

Site investigation SFR

Vegetation in streams in the Forsmark area

Eva Andersson, Svensk Kärnbränslehantering AB

Karin Aquilonius, Lena Sivars Becker,
Studsvik Nuclear AB

Mikael Borgiel, Sveriges Vattnekologer AB

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Svensk Kärnbränslehantering AB

Swedish Nuclear Fuel
and Waste Management Co

Box 250, SE-101 24 Stockholm
Phone +46 8 459 84 00



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Summary

The streams in the model area of Forsmark have previously been thoroughly investigated regarding water chemistry, hydrology, bottom substrate, flooding, percentage coverage of macrophytes and fish migration. Retention of radionuclides in a stream ecosystem is assumed to occur by sorption to sediments or by uptake of radionuclides by macrophytes and it is therefore of interest to know the biomass and production of macrophytes in the streams included in a safety assessment. The general aim of this study was to examine the relation between biomass and the percentage cover of vegetation in streams in the Forsmark area. In this study streams within and nearby the candidate area in Forsmark was investigated. The somewhat larger streams Forsmarksån and Olandsån nearby the candidate area, are assumed to be more similar to future streams developing in Forsmark due to landrise, than the smaller streams present in the candidate area today.

In total 22 vegetation samples were gathered in order to estimate the biomass at the sites. Percentage coverage of macrophytes, and dominating species were noted and the above ground macrophytes were sampled for biomass analysis. In the smaller streams, the biomass varied between 6 and almost 358 g dry weight per square metre. In the larger streams, the dry biomass varied between 0 and 247 g dry weight per square meter. There were no significant difference between macrophyte biomass in smaller and the larger stream. In total 13 macrophyte species were found. The biomass dry weight at 100% covering degree varied depending on macrophyte species.

Although this was a rather small study, it is evident that the biomasses do vary a wide range between sampling squares in the area. However, although it may be difficult to use this data set to estimate the biomass in a specific square meter in the stream section, the relation between biomass weight and covering degree is sufficient to be used when fitting biomass to macrophyte coverage for entire stream sections, and would probably give a reasonable fair estimate of the magnitude of total macrophyte biomass in the streams in the area.

The larger streams in the area could have more or less macrophytes than the smaller streams. However, since the photic depth comprised the whole stream bed even in stream Forsmarksån lacking macrophytes, this indicates that the stream bed at this site is dominated by attached microalgae rather than macrophytes and/or that suitable bottom substrate is lacking. Further investigations estimating occurrence of benthic microalgae could confirm this.

Sammanfattning

Tidigare undersökningar av vattendrag i Forsmarksområdet inkluderar mindre vattendrag i kandidatområdet. Dessa vattendrag är undersökta med avseende på vattenkemi, bottensubstrat, fiskvandring och makrofyttutbredning. Då retention av radionuklider i vattendrag kan ske genom upptag av radionuklider i makrofyter är det av intresse i säkerhetsanalyser att veta biomassan av makrofyter, och inte enbart utbredningen. Denna undersökning syftar huvudsakligen till att hitta ett samband mellan täckningsgrad och biomassa, för makrofyter i vattendrag. Inom denna undersökning utfördes kompletterande undersökningar av makrofyter i vattendrag inom såväl kandidatområdet samt i större vattendrag i kandidatområdets närområde. Landhöjningen i området kommer ge upphov till att nya större vattendrag bildas i Forsmark som troligen mer kommer likna de större vattendragen Forsmarksån och Olandsån i närområdet än de mindre vattendragen inom kandidatområdet.

Totalt togs 22 makrofytprover där våtvikt, torrsvikt och täckningsgrad undersöktes. Torrsvikten av makrofyter i de mindre vattendragen varierade mellan 6 och 358 g torrsvikt per kvadratmeter. Torrsvikten i de större vattendragen varierade mellan 0 och 247 g torrsvikt per kvadratmeter och det var ingen signifikant skillnad mellan biomassan av makrofyter i stora och små vattendrag. Totalt förekom 13 stycken arter av makrofyter. Torrsvikten vid 100 % täckningsgrad varierade mycket beroende av vilken art makrofyter som växte i det aktuella avsnittet av vattendraget. Även om korrelationen mellan täckningsgrad och biomassa inte är tillförlitlig nog att avgöra den exakta biomassan på en bestämd plats så kan den sett över hela vattendraget ge en realistisk bild över storleksordningen på den totala biomassan i vattendraget.

