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Oskarshamn site investigation

Surface water sampling at Simpevarp 2005

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July 2007

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Abstract

Within the site investigation area at Simpevarp surface water has been sampled from November 2002. After a period of two years with basic sampling in the area the program for sampling was changed in 2005 to a program for monitoring in some of the sites. In 2005 sampling has been conducted at totally 14 sites. Eight of these were sites in streams, two were sites in lakes and four were sites at sea in the coastal area. Sampling was performed on twelve occasions in 2005 and the water was analysed for a large number of parameters. In the lakes and at sea vertical measurements were also taken by a multi parameter probe. All data collected has after an initial control been sent to SKB for storage in their database SICADA.

In this report the results from 2005 was evaluated. The results were similar to the results obtained previous years /Ericsson and Engdahl 2004ab, 2005/. As a consequence of a lower run-off in the autumn 2005 some parameters which correlate well with the run-off differed slightly in the autumn, compared to previous years. This was most pronounced at the stream water sites were the measurements of ions and conductivity were a little bit higher in the autumn 2005.

The data gathered are generally considered to be of high quality but the method used for determination of run-off is probably inexact resulting in lower quality of this data set.

The measurements of chlorophyll with the probe in the lakes are disturbed by the high concentration of humus in the water. Since both humic substances and chlorophyll have similar fluorescence in the wavelength used by the probe the concentration of chlorophyll is highly overestimated by these measurements.

The light sensor of the probe is unable to give zero values even in a complete darkness. This results in readings (which are around 5 µmoles/second/m^2 to high) which are not compensated for in the data set.

Sammanfattning

Provtagning av ytvatten har skett inom platsundersökningsområdet vid Simpevarp från november 2002. Efter två års basprovtagning i området övergick provtagningen under 2005 till ett program för monitering vid något färre provplatser. Under 2005 har provtagning skett vid 14 stationer. Åtta av dessa var i vattendrag, två var i sjöar och fyra var platser i havet. Provtagning genomfördes vid tolv tillfällen under 2005 och ett stort antal parametrar analyserades. I sjöarna och i havet genomfördes även vertikala mätningar med en sond. Alla data som samlades in skickades efter en första kvalitetsgranskning till SKB för lagring i databasen SICADA.

I denna rapport har 2005 års resultat utvärderats. Resultaten liknade de som erhållits vid tidigare års undersökningar /Ericsson and Engdahl 2004ab, 2005/. Som en följd av låga flöden under senare delen av 2005 skiljde sig några parametrar som korrelerar med vattenföringen. Detta var tydligast i vattendragen där mätningarna av joner och konduktivitet visade på något högre värden än normalt under hösten 2005.

De data som samlats in har en generellt hög kvalitet. Tre typer av data har dock bedömts ha en lägre kvalitet.

Den metod som använts för bestämning av flödena i vattendragen är inte exakt. Detta har troligen resulterat i flödesdata av en något sämre kvalitet.

De mätningar av klorofyll som utförts med sonden i sjöarna har blivit störd av den höga halten av humus som förekommer i vattnet. Orsaken är att både humusämnen och klorofyll fluorescerar vid den våglängd som används av sonden för att mäta klorofyllhalten. Detta har resulterat i en kraftig övervärdering av klorofyllhalterna i sjöarna.

Sondens ljussensor ger inte nollvärden i totalt mörker. Detta har resulterat i värden som är ungefär 5 µmol/sekund/m^2 för höga.

Contents

1 Introduction

This document reports the data gained by surface water sampling, which is one of the activities performed within the site investigation at Oskarshamn. The work was carried out in accordance with activity plan AP PS 400-05-001. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

Within the site investigation area at Simpevarp surface water has been sampled from November 2002. In 2005 sampling has been conducted at 14 sites (Figure 1-1 and 1-2). Eight of these were sites in streams, two were sites in lakes and four were sites at sea in the coastal area. Sampling was performed on twelve occasions in 2005 and the water was analysed for a large number of parameters. In the lakes and at sea vertical measurements were also taken by a multi parameter probe. All original results have, after an initial control, been sent to SKB for storage in their primary database SICADA. The results are traceable by the activity plan number.

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

Activity plan	**Number**	**Version**
Hydrogeokemisk och ytekologisk monitering av ytvatten 2005	AP PS 400 05 001	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för ytvattenprovtagningar vid platsundersökningar	SKB MD 900.004	1.0

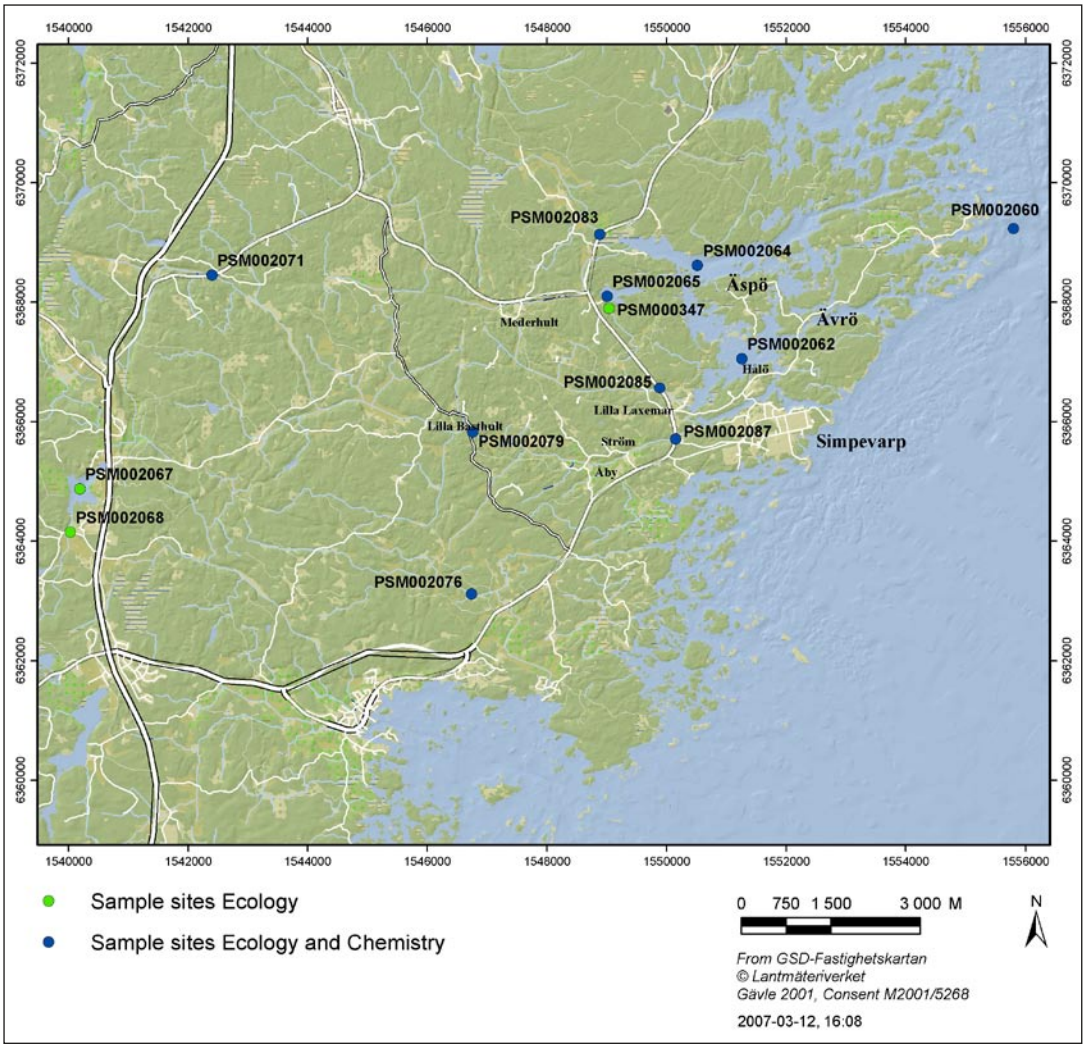

Figure 1-1. *The site investigation area and the sites sampled (January to March).*

Figure 1-2. *The site investigation area and the sites sampled (April to December, PSM002062 was replaced by PSM007097 in May).*

2 Objective and scope

The purpose of the surface water sampling is to characterise the surface water in the site investigation area. A number of streams, lakes and sites in the coastal area were sampled during 2005 (Figure 1-1 and Appendix 1). The sampling was performed once a month and on each sampling occasion all sites planned were sampled during a two day period. (Appendix 2).

The surface water sampling activity consisted mainly of two different programmes, the chemical programme and the ecological programme. The chemical programme included fewer sites and working seasons in comparison with the ecological programme (Appendix 2 and Appendix 3). The working seasons of the two programmes coincided and the sampling was co-ordinated. The ecological programme as well as the chemical basically included the same parameters regardless of the type of water that was sampled (stream, lake or coastal area).

