R-99-69

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ISSN 1402-3091

SKB Rapport R-99-69

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Keywords: Bothnian Sea, line transect, biomass, SCUBA diving, phytobenthos, flora, fauna, SFR, low level waste, SAFE, biosphere, biosfären

Summary

This report is a part the SKB project "SAFE". The aim of SAFE is to update the previous safety analysis of SFR-1. SFR is for the repository of low and intermediate level radioactive waste. The aim of this report is to provide background information of the quantitative distribution of macroscopic (>1 mm) plants and animals on the seafloor (the phytobenthic communities) above the SFR. The phytobenthic plant and animal communities in the Bothnian Sea may constitute over half of the total production of the ecosystem in the coastal zone. Data will be used in a simulation model of the area. The attached plant and animal communities of the seafloor can be the major component to find radioactive isotopes when a leakage should occur from the SFR below the investigated area. Their ability to bioaccumulate the isotopes and the abundance of the plants and animals might to a large extent determine the amount of radionucelides that could be retained in the biological system. This might then affect the form of further dispersed of the radionucelides over larger areas, whether they are kept within and accumulated in the food chain or retained in the sediments or diluted in the water column.

In the investigated area divers described the sea floor substrate and the dominating plant and animal communities along transect lines. In addition, the divers collected quantitative samples. Three transects were placed just above SFR, and two transects were placed from the shore of islands adjacent to SFR. In total, divers collected 54 quantitative samples. Also, divers collected 6 sediment cores for analysis of the organic contents and chlorophylla. The results from the divers estimates of plant and animal species distribution and cover degree, as well as the quantitative samples, indicated the area being fairly rich. An eroded moraine (boulders, stones, gravel and sand) dominated the substrate with occasional rock outcrops. At several sites, on the hard, more stable substrates (boulders, rock) a luxuriant growth of the bladder wrack (*Fucus vesiculosus*) could be seen. Also, the moss *Fontinalis dalecarlica* was not unusual. This moss is frequently observed in the Gulf of Bothnia but does not occur in the Baltic proper. Among the animals, the blue mussel (*Mytilus edulis*) was to a large extent missing, although suitable substrate was present. In the Bothnian Sea the marine mussel *Mytilus* extends up to the Northern Quark, but usually only scattered, few individuals are found at each site along the whole coast. The blue mussel never has the same mass-occurrence as can be observed in the Stockholm archipelago and further south in the Baltic proper. Thus, the ecosystem of the SFR-area has a function somewhat different from the Baltic proper as the filter feeders lack to a large extent.

The species biomass was determined by collecting 54 quantitative samples (usually 12 samples per transect). At comparable depths, when excluding the bladder wrack (*Fucus vesiculosus*) and the blue mussel (*Mytilus edulis*) the total depth distribution of plant and animal biomass was similar those of the Gräsö-Singö area (ranging between 30–60 g dry weight m^{-2} of plants and 20–50 g of animals). However, the total biomass of both the bladder wrack (*Fucus vesiculosus*) and the filter feeding blue mussel (*Mytilus edulis*) was considerable lower in the Forsmark area. This can to some extent be explained by the difference in dominating substrate (mostly rocky) as well as a larger influence from the Baltic proper in the Gräsö-Singö area. For the low amounts of *Mytilus* see explanation given above.

Sammanfattning

Denna rapport beskriver makroskopiska (större än 1 mm) växter och djurs utbredning på havsbottnen ovanför slutförvaretför radioaktivt driftavfall (SFR). Bottensamhällenas växter och djur kan stå för minst hälften av den totala produktionen i Bottenhavets kustområden. Därför är det väsentligt att känna till dessa samhällens utseende och kvantitativa utbredning. Rapporten bildar ett underlagsmaterial för en simuleringsmodel av radioaktiva ämnens eventuella upptag och anrikning i det levande materialet.

Bottnarna ovan slutförvaret domineras av svallade moränavlagringar och består framför allt. av block, sten, grus och sand. Även en och annan häll förekommer. Dessa mer eller mindre hårda och relativt stabila bottnar – åtminstone block- och stenbottnarna – har en rik förekomst av växter och djur som är karakteristiska för hårda bottnar, dvs alger och fastsittande djur. På de mer finkorniga bottnarna (från grus och finare sediment) i området förekommer det delvis rikligt med kärlväxter. Mängden växter och djur är i samma storleksordning som det man finner i Gräsö–Singö–området. I det senare området förekommer dock mycket mer av blåstång (*Fucus vesiclosus*) och blåmusslor (*Mytilus edulis*). Dessa två arter föredrar framför allt häll- men även blockbottnar som förekommer i jämförelsevis mindre mängd i området ovanför slutförvaret. Den mycket låga mängden av blåmusslor kan dock även vara betingad av att området påverkas mer av Bottenhavsförhållanden (framför allt något lägre salthalt) och Gräsö–Singö mer av egentliga Östersjöförhållanden. Mossan *Fontinalis dalecarlica* är vanlig i området vilket antyder en kraftig påverkan från Bottenhavet.

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Introduction

This report is a part the SKB project SAFE (Safety Assessment of the Final Repository of Radioactive Operational Waste). The aim of project SAFE is to update the previous safety analysis of SFR-1. The analysis should be presented to the Swedish authorities not later than in year 2000. SFR-1 is a facility for disposal of low and intermediate level radioactive waste, which is situated in bedrock beneath the Baltic Sea, 1 km off the coast near the Forsmark nuclear power plant in Northern Uppland.

The SKB Reports "Project SAFE – Prestudy" gives an overview of the SAFE project and presents the work that has to be performed to achieve the goal of the project. The results of the present report have been used in the numeric model presented by Johansson (1999). An bathymetric description of the area and its future developement is given by Brydsten (1999) and the pattern of currents and water exchange of today is described by Engkvist (1999).