På de två lokalerna i de större vattendragen som undersöktes, Forsmarksån och Olandsån, växte det makrofyter enbart på den ena lokalen. Där var dock biomassan och täckningsgraden hög. På båda lokalerna omfattade den fotiska zonen hela strömfåran, vilket indikerar att fotosyntes kan förekomma. På lokalen i Forsmarksån, kan till exempel substratkvalitet eller höga flödes hastigheter vara orsak till att inga makrofyter rotat sig där, i stället dominerar troligen lokalen av epilitska alger (mikroalger som sitter fast på ytan av steniga bottenar).

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1 Introduction

SKB is conducting investigations prior to a future enlargement of the SFR repository for low- and medium level nuclear waste situated close to Forsmark nuclear power plant in the Östhammar community. These investigations are concentrated on specific issues of importance for the safety assessment for the enlargement of the SFR-repository. This study is part of a larger investigation program.

The general aim of this study was to examine the relation between biomass and the percentage cover of vegetation in streams. This document reports the performance and results from sampling of vegetation in streams in the Forsmark area. The work was carried out in accordance with activity plan AP SFR-10-006. The sampling of macrophyte vegetation comprised several sites. Representatives of smaller streams were the in- and outlet of Lake Eckarfjärden, and representatives of larger water courses were the Forsmarksån and the Olandsån.

The streams in the model area of Forsmark has been thoroughly investigated regarding water chemistry, hydrology, bottom substrate, flooding, percentage coverage of macrophytes and fish migration /Carlsson et al. 2005, Brydsten and Strömgren 2005, Sonesten 2005, Juston et al. 2007, Tröjbom and Nordén 2010, summarised in Andersson 2010/. In earlier investigations of stream vegetation, the percentage coverage of the stream bed by macrophytes has been noted in some of the smaller streams in the Forsmark area (see Figure 1-1), but this has not been correlated to biomass. Retention of radionuclides in a stream ecosystem is assumed to occur by sorption to sediments or by uptake of radionuclides by macrophytes, and it is therefore of interest to know the biomass and production of macrophytes in the streams included in a safety assessment. The annual production of macrophytes can roughly be assumed to equal the annual maximum biomass. This study investigates the biomass of macrophytes in the end of summer which is thus assumed to also equal the annual production of macrophytes in the Forsmark streams.

Due to landrise, new larger streams will form in the Forsmark area which may more closely resemble the larger streams Forsmarksån and Olandsån than the present small streams in the model area. In order to be able to estimate biomass in modelled future streams, the streams Forsmarksån and Olandsån were included in this study. One station each in Forsmarksån and Olandsån was investigated with regard to depth, width, macrophyte coverage and biomass. The stations were chosen from sites that have earlier been part of a national water testing programme /Brunberg and Blomqvist 1998/.

