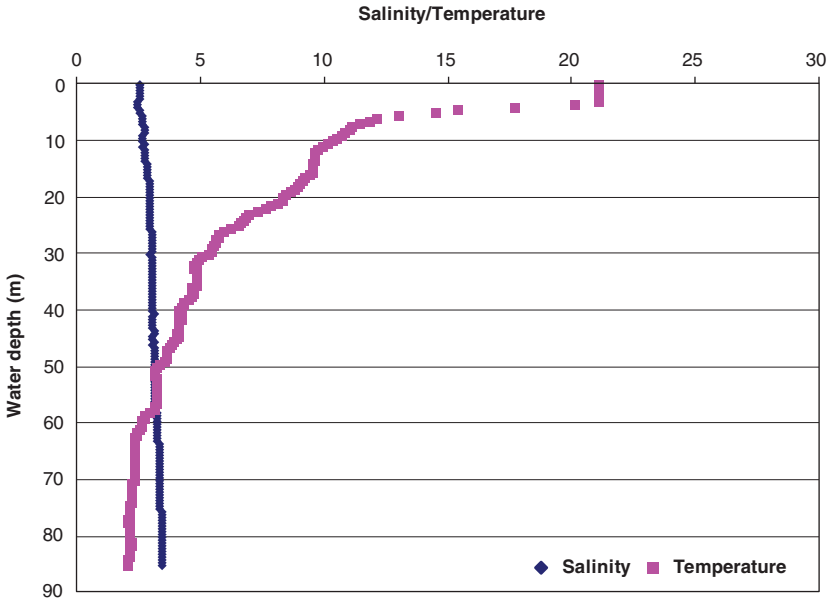

Figure 4. Temperature is the dominating factor for stratification of the water column in the northern regions of the Baltic Sea. At station SE-17, located in the Bothnian Bay, a thermocline can be identified at a water depth of around 5 m. The salinity is constant at a value of around 2–3. The profile is based on CTD data from August 2014.

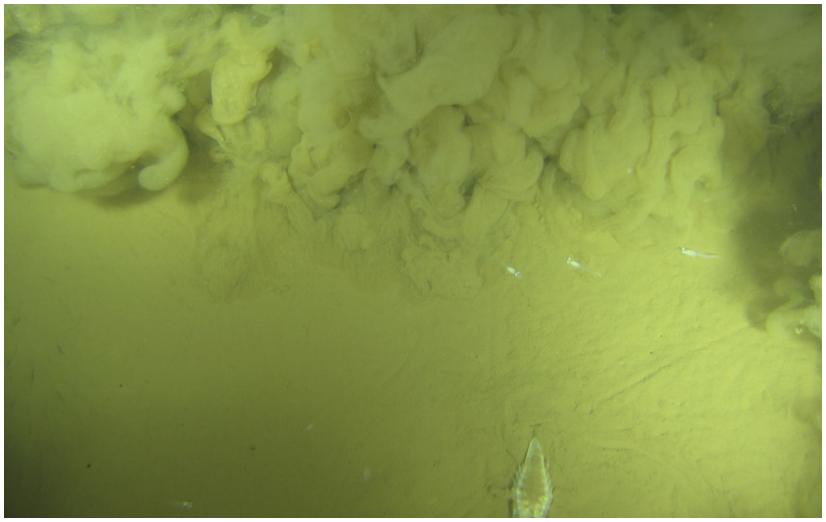

Figure 5. The underwater photograph from station SE-17 shows that benthic fauna exists at the bottom. This means that the bottom water is oxygenated enough. This is also shown by the light colour of the surface sediment which is the oxic layer which covers the reduced conditions underneath.

Table 5. Concentrations of different elements at seven sampling sites within station SE-17, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	113	107	0.969	1.12	0.120	0.077	1 930	1 520	0.41	0.41	4.06	4.45
Site 2	128	119	1.24	1.03	0.105	0.098	1 690	1 270	0.38	0.40	3.80	4.68
Site 3	103	120	0.947	0.967	0.088	0.108	1 710	1 230	0.38	0.39	3.80	4.34
Site 4	100	119	0.907	1.26	0.098	0.098	1 770	1 620	0.37	0.41	3.79	4.46
Site 5	102	121	0.858	1.11	0.074	0.122	1 750	1 510	0.38	0.40	3.86	4.41
Site 6	138	108	1.24	1.06	0.112	0.107	1 810	1 350	0.38	0.38	3.77	4.33
Site 7	121	119	0.951	0.969	0.087	0.106	1 840	1 260	0.39	0.42	3.92	4.44
Average	115	116	1.02	1.07	0.098	0.102	1 786	1 394	0.38	0.40	3.86	4.44
Standard deviation STD	13.5	5.51	0.146	0.0946	0.0147	0.0126	76.32	142.7	0.012	0.010	0.0954	0.108
%RSD	11.7	4.75	14.3	8.81	15.0	12.3	4.274	10.24	3.1	3.0	2.47	2.42

Table 6. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-17. Colour classification in accordance with Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
As	135	115	116
Cd	1.19	1.02	1.07
Co	23.8	28.3	33.3
Cr	100	94.0	85.1
Cu	18.8	42.6	42.0
Hg	0.163	0.10	0.102
Ni	21.0	46.1	51.7
Pb	22.6	44.4	38.8
Zn	187	202	159
S	1 980	1 790	1 390
TN	0.42	0.38	0.40
TOC	4.0	3.9	4.4

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

Elements presented in Figures 6A–J show that there is no general trend in metal concentration patterns at station SE-17. Copper, nickel and lead concentrations seem to have increased since 2003 (Figs. 6E, G and H), while mercury shows the opposite pattern (Fig. 6F).

For elements with available environmental assessment criteria (Swedish EPA 1999), shown in Table 6, arsenic is present in very elevated levels compared to the national background concentrations. The remaining classified elements are moderately elevated. Cadmium and lead levels do not exceed the ecotoxicological assessment criteria (HVMFS 2013:19) in any year (Table 8).

The organic pollutants with available environmental assessment criteria are shown in Figures 7A–F and Table 7 together with the organic substances without available criteria in Figure 7G. Most substances are present in moderate to high concentrations. The substance groups of chlordanes, PCB7 and DDT, and HCB occur at stable concentrations in the surface sediment throughout the three survey years (Figs. 7B, C, E and F). The PAHs, HCHs and DEHP seem to have decreased substantially since 2003 (Figs. 7A, D and G). TBT and nonylphenol concentrations were detectable in 2003 but below LOQ in 2008 and 2014. Simazine and diuron levels were below LOQ all three years (Table 7).

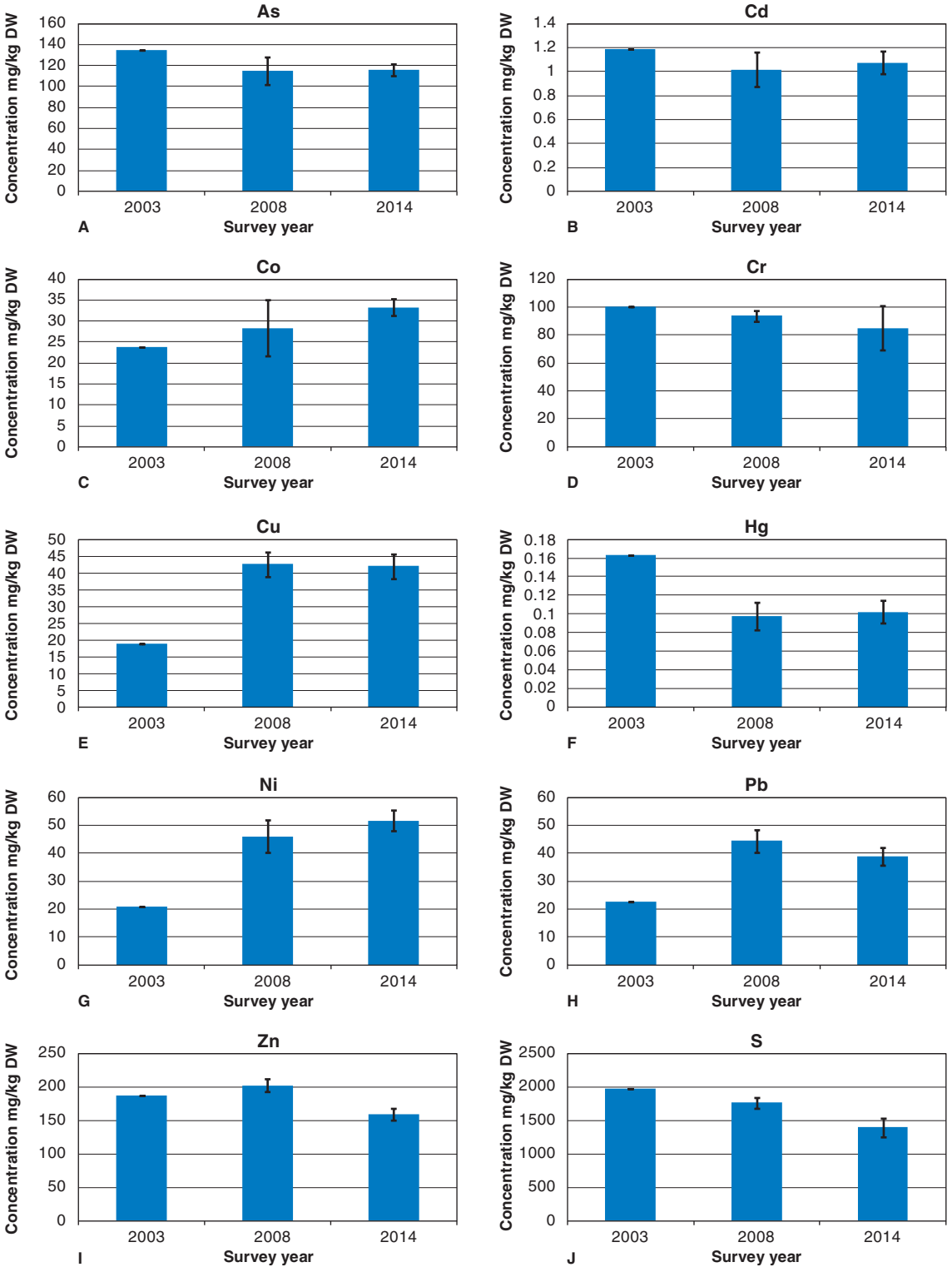

Figure 6. **A–J.** Element concentrations at station SE-17 show no general increasing or decreasing trend. Copper, nickel and lead concentrations seem to have increased since 2003, while mercury demonstrates the opposite pattern. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 7. Concentrations in µg/kg DW of organic micropollutants from 2003 to 2014 at station SE-17. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	8.4	1.2	1.1
Fluoranthene	40	18	19
Sum 11 PAH	486	235	233
Sum 7 PCB	1.4	1.4	1.5
HCB	0.28	0.27	0.28
Sum HCH	0.72	0.14	0.11
Sum DDT	0.48	0.58	0.50
Sum Chlordanes	0.16	0.14	0.18
TBT	3.5	<1	<1.1
Diuron	<20	<2	<0.15
Simazine	<2.0	<2	<0.5
DEHP	500	<20	140
Nonylphenol	240	<10	<30

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 8. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-17. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	1 190	–	1 020	–	1 070	–
Pb	120 000	22 600	–	44 400	–	38 800	–
Anthracene	24	8.4	19	1.2	19	1.1	21
Fluoranthene	2 000	40	1 605	18	1 543	19	1 778
TBT	1.6	3.5	1.3	<1	1.2	<1.0	1.4

Concentration exceeds assessment value.

When classifying the concentrations in accordance to the Swedish EPA environmental assessment criteria it is obvious that most substances occur in levels within class 2 to 4. HCB levels have been stable within class 4 since the start in 2003 and PCB and DDT concentrations have been within class 3 during the same period. PAH levels dropped from class 3 to class 2 and HCH levels from class 4 to class 3 between 2003 and 2008. Chlordane concentrations have been stable within class 4 since 2003. TBT occurred in levels exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) in 2003 (Table 8).

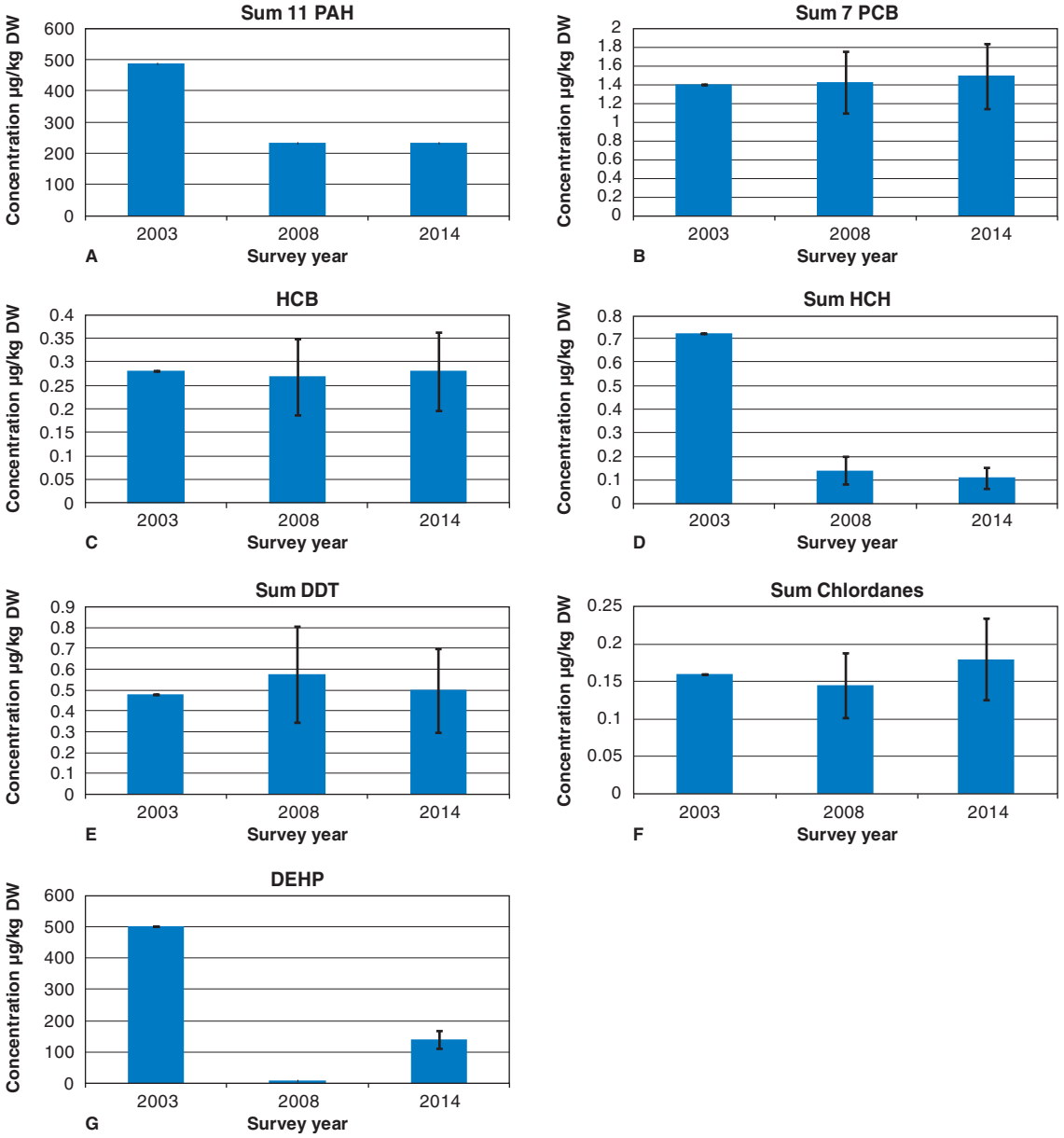

Figure 7. **A–G.** The concentrations of most organic substances at station SE-17 have been stable since 2003. PAHs, HCHs and DEHP seem to have decreased during the same period. The error bars represent laboratory measurement uncertainties.

Station SE-1, southern Bothnian Bay

Station SE-1 is located in the southern part of the Bothnian Bay around 80 km south-east of Skellefteå at a depth of about 113 m. Just like in the north part of the Bothnian Bay, the temperature is the dominating factor controlling water column stratification in the summer and a thermocline is visible at a water depth of around 15 m. Salinity levels are quite stable throughout the water column with a value of 3 in the surface water and 5 at the bottom (Fig. 8).

The sediment at the station consists of reduced postglacial gyttja clay with an oxic layer at the surface. The bottom water is well oxygenated with a concentration of dissolved oxygen of 7.2 mL/L. These conditions are favourable for benthic life and there is evidence of benthic fauna at the underwater photographs from the station (Fig. 9). The average TOC content was 4.7% DW in 2008 and 5.0% DW in 2014 which shows that there has been no significant increase in organic load between the years (Table 9). The element that shows the greatest variation in concentration levels within the station area is arsenic with a relative standard deviation of almost 17% in 2014. In 2008, mercury concentrations were most dispersed.

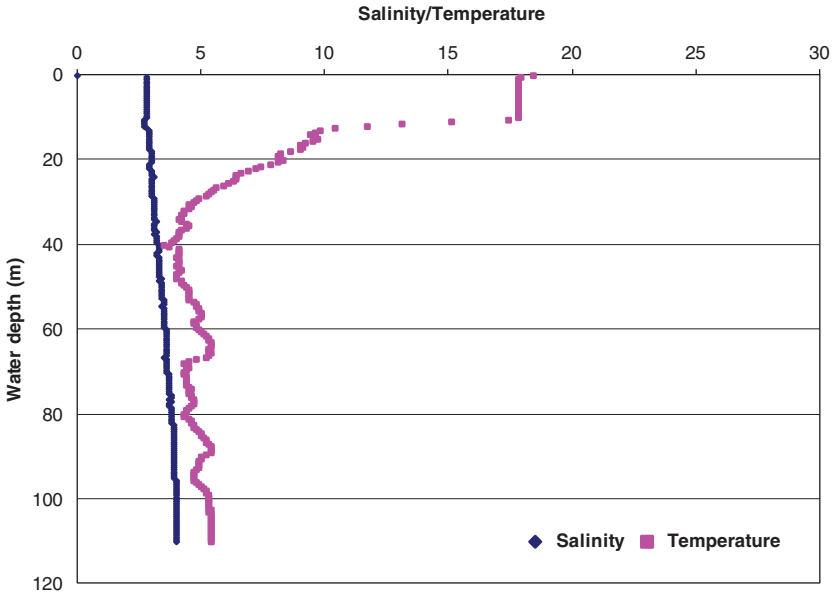

Figure 8. Temperature is the dominating factor for stratification also in this part of the Bothnian Bay. In this part of the Bothnian Bay the thermocline is found at a depth of approximately 15 m. The salinity increases from 3 in the surface water to 5 at the bottom. CTD data were obtained in August 2014.

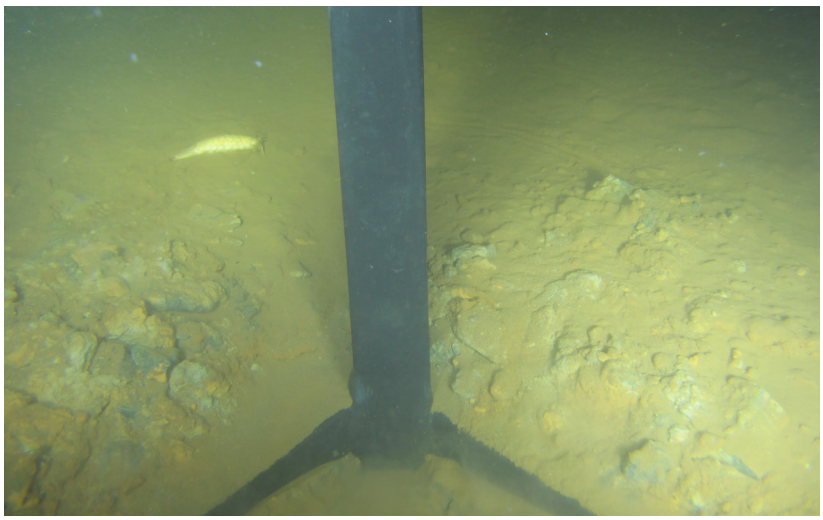

Figure 9. The underwater photograph from station SE-1 shows that there is benthic fauna present at the location *(Saduria entomon)*. This indicates favourable oxygen conditions in the bottom water which is also indicated by the light colour of the sediment surface which is the oxic layer.

Figures 10A–J show potential trends of element concentrations at station SE-1. Most element concentrations display small changes since 2003.

Table 10 presents elements with available environmental assessment criteria (Swedish EPA 1999). From these data it is apparent that most elements occur in concentrations with a large to very large deviation from the national backgrounds. Only chromium and nickel analysed in 2003 and 2008 are present at levels that are within the concentration range for insignificant to small deviation from background concentrations. Cadmium and lead levels do not exceed the ecotoxicological assessment criteria (HVMFS 2013:19) in any year (Table 12).

The organic substances with related assessment criteria are presented in Figures 11A–F and Table 11 together with the organic substances without available criteria in Figure 11G. The sum of PAHs and HCHs indicates that these substances have decreased in the sediment since 2003 (Figs. 11A and D). HCB levels show a different pattern with a continuous increase since 2003 (Fig. 11C). TBT and nonylphenol levels were quantifiable in 2003 but below LOQ in 2008 and 2014. Simazine concentrations have been below LOQ since the start of the program. Diuron levels were below LOQ in 2003 and 2008 but were quantifiable in 2014. DEHP concentrations

Table 9. Concentrations of different parameters at seven sampling sites within station SE-1, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	185	210	1.52	1.56	0.336	0.226	2 500	1 840	0.47	0.47	4.71	4.30
Site 2	165	140	1.61	1.62	0.279	0.268	2 440	1 760	0.47	0.48	4.69	4.97
Site 3	172	221	1.53	1.77	0.267	0.284	2 400	2 000	0.47	0.50	4.62	5.11
Site 4	145	220	1.20	1.69	0.290	0.310	2 380	2 460	0.47	0.51	4.61	5.09
Site 5	182	183	1.42	1.52	0.235	0.280	2 120	1 910	0.47	0.53	4.69	5.11
Site 6	177	172	1.54	1.39	0.271	0.239	2 360	1 710	0.47	0.53	4.69	5.06
Site 7	160	179	1.39	1.55	0.224	0.263	2 370	1 700	0.47	0.47	4.73	5.07
Average	169	189	1.50	1.59	0.271	0.267	2 367	1 911	0.47	0.50	4.68	4.96
Standard deviation STD	12.9	27.4	0.13	0.114	0.0342	0.261	110.4	245.6	0	0.024	0.0416	0.272
%RSD	7.63	14.5	8.65	7.17	12.6	9.79	4.665	12.85	0	4.80	0.890	5.49

Table 10. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-1. Colour classification in accordance with Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
As	140	169	189
Cd	1.46	1.46	1.59
Co	27.3	40.7	40.2
Cr	86.6	80.4	74.6
Cu	49.3	60.2	59.5
Hg	0.313	0.272	0.267
Ni	14.6	33.8	68.8
Pb	78.3	81.8	68.3
Zn	201	270	233
S	2 490	2 370	1 910
TN	0.51	0.47	0.50
TOC	4.8	4.7	5.0

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

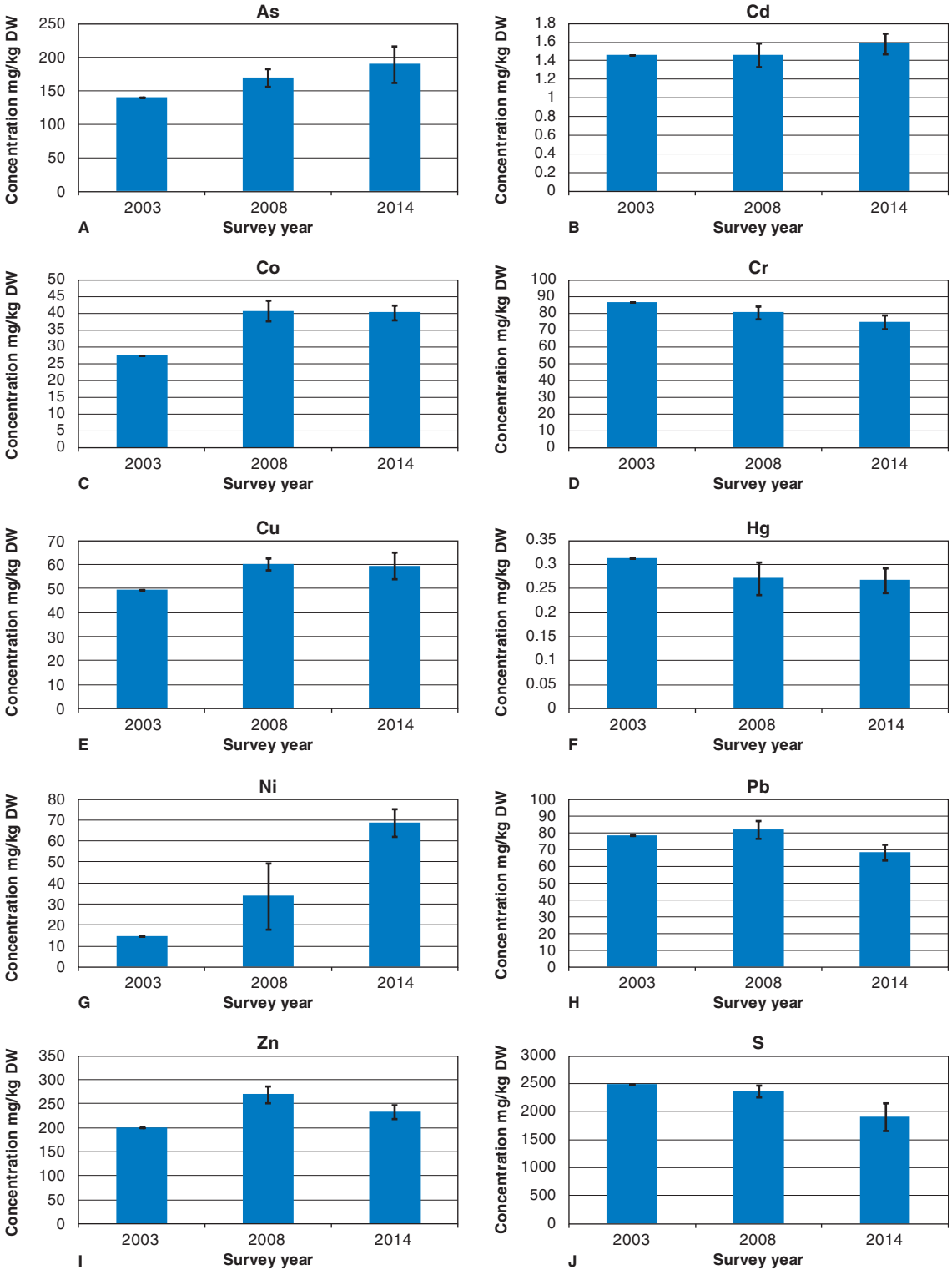

Figure 10. **A–J.** Most element concentrations at station SE-1 have been stable since 2003. The largest changes in concentrations were observed for nickel. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 11. Concentrations in µg/kg DW of organic micropollutants from 2003, 2008 and 2014 at station SE-1. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	7.2	0.21	1.2
Fluoranthene	41	3.1	22
Sum 11 PAH	515	412	302
Sum 7 PCB	1.6	2.7	1.8
HCB	0.31	0.32	0.42
Sum HCH	0.30	0.19	0.14
Sum DDT	0.67	0.79	0.58
Sum Chlordanes	0.19	0.14	0.21
TBT	4.6	<1	<1
Diuron	<20	<2	0.16
Simazine	<2.0	<2	<0.5
DEHP	370	<20	200
Nonylphenol	21	<10	<30

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 12. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-1. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	1 460	–	1 459	–	1 586	–
Pb	120 000	78 300	–	81 814	–	68 329	–
Anthracene	24	7.2	23	2.1	22	1.2	24
Fluoranthene	2 000	41	1 915	31	1 871	22	1 983
TBT	1.6	4.6	1.5	<1	1.5	<1	1.6

Concentration exceeds assessment value.

decreased between 2003 and 2008, when levels were below the limit of quantification, but increased between 2008 and 2014 (Fig. 11G).

When classifying the concentrations in accordance to the Swedish EPA environmental assessment criteria it is shown that substances in the chlordane group and HCB are present in high levels within class 4. HCH concentrations have moved from class 4 in 2003 to class 3 in 2008 and 2014. PAHs, PCB7 and DDTs have been present in concentrations within class 3 since 2003. None of the organic substances anthracene and flouranthtene occur or have occured in levels exceeding the ecotoxicological assessment criteria, while TBT exceeded the normalised assessment value in 2003 (HVMFS 2013:19) (Table 12).

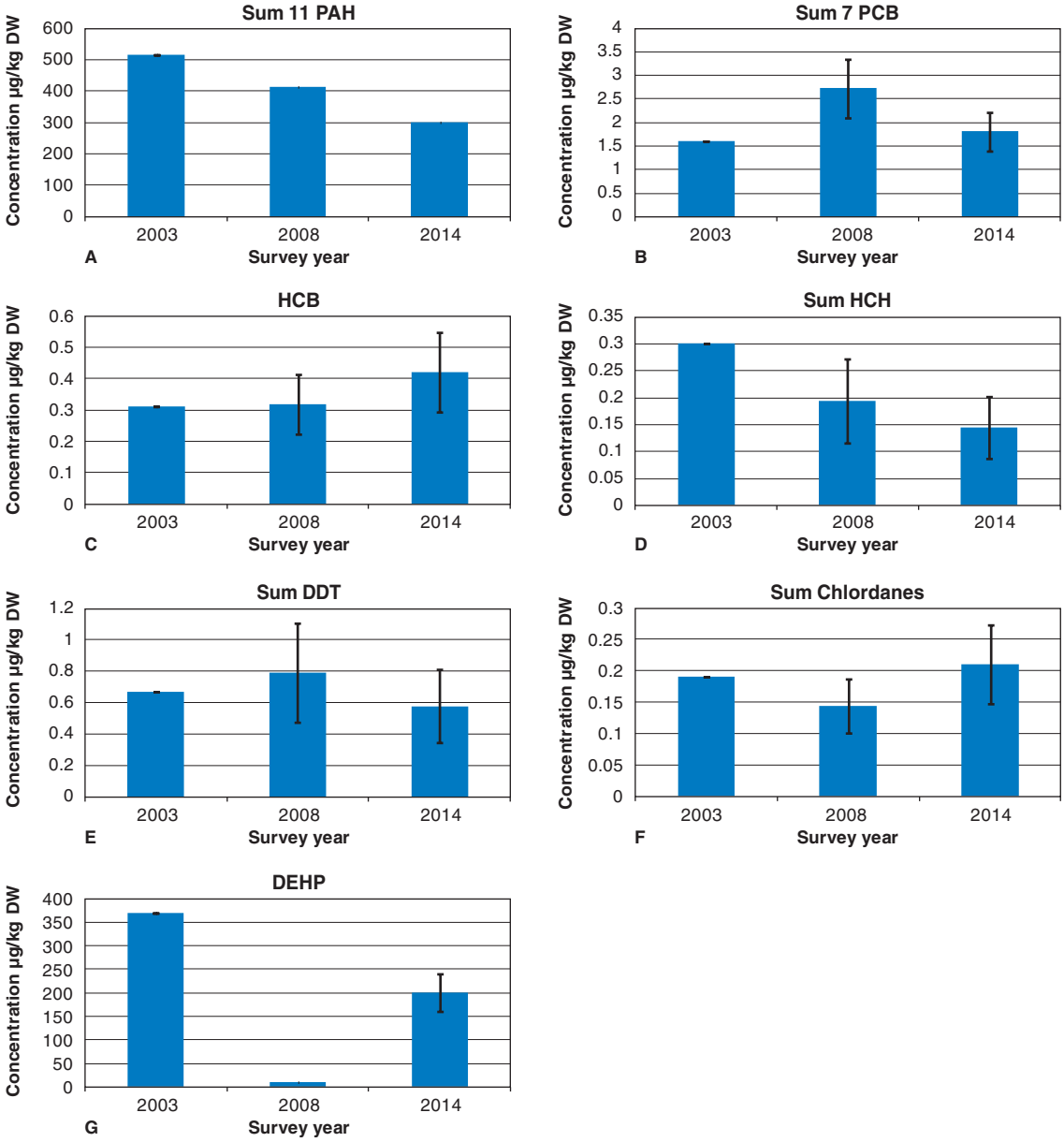

Figure 11. **A–G.** The concentrations of organic substances at station SE-1 show no general trend since 2003. PAHs, HCHs and DEHP seem to have decreased, while HCB levels seem to have increased. The error bars represent laboratory measurement uncertainties.

Station SE-2, Härnösand deep

Station SE-2 is located in a c. 200 m deep sea basin about 55 km east of Härnösand, the Härnösand deep (Fig. 1). Also in this part of the Baltic Sea temperature is the dominating factor for stratification of the water column in summer and a thermocline is visible at a water depth of around 10 m. The surface water salinity is 5 just like in the two locations in the Bothnian Bay, SE-17 and SE-1, but bottom water salinity is slightly higher at 6.5 (Fig. 12).

The sediment at the station consists of reduced postglacial gyttja clay with an anoxic layer at the top. There are no adequate underwater photographs from this station due to a loose sediment composition in the upper part of the sediment which stirred up the material making a slurry in the bottom water. There was however evidence of life at the station since a *Saduria entomon* was recovered in the sediment sampler (Fig. 13).

The bottom water was not as oxygenated as at the two stations in the Bothnian Bay. At SE-2 the concentration of dissolved oxygen was 4.2 mL/L. The average content of TOC was 3.5% DW in 2008 and 2.9% DW in 2014 (Table 13). Mercury is the element with the largest variation within the station area, 49.1% in 2008. In 2014, the variation was only 9.2%. The arsenic concentration in 2008 had an RSD of 15.5%.

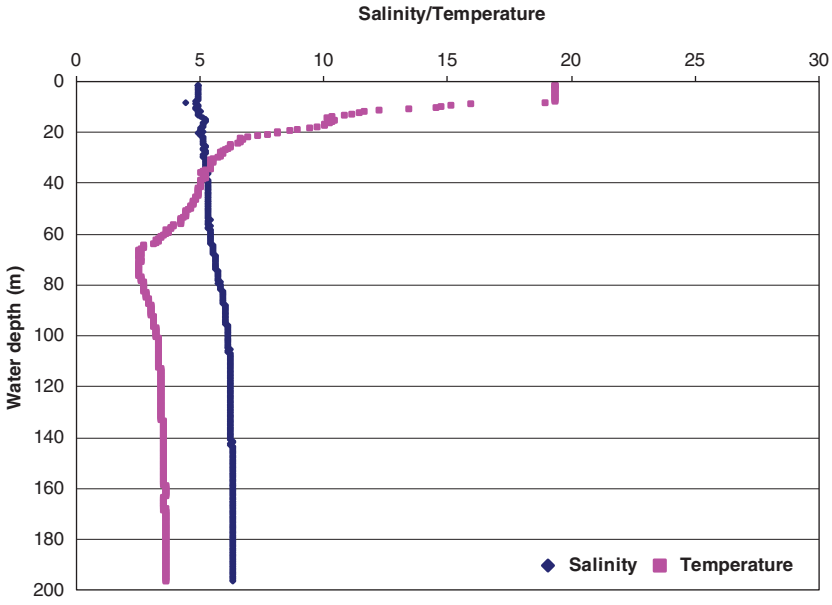

Figure 12. Temperature is the dominating factor for stratification also in this part of the northern Baltic Sea. In the Härnösand deep basin the thermocline is found at a depth of approximately 10 m. The salinity increases from 5 in the surface water to over 6 at the bottom.

Figure 13. A *Saduria entomon* was recovered in one of the sediment samples.

Table 13. Concentrations of different parameters at seven sampling sites within station SE-2, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	148	103	0.874	0.447	0.0774	0.0607	2 510	1 710	0.36	0.27	3.54	2.99
Site 2	156	83.8	0.838	0.394	0.0716	0.0632	2 580	1 310	0.35	0.27	3.55	2.92
Site 3	115	88.0	0.641	0.395	0.0527	0.0550	2 820	1 200	0.35	0.26	3.45	2.98
Site 4	198	89.0	0.717	0.360	0.198	0.0703	2 570	1 480	0.35	0.28	3.56	2.95
Site 5	163	92.5	0.670	0.402	0.101	0.0677	2 780	1 430	0.34	0.26	3.42	2.93
Site 6	185	102	0.816	0.395	0.0921	0.0576	2 260	1 690	0.36	0.28	3.68	2.94
Site 7	155	92.6	0.652	0.319	0.0586	0.0573	2 360	1 340	0.36	0.26	3.57	2.90
Average	160	93.0	0.744	0.387	0.0931	0.0617	2 554	1 451	0.35	0.27	3.54	2.94
Standard deviation STD	24.8	6.62	0.0896	0.0365	0.0456	0.00527	188.5	177.6	0.0070	0.0083	0.0788	0.0297
%RSD	15.5	7.12	12.0	9.43	49.1	8.54	7.380	12.23	2.1	3.1	2.23	1.01

Table 14. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-2. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
As	44.6	160	93.0
Cd	0.275	0.744	0.387
Co	16.4	12.8	22.1
Cr	87.9	82.8	80.6
Cu	27.4	23.4	33.9
Hg	0.0721	0.0931	0.0617
Ni	5.00	34.8	47.0
Pb	28.0	21.7	23.3
Zn	159	194	162
S	1820	2550	1450
TN	0.35	0.35	0.27
TOC	3.14	3.54	2.94

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

Figures 14A–J and Table 14 show potential trends of a number of elements within station SE-2. There is no general decrease in metal concentrations the last few years. Concentrations of arsenic, cadmium, mercury, zinc and sulphur increased between 2003 and 2008 but decreased again between 2008 and 2014 (Figs. 14A, B, F, I and J). Nickel levels have increased since the start of the programme in 2003 (Fig. 14G) whereas chromium concentrations have dropped during the same period (Fig. 14D).

Table 14 presents the elements with available environmental assessment criteria (Swedish EPA 1999). Arsenic occurs in concentrations with very large deviations from background concentrations. All other elements occur in concentrations that show none to medium deviation from the national background. Cadmium and lead levels do not exceed the ecotoxicological assessment criteria (HVMFS 2013:19) in any year (Table 16).

Organic substances with available environmental assessment criteria are presented in Figures 15A–F and Table 15 together with the organic substances without available criteria (Fig. 15G). PAHs, HCHs and DDTs are the chemical groups that show continuously decreasing

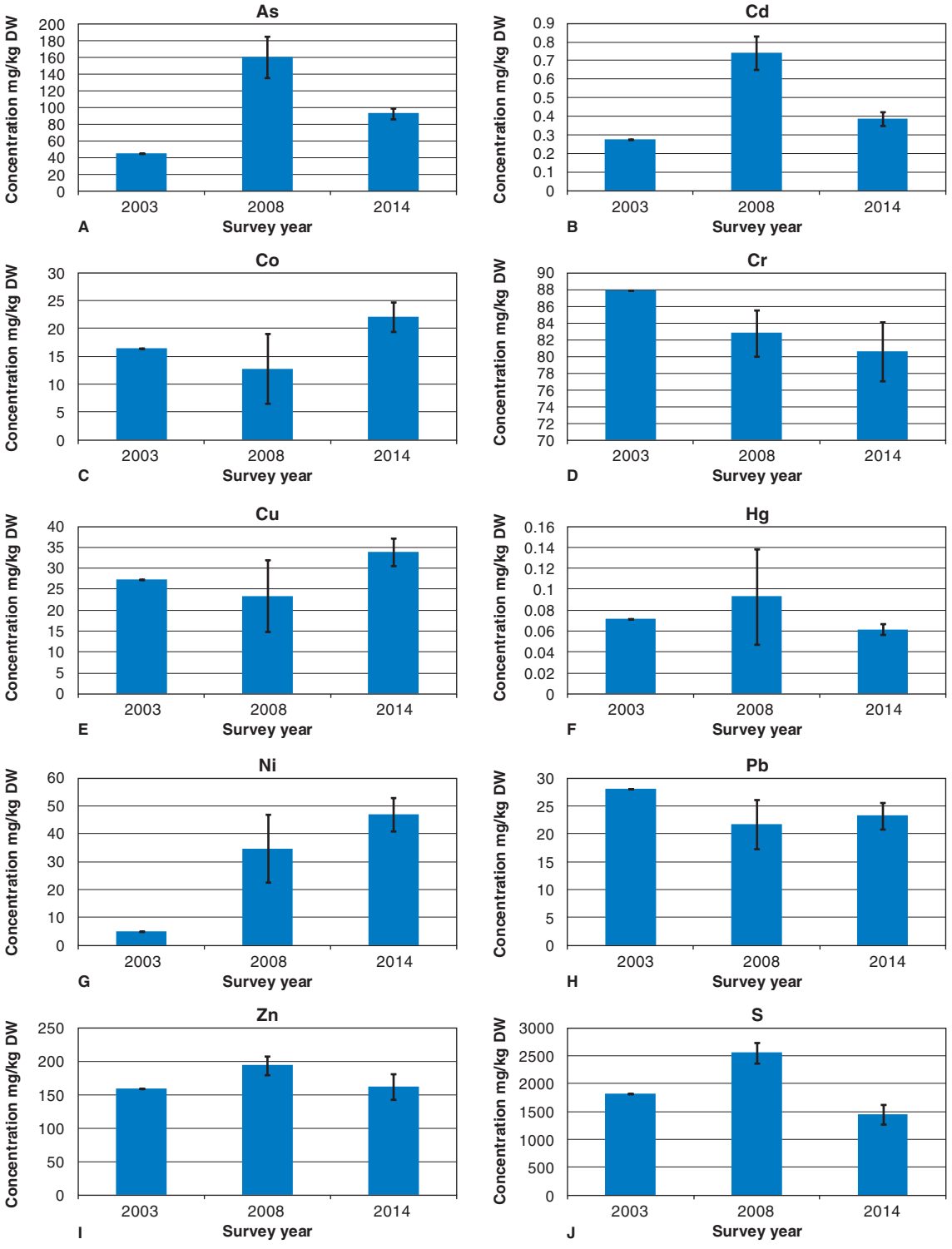

Figure 14. **A–J.** Most element concentrations at station SE-2 have been stable since 2003. The largest changes in concentrations were observed for nickel. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 15. Concentrations in µg/kg DW of organic from 2003, 2008 and 2014 at station SE-2. Colour classification is in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	8.5	1.7	1.4
Fluoranthene	56	33	30
Sum 11 PAH	582	380	346
Sum 7 PCB	1.2	1.6	1.2
HCB	0.29	0.30	0.32
Sum HCH	0.39	0.30	0.20
Sum DDT	1.6	0.89	0.72
Sum Chlordanes	0.15	0.10	0.11
TBT	1.9	<1	<1
Diuron	<20	<2	0.22
Simazine	<2.0	4.6	<0.5
DEHP	210	<20	190
Nonylphenol	<10	<10	<30

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 16. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-2. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	275	–	744	–	387	–
Pb	120 000	28 000	–	21 714	–	23 257	–
Anthracene	24	8.5	15	1.7	17	1.4	14
Fluoranthene	2 000	56	1 255	33	1 415	30	1 178
TBT	1.6	1.9	1.0	<1.0	1.1	<1.0	0.9

Concentration exceeds assessment value.

levels since the start of the programme in 2003 (Figs. 15A, D and E). For PCBs, HCB, chlordanes and DEHP there are no clear trends (Figs. 15B, C, F and G). TBT levels were quantifiable in 2003 but below LOQ the following two years. Diuron levels were below LOQ in 2003 and 2008 but quantifiable in 2014. Simazine concentrations were quantifiable only in 2008 while nonylphenol levels have been below LOQ all years.

When classifying the concentrations in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999), all substances except for PAH and PCB7 occur or have occurred in class 4, high concentrations. DDTs and HCHs moved down from class 4 to class 3 between 2003 and 2008. PCB concentrations moved from class 2 to class 3 between 2003 and 2008 but fell back again between 2008 and 2014. HCB and chlordane concentrations have been within class 4 and PAH11 concentrations within class 3 all three years. In 2003 TBT concentrations exceeded the ecotoxicological assessment criteria (HVMFS 2013:19) (Table 16).

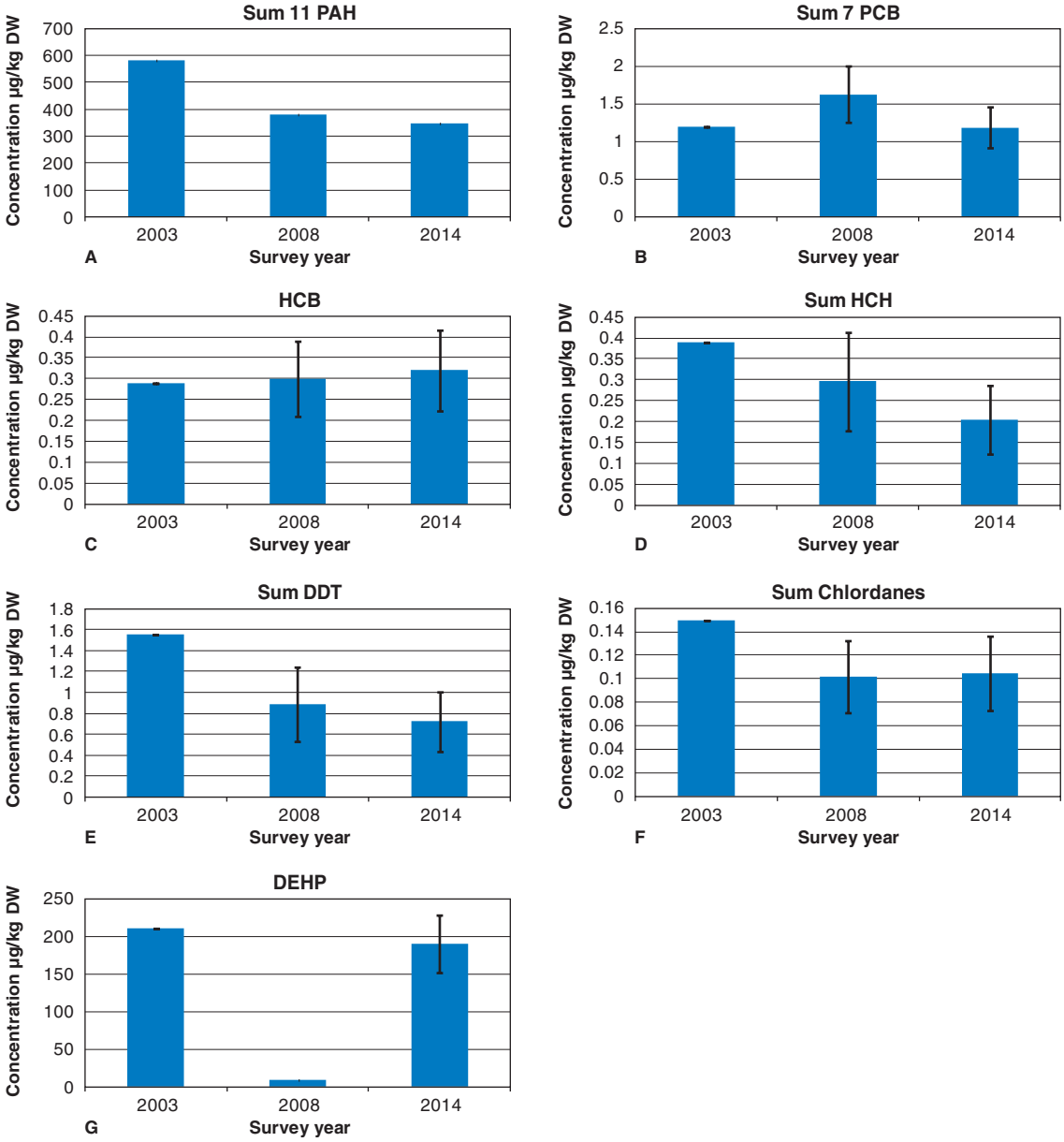

Figure 15. **A–G.** The concentrations of organic substances at station SE-2 show no general trend since 2003. PAHs, HCHs and DDTs are the chemical groups that show decreasing levels since the start of the programme in 2003. The error bars represent laboratory measurement uncertainties.

Station SE-3, southern Bothnian Sea

Station SE-3 is located in the Bothnian Sea around 55 km east of Söderhamn (Fig. 1). The sampling site is situated at a depth of around 78 m. The hydrographical conditions at station SE-3 are similar to the northern stations with temperature as the main factor controlling water stratification in summer. At station SE-3 there is a strong thermocline at around 10 m depth. Salinity levels lie quite consistently at 5 in the whole water column (Fig. 16).

The sediment at station SE-3 consists of postglacial gyttja clay with reduced lamina and spots throughout the whole sediment core and an oxic layer on the top. Photographs taken with the underwater camera are blurry due to resuspension of sediments which makes it impossible to distinguish any features on the seabed. However, *Saduria entomon* was present in almost every sediment sample taken within the station area (Fig. 17). Also other types of fauna was found in the sediment cores and overlying water, e.g. *Marenzelleria* and *Monoporeia*.

The bottom water concentration of dissolved oxygen was similar to that in the Härnösand deep, 4.9 mL/L. Current speed velocity was measured to 0.05 m/s which indicates stagnant

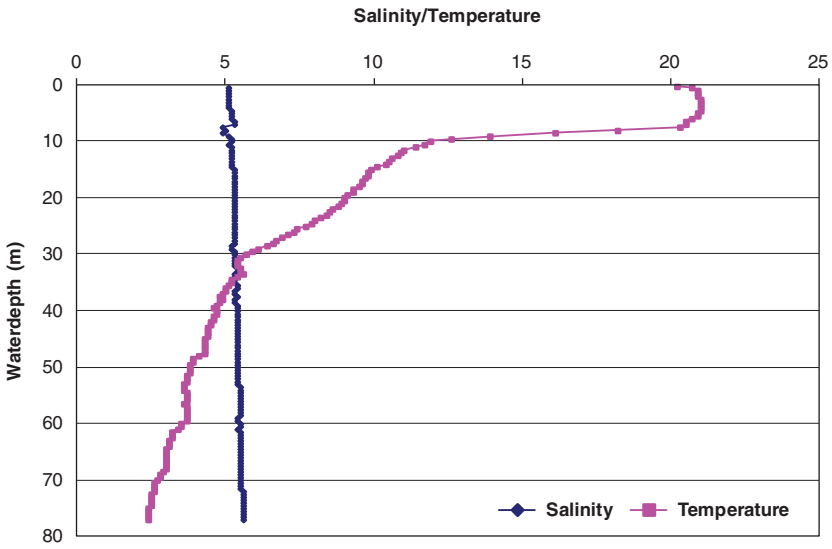

Figure 16. Temperature variation in the water column is the dominating factor for stratification of the water column at this station. Salinity levels lie steady at around 5 throughout both surface and bottom waters.