In August 1998, this SCUBA divers survey was performed of the plant and animal communities of the vegetation covered substrates (i.e. the phytobenthos) above and in the vicinity of SFR. The aim was to estimate the depth distribution and biomass of plants and animals. The phytobenthic plant and animal communities of the Bothnian Sea may constitute over half of the total production of the coastal zone (Kautsky and Kautsky, 1995). The distribution and function of the phytobenthic plant and animal communities in the area is therefor of major importance for the understanding of processes over the SFR. The potential ability of the phytobenthic communities to retain and enrich radioactive isotopes when leaking from the SFR occurs must be evaluated. This divers investigation is a first step to describe and quantify the biomass of the phytobenthic system above SFR. The results are included in a simulation model of the area (Johansson, 1999).

The Forsmark area is situated in the southernmost part of the Bothnian Sea close to the Baltic proper. This influences the occurrence and the distribution of the species, and we expect to find both more fresh water species common in the Bothnian Sea as well as marine species dominating in the Baltic proper in the area (Kautsky 1989, Kautsky 1995, Waern 1952).

Material and methods

The chosen area for investigation was in accordance with the area for the simulation model of the biological processes (Johansson, 1999). The number of stations (transects) was small in comparison to the area surveyed. Therefor, the locations of the stations were chosen (not randomly placed) to cover the whole area. The stations were placed and marked in advance on a navigation chart, so that three came just above SFR (station 1–3) and another two were placed at adjacent islands (station 4–5) (Figure 1). Over SFR, first a buoy was placed out to mark the starting point of the transect. The exact position of the buoy was then determined using a handheld GPS (up to +–60 m precision). When the transects started from islands, the starting point was determined from the boat at some 15 m from shore. A photo and GPS-coordinates documented the island based staring point. At station 6, the 18-m depth, the position was chosen using echo sounder. The position of each station was documented that revisits are possible by giving the GPS-coordinates, marking on the map and photography of the shoreline when appropriate (see Figure 1, Table 1). All the stations were visited in mid August 1998.

Field sampling

The investigation method is in accordance with the national monitoring programme of the vegetation-covered substrates of the Baltic Sea, run by the Swedish EPA and HELCOM guidelines. Divers swam along a meter marked line in a given compass direction. Within a 3–5 m wide zone at each side of the transect line (6–10 m width in total, depending on the visibility) the type of substrate and the siltation (loose sediment dust) was described. Divers estimated the depth distribution and cover degree of the dominating and conspicuous species. The interval where the species occurred for the first and last time was determined by noting the distance from shore on the line (or starting point) and depth measured with a calibrated depth gauge. New notes were done as the diver observed any change, e.g. a new species, change in cover degree of the species or a change in substrate. The estimates were done continuously along the transect and not only at distinct intervals of distance nor in frames. Thus an area estimate was obtained describing the entire section. Special attention was made to find the deepest limit of *Fucus vesiculosus*. As different plants species (and *Mytilus edulis*) tend to occur in different distinct and limited depth zones, the estimates resulted in the establishment of vegetation belts along the transect line. The belts were named after the dominating species.

The cover degree of the macroscopic plants and the blue mussel (*Mytilus edulis*) was given in a seven-point scale: + for occurrence (single observation), 5, 10, 25, 50, 75 and 100%. As species can overgrow each other, e.g. forming a canopy and a bottom layer, the sum of all the species cover degrees at a given site can be more than 100%. The epiphytes were estimated in the same way as the organisms on the sea floor. The type of substrate was classified into rock, boulders, stones, gravel, sand, soft substrate and/or combinations of these. The dust (the silt) on the substrate and the vegetation, used as an measurement of e.g. water movement, was given in a four-point scale: 1= no silt; 2= small amount, 3= more/much- easily stirred by the hand, but settles after a short while; 4=heavily sedimentated – the sight of the diver is blurred for long time.

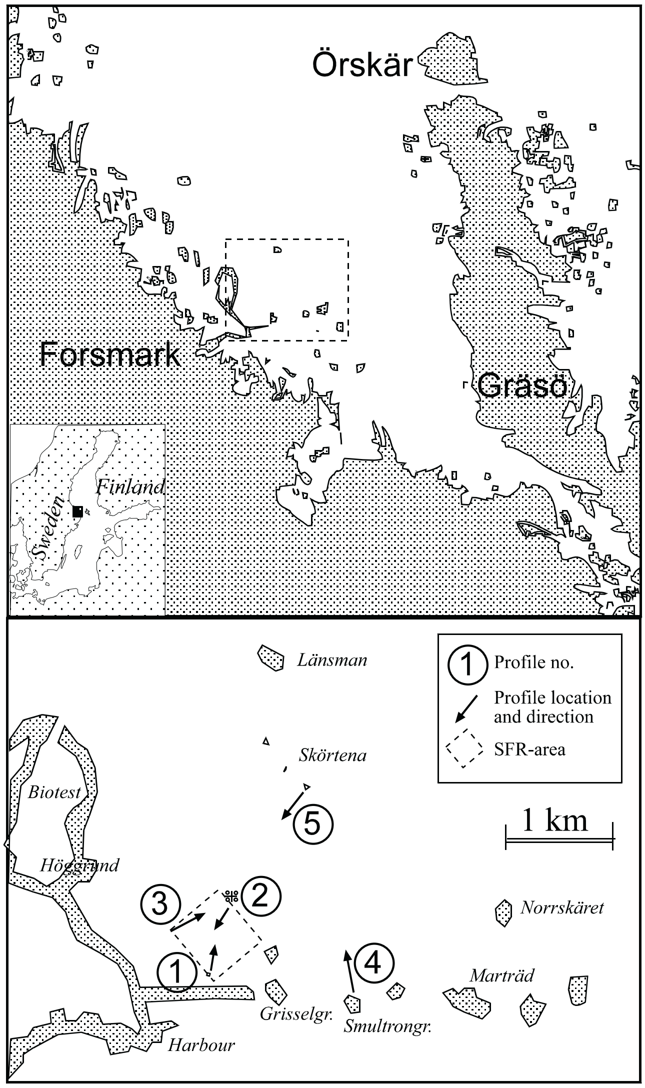


***Figure 1**. SFR, Forsmark 1998. The investigated area. The area of the SFR is indicated on the detailed map by a dashed line. The stations are located at the starting point of the arrows (which indicate the general direction of the transect). For exact position and direction see table 1.*