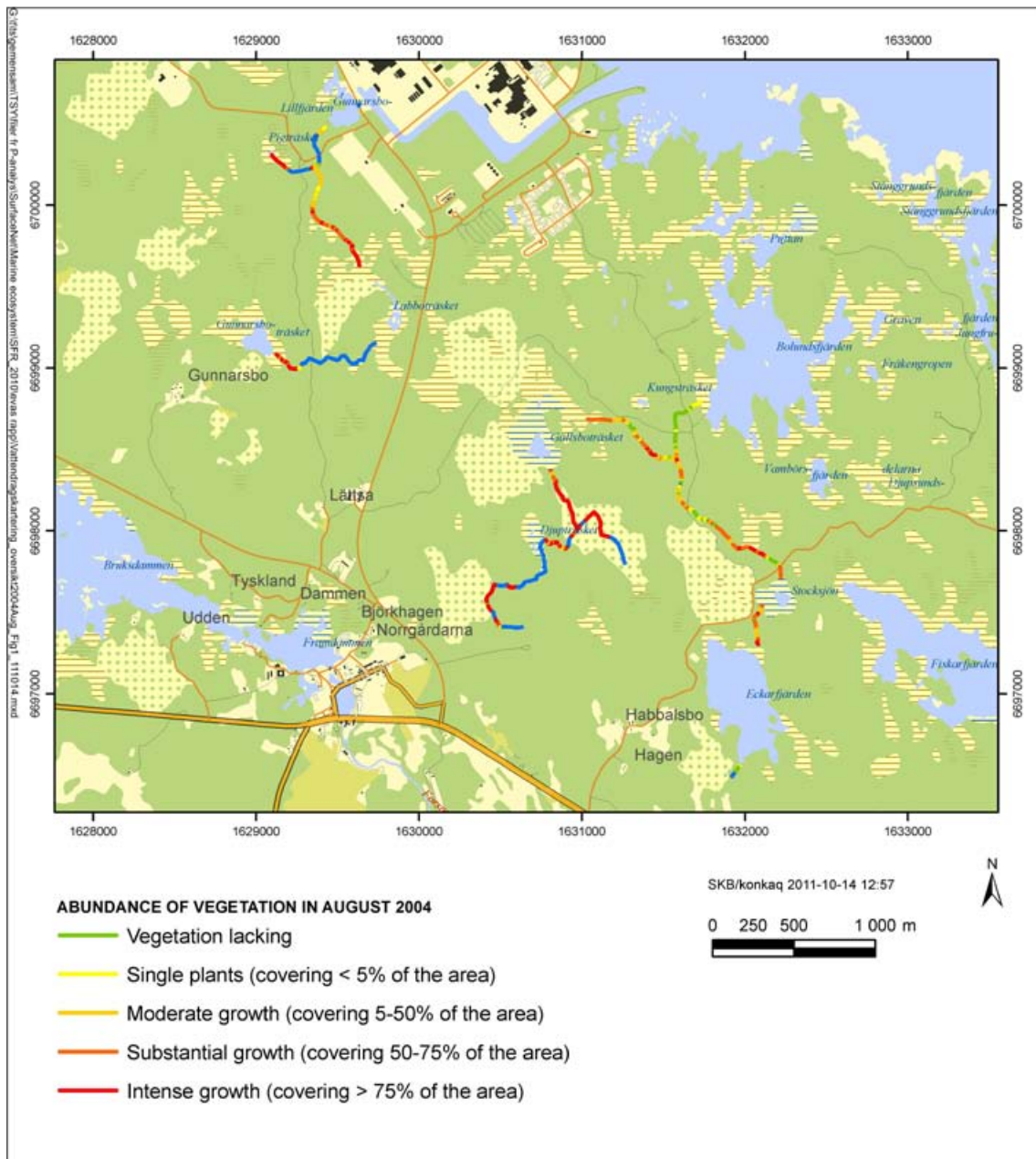


Figure 1-1. Water courses in Forsmark were earlier investigations of stream vegetation and the percentage coverage of the stream bed by macrophytes has been performed, within site investigations performed by SKB.

2 Equipment

A 3-sided aluminium square with the side 50 cm (see Figure 2-1) was used to measure the macrophyte coverage, and macrophytes within the square was sampled to analyse biomass (both wet weight and dry weight).

To investigate the photic depth in Forsmark area and Olandsån a sechi disc was used. A plant rake, B Luther, i.e. a stainless steel rake on a rope (see Figure 2-1), was used to sample for macrophytes in the deeper locations.