A special control programme comprising limited sites and parameters has been performed at one occasion (Appendix 3), where the accuracy of the analysing laboratories was evaluated.

A number of physical and chemical parameters were measured directly on the spot using a multi-parameter probe (Table 2-1). Water samples were also taken for analysis of further parameters and the samples were later sent to different laboratories.

The large number of sites and parameters analysed have generated a large amount of data, which will later be used for advanced analysis and modelling. In this report the evaluation aims to describe the quality of the data sampled in 2005.

Table 2-1. Parameters measured with the multi-parameter probe 2005.

Parameter	Unit	Parameter	Unit
Date/time	(Y/M/D:hh/mm)	Turbidity	(NTU)
Depth	(m)	Light	(PAR)
Water temperature	(C)	Oxygen	(mg/l)
ph		Chlorophyll	(µg/l)
Conductivity	(mS/cm)	Redox potential	(mV)
Salinity	(ppt)	Atmospheric pressure	(psi)

3 Methods

3.1 Sites and sampling frequency

Sampling was performed on twelve occasions in 2005 (Appendix 2). The total number of sampled sites during 2005 was 14 (8 streams, 2 lakes and 4 sites in the coastal area) but the number of sites was reduced April–December 2005 (Appendix 1). The locations of the sites and the type of sampling programmes are shown in Figure 1-1 and 1-2 and in Appendix 1 and 3.

3.2 Execution of sampling and treatment of samples

Methods used when sampling in the field, calibration procedures, treatments of samples before analysis and how samples was stored and transported to the analysing laboratories, is described in P-report /Ericsson and Engdahl 2004ab/.

During 2005 some changes of the methods and procedures used have occurred. In January 2005, measurements of absorbance (at 436 nm wavelength) at all sites were included in the analysing programme at Äspö Laboratory and in May 2005 measurements of density, also performed by Äspö Laboratory, ceased.

In April 2005 the number of sites to be sampled was reduced from 13 to 8 sites and the chemical programme was introduced at PSM000347 Frisksjöns inlopp. This meant that at all the remaining sites the same sampling programmes were performed. One site in the coastal area (PSM002062 Borholmsfjärden) was moved approximately 300 meters east and got a new ID-code, PSM007097 Borholmsfjärden east. The reason for moving the site was that the new site has a larger depth and it is of interest to get data from this deeper part of Borholmsfjärden.

In May 2005 it was decided that samples for analysis of Radium and Radon would be performed by SUERG (Scottish Universities Environmental Research Centre) instead of IFE, Norway. This was done at one occasion in August 2005, when chemical programme class five was performed.

In August 2005 it was decided that samples for analysis of Lantanoides, trace elements and environmental metals would be analysed at every occasion when the chemical programmes were performed, class 5 as well as class 3. The samples were earlier placed in freezer. This meant that analysis of these parameters was performed at two occasions during 2005 (August and December).

3.3 Analysed parameters and Laboratories used

The analysed parameters and the laboratories used are shown in Table 3-1.

Table 3-1. Analysed parameters and Laboratories used January–December 2005.

Components	Analysing Laboratory
Alkalinity, pH, Conductivity, Anions (I-, Cl, Br, SO_4), Density, Absorbance, HS, Fe II + Fe (tot)	Äspö Laboratory
Standard elements (Na, K, Ca, Mg, Si, Fe, Mn, Li, Sr, TOT-S	Analycen, Lidköping (control)
Standard elements (Na, K, Ca, Mg, Si, Fe, Mn, Li, Sr, TOT-S), $^{10}B/^{11}B$, Iodine, Lantanoides, trace elements, environmental metals, La, In, As	Analytica, Luleå
TOC, DOC, DIC, TOT-NP, POP, PON, POC, $N0_3$, NO_2, NH_4, PO_4, Silicate, Chlorophyll, Oxygen	Department of Systems Ecology Stockholm University
Ra- and Rn-isotopes	SUERG, Scotland

3.4 Documentation

All activities were continuously documented. Notes were taken on field conditions, time of sampling, marking of samples, calibration protocols and so forth. Any deviations from the normal routines were also noted and commented in a report, which was sent to SKB after each sampling occasion. Delivery notes with instructions on which components to analyse were always sent with the samples to the different laboratories. In Table 3-2 a number of documents and files delivered to SKB after a sampling occasion can be viewed.

After analysis the data has continuously been reported from the laboratories. As a routine a first preliminary control of the data quality was performed before sending them for storage in the database SICADA.

The original results were stored in the primary databases (SICADA). It is the data in this database that will be used for further interpretation (modelling). The data is traceable in SICADA by the Activity Plan number (AP PS 400-05-001).

Table 3-2. Delivery of documents and files to SKB after a sampling occasion.

Document/file	Media
WC107 – Surface water measurements	File
Activity diary	Paper
Delivery notes to the laboratories	Paper
Calibration notes for the YSI probe	File
Calibration data and additional parameters	Files
Quality checked data and signed document of field measurements	File and paper
All raw data from measurements in the field	Files
PAR profile data (Photosynthetic Active Radiation)	File
Run off data from the streams	File
Sample comments – Observations in the field	File
Deviation reports	Paper
Document of stored samples in refrigerator and freezer	File
Photos from the sites	Files
Delivery control documents (SKB and internal)	Paper

4 Nonconformities

It was not possible to sample all sites at all occasions (Appendix 4). In January the two lakes were impossible to sample because they were covered with thin ice. In February and Mars 2005 the open sea site PSM002060 was not sampled due to strong winds and high waves. In January, February and Mars 2005 field measurements of light (PAR) with the YSI probe were not possible due to malfunction of the light sensor. During summer and autumn two stream sites were dried up and sampling was not possible. During the year, due to ice and snow or low water levels, run-off could not be measured in some streams.

It is very likely that there was a mix-up between two sample bottles from PSM002062 Borholsmfjärden, surface water and bottom water, when sampling in March 2005. The analysed components from these bottles are Standard elements (Na, K, Ca, Mg, Si, Fe, Mn, Li, Sr, TOT-S). The mix up has probably taken place when filtering the samples in the laboratory. A comment has been made but the results remains in SICADA.

Analytical problems with the analysis of Br occurred during the year. All values analysed between 2005-01-01 and 2005-11-28 were erased if the concentration of Br was grater than 0.2 mg/l at the same time as the concentration of Cl was grater than 100 mg/l. The effect of this was that all values on Br from the sea water sites from 2005 were erased from SICADA, except for the values from week 50.

5 Results and discussion

5.1 Run-off

The run-off was measured on each sampling occasion. In some streams and on some occasions measurements were impossible to perform due to coverage of ice or drought. Average values from 2005 of the run-off from the different stream sites when measurements were performed are presented in Table 5-1. The fact that most of the streams were covered with ice during winter and that drought made measurements impossible during most of the summer and autumn means that the calculated run-off averages in Table 5-1 probably are erroneous for many of the streams. However the average run-off in 2005 was lower than in previous years (Figure 5-1). The main reason was that periods with extremely heavy rain did not occur during 2005.

5.2 Biochemical characterisation

5.2.1 Nutrients

Many of the streams had relatively high concentrations of nutrients (Table 5-2). Highest concentrations were generally measured downstream from farmland areas and in the larger tributaries. These results were similar to those measured in previous years /Ericsson and Engdahl 2005/. At many sites there was a clear tendency for the concentration of nutrient to be higher in the summer than in the winter (Figure 5-2).

Table 5-1. Average run-of at the stream water sites in 2005.

Site number	Run-off (m^3/s)	Site number	Run-off (m^3/s)
PSM002068		PSM002083	0.0619
PSM002071	0.0913	PSM002085	0.0098
PSM002076		PSM002087	0.0736
PSM002079	0.0701	PSM000347	0.0017

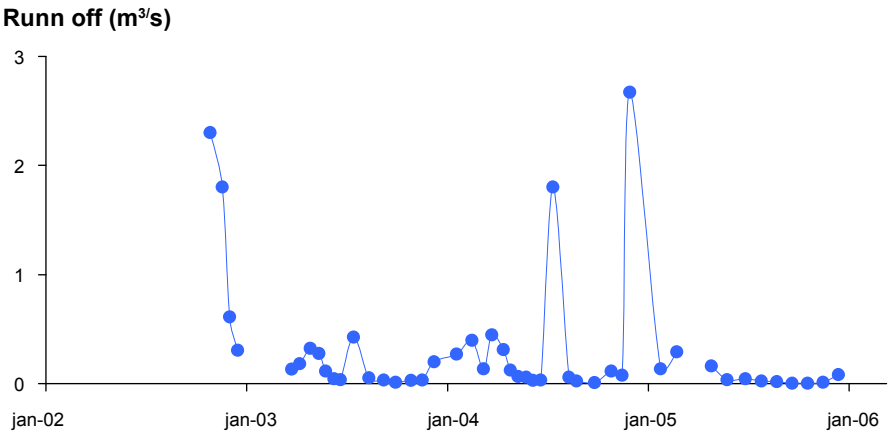

Figure 5-1. *Run-off measured in Laxemarsån (PSM002087) close to the outlet into the sea.*

Table 5-2. Average concentration of nutrients and chlorophyll a from the stream water sites, 2005.