Figure 17. The benthic species *Saduria entomon* is common in the Bothnian Sea and was present in many of the sediment samples.

conditions at the bottom of the basin. The average TOC concentration in 2008 was 3.0% of DW and 2.9% of DW in 2014 (Table 17). Of the presented elements in Table 17, cadmium is the element showing the greatest variation within the area with a relative standard deviation of 13.8% in 2008 and 18.0% in 2014. Mercury concentrations varied to a level of 13.8% in 2008 and 13.4% in 2014.

Elements with available environmental assessment criteria are presented in Figures 18A–J and Table 18. Most element levels seem to have increased between 2003 and 2008 but decreased between 2008 and 2014 (Figs. 18A, E, G–I). Mercury and cobalt instead show a slight increase since 2003 (Figs. 18C and F). Sulphur concentrations did not change between 2003 and 2008 but dropped between 2008 and 2014 (Fig. 18J).

Table 18 presents the elements with available environmental assessment criteria (Swedish EPA 1999). According to this classification system arsenic is present in concentrations with large to very large deviation from the national background. The other elements occur in moderate

Table 17. Concentrations of different parameters at seven sampling sites within station SE-3, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	61.3	50.9	0.243	0.170	0.0796	0.0951	1660	1290	0.32	0.31	2.99	2.92
Site 2	53.6	49.2	0.145	0.242	0.0909	0.0807	1440	1290	0.33	0.31	2.95	2.90
Site 3	56.1	49.1	0.222	0.209	0.0649	0.0885	1730	1160	0.33	0.31	2.96	3.01
Site 4	56.5	54.2	0.201	0.164	0.0903	0.0893	1630	1240	0.33	0.31	2.96	2.89
Site 5	58.2	63.3	0.209	0.161	0.0849	0.0599	1550	1210	0.33	0.32	2.98	2.92
Site 6	58.6	44.0	0.201	0.253	0.0751	0.0889	1680	1130		0.32		2.93
Site 7	56.1	50.5	0.221	0.236	0.104	0.0964	1650	1330	0.32	0.35	2.98	2.93
Average	57.2	51.6	0.206	0.205	0.0842	0.0855	1620	1236	0.33	0.32	2.97	2.93
Standard deviation STD	2.26	5.54	0.0284	0.0368	0.0117	0.0155	89.12	68.00	0.0047	0.014	0.141	0.0360
%RSD	3.94	10.7	13.8	18.0	13.8	13.4	5.501	5.503	1.4	4.3	0.476	1.23

Table 18. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-3. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
As	38.7	57.2	51.6
Cd	0.229	0.206	0.205
Co	16.9	18.6	21.6
Cr	97.2	98.7	80.8
Cu	30.9	42.7	37.6
Hg	0.0651	0.0842	0.0855
Ni	36.5	48.2	44.4
Pb	34.7	39.5	28.1
Zn	145	197	151
S	1630	1620	1240
TN	0.37	0.33	0.32
TOC	2.95	2.97	2.93

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

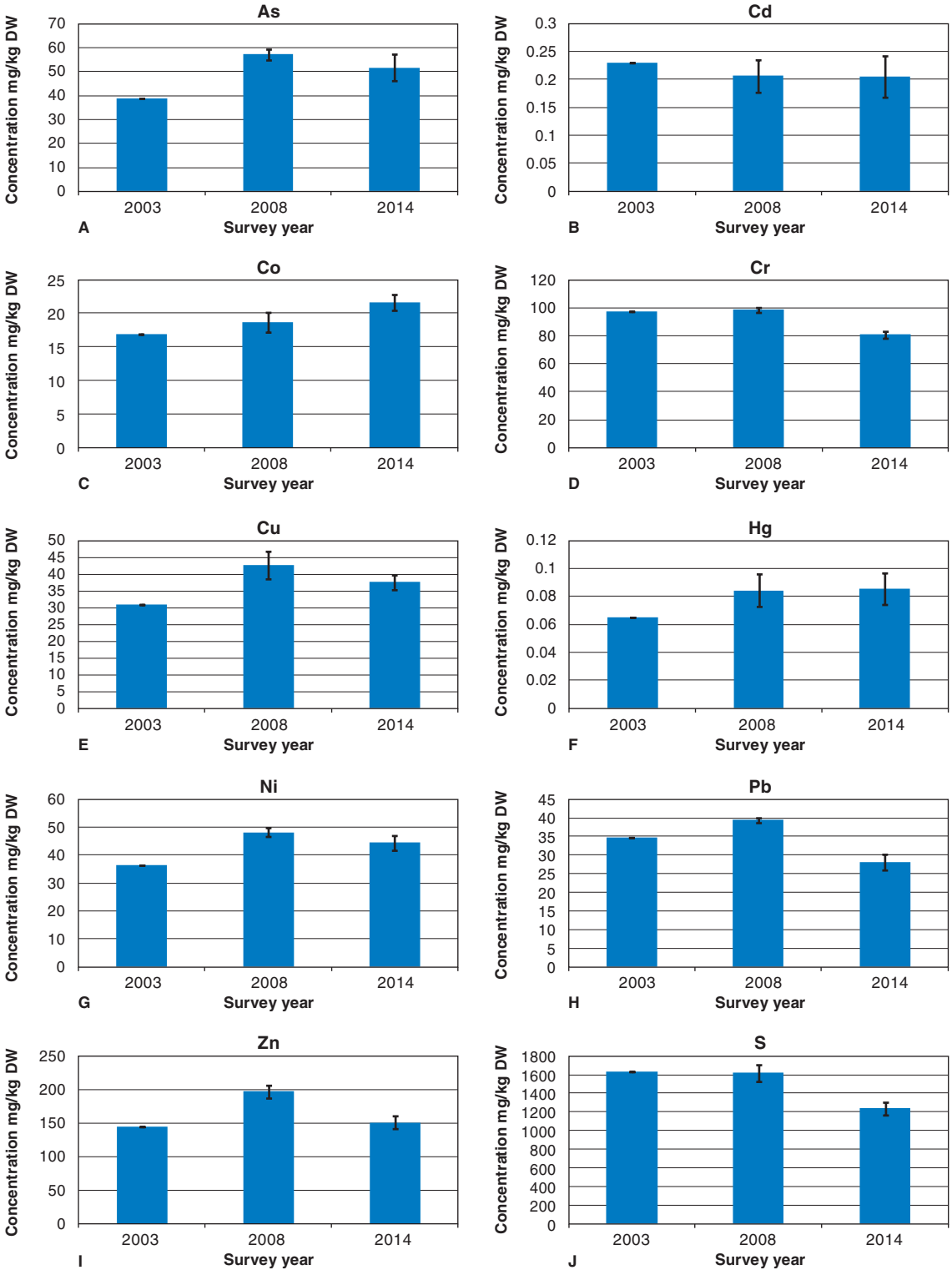

Figure 18. **A–J.** There is no general trend in element concentration since 2003 at station SE-3. Most element concentrations seem to have increased between 2003 and 2008 but decreased between 2008 and 2014. Mercury and cobalt show a slight continuous increase since 2003. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 19. Concentrations in µg/kg DW of organic micropollutants from 2003, 2008 and 2014 at station SE-3. Colour classification is in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	6.1	1.9	1.0
Fluoranthene	55	32	22
Sum 11 PAH	610	431	283
Sum 7 PCB	0.49	1.5	0.88
HCB	0.74	0.35	0.32
Sum HCH	2.0	0.15	0.092
Sum DDT	0.88	0.94	0.59
Sum Chlordanes	0.15	0.093	0.12
TBT	<1	<1	<1
Diuron	<20	<2	0.17
Simazine	<2.0	<2	<0.5
DEHP	1 700	<20	130
Nonylphenol	5.4	<10	<30

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 20. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-3. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	229	–	206	–	205	–
Pb	120 000	34 700	–	39 457	–	28 057	–
Anthracene	24	6.1	14	1.9	14	1.0	14
Fluoranthene	2 000	55	1 180	32	1 188	22	1 171
TBT	1.6	<1.0	0.9	<1.0	1.0	<1.0	0.9

concentrations. Lead is the only element that has reached the same level as the national background concentration. Cadmium and lead levels do not exceed the ecotoxicological assessment criteria (HVMFS 2013:19) in any year (Table 20).

Organic substances with available environmental assessment criteria are presented in Figures 19A–F and Table 19 together with the organic substances without available criteria (Fig. 19G). Data show that the PAHs, HCB and HCHs and DEHP are the substances that have decreased in levels since 2003 (Figs. 19A, C, D and G). DDTs and PCB7 concentrations seem to have decreased between 2008 and 2014 (Figs. 19B and E). Concentrations of the chlordane group decreased between 2003 and 2008 but increased slightly between 2008 and 2014 (Fig. 19F). The levels of TBT and simazine have been below LOQ all survey years. Diuron concentrations were quantifiable only in 2014 whereas nonylphenol was possible to measure only in 2003.

Table 19 presents concentrations of organic micropollutants divided into classes according to the Swedish EPA environmental assessment criteria (Swedish EPA 1999). All substances, except PAHs, PCB7 and DDT, occur or have occurred in high concentrations. The HCHs were included in class 4 in 2003 but have dropped one class to class 3 between 2003 and 2014. HCB

concentrations went from class 3 in 2003 to class 4 in 2008 and 2014. The chlordanes are and have been present in concentrations within class 4 since the start of the programme in 2003. None of the organic substances occur or have occurred in levels exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) (Table 20).

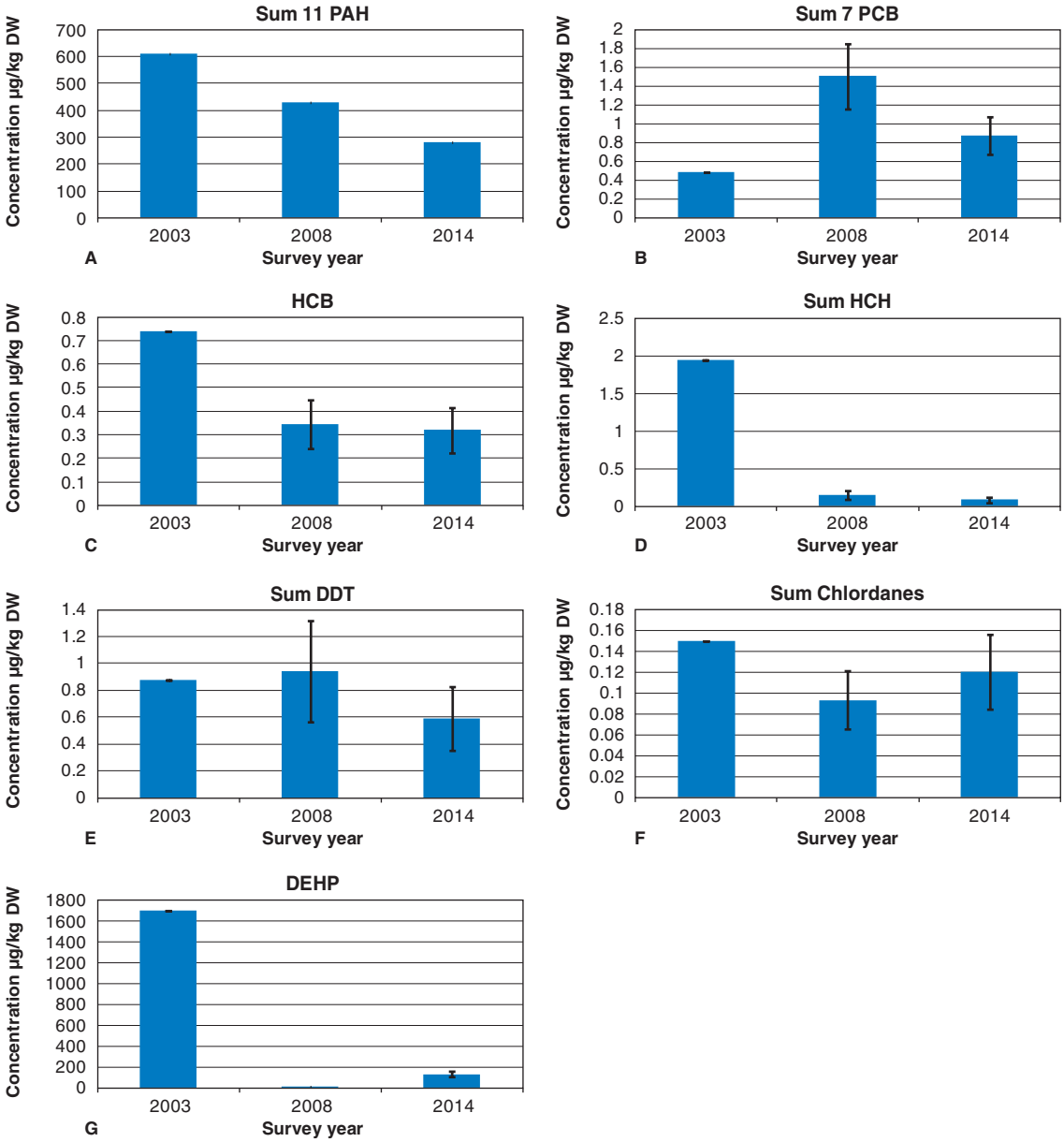

Figure 19. **A–G**. The concentrations of organic substances at station SE-2 show no general trend since 2003. PAH, HCB, HCH and DEHP levels have decreased since 2003. DDT and PCB7 concentrations seem to have decreased between 2008 and 2014. The error bars represent laboratory measurement uncertainties.

Station SE-4, Åland deep

Station SE-4 is located north-north-east of Norrtälje and west of Åland in the part of the Baltic called the Åland Sea (Fig. 1). The Åland deep has a water depth of around 230 m. CTD data from the station were obtained in August 2014 and show that surface water salinity is unchanged from the northern conditions and was 5 in the surface water (Fig. 20). Bottom water salinity at station SE-4 was higher than the northern stations and lie at 7. Stratification of the water column is caused by temperature differences and a thermocline can be identified at a depth of approximately 10 m (Fig. 20). However, there is a slight increase in salinity at around 30 m depth which could be considered as a weak halocline (Fig. 20). Bottom water current speed was measured to 0.026 m/s which indicates stagnant water suitable for sedimentation of fine-grained material.

The sediment at station SE-4 consists of reduced postglacial gyttja clay with an oxic layer on the top. The bottom water was oxygenated with a dissolved oxygen concentration of 5.4 mL/L. In 2008 there were signs of benthic life on the seafloor (Fig. 21A). This was not visible on the underwater photographs from 2014 (Fig. 20B). This may be due to the presence of resuspended material at the bottom in 2014.

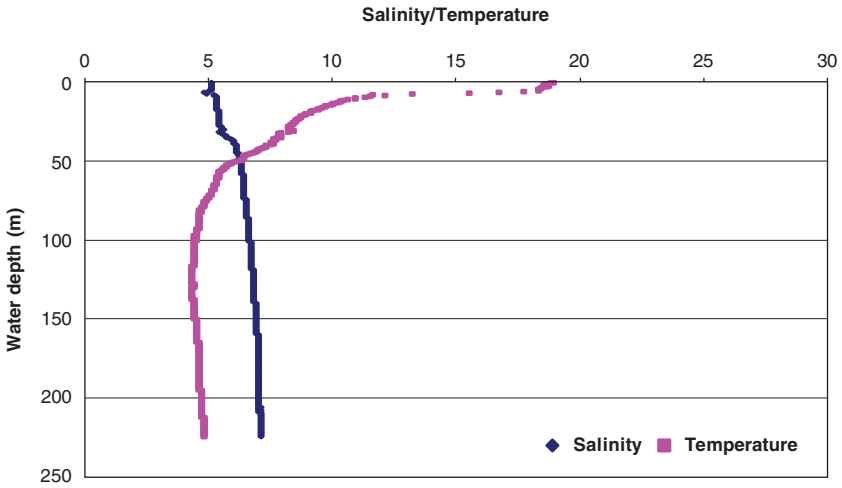

Figure 20. Temperature is the dominating factor for stratification of the water column in the Åland Sea. Salinity increases at around 30 m which could be considered a halocline. Bottom water salinity has increased compared to the northern stations from around 5 to 7.

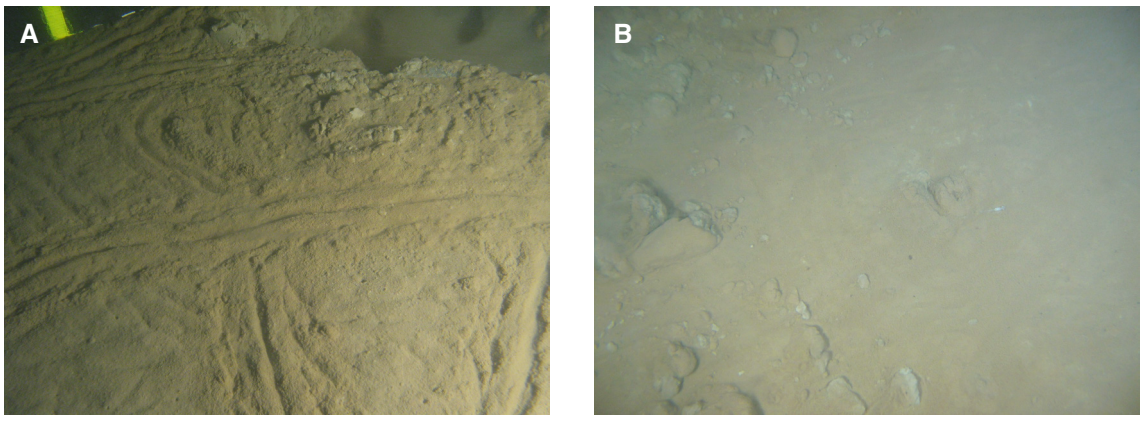

Figure 21. **A.** Underwater photographs from 2008 show evidence of life in the form of tracks and trails from benthic organisms. **B.** In 2014 there were no visible tracks or trails from benthic organisms on the underwater photographs. This may be due to the presence of resuspended material in the bottom water affecting the visibility.

Table 21. Concentrations of different parameters at seven sampling sites within station SE-4, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	21.3	13.9	0.395	0.312	0.110	0.0780	2 540	2 270	0.46	0.45	3.80	3.73
Site 2	20.1	16.3	0.342	0.385	0.0919	0.0645	2 410	1 940	0.44	0.45	3.80	4.05
Site 3	20.6	13.1	0.358	0.332	0.0798	0.0651	2 420	2 040	0.47	0.43	3.92	3.89
Site 4	19.1	16.6	0.356	0.342	0.0802	0.0798	2 490	2 340	0.45	0.45	3.79	3.96
Site 5	20.0	17.9	0.408	0.278	0.0830	0.0660	2 450	1 870	0.46	0.42	3.93	3.91
Site 6	19.9	17.8	0.355	0.392	0.0919	0.103	2 590	2 310	0.46	0.44	3.95	3.95
Site 7	19.3	16.6	0.342	0.369	0.104	0.0917	2 730	2 310	0.45	0.43	3.79	3.90
Average	20.0	16.0	0.365	0.344	0.0915	0.0783	2 519	2 154	0.46	0.44	3.85	3.91
Standard deviation STD	0.693	1.71	0.0240	0.381	0.0109	0.0137	105.1	183.7	0.0090	0.011	0.0690	0.0899
%RSD	3.46	10.7	6.58	11.1	11.9	17.5	4.172	8.526	2.0	2.6	1.79	2.30

Table 22. Concentrations in mg/kg DW of elements from 2003 to 2014 at station SE-4. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
As	19.0	20.0	16.0
Cd	0.273	0.365	0.344
Co	15.2	9.06	18.6
Cr	94.9	96.9	81.5
Cu	29.1	23.9	36.5
Hg	0.111	0.0915	0.0783
Ni	31.4	49.8	42.6
Pb	35.4	27.9	28.6
Zn	165	195	148
S	2 570	2 520	2 150
TN	0.45	0.46	0.44
TOC	3.56	3.85	3.91

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

The average TOC concentration was 3.85% of DW in 2008 and 3.91% of DW in 2014 (Table 21). Of the elements presented in Table 17, mercury shows the largest variation in concentrations within the station area both in 2008 and 2014 with RSD values of 11.9% and 17.5% respectively.

Elements with available environmental assessment criteria are presented in Figures 22A–J and Table 22. The presented data show that mercury and sulphur are the only elements with concentrations that have decreased continuously since 2003 (Figs. 22F and J). Cadmium, cobalt, copper and nickel seem to have increased in levels in 2014 compared to 2003 (Figs. 22B, C, E and G).

Table 22 presents element data grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). From the table it is obvious that none of the elements occur or have occurred in concentration with large or very large deviation from the national background. This means that station SE-4 is not very polluted by heavy metals. Cadmium and lead levels do not exceed the ecotoxicological assessment criteria (HVMFS 2013:19) in any year (Table 24).

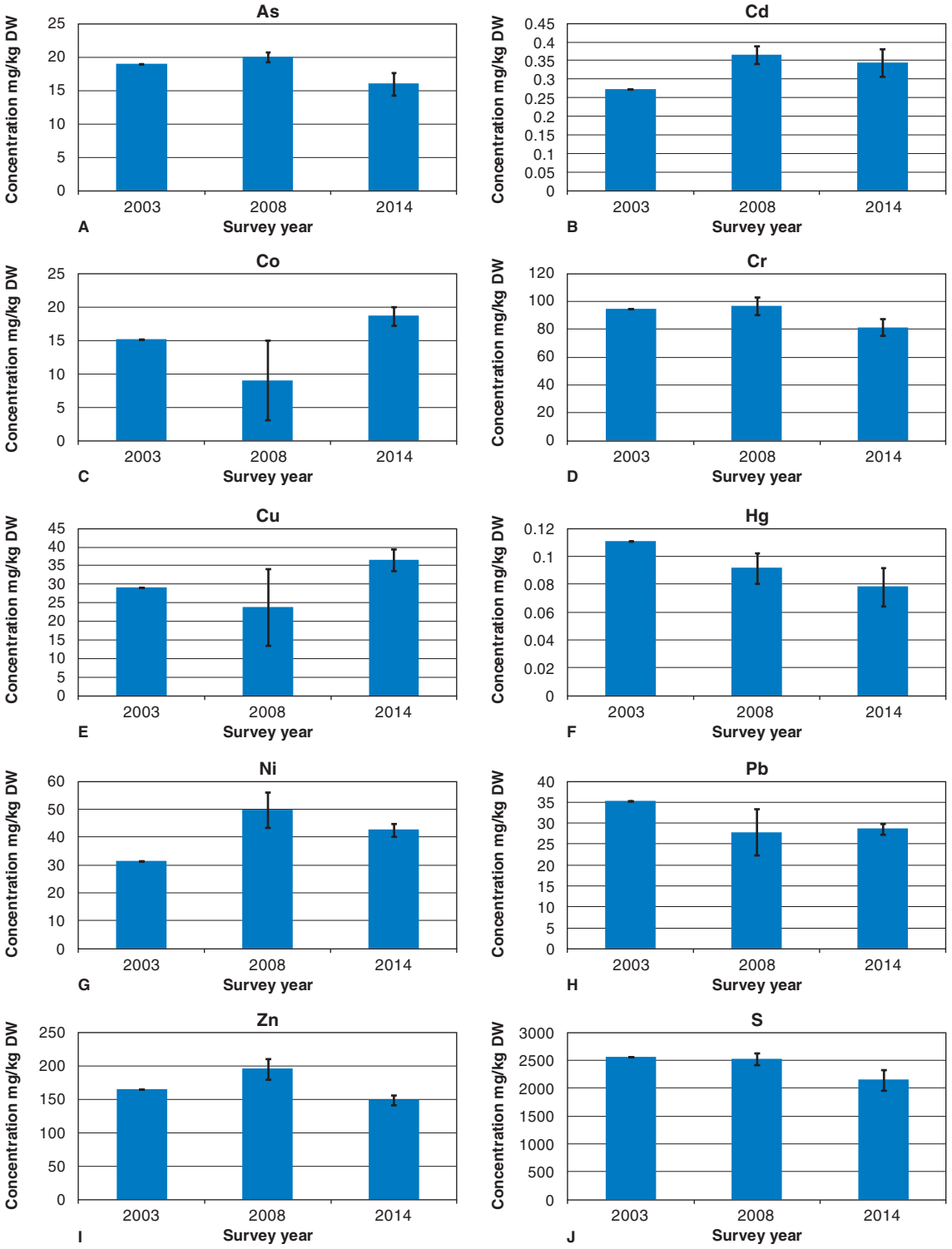

Figure 22. **A–J.** There is no general trend in element concentration since 2003 at station SE-4. Mercury and sulphur are the only elements with continuously decreasing concentrations since 2003. Cadmium, cobalt, copper and nickel seem to have increased in levels in 2014 compared to 2003. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 23. Concentrations in µg/kg DW of organic micropollutants from 2003, 2008 and 2014 at station SE-4. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	8.0	1.4	1.1
Fluoranthene	68	29	33
Sum 11 PAH	631	312	333
Sum 7 PCB	4.4	1.7	1.2
HCB	0.42	0.23	0.28
Sum HCH	1.8	0.38	0.22
Sum DDT	1.1	0.96	0.75
Sum Chlordanes	0.15	0.10	0.10
TBT	2.4	<1.0	<1.0
Diuron	<20	<2	0.23
Simazine	<2.0	<2	<0.5
DEHP	1 700	<20	120
Nonylphenol	11	<10	43

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 24. The levels of the metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-4. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	273	–	365	–	344	–
Pb	120 000	35 400	–	27 914	–	28 629	–
Anthracene	24	8	17	1.4	19	1.1	19
Fluoranthene	2 000	68	1 425	29	1 542	33	1 565
TBT	1.6	2.4	1.1	<1.0	1.2	<1.0	1.3

Concentration exceeds assessment value.

Organic substances with available environmental assessment criteria are presented in Figures 23A–F and Table 23 together with organic substances without available criteria (Figs. 23G and H). All substances except nonylphenol have decreased in levels since 2003 (Figs. 23A–G and H). TBT concentrations were quantifiable in 2003 but below LOQ the two following years. Diuron levels were quantifiable in 2014 whereas simazine levels have been below LOQ all three years. The DEHP level was below LOQ in 2008 (Fig. 23G).

Table 23 presents concentrations of organic substances grouped into classes according to the Swedish EPA environmental assessment criteria (Swedish EPA 1999). All substances except the PAH11 and fluoranthene are or have been occurring in class 4, high concentrations. PAH11 levels have been stable in class 3 since 2003. Chlordane and HCB concentrations are still within class 4. The PCB7, DDTs and HCHs have decreased from class 4 in 2003 to class 3 or 2. In 2003 the TBT concentration exceeded the ecotoxicological assessment criteria (HVMFS 2013:19) (Table 24).

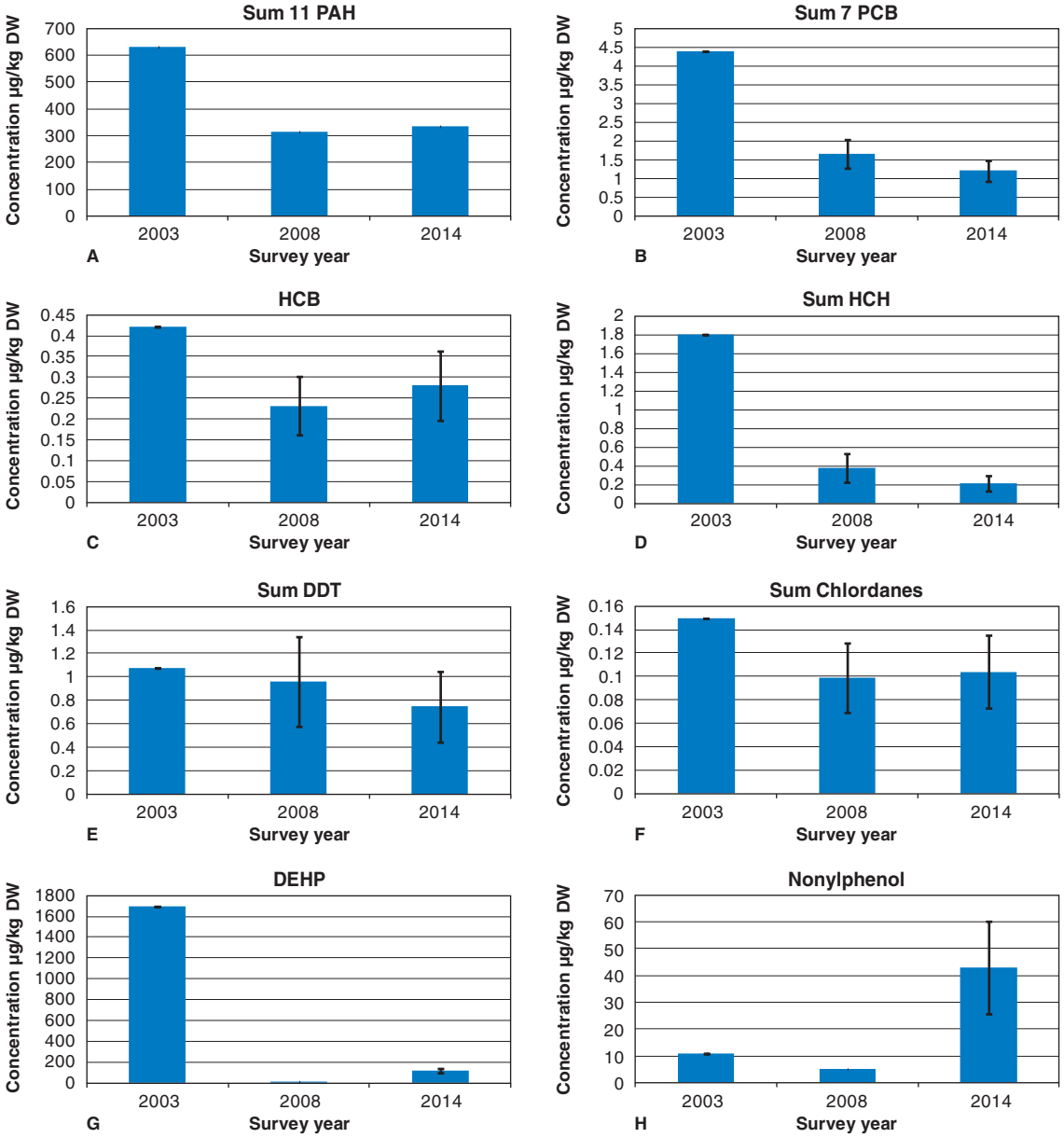

Figure 23. **A–H.** All substances except nonylphenol have decreased in levels at station SE-4 since 2003. The error bars represent laboratory measurement uncertainties.

Station SE-5, north-east of Gotska Sandön

Station SE-5 is located around 130 km east of Stockholm (Fig. 1). The basin has a water depth of approximately 175 m. CTD data from this station were obtained in May 2014 and show that the temperature decreases rapidly in the surface water and keeps on decreasing down to 60 m where it increases again and lies steady at around 5 °C down to the bottom. At 60 m depth there is also a visible halocline where salinity increases (Fig. 24).

Bottom water current speed was measured to 0.026 m/s which means that the bottom water is stagnant and suitable for deposition of fine-grained material. The sediment at the location consists of reduced laminated postglacial clay gyttja without an oxygenated surface layer (Fig. 25).

The surface sediment is rich in organic carbon, over 6% of dry weight, and is considered a clay gyttja (Table 25). The amount of dissolved oxygen in the bottom water was measured to 0 which indicates anoxic conditions unfavourable to living organisms. Due to the high water content in the surface sediments at this station, it was not possible to deploy the underwater camera on the seabed without resuspending the sediments. Therefore the photographs from this site do not give much information of the sediment surface (Fig. 26).

The average TOC content was 11.5% of DW in 2008 and 14.4% of DW in 2014 (Table 25). These high values classify the sediments as gyttja rather than clay. The sediment at station SE-5 shows high relative standard deviation numbers for almost all parameters presented in Table 25. Arsenic and mercury concentrations from 2014 show a high variation with RSD values of 52% and 115%. These high values of RSD might be a result of natural variation but can also depend on concentrations sometimes being below LOQ. These results are reported as <values and estimated as 0 in the calculation function.

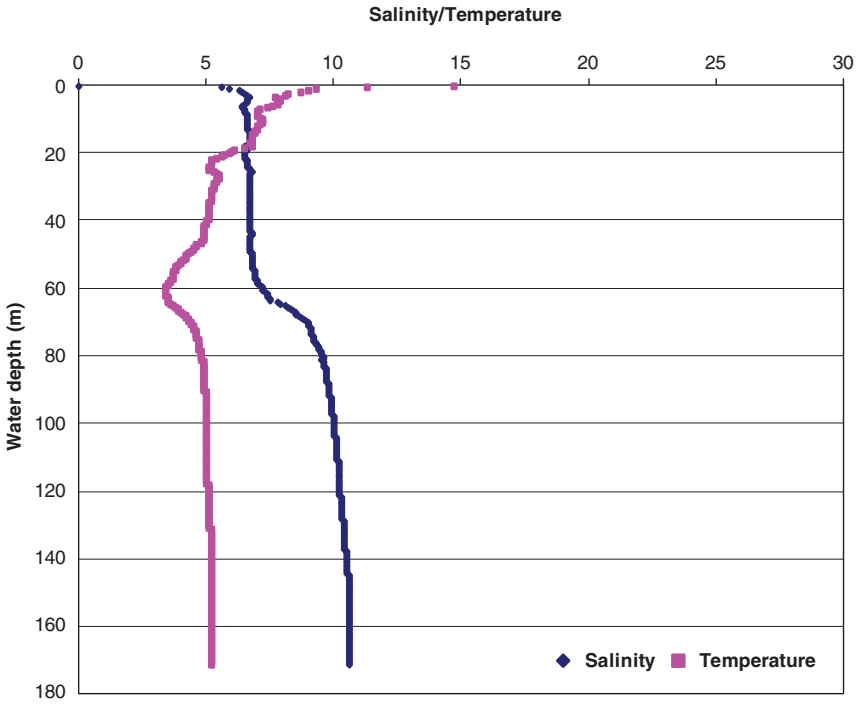

Figure 24. In the sea basin at station SE-5 the water column is stratified by a coinciding thermocline and halocline. CTD data were collected in May 2014.

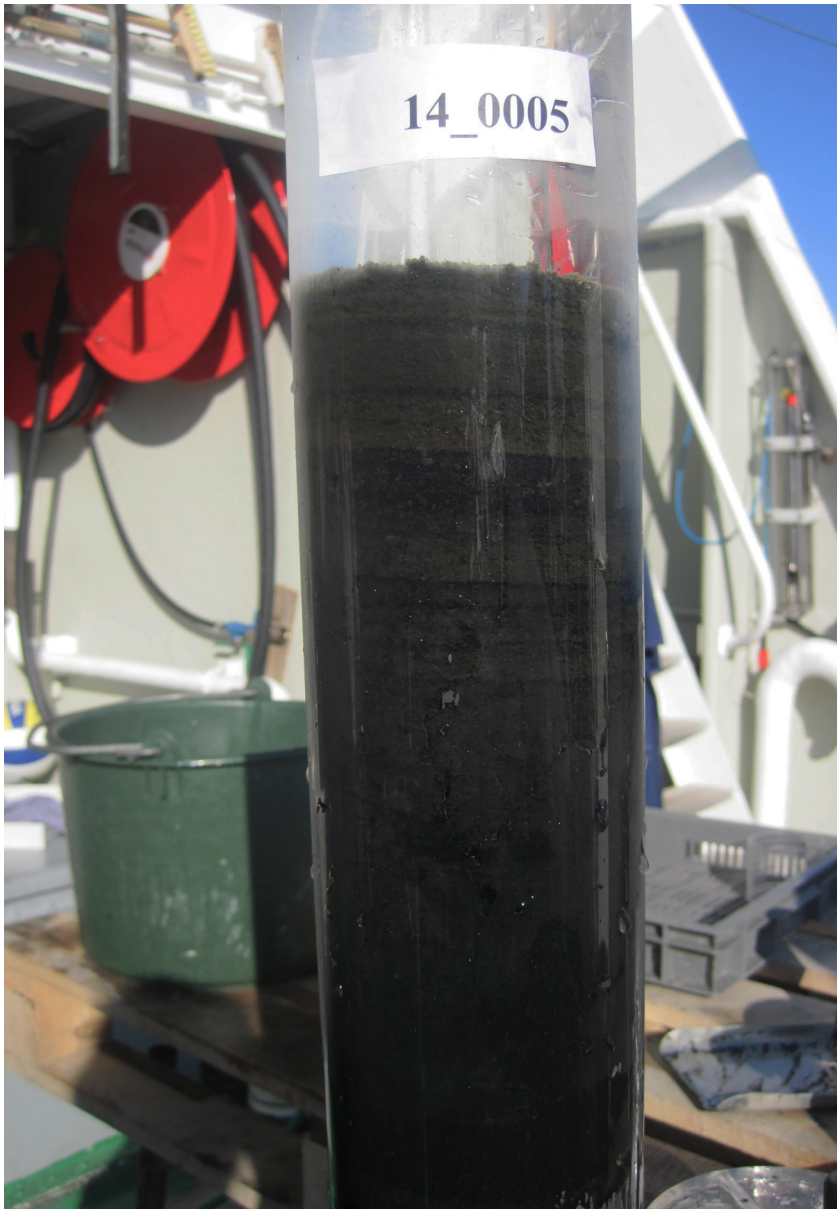

Figure 25. The sediment is composed of reduced postglacial clay gyttja with high water content. There is no oxygenated layer at the top which makes the seabed hostile to living organisms.

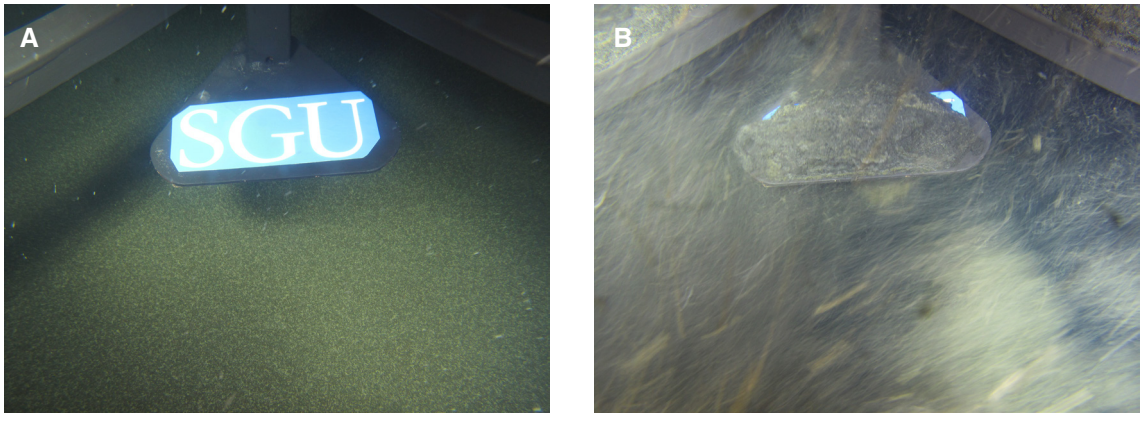

Figure 26. **A.** Underwater photograph taken before the cage was deployed on the sediment surface. **B.** Underwater photograph taken after the deployment of the cage. Due to high water content the sediment was resuspended and the photographs do not give much information about the seabed.

Table 25. Concentrations of different parameters at seven sampling sites within station SE-5, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	14.7	30.5	3.80	2.14	<0.08	<0.6	11 200	6 490	1.4	1.5	11.5	13.3
Site 2	16.4	15.8	4.13	1.58	<0.08	0.0541	11 700	8 800	1.3	2.0	11.1	16.8
Site 3	7.57	9.12	1.65	1.49	0.0787	<0.04	13 800	15 000	1.4	1.3	11.1	13.1
Site 4	10.9	10.7	2.59	2.20	0.147	0.0485	14 000	13 300	1.4	1.7	10.8	14.1
Site 5	15.1	11.4	3.46	2.27	<0.08	0.0522	12 100	12 300	1.4	1.6	11.7	12.7
Site 6	12.3	9.94	3.11	1.77	0.0795	<0.04	12 600	13 100	1.5	1.9	13.2	15.8
Site 7	12.6	8.73	3.12	1.53	0.0995	<0.04	12 300	13 400	1.3	1.9	11.1	15.1
Average	12.8	13.7	3.10	1.85	0.0578	0.0221	12 529	11 770	1.4	1.7	11.5	14.4
Standard deviation STD	2.75	7.18	0.760	0.315	0.0543	0.0256	961.72	2782	0.057	0.22	0.753	1.43
%RSD	21.5	52.2	24.3	17.0	93.9	116	7.6762	23.64	4.1	13	6.55	9.93

Table 26. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-5. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
As	15.9	12.8	13.7
Cd	3.22	3.12	1.85
Co	6.97	5.5	8.30
Cr	43.8	38.3	65.6
Cu	88.8	112	91.1
Hg	0.0589	0.0578	0.0221
Ni	5.00	40.1	54.4
Pb	21.1	17.2	26.1
Zn	247	274	182
S	14 700	12 500	11 770
TN	1.6	1.4	1.7
TOC	12.3	11.5	14.4

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

Elements with available environmental assessment criteria plus sulphur are presented in Figures 27A–J and Table 26. Cadmium, copper, mercury and zinc concentrations seem to have decreased since 2008 (Figs. 27B, E, F and I), while cobalt and chromium show the opposite (Figs. 27C and D). Nickel levels seem to have increased continuously since 2003 (Fig. 27G).

Table 26 presents element concentration data grouped into classes according to the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Cadmium is the most elevated element at station SE-5 with levels within class 5 in 2003 and 2008. Cadmium levels dropped between 2008 and 2014 and were in 2014 within class 4. Copper occurs in concentrations within class 4 at all survey years. Zinc has gone from class 4 in 2003 and 2008 to class 3 in 2014. All other elements occur in concentrations within class 1 to 3, with none to medium deviation from the national backgrounds for each element. Cadmium levels exceeded the ecotoxicological assessment criteria in 2003 and 2008 (Table 28).

Organic micropollutants with available environmental assessment criteria are presented in Figures 28A–F and Table 27 together with organic substances without available criteria (Figs. 28G, H and I). The substances PCB7, HCHs, DDTs and chlordanes showed concentra-

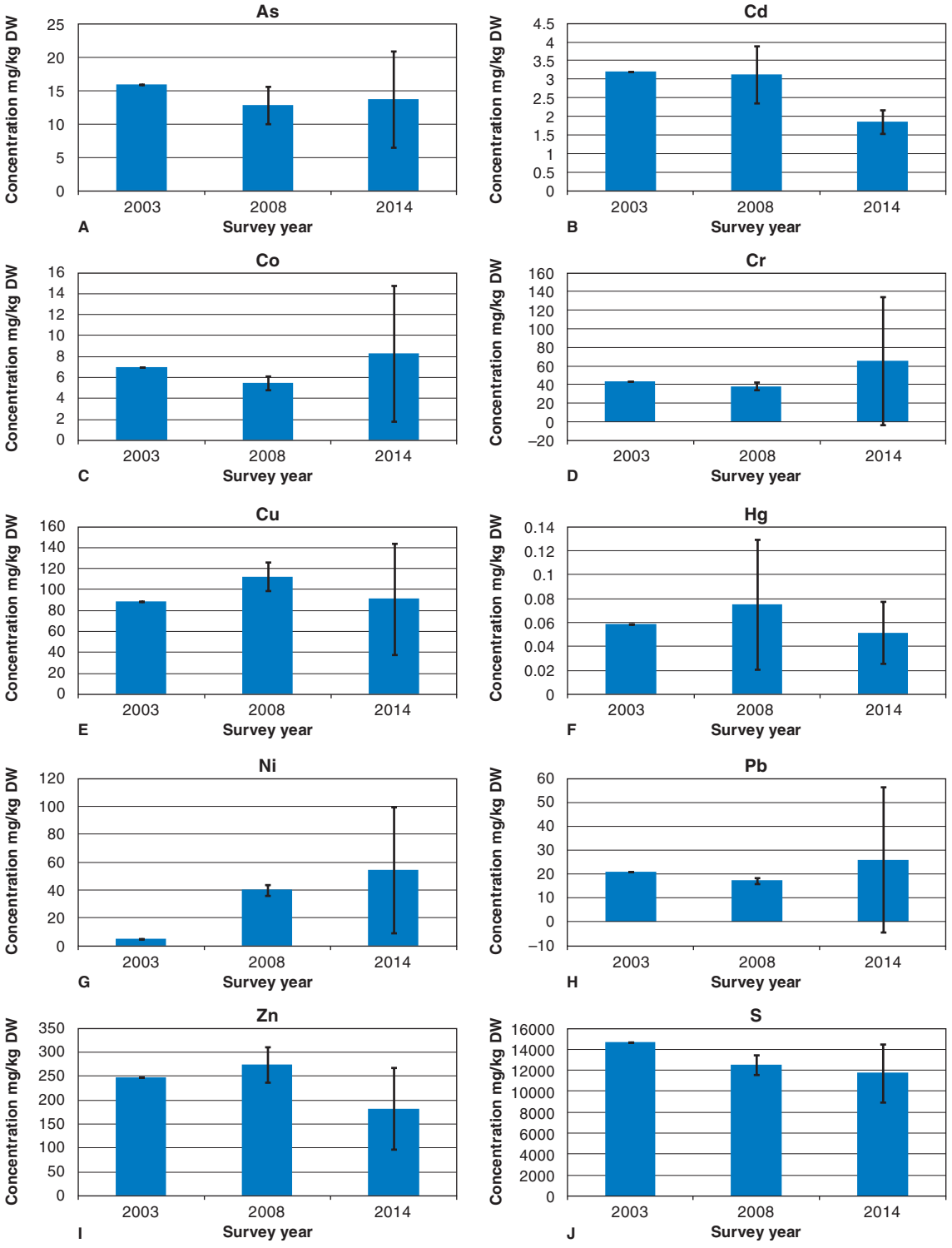

Figure 27. **A–J.** There is no general trend in element concentration at station SE-5. Cadmium, copper, mercury and zinc concentrations seem to have decreased since 2008, while cobalt and chromium show the opposite, but with large standard deviations. Nickel levels seem to have increased continuously since 2003. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 27. Concentrations in µg/kg DW of organic micropollutants from 2003, 2008 and 2014 at station SE-5. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	37	3.4	2.9
Fluoranthene	130	61	87
Sum 11 PAH	1 157	686	695
Sum 7 PCB	1.1	3.8	2.69
HCB	0.93	0.31	0.81
Sum HCH	0.33	1.2	1.1
Sum DDT	3.3	4.4	3.5
Sum Chlordanes	0.45	0.59	0.52
TBT	110	14	8.7
Diuron	<30	<2	0.31
Simazine	<5.0	<2	<0.5
DEHP	1 200	45	590
Nonylphenol	130	<20	150

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 28. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-5. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	3 220	–	3 123	–	1 854	–
Pb	120 000	21 100	–	17 220	–	26 056	–
Anthracene	24	37	59	3.4	55	2.9	69
Fluoranthene	2 000	130	4 910	61	4 595	87	5 770
TBT	1.6	110	3.9	14	3.7	8.7	4.6

Concentration exceeds assessment value.

tion maxima in 2008 and tended to have higher concentrations in 2014 than is 2003 (Figs. 28B and D–F). PAH11 and TBT decreased between 2003 and 2008 and remained relatively stable between 2008 and 2014 (Figs. 28A and G). Diuron concentrations were quantifiable only in 2014 whereas simazine levels have been below LOQ all three years.

Table 27 presents the concentrations of micropollutants grouped into classes according to the Swedish EPA environmental assessment criteria (Swedish EPA 1999). The table shows that all substances except for PCB7 occur or have occurred in concentrations within class 4 and 5. The PAH11 concentrations have dropped since 2003 from class 4 to class 3. HCB, HCH and DDT are present in concentrations within class 4 and the chlordane levels are within class 5. TBT has occurred in concentrations exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) all three years (Table 28).

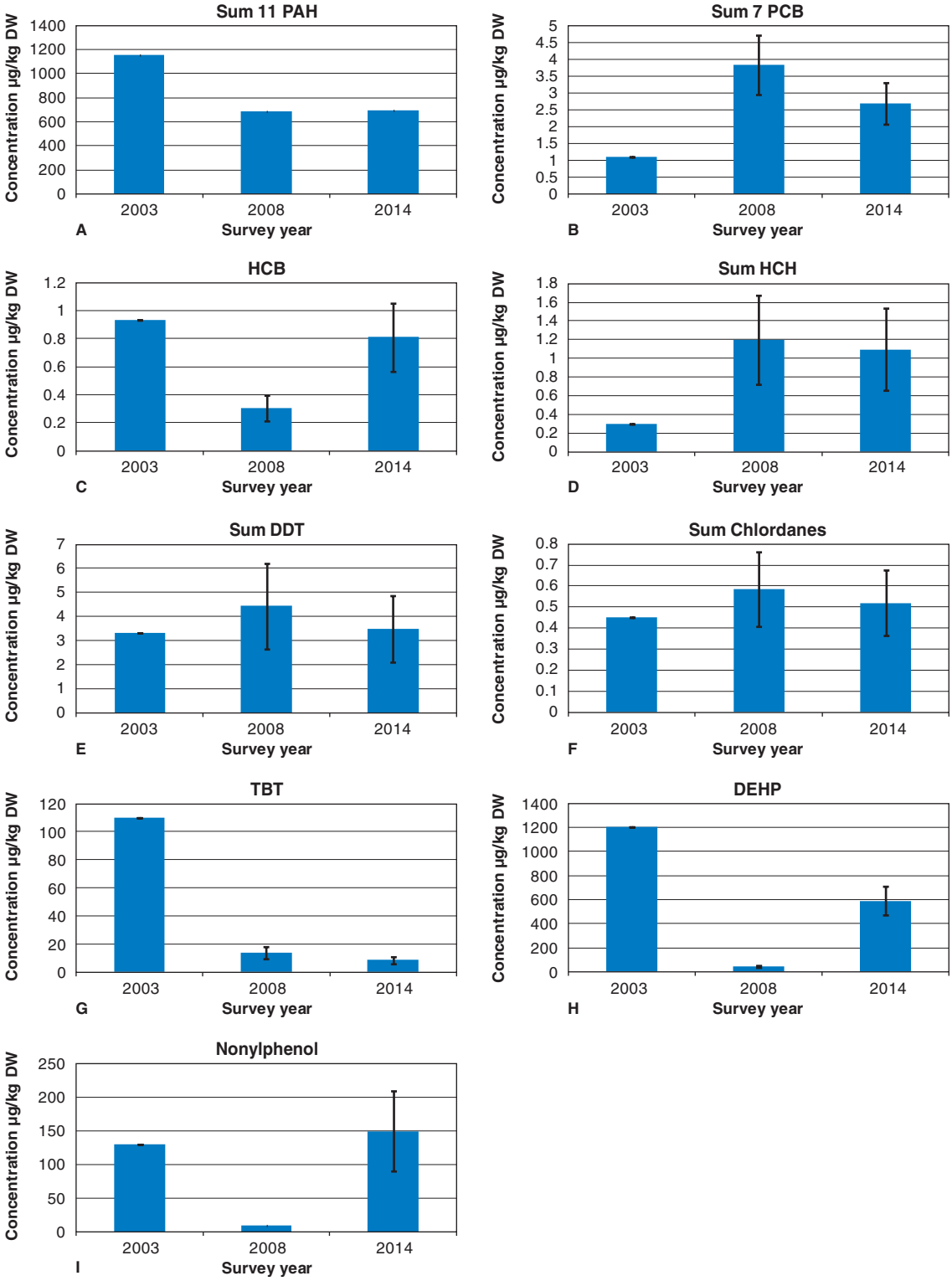

Figure 28. **A–I.** At station SE-5, the substances PCB7, HCHs, DDTs and chlordanes showed concentration maxima in 2008. PAH11 and TBT decreased between 2003 and 2008 and remained relatively stable between 2008 and 2014. The error bars represent laboratory measurement uncertainties.