Table 1. SFR, Forsmark 1998. The station name, position (GPS, WGS84-system), date of visit, compass direction of divers transect and number of samples taken

Station no.	Name of station	Date	Position (GPS) N °	min'	E °	min'	Com-pass	No. of samples	Sediment-cores
1	SW corner SFR	18/8	60	24.774	18	13.138	10	12	0
2	NE corner SFR (Grynnan)	19/8	60	25.127	18	13.505	245	12	0
3	NW corner SFR	19/8	60	25.024	18	12.995	90	6	3
4	Smultrongrundet	18/8	60	24.657	18	14.685	345	12	0
5	Skörtena	20/8	60	25.747	18	14.127	220	12	0
6	18-m hålet	20/8	60	25.336	18	14.803		0	3

Quantitative samples were collected by tossing frames of the size 0.2x0.2 m within the identified belts. The divers placed three frames at a given depth within the belt by throwing them haphazardly over the shoulder. The entire content within the frame was scraped into a bag attached to one open side of the frame. The samples were analysed by sorting each species separately and dried in 60°C to constant weight (about two weeks). Animals were also counted. If not otherwhise stated in the text, biomass is given in g dry weight m^{-2}, including shells when present. In all, 54 quantitative samples were collected.

The divers collected six sediment cores at two sites (station 3 and 6). After determining the approximate redox- cline by the eye, the upper 0.01 m of the core was sliced off and frozen and kept for further analysis. The organic matter of the sample was determined by drying the sample and then burning it in 500°C. The chlorophyll a content of the sediment was determined by extracting a given amount of sediment with acetone and then measured in a spectrophotograph (Svensk Standard SS 02 81 46). Values were given in % and µg per gram wet weight of sediment for organic matter and chlorophyll respectively. The organic contents in g per m^{-2} and chlorophyll in mg per m^{-2} was estimated using the following assumptions: One cm^{-3} sediment covers one cm^{-2} and knowing the density of the components (assuming that organic matter has a density of approximately 1.5 and sediments around 2.5 (silica=2.33, aluminium=2.7), and after including a correcting for the water contents (density=1) of the sediment, an estimate of the wet weight of one cm^{-3} was obtained. We measured the contents per g of wet sediment and thus an estimate for one m^2 could be calculated. The estimates should be acceptable for chlorophyll as it can be assumed that most microscopic vegetation is found at the surface of the sediments. The estimate for organic matter is more rough as organic matter can be found much deeper down in the sediments (we collected just the upper cm) and might perhaps only give a hint of the magnitude of organic matter per m^2 found.

Results and discussion

Description of the diver transects

The stations are described in the order of the divers notes, from the deepest point of the transect towards the surface. Some photographs are given in appendix 1. A copy of the field data is given in appendix 2. A table of the biomass of all quantitative samples taken along the transects is given in appendix 3.

Station 1, SW corner SFR

The station was visited 18 August. A transect was placed at the starting point at 2.4 m depth and the divers swam in 10° compass angle, 95 m long down to 4.5 m depth. (Figure 2).

The substrate of this, shallow, gently sloping transect was characterised by a mixture boulders, stones and gravel all the way and with occasional minor areas of sand. The vegetation was similar and beautiful along the whole transect. The transect did not go down to depths where most attached plants disappear due to lack of light. However, there was a slight tendency of zonation of the plant communities along the transect. Deeper down, the red alga *Furcellaria lumbricalis* was common together with other red algae, and few characeae occurred (*Tolypella nidifica*). The filamentous red algae *Polysiphonia nigrescens* and *Ceramium tenuicorne* characterised the plant communities and the bladder wrack (*Fucus vesiculosus*) grew richly along the whole transect. *Fucus* covered up to 50 % of the substrate. The morphology of the *Fucus* –plants was both the broad thallus form common in the Baltic proper, and the more narrow form characteristic for the Bothnian Sea. Also, the moss *Fontinalis dalecarlica* occurred frequently. This moss is typical for the Gulf of Bothnia and does not occur in the Baltic proper. Phanerogames occurred scattered along the whole transect (e.g. *Zannichellia palustre* and *Ruppia* sp.). Closer to the surface the phanerogames increased, and from about 3 m depth *Potamogeton perfoliatus* and *P.pectinatus* covered up to 50% of the substrate. The phanerogames are dependent on substrates into which they can attach their roots. Their occurrence thus reflects the presence of finer substrates, i.e. gravel and finer fractions.

The plant biomass was the second highest observed in the area (227 g dry weight m^{-2} at around 3.3 m depth) (Figure 2, Table 2). This was mainly due to the luxuriant occurrence of *Fucus vesiculosus* (135 g) (Table 3). At the most shallow sites of the transect (2.5 m depth) the animal biomass of 137 g was dominated by the filter feeder *Cardium* sp. (92 g) but also the herbivores (dominated by the snail *Theodoxus fluviatilis*) was not uncommon (22 g) (Table 3). Deeper down the detritivorous Baltic mussel *Macoma balthica* increased in abundance.