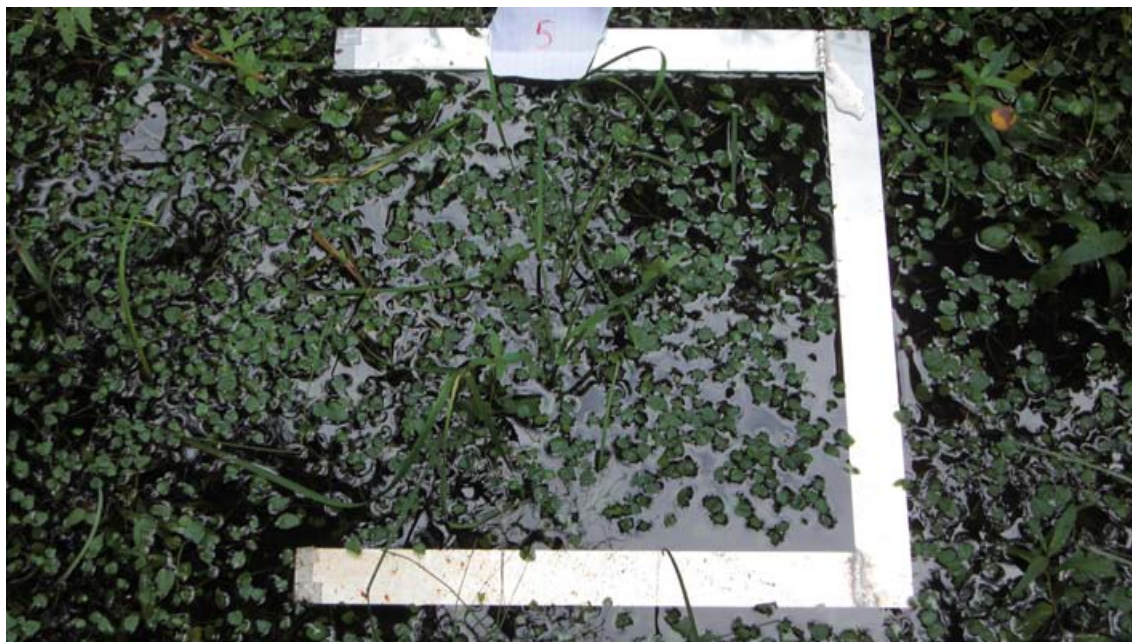


Figure 2-1. A aluminium frame used for sampling of macrophyte biomasses, here from site 5 in the outlet of Lake Eckarfjärden.



Figure 2-2. A plant rake, B Luther, a stainless steel rake on a rope used for sampling of macrophytes.

3 Execution

3.1 Execution of field work

The field work was performed in Forsmark on 31st August and 1st September 2010. During the field work the inlet and outlet from Lake Eckarfjärden, the Forsmarksån and the Olandsån was visited (Figure 3-1).

In total 22 vegetation samples were gathered in order to estimate the biomass at the sites, five vegetation samples in the inlet to Lake Eckarfjärden, 12 in the outlet, and five in Olandsån. Percentage coverage of macrophytes, and dominating species were noted and the above ground macrophytes were sampled for biomass analysis.

In Forsmarksån (coordinates 6695007, 1632487) and Olandsån (6692542, 1634508) (see Figure 3-1), depth and width of the streams were measured. A sechi disc was also used to estimate photic depth. The sechi disc was lowered until no longer visible which correspond to the sechi depth (half the photic depth). Abundance of macrophytes was noted in the two streams.

In the Forsmarksån, no macrophytes were noted from the shore and a plant rake, B Luther, was used to investigate whether there were macrophytes in the deeper locations.

In the Olandsån the 5 macrophyte samples were gathered along a transect across the stream, 10 m downstream from the bridge in Ledsundet.