Station SE-8, Landsort deep

Station SE-8 is located approximately 80 km east of Nyköping (Fig. 1). The basin is called Landsort deep and is the deepest depression in the Baltic Sea. The site is situated in the north part of the basin at a depth of around 400 m. According to the nautical chart the site is situated within a former dumping ground for explosives (Fig. 29). Due to depth restrictions for the sensors and underwater camera, the camera cage has not been deployed at SE-8 during any of the three field campaigns and thus, no sensor data or underwater photographs are available from this site.

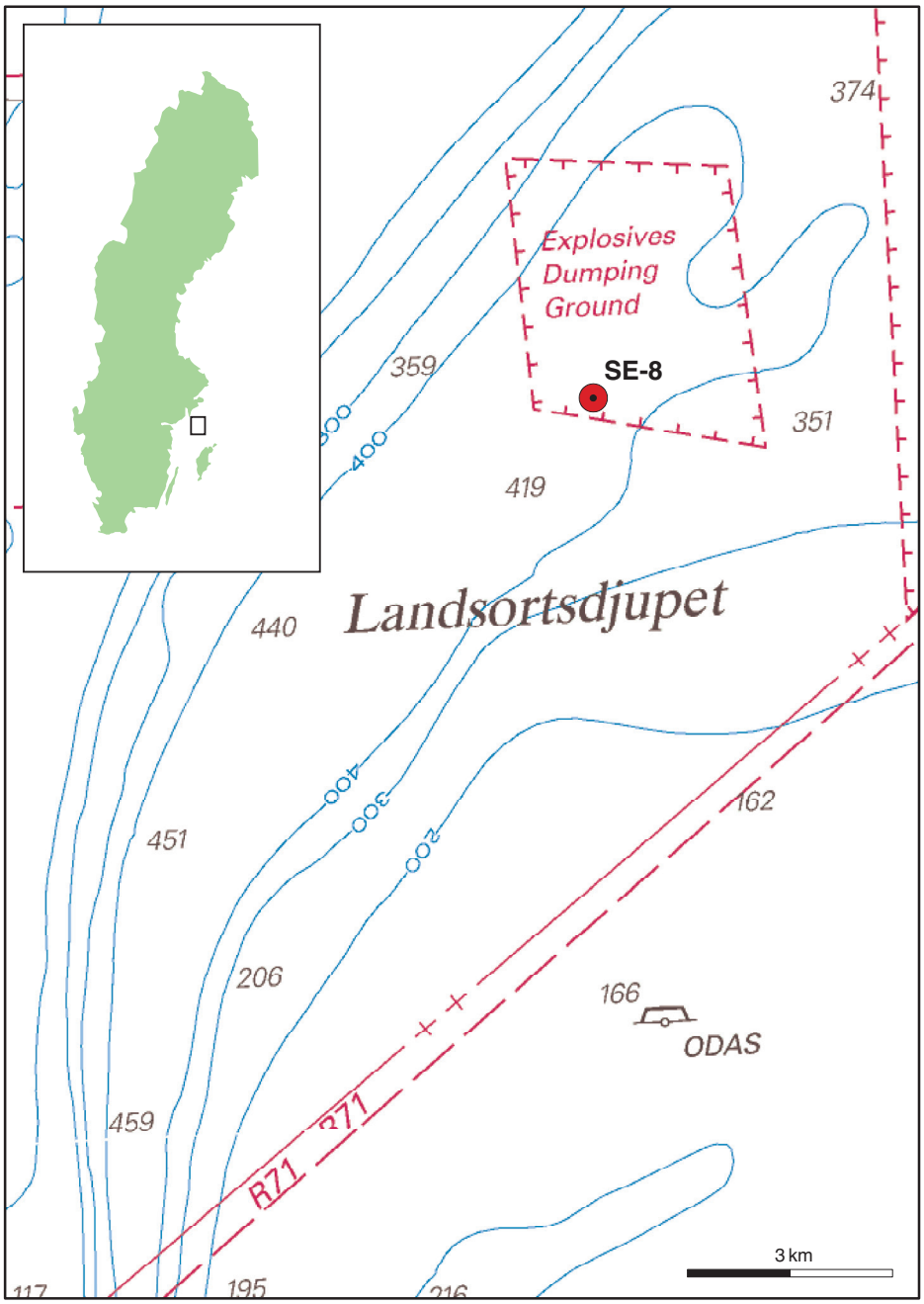

Figure 29. Station SE-8 is located in the northern part of the Landsort deep within a former dumping site for explosives. Nautical chart: Swedish Maritime Authorities.

The surface sediment at station SE-8 is rich in organic carbon, over 6% of DW, and consequently the sediment is considered a clay gyttja (Table 29). The average TOC concentration was 11.3% DW in 2008 and 14.4% DW in 2014. The element concentration variation was very high at station SE-8 during the survey year 2014. This is due to extremely high concentrations in one of the samples within the station area. In this particular sample, concentrations of arsenic, cadmium, cobalt, copper, nickel, lead, sulphur and zinc stand out considerably compared to the six other samples from the same station. The seven samples were all collected within the station radius of 50 m and it is possible that site 1 was located in more contaminated sediments.

Elements with available environmental assessment criteria are presented in Figures 30A–J and Table 30. Data from 2014 are presented in two ways: average element concentrations with all seven sampling sites included (2014b) and average element data with the sample showing higher levels excluded (2014a). Average concentrations of all elements except chromium become much higher when including the deviating sample. Compared to the 2014 data, where the more contaminated sample has been excluded, most element concentrations display the highest values

Table 29. Concentrations of different parameters at seven sampling sites within station SE-8, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	15.7	116	4.13	29.8	<0.08	0.436	11 200	105 000	1.44	1.79	10.5	14.8
Site 2	19.2	13.9	4.62	3.32	<0.05	<0.04	11 400	11 400	1.37	1.76	11.0	14.4
Site 3	17.6	14.5	4.71	3.32	<0.08	<0.04	11 600	11 900	1.33	1.83	10.0	14.7
Site 4	21.3	13.9	6.27	3.22	<0.08	0.0884	13 600	10 800	1.63	1.74	13.6	14.3
Site 5	27.9	13.3	6.71	2.73	<0.08	<0.04	12 200	11 000	1.44	1.78	11.7	14.6
Site 6	18.1	13.9	4.83	3.06	<0.08	<0.04	11 400	10 900	1.37	1.64	11.2	13.9
Site 7	20.0	15.3	4.59	3.28	<0.07	0.0603	11 000	12 100	1.43	1.74	11.4	14.1
Average	20.0	28.7	5.12	6.96	0	0.0835	11 771	24 729	1.43	1.75	11.3	14.4
Standard deviation STD	3.64	35.7	0.896	9.33	0	0.148	824.13	32 774	0.0906	0.0550	1.05	0.307
%RSD	18.2	124	17.5	134		177	7.0011	132.53	6.33	3.13	9.28	2.13

Table 30. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-8. Due to deviating sample from site 1 in 2014, two average values were calculated (sample included in 2014b but excluded in 2014a). Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014a	2014b
As	16.6	20.0	14.1	28.7
Cd	3.62	5.12	3.16	6.96
Co	4.70	9.51	6.27	12.6
Cr	21.4	43.6	33	32.6
Cu	104	179.0	114	229
Hg	0.0596	–	0.0248	0.0835
Ni	24.5	38.6	41.3	82.4
Pb	11.7	20.5	15.2	30.7
Zn	229	423	230	486
S	12 000	11 770	11 350	24 730
TN	2.2	1.4	1.8	
TOC	15.7	11.3	14.4	

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

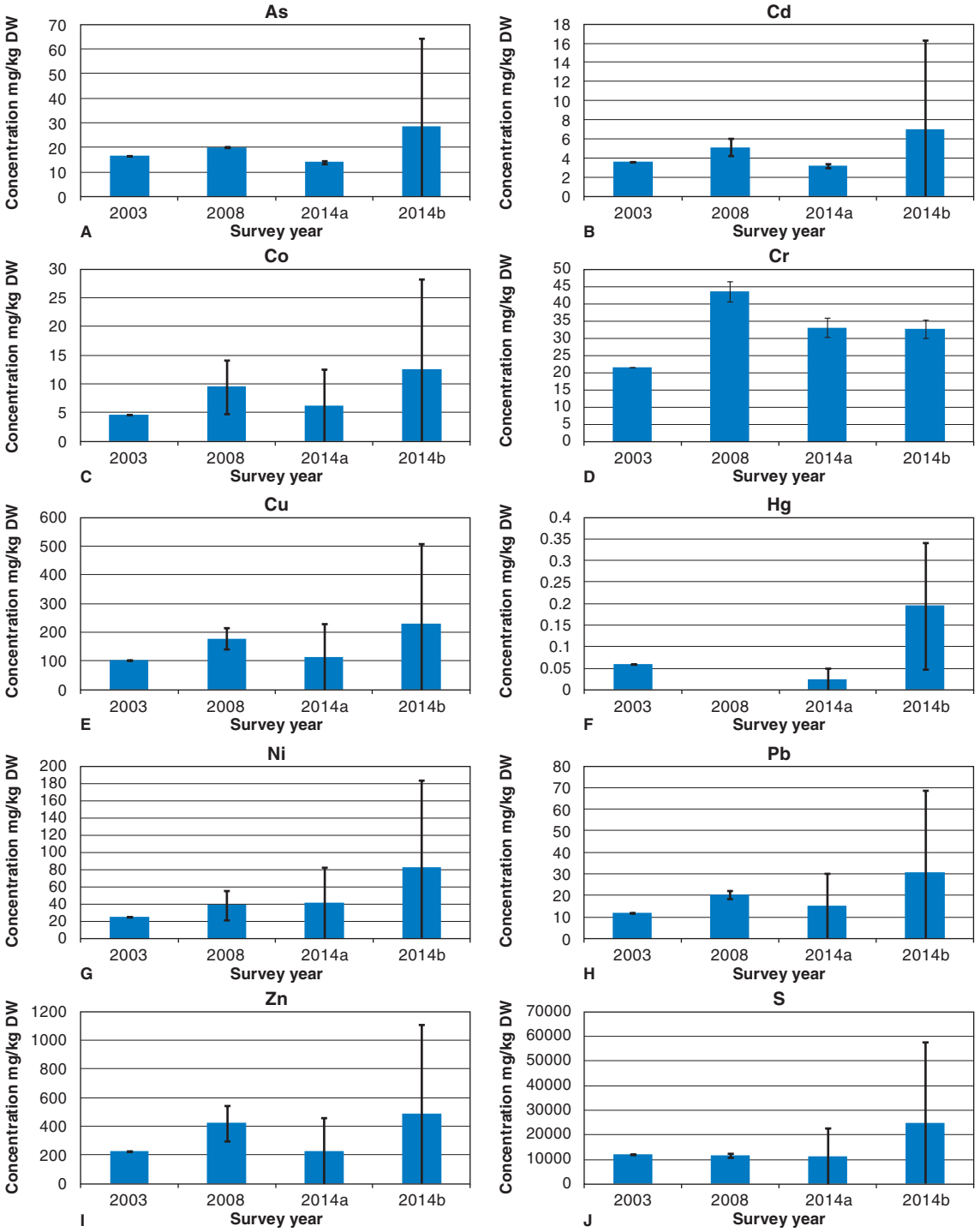

Figure 30. **A–J.** Data from 2014 are presented in two ways at station SE-8: average element concentrations with all seven sampling sites included (2014b) and average element data with one deviating sample showing higher levels excluded (2014a). Average concentrations of all elements except chromium become much higher when including the deviating sample. The error bars from 2008 and 2014 show standard deviations.

Table 31. Concentrations in µg/kg DW of organic micropollutants from 2003, 2008 and 2014 at station SE-8. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	6.4	2.1	4.2
Fluoranthene	97	37	110
Sum 11 PAH	870	393	1 170
Sum 7 PCB	2.2	2.5	4.79
HCB	0.46	0.16	0.93
Sum HCH	0.90	0.61	1.3
Sum DDT	4.8	3.0	6.1
Sum Chlordanes	0.30	0.53	0.81
TBT	51	19	11
Diuron	<40	<2	0.2
Simazine	<10	<2	<0.5
DEHP	2 800	390	340
Nonylphenol	360	<20	110

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 32. The levels of metals and substances with available ecotoxicological assessment criteria (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-8. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	3 620	–	5 123	–	3 160	–
Pb	120 000	11 700	–	20 529	–	15 200	–
Anthracene	24	6.4	75	2.1	54	4.2	69
Fluoranthene	2 000	97	6 290	37	4 528	110	5 751
TBT	1.6	51	5.0	19	3.6	11	4.6

Concentration exceeds assessment value.

in 2008 (Figs. 30A–E, H and I). Sulphur concentrations have been quite stable since 2003 (Fig. 30J), while nickel levels have increased slightly (Fig. 30G).

Table 30 presents element data grouped into classes according to the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Cadmium, copper and zinc stick out as the most elevated elements with concentrations within class 4 and 5. The other elements occur in levels within class 1 to 3 if data from 2014b are excluded. Cadmium levels exceeded the ecotoxicological assessment criteria (HVMFS 2013:19) all three survey years (Table 32).

Organic substances with available environmental assessment criteria are presented in Figures 31A–F and Table 31 together with organic substances without available criteria (Figs. 31G, H and I). It is obvious that all substances except TBT and DEHP have increased in concentration since 2008. The concentrations of PAHs, HCB, HCHs, DDTs, chlordanes and nonylphenol decreased between 2003 and 2008 (Figs. 31A, C–F and I). The PCB7, on the other hand, have increased continuously since 2003 (Fig. 31B). TBT and DEHP levels seem to have dropped since 2003 (Figs. 31 G and H). Diuron levels were only quantifiable in 2014 whereas simazine concentrations have been below LOQ all three survey years.

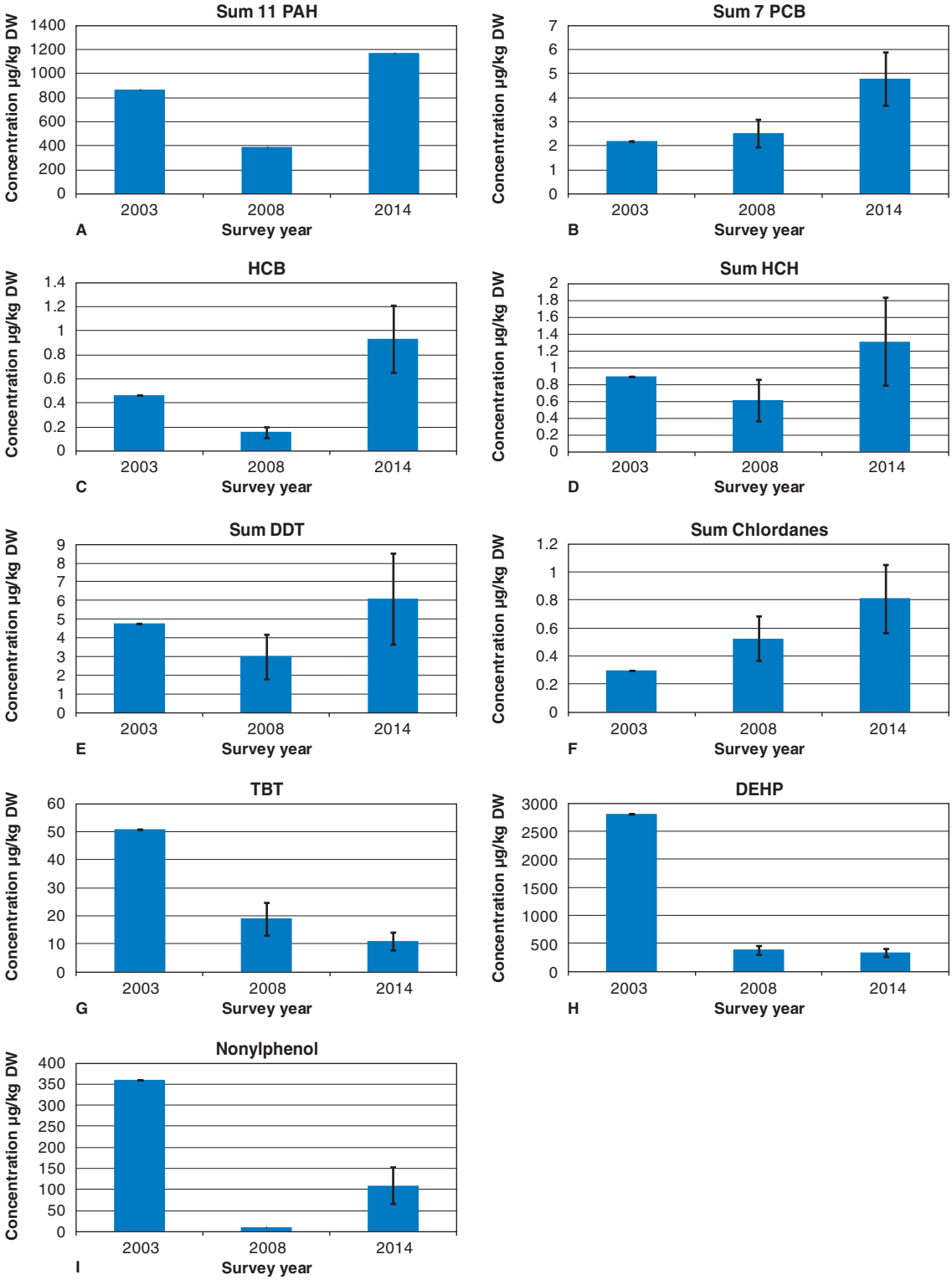

Figure 31. **A–I.** At station SE-8, all substances except TBT and DEHP increased in concentration between 2008 and 2014. TBT and DEHP have decreased in levels since 2003. The error bars represent laboratory measurement uncertainties.

Table 31 presents concentrations of the organic micropollutants grouped into classes according to the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Since all substances have increased in concentration since 2008, many of them have also moved one class upwards in the classification system. PAH11, PCB7 and HCB moved from class 3 to class 4 between the two years. DDT moved from class 4 to class 5, very high concentration, between 2008 and 2014. HCH remained in class 4 and chlordanes remained in class 5 the whole period. TBT has occurred in concentrations exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) all three years (Table 32).

Station SE-9, Norrköping deep

Station SE-9 is located around 120 km south-east of Norrköping, between the mainland and the north cape of Gotland (Fig 1). The station is situated in the Norrköping deep which has a depth of around 180 m. Due to recording problems no CTD data were obtained in 2014. However, there is a CTD plot from May 2008 that illustrates one thermocline at around 10 m and one at 75 m. There is also a halocline visible at 75 m. The surface salinity lies at 7 and increases downward and stays at just below 11 in the bottom water (Fig. 32).

Bottom water speed was measured to 0.031 m/s which indicates stagnant bottom water conditions suitable for sedimentation of fine-grained particles. The sediment consists of reduced laminated postglacial clay gyttja. On the sediment surface newly settled material from the annual spring bloom is visible as a fluffy layer (Fig. 33). Dissolved oxygen concentration was measured to 0.1 mL/L indicating hypoxia in the bottom water which makes this station unfavourable to living organisms.

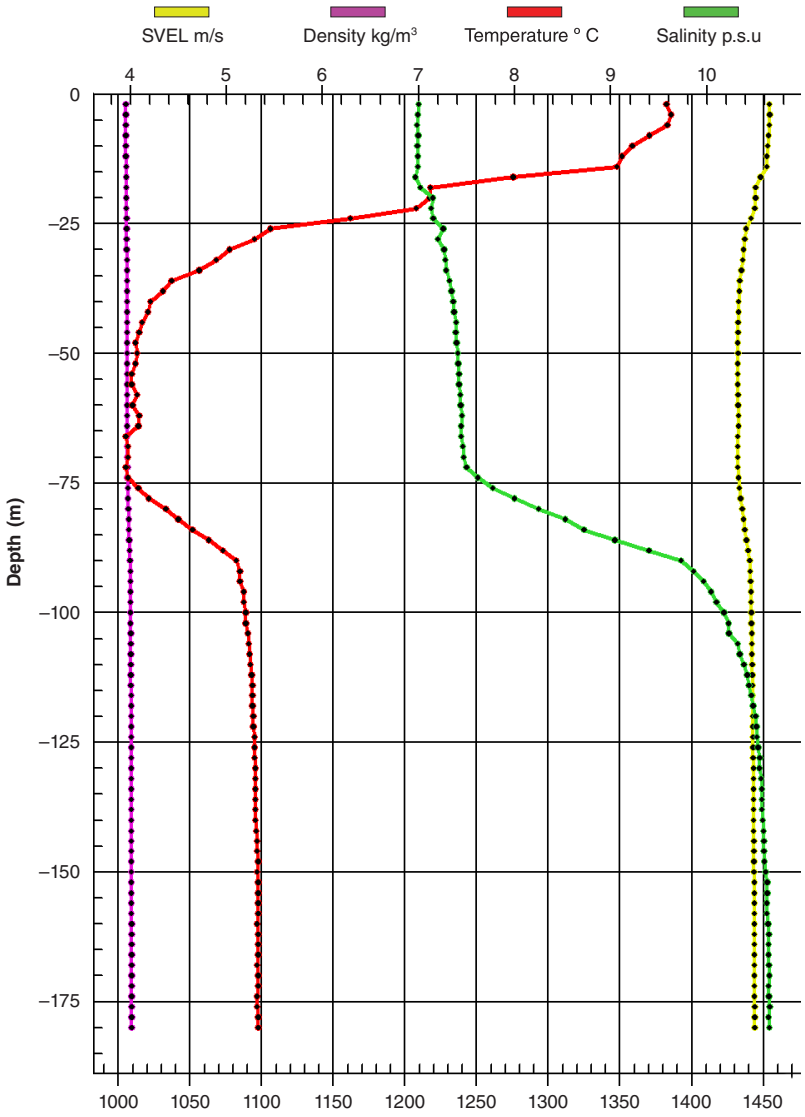

Figure 32. The plot is from the field campaign of 2008 and illustrates sound velocity (yellow), density (purple), temperature (red) and salinity (green) through the water column. There are two visible thermoclines, one at approximately 10 m and one at 75 m. A halocline can be identified at 75 m.

The average TOC concentration was 9.6% of DW in 2008 and 11.0% of DW in 2014 (Table 33). From the presented element data it is shown that the variation in concentrations is quite large for a number of parameters within station SE-9. All parameters, except arsenic and cadmium, have an RSD of over 20%.

Elements with available environmental assessment criteria plus sulphur are presented in Figures 34A–J and Table 34. Arsenic, cadmium, chromium, lead, zinc and sulphur show the same pattern with concentration maxima in 2008 (Figs. 34A, B, D, H, I and J). Nickel levels have increased continuously since 2003 (Fig. 34G).

Table 34 presents element data grouped into classes according to the Swedish EPA environmental assessment criteria (Swedish EPA 1999). At station SE-9 cadmium, copper, nickel and zinc occur in concentrations with the largest deviation from the national background. Nickel went from class 2 to class 4 between 2008 and 2014 whereas cadmium has remained within class 5 all three years. Zinc concentrations were highest in 2008 when they were included in class 5.

Figure 33. The sediment at station SE-9 consists of laminated reduced post-glacial clay gyttja with a fluffy layer on top. This fluffy layer consists of settled algae from the annual algal blooms.

Table 33. Concentrations of different parameters at seven sampling sites within station SE-9, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	20.9	21.3	4.13	3.73	<0.07	0.0451	19 000	19 900	0.85	1.4	7.70	11.3
Site 2	23.3	21.2	3.37	3.80	0.0704	0.100	36 200	23 800	0.97	0.94	8.66	8.48
Site 3	23.2	20.3	3.54	3.43	0.0647	0.0840	20 800	23 100	0.98	0.81	8.65	7.43
Site 4	22.4	16.8	4.08	2.93	0.0765	0.0462	16 000	13 200	1.7	1.5	14.1	12.9
Site 5	22.9	14.9	3.80	2.69	0.0791	0.0554	19 100	12 200	1.3	1.7	11.0	14.2
Site 6	21.0	17.9	4.92	2.94	0.129	<0.04	17 500	12 300	0.90	1.6	8.1	13.8
Site 7	20.3	18.8	3.58	4.92	0.0783	0.126	29 800	15 600	1.1	0.89	9.30	8.68
Average	22.0	18.7	3.91	3.49	0.0711	0.0652	22 629	17 157	1.1	1.3	9.64	11.0
Standard deviation STD	1.15	2.21	0.485	0.702	0.0350	0.0385	6 916.0	4 678.5	0.27	0.33	2.05	2.57
%RSD	5.21	11.8	11.8	20.1	49.3	59.0	30.563	27.268	24	27	21.3	23.4

Table 34. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-9. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
As	20.4	22.0	18.7
Cd	3.07	3.92	3.49
Co	12.8	11.5	14.8
Cr	51.5	61.7	49.7
Cu	104	83.8	86.6
Hg	0.0677	0.0711	0.0652
Ni	5	39.8	69.5
Pb	25.8	30.8	28.7
Zn	254	444	314
S	16 600	22 630	17 160
TN	1.2	1.1	1.3
TOC	10.1	9.64	11.0

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

Cadmium levels exceeded the ecotoxicological assessment criteria (HVMFS 2013:19) all three years (Table 36).

Concentrations of organic pollutants with available environmental assessment criteria are presented in Figures 35A–F and Table 35 together with organic substances without available criteria (Figs. 35 G and H). The PAHs, PCB7, HCHs, DDTs and chlordanes follow the same pattern with concentration maxima in 2008 (Figs. 35A, B, D, E and F). HCB levels are stable between 2008 and 2014 while being below LOQ in 2003. (Fig. 35C). Both TBT and DEHP levels show the same pattern with levels decreasing between 2003 and 2008 and increasing between 2008 and 2014 (Figs. 35G and H). Diuron levels were quantifiable in 2014 whereas simazine concentrations have been below LOQ all three survey years.

Table 35 presents concentrations of organic micropollutants grouped into classes according to the Swedish EPA environmental assessment criteria (Swedish EPA 1999). The table shows that most substances occur and have occurred in high concentrations. HCB levels were below LOQ

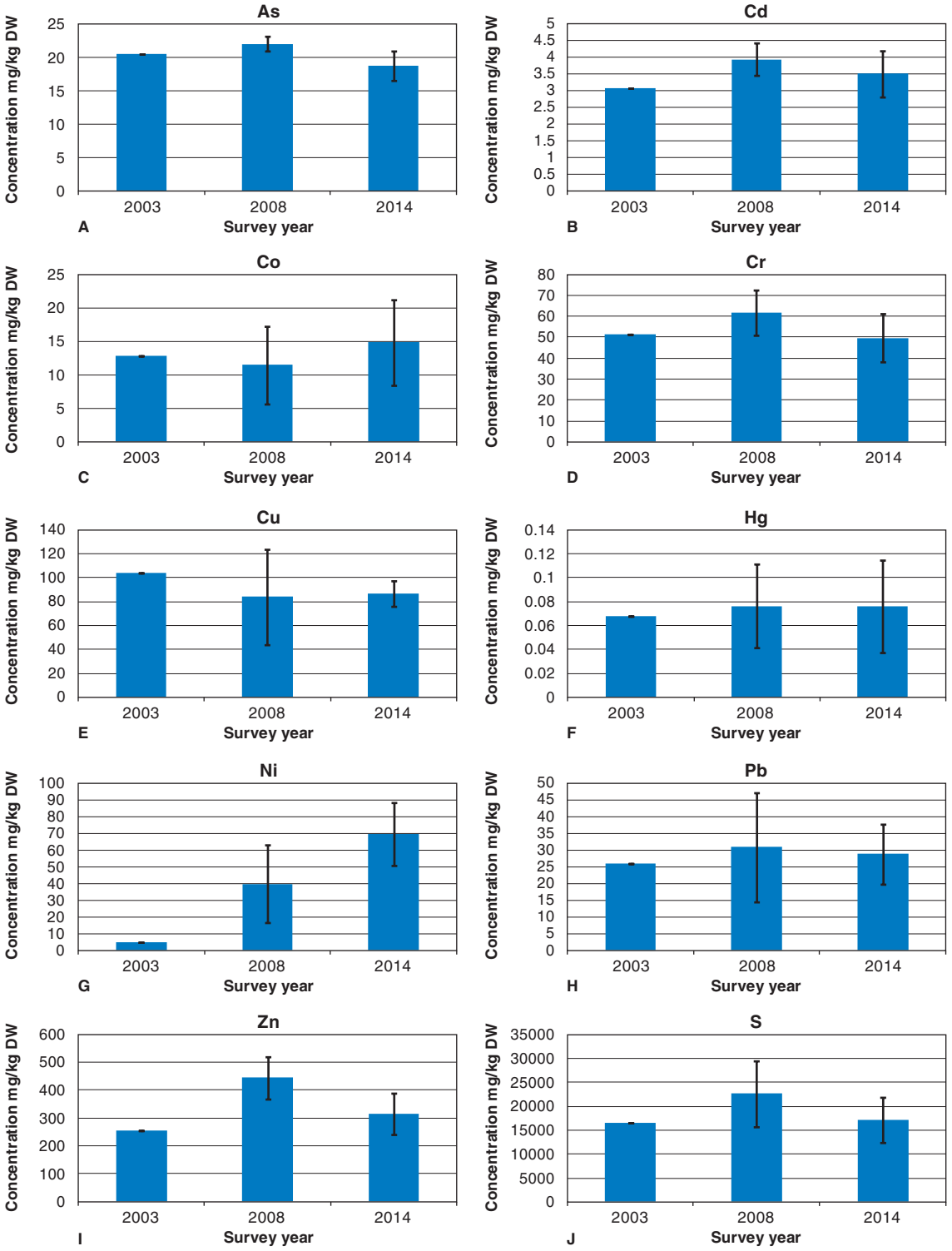

Figure 34. **A–J.** Most elements at station SE-9 showed concentration maxima in 2008, while nickel levels have increased continuously since 2003. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 35. Concentrations in µg/kg DW of organic micropollutants from 2003, 2008 and 2014 at station SE-9. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	26	9.5	5.2
Fluoranthene	110	152	110
Sum 11 PAH	1 199	1 789	1 133
Sum 7 PCB	3.2	7.1	4.7
HCB	<0.4	0.25	0.25
Sum HCH	0.97	1.8	1.0
Sum DDT	4.8	9.7	5.4
Sum Chlordanes	0.30	1.2	0.82
TBT	13	9.9	23
Diuron	<20	<2	0.16
Simazine	<2	<2	<0.5
DEHP	2 000	50	280
Nonylphenol	<20	<20	64

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 36. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-9. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	3 070	–	3 917	–	3 491	–
Pb	120 000	25 800	–	30 800	–	28 743	–
Anthracene	24	26	48	9.5	46	5.2	53
Fluoranthene	2 000	110	4 030	152	3 857	110	4 384
TBT	1.6	13	3.2	9.9	3.1	23	3.5

Concentration exceeds assessment value.

in 2003 but in class 4 in 2008 and 2014. PCB concentrations were in class 3 in 2003 but in class 4 in 2008 and 2014. Chlordane concentrations went from class 4 to class 5 between 2003. TBT has occurred in concentrations exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) all three years (Table 36).

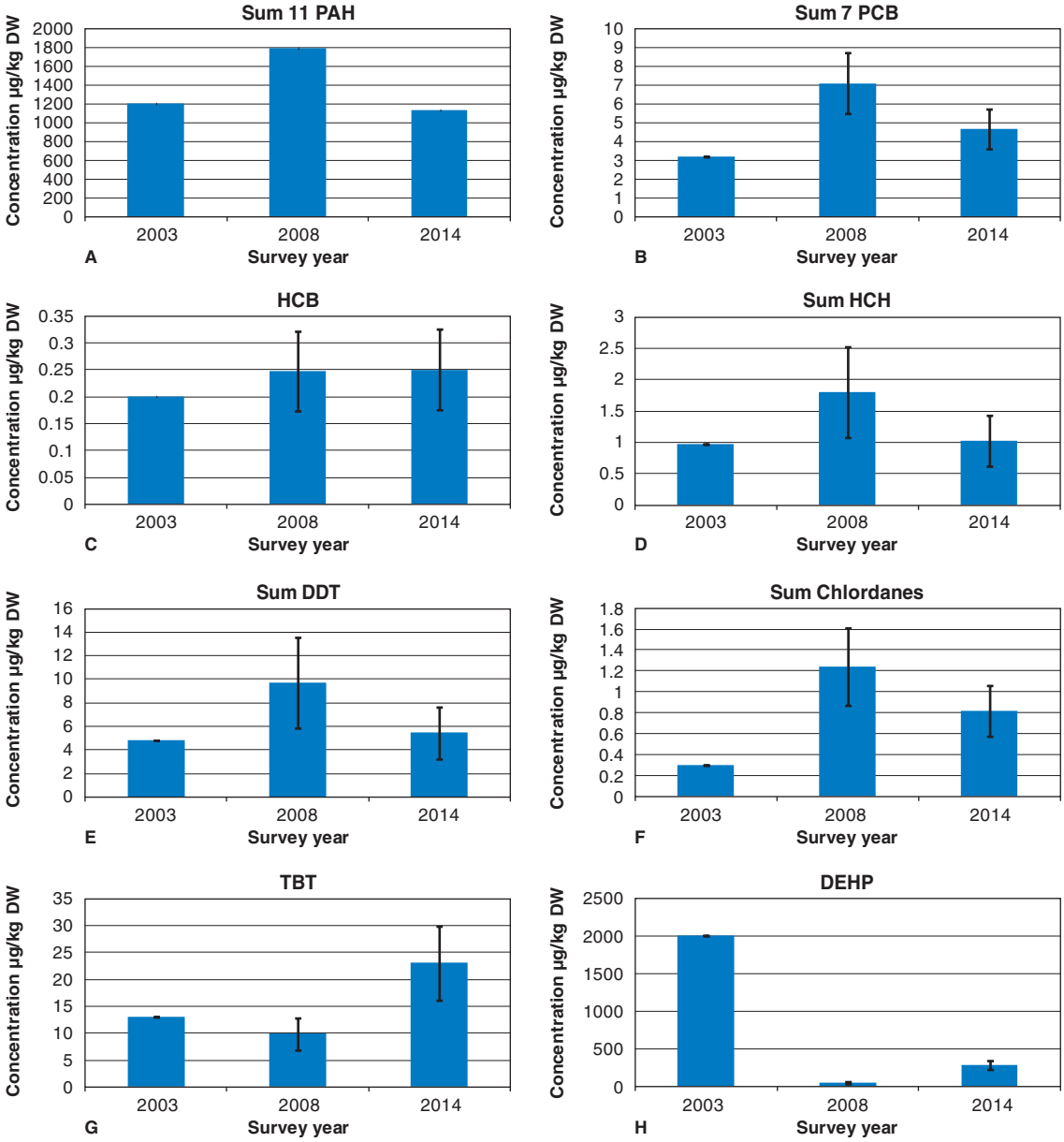

Figure 35. **A–H.** At station SE-9, the PAHs, PCB7, HCHs, DDTs and chlordanes follow the same pattern with concentration maxima in 2008. HCB levels are stable between 2008 and 2014 while being below LOQ in 2003. The error bars represent laboratory measurement uncertainties.

Station SE-6, Fårö deep

Station SE-6 is located around 30 km east of the north cape of Gotland (Fig. 1). The site is situated in the Fårö deep which is a sea basin with a depth of approximately 195 m. CTD data obtained in May 2014 show that temperature decreases from around 10 °C in the surface waters to around 3.5 °C at 60 m where it increases again and stays at 6 °C in the bottom water (Fig. 36). Salinity levels are stable at a value of over 6 down to a depth of 55 m where they increase again to a value of 11 in the bottom water (Fig. 36). The bottom current speed was measured to 0.04 m/s indicating stagnant bottom water suitable for sedimentation of fine-grained particles.

The sediment at station SE-6 is composed of laminated reduced postglacial clay gyttja over postglacial gyttja clay (Appendix 1). There is no oxic layer on top of the reduced sediment, only fresh material from the spring bloom (Fig. 37). Due to the loose character of the sediment it was not possible to deploy the camera cage steady on the seabed and hence, no underwater photographs are available from this station. The dissolved oxygen concentration in the bottom water was measured to 0 mL/L designating anoxic conditions hostile to living organisms.

The average TOC content was 13.0% of DW in 2008 and 13.9% of DW in 2014. The vari-

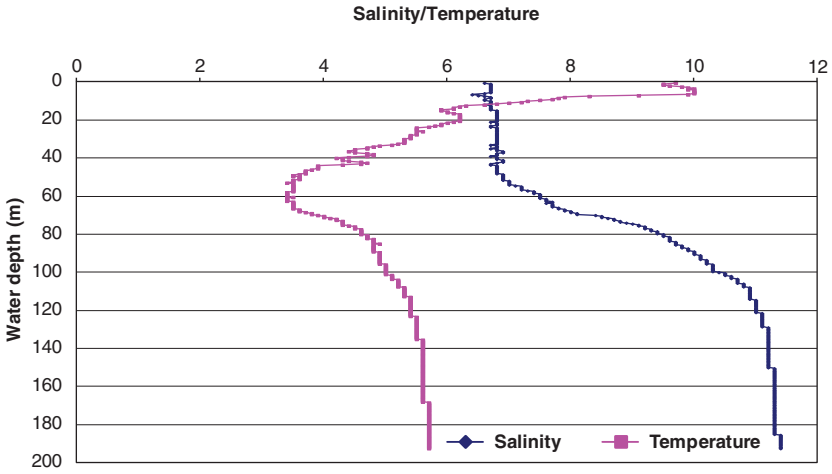

Figure 36. CTD data collected in May 2014 show that there is a halocline at around 55 m. The thermocline is not as visible and the temperature decreases from 10 °C at the surface to 3.5 °C at 60 m where it again increases and stays at 6 °C in the bottom water.

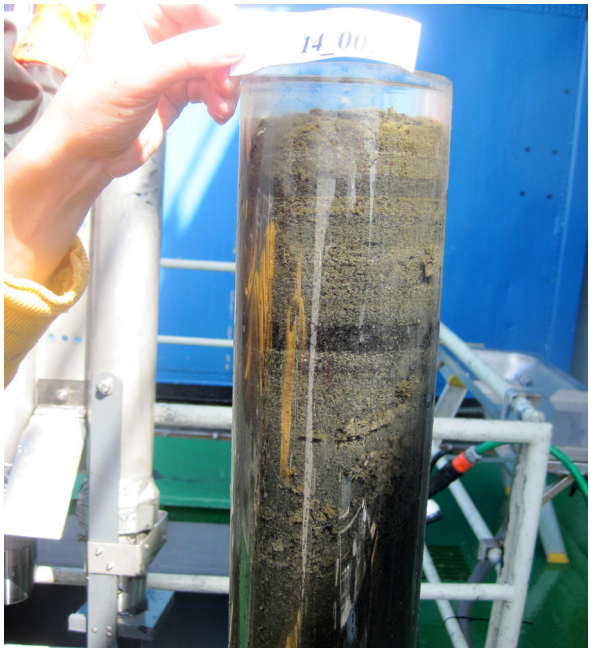

Figure 37. The sediment at station SE-6 consists of laminated reduced postglacial clay gyttja with a fluffy layer on top. This fluffy layer is composed of settled algae from the annual algal blooms.

ation in concentrations is highest for mercury. In 2008 the RSD was 245% for mercury and in 2014 the number was 65%. This is due to the function calculating the average of the listed concentration, since <values are estimated as zero. In 2008, six out of seven mercury concentrations were below LOQ which gives a very small average that is used in the calculation of the relative standard deviation (RSD). The same is applicable to mercury data from 2014 (Table 37). Apart from mercury, arsenic and cadmium concentrations from 2008 show the largest variation within the station area.

Elements with available environmental assessment criteria plus sulphur are presented in Figures 38A–J and Table 38. Element concentrations at this station were relatively stable throughout the three survey years. Nickel levels may have increased and lead levels decreased since 2003 (Figs. 38G and H).

Table 38 presents element concentrations grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). From this table it is obvious that cadmium, copper and zinc concentrations are the most elevated at station SE-6. Cadmium concentrations have remained within class 5 since 2003 whereas copper and zinc both went from class 4 in 2003 to class 5 in 2008 and then back again. Cadmium levels exceeded the ecotoxicological assessment criteria (HVMFS 2013:19) all three years (Table 40).

Table 37. Concentrations of different parameters at seven sampling sites within station SE-6, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	21.9	17.5	5.35	3.06	<0.08	0.0621	14 800	11 800	1.7	1.6	13.7	13.3
Site 2	14.7	15.7	3.78	3.05	<0.08	0.0506	14 700	10 500	1.5	1.7	11.7	14.6
Site 3	11.0	18.4	2.54	3.91	<0.05	0.0590	16 200	13 000	1.5	1.5	12.4	13.3
Site 4	16.8	18.2	4.36	4.14	0.0697	0.0631	14 400	13 900	1.4	1.6	11.9	13.6
Site 5	17.6	14.7	4.65	2.75	<0.06	<0.05	15 000	11 400	1.7	1.7	12.7	14.2
Site 6	17.0	18.3	4.15	2.83	<0.04	<0.04	13 200	10 400	1.8	1.6	14.6	13.7
Site 7	14.4	17.5	3.36	2.89	<0.08	0.0443	15 400	10 700	1.7	1.7	13.8	14.9
Average	16.2	17.2	4.03	3.23	0.00996	0.0399	14 814	11 671	1.6	1.6	13.0	13.9
Standard deviation STD	3.12	1.33	0.844	0.515	0.0244	0.0259	852.61	1 239.5	0.13	0.060	1.00	0.586
%RSD	19.2	7.72	20.9	15.9	245	65.1	5.76	10.6	8.0	3.7	7.73	4.21

Table 38. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-6. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
As	20.4	16.2	17.2
Cd	3.68	4.03	3.23
Co	7.56	7.6	7.57
Cr	41.4	39.3	48.0
Cu	93.6	141	113
Hg	0.0638	0.00996	0.0399
Ni	31.9	24.9	46.9
Pb	26.9	21.8	17.8
Zn	253	318	220
S	13 300	14 800	11 700
TN	1.7	1.6	1.6
TOC	12.7	13.0	13.9

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

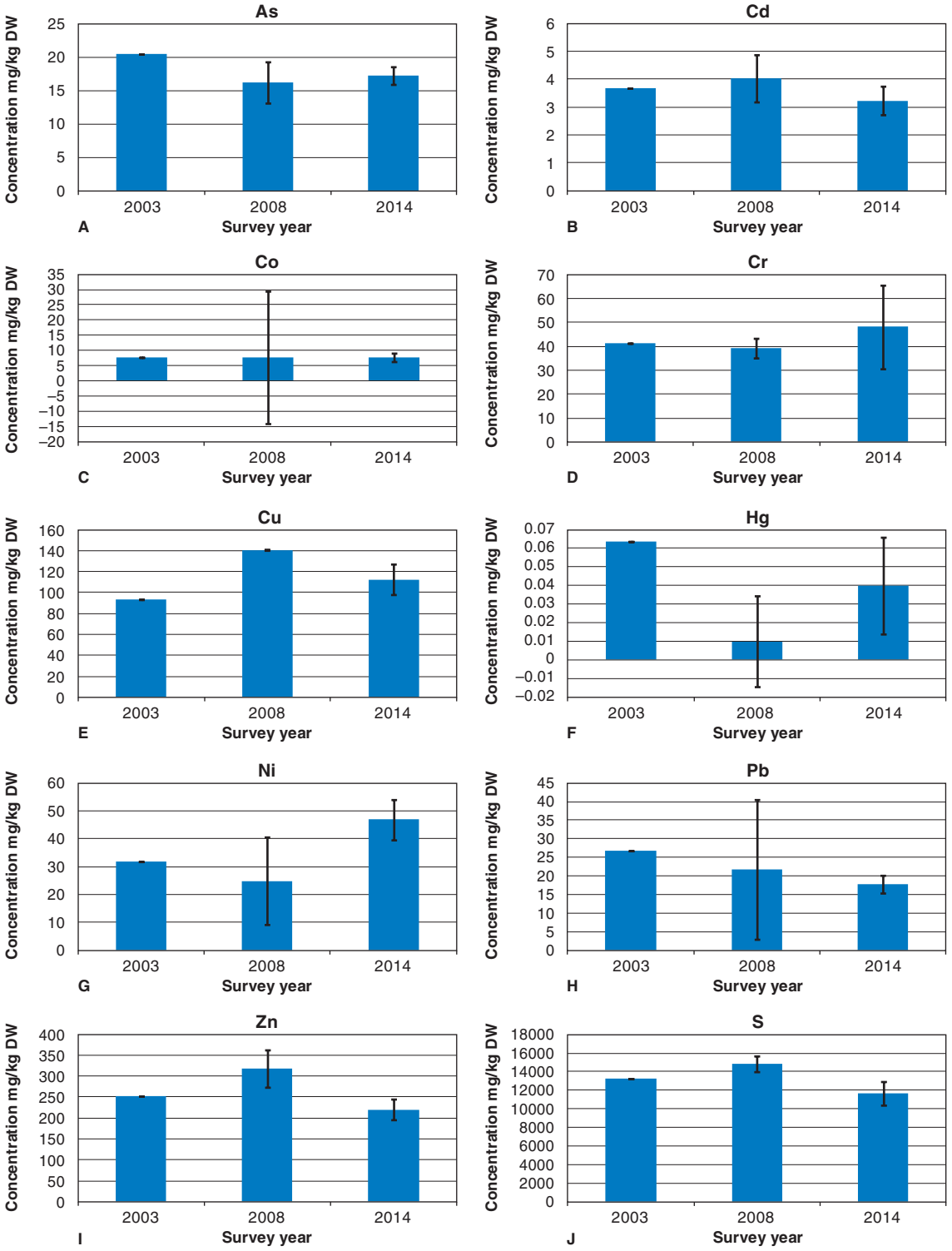

Figure 38. **A–J.** Element concentrations at station SE-6 were relatively stable throughout the three survey years. Nickel levels may have increased and lead levels decreased since 2003 (Figs. 38G and H). The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 39. Concentrations in µg/kg DW of organic micropollutants from 2003, 2008 and 2014 at station SE-6. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	12	2.0	4.8
Fluoranthene	150	31	98
Sum 11 PAH	1 449	349	1 115
Sum 7 PCB	1.9	4.6	4.4
HCB	<3	0.27	0.57
Sum HCH	3.7	1.3	1.0
Sum DDT	7.4	6.0	5.7
Sum Chlordanes	0.37	0.63	0.66
TBT	50	17.0	11
Diuron	<2	<2	0.22
Simazine	<2	<2	0.91
DEHP	670	100	110
Nonylphenol	170	<20	35

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 40. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-6. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	3 680	–	4 027	–	3 233	–
Pb	120 000	26 900	–	21 786	–	17 786	–
Anthracene	24	12	61	2.0	62	4.8	67
Fluoranthene	2 000	150	5 095	31	5 191	98	5 570
TBT	1.6	50	4.1	17.0	4.2	11	4.5

Concentration exceeds assessment value.

Organic substances with available environmental assessment criteria are presented in Figures 39A–F and Table 39 together with organic substances without available criteria (Figs. 39G–I). The different substance concentrations show different patterns between the three years. PAHs, HCB, HCHs, DDTs, TBT, DEHP and nonylphenol had their concentration maxima in 2003 (Figs. 39A, C–E and G–I). Of these substances, PAH and HCB levels seem to have increased in 2014 compared to 2008 (Figs. 39A and C). In contrast to the other substances, PCB7 and chlordane displayed lower concentrations in 2003 than in 2008 and 2014 (Figs. 39B and F). Diuron and simazine levels were only quantifiable in 2014.

Table 39 presents concentrations of the organic micropollutants divided into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). From the table it can be stated that most substances occur in high concentrations, class 4–5. The PCBs have gone from concentrations within class 3 in 2003 to class 4 in 2008 and 2014. HCB levels were below LOQ in 2003 but were in class 4 in 2008 and 2014. HCH concentrations went from class 5 to 4 between 2003 and 2008 while DDT did the same transfer between 2008 and 2014.

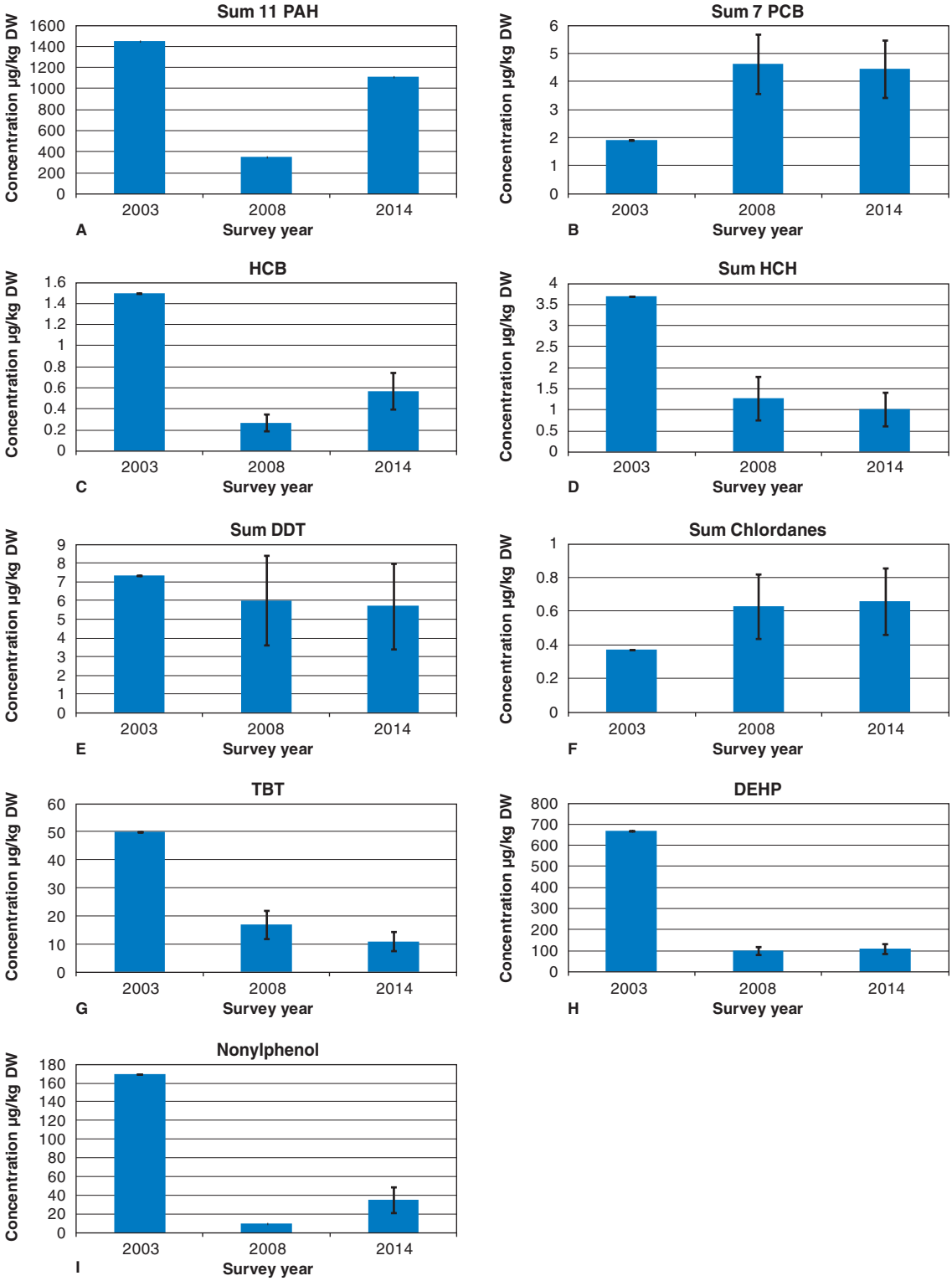

Figure 39. **A–I.** At station SE-6, most substances had their concentration maxima in 2003. Of these substances, PAH and HCB levels seem to have increased in 2014 compared to 2008. PCB7 and chlordane displayed lower concentrations in 2003 than in 2008 and 2014. The error bars represent laboratory measurement uncertainties.