Site number	NH_4-N (mg/l)	NO_3-N/NO_2-N (mg/l)	N-tot (mg/l)	P-tot (mg/l)	PO_4-P (mg/l)	POP (mg/l)	PON (mg/l)	Clorophyll a (µg/l)
PSM002068	0.081	0.131	1.080	0.019	0.002	0.009	0.066	
PSM002071	0.056	0.253	0.939	0.020	0.003	0.009	0.072	
PSM002076	0.140	0.202	1.563	0.042	0.011	0.012	0.093	
PSM002079	0.048	0.236	0.928	0.028	0.005	0.014	0.075	
PSM002083	0.042	0.163	1.098	0.044	0.009	0.025	0.148	2.1
PSM002085	0.100	0.743	2.037	0.054	0.012	0.016	0.085	
PSM002087	0.052	0.268	1.040	0.034	0.006	0.016	0.092	1.8
PSM000347	0.019	0.093	0.841	0.030	0.005	0.013	0.076	

Lake Jämsen (PSM002067) was only sampled twice during winter. This makes a comparison with Lake Frisksjön (PSM002065) difficult (Table 5-3). However the results were similar to previous years (Figure 5-3). In the lakes a larger part of the nutrients were bound to particles (mostly plankton) in the summer month compared to the winter conditions (Figure 5-4).

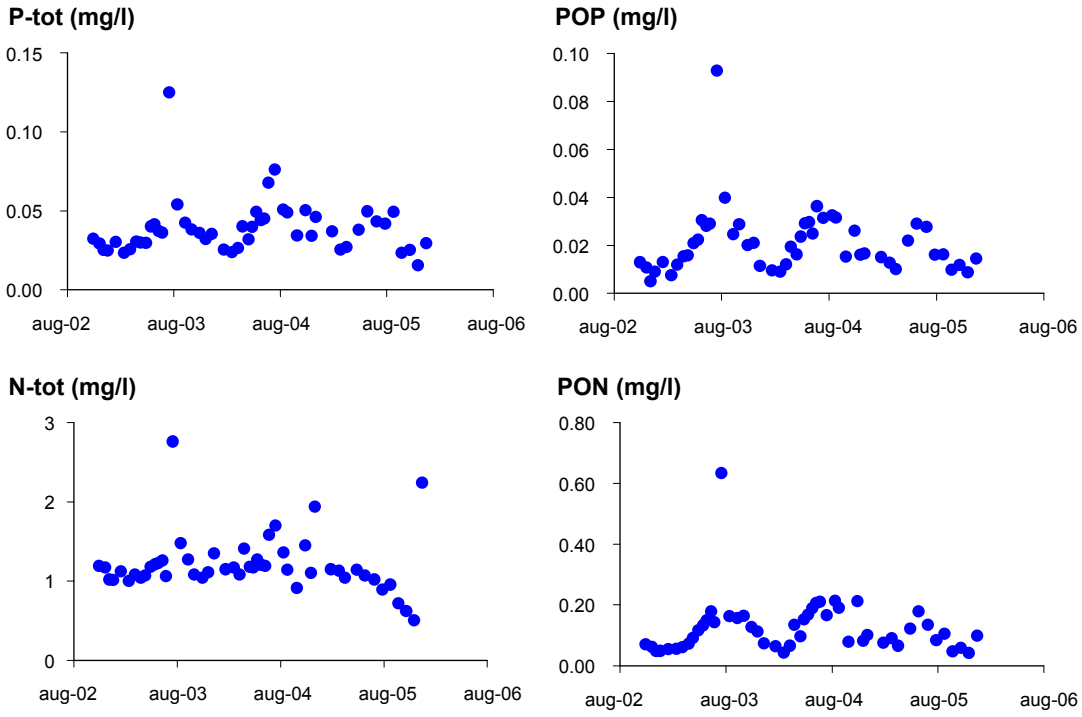

Figure 5-2. *Nutrients measured as total phosphorus, particulate phosphorus, total nitrogen and particulate nitrogen in Laxemarsån (PSM002087).*

Previous years the concentration of nutrients at the sea sites was generally higher at the more secluded sites (PSM002062 and PSM002064) compared to the open sea site PSM002060 /Ericsson and Engdahl 2005/. The results from this year (Table 5-4) were more difficult to interpret because of changes in the program with only one sampling occasion at the open sea site. At the sites there was a tendency for the concentration of ammonium and nitrite/nitrate to be lower in the summer than in the winter (Figure 5-5). The probable reason is higher concentration of plankton but the concentration of chlorophyll a did not vary accordingly (Figure 5-5).

Table 5-3. Average concentration of nutrients and chlorophyll a at the investigated lakes, 2005.

Site number	Depth zone	NH_4-N (mg/l)	NO_3-N/NO_2-N (mg/l)	N-tot (mg/l)	P-tot (mg/l)	PO_4-P (mg/l)	POP (mg/l)	PON (mg/l)	Clorophyll a (µg/l)
PSM002065	Surface	0.145	0.109	1.023	0.027	0.002	0.013	0.123	7.7
PSM002065	Bottom	0.162	0.106	1.020	0.026	0.002	0.011	0.097	6.4
PSM002067	Surface	0.029	0.251	1.060	0.017	0.002	0.008	0.044	0.5
PSM002067	Bottom	0.036	0.405	1.120	0.020	0.002	0.011	0.066	1.2

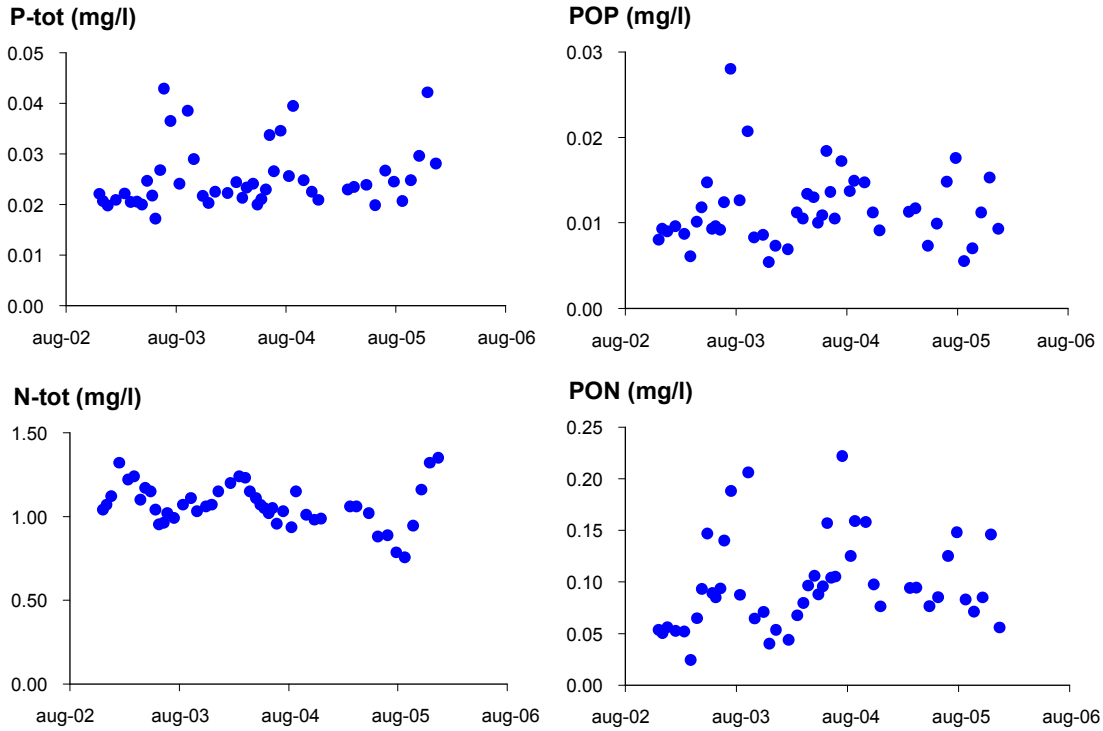

Figure 5-3. *Nutrients measured as total phosphorus, particulate phosphorus, total nitrogen and particulate nitrogen in the surface water of Lake Frisksjön (PSM002065).*