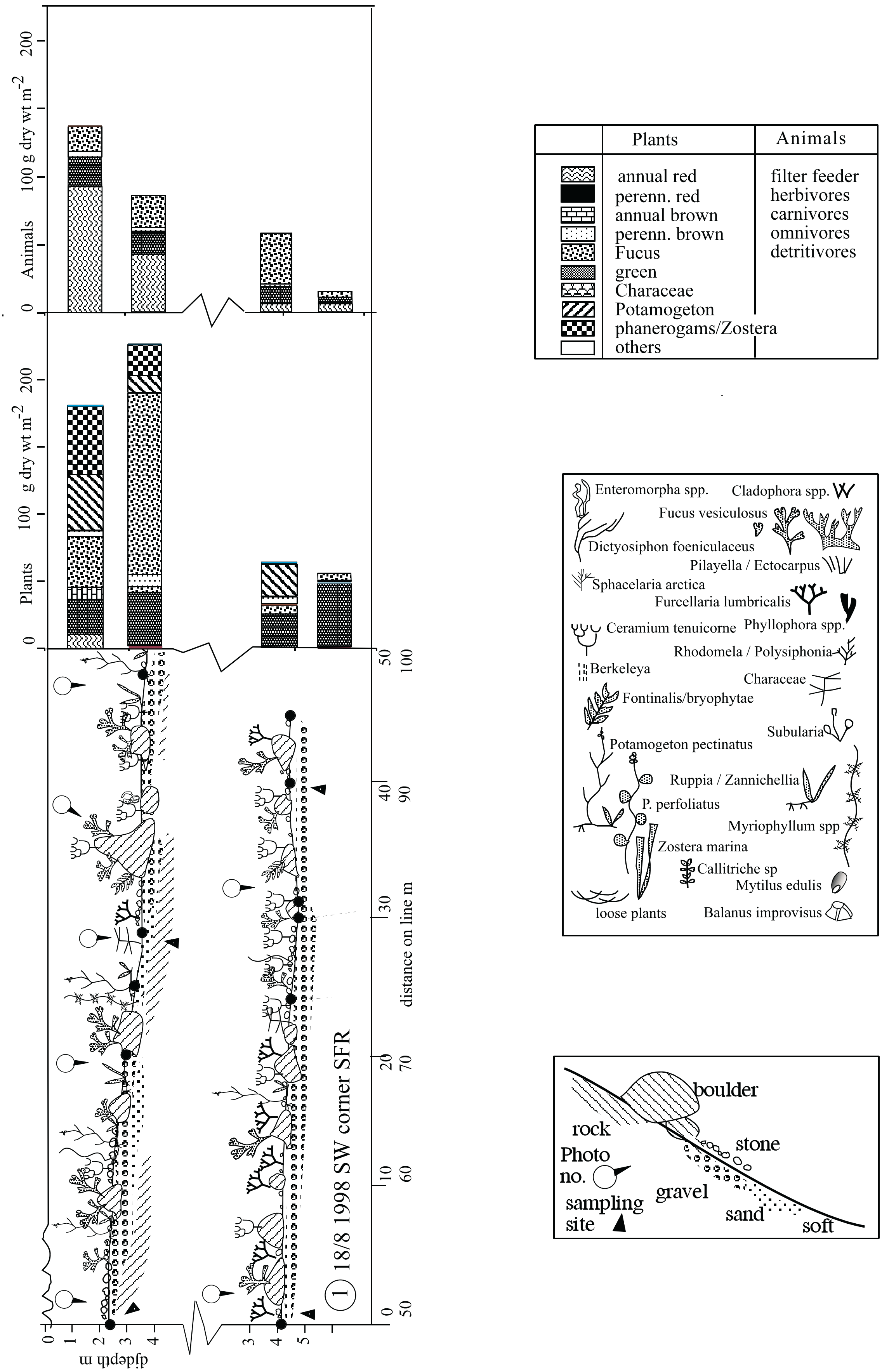


***Figure 2.** SFR, Forsmark 1998. Station 1. The depth distribution of the transect substrate and plant communities as well as plant and animal biomass.*

Table 2. SFR, Forsmark 1998. The total biomass per station of plant systematic/functional group and animal trophic group

station no.	*1*	*2*	*3*	*4*	*5*
Plant groups					
bluegreen	0.014	0.016	0	0.548	0
annual red	3.434	1.052	0.227	2.529	1.821
perennial red	34.398	34.248	0.363	11.144	18.117
annual brown	5.479	2.255	0	0.785	3.678
perennial brown	2.304	1.058	1.234	1.728	0.006
Fucus vesiculosus	44.309	2.960	0	0.150	132.979
green	2.484	0.189	0	3.446	4.938
characeae	0.523	0	0	0	0.712
Potamogeton spp	19.448	0	0	0	0.793
Zostera	0	0	0	0	0
phanerogams	18.593	0	0	0	2.878
others	0.789	1.601	0	1.186	0.348
sum Plants	*131.775*	*43.378*	*1.823*	*21.518*	*166.270*
Animal trophic groups					
filter feeders	36.540	0.266	0.003	0.680	12.391
herbivores	14.107	2.534	0.006	0.473	5.541
carnivores	0.137	0.096	0.009	0.049	0.037
omnivores	2.106	1.827	0.056	0.530	0.735
detritivores	20.939	2.345	30.463	25.135	9.113
Mytilus edulis	0.205	1.706	0	0.047	0.103
sum Animals	*74.034*	*8.773*	*30.537*	*26.914*	*27.921*

Table 3. SFR, Forsmark 1998. The plant systematic/functional group and animal trophic group mean biomass for each sampling depth of the station