Chlordane concentrations have remained within class 5 since 2003. The PAHs went from class 4 to 3 between 2003 and 2008 and then from class 3 to 4 between 2008 and 2014. TBT has occurred in concentrations exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) all three years (Table 40).

Station SE-7, south-east Gotland basin

Station SE-7 is located east of the south cape of Gotland (Fig. 1). The site is situated in the Gotland basin at a depth of about 177 m. CTD data obtained during the survey in May 2014 show that salinity lies between 6 and 7 down to a depth of around 70 m where it starts to increase (Fig. 40). Salinity then gradually increases down to the bottom where it stops at a value of around 12. The temperature decreases down to around 70 m where it fluctuates. Below 70 m, the temperature follows the salinity pattern and increases gradually down to the bottom where it ends on 6 °C. Bottom current speed was measured to 0.025 m/s designating stagnant water suitable for sedimentation of fine-grained particles.

The sediment at station SE-7 consists of a watery reduced layer with fresh organic matter on top of postglacial gyttja clay (Appendix 1). The concentration of dissolved oxygen in the bottom water was measured to 0 mL/L pointing at a hostile environment for benthic organisms. There is no evidence of life in the underwater photographs taken at the station (Fig. 41).

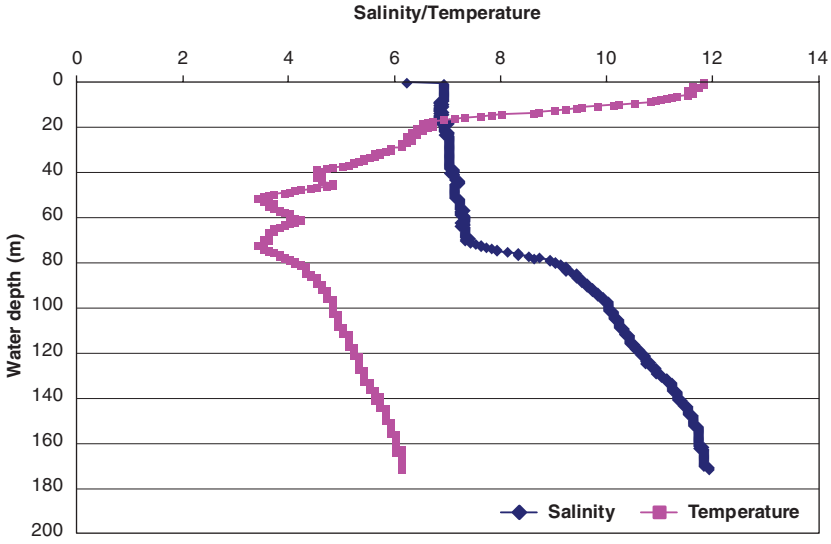

Figure 40. CTD data obtained in May 2014 show that the salinity is quite stable down to a depth of 70 m where it gradually starts to increase. Temperature fluctuates but decreases from the surface down to 70 m where it gradually increases.

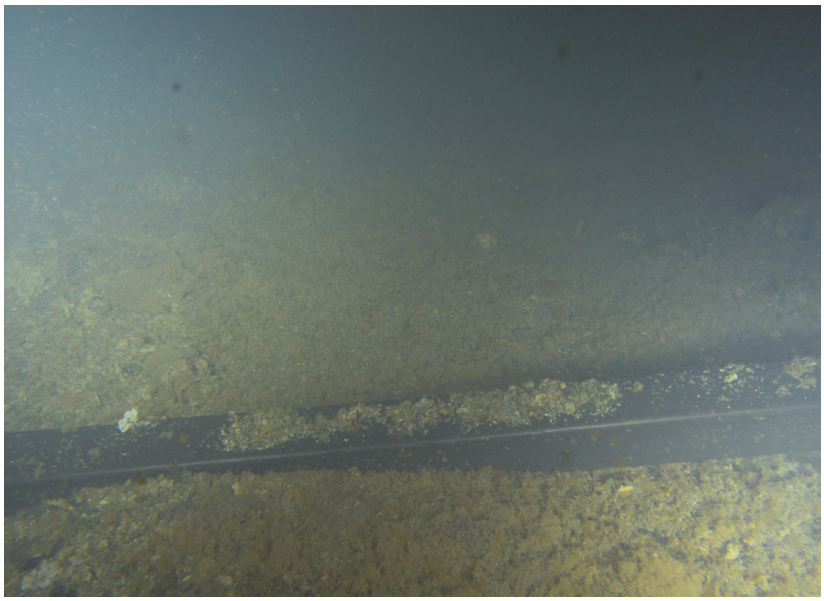

Figure 41. The sediment at station SE-7 consists of a reduced water rich layer with fresh organic matter on the top. The oxygen concentration in the bottom water was measured to 0 mL/L and there is no evidence of benthic life.

The average TOC concentration was 11.3% of DW in 2008 and 12.6% of DW in 2014. The parameters showing the largest variation in concentration within the station area are mercury and cadmium. In 2014, mercury levels had an RSD value of 17.5%. In 2008 this level was lower, 14.6%. Cadmium concentrations varied to a degree of almost 15% in 2014. In 2008 this level was much lower, around 5% (Table 41).

Elements with available environmental assessment criteria plus sulphur are presented in Figures 42A–J and Table 42. All elements except nickel show the same pattern with concentration maxima in 2008 (Figs. 41A–F and H–J). Nickel has, however, increased since 2003 (Fig. 42G).

For the elements with available assessment criteria (Swedish EPA 1999) presented in Table 42, arsenic, cadmium, copper and zinc are or have been present in class 4 and 5. Cadmium concentrations have been within class 5 since the start of the programme in 2003. Both copper and zinc went from class 4 to class 5 between 2003 and 2008 but fell back into class 4 again after 2008. Arsenic concentrations rose from class 3 into class 4 between 2003 and 2008 but fell back into class 3 after 2008. All other elements occur in levels with none to medium deviations from

Table 41. Concentrations of different parameters at seven sampling sites within station SE-7, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg TS.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/TS)	TN (%/TS)	TOC (%/TS)	TOC (%/TS)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	26.0	20.8	4.54	3.76	0.0938	0.0879	18 500	14 500	1.6	1.5	14.1	12.5
Site 2	34.0	24.3	4.53	3.15	0.102	0.0950	17 800	18 500	1.3	1.3	10.8	11.7
Site 3	39.7	24.7	5.18	4.05	0.0948	0.0857	24 400	16 500	1.2	1.5	10.1	12.7
Site 4	32.2	21	4.54	3.59	0.0948	0.0724	22 000	15 000	1.2	1.7	10.8	13.7
Site 5	31.0	26.0	4.61	4.09	0.0658	0.0981	23 100	17 900	1.3	1.3	11.2	11.4
Site 6	34.9	14.3	4.45	2.47	0.0834	0.0523	21 300	12 400	1.3	1.7	10.8	13.5
Site 7	31.5	24.4	4.56	3.80	0.0710	0.0843	22 800	17 000	1.3	1.5	11.1	12.5
Average	32.8	22.2	4.63	3.56	0.0865	0.0822	21 414	15 971	1.3	1.5	11.3	12.6
Standard deviation STD	3.87	3.7	0.229	0.531	0.0126	0.0144	2 254.8	1 975.4	0.13	0.15	1.20	0.772
%RSD	11.8	16.6	4.94	14.9	14.6	17.5	10.529	12.368	9.61	10	10.6	6.15

Table 42. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-7. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
As	19.0	32.8	22.2
Cd	2.92	4.63	3.56
Co	6.08	17.6	10.4
Cr	32.8	63.4	44.4
Cu	82.1	139	104
Hg	0.0855	0.0865	0.0822
Ni	5.00	31.9	53.0
Pb	27.3	48.6	25.1
Zn	215	447	246
S	14 600	21 400	16 000
TN	1.4	1.3	1.5
TOC	11.3	11.3	12.6

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

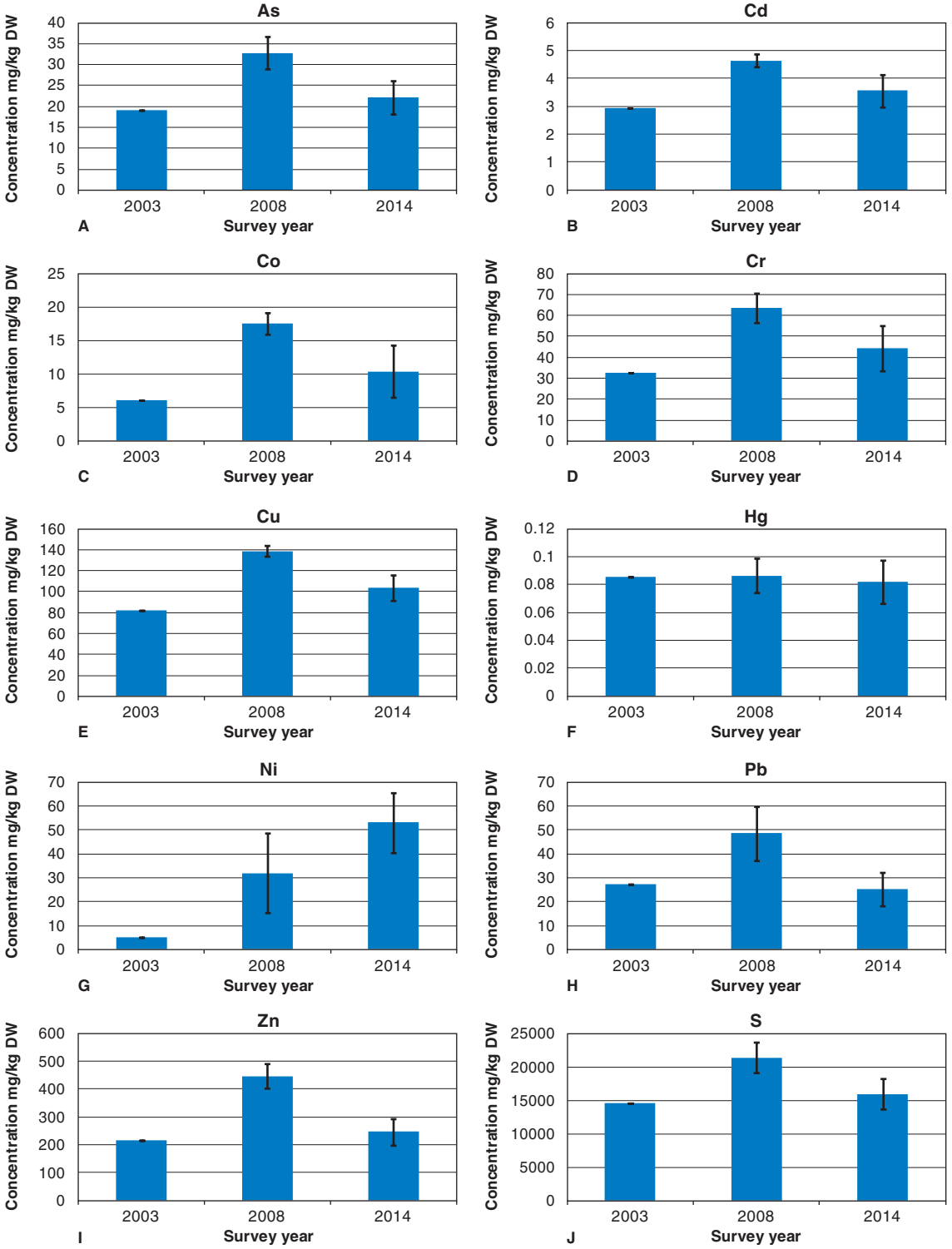

Figure 42. **A–J.** At station SE-7, all elements except nickel show the same pattern with concentration maxima in 2008. Nickel has increased since 2003. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 43. Concentrations in µg/kg DW of organic micropollutants from 2003, 2008 and 2014 at station SE-7. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	15	8.6	4.9
Fluoranthene	230	145	100
Sum 11 PAH	2 003	1 501	978
Sum 7 PCB	5.3	7.4	4.2
HCB	0.28	0.22	0.29
Sum HCH	0.60	1.2	0.61
Sum DDT	22	10	5.5
Sum Chlordanes	0.94	1.2	0.67
TBT	56	32	28
Diuron	<30	<2	0.18
Simazine	<5	<2	1.0
DEHP	2 300	130	400
Nonylphenol	240	<20	80

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 44. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-7. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	2 920	–	4 630	–	3 559	–
Pb	120 000	27 300	–	48 571	–	25 114	–
Anthracene	24	15	54	8.6	54	4.9	60
Fluoranthene	2 000	230	4 505	145	4 511	100	5 023
TBT	1.6	56	3.6	32.0	3.6	28	4.0

Concentration exceeds assessment value.

the national backgrounds. Cadmium levels exceeded the ecotoxicological assessment criteria (HVMFS 2013:19) all three year (Table 44).

The organic pollutants with available environmental assessment criteria are presented in Figures 43A–F and Table 43 together with organic substances without available criteria (Figs. 43G–I). The PAHs, DDTs, TBT, DEHP and nonylphenol have decreased since 2003 (Figs. 43A, E and G–I). PCB7, HCH and chlordane levels displayed maxima in 2008 (Figs. 43A, D and F). HCB levels have been quite stable since 2003 (Fig. 43C). Diuron and simazine levels were below LOQ in 2003 and 2008 but quantifiable in 2014.

Table 43 lists concentrations of organic pollutants grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). It appears that all substances occur in high to very high concentrations, class 4 and 5. Chlordane concentrations have been within class 5 since the beginning of the programme in 2003. DDT went from class 5 to class 4 between 2008 and 2014. PAH11, PCB7, HCB, and HCH levels have been constant in class 4 since 2003. TBT has occurred in concentrations exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) all three years (Table 44).

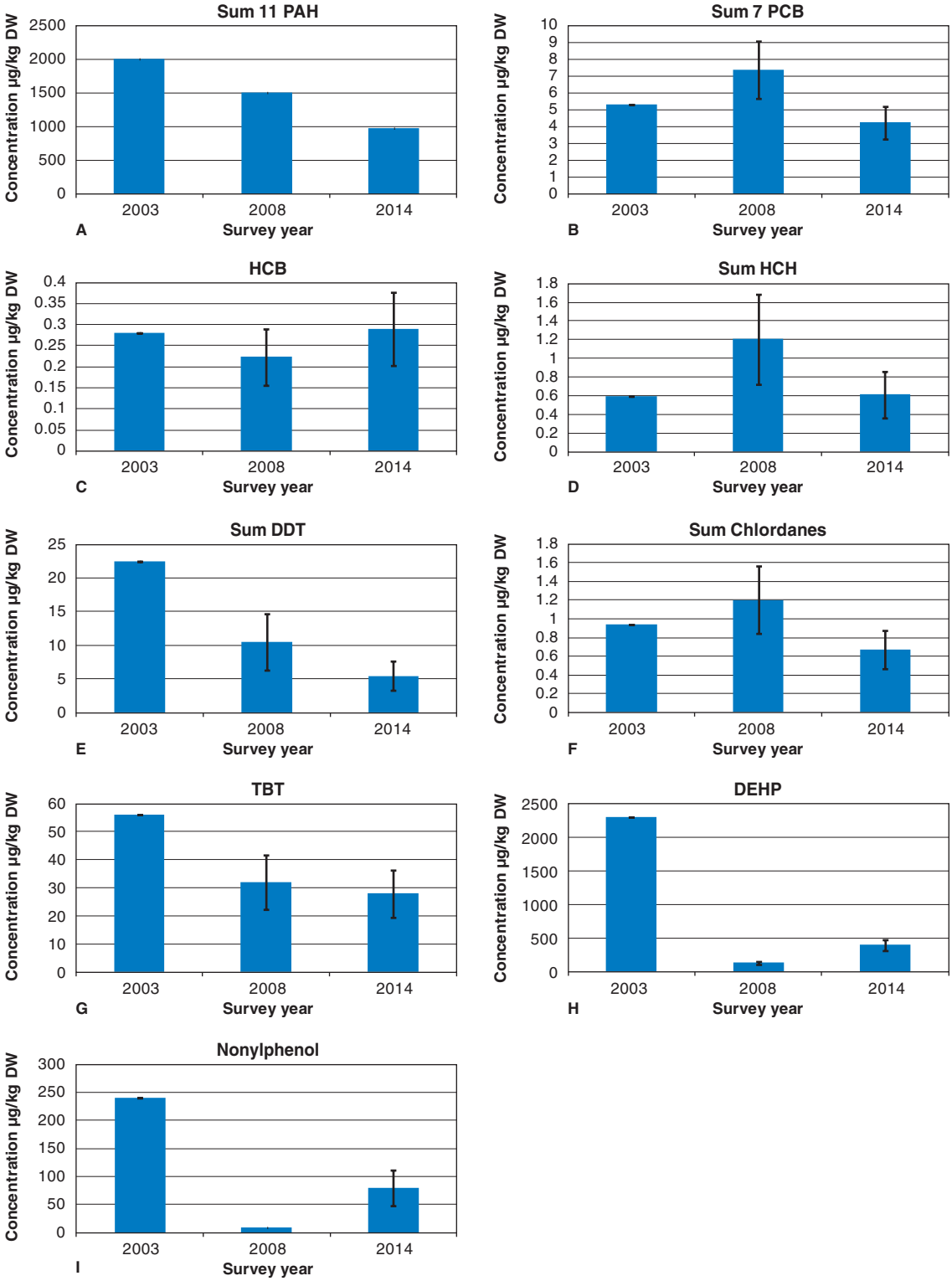

Figure 43. **A–I.** At station SE-7, most substances have decreased in concentration since 2003. PCB7, HCHs and chlordanes had concentration maxima in 2008. The error bars represent laboratory measurement uncertainties.

Station SE-10, Karlsö deep

Station SE-10 is located between the north cape of Öland and the south cape of Gotland (Fig. 1). The site is situated in the sea basin Karlsö deep which has a depth of around 110 m. CTD data were obtained in May 2014 and show that the water column is divided into two strata. The first stretches between the surface and down to about 35 m where the temperature drops rapidly from c. 6 °C to c. 4 °C at 44 m which represents the thermocline. Salinity increases from around 7 in the surface water to almost 9.5 at 85 m where it is stabilised and remains at 10 to the bottom (Fig. 44). Bottom current speed was measured to 0.019 m/s signifying stagnant conditions suitable for sedimentation of fine-grained material.

The sediment at station SE-10 consists of 10 cm laminated reduced postglacial clay gyttja on top of postglacial clay (Fig. 45 and Appendix 1). The dissolved oxygen concentration was

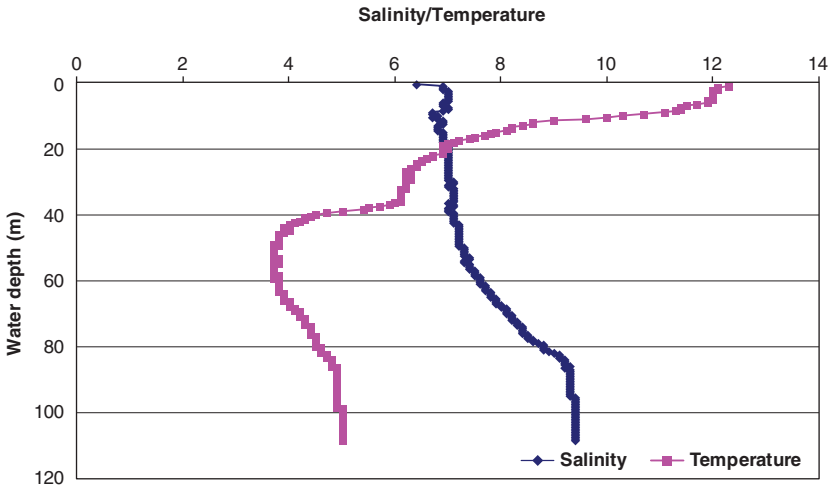

Figure 44. CTD data obtained in May 2014 indicate a thermocline at 35 m. Salinity increases slowly from about 7 in the surface water to almost 9.5 in the bottom water.

Figure 45. The sediment at station SE-10 consists of laminated reduced postglacial clay gyttja.

measured to 0 mL/L indicating an anoxic and hostile environment without any signs of living organisms. The average TOC concentration was 10.9% of DW in 2008 and 11.3% of DW in 2014. The variation in mercury concentration within the station area was very high in 2014 with an RSD value of 87.2% (Table 45). As at station SE-6, mercury concentrations are very low and mostly below the LOQ. Since <values are estimated to zero by the function calculating average concentrations, the average becomes very low and hence also the RSD. RSD levels of the other presented parameters are under 15%.

Elements with available environmental assessment criteria and sulphur are presented in Figures 46A–J and Table 46. All presented elements, except mercury and nickel, show the same pattern with increasing levels between 2003 and 2008 and decreasing levels between 2008 and 2014 (Figs. 46A–E and H–J). Mercury concentrations have dropped since 2003 (Fig. 46F), while nickel concentrations seem to have increased (Fig. 46G).

Table 46 lists concentrations of elements divided into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Most elements occur in concentrations with none to medium deviation from the national backgrounds. Exceptions are cadmium,

Table 45. Concentrations of different parameters at seven sampling sites within station SE-10, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg TS.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/TS)	TN (%/TS)	TOC (%/TS)	TOC (%/TS)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	19.4	14.2	2.50	1.90	0.0699	0.0561	13 900	10 600	1.4	1.4	11.1	11.9
Site 2	17.8	12.8	2.33	1.95	0.100	0.0517	13 100	11 000	1.5	1.4	12.1	12.4
Site 3	19.6	11.9	2.45	1.75	0.0864	0.0585	14 700	10 600	1.3	1.5	10.6	12.5
Site 4	19.7	11.9	2.66	1.63	0.0811	<0.06	14 400	11 800	1.3	1.3	10.9	10.5
Site 5	19.6	11.9	2.33	1.81	0.0679	<0.04	14 300	11 000	1.3	1.2	10.6	10.6
Site 6	19.2	13.0	2.44	2.30	0.0722	0.0645	15 900	13 000	1.2	1.1	9.81	9.52
Site 7	20.6	14.0	3.07	2.03	0.0694	<0.05	13 600	10 700	1.3	1.4	11.1	11.5
Average	19.4	12.8	2.54	1.91	0.0819	0.0330	14 271	11 243	1.3	1.3	10.9	11.3
Standard deviation STD	0.775	0.916	0.0240	0.201	0.0120	0.0288	829.31	813.91	0.072	0.12	0.638	1.01
%RSD	3.99	7.15	9.45	10.5	14.7	87.2	5.81	7.24	5.4	9.0	5.87	8.98

Table 46. Concentrations in mg/kg DW of elements from 2003 to 2014 at station SE-10. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC content.

	2003	2008	2014
As	13.1	19.4	12.8
Cd	1.63	2.54	1.91
Co	9.07	14.4	10.7
Cr	42.3	65.6	55.6
Cu	58.9	101.8	76.1
Hg	0.101	0.0819	0.0330
Ni	30.2	24.9	49.4
Pb	25.9	37.3	25.1
Zn	167	285	164
S	13 500	14 300	11 200
TN	1.1	1.3	1.3
TOC	8.90	10.9	11.3

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

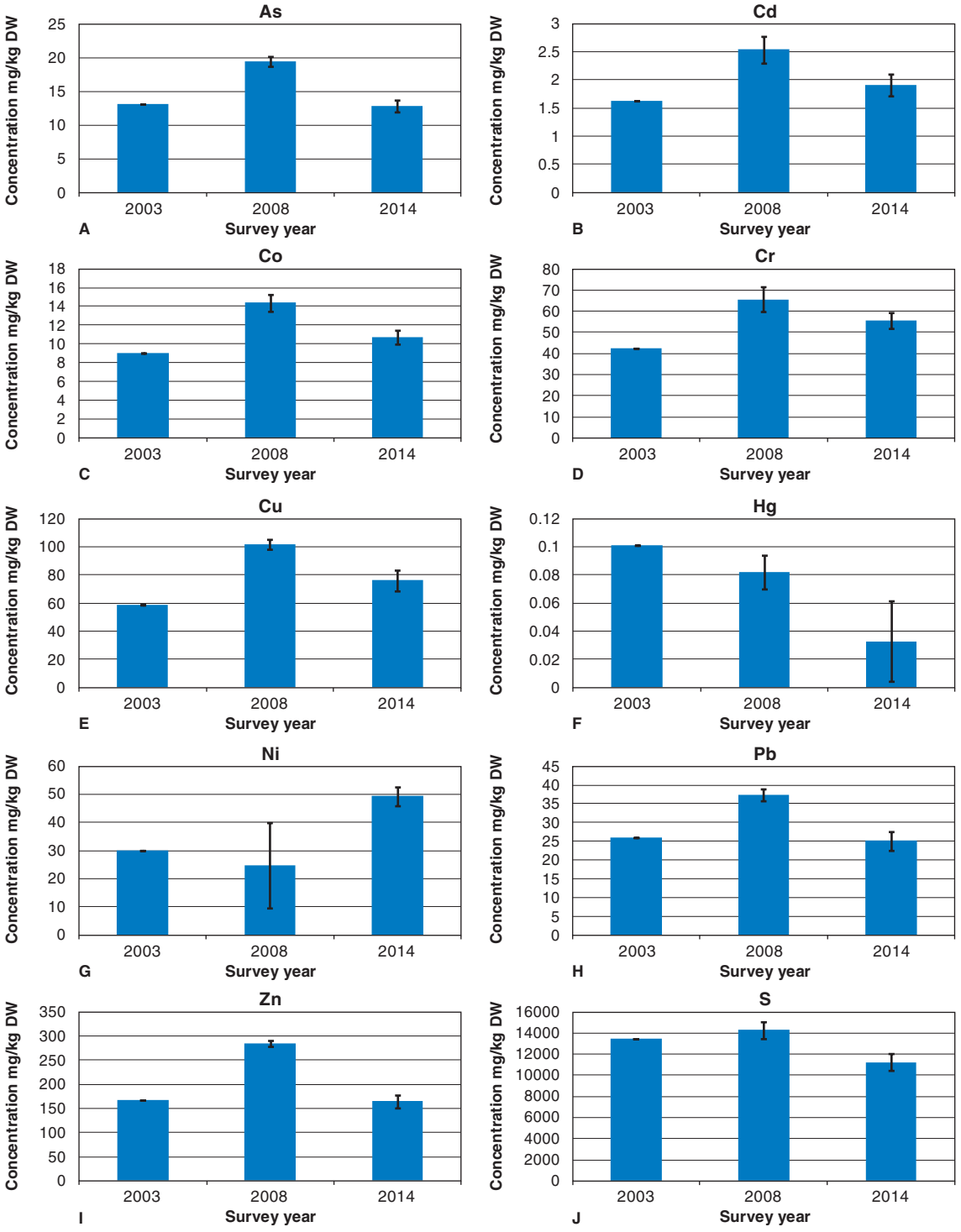

Figure 46. **A–J.** At station SE-10, most elements displayed concentration maxima in 2008. Mercury seems to have decreased since 2003 while nickel shows an increasing tendency. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 47. Concentrations in µg/kg DW of organic micropollutants from 2003 to 2014 at station SE-10. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	13	7.6	3.4
Fluoranthene	140	130	74
Sum 11 PAH	1 388	1 240	699
Sum 7 PCB	5.2	5.3	3.0
HCB	0.20	0.27	0.37
Sum HCH	0.63	1.3	0.81
Sum DDT	2.9	6.3	3.0
Sum Chlordanes	0.73	0.77	0.44
TBT	18	19	9.8
Diuron	<20	<2	0.18
Simazine	<2	<2	<0.5
DEHP	940	140	240
Nonylphenol	100	<20	46

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 48. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-7. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	1 630	–	2 540	–	1 910	–
Pb	120 000	25 900	–	37 329	–	25 143	–
Anthracene	24	13	43	7.6	52	3.4	54
Fluoranthene	2 000	140	3 560	131	4 350	74	4 508
TBT	1.6	18	2.8	19.0	3.5	9.8	3.6

Concentration exceeds assessment value.

copper and zink. Cadmium concentrations have consistently been within class 4 since 2003. Copper concentrations increased from class 3 to class 4 between 2003 and 2008 and have remained high. Zinc levels increased from class 3 to class 4 between 2003 and 2008 but fell back into class 3 after that. Cadmium levels exceeded the ecotoxicological assessment criteria (HVMFS 2013:19) in 2008, but not in 2003 or 2014 (Table 48).

Organic substances with available environmental assessment criteria are presented in Figures 47A–F and Table 47 together with organic substances without available criteria (Figs. 47G–I). The concentrations of PCB7, HCHs, DDTs, chlordanes and TBT were highest in 2008 (Figs. 47B, D–G). HCB concentrations have increased and PAH concentrations have decreased since 2003 (Figs. 47A and C). The levels of DEHP and nonylphenol decreased between 2003 and 2008 but increased again between 2008 and 2014 (Figs. 47H and I). Diuron levels were below LOQ in 2003 and 2008 but quantifiable in 2014. Simazine concentrations have been below LOQ all three years.

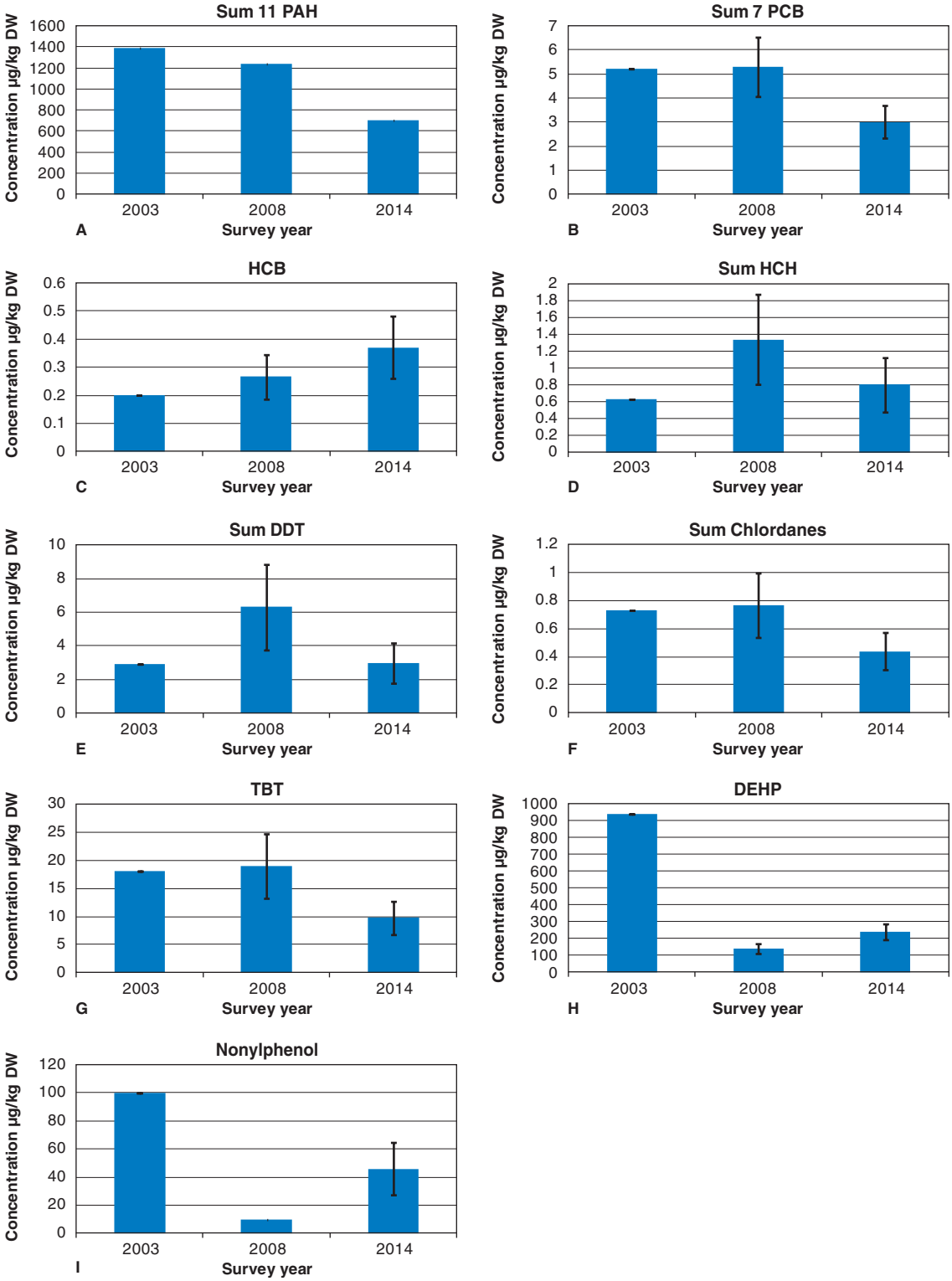

Figure 47. **A–I.** At station SE-10, most organic substances displayed concentration maxima in 2008. PAHs seem to have decreased since 2003 while HCB seems to have increased. The error bars represent laboratory measurement uncertainties.

Table 47 lists concentrations of organic substances grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). At station SE-10 the DDTs and chlordanes are present in the most elevated concentrations. The PAH11 have moved from class 4 to class 3 between 2008 and 2014. Chlordane concentrations have been within class 5 since 2003. DDT levels went from class 4 to class 5 between 2003 and 2008 and back to class 4 again between 2008 and 2014. PCB7 concentrations decreased between 2008 and 2014 and went from class 4 to class 3. The HCH levels have been stable in class 4 since 2003, while HCB levels increased from class 3 to class 4 between 2003 and 2008. TBT has occurred in concentrations exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) all three years (Table 48).

Station SE-11, north Bornholm Basin

Station SE-11 has become two stations during the project (Fig. 48). Station SE-11 old is the original sampling station examined and chosen by Cato and Kjellin in 2003 (Cato & Kjellin 2005, Cato & Kjellin 2008). This station was used as sampling site during 2003 and 2008. However, as the project of laying the Nordstream pipeline progressed SGU assessed the risk of possible disturbances of the seafloor at SE-11 and received funding for the survey and adoption of a new station. As a result of this a new sampling station, SE-11 new, was identified as a potential replacement for SE-11 old in case this station was damaged by the laying of the pipelines (Cato & Apler 2014). The new station was sampled along with the old in 2014 for comparison of the suitability for sampling between the two locations.

From underwater photographs taken during the field campaign in 2014, disturbances of the surface sediment at station SE-11 old was evident (Appendix 1). Due to this discovery the old station was dismissed and SE-11 new has been adopted as the new monitoring station in the Bornholm basin from 2014 and onwards. Therefore no chemical data was commissioned from SE-11 old in 2014. However, chemical data from 2003 and 2008 from SE-11 old will be presented along with data from SE-11 new from 2010 and 2014 in this report.

The stations SE-11 old and SE-11 new are located in the north part of the Bornholm Basin about 70 km south (SE-11 old) and 85 km south-east (SE-11 new) of Karlskrona (Figs. 1 and 48). The depths at the two different stations are c. 75 m at SE-11 old and c. 70 m at SE-11 new. CTD data obtained in May 2014 show similar salinity and temperature patterns through the water column at the two stations (Fig. 49). Salinity levels are stable at a value of 7.5 down to a water depth of 45 m at SE-11 old and 50 m at SE-11 new. At these depths, which are thought to be haloclines, the salinity increases gradually to a value of over 16 in the bottom water. The temperature drops from around 11 °C in the surface water down to around 7 °C at 35 m where the thermocline appears. Below 35 m the temperature fluctuates, especially at SE-11 new, down to the bottom water where it stabilises at 6 °C (Fig. 49). Bottom current speeds were measured to 0.089 m/s at SE-11 old and 0.048 m/s at station SE-11 new indicating stagnant bottom water suitable for the sedimentation of fine-grained particles at both stations.

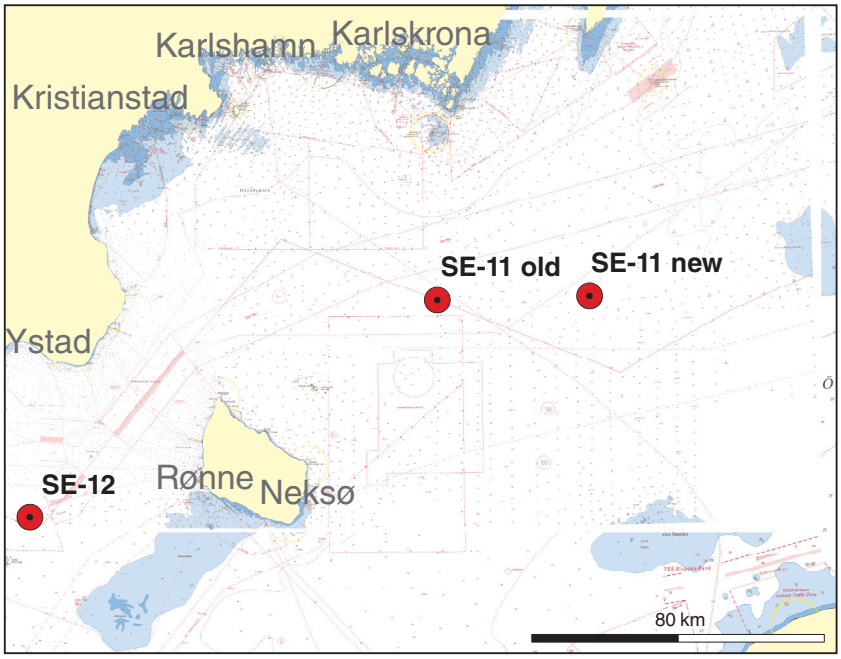

Figure 48. The stations SE-11 old and SE-11 new are located in the north part of the Bornholm Basin about 70 km south (SE-11 old) and 85 km south-east (SE-11 new) of Karlskrona.

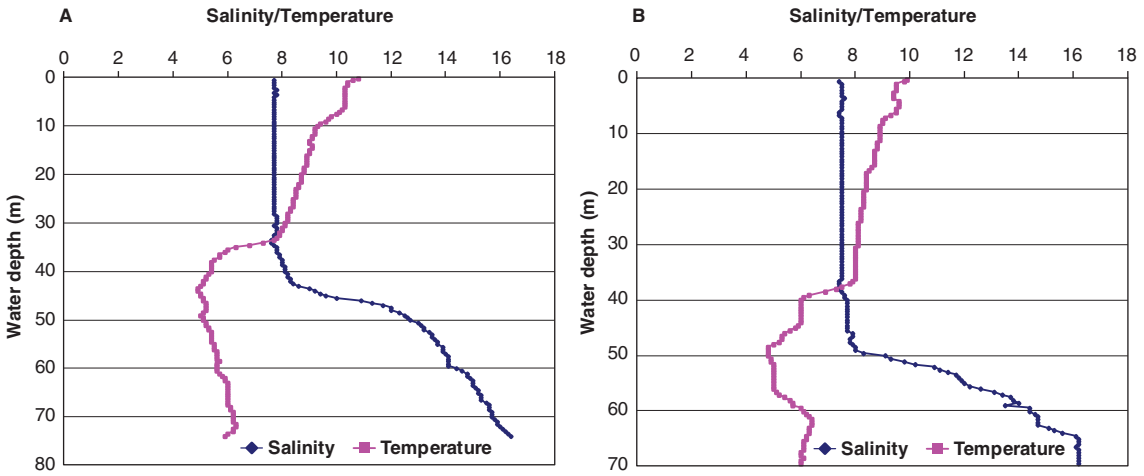

Figure 49. **A.** The temperature and salinity profiles based on CTD data obtained in May 2014 show that there is a halocline at 45 m at station SE-11 old. The thermocline appears at around 35 m.
B. The temperature and salinity profiles based on CTD data obtained in May 2014 show that there is a halocline at 50 m at station SE-11 new. The thermocline appears at around 35 m.

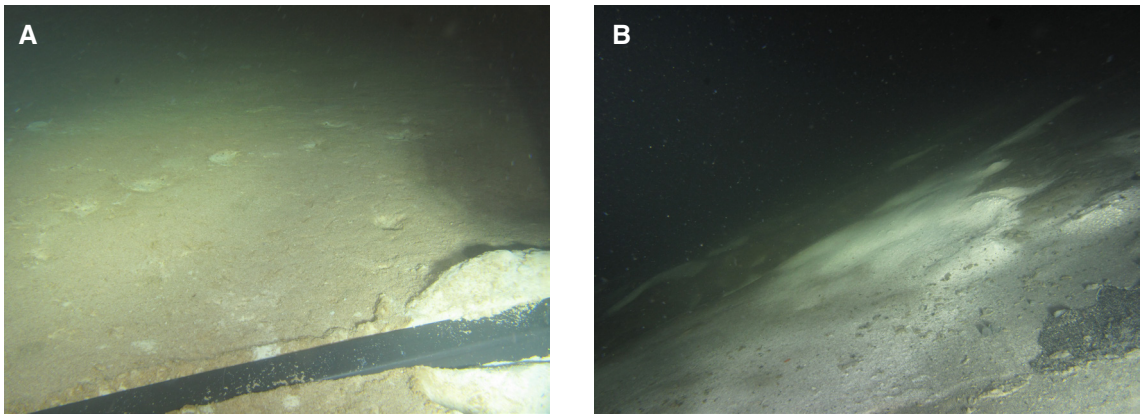

Figure 50. **A.** The seabed at station SE-11 old is oxygenated. **B.** The seabed at station SE-11 new is reduced and covered with *Beggiatoa*.

The sediment at both stations consists of postglacial gyttja clay. The surface sediment at SE-11 old is oxygenated whereas surface sediments are covered with Beggiatoa at SE-11 new (Figs. 50A and B). In 2008 there was evidence of digging worms at SE-11 old. There were, however, no signs of life at SE-11 new in 2010 or 2014. Dissolved oxygen concentrations were measured to 3.6 mL/L at SE-11 old and 0.7 mL/L at SE-11 new. This means that SE-11 old has more hospitable conditions for benthic life than SE-11 new which makes SE-11 new more suitable for sediment monitoring since there is less risk of bioturbation.

The average TOC concentration at SE-11 old was 4.7% of DW in 2003 and 4.8% of DW in 2008. In 2010 and 2014 TOC levels at SE-11 new were analysed giving average concentrations of 5.2% of DW in 2010 and 5.5% of DW in 2014. The variation data presented are from SE-11 new from 2010 and 2014 since there were no multiple samples analysed at SE-11 old in 2003. The concentration variation within SE-11 new is largest for mercury and cadmium in 2010 with a RSD of 15.4% and 18.7% respectively (Table 49).

Table 49. Concentrations of different parameters at seven sampling sites within station SE-11 new, as well as average concentrations and relative standard deviations for years 2010 and 2014. Element concentration in mg/kg TS.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/TS)	TN (%/TS)	TOC (%/TS)	TOC (%/TS)
Survey year	2010	2014	2010	2014	2010	2014	2010	2014	2010	2014	2010	2014
Site 1	13.9	10.8	1.11	0.759	0.0867	0.0728	9530	10100	0.61	0.70	4.89	5.39
Site 2	10.7	14.3	0.798	0.949	0.0581	0.0724	8490	8960	0.81	0.70	5.89	5.39
Site 3	10.4	11.5	0.820	0.774	0.0649	0.0708	8690	11100	0.72	0.65	5.20	5.20
Site 4	9.21	12.8	0.768	0.801	0.0455	0.0641	7470	11800	0.68	0.74	5.16	5.62
Site 5	11.1	12.5	0.918	1.12	0.0682	0.0868	9280	10300	0.64	0.59	5.03	4.62
Site 6	11.5	12.8	1.16	0.933	0.0765	0.0813	8010	8790	0.63	0.63	5.04	5.02
Site 7	10.6	12.3	0.908	1.03	0.0607	0.0540	8780	14600	0.63	1.1	5.04	6.94
Average	11.1	12.4	0.926	0.909	0.0658	0.0717	8607	10807	0.67	0.72	5.18	5.45
Standard deviation STD	1.33	1.02	0.142	0.127	0.0123	0.00996	655.1	1840	0.065	0.14	0.305	0.675
%RSD	12.1	8.22	15.4	14.0	18.7	13.9	7.612	17.02	9.67	17	5.89	12.4

Table 50. Concentrations in mg/kg DW of elements from 2003 and 2008 at station SE-11 old. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC content.

	2003	2008
As	14.1	15.5
Cd	0.87	0.95
Co	15.3	15.0
Cr	85	86.1
Cu	44.2	54.3
Hg	0.0842	0.0791
Ni	31.6	<10
Pb	27.2	9.2
Zn	62.6	52.0
S	10400	10160
TN	0.58	0.60
TOC	4.74	4.80

Table 51. Concentrations in mg/kg DW of elements from 2010 and 2014 at station SE-11 new. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC content.

	2010	2014
As	11.1	12.4
Cd	0.926	0.909
Co	15.9	15.1
Cr	89.9	73.3
Cu	57.3	44.6
Hg	0.0658	0.0717
Ni	52.0	43.6
Pb	32.5	53.1
Zn	161	151
S	8600	10800
TN	0.67	0.72
TOC	5.18	5.45

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

A few elements from SE-11 old and SE-11 new are presented in Figures 51A–F and Tables 50 and 51. At both station SE-11 old and SE-11 new, elements occur in concentrations in class 1 to 3, none to medium deviation from the national background (Tables 50 and 51). Nickel and lead concentrations decreased at SE-11 old between 2003 and 2008, while lead increased at SE-11 new between 2010 and 2014 (Figs. 51B, C and E). Cadmium and lead levels do not exceed the ecotoxicological assessment criteria (HVMFS 2013:19) in any year (Table 54).

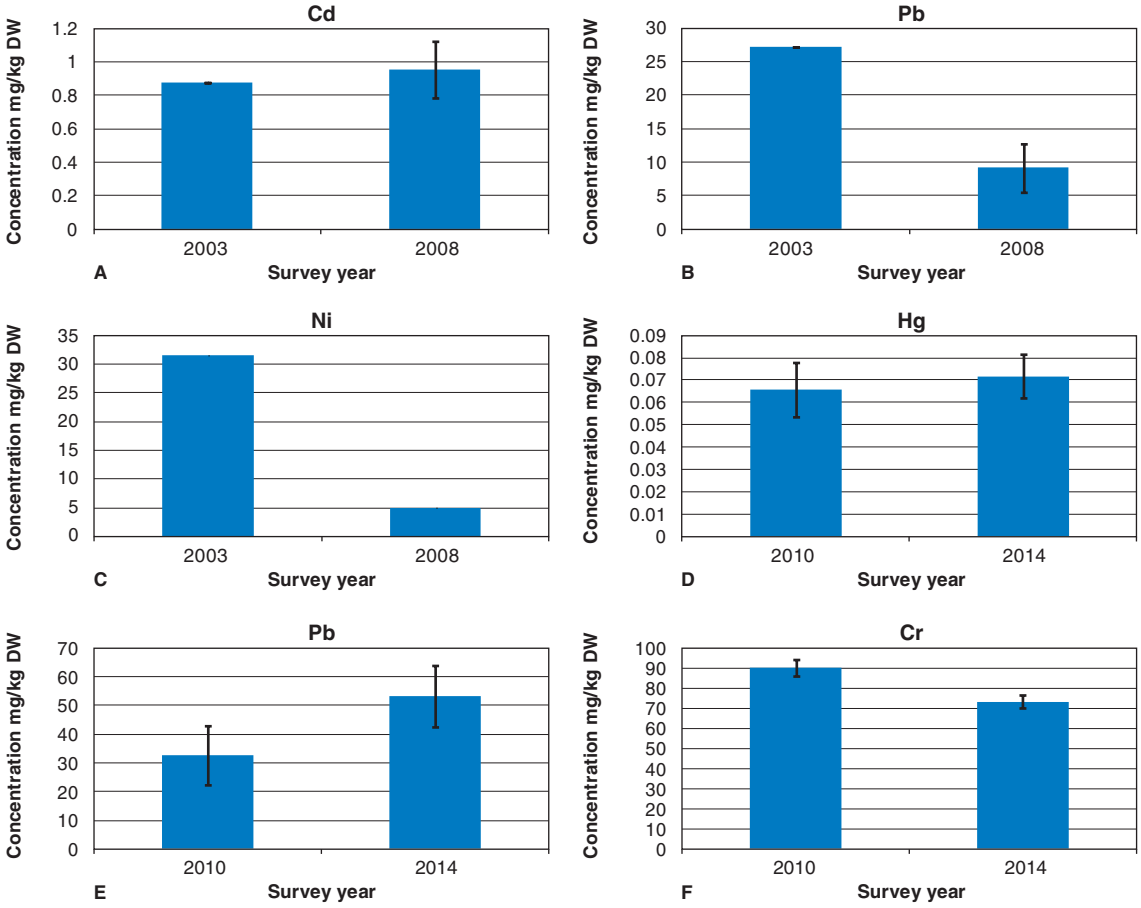

Figure 51. **A–F.** There is no general trend in element concentrations at SE-11 old (A–C) and new (D–F). At SE-11 old, lead and nickel seem to decrease between 2003 and 2008. The values from 2008, 2010 and 2014 are average values of seven replicates and the error bars show standard deviations.