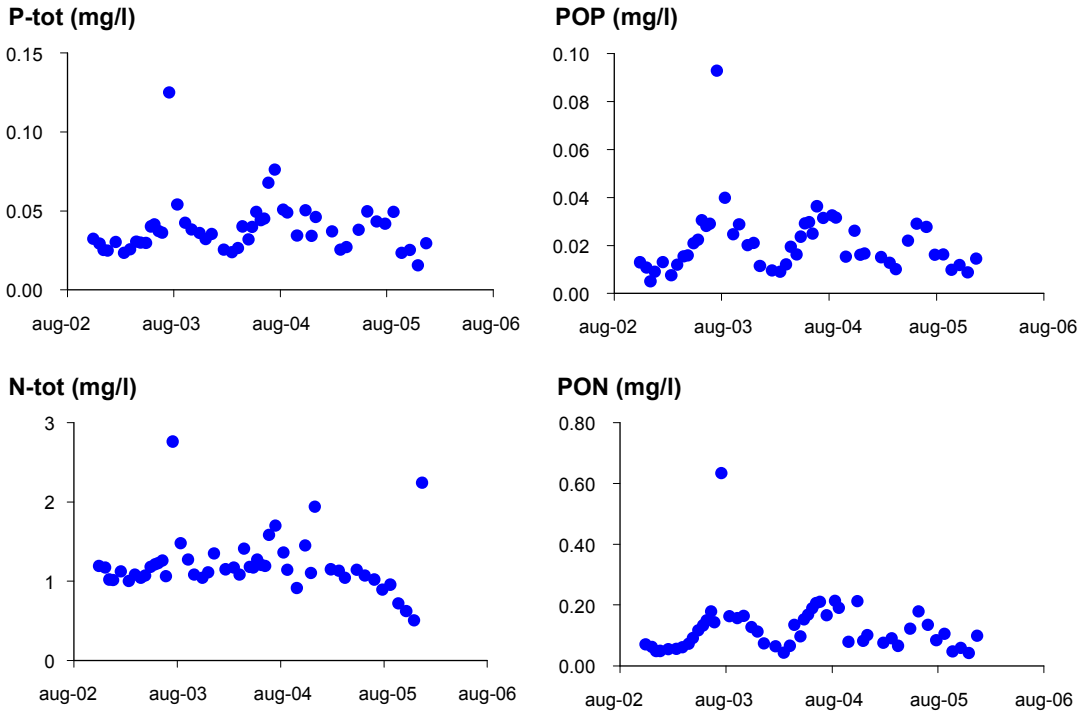

Figure 5-4. *Concentrations of chlorophyll and NO_2-N/NO_3-N in the surface water of Lake Frisksjön (PSM002065).*

Table 5-4. Average concentration of nutrients and chlorophyll a at the investigated sites in the sea, 2005.

Site number	Depth zone	NH_4-N (mg/l)	NO_3-N/NO_2-N (mg/l)	N-tot (mg/l)	P-tot (mg/l)	PO_4-P (mg/l)	POP (mg/l)	PON (mg/l)	Clorophyll a (µg/l)
PSM002060	Surface	0.003	0.049	0.296	0.042	0.035	0.002	0.015	0.4
PSM002060	Bottom	0.002	0.050	0.303	0.044	0.036	0.003	0.023	0.6
PSM002062	Surface	0.021	0.108	0.686	0.028	0.003	0.016	0.073	8.2
PSM002062	Bottom	0.021	0.076	0.523	0.028	0.005	0.012	0.083	5.7
PSM007097	Surface	0.008	0.011	0.497	0.021	0.001	0.013	0.105	4.2
PSM007097	Bottom	0.099	0.007	0.588	0.045	0.006	0.038	0.173	7.0
PSM002064	Surface	0.006	0.029	0.441	0.022	0.003	0.010	0.070	4.2
PSM002064	Bottom	0.142	0.030	0.533	0.061	0.016	0.043	0.077	2.2

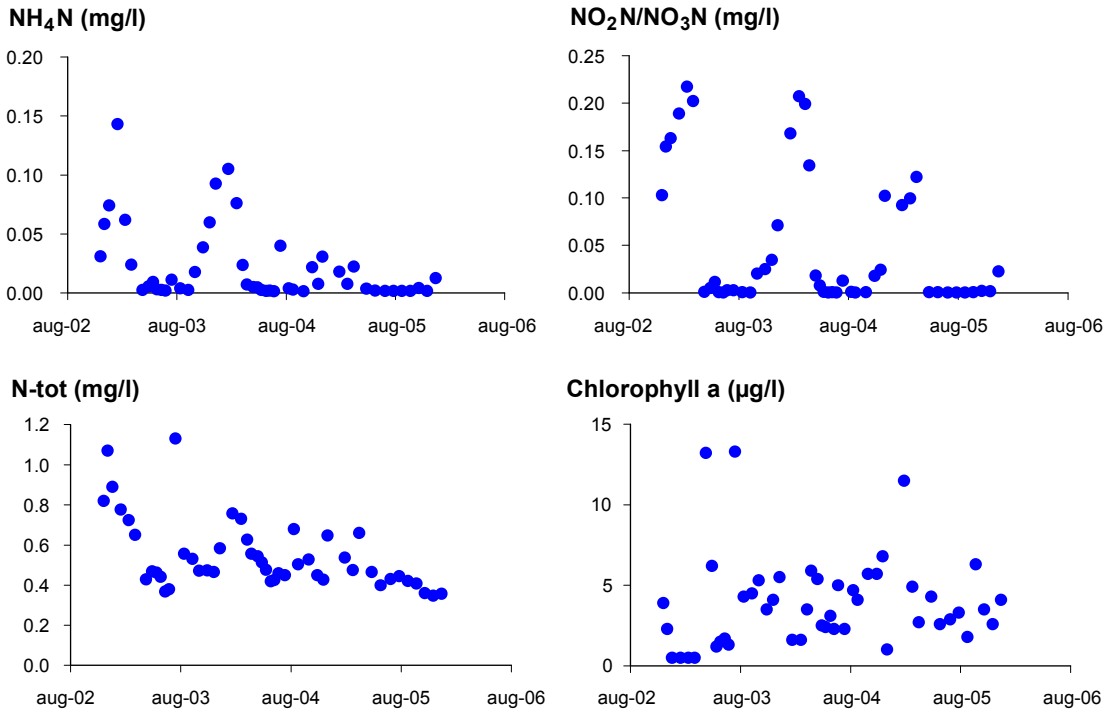

Figure 5-5. *Chlorophyll a and nutrients measured as ammonium, nitrite/nitrate and total nitrogen in the surface water of Granholmsfjärden (PSM002064).*

5.2.2 Carbon fractions

The streams in the area were humic with high concentrations of organic carbons (Table 5-5). At most stream sites there was a tendency of higher concentrations of organic carbon during the summer months (Figure 5-6). There was not any obvious seasonal pattern in the concentrations of DIC (dissolved inorganic carbon) which strongly varied with the run-off (Figure 5-7).

As in the streams the water in the small lakes were strongly coloured with humus. The concentration of TOC (total organic carbon) and DOC (dissolved organic carbon) were high which led to low transparency of the water (Table 5-6). These results were similar to those measured in previous years (Figure 5-8). There was no obvious seasonal variation, neither in the concentration of DOC and TOC (dissolved organic carbon and total organic carbon) or in the transparency (Figure 5-8). A tendency of higher values of POC (particulate organic carbon) in the spring and summer month can probably be explained with higher concentrations of plankton during these months.

Similar to results from previous years the concentrations of organic carbon fractions were higher at the two most secluded sites in the sea (PSM002062, PSM002064 and PSM007097) (Table 5-7). As a consequence the transparency was reduced compared to what is normal for sea water in the area. As in the lakes there was no obvious seasonal pattern of the carbon fractions (Figure 5-9).

Table 5-5. Average concentration of carbon fractions at the investigated stream water sites, 2005.

Site number	Depth zone	POC (mg/l)	DOC (mg/l)	TOC (mg/l)	DIC (mg/l)
PSM002068	Surface	1.11	22.0	22.5	2.57
PSM002071	Surface	1.05	14.9	15.4	2.67
PSM002076	Surface	1.13	25.1	25.1	3.87
PSM002079	Surface	1.03	14.4	14.9	4.27
PSM002083	Surface	1.93	18.9	19.8	4.54
PSM002085	Surface	0.939	20.3	20.8	15.2
PSM002087	Surface	1.19	15.0	15.8	5.13
PSM000347	Surface	0.93	16.7	16.8	4.10