Profile no.	*1*	*1*	*1*	*1*	*2*	*2*	*2*	*2*	*3*	*3*	*4*	*4*	*4*	*4*	*5*	*5*	*5*	*5*
Depth m	*2.4*	*3.3*	*4.2*	*4.5*	*3*	*4.5*	*6*	*9*	*10.5*	*10.8*	*1.8*	*5.1*	*8.1*	*10.5*	*0.5*	*3*	*3.9*	*6.6*
Plant groups																		
bluegreen	0	0	0.027	0.027	0.000	0.063	0.000	0	0	0	2.193	0	0	0	0	0	0	0
annual red	10.463	2.169	0.072	1.031	1.818	0.263	1.975	0.152	0.372	0.082	2.113	5.831	2.136	0.035	0.055	4.593	2.089	0.546
perennial red	25.822	39.729	24.797	47.246	52.935	49.269	30.554	4.234	0.400	0.326	0.043	40.418	3.617	0.501	0.153	32.449	15.688	24.178
annual brown	9.302	4.309	6.357	1.949	0.000	8.751	0	0.269	0	0	3.053	0.053	0.035	0.000	13.608	0.230	0.808	0.068
perennial brown	0.039	8.624	0	0.554	0.000	0.027	0	4.205	2.049	0.418	0.000	0.085	6.082	0.746	0	0	0	0.024
Fucus vesiculosus	37.236	135.022	1.378	3.599	0.000	11.704	0.134	0	0	0	0.421	0.180	0	0	0.124	126.458	404.811	0.523
green	4.595	0.290	4.743	0.309	0.440	0.316	0.000	0	0	0	13.778	0.008	0	0	19.526	0.174	0.051	0.001
characeae	0.537	0.595	0.959	0	0	0	0	0	0	0	0	0	0	0	0	2.829	0	0.019
Potamogeton spp	41.605	12.491	23.577	0.121	0	0	0	0	0	0	0	0	0	0	0	3.172	0	0.000
Zostera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
phanerogams	50.640	22.859	0.873	0	0	0	0	0	0	0	0	0	0	0	0	11.513	0	0
others	1.084	0.599	1.273	0.199	0.000	3.883	2.520	0	0	0	4.613	0.133	0	0	0.016	0.055	0.046	1.275
sum Plants	*181.323*	*226.687*	*64.055*	*55.035*	*55.194*	*74.277*	*35.183*	*8.860*	*2.821*	*0.826*	*26.213*	*46.708*	*11.870*	*1.282*	*33.482*	*181.473*	*423.493*	*26.634*
Animal trophic groups																		
filter feeders	92.220	42.202	5.880	5.858	0.000	0.000	1.063	0	0.006	0	0	0.448	0.263	2.010	0	39.466	0.000	10.100
herbivores	21.564	17.100	12.804	4.960	4.803	3.857	1.459	0.017	0.012	0.001	0.189	1.601	0.099	0.003	1.193	11.772	6.486	2.711
carnivores	0.107	0.015	0.370	0.054	0.279	0.105	0	0	0.004	0.013	0.018	0.000	0.023	0.156	0.064	0.037	0.001	0.046
omnivores	3.746	2.702	1.339	0.638	1.859	0.188	4.857	0.404	0.063	0.049	0.617	1.087	0.320	0.096	0.628	1.113	0.617	0.583
detritivores	18.195	23.919	37.595	4.047	2.413	1.079	2.625	3.262	48.339	12.587	0.000	1.157	0.123	99.261	2.900	15.525	1.134	16.894
Mytilus edulis	0.721	0	0	0.101	4.983	1.567	0.274	0	0	0	0	0.188	0	0	0	0.313	0.101	0
sum Animals	*136.553*	*85.937*	*57.987*	*15.657*	*14.337*	*6.795*	*10.278*	*3.683*	*48.424*	*12.650*	*0.824*	*4.480*	*0.828*	*101.525*	*4.785*	*68.226*	*8.338*	*30.334*

Station no. 2, NE corner of SFR (Grynnan)

The station was investigated 19 August. The transect started at 3 m depth and the most shallow part was at 2.6 m. Divers swam in 245° compass direction, 110 m long down to 9 m depth (Figure 3).

The diver estimates started at 9 m depth on a greyish, sediment-rich substrate of small boulders and gravel. Here, the vegetation was sparse with only few individuals of red algae (*Ceramium tenuicorne*, *Polysiphonia nigrescens* and *Furcellaria lumbricalis*). The transect soon became steeper upwards with more boulders. *Ceramium tenuicorne* and *Polysiphonia nigrescens* increased. At 8 m depth the first individual of *Fontinalis dalecarlica* occurred and at 6.3 m the deepest findings of *Fucus vesiculosus* were made. Closer to the surface, the *Fucus* covered up to 100% of the substrate, especially on the occasionally occurring rock substrate at around 4 m depth. When boulder substrate dominated, the *Fucus* grew more scattered (around 10–25% coverage). The *Fucus* individuals grew luxuriantly with a broad thallus, but also the narrow-thallus form occurred. Some of the *Fucus* plants were fertile. On the boulders the filamentous red algae *Polysiphonia nigrescens* and *Ceramium tenuicorne* dominated. The transect was similar up to 3 m depth where also the bluegreen alga *Rivularia atra* and the green algae *Enteromorpha* sp. and *Cladophora glomerata* occurred in larger amounts.

Both the plant and animal biomass was fairly low (max. 74 g and 14 g dry weight respectively). At all depths the perennial red algae (mainly *Polysiphonia nigrescens*) dominated the biomass (Figure 3, Table 3 and appendix 2). The low animal biomass was evenly composed of herbivores, omnivores and detritivores (Table 2 and 3).