Concentrations of a few organic substances from the two stations are presented in Figures 52A–G and Tables 52 and 53. When comparing the concentrations between the two stations, the largest changes have occurred at SE-11 old. PCB7 increased and TBT decreased between 2003 and 2008 at SE-11 old (Figs. 52A and C). At SE-11 old, DDTs and chlordanes were included in class 5 in 2008, and these are also the substances included in class 5 at SE-11 new (Tables 52 and 53). In general, concentrations from SE-11 old in 2008 and from SE-11 new in 2010 are similar. TBT concentrations increased at SE-11 new between 2010 and 2014 (Fig 52G). Diuron and simazine levels were both below LOQ both years at SE-11 old. DEHP and nonylphenol concentrations decreased between 2003 and 2008 (Table 52). No analyses of diuron, simazine, DEHP or nonylphenol were made in 2010 in the sediments from SE-11 new. TBT concentrations exceeded the ecotoxicological assessment criteria all years at both stations.

Table 52. Concentrations in µg/kg DW of organic micropollutants from 2003 and 2008 at station SE-11 old. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999).

	2003	2008
Anthracene	16	8.9
Fluoranthene	100	138
Sum 11 PAH	1 285	1 680
Sum 7 PCB	1.7	4.1
HCB	<2	0.14
Sum HCH	0.54	0.48
Sum DDT	4.8	6.5
Sum Chlordanes	0.15	0.43
TBT	5.4	2.9
Diuron	<20	<2
Simazine	<2	<2
DEHP	470	39
Nonylphenol	17	<10

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 53. Concentrations in µg/kg DW of organic micropollutants from 2010 and 2014 at station SE-11 new. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999).

	2010	2014
Anthracene	8.0	6.9
Fluoranthene	135	120
Sum 11 PAH	1 700	1 147
Sum 7 PCB	3.9	3.3
HCB	0.20	0.24
Sum HCH	0.42	0.44
Sum DDT	6.0	6.3
Sum Chlordanes	0.40	0.42
TBT	6	7.9
Diuron	not analysed	0.16
Simazine	not analysed	<0.5
DEHP	not analysed	170
Nonylphenol	not analysed	31

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 54. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-11 old and SE-11 new. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008
Cd	2 300	873	–	953	–
Pb	120 000	2 720	–	9 186	–
Anthracene	24	16	23	8.9	23
Fluoranthene	2 000	100	1 895	138	1 918
TBT	1.6	5	1.5	2.9	1.5

	Sediment concentration 2010	Normalised assessment value 2010	Sediment concentration 2014	Normalised assessment value 2014
Cd	926	–	909	–
Pb	32 454	–	53 100	–
Anthracene	8.0	25	6.9	26
Fluoranthene	135	2 071	120	2 182
TBT	6	1.7	7.9	1.7

Concentration exceeds assessment value.

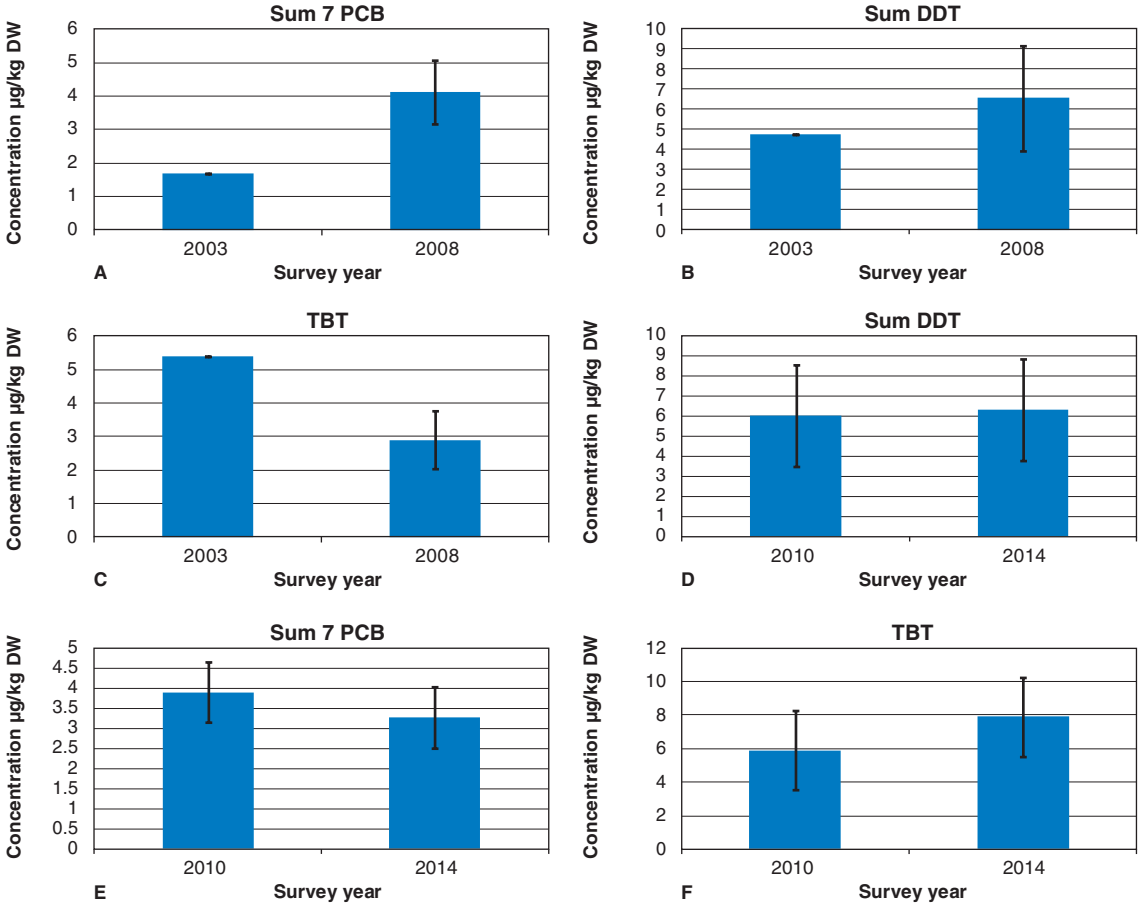

Figure 52. **A–F.** Concentrations of organic substances at both SE-11 stations are relatively stable. At SE-11 old (A–C), PCB7 seem to have increased between 2003 and 2008, while TBT levels seem to have decreased during the same period. The error bars represent laboratory measurement uncertainties.

Station SE-12, Arkona Basin

Station SE-12 is located around 50 km south of Ystad in the Arkona basin (Fig. 1). This sampling station is situated at a water depth of about 46 m. From CTD data obtained in May 2014 it is clear that the Arkona basin is much more influenced by marine water inflow from Skagerrak and Kattegatt than the stations in the northern Baltic Sea. Salinity and temperature are stable from the surface water and down to a depth of about 30 m where a thermocline and halocline exist (Fig. 53). Salinity lies at 18 in the bottom water and the temperature drops from 11 °C at the thermocline to 6.7 °C at the bottom. Bottom current speed was measured to 0.12 m/s which is faster than at previous stations but still stagnant enough for sedimentation of fine-grained particles.

The sediment at station SE-12 consists of postglacial gyttja clay. The surface is oxygenated but without visible flora or fauna (Fig. 54). The dissolved oxygen concentration was measured to 4.4 mL/L which means that the bottom water is oxygenated enough to hold benthic life. Two shells were found in the sediment in one sediment core from within the station area (Appendix 1).

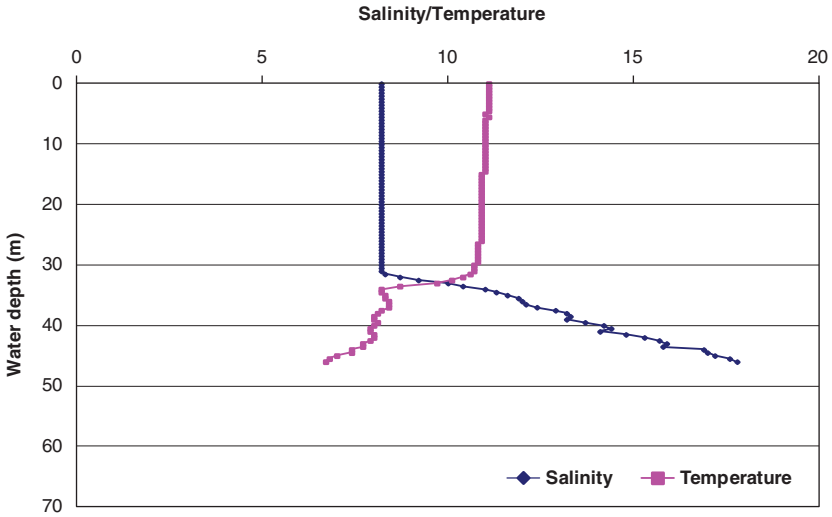

Figure 53. CTD data obtained in May show that both salinity and temperature are stable down to about 30 m where a halocline and thermocline are visible.

Figure 54. The sediment surface at station SE-12 is oxygenated but there are no visible signs of benthic organisms.

Table 55. Concentrations of different parameters at seven sampling sites within station SE-12, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg TS.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/TS)	TN (%/TS)	TOC (%/TS)	TOC (%/TS)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	23.0	9.75	0.189	0.353	0.185	0.159	8 200	8 200	0.70	0.66	5.75	5.95
Site 2	11.8	15.4	0.254	0.418	0.162	0.202	7 600	10 400	0.71	0.68	5.70	5.90
Site 3	22.0	22.5	0.212	0.352	0.172	0.183	7 620	8 580	0.69	0.70	5.71	5.99
Site 4	16.3	12.2	0.269	0.352	0.303	0.195	7 200	10 500	0.72	0.70	5.77	6.08
Site 5	20.7	14.8	0.193	0.442	0.244	0.141	7 480	10 600	0.69	0.66	5.70	5.79
Site 6	15.2	18.7	0.325	0.466	0.21	0.183	8 470	10 500	0.70	0.66	5.70	5.82
Site 7	16.3	17.5	0.466	0.246	0.235	0.171	13 600	7 820	0.67	0.7	5.70	5.95
Average	17.9	15.8	0.273	0.376	0.216	0.176	8 596	9 514	0.70	0.68	5.72	5.93
Standard deviation STD	6.75	3.90	0.0906	0.0685	0.0456	0.0195	2 082	1 157	0.015	0.019	0.0270	0.0921
%RSD	46.2	24.7	33.25	18.2	21.1	11.1	24.2	12.2	2.13	2.72	0.471	1.55

Table 56. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-12. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC content.

	2003	2008	2014
As	10.9	17.9	15.8
Cd	0.373	0.273	0.376
Co	9.25	11.5	9.83
Cr	86	89.8	73.8
Cu	38.6	50.4	42.8
Hg	0.196	0.216	0.176
Ni	27.2	9.2	33.6
Pb	81.3	92.4	79.4
Zn	134	179	127
S	9 260	8 600	9 500
TN	0.73	0.70	0.68
TOC	5.99	5.72	5.93

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

The average TOC concentration was 5.7% of DW in 2008 and 5.9% of DW in 2014. The largest variation is seen in arsenic concentrations from 2008 where the RSD is 46% (Table 55). Arsenic concentrations from 2014 and sulphur concentrations from 2008 are also quite variable within the station area with an RSD of 26.7% and 26.2%, respectively.

Elements with available assessment criteria and sulphur are presented in Figures 55A–J and Table 56. Data show that most element concentrations have their maxima in 2008, but in general, levels seem to be similar when comparing the two years 2003 and 2014. Cadmium and nickel concentrations were lowest in 2008, in contrast to the other elements (Figs. 55B and G).

Table 56 presents element data grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Data show that lead is the most elevated element with concentrations within class 4. All the other elements are present in concentrations with none to medium deviation from the national background. Cadmium and lead levels do not exceed the ecotoxicological assessment criteria (HVMFS 2013:19) in any year (Table 58).

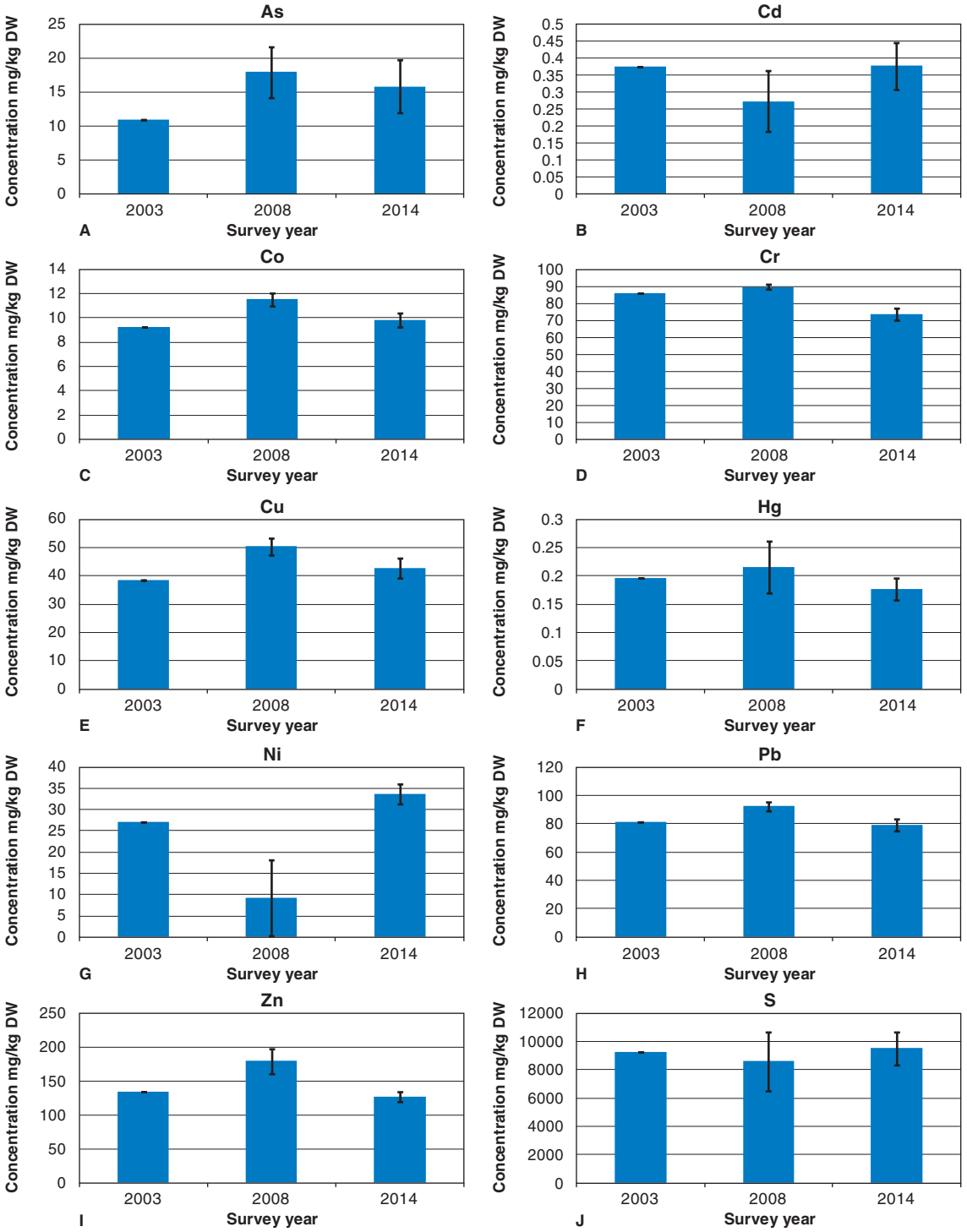

Figure 55. **A–J.** Most element at station SE-12 seem to have their concentration maxima in 2008, except for cadmium, nickel and sulphur. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 57. Concentrations in µg/kg DW of organic micropollutants from 2003 to 2014 at station SE-12. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC content.

	2003	2008	2014
Anthracene	27	16	15
Fluoranthene	240	270	260
Sum 11 PAH	2 447	2 822	2 561
Sum 7 PCB	6.0	7.6	8.9
HCB	0.27	0.35	0.55
Sum HCH	0.95	0.58	0.61
Sum DDT	4.3	6.5	8.0
Sum Chlordanes	0.15	0.40	0.94
TBT	17	5.6	6.5
Diuron	<20	<2	0.18
Simazine	<2	<2	<0.5
DEHP	2 000	<20	120
Nonylphenol	18	<10	<30

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 58. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-12. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	373	–	273	–	376	–
Pb	120 000	81 300	–	92 357	–	79 429	–
Anthracene	24	27	29	16	27	15	28
Fluoranthene	2 000	240	2 395	269	2 287	260	2 370
TBT	1.6	17	1.9	5.6	1.8	6.5	1.9

Concentration exceeds assessment value.

Organic substances with available environmental assessment criteria are presented in Figures 56A–F and Table 57 together with organic substances without available criteria (Figs. 56G–I). At station SE-12, PCB7, HCB, DDT and chlordane concentrations seem to have increased continuously since 2003 (Figs. 56B, C, E and F). HCH, TBT and DEHP concentrations seem to have decreased between 2003 and 2008 (Figs. 56D, G and H). The PAHs increased in levels between 2003 and 2008 and decreased between 2008 and 2014 (Fig. 56A). Diuron levels were below LOQ in 2003 and 2008 and quantifiable in 2014. Simazine concentrations were below LOQ all survey years.

Table 57 presents concentrations of organic substances grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). All substances occur in high to very high concentrations. PAH, DDT and chlordane levels went from class 4 to class 5 between 2003 and 2008. TBT has occurred in concentrations exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) all three years (Table 58).

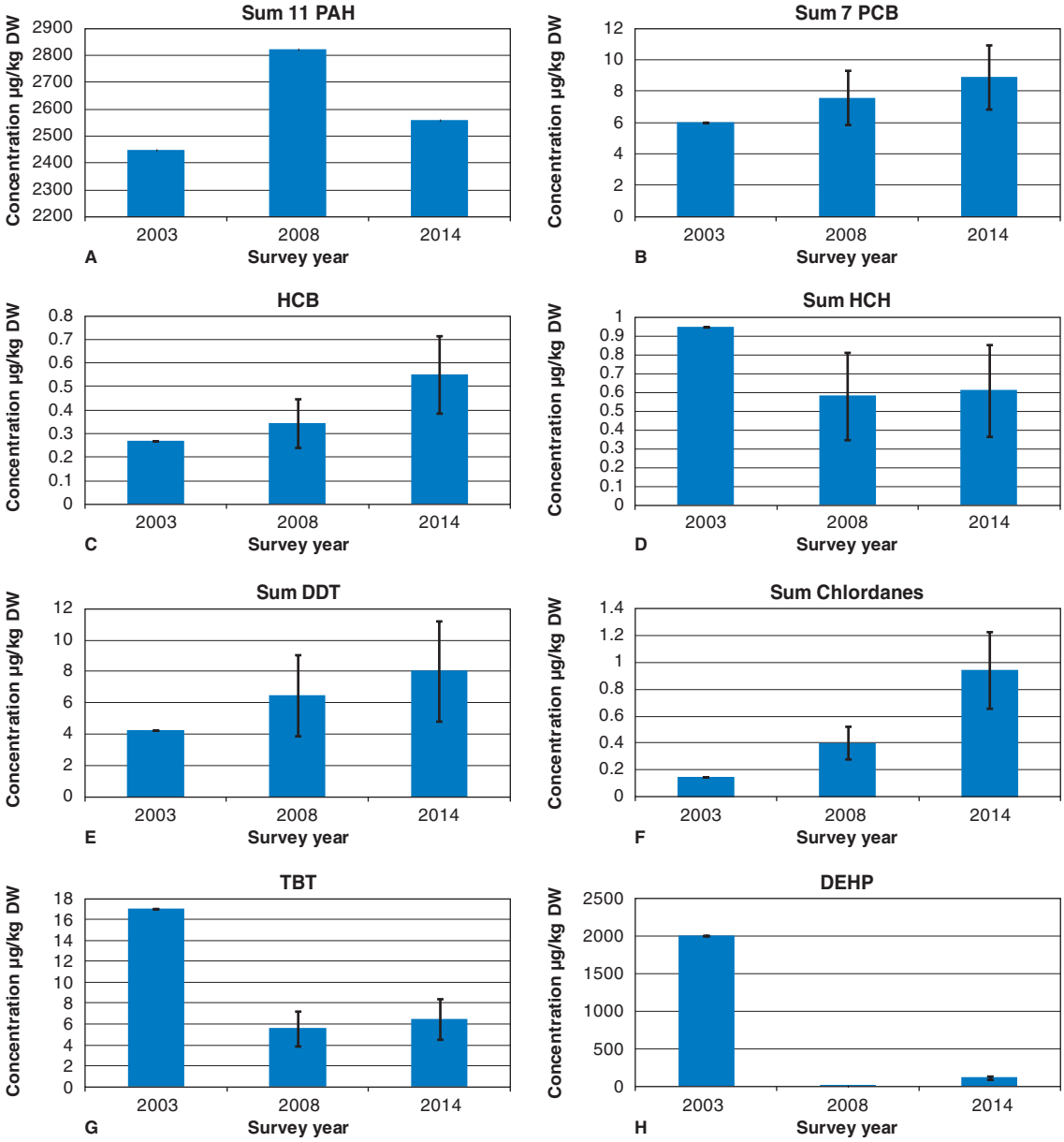

Figure 56. **A–H.** At station SE-12, PCB7, HCB, DDT and chlordane concentrations seem to have increased continuously since 2003. HCH, TBT and DEHP concentrations seem to have decreased between 2003 and 2008. The error bars represent laboratory measurement uncertainties.

Station SE-13, south Rödebank

Station SE-13 is located south of Rödebank about 40 km west of Halmstad (Fig. 1). The sampling station is situated at a depth of around 46.5 m. CTD data were collected in May 2014 and show increasing salinity and decreasing temperature with depth with the largest changes occurring at 10–17 m, where a thermocline and a halocline are present. At the halocline the salinity goes from 17 down to 32. From the halocline down to the bottom, the water salinity increases slightly to 34. The temperature shows an opposite trend with a thermocline that starts at 10 m at a temperature of 15 °C (Fig. 57). The temperature then drops and stabilises at around 7 °C at 18 m. Bottom current speed was measured to 0.02 m/s which is a bottom current allowing fine-grained particles to settle onto the seafloor.

The sediment at station SE-12 consists of postglacial gyttja clay which is oxygenated all through the sediment cores (Appendix 1). The site is hospitable for living organisms such as sea urchins, brittlestars and mussels (Fig. 58 and Appendix 1). The bottom water is well oxygenated with a measured concentration of 6.2 mL/L in May 2014.

The average TOC concentration in 2008 was 2.4% of DW and in 2014 it was 2.6% of DW. The parameter showing the greatest concentration variation within the station area is cadmium from 2008 with a RSD of 23.2%. Mercury concentrations vary to a degree of 15.8% in 2014. All other parameters possess RSD values under 15% (Table 59).

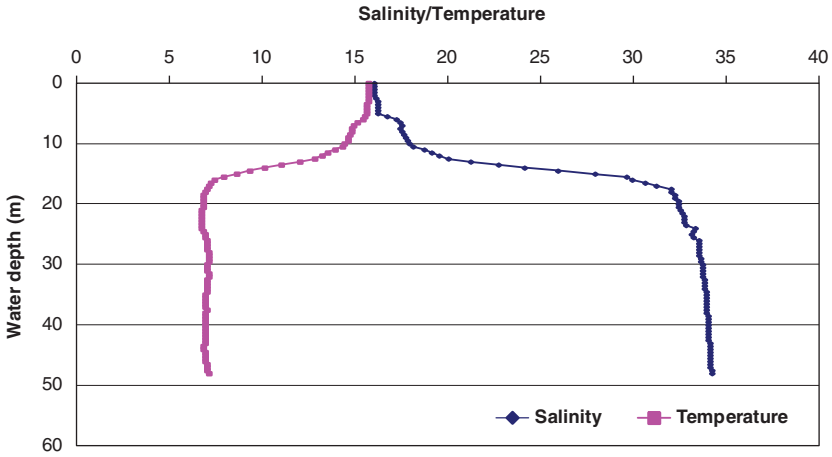

Figure 57. CTD data obtained in May 2014 show that both a halocline and a thermocline are present at 10–17 m.

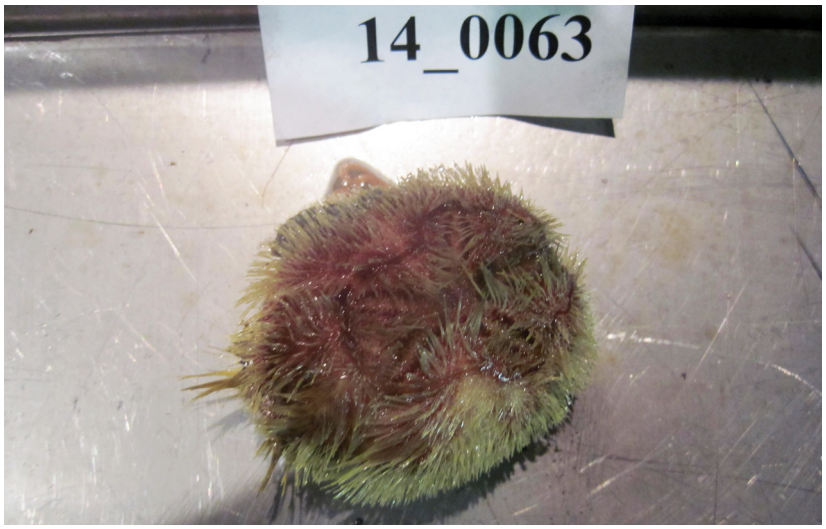

Figure 58. The conditions at SE-13 are favourable for benthic organisms and a sea urchin was present in one of the sediment cores.

Elements with available environmental assessment criteria and sulphur are presented in Figures 59A–J and Table 60. There is no general trend in element concentrations at SE-13. Levels are relatively low compared to the Baltic Sea stations. Table 60 presents concentrations of elements grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). According to the classification metal concentrations lie in classes 1 to 3 which means no to moderate deviations from the natural backgrounds. Mercury levels fell in class 3 in 2003 and zinc levels were within class 3 in 2008. Cadmium and lead levels do not exceed the ecotoxicological assessment criteria (HVMFS 2013:19) in any year (Table 62).

Organic substances with available environmental assessment criteria are presented in Figures 60A–F and Table 61 together with organic substances without available criteria (Figs. 60G and H). Concentration data show that PAH, HCH, chlordane and TBT concentrations have declined continuously since 2003 (Figs. 60A, D, F and G). Levels of PCB7 and DDTs are relatively stable with concentration maxima in 2008 (Figs. 60B and E). HCB levels were below LOQ in 2003 but were quantifiable in 2008 and 2014 (Fig. 60C). DEHP were higher in 2014 than the previous

Table 59. Concentrations of different parameters at seven sampling sites within station SE-13 new, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	15.3	14.1	0.0349	0.0843	0.0819	0.0844	5 330	3 790	0.31	0.31	2.46	2.85
Site 2	13.7	10.7	0.0369	0.105	0.0774	0.0655	4 810	3 210	0.29	0.27	2.37	2.67
Site 3	14.4	11.7	0.0348	0.103	0.0726	0.0692	4 540	3 590	0.30	0.28	2.34	2.48
Site 4	16.7	13.8	0.0251	0.0675	0.0681	0.0726	4 350	3 510	0.29	0.29	2.42	2.61
Site 5	14.5	10.8	0.0255	0.107	0.0679	0.0717	5 470	3 760	0.32	0.32	2.54	2.56
Site 6	14.8	12.6	0.0312	0.089	0.0639	0.0786	3 930	3 890	0.29	0.30	2.31	2.57
Site 7	11.6	11.7	0.0504	0.0907	0.0651	0.105	4 500	3 910	0.28	0.26	2.32	2.44
Average	14.4	12.2	0.0341	0.0924	0.0710	0.0781	4 704	3 666	0.30	0.29	2.39	2.60
Standard deviation STD	1.44	1.26	0.00791	0.0130	0.00616	0.0124	504.7	230.5	0.013	0.02	0.778	0.125
%RSD	10.0	10.3	23.2	14.1	8.68	15.8	10.73	6.289	4.3	6.9	3.25	4.83

Table 60. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-13. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC content.

	2003	2008	2014
As	11.5	14.4	12.2
Cd	0.109	0.0341	0.0924
Co	8.54	11.1	9.04
Cr	74.1	82.2	65.0
Cu	11.3	16.3	17.1
Hg	0.110	0.071	0.078
Ni	19.7	13.9	22.3
Pb	34.7	40.1	33.1
Zn	86.4	133	87.8
S	5 000	4 700	3 670
TN	0.30	0.30	0.29
TOC	2.44	2.39	2.60

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

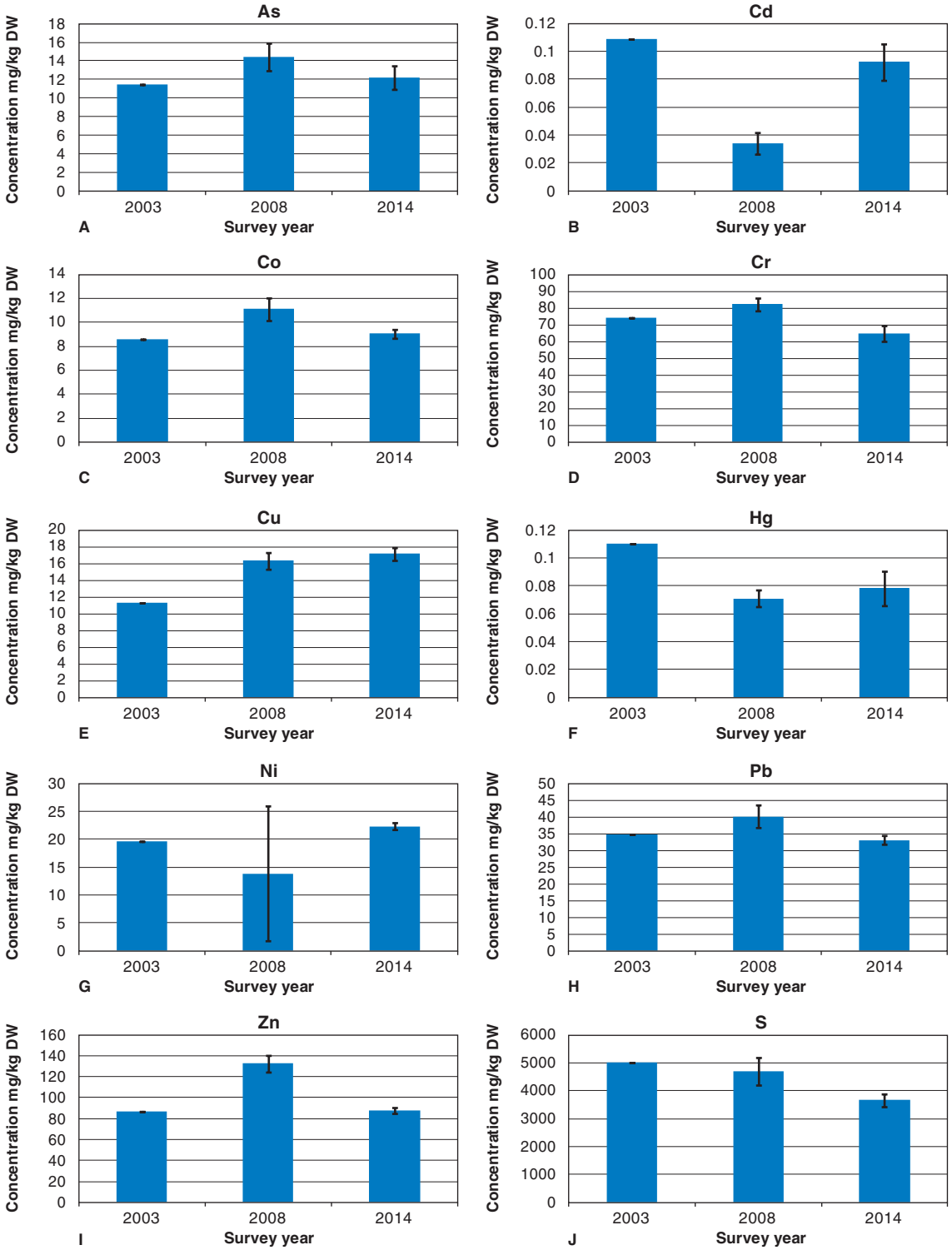

Figure 59. **A–J.** There is no general trend in element concentration at station SE-13. Levels are relatively low compared to Baltic Sea stations. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 61. Concentrations in µg/kg DW of organic micropollutants from 2003, 2008 and 2014 at station SE-13. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC.

	2003	2008	2014
Anthracene	12	5	3.7
Fluoranthene	90	74	60
Sum 11 PAH	870	778	628
Sum 7 PCB	2.0	2.5	1.8
HCB	<2	0.15	0.21
Sum HCH	0.82	0.16	0.090
Sum DDT	0.81	1.0	0.73
Sum Chlordanes	0.15	0.13	0.077
TBT	5	3.6	<1.0
Diuron	<20	<2	<0.15
Simazine	<2	<2	<0.5
DEHP	8.5	<20	91
Nonylphenol	21	<10	<30

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 62. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-13. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	109	–	34	–	92	–
Pb	120 000	34 700	–	40 129	–	33 071	–
Anthracene	24	12	12	5	11	3.7	12
Fluoranthene	2 000	90	975	74	958	60	1 039
TBT	1.6	5	0.78	3.6	0.77	<1.0	0.83

Concentration exceeds assessment value.

two survey years (Fig. 60H). Diuron and simazine levels were below LOQ all three years, while nonylphenol concentrations were detectable in 2003 (Table 61).

Table 61 presents concentrations of organic substances grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). The presented substances occur in medium to high concentrations at SE-13. All substances except HCB are now within class 3. HCB concentrations on the other hand have gone from class 3 in 2003 and 2008 to class 4 in 2014. PAHs and HCHs were present in levels within class 4 in 2003 but have dropped one class since then. Chlordane concentrations went from class 4 in 2008 to class 3 in 2014. TBT occurred in levels exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) in 2003 and 2008. The measured concentration of anthracene in 2003 coincide with the normalised assessment value (Table 62).

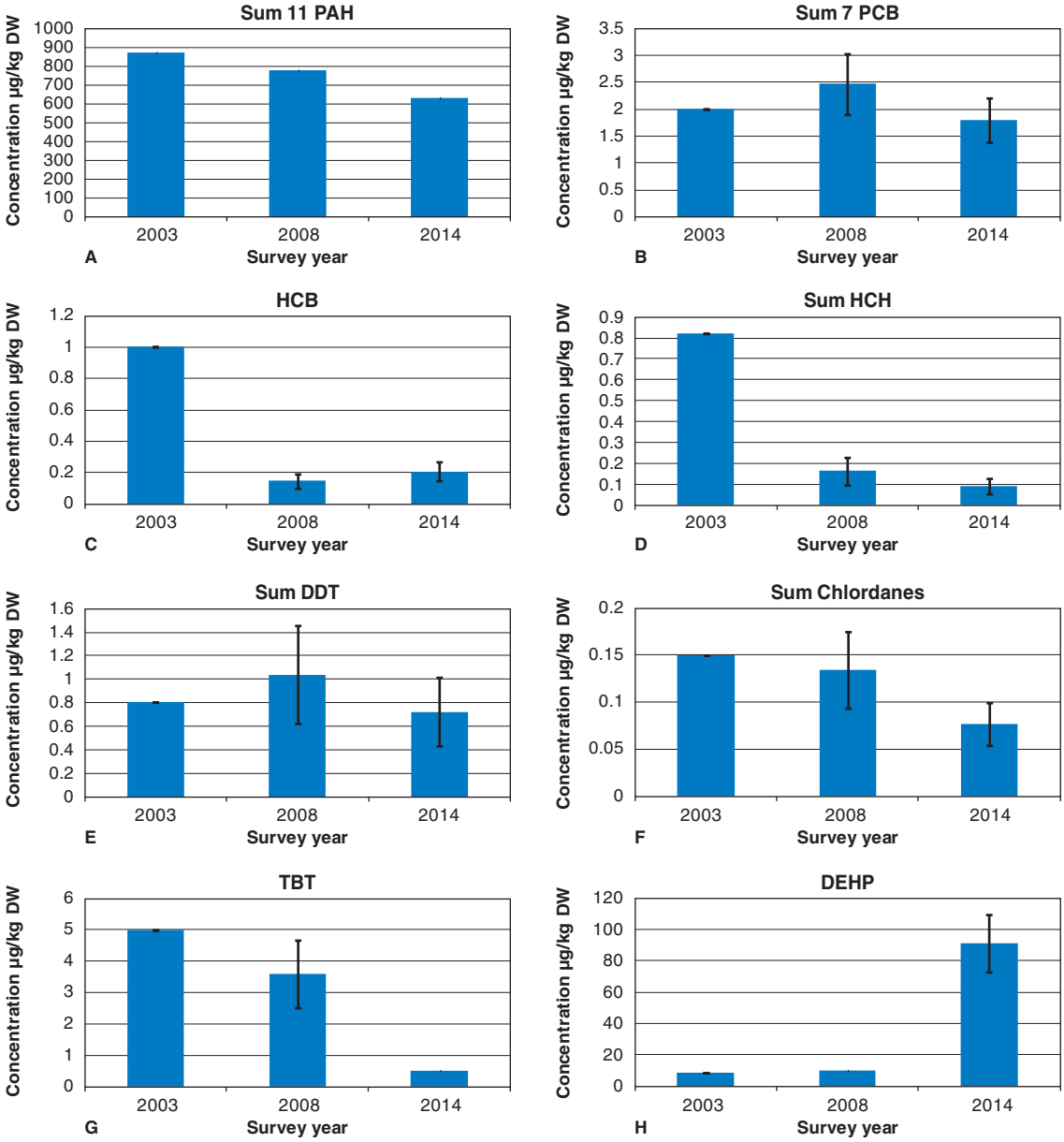

Figure 60. **A–H.** At station SE-13, most substances have decreased in concentrations since 2003. DEHP seem to have increased between 2008 and 2014. The error bars represent laboratory measurement uncertainties.

Station SE-15, Deep trench

Station SE-15 is located about 40 km west-north-west of Kungälv on the Swedish west coast (Fig. 1). The sampling site is situated in the deep trench at a depth of around 91 m. CTD data from May 2014, show that there is a well developed halocline at 5 m where the salinity rises from 20 to almost 30. Under the halocline the salinity increases slowly to about 35 in the bottom water (Fig. 61). The temperature also changes and two smaller thermoclines are visible at 6 and 30 m. Bottom current speed was measured to 0.27 m/s which is faster than in most accumulation bottoms in the Baltic Sea.

The sediment at station SE-15 consists of postglacial gyttja clay with a well oxygenated surface (Appendix 1). The bottom water is well oxygenated with a measured dissolved oxygen concentration of 7.4 mL/L. These conditions are suitable for benthic life and there is a rich fauna found at this location. Sea urchins, brittle stars and hagfish are frequent at the seabed (Figs. 62–63).

The average TOC concentration was 1.7% of DW in 2008 and 1.9% of DW in 2014 (Table 63). The parameter with the largest concentration variation within the area is mercury. In 2008 the RSD for mercury concentrations was almost 16.4% and in 2014 14.5%. The variation in concentrations of the other parameters does not exceed 14%.

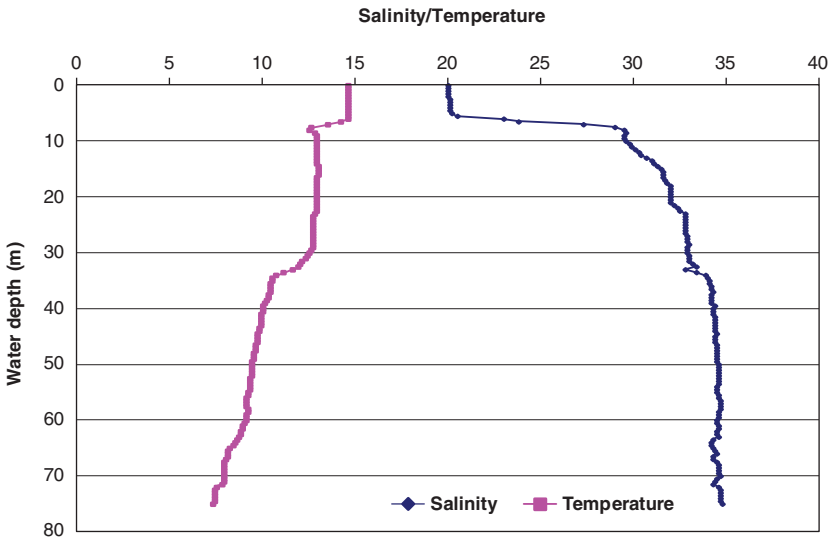

Figure 61. CTD data obtained in May 2014 show a well defined halocline at 5 m where the salinity rises from 20 to 30 in just a few metres. Two smaller thermoclines are visible at 6 and 30 m.

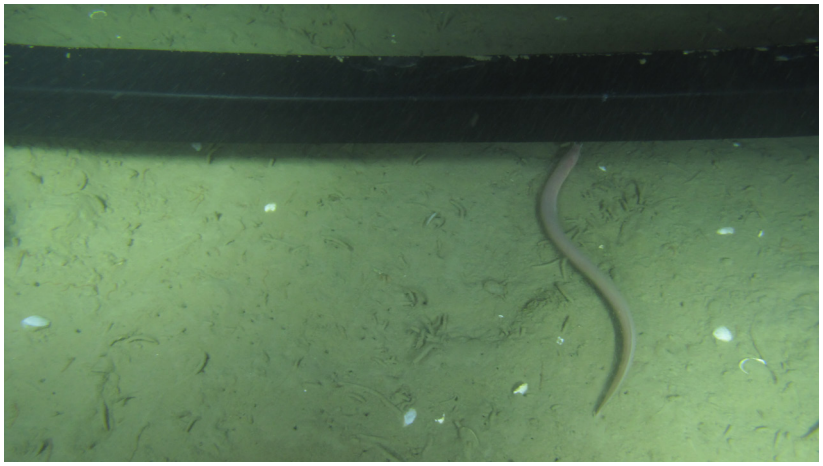

Figure 62. The seafloor at station SE-15 is well oxygenated with a rich fauna compared to the Baltic conditions. A hagfish is swimming under the cage of the camera.

Figure 63. **A.** A sea urchin is present in one of the sediment cores. **B.** A hagfish found in one of the sediment cores.

Table 63. Concentrations of different parameters at seven sampling sites within station SE-15 new, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	16.9	15.2	0.105	0.100	0.0889	0.0991	4750	4070	0.22	0.22	1.77	1.91
Site 2	17.5	15.9	0.0943	0.0891	0.104	0.0858	5260	4650	0.22	0.21	1.73	1.76
Site 3	18.4	15.9	0.0906	0.0991	0.0812	0.0889	5190	3750	0.21	0.21	1.74	1.78
Site 4	16.3	16.7	0.105	0.117	0.0756	0.0944	5450	3640	0.21	0.22	1.66	1.87
Site 5	18.9	16.3	0.0969	0.132	0.0815	0.120	4930	4570	0.21	0.25	1.69	1.91
Site 6	15.8	16.5	0.0836	0.112	0.0753	0.0737	4580	3660	0.20	0.24	1.62	1.82
Site 7	17.8	16.0	0.0673	0.108	0.117	0.106	5150	3840	0.21	0.25	1.71	1.98
Average	17.4	16.1	0.0918	0.108	0.0891	0.0954	5044	4026	0.21	0.23	1.70	1.86
Standard deviation STD	1.03	0.456	0.0122	0.0129	0.0146	0.0138	282.5	393.0	0.0064	0.016	0.0471	0.0732
%RSD	5.93	2.84	13.3	12.0	16.4	14.5	5.601	9.761	3.0	7.2	2.77	3.93

Table 64. Concentrations in mg/kg DW of elements from 2003, 2008 and 2014 at station SE-15. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC content.

	2003	2008	2014
As	15.9	17.4	16.1
Cd	0.0986	0.0918	0.108
Co	6.75	9.3	7.08
Cr	76.9	82.5	69.4
Cu	10.2	15.4	15.1
Hg	0.116	0.089	0.095
Ni	18.3	29.6	20.5
Pb	27.6	30.2	24.6
Zn	76.8	102	66.8
S	4890	5040	4030
TN	0.25	0.21	0.23
TOC	1.88	1.70	1.86

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

Elements with available environmental assessment criteria plus sulphur are presented in Figures 64A–J and Table 64. All elements except cadmium and mercury follow the same pattern with concentrations increasing between 2003 and 2008 and decreasing between 2008 and 2014 (Figs. 64A, C–E and G–J). Cadmium and mercury concentrations are relatively stable, with the lowest values in 2008 (Figs. 64B and F).

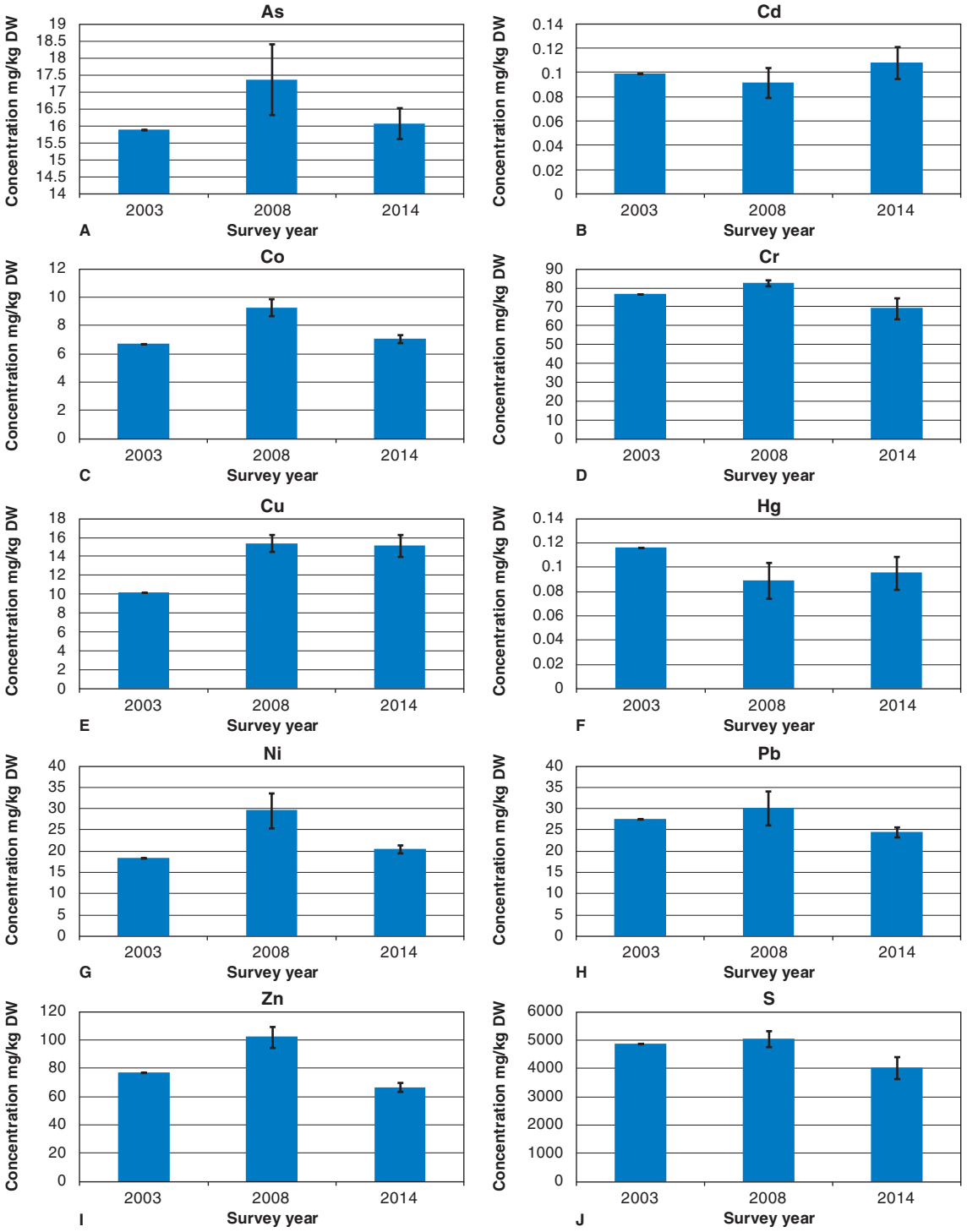

Figure 64. **A–J.** There is no general trend in element concentration at station SE-15 and levels are relatively stable between years. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 65. Concentrations in µg/kg DW of organic micropollutants from 2003 to 2014 at station SE-15. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC content.

	2003	2008	2014
Anthracene	12	4.7	4.1
Fluoranthene	76	57	49
Sum 11 PAH	565	460	453
Sum 7 PCB	2.5	5.5	1.1
HCB	0.19	0.21	0.26
Sum HCH	0.30	0.16	0.052
Sum DDT	0.44	0.62	0.37
Sum Chlordanes	0.15	0.060	0.053
TBT	3.8	1.7	<1.0
Diuron	<20	<2	<0.15
Simazine	<2	2.9	<0.5
DEHP	1 100	<20	170
Nonylphenol	12	<10	<30

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 66. The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-15. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	98.6	–	91.8	–	108	–
Pb	120 000	27 600	–	30 157	–	24 557	–
Anthracene	24	12	9	4.7	8	4.1	9
Fluoranthene	2 000	76	750	57	681	49	745
TBT	1.6	3.8	0.60	1.7	0.54	<1.0	0.60

Concentration exceeds assessment value.

Table 64 shows element concentrations grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). From the grouping it is obvious that metal concentrations are quite moderate in the sediment at station SE-15. Arsenic levels were in class 3 in 2008 and mercury concentrations were within class 3 in 2003. All other elements can be grouped into class 1 and 2 with none to small deviations from the national backgrounds. Cadmium and lead levels do not exceed the ecotoxicological assessment criteria (HVMFS 2013:19) in any year (Table 66).

Organic substances with available environmental assessment criteria are presented in Figures 65A–F and Table 65 together with organic substances without available criteria (Figs. 65G and H). PAH, HCH, chlordane and TBT concentrations have declined continuously since 2003 (Figs. 65A, D, F and G). PCB7 and DDT levels were highest in 2008, but seem to be lower in 2014 compared to 2003 (Figs. 65B and E). HCB concentrations, on the other hand, seem to have risen since 2003 (Fig. 65C). Diuron concentrations have been below LOQ all three years. Simazine levels were only quantifiable in 2008 and nonylphenol levels were quantifiable in 2003.