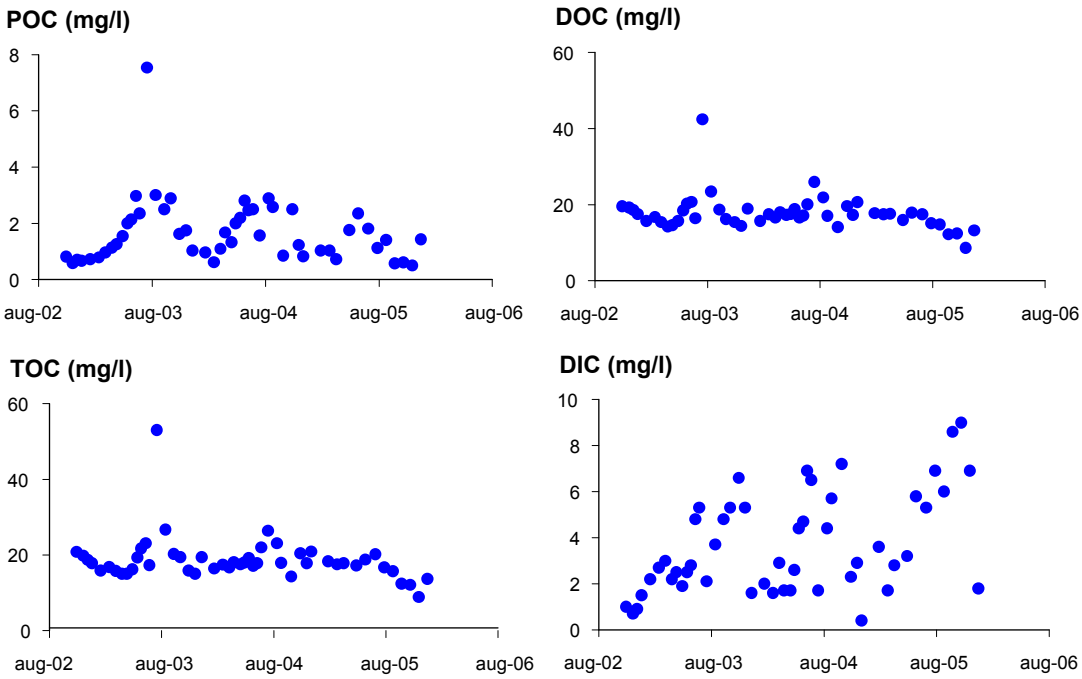

Figure 5-6. Carbon fractions in Laxemarsån (PSM002087).

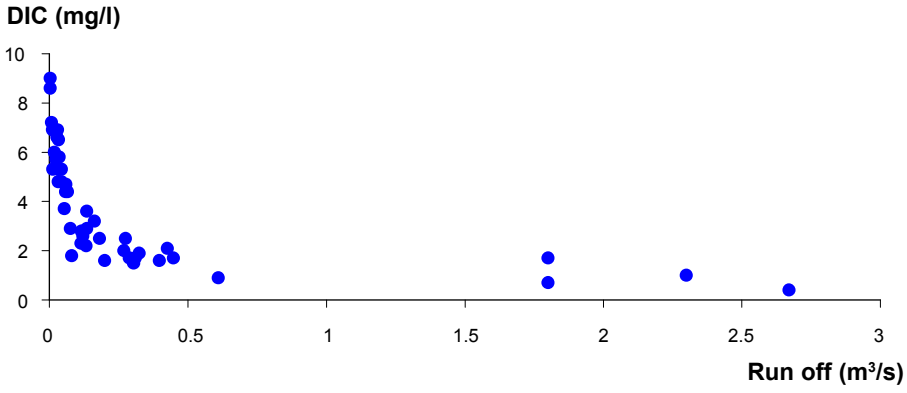

Figure 5-7. The correlation between the concentration of DIC (dissolved organic carbon) and run-off in Laxemarsån (PSM002087).

Table 5-6. Average concentration of carbon fractions and transparency at the investigated lake sites, 2005.

Site number	Depth zone	Depth (m)	POC (mg/l)	DOC (mg/l)	TOC (mg/l)	DIC (mg/l)	Transparency (m)
PSM002065	Surface	0.5	0.943	14.7	15.0	2.39	1.8
PSM002065	Bottom	2.0	0.806	14.4	14.8	2.52	
PSM002067	Surface	0.5	0.575	18.7	19.1	2.85	1.0
PSM002067	Bottom	10	0.904	15.0	15.8	3.80	

Table 5-7. Average concentration of carbon fractions and transparency at the investigated sea sites, 2005.

Site number	Depth zone	Depth (m)	POC (mg/l)	DOC (mg/l)	TOC (mg/l)	DIC (mg/l)	Transparency (m)
PSM002060	Surface	0.5	0.101	4.00	3.80	17.4	10.3
PSM002060	Bottom	29	0.299	3.70	3.80	17.3	
PSM002062	Surface	0.5	0.544	8.70	8.88	12.2	2.1
PSM002062	Bottom	8	0.550	6.65	6.65	14.1	
PSM007097	Surface	0.5	0.723	6.63	6.75	14.9	3.0
PSM007097	Bottom	2.5	1.154	5.56	5.74	17.3	
PSM002064	Surface	0.5	0.525	5.73	5.94	15.5	3.7
PSM002064	Bottom	16	0.643	5.03	5.05	17.8	

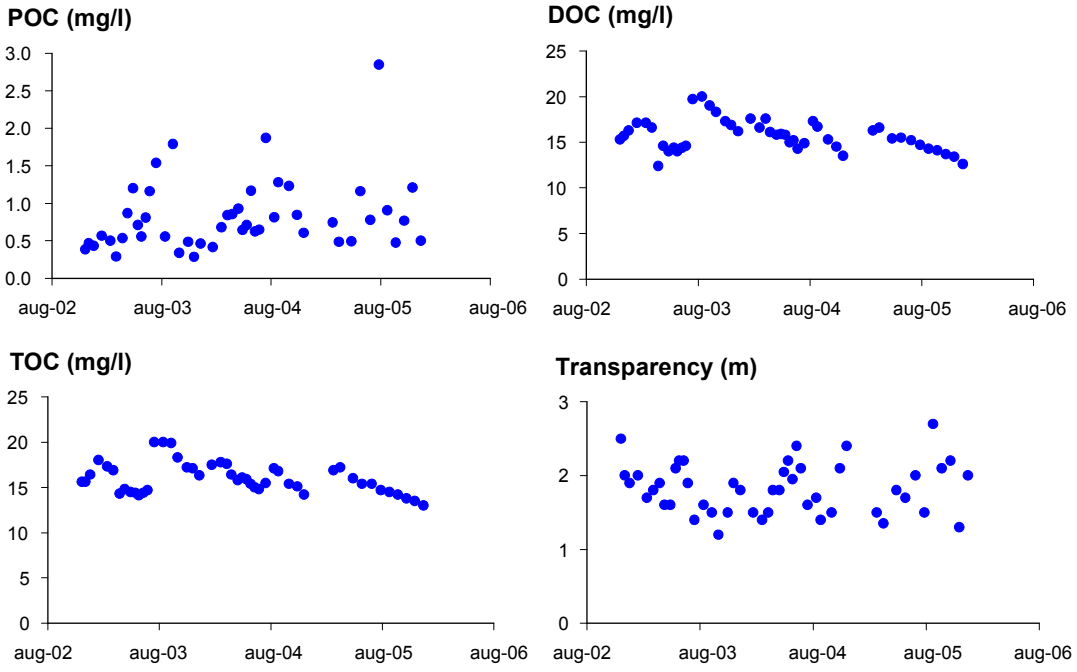

Figure 5-8. *Carbon fractions and transparency of the surface water in Lake Frisksjön (PSM002065).*

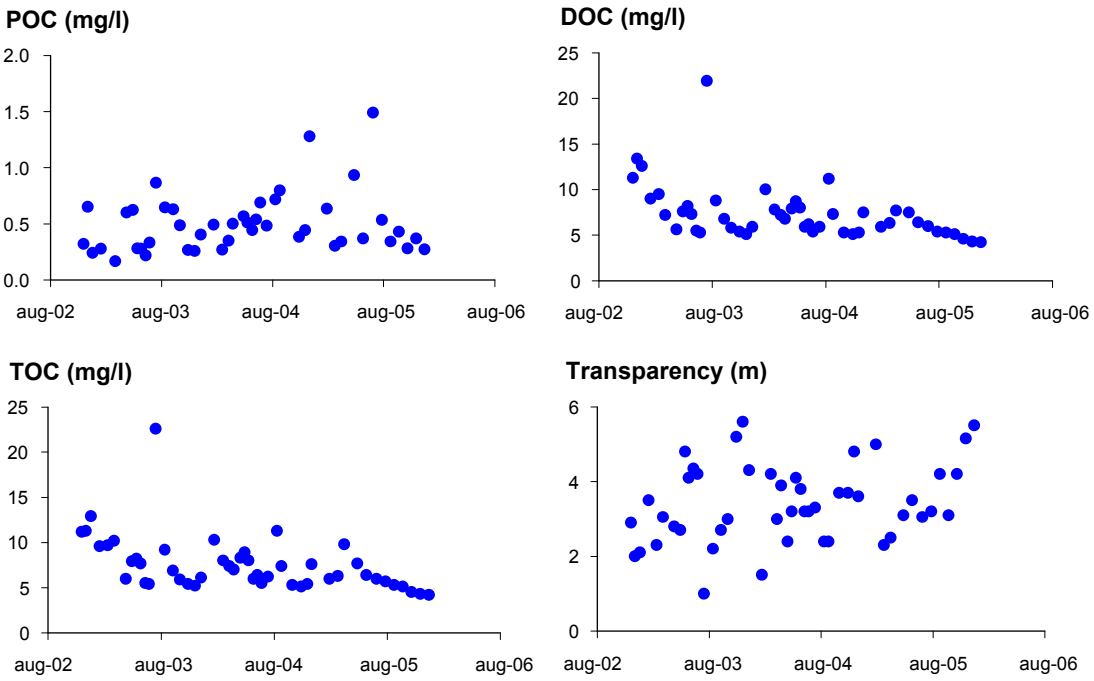

Figure 5-9. *Carbon fractions and transparency of the surface water sea site of Granholmsfjärden (PSM002064).*

5.2.3 Acidification

In the streams HCO_3 and pH strongly correlated with the run-off (Figure 5-10). The minimum concentration of HCO_3 and the minimum pH varied between the streams with a markedly higher value at the site PSM002085 in Ekerumsbäcken, but there is no indication of problems with acidification at the sampled sites (Table 5-8).