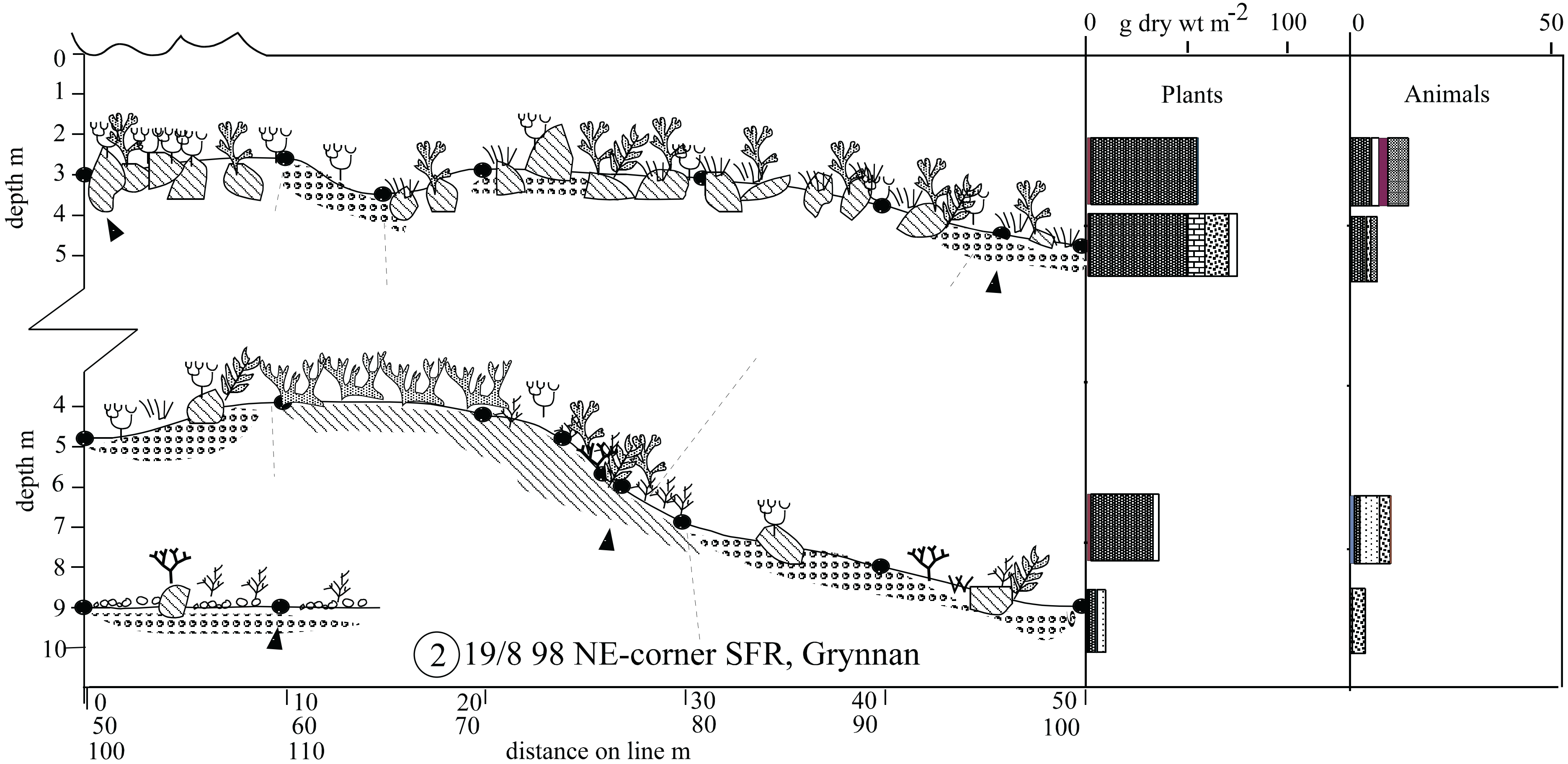


***Figure 3**. SFR, Forsmark 1998. Station 2. The depth distribution of the transect substrate and plant communities as well as plant and animal biomass. For the description of symbols, see legends of figure 2.*

Station no. 3, NW corner of the SFR

The station started at 10.5 m depth and the divers swam 25 m in the compass direction of 90°.

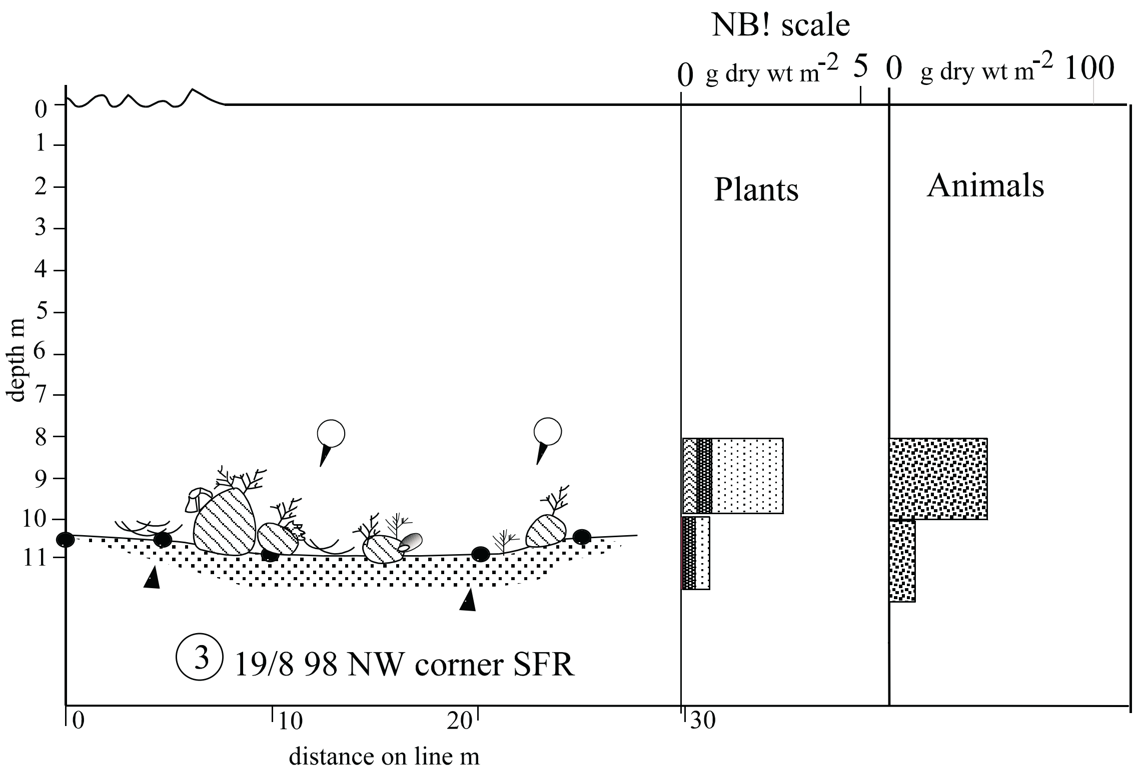
The sediment-rich substrate was even and sandy with some, scattered boulders (Figure 4). A large amount of shells of *Macoma balthica* could be seen on the sediment surface, as well as many trails from the isopod *Mesidothea entomon*. On the boulders the brown alga *Sphacelaria arctica* and few red algae (*Polysiphonia nigrescens* and *Ceramium tenuicorne*) grew in low abundance. On hard substrates in the Bothnian Sea *Sphacelaria* often forms the lower limit of attached plants.