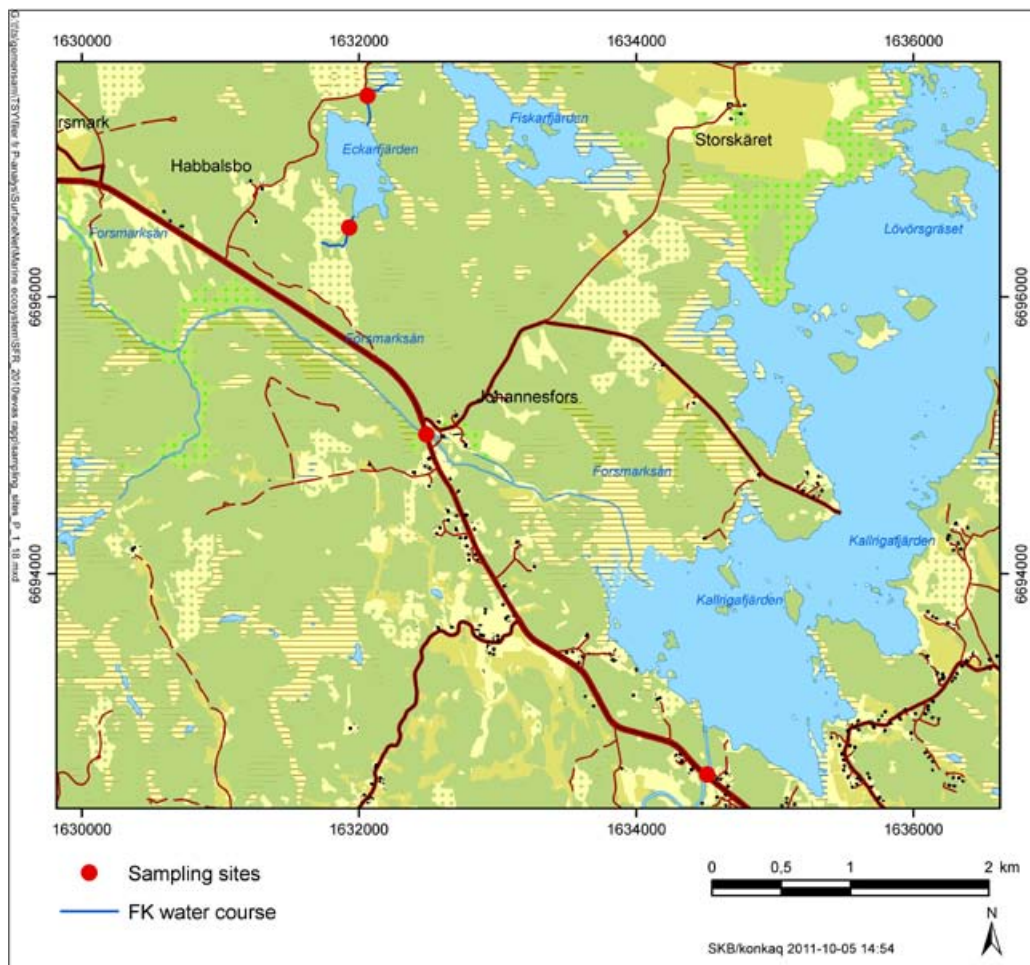


Figure 3-1. Location of stream sampling areas for biomass analysis of macrophytes in the Forsmark area, the inlet and outlet to Lake Eckarfjärden, Forsmarksån and Olandsån.

3.2 Execution in the laboratory

Wet weight was analyzed the same day as sampling. The samples were washed from dirt and put on a paper to absorb the surplus water after the rinsing of the macrophytes. The wet weight was measured after which the samples were frozen until further analysis, which included dry weight biomass determination of the main vegetation types. Dry weight was established after two weeks at 60° C, with an estimated weight on a scale accuracy of 0.1 mg.

4 Nonconformities

No nonconformities were noticed during the study.

5 Results

5.1 Vegetation in streams

In the small (inlet and outlet) streams to and from Lake Eckarfjärden, the macrophytes coverage varied between 25 and 100%, and the biomass varied between 6 and almost 360 g dry weight per square metre. This corresponds to a biomass of carbon between 2 and 148 g C per square meter, assuming a conversion factor of 0.395 g C per g dry weight from /Kautsky 1995/ (Table 5-1). The flora was quite diverse but many samples were dominated by *Carex sp.* (Starr), *Mentha xverticillata* (Kransmynta) and *Ranunculus sp.* (Ranunkel). The percentage cover, from the earlier investigation performed in 2004, was generally in the same magnitude as found in this investigation, especially in the outlet from Lake Eckarfjärden (see Figure 5-1 and Table 5-1).