Similar to the results from previous years the lakes had relatively high concentrations of HCO_3 and relatively high pH values during 2005 /Ericsson and Engdahl 2005 and Table 5-9/.

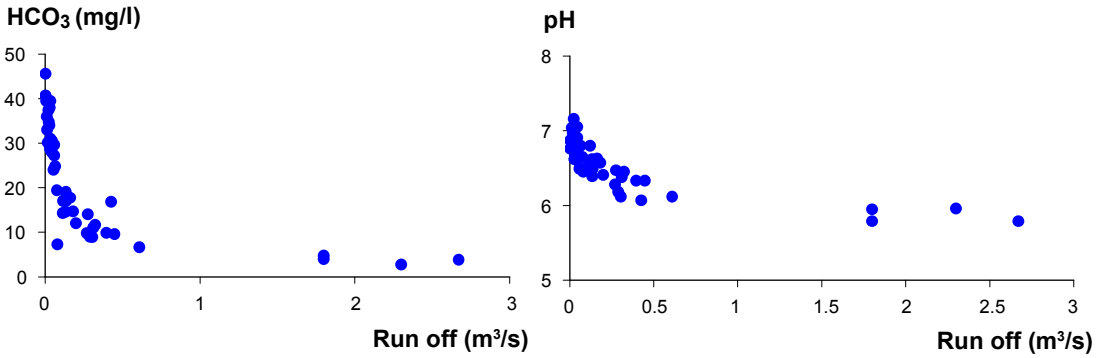

Figure 5-10. *Relation of the concentration of HCO_3 and pH to the run-off at the stream water site Laxemarsån (PSM002087).*

Table 5-8. Minimum concentration of HCO_3 and minimum pH at the stream water sites, 2005.

Site number	Depth zone	HCO_3 mg/l)	pH
PSM002068	Surface	10.8	5.99
PSM002071	Surface	12.0	6.35
PSM002076	Surface	16.0	6.06
PSM002079	Surface	6.2	6.04
PSM002083	Surface	8.2	6.02
PSM002085	Surface	38.3	7.17
PSM002087	Surface	7.3	6.18
PSM000347	Surface	14.0	6.13

Table 5-9. Minimum concentration of HCO_3 and minimum pH in the lakes, 2005.

Site number	Depth zone	Depth (m)	HCO_3 mg/l)	pH
PSM002065	Surface	0.5	11.2	6.21
PSM002065	Bottom	2.0	11.6	6.25
PSM002067	Surface	0.5	13.4	6.25
PSM002067	Bottom	10	15.8	6.36

5.2.4 Oxygen

The concentration of oxygen was quite low at some of the stream water sites (Table 5-10). Low concentrations of oxygen mostly appeared in the summer as a consequence of high water temperature (Figure 5-11).

The oxygen concentration in the bottom water of the lakes was occasionally low or very low (Table 5-11). More or less pronounced thermoclines evolved in both winter and summer. In Lake Frisksjön the thermocline was broken regularly in April and in late autumn but also at other times (probably as a consequence of strong winds). When the thermocline was broken a rapid raise of the oxygen concentration in the bottom water occurred (Figure 5-12).

At the sea sites the concentration of oxygen in the bottom water was occasionally low at the more secluded sites (Table 5-12). Especially the site in Granholmsfjärden showed a similar pattern of thermocline build up and breakage as Lake Frisksjön.

Table 5-10. Minimum, average and maximum concentration of oxygen measured at the stream water sites, 2005.

Site number	Depth zone	Oxygen (min) (mg/l)	Oxygen (aver.) (mg/l)	Oxygen (max) (mg/l)
PSM002068	Surface	8.8	9.6	10.2
PSM002071	Surface	10.0	10.8	11.7
PSM002076	Surface	8.7	9.1	9.6
PSM002079	Surface	6.5	9.2	11.8
PSM002083	Surface	7.0	8.9	10.8
PSM002085	Surface	8.2	11.9	14.1
PSM002087	Surface	5.1	8.8	12.2
PSM000347	Surface	7.2	9.6	11.1

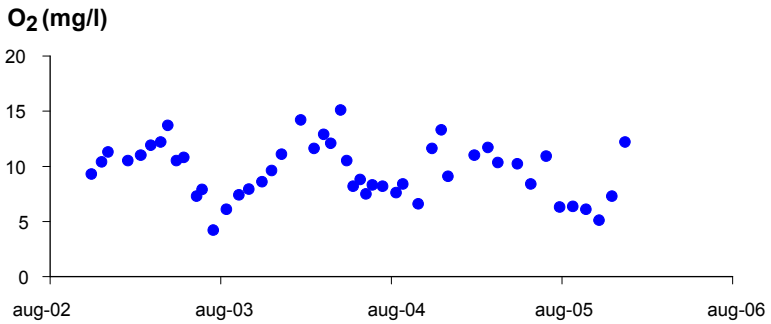

Figure 5-11. Concentration of oxygen at the stream water site Laxemarsån (PSM002087).

Table 5-11. Minimum, average and maximum concentration of oxygen in the surface and bottom water at lake water sites, 2005.

Site number	Depth zone	Oxygen (min) (mg/l)	Oxygen (aver.) (mg/l)	Oxygen (max) (mg/l)
PSM002065	Surface	8.5	9.8	11.1
PSM002065	Bottom	0.6	6.4	10.9
PSM002067	Surface	10.0	10.2	10.4
PSM002067	Bottom	1.8	3.0	4.2

Table 5-12. Minimum, average and maximum concentration of oxygen in the surface and bottom water at the sea water sites, 2005.

Site number	Depth zone	Oxygen (min) (mg/l)	Oxygen (aver.) (mg/l)	Oxygen (max) (mg/l)
PSM002060	Surface	12.3	12.3	12.3
PSM002060	Bottom	11.7	11.7	11.7
PSM002062	Surface	9.9	11.7	12.9
PSM002062	Bottom	3.9	7.3	10.6
PSM007097	Surface	8.7	10.5	13.4
PSM007097	Bottom	0.1	5.5	12.8
PSM002064	Surface	8.5	10.7	13.1
PSM002064	Bottom	0.1	6.1	12.7

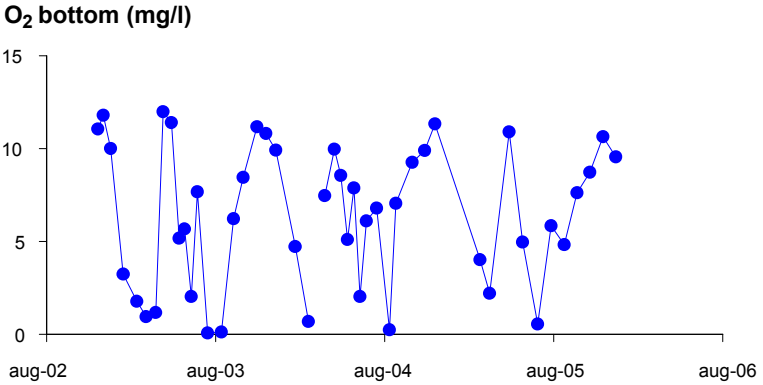

Figure 5-12. Concentration of oxygen in the bottom water of Lake Frisksjön (PSM002065).

5.3 Chemical characterisation

5.3.1 Major ions and conductivity

The concentration of major ions and the conductivity is presented in Tables 5-13 to 5-15. The concentration of ions was similar at most stream sites. The site PSM002068 differed with slightly lower concentrations and lower conductivity. The site PSM002085 had markedly higher concentrations and higher conductivity than the other streams suggesting different composition of the bedrock in the tributary. The concentration of most ions correlated well to the run off (Figure 5-13).

The concentration of ions and conductivity was similar in the two lakes (Table 5-14).

The sea sites differed with lower average concentrations of ions and lower average conductivity at the more secluded sites in Granholmsfjärden and Borholmsfjärden, especially in the surface water. This was probably a consequence of the outflow of fresh water and poor turn over at the more secluded sites. At the open sea site the variation of the ion concentration in the surface water has also been small compared to the variation at the more secluded sites (Figure 5-14 and 5-15).