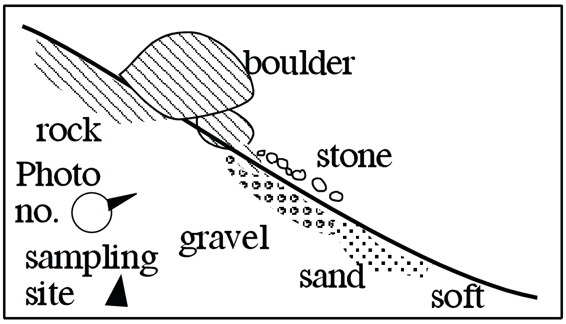
The plant biomass was low on this deep station (max. 3 g m^{-2}) (Figure 4, Table 3). The perennial brown alga *Sphacelaria arctica* dominated the low biomass. The animal biomass was totally dominated by the detritivores (i.e. *Macoma balthica*) having a max. biomass of 48 g dry weight m^{-2}, including shells (Table 3 and appendix 2).

The divers collected three sediment cores at 0, 5 and 10 m distance from the starting point. The sediment cores consisted of fine-grained sandy material and were oxidised down to 0.03 m depth (Table 4).

Table 4. SFR, Forsmark 1998. Sediment core visual thickness of oxidised sediments (unit m), the contents of organic matter (% of dry weight) and chlorophyll a per g wet weight of sediment in the uppermost cm of the core. Chlorophyl a is expressed as chl-a (C_V), and corrected values chl-a (C_{VL}) and pheopigment (C_{feo}) contents. An estimate of the g m^{-2} of organic matter and mg m^{-2} of chlorophyll was estimated

Station no.	distance to redox m	organic content %	Cv	Cv L	C feo	organic content g/m²	Cv mg/m²	Cv L mg/m²	C feo mg/m²
			μg/g sediment wet weight						
3 -	0.03	-	-	-	-				
6 core 1	0.001	0.35	4.7	3.1	2.8	-175.0	4.7	3.1	2.8
6 core 2	0.001	0.19	8.7	5.2	6.1	- 95.0	8.7	5.2	6.1
6 core 3	0.001	0.36	5.7	3.7	4.3	-180.0	5.7	3.7	4.3
6 mean 1–3		0.3	6.4	4.0	4.4	–150.0	6.4	4.0	4.4
st.dev.		0.095394	3.4	2.0	2.0	47.7	2.1	1.1	1.6
water contents (%)		35							
density sediment (g/c		2.5							





	Plants	Animals
	annual red	filter feeder
	perenn. red	herbivores
	annual brown	carnivores
	perenn. brown	omnivores
	Fucus	detritivores
	green	
	Characeae	
	Potamogeton	
	phanerogams/Zostera	
	others	

***Figure 4**. SFR, Forsmark 1998. Station 3. The depth distribution of the transect substrate and plant communities as well as plant and animal biomass. For the description of symbols, see also legends of figure 2.*

Station no. 4, Smultrongrundet

The transect started from large boulders at the shore of this island. Divers swam in 345°compass direction down to 10.5 m depth, 61 m from shore (Figure 5).

At 10.5 m depth, the substrate consisted of a flat, compact, sandy bottom with gravel. The substrate seemed to be poor with only few tracks from *Mesidothea entomon* and scattered *Macoma*-shells. Also, few blue mussels (*Mytilus edulis*) and short turfs of an unidentified small alga (probably *Sphacelaria arctica*) were observed. At 50 m from the shoreline the transect turned into a slope of boulders steep upwards. At the sides of the boulders a rich growth of barnacles (*Balanus improvisus*) occurred. On the top of the boulders short turf of *Sphacelaria arctica* and *Ceramium tenuicorne* grew. The red alga *Phyllophora* sp. occurred growing with a twisted thallus. The red algae *Ceramium tenuicorne* and *Polysiphonia nigrescens* increased towards the surface. The moss *Fontinalis dalecarlica* had its deepest finding at 6.9 m depth. The bladder wrack (*Fucus vesiculosus*) occurred from 5.1 m depth and then scattered upwards up to 2 m depth, but never in large amounts. Closer to the shore some phanerogames occurred, especially *Ruppia* sp., a few *Zannichellia palustris*, *Potamogeton pectinatus* and *Myriophyllum* sp. (presumably *M.spicatum*). The *Chara* sp. grew densely in few, scattered plots. Although, there was a variety of different plant (and animal) communities, the major impression was a grey and poor transect with several areas close to the surface having almost no growth.