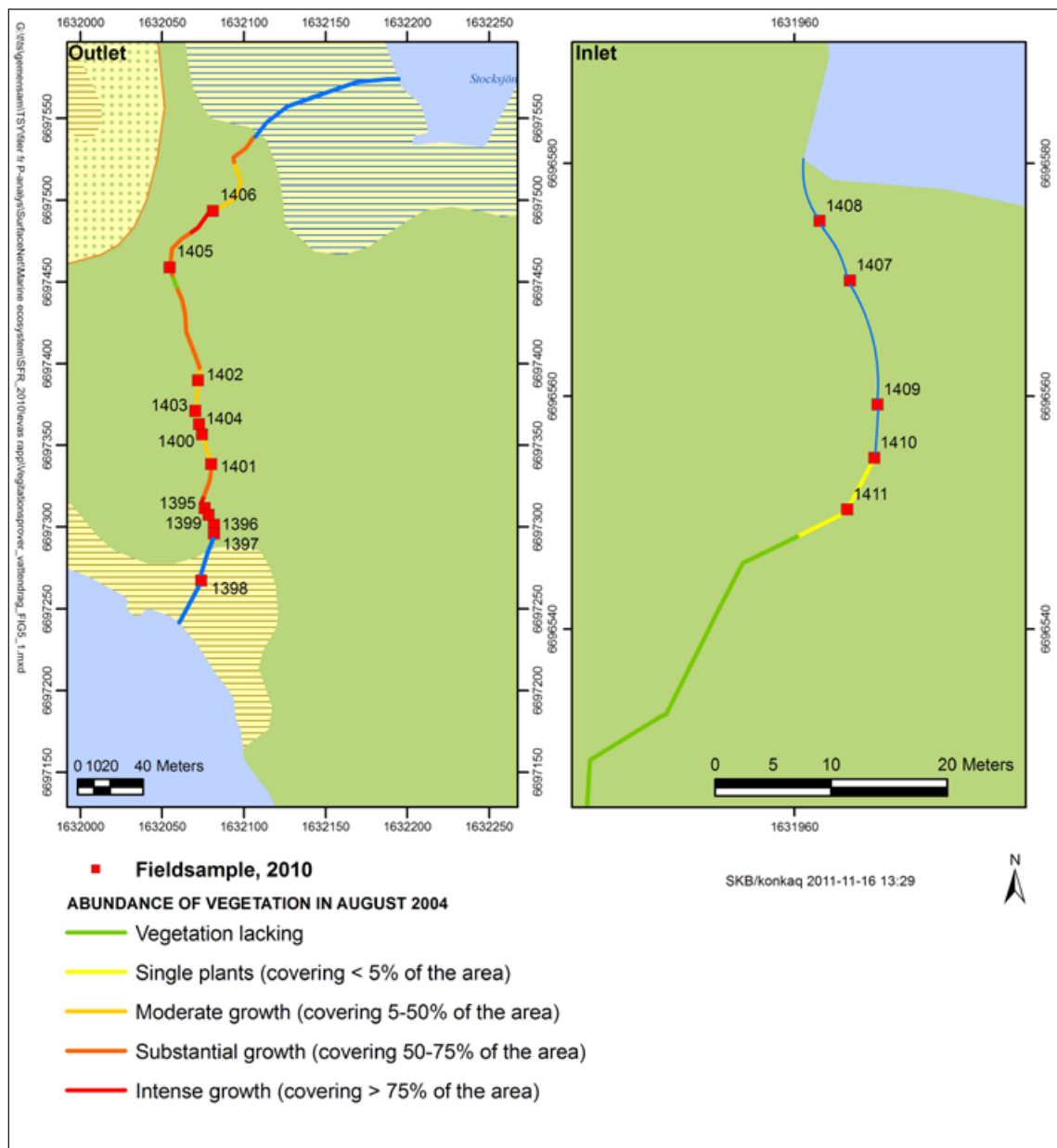


Figure 5-1. Sampling sites in the outlet (left) and inlet (right) of Lake Eckarfjärden, along with percentage cover found in investigations from 2004. Blue line denotes the watercourse.

Table 5-1. Macrophyte coverage in the samples from the outlet and inlet of Lake Eckarfjärden, wet weight, dry weight, carbon content and dominating species.

Square	GPS coord. (x,y)	Macro-phyte coverage (%)	Wet weight (gm ⁻²)	Dry weight (gm ⁻²)	Carbon weight (gCm ⁻²)	Species
1	6697312, 1632075	100	2,188	126	50	<i>Ranunculus flammula, Mentha xverticillata</i>
2	6697301, 1632084	100	1,024	73	29	<i>Carex sp</i>
3	6697297, 1632069	75	816	95	38	<i>Sium latifolium, Carex rostrata, Menyanthes trifoliata, Lemna minor, carex sp</i>
4	6697268, 1632081	100	864	358	141	<i>Carex sp.</i>
5	6697307, 1632079	100	1,532	79	31	<i>Ranunculus flammula, Mentha xverticillata</i>
6	6697358, 1632065	75	716	48	19	<i>Sparganium natans</i>
7	6697339, 1632071	50	312	23	9	<i>Alisma plantago-aquatica</i>
8	6697390, 1632064	100	948	54	21	<i>Sparganium natans, Mentha xverticillata</i>
9	6697371, 1632075	75	664	46	18	<i>Alisma plantago aquatica</i>
10	6697363, 1632074	25	172	12	5	<i>Ranunculus flammula, Mentha xverticillata</i>
11	6697454, 1632079	25	88	7	3	<i>Mentha xverticillata</i>
12	6697482, 1632088	50	268	18	7	<i>Galium palustre ssp elongatum</i>
13	6696607, 1631914	25	88	8	3	<i>Lysimachia thyrsoiflora</i>
14	6669657, 1631962	100	824	110	43	<i>Carex sp.</i>
15	6696559, 1631967	50	212	13	5	<i>Ranunculus sp ?</i>
16	6696555, 1631967	50	444	62	25	<i>Carex sp.</i>
17	6696550, 1631965	25	120	6	2	<i>Ranunculus flammula</i>
Mean		66	664	67	26	
Median		75	664	48	19	
Std. dev.		30	548	82	33	
min		25	88	6	2	
max		100	2,188	358	141	
n		17	17	17	17	

In stream Forsmarksån (Figure 3-1), there were only sparse observations of macrophytes (less than 5%) and no macrophytes were gathered with a plant rake at the site. Therefore no biomass estimates were done for this stream.