Table 5-13. Average concentration of major ions and conductivity at the stream water sites, 2005. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	Depth zone	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	HCO_3 (mg/l)	Cl (mg/l)	SO_4 (mg/l)	Br (mg/l)	Conductivity (mS/m)
PSM002068	Surface	3.97	0.807	7.13	1.77	12.9	4.63	6.58	0.200	7.40
PSM002071	Surface	10.2	1.36	8.73	2.37	14.7	17.1	12.3	0.200	12.9
PSM002076	Surface	6.17	0.987	13.4	2.33	20.2	7.80	17.6	0.200	12.4
PSM002079	Surface	13.8	1.81	12.9	3.39	21.7	23.2	18.2	0.200	17.9
PSM002083	Surface	13.4	1.64	13.5	3.14	23.7	17.9	19.4	0.216	18.0
PSM002085	Surface	16.8	1.29	29.1	3.76	86.0	10.9	25.2	0.220	24.8
PSM002087	Surface	14.1	2.12	14.3	3.77	26.2	23.8	19.7	0.202	19.3
PSM000347	Surface	14.8	1.62	9.87	2.37	21.9	21.6	10.6	0.200	15.9

Table 5-14. Average concentration of major ions and conductivity at the lake water sites, 2005. Figures in italic indicate that some individual values in the calculation were below the detection limit of the analysis.

Site number	Depth zone	Depth (m)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	HCO_3 (mg/l)	Cl (mg/l)	SO_4 (mg/l)	Br (mg/l)	Conductivity (mS/m)
PSM002065	Surface	0.5	10.0	1.61	7.06	2.35	13.1	13.6	12.1	*0.202*	12.6
PSM002065	Bottom	2.0	9.95	1.60	7.05	2.35	13.3	12.6	12.0	*0.202*	12.5
PSM002067	Surface	0.5	7.00	1.24	8.30	2.20	14.3	10.2	8.77	*0.200*	10.4
PSM002067	Bottom	10	12.1	1.44	9.80	2.70	17.0	17.7	9.25	*0.200*	13.0

Table 5-15. Average concentration of major ions and conductivity at the sea water sites, 2005. The values on Br are single measurements from week 50.

Site number	Depth zone	Depth (m)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	HCO_3 (mg/l)	Cl (mg/l)	SO_4 (mg/l)	Br (mg/l)	Conductivity (mS/m)
PSM002060	Surface	0.5	2,110	76.5	99.9	248	95.1	3,930	563		1,240
PSM002060	Bottom	29	2,150	77.1	101	255	97.2	4,040	580		1,260
PSM002062	Surface	0.5	1,352	52.4	71.0	165	62.1	2,260	326		741
PSM002062	Bottom	8	1,560	57.3	76.3	179	77.1	3,025	434		969
PSM007097	Surface	0.5	1,699	67.8	88.1	212	83.0	3,226	466	11.7	1,035
PSM007097	Bottom	2.5	1,853	74.4	96.1	230	94.2	3,533	485	12.4	1,113
PSM002064	Surface	0.5	1,776	70.6	90.3	220	84.6	3,398	474	12.4	1,074
PSM002064	Bottom	16	1,923	76.0	97.4	237	94.7	3,648	509	12.2	1,148

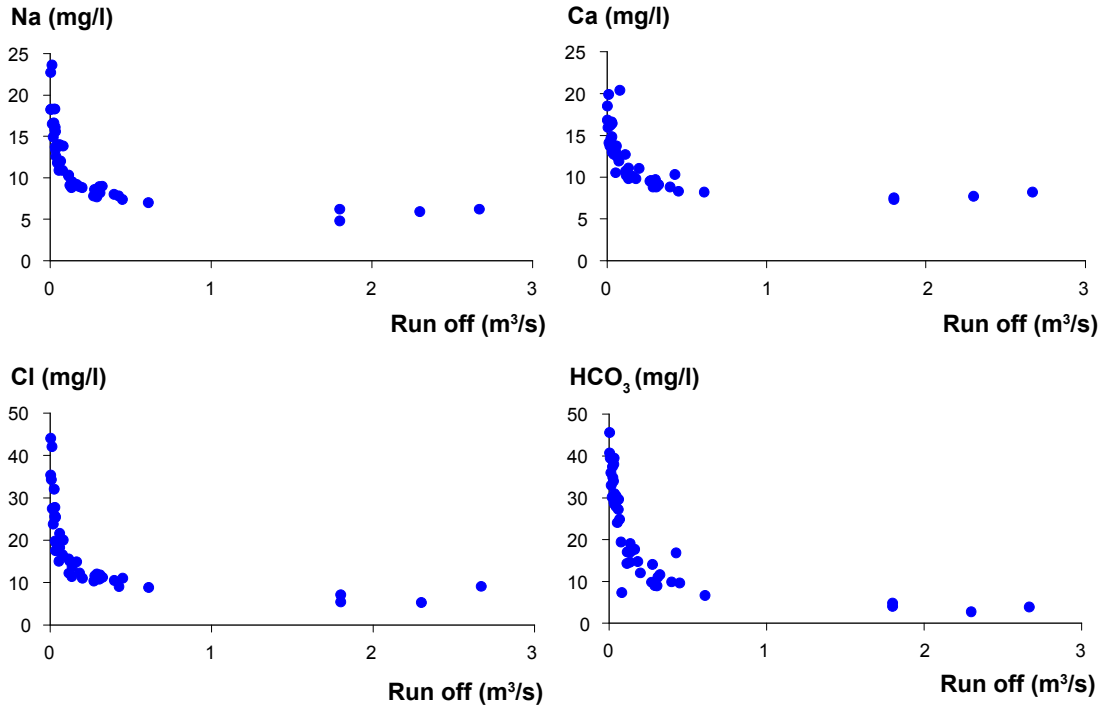

Figure 5-13. *Relation of the concentration of some major ions to the run-off at the stream water site Laxemarsån (PSM002087).*

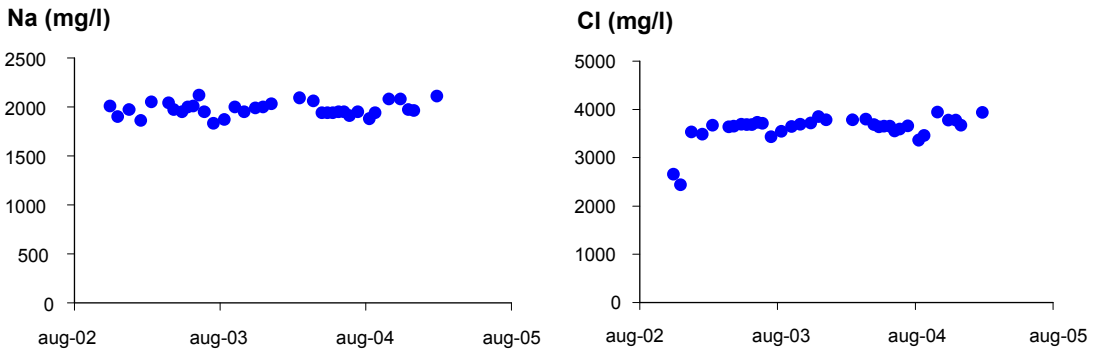

Figure 5-14. *Concentration of Na and Cl in the surface water at the open sea site Kråkelund (PSM002060).*

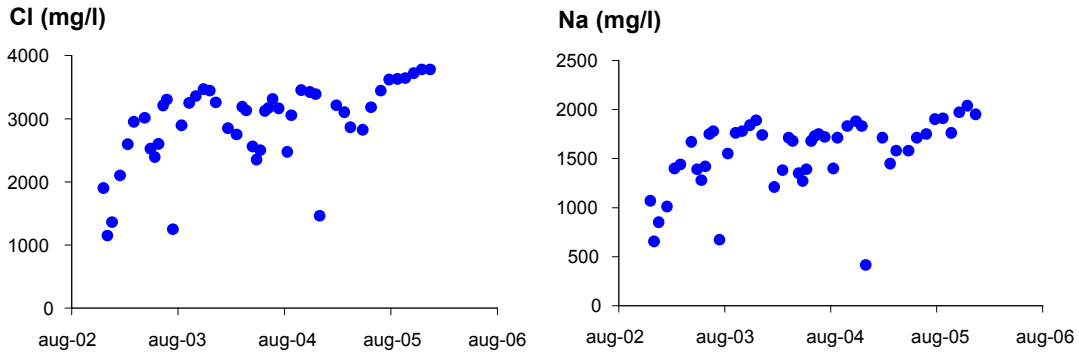

Figure 5-15. *Concentration of Na and Cl in the surface water at the secluded sea site Granholmsfjärden (PSM002064).*

5.3.2 Isotopes

The results of the measurements of isotopes are presented in Table 5-16 to 5-18. For radium all sites had values below the detection limit. These results are considerably lower than the results obtained previous years /Ericsson and Engdahl 2004a, 2005/. The measurements of radon varied between the sites with a markedly higher value at the stream site PSM002083. These results were similar to previous years /Ericsson and Engdahl 2004a, 2005/. The ratio of boron ($^{10}B/^{11}B$) varied only little between the streams and the lakes but at the sea sites the ratio was lower. Similar results were obtained previous years /Ericsson and Engdahl 2004a, 2005/.