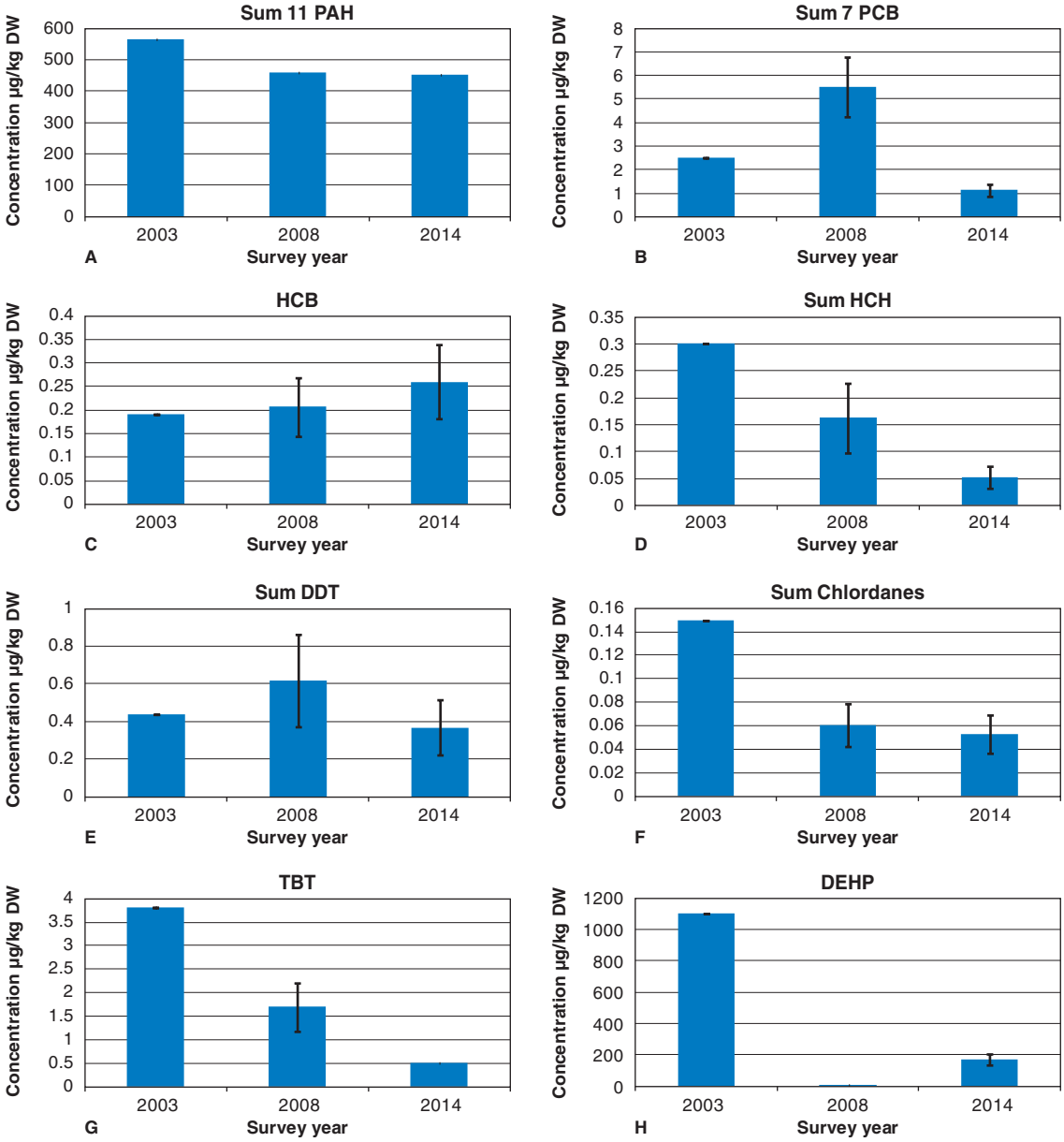

Figure 65. **A–H.** At station SE-15, PAH, HCH, chlordane and TBT concentrations have declined continuously since 2003. PCB7 and DDT levels were highest in 2008, but seem to be lower in 2014 compared to 2003. The error bars represent laboratory measurement uncertainties.

Table 65 presents concentrations of organic substances grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). The grouping shows that most organic substances occur in class 3 representing moderate concentrations. HCB is the only substance present in high concentrations during the recent years. The chlordanes were grouped into class 4 in 2003 but have dropped one class since then to class 3. The PCBs have since 2008 gone from high to low concentrations. TBT occurred in levels exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) in 2003 and 2008. Anthracene levels exceeded the assessment criteria in 2003 (Table 66).

Station SE-16, east Skagerrak

Station SE-16 is located about 48 km west of Fjällbacka on the Swedish west coast (Fig. 1). The sampling site is situated in a basin in Skagerrak which borders to the North Sea giving the sea marine conditions with high salinity and a more diverse flora and fauna. CTD data obtained in May 2014 reveals that the water column is stratified by a thermocline and halocline that coincide at about 10 m water depth (Fig. 66). Under the thermo- and haloclines both temperature and salinity stabilise and lie constant at about 7 °C for temperature and 35 for salinity.

The surface sediment at SE-16 consists of postglacial gyttja clay. The bottom water is well oxygenated with a measured concentration of dissolved oxygen of 7.5 mL/L. This is reflected in the sediment which is well bioturbated by benthic organisms. Fish, shrimps and hagfish drawn to the spotlights of the camera are visible in the underwater photographs taken at the station (Fig. 67).

The average TOC concentration was 1.9% of DW in 2008 and 2.0% of DW in 2014. The parameters with the highest variation in levels are arsenic and cadmium. Both in 2008 and 2014, the arsenic concentrations had an RSD of 16%. Cadmium concentrations from 2008 have an RSD value of almost 20% (Table 67).

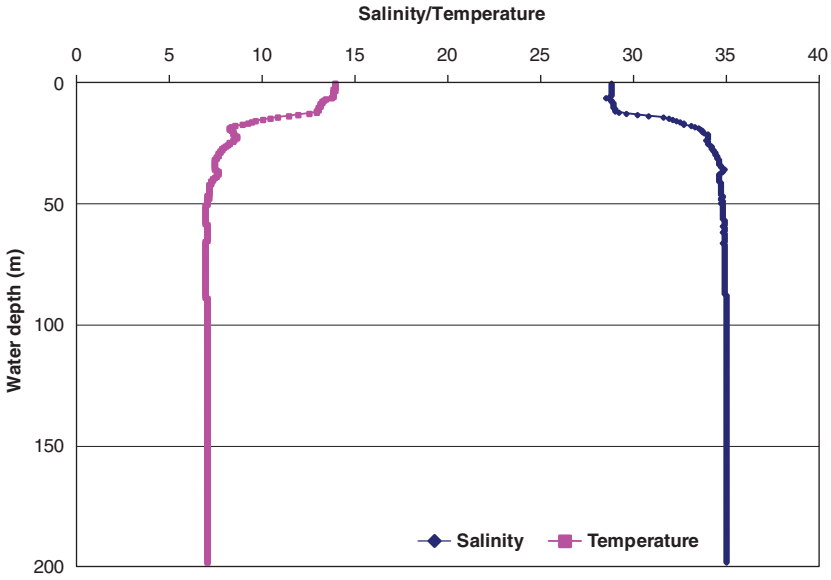

Figure 66. CTD data obtained in May 2014 reveal a thermocline and halocline that coincide at 10 m. Both temperature and salinity are stabilised and constant below 30 m water depth.

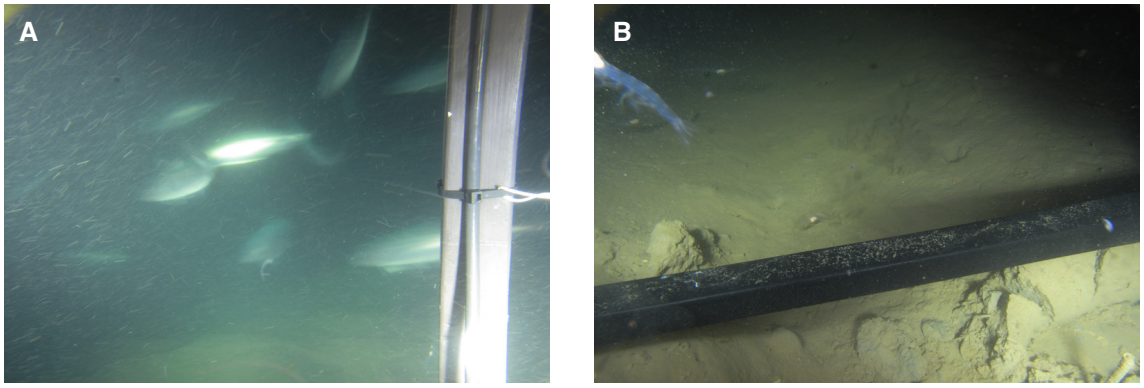

Figure 67. **A.** Pelagic fauna is drawn to the lights from the underwater camera. There were plenty of fish swimming in the station basin. **B.** Shrimps were also attracted to the light from the camera.

Table 67. Concentrations of different parameters at seven sampling sites within station SE-16 new, as well as average concentrations and relative standard deviations for years 2008 and 2014. Element concentration in mg/kg DW.

Parameter	As	As	Cd	Cd	Hg	Hg	S	S	TN (%/DW)	TN (%/DW)	TOC (%/DW)	TOC (%/DW)
Survey year	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014	2008	2014
Site 1	18.5	11.6	0.0210	0.0916	0.0907	0.107	4020	3020	0.23	0.2	1.92	1.98
Site 2	18.4	18.9	0.0269	0.0963	0.0853	0.0868	4100	3730	0.23	0.22	1.94	2.05
Site 3	17.0	16.8	0.0260	0.107	0.0880	0.107	4250	3570	0.23	0.2	2.00	2.02
Site 4	18.5	14.3	0.0340	0.0735	0.0885	0.0906	3970	3670	0.24	0.21	1.93	2.04
Site 5	10.9	12.2	0.0306	0.0846	0.117	0.110	3800	2910	0.21	0.18	1.84	1.9
Site 6	20.5	16.3	0.0390	0.0994	0.0884	0.0784	4570	3660	0.23	0.25	1.97	2.13
Site 7	19.0	15.1	0.0361	0.0868	0.0844	0.0862	4630	3520	0.22	0.22	1.92	2.02
Average	17.5	15.0	0.0305	0.0913	0.0918	0.0951	4191	3440	0.23	0.21	1.93	2.02
Standard deviation STD	2.9	2.39	0.00585	0.0101	0.0105	0.0117	287.6	308.5	0.0088	0.020	0.0461	0.0648
%RSD	16	15.9	19.2	11.1	11.4	12.3	6.862	8.967	3.9	10	2.39	3.21

Table 68. Concentrations in mg/kg DW of elements from 2003 to 2014 at station SE-16. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). Concentrations are not normalised to TOC content.

	2003	2008	2014
As	14.8	17.5	15.0
Cd	0.0821	0.0305	0.0913
Co	7.69	11.5	9.42
Cr	88.4	103.4	80.4
Cu	10.2	15.4	15.9
Hg	0.106	0.0918	0.0951
Ni	18.1	27.7	27.0
Pb	31.8	35.3	34.0
Zn	80.3	118	79.6
S	4920	4190	3440
TN	0.23	0.23	0.21
TOC	2.01	1.93	2.02

Class 1	None or insignificant deviation from national background
Class 2	Little deviation from national background
Class 3	Medium deviation from national background
Class 4	Large deviation from national background
Class 5	Very large deviation from national background

Elements with available assessment criteria plus sulphur are presented in Figures 68A–J and Table 68. From concentration data it is clear that most element concentrations are relatively stable throughout the three survey years. However, cadmium displayed concentration minimum in 2008, while zink had a concentration maximum the same year (Figs. 68B and I). Copper levels have increased since 2003 while sulphur levels have declined during the same period (Figs. 68E and J).

Table 68 presents element concentrations grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). The table reveals that most elements are present in concentrations with none to little deviation from the national backgrounds. Arsenic levels were grouped into class 3 in 2008 and mercury concentrations were within class 3 in 2003. Cadmium and lead levels do not exceed the ecotoxicological assessment criteria (HVMFS 2013:19) in any year (Table 70).

Organic substances with available environmental assessment criteria are presented in Figures 69A–F and Table 69 together with organic substances without available criteria (Fig. 69G).

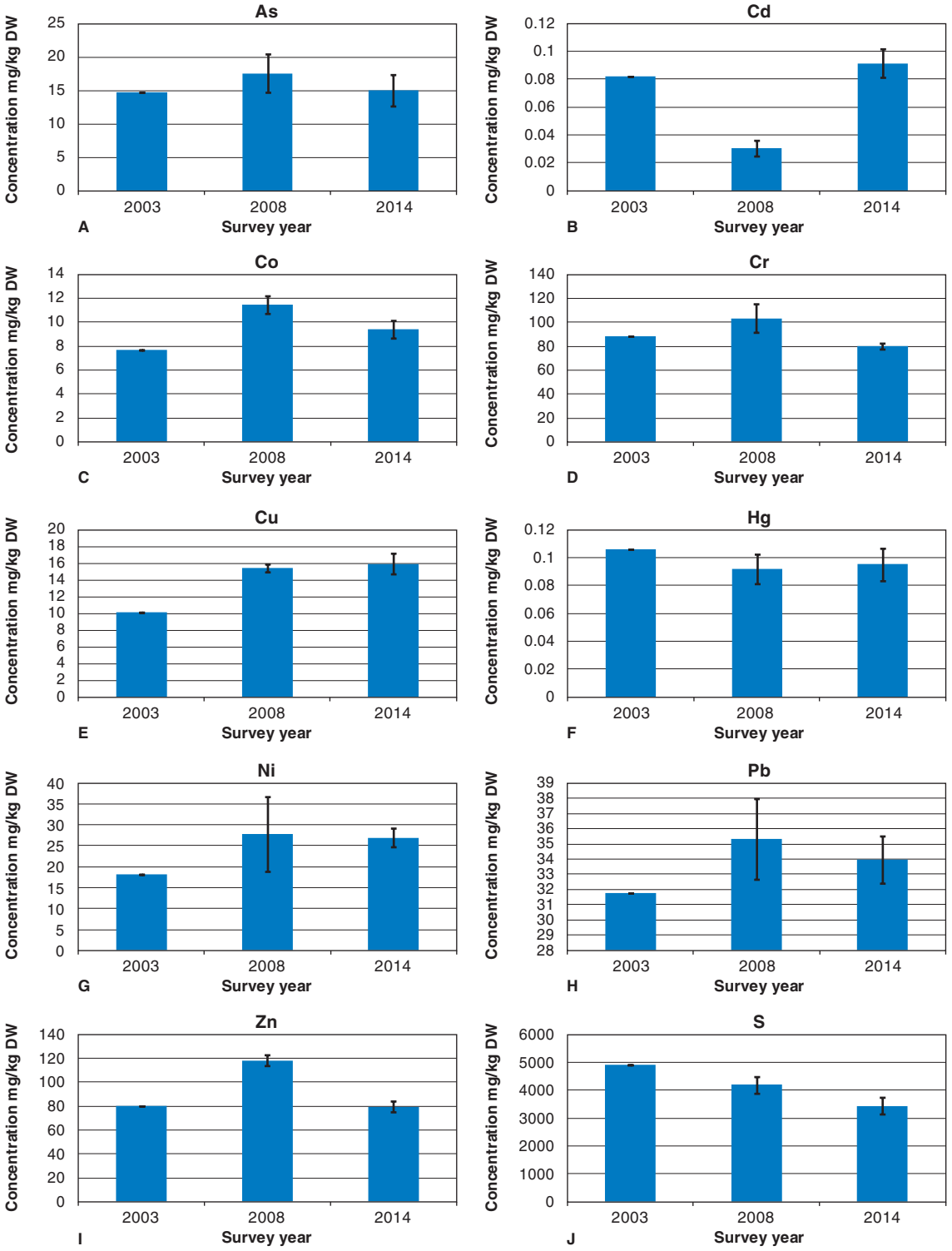

Figure 68. **A–J.** Most element concentrations are relatively stable throughout the three survey years, at station SE-16. Cadmium displayed concentration minimum in 2008, while zink had a concentration maximum the same year. Copper levels have increased since 2003 while sulphur levels have declined during the same period. The values from 2008 and 2014 are average values of seven replicates and the error bars show standard deviations.

Table 69. Concentrations in µg/kg DW of organic micropollutants from 2003 to 2014 at station SE-16. Colour classification in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999).

	2003	2008	2014
Anthracene	19	5.7	6.4
Fluoranthene	120	81	83
Sum 11 PAH	1 102	739	884
Sum 7 PCB	1.5	1.7	1.7
HCB	<0.2	0.17	0.31
Sum HCH	0.30	0.10	0.076
Sum DDT	1.1	0.73	0.65
Sum Chlordanes	0.15	0.076	0.11
TBT	2.0	<1	<1.1
Diuron	<20	<2	0.17
Simazine	<2	<2	<0.5
DEHP	130	<20	140
Nonylphenol	<10	<10	<30

	Concentration
Class 1	None
Class 2	Low
Class 3	Medium
Class 4	High
Class 5	Very high

Table 70.The levels of metals and substances with available ecotoxicological assessment critera (HVMFS 2013:19) and the corresponding assessment values normalised to TOC concentrations [assessment criteria * (TOC concentration %/5] at SE-16. Concentrations expressed in µg/kg DW.

	Assessment criteria (HVMFS 2013:19)	Sediment concentration 2003	Normalised assessment value 2003	Sediment concentration 2008	Normalised assessment value 2008	Sediment concentration 2014	Normalised assessment value 2014
Cd	2 300	82.1	–	30.5	–	91.3	–
Pb	120 000	31 800	–	35 329	–	33 971	–
Anthracene	24	19	10	5.7	9	6.4	10
Fluoranthene	2 000	120	805	81	773	83	808
TBT	1.6	2.0	0.64	<1	0.62	<1.0	0.65

Concentration exceeds assessment value.

There is no general trend in concentrations of organic substances at SE-16. The substances that seem to decrease in levels are HCHs and DDTs (Figs. 69D and E). HCB, on the other hand, has increased in levels since 2003 (Fig. 69C). PAHs and clordanes showed concentration minima in 2008, while the PCB levels have been stable since 2003 (Figs. 69A, B and F). TBT levels decreased between 2003 and 2008 and stabilised below LOQ in 2008 and 2014. Diuron levels were below LOQ in 2003 and 2008 but in 2014 concentrations were quantifiable. Simazine and nonylphenol levels have been below LOQ since the start of the program in 2003 (Table 69).

Table 69 presents concentrations of organic substances grouped into classes in accordance with the Swedish EPA environmental assessment criteria (Swedish EPA 1999). The table shows that concentrations of all substances lie within class 3 and 4, meaning medium to high concentrations. PAH11 and chlordane concentrations were grouped into class 3 in 2003, rose one class in 2008 but fell back into class 3 again in 2014. The DDTs started in class 4 in 2003 but fell down into class 3 in 2008. In 2003 the levels of both TBT and anthracene exceeded the ecotoxicological assessment criteria (HVMFS 2013:19) (Table 70).

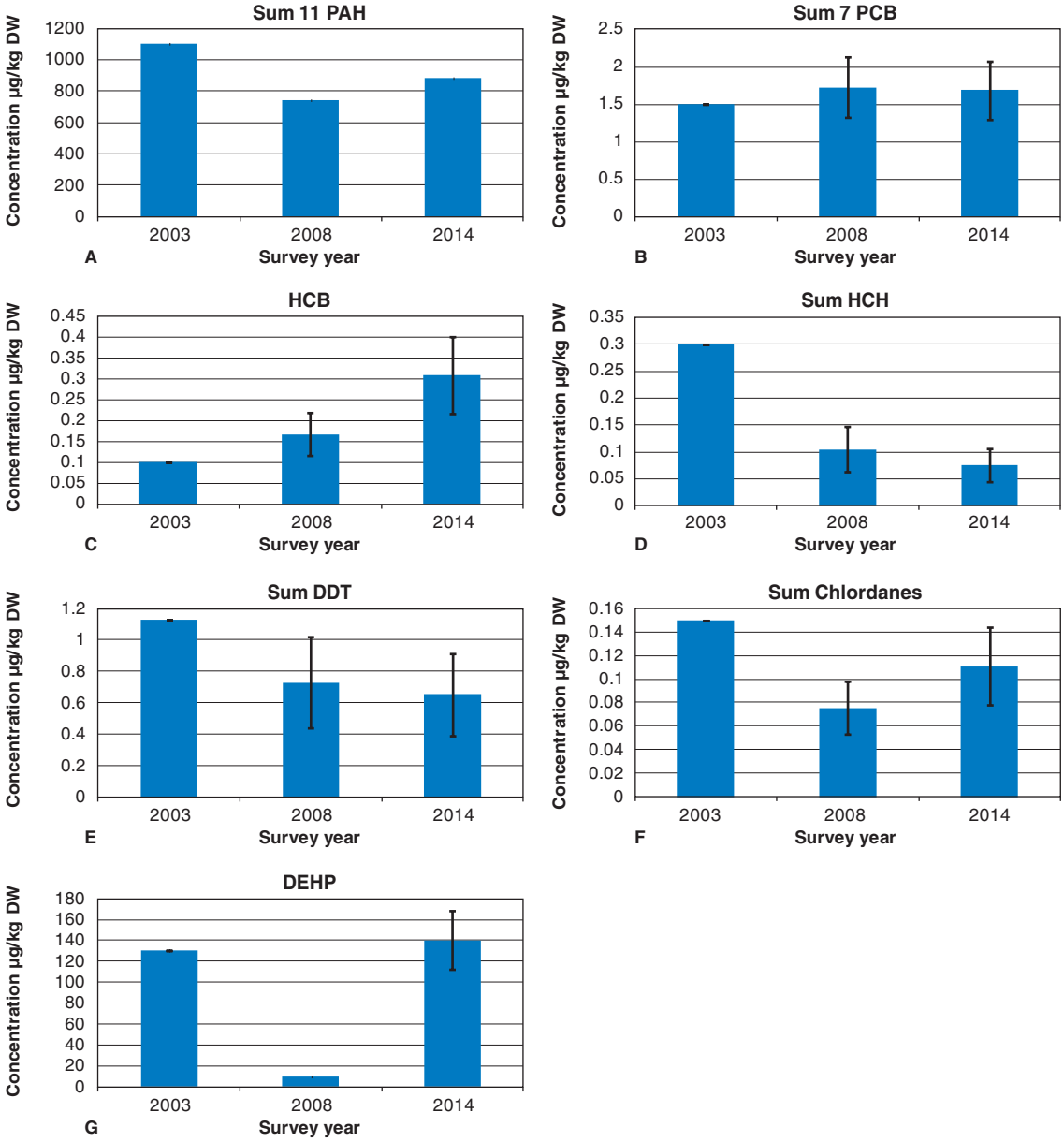

Figure 69. **A–G.** At station SE-16, HCH and DDT concentrations have declined continuously since 2003, while HCB concentrations have increased. The error bars represent laboratory measurement uncertainties.

DISCUSSION

This report gives an overview of the SSTMP outline, methods and results. All data with additional information are available through the public database for sediment monitoring data at SGU's web site (Geological survey of Sweden 2014). In this report, a selection of the analysed elements and organic substances, known to be of environmental concern, has been presented.

The SSTMP is designed to be performed every 5–6 years. The interval is set based on a number of factors such as cost efficiency, sediment accumulation rates and the length of the EU marine water management cycle of 6 years. In 2014, the third monitoring campaign was conducted and it might therefore be possible to distinguish trends of pollutant loads in the offshore sediment records. However, the SSTMP is a project in its early stages and analysis methods have changed along the way to better fit the requirements of directives and budgets. For example, the analytical method was changed for some elements between 2008 and 2014, while the laboratory for analyses of organic substances was changed between 2003 and 2008. This may affect the comparability of datasets between different years and might have caused the drastic decline in DEHP concentrations between 2003 and 2008. In this report the absolute concentration values have been used to evaluate trends and no analyses of statistical significance have been made. This has to be taken into consideration when using these data in other contexts.

Data from the three conducted monitoring campaigns imply that levels of old, banned pesticides such as DDT and chlordane are still very high in the most recently settled sediments at a number of stations along the Swedish coast. Levels of organic contaminants differ between the different basins. Chlordanes occur in the most elevated levels compared to the Swedish EPA environmental assessment criteria, in the sediments of all sampled stations in the Baltic Sea. This substance group is in class 5 in the north and south Baltic Proper and in class 4 in the Bothnian Bay and Bothnian Sea. On the west coast, levels of chlordanes are lower. DDTs occur in class 5 in the Landsort deep and in the south Baltic Proper. HCB, a banned pesticide and unwanted byproduct in various industrial processes, occurs in high levels (class 4) in the sediments of all sampled stations in 2014, both in the Baltic Sea and on the west coast. The concentration of this compound seem to have an increasing tendency. In general, the levels of organic contaminants are most elevated in the Baltic Proper, followed by the Bothnian Bay and Bothnian Sea, while they are lower on the west coast. PCBs, DDT, chlordanes and a number of other pesticides were banned in Sweden in the 1970s due to, for example, the discovery of high PCB levels in dead sea eagles in the Stockholm archipelago in 1966 (Jensen 1972). It is remarkable that these substances still occur in high levels in recently settled sediments despite having been banned for 40 years. TBT, used as an antifouling paint, has been banned in different steps in Europe from 1989 to 2008 due to its toxicity to marine organisms. Since the start of SSTMP it is shown that the TBT levels have decreased in most areas but it is still occurring in concentrations exceeding the ecotoxicological assessment criteria (HVMFS 2013:19) at all sampled stations in the Baltic Proper.

Also some heavy metals occur in high concentrations in the sediments at many of the monitoring stations. When comparing metal concentrations between different basins, three areas with different loads of metals can be differentiated. In the Bothnian Bay and Bothnian Sea, arsenic show the most elevated levels, while in the north Baltic Proper, cadmium, copper and zinc show the most elevated concentrations. In five out of six sampling stations in the north Baltic Proper, cadmium levels exceed the ecotoxicological assessment criteria (HVMFS 2013:19). In the south Baltic Proper and on the west coast, element concentrations are generally low. Metal contamination is harder to assess since metals are natural components of bedrock and soil. For instance, the high levels of cadmium in the sediments around Gotland may partly be reflected by the natural background levels in bedrock and soil in this area (Andersson et al. 2014). This is also the case of arsenic in the Bothnian Bay and Bothnian Sea. This area possesses high

natural levels of arsenic in the bedrock (Andersson et al. 2014). Both heavy metals and organic pollutants have documented negative effects on living organisms in high doses and it is urgent that the anthropogenic sources of these contaminants are identified and taken care of in the near future in order to establish healthy coastal and marine environments in the Baltic Sea.

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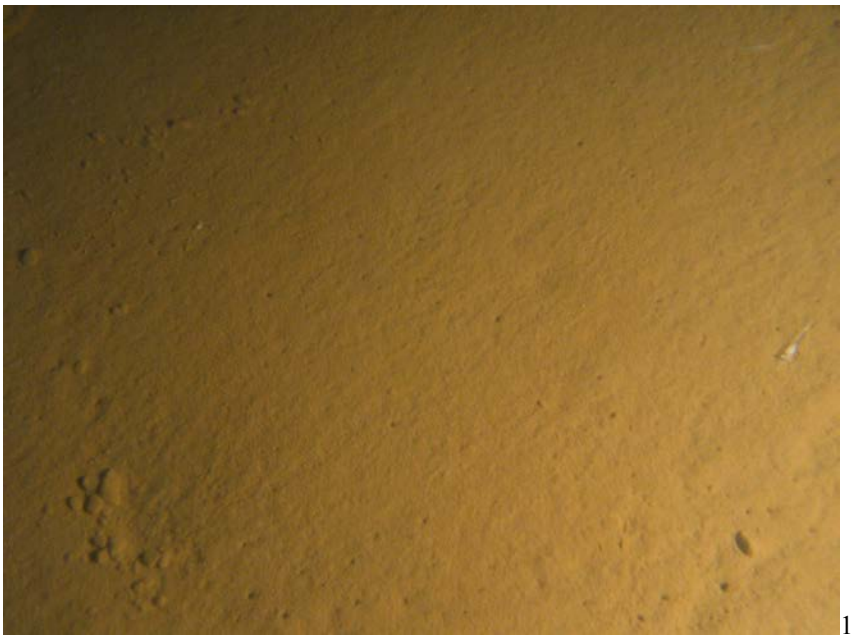
OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_17:1** **Kartblad: nmos08** **Prov nr: 08_0170**
Provtagare Geminilod **Vattendjup (m)** 87,5

Djup i cm	Lagerföljd	Anmärkning
0-51	Postglacial lergyttja	Laminerad, 0-2 cm oxiderad yta, brun (10YR3/2), 2-33 cm växlande färg på lamineringarna, bruna laminae (10YR3/2), gröngrå laminae (5Y3/2), svarta laminae (2.5/N), 33-51 cm svart lergyttja (2.5/N).

Frågeställning:
Slutsats/ Kommentar:



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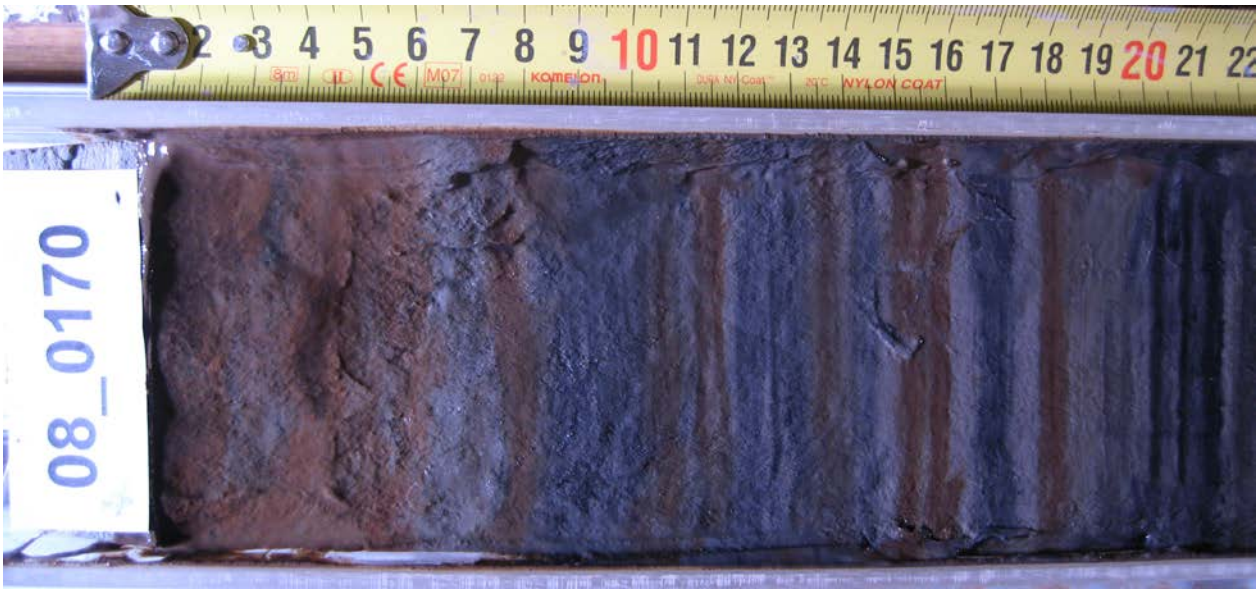

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OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE-1:1** **Kartblad: nmos08** **Prov nr: 08_0163**
Provtagare Geminilod **Vattendjup (m)** 113

Djup i cm	Lagerföljd	Anmärkning
0-41	Postglacial lergyttja	Laminerad. 0-3 cm oxiderad yta, mörkbrun (10YR2/2), 3-15 cm gröngrå matrix (5Y3/1) med enstaka mörkbruna skikt, 15-41 cm svarta sulfidskikt (2.5/N) med enstaka inslag av gröngrå skikt (5Y3/1).

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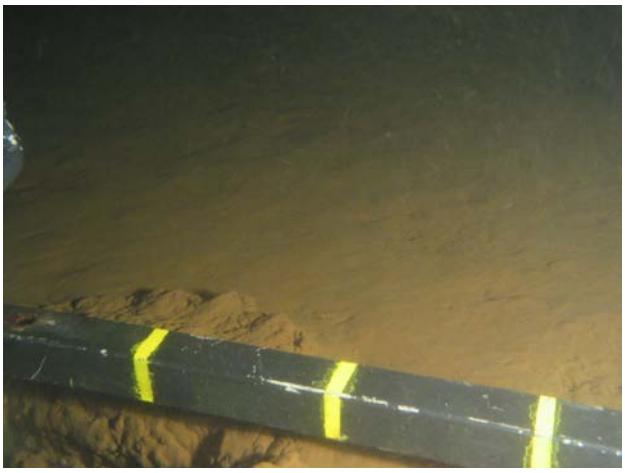
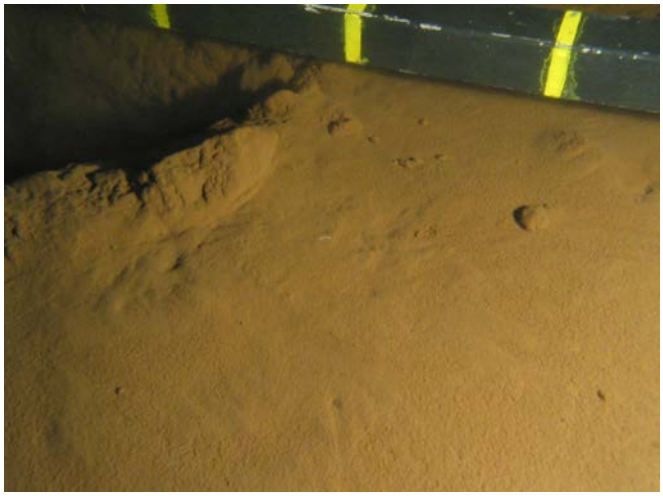
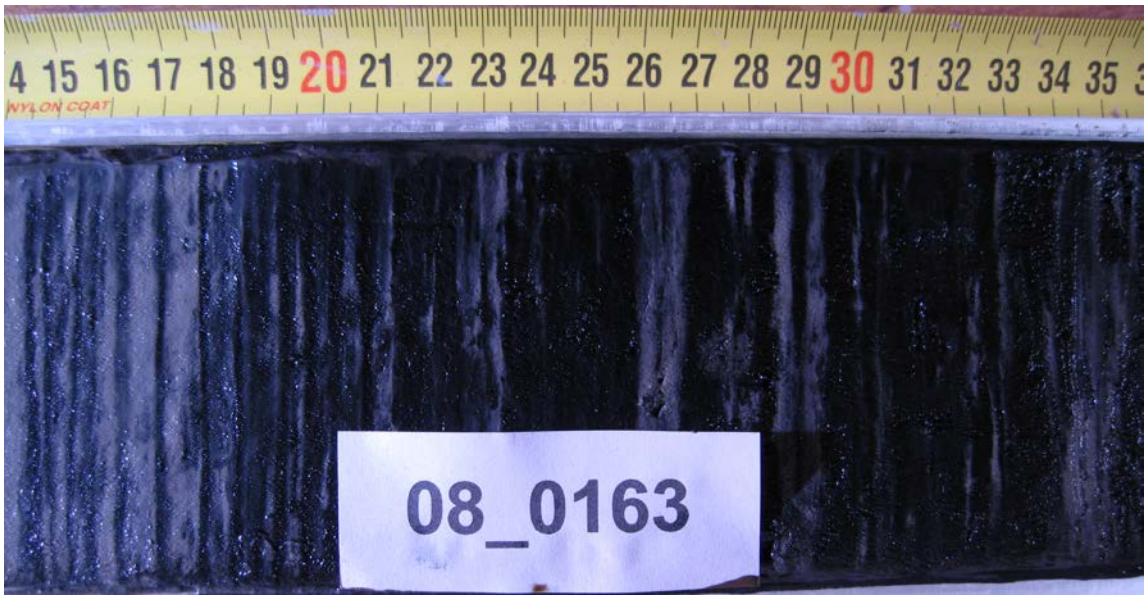
Slutsats/ Kommentar: SE-1:1






08_0163


08_0163


08_0163

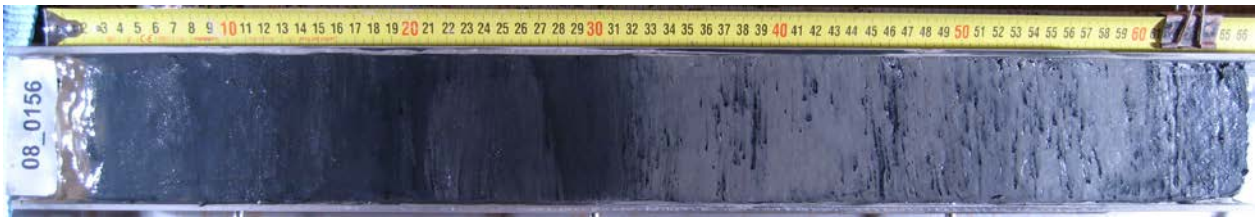
OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE-2:1** **Kartblad: nmos08** **Prov nr: 08_0156**
Provtagare Geminilod **Vattendjup (m)** 200,2

Djup i cm	Lagerföljd	Anmärkning
0 - 66	Postglacial lergyttja	Oxiderad yta, 0-2 cm, brun (2.5Y3/2), 2-32 cm svart (5Y2.5/1)
		32-66 cm grågrön rikligt med sulfidfläckar (5Y4/1).

Frågeställning:
Slutsats/ Kommentar: Station SE-2:1, NMO_2008.



OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_3** **Kartblad: Nmos08** **Prov nr: 08_0149**
Provtagare Geminilod **Vattendjup (m)** 78,8

Djup i cm	Lagerföljd	Anmärkning
0-42	Postglacial gyttjelera	Oxiderad yta (0-3cm), bioturberad, färg: brunt 2.5Y3/2.
		Färg: grått 2.5Y3/1 (3-37cm), svart 2.5/N (37-43)

Frågeställning:
Slutsats/ Kommentar: Stora blyvikter. Station SE-3:1_2008. Bottenvatten 0-2 m slambemängt (syns på ekolodet) trots lugnt väder i flera veckor. Bottenström?

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OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_4_1** **Kartblad: nmos08** **Prov nr: 08_0095**
Provtagare Geminilod **Vattendjup (m)**

Djup i cm	Lagerföljd	Anmärkning
0-70	Postglacial lergyttja	Oxiderad yta, reducerad nedåt. Recent sedimentation. Färg: 5Y4/2 (0-3 cm), 2,5N (6-7 cm), 5Y4/1 (7-11 cm), 5Y2,5/1 (11-50 cm). Lätt gashaltigt.
		Krypspår , ishavsskorv, ponteporeja

Frågeställning:
Slutsats/ Kommentar:


08-0095
08-0099

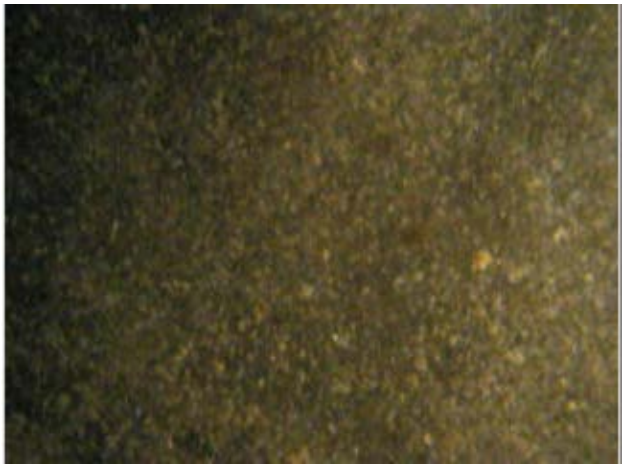

08-0095
08-0099
WYLON COAT

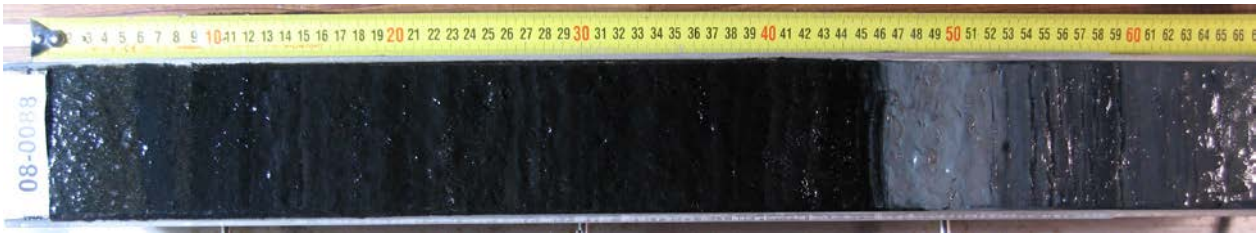
OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_5_1** **Kartblad: nmos08** **Prov nr: 08_0088**
Provtagare Geminilod **Vattendjup (m)** 174,7

Djup i cm	Lagerföljd	Anmärkning
0-46	Postglacial lergyttja	Färg: svart (2,5/N), laminerad, underkonsoliderad, recent sedimentation, metangas
46-52	Postglacial lergyttja	Färg: Beige (4/10Y), bioturberat
52-70	Postglacial lergyttja	Färg:svartgrå (3/N), laminerad, underkonsoliderad, recent sedimentation, metangas

Frågeställning:
Slutsats/ Kommentar:






08-0088


08-0088


08-0088

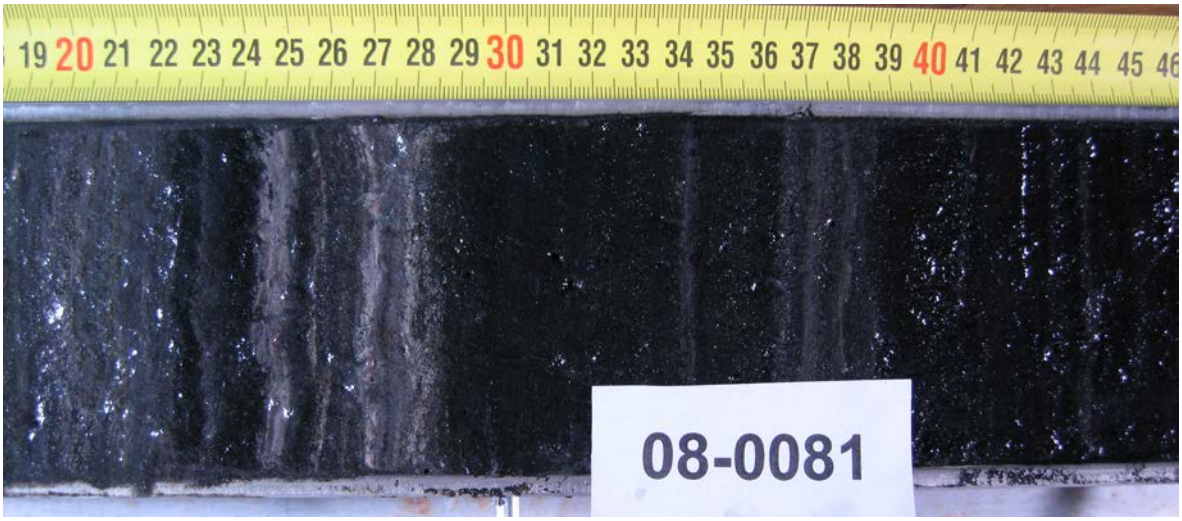
OBSERVATIONSDOKUMENT

Linje nr: **Site nr:** SE_8_1 **Kartblad:** **nmos08** **Prov nr:** 08_0081
Provtagare Geminilod **Vattendjup (m)** 403

Djup i cm	Lagerföljd	Anmärkning
0-67	Postglacial lergyttja	Löst, recent sediment, reducerat, laminerat

Frågeställning:
Slutsats/ Kommentar:

Efter 12 timmar i luft (oxiderad)


19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
08-0081


7 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51
08-0081


41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68
08-0081

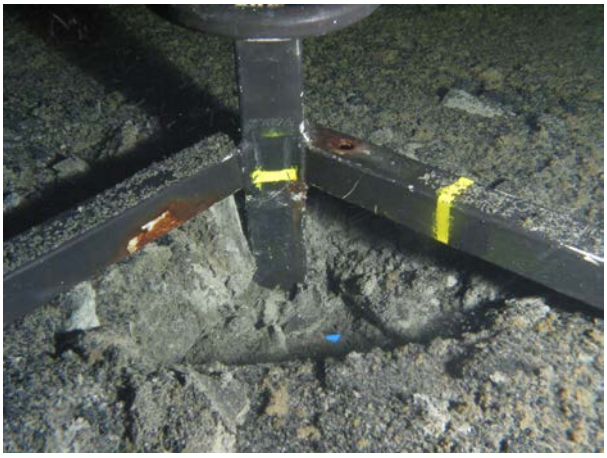

4 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68
08-0081

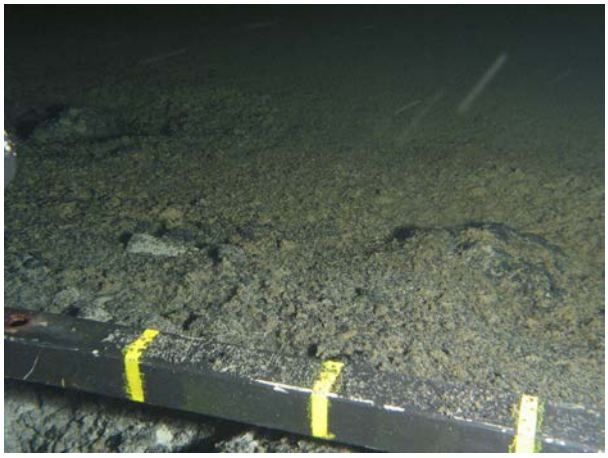
OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_9_1** **Kartblad: nmos08** **Prov nr: 08_0074**
Provtagare Geminilod **Vattendjup (m)** 177,9

Djup i cm	Lagerföljd	Anmärkning
0-18	Postglacial lergyttja	Recent sedimentation, Reducerad. Laminerad (ca 30 laminae.) Färg: 2.5/N växelvis med 3/5GY
18-45	Postglacial gyttjelera	Homogen med tunna sulfidskikt/band. Färg: 3/10Y

Frågeställning:
Slutsats/ Kommentar:






08-0074


08-0074
KOMELON
NYLON COAT


08-0074
KOMELON
NYLON COAT

OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_6_1** **Kartblad: nmos08** **Prov nr: 08_0067**
Provtagare Geminilod **Vattendjup (m)** 174

Djup i cm	Lagerföljd	Anmärkning
0-34	Postglacial lergyttja	Recent sedimentation, reducerat sediment, sapropel 0-34 cm, laminerad. Färg: 2.5/10Y
34-60	Postglacial gyttjelera	Laminerad, Färg: 3/10Y

Frågeställning:
Slutsats/ Kommentar:

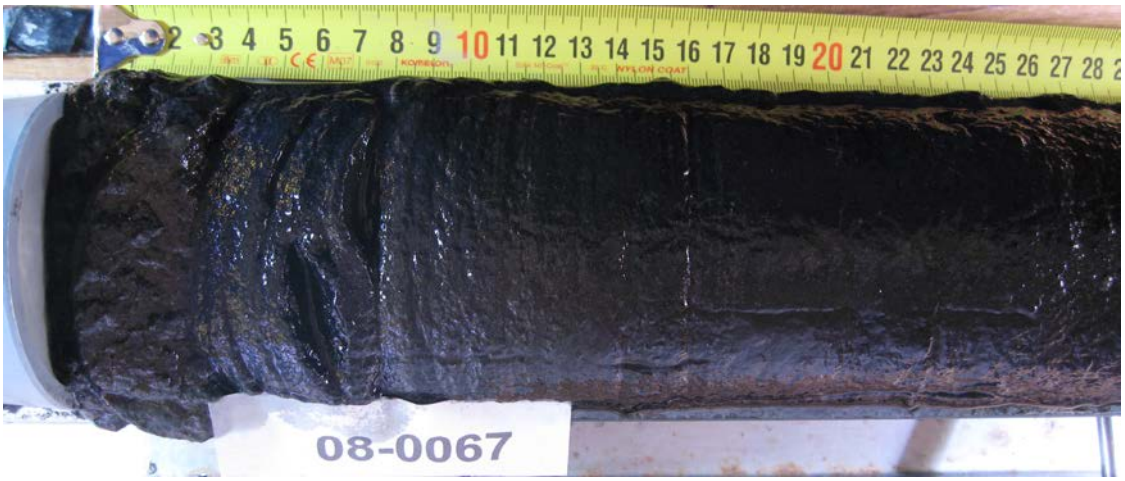


Bild 1. Sedimentet består av postglacial, mycket lös, laminerad lergyttja (sapropel)

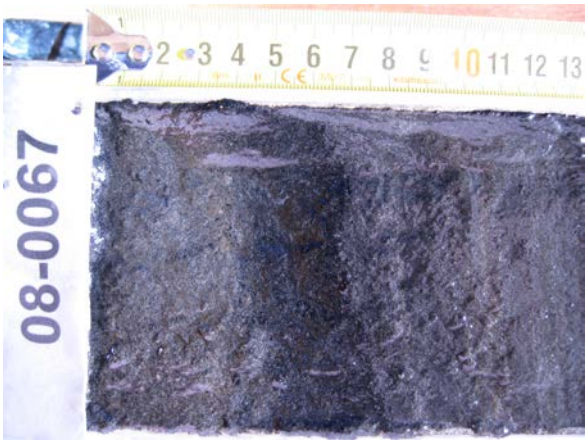


Bild 2. Ytan

Bild 3. Hink med sapropel

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OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_7_1** **Kartblad: nmos08** **Prov nr: 08_0060**
Provtagare Geminilod **Vattendjup (m)** 173.2

Djup i cm	Lagerföljd	Anmärkning
0-60	Postglacial lergyttja	Reducerad miljö i hela kärnan, sapropel 0-8 cm, fina lamineringar mellan 0-8 cm, och 29-36 cm

Frågeställning:
Slutsats/ Kommentar:

OBSERVATIONSDOKUMENT

Linje nr: **Site nr: se_7_2** **Kartblad: nmos08** **Prov nr: 08_0061**
Provtagare Geminilod **Vattendjup (m)** 173,4

Djup i cm	Lagerföljd	Anmärkning
0-45	Postglacial lergyttja	Reducerad miljö i hela kärnan, sapropel 0-8 cm, fina lamineringar mellan 0-8 cm, och 29-36 cm

Frågeställning:
Slutsats/ Kommentar:

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OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_7_3** **Kartblad: nmos08** **Prov nr: 08_0062**
Provtagare Geminilod **Vattendjup (m)**

Djup i cm	Lagerföljd	Anmärkning
0-45	Postglacial lergyttja	Reducerad miljö i hela kärnan, sapropel 0-8 cm, fina lamineringar mellan 0-8 cm, och 29-36 cm

Frågeställning:
Slutsats/ Kommentar:

OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_10_1** **Kartblad: nmos08** **Prov nr: 08_0053**
Provtagare Geminilod **Vattendjup (m)** 111

Djup i cm	Lagerföljd	Anmärkning
0-11	Postglacial lergyttja	Reducerad, laminerad, färg:2,5/N
11-53	Postglacial lera	Laminerad, hiatus vid 11 cm, färg (11-40 och 47-53 cm): 3/5GY (40-47 cm): 4/10Y

Frågeställning:
Slutsats/ Kommentar:

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08-0053


08-0053


08-0053
WYLON COAT


08-0053

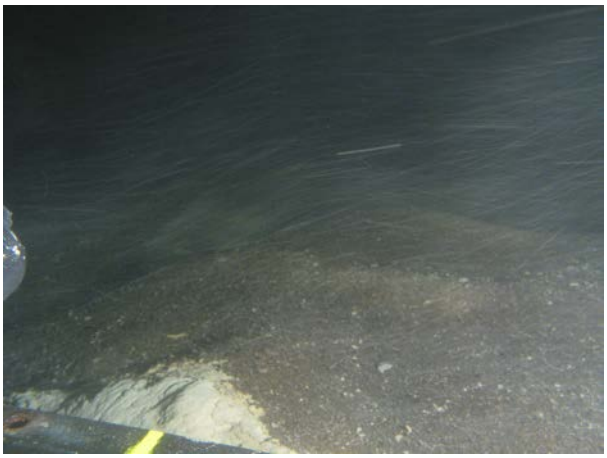
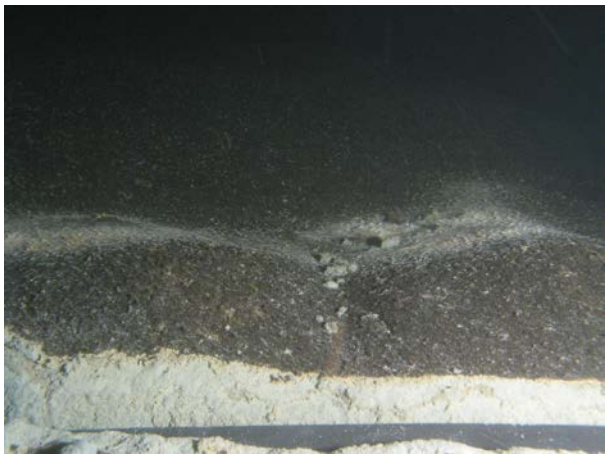
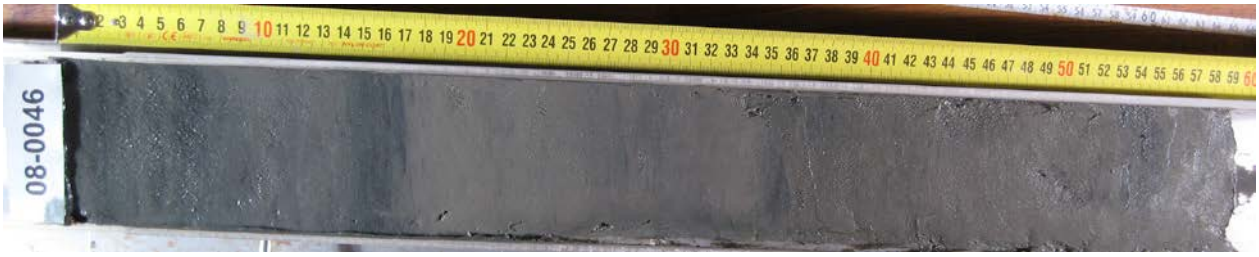
OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_11_1** **Kartblad: nmos08** **Prov nr: 08_0046**
Provtagare Geminilod **Vattendjup (m)** 75,2

Djup i cm	Lagerföljd	Anmärkning
0-17	Postglacial lergyttja	Svart 2.5/N. Fläckvis *Begiatoa* i ytan. Recent, laminerad
17-59	Postglacial lergyttja	Grågrön 5Y3/2

Frågeställning:
Slutsats/ Kommentar: Levande polychaete i ytan



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OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_11_5** **Kartblad: nmos08** **Prov nr: 08_0050**
Provtagare Geminilod **Vattendjup (m)** 75,5

Djup i cm	Lagerföljd	Anmärkning
0-17	Postglacial lergyttja	Svart 2.5/N. Fläckvis *Begiatoa* i ytan. Recent, laminerad
17-56	Postglacial lergyttja	Grågrön 5Y3/2

Frågeställning:
Slutsats/ Kommentar:

OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_12_1** **Kartblad: nmos08** **Prov nr: 08_0039**
Provtagare Geminilod **Vattendjup (m)** 46,9

Djup i cm	Lagerföljd	Anmärkning
0-52	Postglacial lergyttja	Färg: Grönsvart 2,5/N som mot djupet övergår till 2,5/10Y Enstaka svarta sulfidband och grågröna skikt. Polychaet på 0-1 cm. Reducerad yta, samt hela kärnan. Recent sedimentation.