In stream Olandsån, the macrophyte coverage was dense, ~ 75%. The dry biomass varied between 21 and 247 g dry weight per square meter which corresponds to a biomass of carbon between 8 and 98 g C per square meter, assuming the conversion factor from /Kautsky 1995/ (Table 5-2). In Olandsån the flora was different than in the small streams and dominated by *Schoenoplectus lacustris* (Säv) and *Sium latifolium* (Vattenmärke).

In total 13 species of macrophytes were encountered in the investigation (Table 5-3). The relation between dry weight and percentage coverage of macrophytes per square meter, considering samples from both the smaller streams in connection to Lake Eckarfjärden and Olandsån, correlates fairly well (Figure 5-2). Although, the variation increases with percentage coverage. The percentage coverage in general was higher in the sampling sites in Olandsån, although comparing the carbon content normalized to the percentage coverage (i.e. g C per square meter divided by the percentage coverage), they are in the same magnitude for percentage coverage of 100% (Figure 5-3).

Table 5-2. Macrophyte samples, in a transect across stream Olandsån 10 m downstream bridge, in coverage, wet weigh, dry weight, carbon content and dominating species.

Square	GPS coord. (x, y)	Macrophyte coverage (%)	Wet weight (gm ⁻²)	Dry weight (gm ⁻²)	Carbon weight (gCm ⁻²)	Species
1	6692528, 1634504	100	1,608	205	81	<i>Schoenoplectus lacustris</i>
2	6692528, 1634500	100	2,920	247	98	<i>Schoenoplectus lacustris</i>
3	6692528, 1634446	75	608	34	13	<i>Sium latifolium</i>
4	6692528, 1634442	100	468	21	8	<i>Sium latifolium</i>
5	6692528, 1634438	100	1,696	111	44	<i>Schoenoplectus lacustris</i>
Mean		95	1,460	124	49	
Median		100	1,608	111	44	
Std. dev.		10	885	90	40	
min		75	468	21	8	
max		100	2,920	247	98	
n		5	5	5	5	

Table 5-3. Macrophyte species found in the investigation. The right column indicates in which of the samples the species has been found where O stands for stream Olandsån and the rest is from the small streams surrounding Lake Eckarfjärden (Figure 3-1).

Species (latin name)	Species (Swedish name)	Found in sample square No
<i>Alisma plantago-aquatica</i>	Svalting	7, 9
<i>Carex sp.</i>	Starr	2, 3, 4, 14, 16,
<i>Carex rostrata</i>	Flaskstarr	3
<i>Galium palustre ssp</i>	Stor vattenmåra	12
<i>Lemna minor</i>	Andmat	3
<i>Lysimachia thyrsoiflora</i>	Topplösa	13
<i>Mentha xverticillata</i>	Kransmynta	1, 5, 8, 10, 11,
<i>Menyanthes trifoliata</i>	Vattenklöver	3
<i>Ranunculus sp</i>	Ranunkel	15, 17
<i>Ranunculus flammula</i>	Ärtranunkel	1, 5, 10,
<i>Schoenoplectus lacustris</i>	Säv	O1, O2, O5
<i>Sium latifolium</i>	Vattenmärke	3, O3, O4
<i>Sparganium natans</i>	Dvärgigelknopp	6, 8