Table 5-16. Isotope data from the investigated sites in the streams 2005. Figures in italic indicate that some individual values were below the detection limit of the analysis.

Site number	Depth zone	^{226}Ra (Bq/l)	^{222}Rn (Bq/l)	$^{10}B/^{11}B$ (atomic)
PSM002068	Surface	–	–	–
PSM002071	Surface	–	–	–
PSM002076	Surface	–	–	–
PSM002079	Surface	*0.030*	*0.030*	0.2437
PSM002083	Surface	*0.030*	0.813	0.2428
PSM002085	Surface	–	–	–
PSM002087	Surface	*0.030*	*0.030*	0.2441
PSM000347	Surface	–	–	–

Table 5-17. Isotope data from the investigated sites in the lakes 2005. Figures in italic indicate that some individual values were below the detection limit of the analysis.

Site number	Depth zone	Depth (m)	^{226}Ra (Bq/l)	^{222}Rn (Bq/l)	$^{10}B/^{11}B$ (atomic)
PSM002065	Surface	0.5	*0.030*	*0.030*	0.2435
PSM002065	Bottom	2.0	*0.030*	0.056	0.2444
PSM002067	Surface	0.5	–	–	–
PSM002067	Bottom	10	–	–	–

Table 5-18. Isotope data from the investigated sea sites 2005. Figures in italic indicate that some individual values were below the detection limit of the analysis.

Site number	Depth zone	Depth (m)	^{226}Ra (Bq/l)	^{222}Rn (Bq/l)	^{10}B/^{11}B (atomic)
PSM002060	Surface	0.5	–	–	–
PSM002060	Bottom	29	–	–	–
PSM002062	Surface	0.5	–	–	–
PSM002062	Bottom	8	–	–	–
PSM007097	Surface	0.5	*0.030*	0.111	0.2372
PSM007097	Bottom	2.5	*0.030*	0.077	0.2374
PSM002064	Surface	0.5	*0.030*	*0.030*	0.2369
PSM002064	Bottom	16	*0.030*	0.026	0.2373

5.4 Effect on the results of methodological changes

No major change of methods that could have an effect on the results occurred in 2005.

5.5 Accuracy of data

Data has continuously been assessed after analysis and before storage into SICADA. Generally very few analysing errors or contaminations have been detected and it is our opinion that the data is of high quality.

Two sets of data are of lower quality. The first is the measurements of the run-off at the stream sites. These measurements have been performed with a float method (BIN HR 013) (see methods) which, for many reasons, has been the only possible way to perform measurements of the run-off. The accuracy of this method is quite low compared to measurements with discharge weirs and gauges. The difficulties with measurement of run-off when the stream sites are covered with ice during winter also cause loss of data, which are important to have when calculating transports. The second data set with lower quality is the measurements of chlorophyll performed in the lakes by the multi parameter probe. The problem seems to be that both humic substances and chlorophyll have similar fluorescence in the wavelength used by the probe. Since the inland waters contains high concentrations of humic substances the probe to large proportion measure humic substances as chlorophyll.

Another problem with the probe data is that the sensor measuring photosynthetically active radiation (PAR) is unable to give a zero value, when it is completely dark. The lowest PAR value that the sensor can show seems to be around 5 µmoles/second/m^2. The manufacturer says that this error is due to an electronic mismatch between the probe port and the light sensor and suggests that the offset could be subtracted.

6 References

Ericsson U, Engdahl A, 2004a. Oskarshamn site investigation. Surface water sampling in Simpevarp 2002–2003. SKB P-04-13. Svensk Kärnbränslehantering AB.

Ericsson U, Engdahl A, 2004b. Oskarshamn site investigation. Surface water sampling in Oskarshamn October 2003 to February 2004. SKB P-04-75. Svensk Kärnbränslehantering AB.

Ericsson U, Engdahl A, 2005. Oskarshamn site investigation. Surface water sampling at Simpevarp 2004. SKB P-05-118. Svensk Kärnbränslehantering AB.

Appendix 1

Sites, co-ordinates and sampling depths

Sites, depths and co-ordinates January 2005–March 2005.

ID-code	Name	Type of water	Co-ordinate X	Co-ordinate Y	Sampling depth (m)
PSM002060	Kråkelund	Sea	636924	155580	0.5–29
PSM002062*	Borholmsfjärden	Sea	636706	155126	0.5–3
PSM002064	Granholmsfjärden	Sea	636862	155052	0.5–17
PSM002065	Frisksjön	Lake	636810	154901	0.5–3
PSM002067	Jämsen	Lake	636490	154019	0.5–11
PSM002068	Köksmåla	Stream	636416	154002	0.1
PSM002071	Plittorp	Stream	636845	154238	0.1
PSM002076	Övrahammar	Stream	636312	154673	0.1
PSM002079	Kvarnstugan	Stream	636583	154674	0.1
PSM002083	Smedtorpet	Stream	636912	154888	0.1
PSM002085	Ekerum	Stream	636656	154986	0.1
PSM002087	Ekhyddan	Stream	636570	155012	0.1
PSM000347	Frisksjöns inlopp	Stream	636791	154904	0.1

* PSM002062 was sampled January–April 2005.

Sites, depths and co-ordinates April 2005–December 2005.

ID-code	Name	Type of water	Co-ordinate X	Co-ordinate Y	Sampling depth (m)
PSM007097*	Borholmsfjärden east	Sea	636714	155156	0.5–7.0
PSM002064	Granholmsfjärden	Sea	636862	155052	0.5–17
PSM002065	Frisksjön	Lake	636810	154901	0.5–3
PSM002079	Kvarnstugan	Stream	636583	154674	0.1
PSM002083	Smedtorpet	Stream	636912	154888	0.1
PSM002085	Ekerum	Stream	636656	154986	0.1
PSM002087	Ekhyddan	Stream	636570	155012	0.1
PSM000347	Frisksjöns inlopp	Stream	636791	154904	0.1

* PSM007097 was sampled May–December 2005.

Appendix 2

Schedule – Surface water sampling, weekly working seasons

Sampling occations and programme Jan 2005–Dec 2005.

Month Programme	Jan Week nr	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Ecological	4	8	11	17	21	26	30	34	38	42	46	50
Chemical (class 3)			11		21							50*
Chemical (class 5)								34*				
Control			11									

* Package 5 (Lantanoides, environmental metals, trace elements, In, La, As) was also anlysed.

Appendix 3

Programmes performed at the different sites

Sites and programmes 2005.

ID-code	Name	Type of water	Ecological programme	Chemical programme	Control programme
PSM002060	Kråkelund	Sea	X	X	
PSM002062	Borholmsfjärden	Sea	X	X	
PSM007097	Borholmsfjärden east	Sea	X	X	
PSM002064	Granholmsfjärden	Sea	X	X	X
PSM002065	Frisksjön	Lake	X	X	X
PSM002067	Jämsen	Lake	X		
PSM002068	Köksmåla	Stream	X		X
PSM002071	Plittorp	Stream	X		
PSM002076	Övrahammar	Stream	X	X	
PSM002079	Kvarnstugan	Stream	X	X	
PSM002083	Smedtorpet	Stream	X	X	
PSM002085	Ekerum	Stream	X	X	
PSM002087	Ekhyddan	Stream	X	X	
PSM000347	Frisksjöns inlopp	Stream	X	April–Dec	

Appendix 4

Sampling sites and weeks when not sampled

Sampling start for the sites and weeks when not sampled 2005.

ID-code	Name	Type of water	Sampling start (week)	Weeks when not sampled	Comment
PSM002060*	Kråkelund	Sea	44-2002	8, 11	Stormy weather
PSM002062**	Borholmsfjärden	Sea	47-2002		
PSM007097***	Borholmsfjärden east	Sea	21-2005		
PSM002064	Granholmsfjärden	Sea	47-2002		
PSM002065	Frisksjön	Lake	47-2002	4	Unsafe ice
PSM002067*	Jämsen	Lake	44-2002	4	Unsafe ice
PSM002068*	Köksmåla	Stream	47-2002		
PSM002071*	Plittorp	Stream	49-2002		
PSM002076*	Övrahammar	Stream	49-2002		Dried up
PSM002079	Kvarnstugan	Stream	47-2002		
PSM002083	Smedtorpet	Stream	44-2002		
PSM002085	Ekerum	Stream	44-2002	30, 34, 38, 42, 46	Dried up
PSM002087	Ekhyddan	Stream	44-2002		
PSM000347	Frisksjöns inlopp	Stream	04-2005	30, 34, 38, 42, 46, 50	Dried up

* Sample period: January–March 2005.

** Sample period for PMS002062: January–April 2005.

*** Sample period for PMS007097: May–December 2005.