Frågeställning:
Slutsats/ Kommentar:

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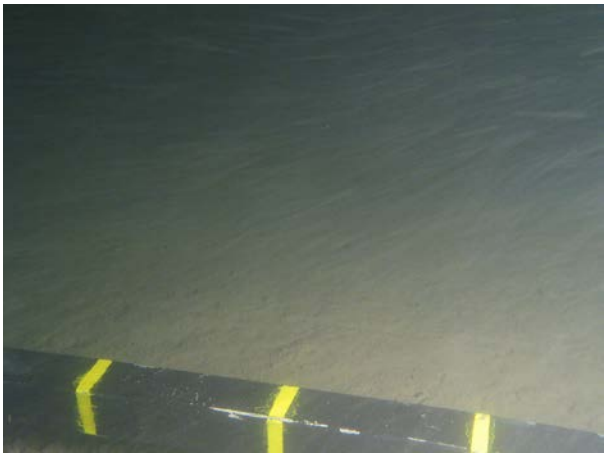
08-0039

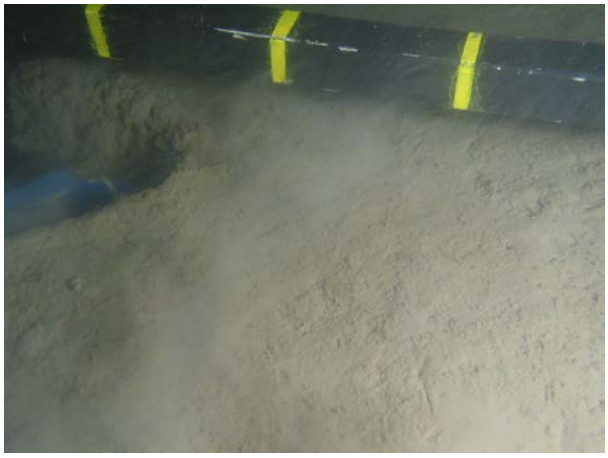
OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_13_1** **Kartblad: nmos08** **Prov nr: 08_0032**
Provtagare Geminilod **Vattendjup (m)** 47,5

Djup i cm	Lagerföljd	Anmärkning
0-40	Postglacial lergyttja	Homogen, färg grågrön 5Y2,5/2 i de översta 0-15 cm med enstaka sulfidfläckar. Färg 15-40 cm 5Y3/2, dvs något ljusare. Den mörkare färgtonen och sulfidfläckarna tyder på en högre organisk produktion vid avsättningen av de översta 15 cm.

Frågeställning:
Slutsats/ Kommentar: Trålspår observerat på SE-13_2, SE-13_3





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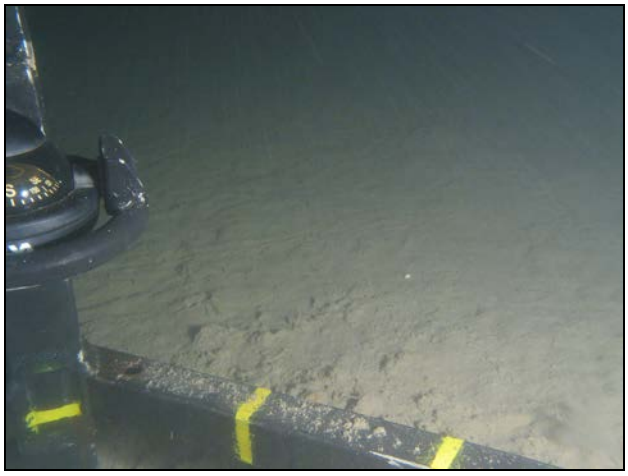
Skal och sjöborre från sedimenten på station SE-13 (08_0032 – 08_0038). Från uppe t.vä.: *Pecten (Chlamus) septemradiatus, Leda pernula, Nucula tennis, Cyprina islandica, Syndosmya nitida.* Mellersta raden från vä.: *Turitella communis, Balanus sp.* Nedre raden från vä.: *Pecten (Chlamus) tigrinus, Dentalium dentalis, Brysopsis lyrifera, Apporrhais pes-pelicani.* Foto: 2005-08-22.

OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_15_1** **Kartblad: nmos08** **Prov nr: 08_0018**
Provtagare Geminilod **Vattendjup (m)** 94

Djup i cm	Lagerföljd	Anmärkning
0-38	Postglacial gyttjelera	Bioturberat ned till 30cm. Maskhål.

Frågeställning:
Slutsats/ Kommentar: Stora blyvikterna. Detta dokument gäller som beskrivning även för proverna 08_0019-0024._

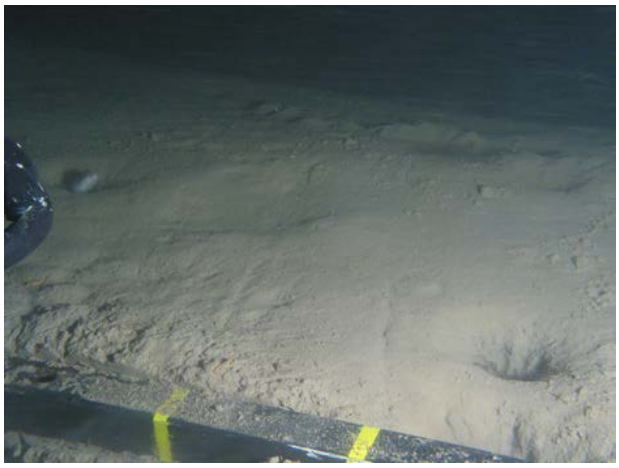


OBSERVATIONSDOKUMENT

Linje nr: **Site nr: SE_16_1** **Kartblad: nmos08** **Prov nr: 08_0025**
Provtagare Geminilod **Vattendjup (m)** 196 m

Djup i cm	Lagerföljd	Anmärkning
0-48	Postglacial gyttjelera	Recent sedimentation, pirål, havskräfthålor, bioturberat, poly-
		Chaetgångar ned till ca 30 cm. Färg 5Y3/2 som vid 30 cm övergår i 5Y2,5/2. Homogen.

Frågeställning:
Slutsats/ Kommentar:



OBSERVATIONSDOKUMENT **Projekt : NMOS14**

Site nr: NMOS14_SE_17 **Prov nr: 14_0126, 14_0127, 14_0128, 14_0129, 14_0130, 14_0131, 14_0132**
Provtagare g-max **Vattendjup (m)** 87,3
Position i Sweref 99TM **N: 7255863.7 (14_0126)** **E: 0892222.2 (14_0126)**

Djup i cm	Lagerföljd	Anmärkning
0-50	Postglacial lergyttja	Oxiderad yta. Laminerade sediment med mörka reducerade band. Svavelvätelukt. 5Y3/2 Recent sedimentation 14_0031: Levande skorv syntes i UV bilderna och en kom upp i provet.

Syrgashalt i bottenvattnet: 8.1 ml/liter

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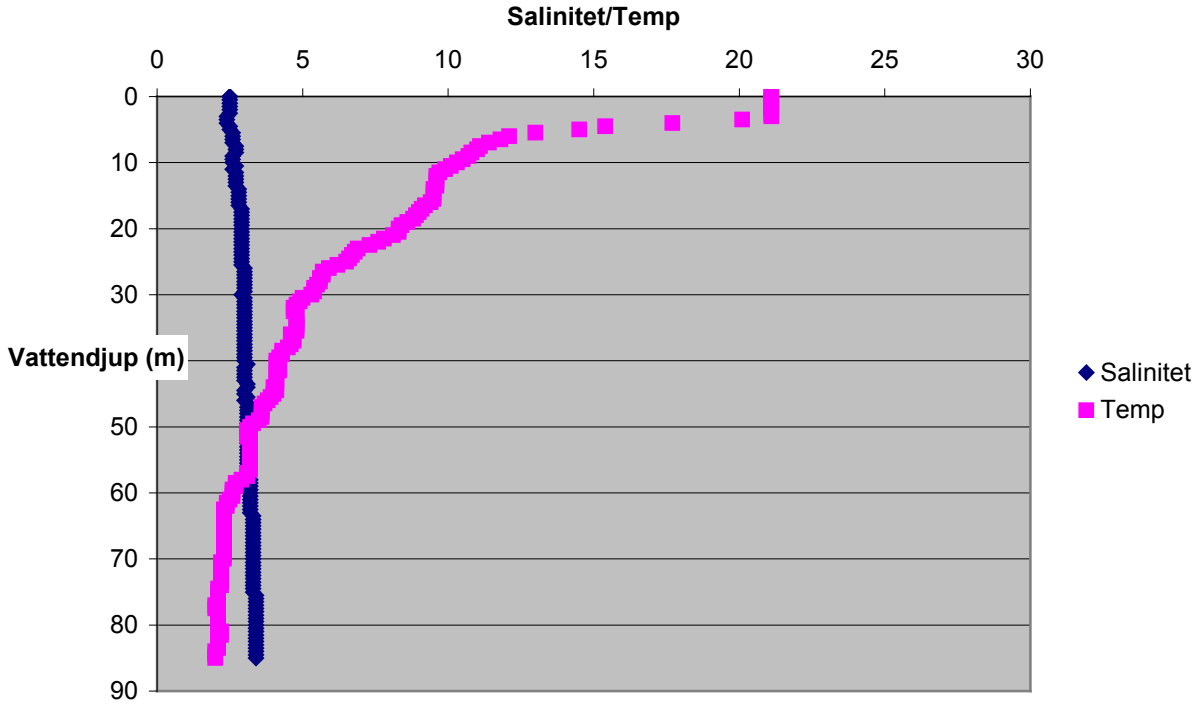
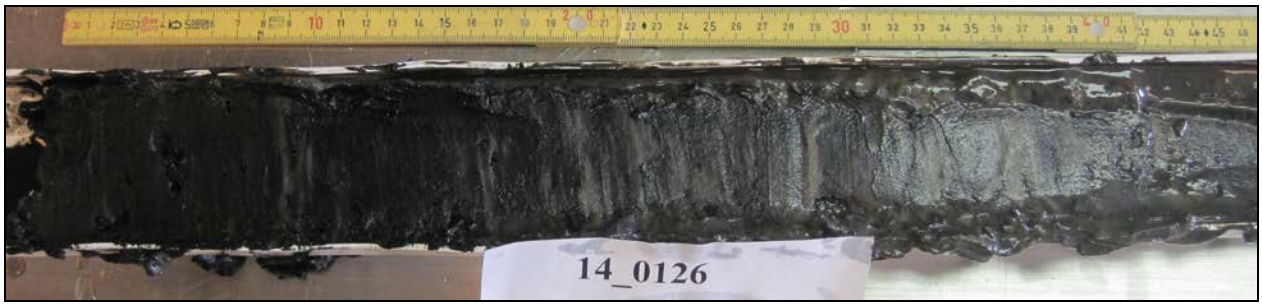
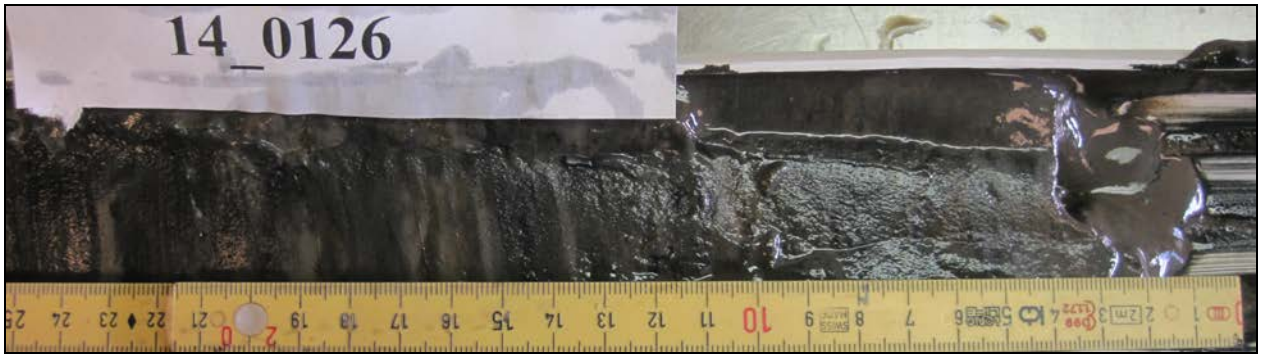
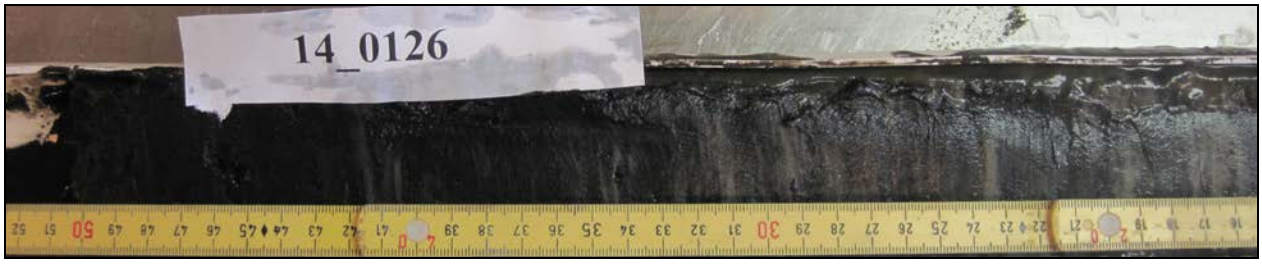
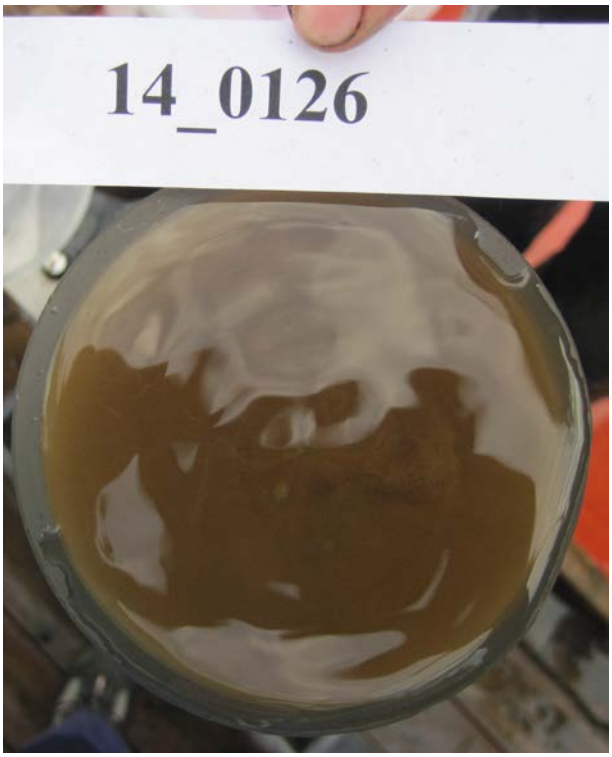
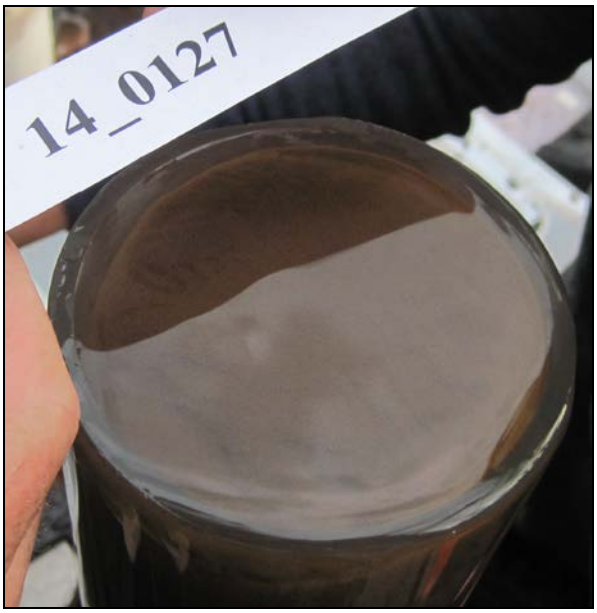

Salinitet/Temp
0
5
10
15
20
25
30
0
10
20
30
50
60
70
80
90
Vattendjup (m)
Salinitet
Temp


14_0126

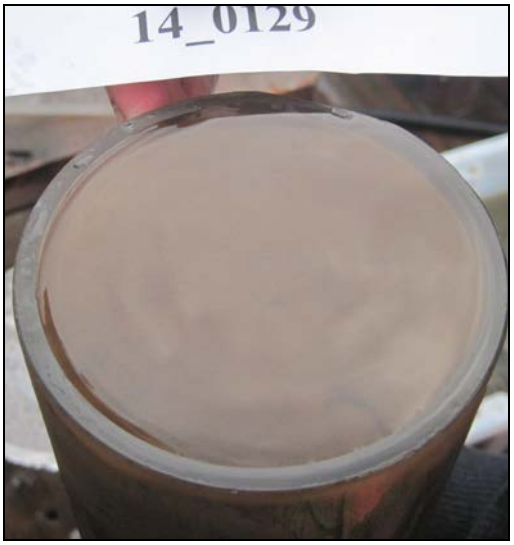

14_0126


14_0126


14_0126


14_0127


14_0128


14_0129

Bottenytorna på samtliga provtagningspunkter på stationen är identiska och vittnar om en homogen och representativ plats.

OBSERVATIONSDOKUMENT

Projekt : NMOS14

Site nr: NMOS14_SE-01 **Prov nr: 14_0133, 14_0134, 14_0135, 14_0136, 14_0137, 14_0138, 14_0139**
Provtagare Gmax **Vattendjup (m)** 113
Position i Sweref 99TM **N: 7137577.5** **E: 839032.5**

Djup i cm	Lagerföljd	Anmärkning
0-32	Postglacial lergyttja	Små konkretioner

Syrgashalt i bottenvattnet: 7.0 ml/L

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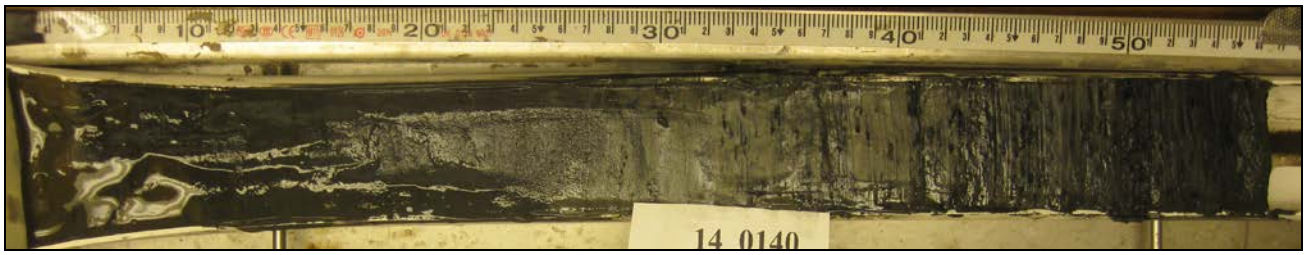
OBSERVATIONSDOKUMENT

Projekt : NMOS14

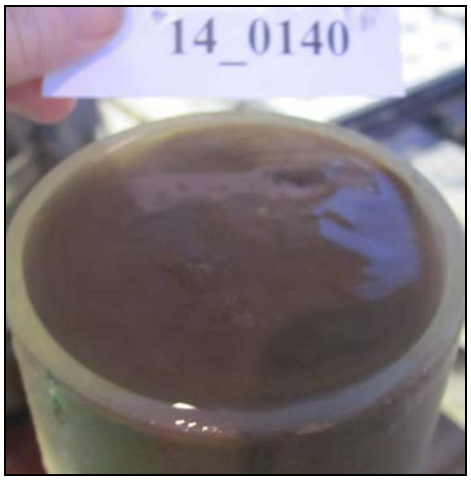
Site nr: NMOS14_SE-02 **Prov nr: 14_0140, 14_0141, 14_142, 14_0143, 14_0144, 14_0145, 14_0146**
Provtagare g-max **Vattendjup (m)** 200
Position i Sweref 99TM **N: 6956652.2** **E: 704410.3**

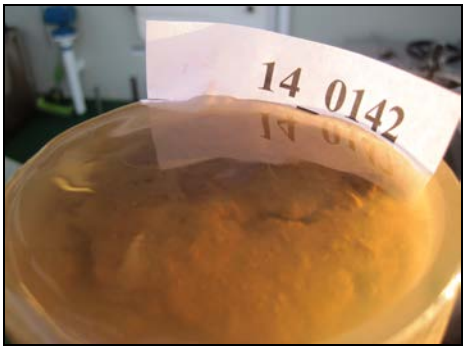
Djup i cm	Lagerföljd	Anmärkning
0-55	Postglacial gyttjelera	Oxiderad yta, reducerade fläckar, mindre gyttja längre ned i provet, Skorv och räkor

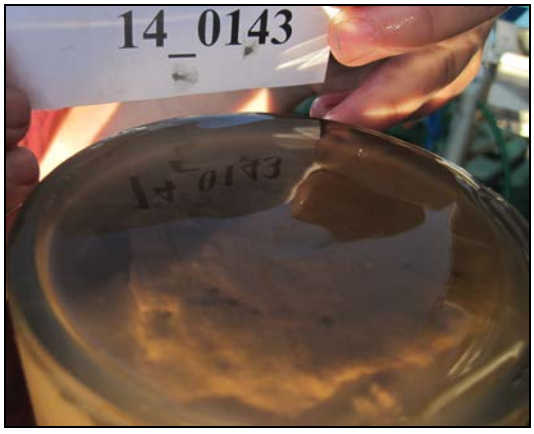
Syrgashalt i bottenvattnet:



UV-bilderna var så dåliga pga slam att de inte visas här.

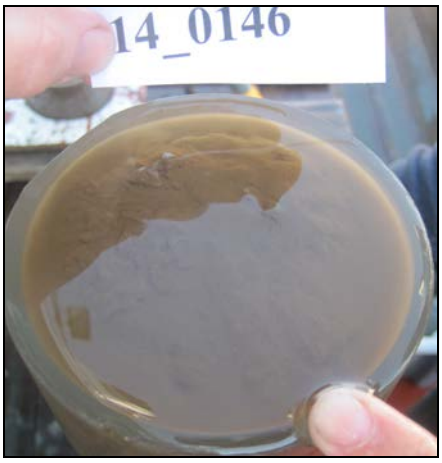


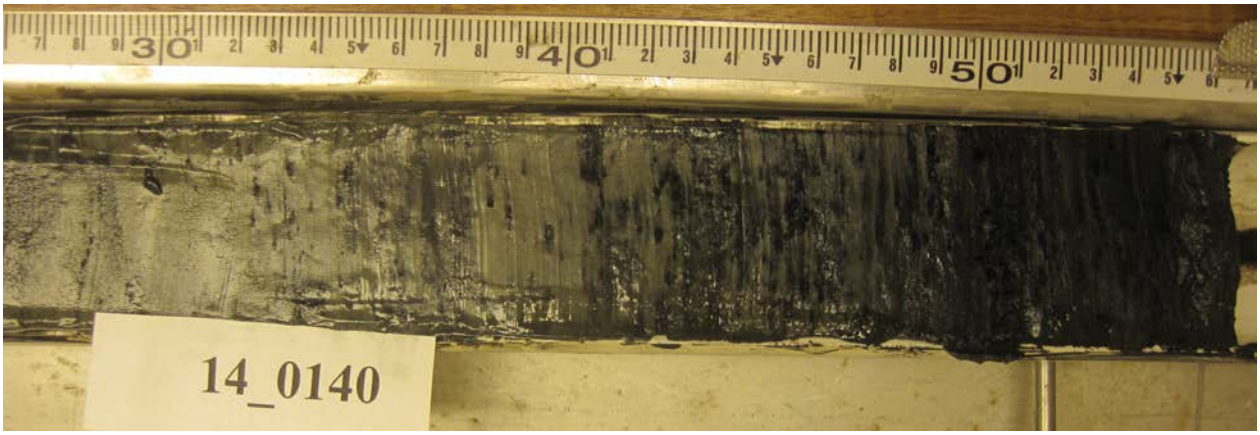




SGU
Maringeologi


14_0145


14_0146


14_0140

OBSERVATIONSDOKUMENT

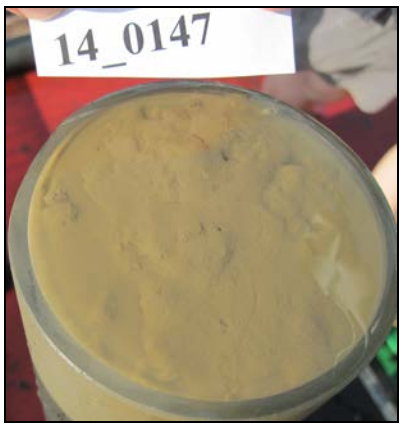
Projekt : NMOS14

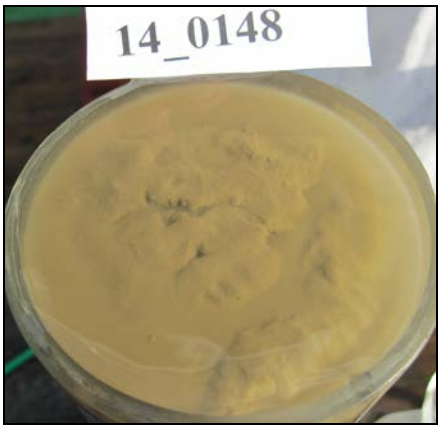
Site nr: NMOS14_SE-03 **Prov nr: 14_0147, 14_0148, 14_149, 14_0150, 14_0151, 14_0152, 14_0153**
Provtagare g-max **Vattendjup (m)** 78
Position i Sweref 99TM **N: 6795703,2** **E: 0668233,3**

Djup i cm	Lagerföljd	Anmärkning
0-3 3-53	Postglacial gyttjelera	Oxiderad yta. Ökande antal nedåt i sedimenten med reducerade fläckar och skikt. Recent sedimentation.
		Fann räka, skorv (ihavsgråsugga)och havsborstmask i första provet. Inga UV-bilder på grund av för grumligt vatten, likadant skedde 2008. Stora skorvar (1-5 cm långa som grumlar provet och ytan, får med i nästan alla prover). Svårighet att inte få omrörning på ytan i alla prover det ofta kommer med levande djur. Grävhål i ytorna, spår efter räkor och skorv. Skorvar (ibland stora och ofta väldigt små kom med i alla prover).

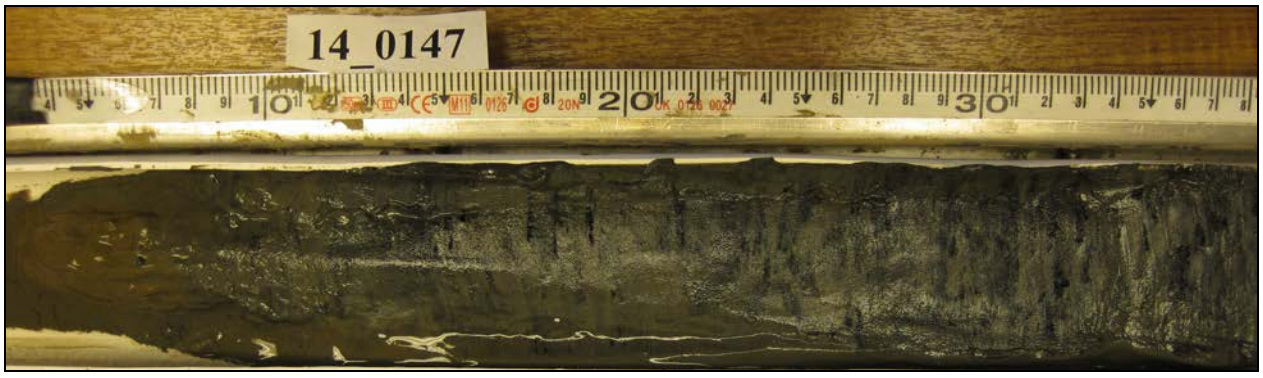
Syrgashalt i bottenvattnet: Oxygen_conc, 4.9 ml/liter

UV-bilderna var så dåliga pga slam att de inte visas här. Blev dålig sikt i vattnet från 62 meter djup.





SGU
Maringeologi



Bilder på Ishavsgråsugga nedan.


14_0147


4_0148

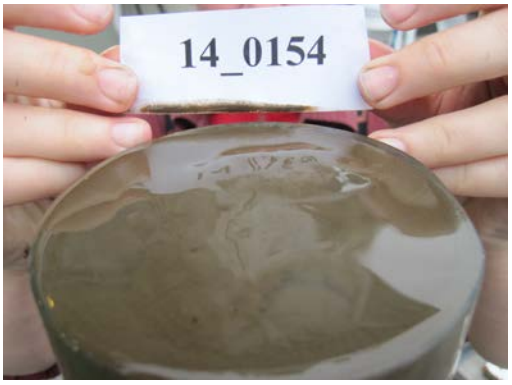
OBSERVATIONSDOKUMENT

Projekt : NMOS14

Site nr: NMOS14_SE-4 **Prov nr: 14_0154, 14_0155,14_ 0156,14_ 0157, 14_0158, 14_0159,14_ 0160**
Provtagare g-max **Vattendjup (m)** 227
Position i Sweref 99TM **N: 6679642.5** **E: 0724321.3**

Djup i cm	Lagerföljd	Anmärkning
0-72	Postglacial gyttjelera	Lite gas i nedre delen
		Underliggande material pressats upp till ytan

Syrgashalt i bottenvattnet: Oxygen_conc, 5.4 ml/liter



OBSERVATIONSDOKUMENT

Projekt : NMOS14

Site nr: NMOS_5_1

Prov nr: 14_0001, 14_0002, 14_0003, 14_0004, 14_005, 14_0006, 14_0007

Provtagare g-max **Vattendjup (m)** 174

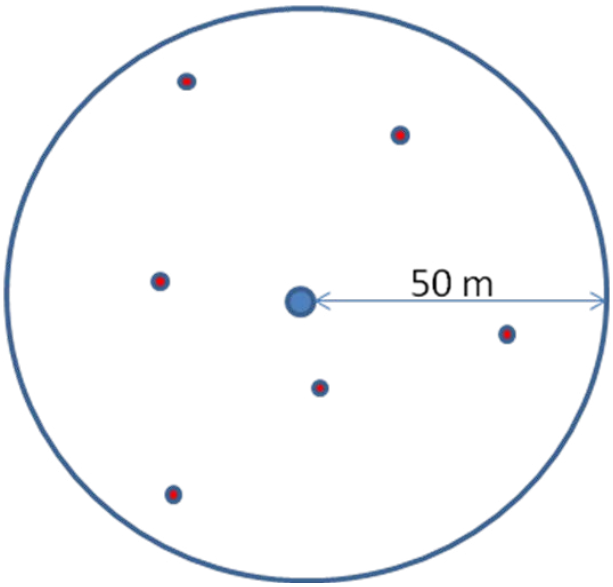
Position i Sweref 99TM **N: 6549634.5** **E: 6549634.5**

Djup i cm	Lagerföljd	Anmärkning
0-50 cm	Pg.gyL	Reducerad, mycket vattenhaltig, flytande konsistens, lukt av svavelväte, svart färg

Frågeställning:

Slutsats/ Kommentar: UV-bild omöjlig att ta pga mycket lös botten

0-30 cm äe kärnan recent med en tydlig lukt av svavelväte. Färgen är svart och det tyder på total syrebrist i sedimentet. Syrgashalten i bottenvattnet var nära 0 ml/l .

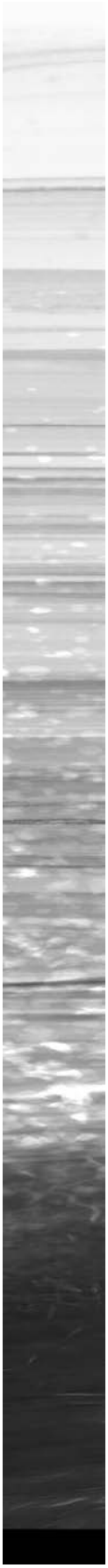


G-maxkärnans sedimentyta från masterstationen är ostörd och ger en bild av de anoxiska förhållandena i bassängen.

Ytsedimentet från slavstationerna är ostörda och ser likadant ut och visar på så vis att bassängens ytsediment är homogen i sin sammansättning.

Ytsedimentet från slavstationerna är ostörda och ser likadant ut och visar på så vis att bassängens ytsediment är homogen i sin sammansättning. Samtliga kärnor är fint laminerade i de övre 20 cm.

Ytsedimentet från slavstationerna är ostörda och ser likadant ut och visar på så vis att bassängens ytsediment är homogen i sin sammansättning. Samtliga kärnor är fint laminerade i de övre 20 cm.



Röntgenanalysen tyder på att det är gas i sedimenten vilket i sin tur betyder att miljön är anoxisk.

OBSERVATIONSDOKUMENT **Projekt : NMOS14**

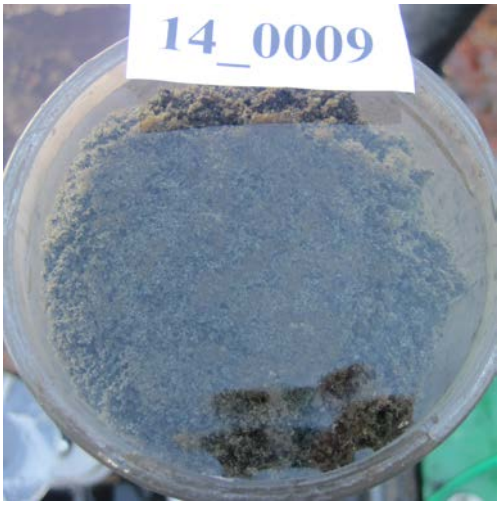
Site nr: NMOS14_8 **Prov nr:** 14_0008, 14_0009, 14_0010, 14_0011, 14_0012, 14_0013, 14_0014
Provtagare Gmax **Vattendjup (m)** 401
Position i Sweref 99TM **N: 6509083.7** **E: 0694602.6**

Djup i cm	Lagerföljd	Anmärkning
0-62	Postglacial gyttjelera	0-30 cm, reducerad, svart, flytande, lukt av H2S
		30-62 cm, fast, reducerade skikt,

Frågeställning:
Slutsats/ Kommentar: Ingen UV-bild på grund av känsliga instrument. Sedimenten på platsen är extremt lösa och gashaltiga. Detta gör det mycket svårt att provta dem. Ytsedimenten är ostörda när de tas upp från vattnet med störs nästan direkt pga gasavgång som rör upp ytan.

Kärnan är 62 cm lång och består av postglacial recent gyttjelera. De översta 30 cm är helt reducerade och flytande till konsistensen.


En plastbit hittades i botten på en av sedimentkärnorna tagen på 401 m djup.



Ytsedimentet från slavstationerna är ostörda och ser likadant ut och visar på så vis att bassängens ytsediment är homogen i sin sammansättning.

SGU
Maringeologi

Sedimentytorna är ostörda när de tas ut ur provtagaren. Men den kraftiga gasutvecklingen i sedimentet gör att ytan snabbt grumlas upp. Provtagning av ytan måste gå snabbt.

Ytsedimentet från slavstationerna är ostörda och ser likadant ut och visar på så vis att bassängens ytsediment är homogen i sin sammansättning

Ytsedimentet med färskt organiskt material.

Röntgenbilden avslöjar gasutveckling i sedimentet.

OBSERVATIONSDOKUMENT **Projekt : NMOS14**

Site nr: NMOS14_9_1 **Prov nr:** 14_0015, 14_0016, 14_0017, 14_0018, 14_0019, 14_0020, 14_0021
Provtagare g-max **Vattendjup (m)** 178,3
Position i Sweref 99TM **N:** 6435242.5 **E:** 0672994.9

Djup i cm	Lagerföljd	Anmärkning
0-20	Postglacial lergyttja	Recent sedimentation, Reducerad. Laminerad . Färg: 2.5/N växelvis med 3/5GY
20-57	Postglacial gyttjelera	Homogen med tunna sulfidskikt/band. Färg: 3/10Y

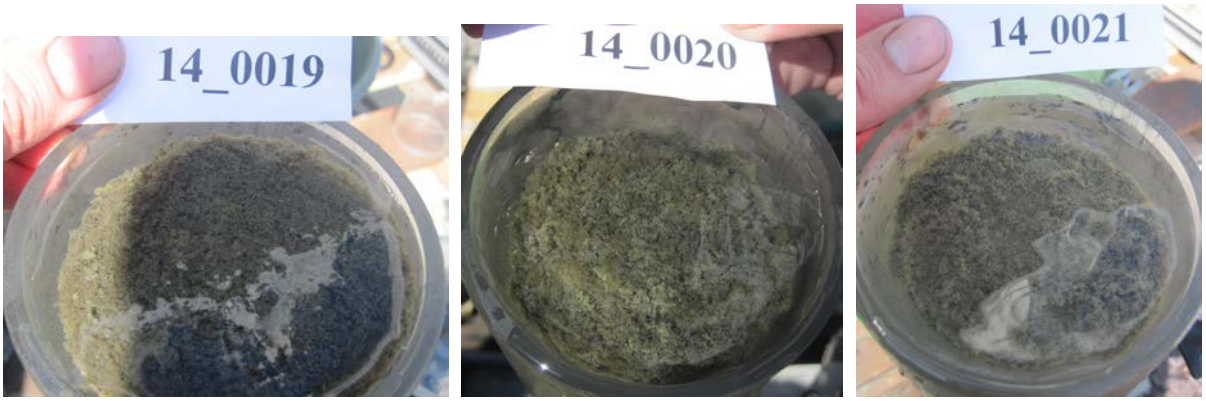
Frågeställning:
Slutsats/ Kommentar:

Sedimentet på station SE-9 är gyttjigt, flytande och reducerat i ytan, 0- ca 20 cm, därunder är leran postglacial men inte recent och normalkonsoliderad. Färgen är grå och det förekommer sulfidskikt. Den flytande, reducerade ytan har runnit bort vid fotograferingen.

I sedimentet i röntgenröret syns den fina lamineringen 0-20 cm mycket tydligt. På bottenytan ligger ett fluffigt lager med färskt organiskt material.

SGU
Maringeologi

I ytan ligger färskt organiskt material som ett ludd. Under detta materiel ligger den reducerade, laminerade postglaciala lergyttjan.



Ytsedimentet från slavstationerna är ostörda och ser likadant ut och visar på så vis att bassängens ytsediment är homogen i sin sammansättning.

OBSERVATIONSDOKUMENT **Projekt : NMOS14**

Site nr: NMOS14_6 **Prov nr:** 14_0022, 14_0023, 14_0024, 14_0025, 14_0026, 14_0027, 14_0028
Provtagare Gmax **Vattendjup (m)** 194.4
Position i Sweref 99TM **N: 6432635.7** **E: 0788142.0**

Djup i cm	Lagerföljd	Anmärkning
0-30	Postglacial lergyttja	Recent sedimentation, reducerat sediment, sapropel 0-30 cm, laminerad. Färg: 2.5/10Y
30-60	Postglacial gyttjelera	Täta sulfidskikt, Färg: 3/10Y

Frågeställning:
Slutsats/ Kommentar:

Kärnan består av svart, flytande lergyttja (sapropel) 0-30 cm. Under detta ligger en mer normalkonsoliderad postglacial gyttjelera med täta sulfidskikt.

Övergången mellan den postglaciala lergyttjan och gyttjeleran går vid ca 30 cm.

Ytsedimentet från slavstationerna är ostörda och ser likadant ut och visar på så vis att bassängens ytsediment är homogen i sin sammansättning


14_0025


14_0026


14_0027

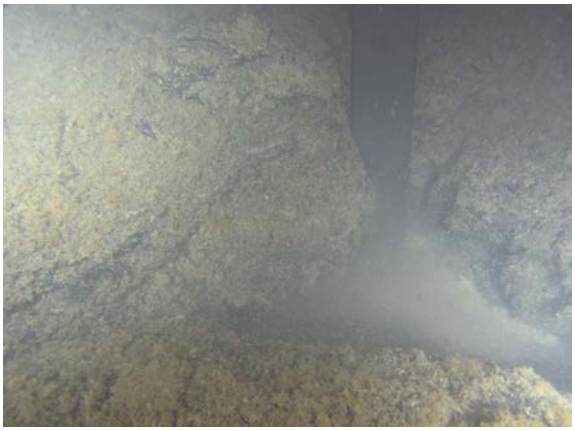

14_0028

OBSERVATIONSDOKUMENT **Projekt : NMOS14**

Site nr: NMOS14_7 **Prov nr:** 14_0029, 14_0030, 14_0031, 14_0032, 14_0033, 14_0034, 14_0035
Provtagare Gmax **Vattendjup (m)**
Position i Sweref 99TM **N: 6327221.5** **E: 0763118.2**

Djup i cm	Lagerföljd	Anmärkning
0-10	Postglacial lergyttja	Reducerad flytande sediment med fluffigt, färskt organiskt material på toppen.
10-49	Postglacial gyttjelera	Sulfidskikt förekommer vid ca 20 cm och 32 cm.

Frågeställning:
Slutsats/ Kommentar:

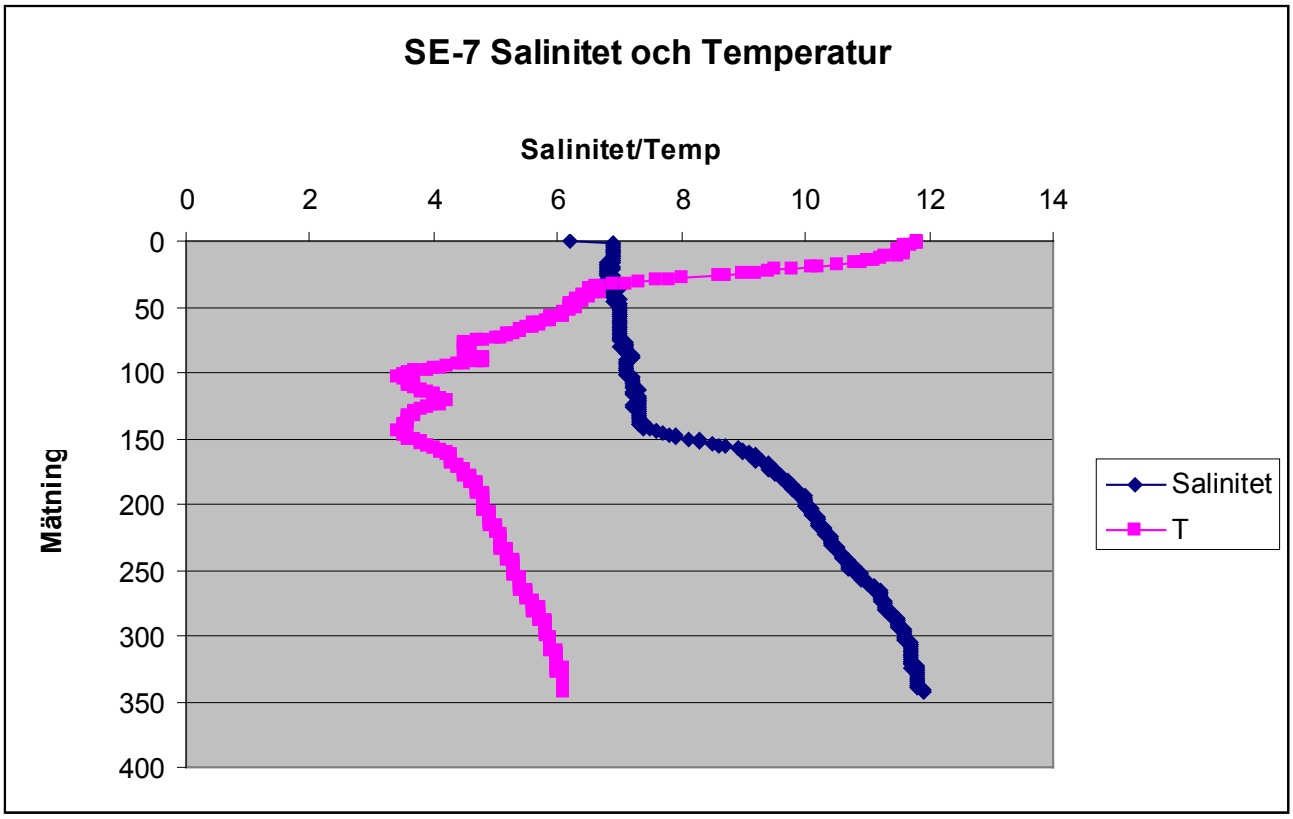



Sedimentet på SE-7, Gotlandsdjupet, ligger på ett djup av 173 m och är löst och reducerat. Syrgashalten är 0 och saliniteten ligger på omkring 11.5 i bottenvattnet.

Kärnan är 49 cm lång och sedimentet är flytande och reducerat i den översta delen. Resterande del är normalkonsoliderad och innehåller sulfidskikt.

SGU
Maringeologi

Bottenytan på station SE-7 är täckt av färskt organiskt material. Vid ca 10 cm går en skarp gräns i sedimentet mellan lagret med recent lergyttja och den icke recenta postglaciala gyttjeleran.