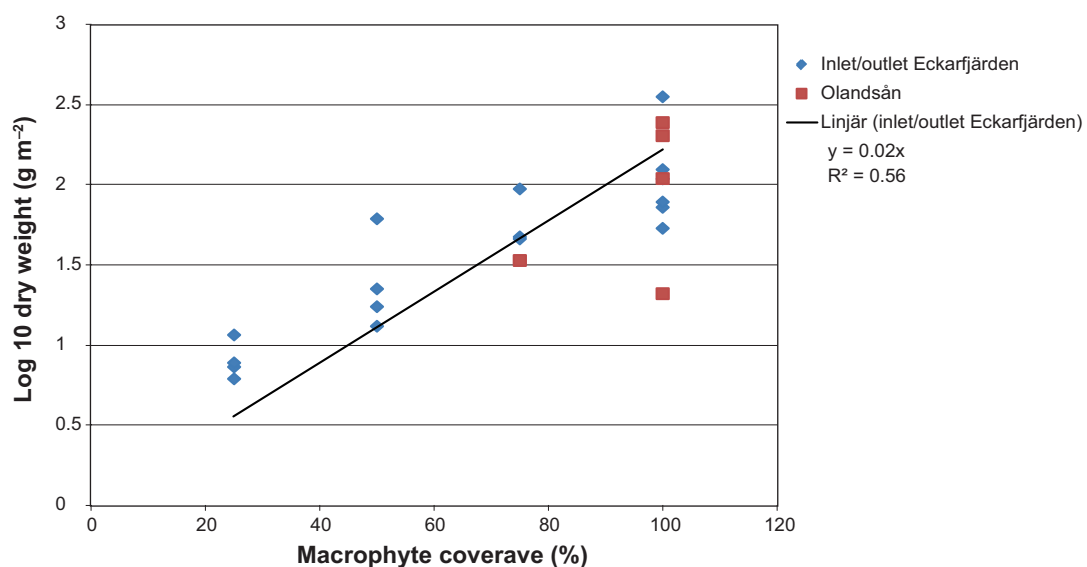


Figure 5-2. Dry weight of macrophytes plotted against percentage coverage in samples from sites located both in the inlet and outlet of Eckarfjärden (blue squares) and in the Olandsån (brown squares). Note the logarithmic scale on the Y-axis.

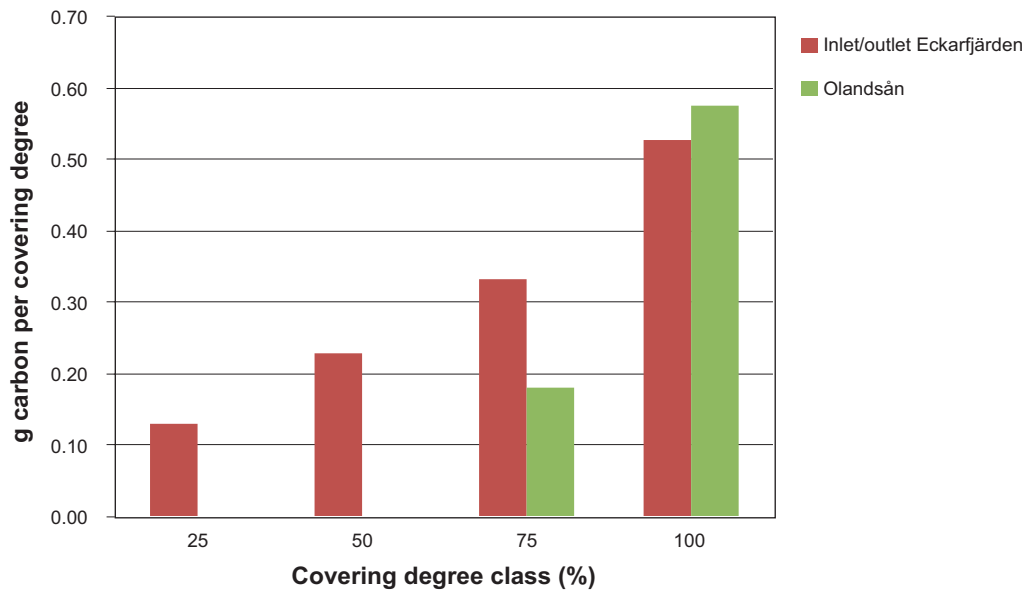


Figure 5-3. Mean normalized carbon content per square meter and covering degree (i.e. carbon content divided by percentage coverage) and class of percentage coverage, from sites located in the inlet and outlet of Eckarfjärden and in the Olandsån. Note that there was only 1 sample from Olandsån in the 75% covering degree class.

5.2 Depth, width, photic depth

The width of the Forsmarksån was 11 meters and the width of the Olandsån was 19 meter at the sampling sites. The maximum depth was 0.6 and 0.35 meters respectively and the photic zone comprised the whole stream bed at both sites. Due to the shallow depths of the streams it was difficult to measure a light extinction curve that could estimate the photic depth with a good accuracy, since the whole stream bed probably were photic at the sites.

6 Conclusions

Although this was a rather small study, it is evident that the biomasses do vary a wide range between sampling squares in the area. However, although it may be difficult to use this data set to estimate the biomass in a specific square meter in the stream section, the relation between biomass weight and covering degree is sufficient to be used when fitting biomass to macrophyte coverage for entire stream sections, and would probably give a reasonable fair estimate of the magnitude of total macrophyte biomass in the streams in the area.

The larger streams in the area could have more or less macrophytes than the small streams. However, since the photic depth comprised the whole stream bed even in stream Forsmarksån lacking of macrophytes, this indicates that the stream bed at this site is dominated by attached microalgae rather than macrophytes and/or that suitable bottom substrate is lacking. Further investigations estimating occurrence of benthic microalgae could confirm this.

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