SE-7 Salinitet och Temperatur
Salinitet/Temp
0
2
4
6
8
10
12
14
Mätning
0
50
100
150
200
250
300
350
400
Salinitet
T

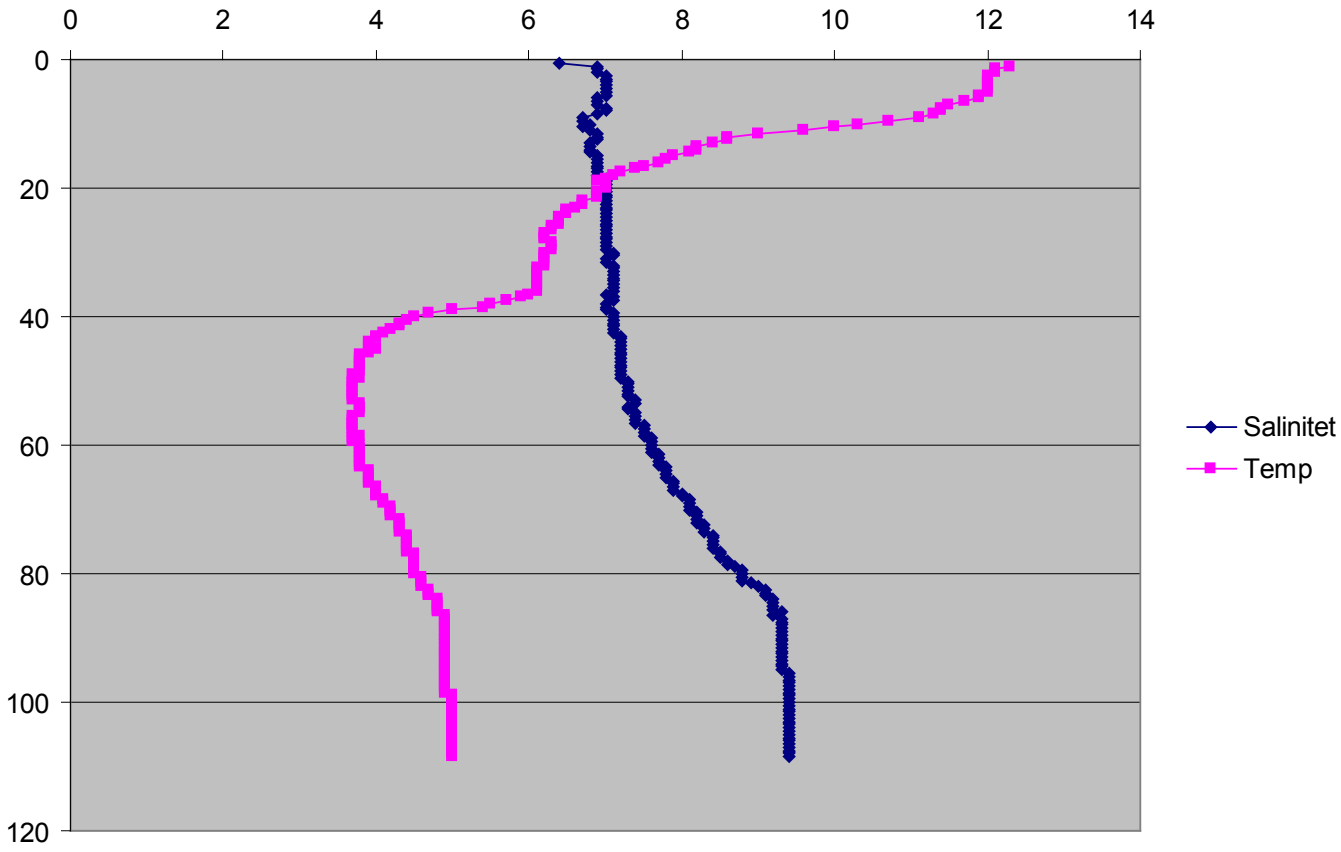
OBSERVATIONSDOKUMENT

Projekt : NMOS14

Site nr: NMOS14_10 **Prov nr:** 14_0036, 14_0037, 14_0038, 14_0039, 14_0040, 14_0041, 14_0042
Provtagare Gmax **Vattendjup (m)** 110.3
Position i Sweref 99TM **N: 6335386.3** **E: 0661488.5**

Djup i cm	Lagerföljd	Anmärkning
0-10	Postglacial lergyttja	Reducerad, laminerad, färg:2,5/N
11-50	Postglacial lera	Sulfidskikt och band, färg: 3/5GY 4/10Y

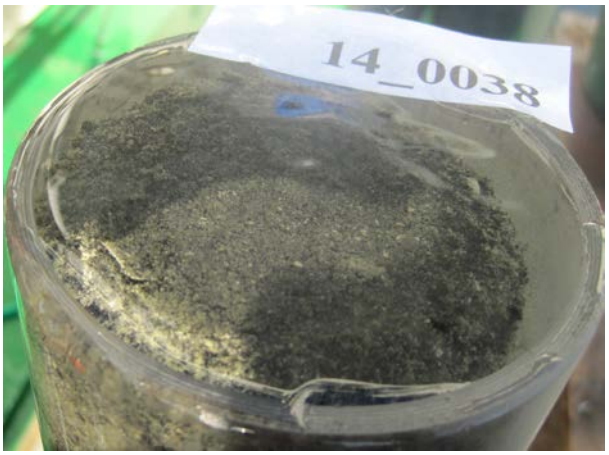
Syrgashalt i bottenvattnet: 0 ml/l



SGU
Maringeologi

De översta 10 cm är flytande, laminerade och reducerade. Under detta lager kommer en grå postglacial gyttjelera.

Ytsedimentet från slavstationerna är ostörda och ser likadant ut och visar på så vis att bassängens ytsediment är homogen i sin sammansättning



Lamineringen i de översta 10 cm är tydlig i den ostörda kärnan.

OBSERVATIONSDOKUMENT **Projekt : NMOS14**

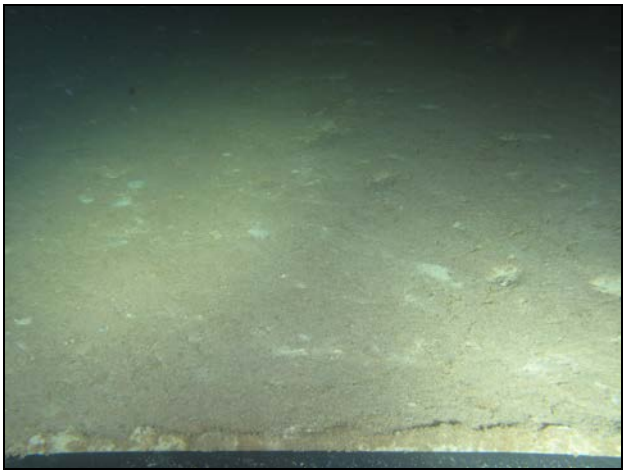
Site nr: NMOS14_11 **Prov nr: 14_0078, 14_0079, 14_0080, 14_0081, 14_0082, 14_0083, 14_0084,**
Provtagare Gmax **Vattendjup (m) 74.68**
Position i Sweref 99TM **N: 6155030.2** **E: 545673.9**

Djup i cm	Lagerföljd	Anmärkning
0-30	Postglacial lergyttja.	Oxiderad yta, därunder reducerade band. Gradvis kontakt mot nästa lager, luktar svagt av svavelväte. 2,5Y3/2
30-52	Postglacial gyttjelera.	5Y4/1

Syrgashalt i bottenvattnet: 3,6 ml/l

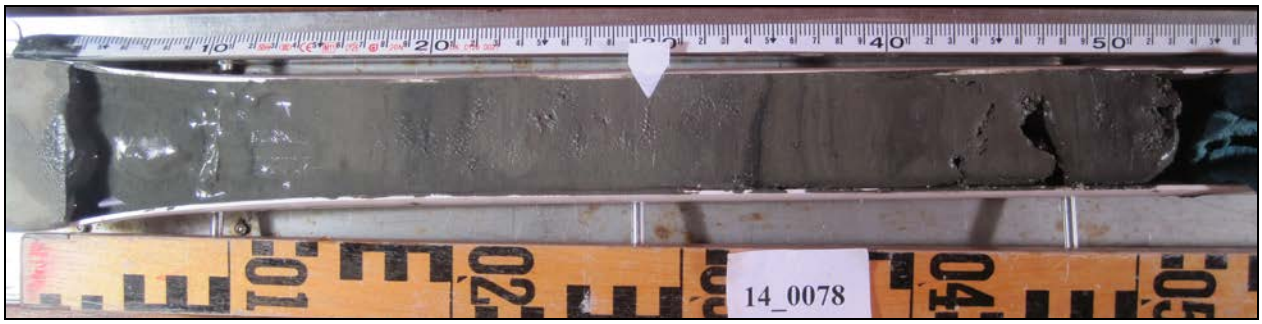
I flera av kärnorna på denna site uppträdde tydliga störningar i sedimentets övre 0-4 dm. Sedimentet genomsätts av slag, färgskiftningar och konsolideringsvariationer med en kaotiskt växlande såväl vertikal som horisontell utbredning, se bilder på prov 14_0081nedan). Även två sedimentproppar (i stötlod respektive röntgenhållare, se bilder nedan) tagna med några meters mellanrum, uppvisar en svårkorrelerad lagerföljd med flera tecken på störningar.
Störningarna påminner något om vattenavgångsstrukturer vilka bildas när vattenmättade sediment sätts i plötslig rörelse. I ytan på en av kärnorna (prov 14_0082) förekom även cm-stora klumpar av sediment som föreföll ha fallit ned på ytan och sedan täckts med ett tunt skikt yngre sediment. Dessutom syns på fotografierna från UV-kamera (UV-bild 1-2) flera gropar som förefaller ha bildats av något nedfallande material.
En rimlig tolkning av dessa fenomen är att de har antropogent ursprung. Närmast liggande infrastruktur som under anläggningsskedet skulle ha kunnat orsaka denna integritetsstörning på havsbotten är Nordstreams gasledning som ligger c:a 1,5 kabellängder från siten.
.


UV-bild 1

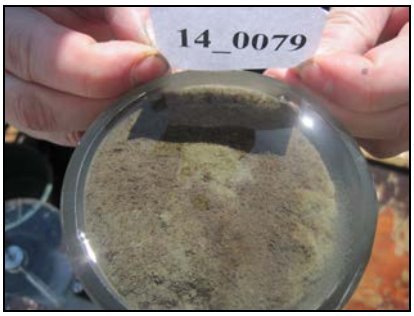

UV-bild 2

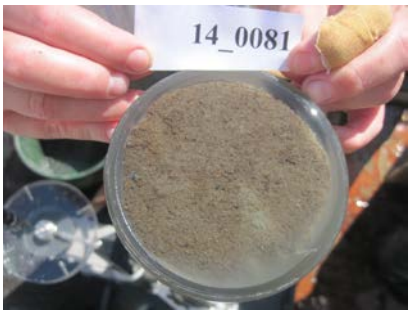
Sedimentkärna i röntgenhållaren

SGU
Maringeologi



Sedimentkärna från stötlod.





Kaotiskt störd sedimentation prov 14_0081

Till vänster i röret cm-stora klumpar av sediment som verkar ha fallit ned på bottenytan vid prov 14_0082 och sedan täckts med ett tunt skikt yngre sediment.

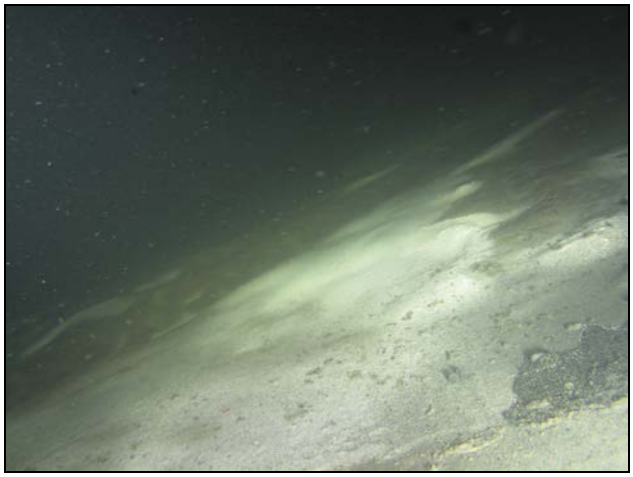
OBSERVATIONSDOKUMENT

Projekt : NMOS14

Site nr: NMOS14_11N **Prov nr:** 14_0071, 14_0072, 14_0073, 14_0074, 14_0075, 14_0076, 14_0077
Provtagare **Gmax** **Vattendjup (m)** **70.0600**
Position i Sweref 99TM **N: 6156134.1** **E: 0587707.9**

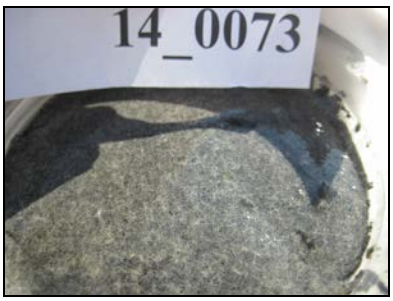
Djup i cm	Lagerföljd	Anmärkning
0-44	Postglacial lergyttja	Beggiatoa på ytan.. 2,5/10G

Syrgashalt i bottenvattnet: 0,7 ml/l




De lösa sedimentet täcks av utbredda skikt av svavelbakterien Beggiatoa.

Postglacial sulfidlergyttja



Ostörda överytor med en hinna av Beggiatoa.

SGU
Maringeologi

Ostörd överyta från 14077 med Beggiatoa och en liten röd spolformad evertebrat, för övrigt ej artbestämd.

OBSERVATIONSDOKUMENT

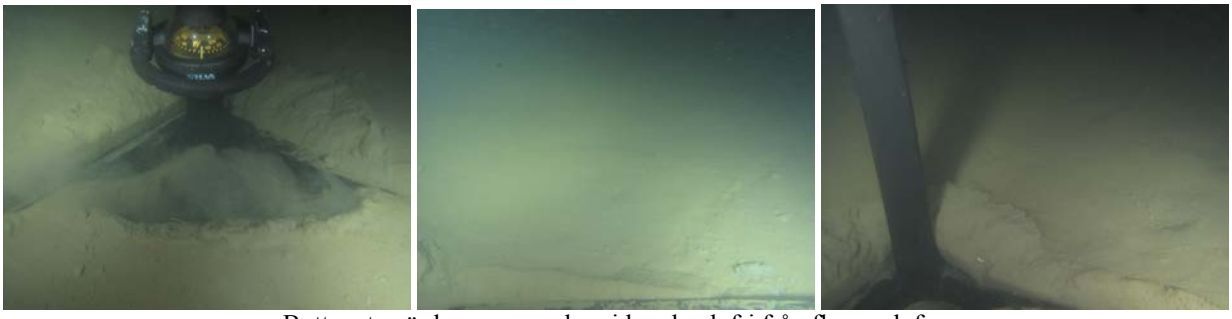
Projekt : NMOS14

Site nr: NMOS14_12 **Prov nr:** 14_0064, 14_0065, 14_0066, 14_0067, 14_0068, 14_0069, 14_0070
Provtagare **Gmax** **Vattendjup (m)** **46.2100**
Position i Sweref 99TM **N: 6095136.1** **E: 0433354.4**

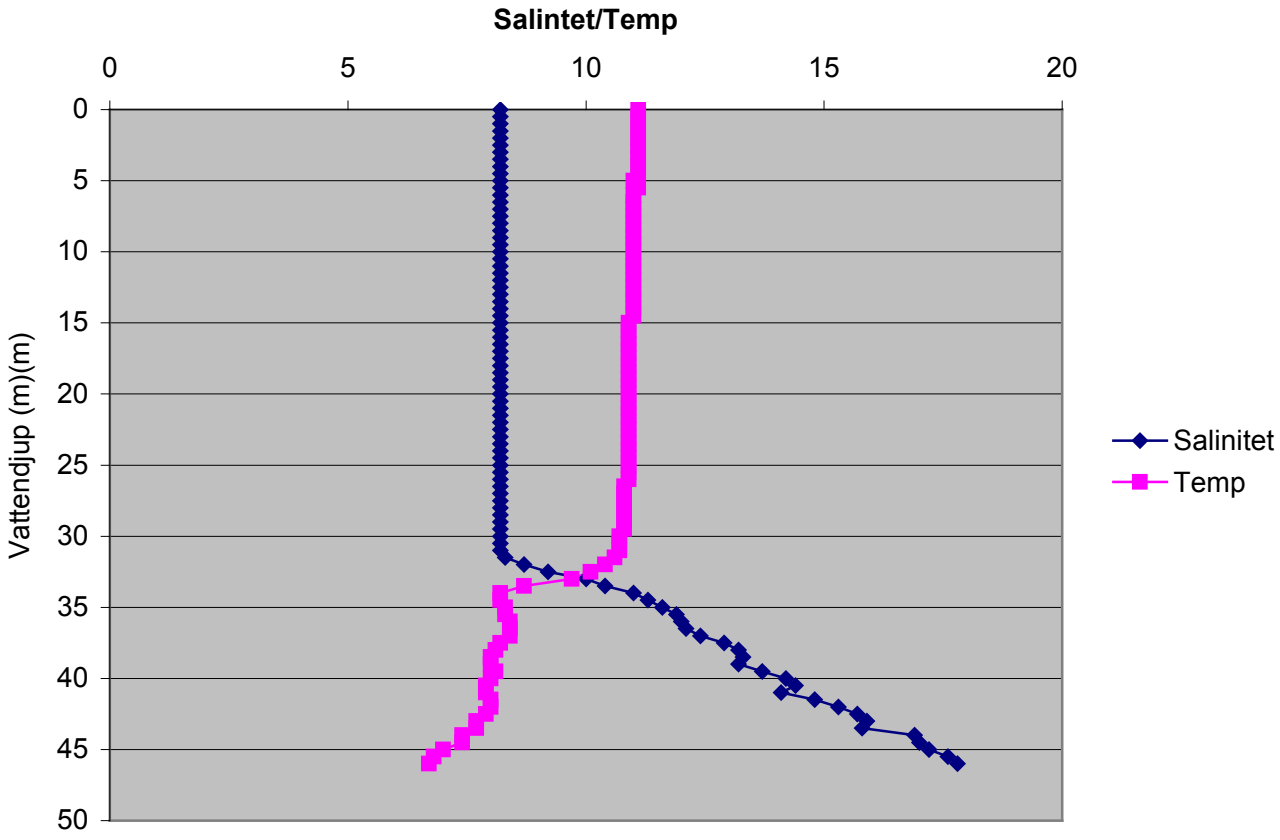
Djup i cm	Lagerföljd	Anmärkning
0-44	Postglacial sulfidgyttjelera.	Tätt diffust laminerad med reducerade skikt vilket germycket mörkt grå färg, Luktar svavel.

I Arkonabassängen syns ett tydligt språngskikt (haloklin/termoklin) vid 30m vattendjup

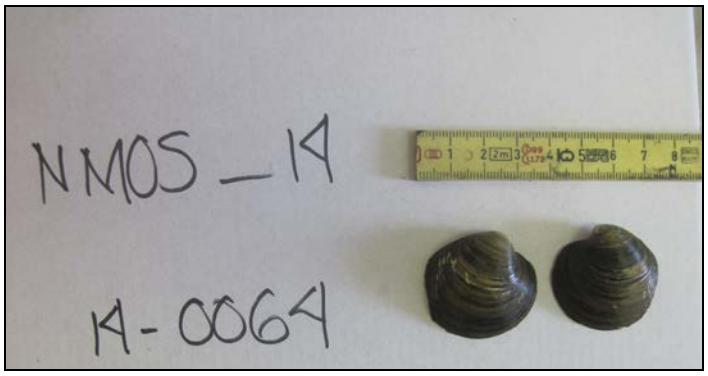
Syrgashalt i bottenvattnet: 4,4 ml/l



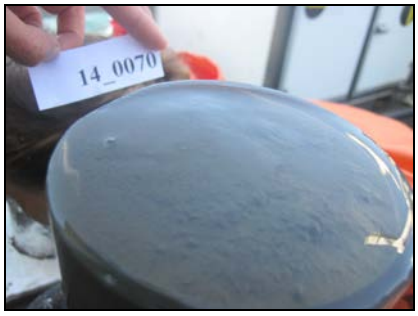
Bottenytan är homogen och oxiderad och fri från flora och fauna.
I Arkonabassängen syns ett tydligt språngskikt (haloklin/termoklin) vid 30m vattendjup.



Ytterligare provtagning visade att den postglaciala lergyttjan fortsatte ner ytterligare minst 10 cm.



Östersjömussla (*Macoma baltica*) med av utfälld järnsulfid svärtade skal.



Ostörda överytor i repektive delprov.

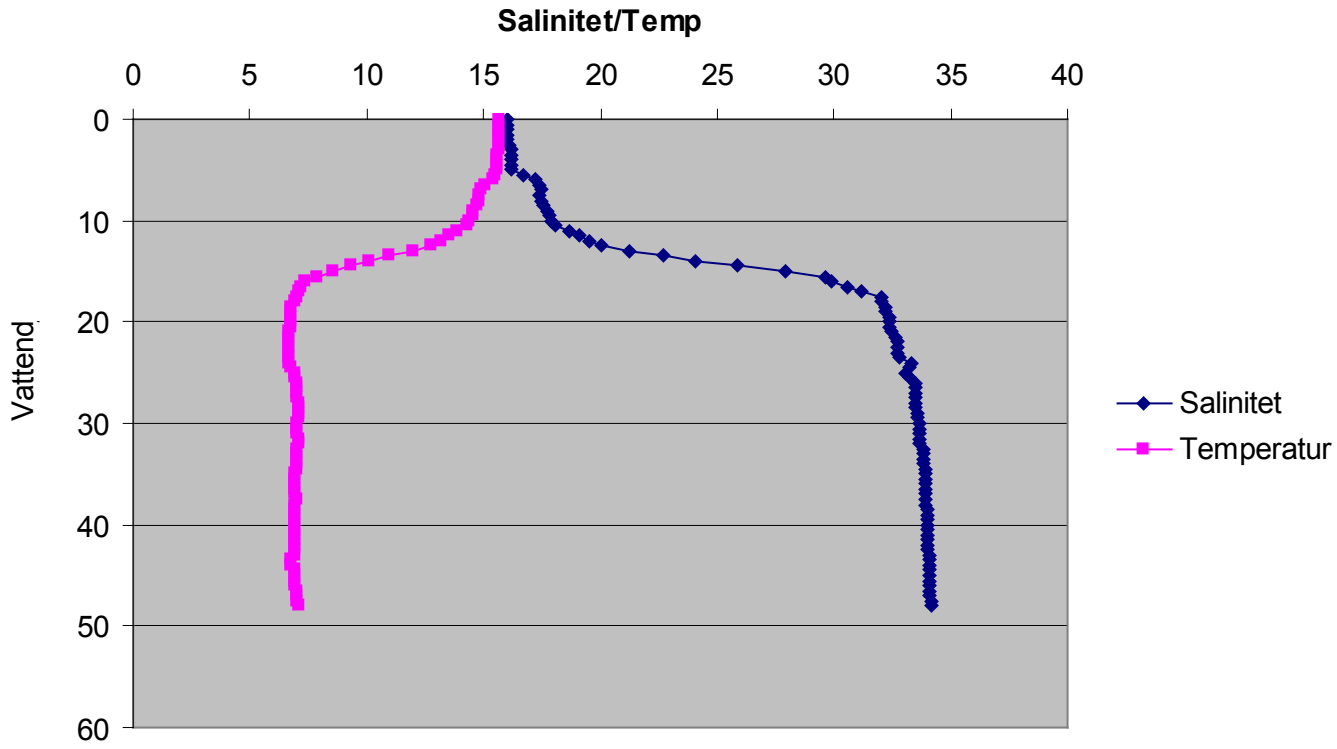
OBSERVATIONSDOKUMENT **Projekt : NMOS14**

Site nr: NMOS14_13 **Prov nr:** 14_0057, 14_0058, 14_0059, 14_0060, 14_0061, 14_0062, 14_0063
Provtagare **Gmax** **Vattendjup (m)** **46.8300**
Position i Sweref 99TM **N: 6284718.3** **E: 0321409.4**

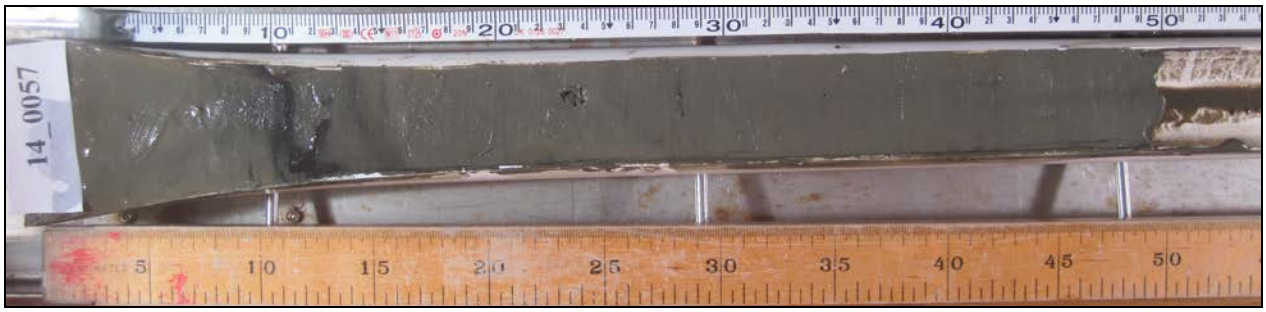
Djup i cm	Lagerföljd	Anmärkning
0-16	Postglacial lergyttja	Reducerade band. Gradvis kontakt mot nästa lager 5Y4/4
16-50	Postglacial gyttjelera	5Y4/2

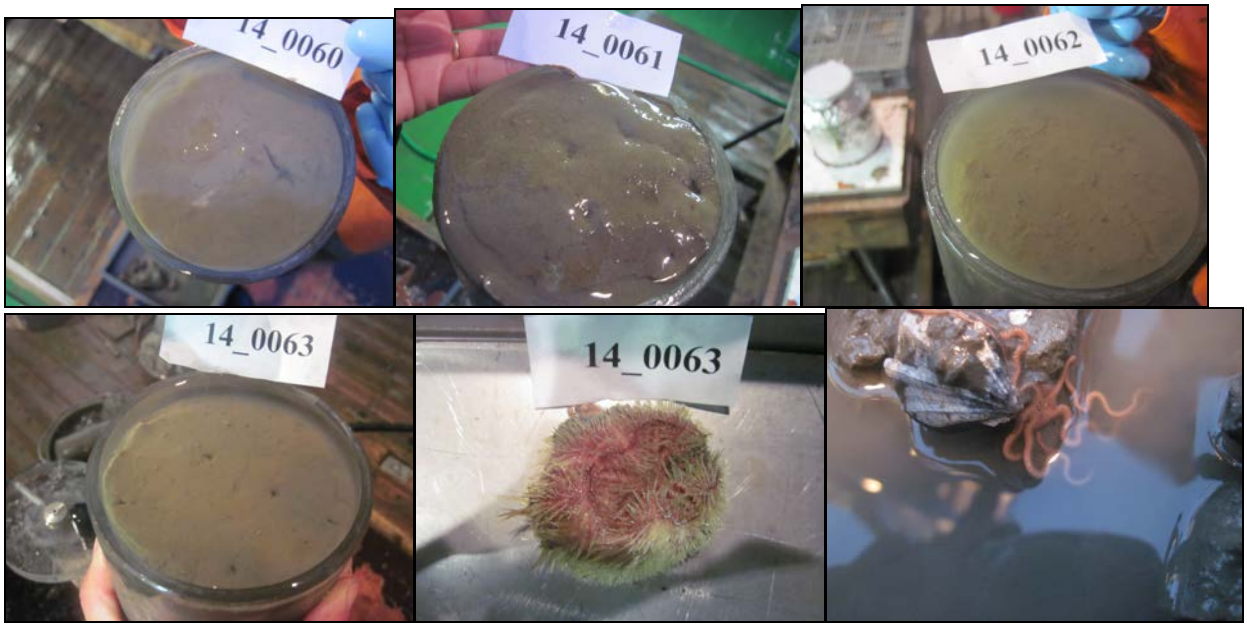
Från prov 14_0059, ormstjärna
Från 14_0063 sjöborre
Vid Rödebank syns ett tydligt språngskikt (haloklin/termoklin) vid omkring 17 m.

Syrgashalt i bottenvattnet: 6.2 ml/liter



Vid Rödebank syns ett tydligt språngskikt (haloklin/termoklin) vid omkring 17 m.





sjöborre Från prov 14_0059, ormstjärna

OBSERVATIONSDOKUMENT

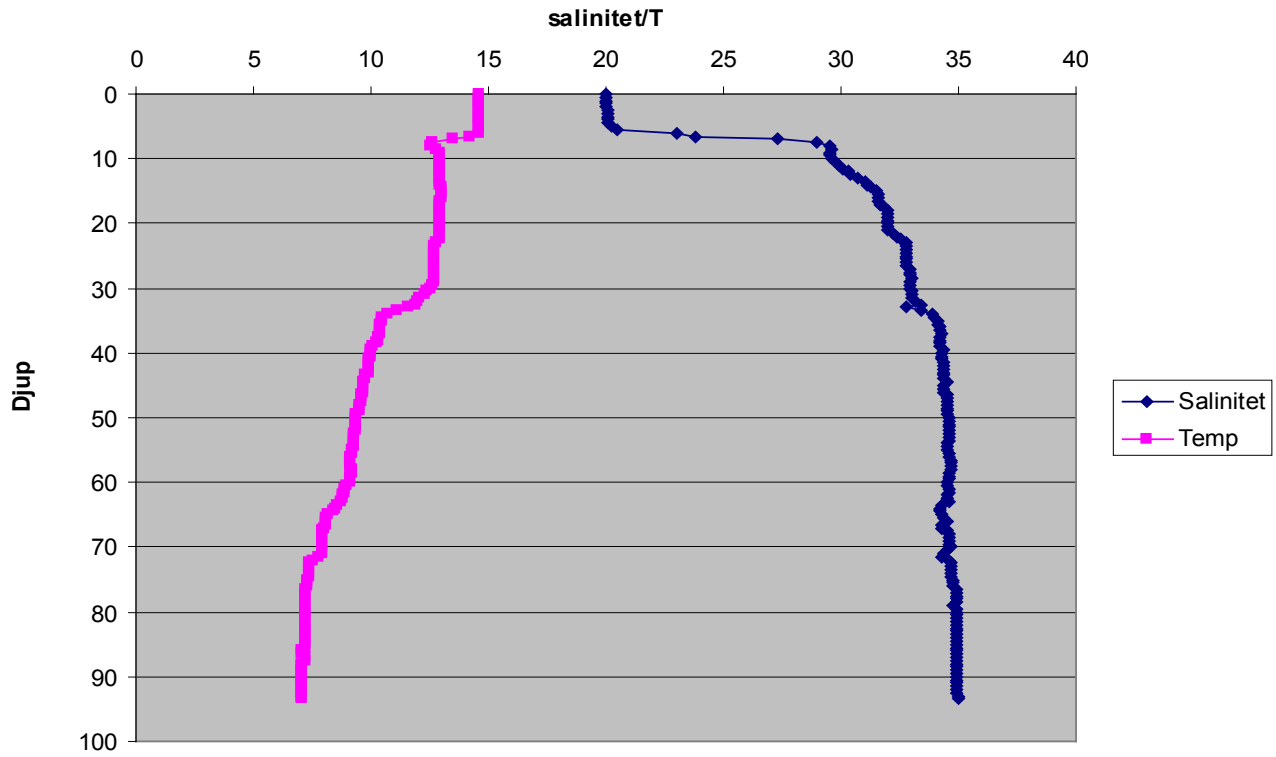
Projekt : NMOS14

Site nr: NMOS14_15 **Prov nr:** 14_0050, 14_0051, 14_0052, 14_0053, 14_0054, 14_0055, 14_0056
Provtagare Gmax **Vattendjup (m)** **90.6200**
Position i Sweref 99TM **N: 6426121.1** **E: 0276800.8**

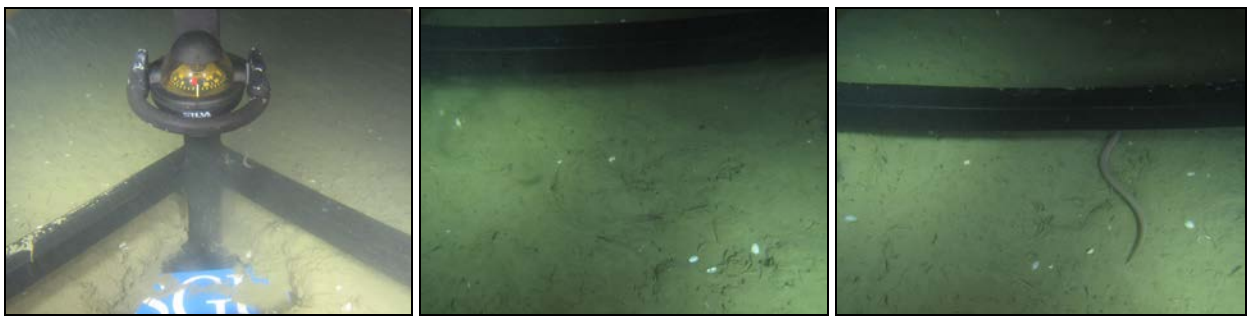
Djup i cm	Lagerföljd	Anmärkning
0-53	Postglacial lergyttja	Oxiderad yta, tätt sulfidlaminerad därunder.,Munsell N2,5/1
		Sedimentytan är full av liv och bioturberas av pirål, små musslor och sjöborrar.
		Det finns rikligt med liv i ytsedimenten. Bioturbation sker ner till omkring 20-30 cm. Polychaeter och sjöborrar finns det rikligt av. Även Pirålen slank med i provtagaren.

Vi har en tydlig halo-/termoklin vid ca 5 m djup.

Syrgashalt i bottenvattnet: 7,4 ml/l

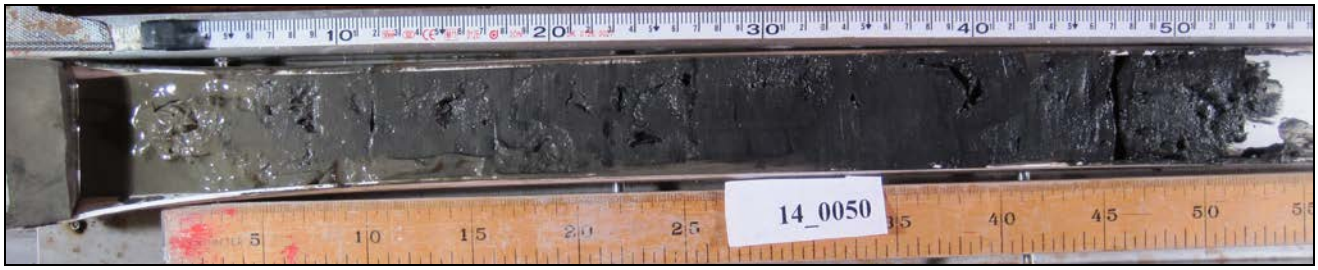


Vi har en tydlig halo-/termoklin vid ca 5 m djup.



Sedimentytan är full av liv och bioturberas av pirål, små musslor och sjöborrar.

SGU
Maringeologi


14_0050


14_0050


14_0051


14_0052


14_0053


14_0054


14_0055


Det finns rikligt med liv i ytsedimenten. Bioturbation sker ner till omkring 20-30 cm. Polychaeter och sjöborrar finns det rikligt av. Även Pirålen slank med i provtagaren.

OBSERVATIONSDOKUMENT

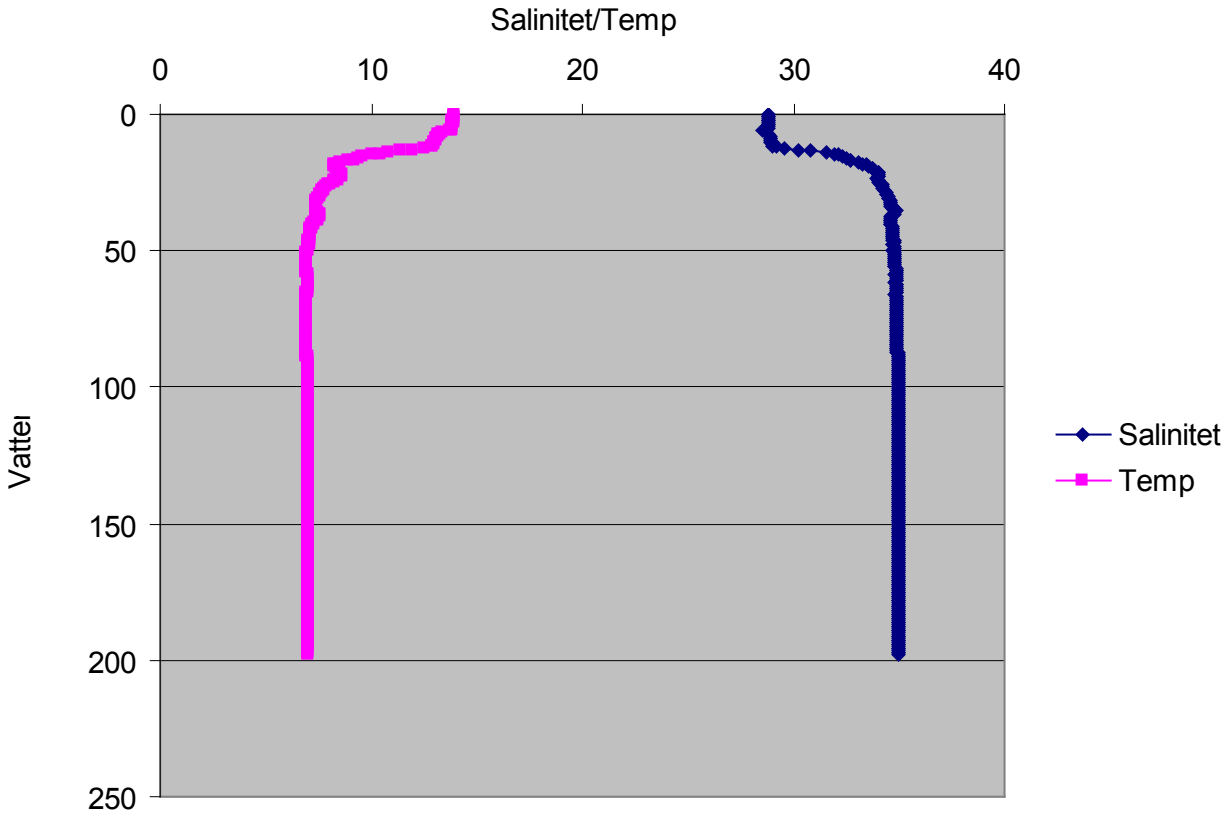
Projekt : NMOS14

Site nr: NMOS14_16_1 **Prov nr:** 14_0043, 14_0044, 14_0045, 14_0046, 14_0047, 14_0048, 14_0049
Provtagare g-max **Vattendjup (m)** **191.2100**
Position i Sweref 99TM **N: 6504575.8** **E: 0236250.9**

Djup i cm	Lagerföljd	Anmärkning
0-29	Postglacial gyttjelera	Reducerade skikt, tunna lamina 5Y4/2
29-31	Postglacial lera	2,5Y3/2
31-47	Postglacial gyttjelera	Reducerade skikt, tunna lamina, något frekventare än i lager 1. 5Y4/2

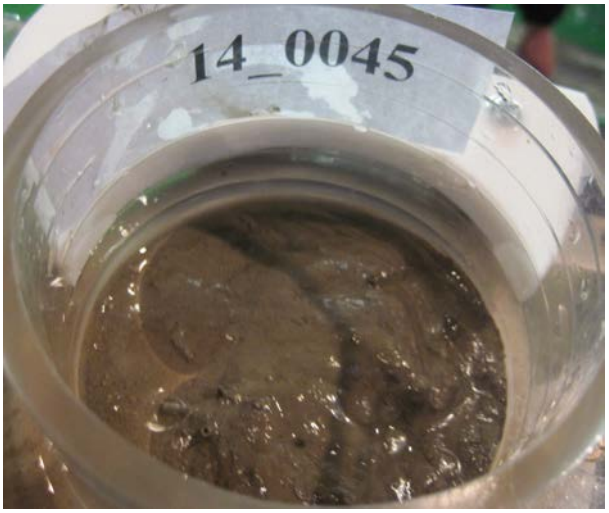
Syrgashalt i bottenvattnet: 7,5 ml/l

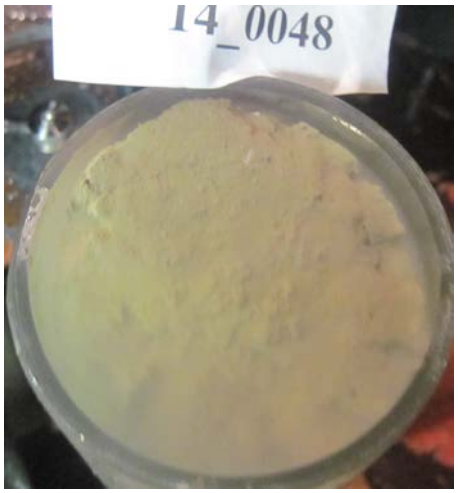
Sedimentytan är oxiderad och bottenvattnet kryllar av liv. Räkor och torskar simmar i ljuset av UV-kamerans spotlights. Bottenytan på stationen är kuperad och inte jämn.



I Djupa rännan syns ett språngskikt (haloklin/termoklin) vid ca 10 m vattendjup.

Ljusare skikt med ej gyttjig postglacial lera på 29-31 cm





Sedimentytorna på samtliga stationer liknar varandra. De är oxiderade och fulla av polycheater och maskar.

APPENDIX 2

Appendix 2. Organic substances analysed in 2014, maximum and minimum values and the number of stations (out of 16) where LOQ has been exceeded.

Chemical name	Acronym	CAS-no	LOQ (ng/g) at 10 g DW	Min > LOQ (ng/g)	Max (ng/g)	LOQ exceeded at number of stations
Pesticides						
3-(3,4-Dichlorophenyl)-1,1-dimethylurea	Diuron	330-54-1	0,15	0,16	0,31	13
2,4-Bis(ethylamino)-6-chloro-1,3,5-triazine	Simazine	122-34-9	0,5	0,91	1	2
2-(tert-Butylamino)-4-(cyclopropylamino)-6-(methylthio)-s-triazine	Irgarol	28159-98-0	0,15	0,23	1,7	6
α-1,2,3,4,5,6-hexachlorocyclohexane	a-HCH	319-84-6	0,01	0,014	0,24	16
β-1,2,3,4,5,6-hexachlorocyclohexane	b-HCH	319-85-7	0,02	0,024	1,1	16
γ-1,2,3,4,5,6-Hexachlorocyclohexane	g-HCH	58-89-9	0,01	0,012	0,13	14
Dichlorodiphenyldichloroethane (p,p' isomer)	pp-DDD	72-54-8	0,02	0,029	4,3	15
Dichlorodiphenyltrichloroethane (p,p' isomer)	pp-DDT	50-29-3	0,02	0,025	0,36	15
Dichlorodiphenyltrichloroethane (o,p' isomer)	op-DDT	789-02-6	0,04			0
1,1-Dichloro-2,2-bis(4-chlorophenyl)ethene (p,p' isomer)	pp-DDE	72-55-9	0,02	0,15	3,4	16
Polycyclic aAromatic Hydrocarbons (PAHs)						
Anthracene		120-12-7	0,01	1	15	16
Fluoranthene		206-44-0	0,12	19	260	16
Naphtalene		91-20-3	0,5	2,5	26	16
Acenaphtylene		208-96-8	1,5	2,6	100	6
Pyrene		129-00-0	0,12	14	230	16
Phenanthrene		1985-01-08	0,2	7,1	84	16
Acenaphtene		83-32-9	0,2	0,52	5,5	6
Dibenz(a,h)anthracene		53-70-3	0,05	6,4	80	16
Chrysene		218-01-9	0,06	15	100	16
Benzo(a)anthracene		56-55-3	0,06	5,8	130	16
Fluorene		86-73-7	0,1	0,6	12	16
Benzo(a)pyrene		50-32-8	0,05	11	220	16
Benzo(b)fluoranthene		205-99-2	0,07	37	190	16
Benzo(ghi)perylene		191-24-2	0,1	43	570	16
Benzo(k)fluoranthene		207-08-9	0,04	14	200	16
Indeno(1,2,3-cd)pyrene		193-39-5	0,2	50	620	16
Dioxins, furanes and dioxin-like PCBs						
2,3,7,8-T4CDD		1746-01-6	0,3			0
1,2,3,7,8-P5CDD		40321-76-4	1,5			0
1,2,3,4,7,8-H6CDD		39227-28-6	1,5			0
1,2,3,6,7,8-H6CDD		57653-85-7	1,5	1,9	2,9	5
1,2,3,7,8,9-H6CDD		19408-74-3	1,5	1,8	2,1	4
1,2,3,4,6,7,8-H7CDD		35822-46-9	1,5	6,7	26	16
1,2,3,4,6,7,8,9-O8CDD		3268-87-9	2,5	19	140	16
2,3,7,8-T4CDF		51207-31-9	0,3	1,1	4,6	16
1,2,3,7,8-P5CDF		57117-41-6	1,5	1,6	3,9	5
2,3,4,7,8-P5CDF		57117-31-4	1,5	1,9	5,7	15
1,2,3,4,7,8-H6CDF		70648-26-9	1,5	1,7	6,5	15
1,2,3,6,7,8-H6CDF		57117-44-9	0,3	0,96	5,1	16
1,2,3,7,8,9-H6CDF		72918-21-9	1,5			0
2,3,4,6,7,8-H6CDF		60851-34-5	1,5	1,6	4,8	14
1,2,3,4,6,7,8-H7CDF		67562-39-4	1,5	8,7	42	16
1,2,3,4,7,8,9-H7CDF		55673-89-7	1,5	1,6	2,8	5
1,2,3,4,6,7,8,9-O8CDF		39001-02-0	2,5	7,1	88	16
3,3',4,4'-T4CB	PCB77	32598-13-3	0,5	5,1	92	16
3,3',4',5-T4CB	PCB81	70362-50-4	0,5	0,59	1,1	8
2,3,3',4,4'-P5CB	PCB105	32598-14-4	1,5	21	92	16
2,3,4,4',5-P5CB	PCB114	74472-37-0	1,5	1,7	3,4	5
2,3',4,4',5'-P5CB	PCB123	65510-44-3	1,5	1,8	29	11
3,3',4,4',5-P5CB	PCB126	57465-28-8	0,5	1,3	6,6	16
2,3,3',4,4',5-H6CB	PCB156	38380-08-4	1,5	8,8	39	16
2,3,3',4,4',5'-H6CB	PCB157	69782-90-7	1,5	2,2	10	16

2,3',4,4',5,5'-H6CB	PCB167	52663-72-6	1,5	5,1	30	16
3,3',4,4',5,5'-H6CB	PCB169	32774-16-6	0,5	0,53	1,7	6
2,3,3',4,4',5,5'-H7CB	PCB189	39635-31-9	1,5	1,6	7,2	16
Chlorinated Biphenyls (PCBs)						
2,4,4'-Trichlorobiphenyl	PCB28	7012-37-5	0,04	0,045	0,54	10
2,2',5,5'-Tetrachlorobiphenyl	PCB52	35693-99-3	0,05	0,067	0,73	16
2,2',4,5,5'-Pentachlorobiphenyl	PCB101	37680-73-2	0,04	0,094	1,4	16
2,3',4,4',5-Pentachlorobiphenyl	PCB118	31508-00-6	0,03	0,14	1,2	16
2,2',4,4',5,5'-Hexachlorobiphenyl	PCB153	35065-27-1	0,03	0,19	2,4	16
2,2',3,4,4',5'-Hexachlorobiphenyl	PCB138	35065-28-2	0,03	0,22	2,2	16
2,2',3,4,4',5,5'-Heptachlorobiphenyl	PCB180	35065-29-3	0,03	0,05	0,97	16
Other chlorinated substances						
Hexachlorobenzene	HCB	118-74-1	0,02	0,21	0,93	16
Hexachlorobutadiene	HCBD	87-68-3	3			0
C10-13-Chloroalkanes	SCCP	-	10			0
C14-C17-Chloroalkanes	MCCP	-	10			0
4,7-Methano-1h-Indene, 1,2,3,4,5,6,7,8,8-Nonachloro-2,3,3a,4,7,7a-Hexahydro-, (1α,2β,3α,3aα,4β,7β,7aα)-	trans-nonachlor	39765-80-5	0,01	0,02	0,28	15
1,2,4,5,6,7,8,8-Octachloro-3a,4,7,7a-tetrahydro-4,7-methanoindane	a-chlordane	5103-71-9	0,01	0,011	0,49	16
2,2,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene	g-chlordane	5103-74-2	0,01	0,015	0,49	16
1,2,3-Triklorbensen		87-61-6	0,2			0
1,2,4-Triklorbensen		120-82-1	0,2	0,3	1,4	10
1,3,5-Triklorbensen		108-70-3	0,2			0
Trichloromethane	Chloroform	67-66-3	4,5			0
Brominated Diphenyl Ethers (BDEs)						
2,2′,4,4′,5,5′-Hexabromodiphenyl ether	PBDE153	68631-49-2	0,025	0,029	0,031	2
2,2′,4,4′,5,6′-Hexabromodiphenyl ether	PBDE 154	207122-15-4	0,025	0,048	0,065	2
2,4,4'-Tribromodiphenyl ether	PBDE 28	41318-75-6	0,025	0,032	0,032	1
2,2′,4,4′-Tetrabromodiphenyl ether	PBDE 47	5436-43-1	0,02	0,035	0,21	16
2,2′,3,4,4′-Pentabromodiphenyl ether	PBDE 85	182346-21-0	0,025	0,063	0,37	15
2,2′,4,4′,6-Pentabromodiphenyl ether	PBDE-100	189084-64-8	0,02	0,022	0,064	6
2,2′,4,4′,5-Pentabromodiphenyl ether	PBDE-99	60348-60-9	0,02	0,024	0,24	14
2,3',4,4'-Tetrabromodiphenyl ether	PBDE-66	189084-61-5	0,025	0,17	0,27	2
2,2',3,4,4',5',6-Heptabromodiphenyl ether	PBDE-183	207122-16-5	0,03			0
Decabromodiphenyl ether	PBDE-209	1163-19-5	0,3			0
Organotin compounds						
Monobutyltin	MBT	78763-54-9	1	1,5	15	12
Dibutyltin	DBT	1002-53-5	1	1,2	9,1	11
Tributyltin compounds	TBT	-	1	6,5	28	8
Monophenyltin	MPhT	2406-68-0	1	1,5	1,9	2
Difenyltenn	DPhT	1011-95-6	1	2,1	2,4	2
Triphenyltin	TPhT	892-20-6	1			0
Monooctyltin	MOT	15231-57-9	1	1,2	4,3	10
Dioctyltin	DOT	15231-44-4	1	1,2	5,5	12
Tricyclohexyltin	TCT	6056-50-4	1			0
Perfluorinated compounds						
Perfluorooctane sulfonate	PFOS	2795-39-3	0,3	0,52	11	16
Perfluorooctane sulfonamide	PFOSA	754-91-6	0,3			0
Perfluorobutane sulfonate	PFBS	29420-49-3	0,3			0
Perfluorohexane sulfonate	PFHxS	432-50-7	0,3			0
Perfluorodecane sulfonate	PFDS	67906-42-7	0,3			0
Perfluorooctanoic acid	PFOA	335-67-1	0,3	0,76	2,4	5
Perfluorohexanoic acid	PFHxA	307-24-4	0,9			0
Perfluorodecanoic acid	PFDA	335-76-2	0,15	0,16	3,5	15
Perfluoroundecanoic acid	PFUnDA	2058-94-8	0,15	0,15	1,8	16
Perfluoroheptanoic acid	PFHpA	375-85-9	0,15	0,16	0,38	5
Perfluorononanoic acid	PFNA	375-95-1	0,3	1,5	6,3	5

Other polluting substances						
4-n-nonylphenol-4		104-40-5	1			0
4-iso- nonylphenol	branched nonyl phenol	-	30	31	150	8
4-n-octylphenol		1806-26-4	1			0
4-tert-octylphenol-5		140-66-9	1	1,3	1,3	1
Diethyl phthalate	DEP	84-66-2	10			0
Diisobutyl phthalate	DIBP	84-69-5	4	13,7	42	6
Dibutyl phthalate	DBP	84-74-2	6	21,6	890	7
Benzyl butyl phthalate	BBP	85-68-7	4	13	164	5
Dioctyl phthalate	DEHP	117-81-7	10	91	590	16
Diisononyl phthalate	DINP	28553-12-0	30	120	260	3
Diisodecyl phthalate	DIDP	26761-40-0	30	120	290	3
Hexabromocyclododecane	HBCDD	-	3			0
Alpha-Endosulfan		959-98-8	0,2			0
Beta-Endosulfan		33213-65-9	0,2			0
Endosulfan sulfate		1031-07-8	0,2			0

Due to very high water content in the surface sediments of the Baltic Sea the limit of quantification might vary and is sometimes higher than the given LOQ values in the table.