The plant biomass war comparatively low (max. 47 g dry weight m^{-2}) and was dominated by green algae close to the surface and perennial red algae deeper down (at 5.1 m depth) (Figure 5, Table 3). Except for the area at 10 m depth also the animal biomass was low along the transect (max 4.5 g dry weight m^{-2}) (Table 3). At 10 m the detritivore mussel *Macoma balthica* had the comparatively high biomass of 100 g dry weight m^{-2} (including shells) (Table 3).

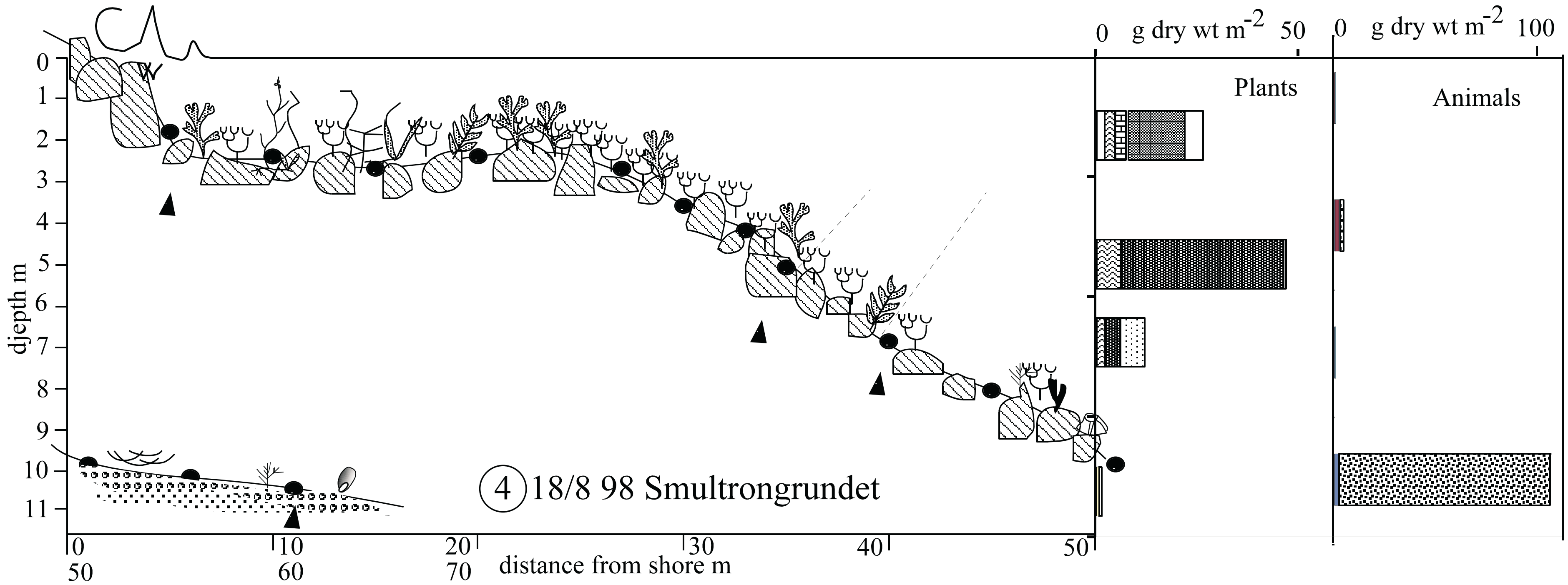


***Figure 5**. SFR, Forsmark 1998. Station 4. The depth distribution of the transect substrate and plant communities as well as plant and animal biomass. For the description of symbols, see legends of figure 2 and 4.*

Station no. 5, Skörtena

This island in the northeastern part of the investigated area was visited the 20 August. The divers swam in 220° compass direction down to 8.3 m depth, 65 m from shore (Figure 6).

At 6.5 m depth the substrate was sandy with only a few tracks from animals. However, the divers observed several small craters in the sand probably caused by the feeding activity of fish. Only a few shells of the detritivorous mussel *Macoma balthica* were observed. On several of the few, scattered boulders on the sandy substrate, at 7.5 m depth, the red alga *Ceramium tenuicorne* and the bladder wrack *Fucus vesiculosus* were attached. Also some *Furcellaria lumbricalis* grew. This was the deepest finding of *Fucus* in this survey. *Fucus* would probably grow deeper down on this locality if suitable substrate had occurred deeper down. At Örskär, the northern tip of Gräsö, some 15 km NNE of this site, in 1944 Mats Waern found *Fucus* down to 10 m depth (Waern 1952). The present observation of *Fucus* growing at least at 7.5 m depth indicates the area being fairly unpolluted. From 47 m from the shore the stones and boulders increased as well as the occurrence of *Fucus*. *Fucus* was then present up to 0.5 m depth. The two morphologies of *Fucus* occurred (broad and narrow growing thallus) along the transect. The broad –thallus form was often undulated and had many small shoots higher up on the thallus. These adventitious growths might be a sign of any kind of disturbance, e.g. mechanical injury (from ice or grazing) or pollution. The *Fucus* was abundant and in some parts covered the entire substrate, especially where rocks occurred. At spots where sand and gravel dominated, phanerogames grew. Just before the shoreline from 0.5 m depth, large amounts of *Chorda filum* and also *Dictyosiphon foeniculaceus* occurred. The transect made a rich and beautiful impression.

The plant biomass was totally dominated by *Fucus vesiculosus* at the intermediate depths (3–4 m) with the max. biomass 404 g dry weight m^{-2} of a total of 423 g (Figure 6, Table 3). At the surface the green alga (*Cladophora glomerata*) and the annual brown algae (*Dictyosiphon* and *Chorda*) dominated the samples (Table 3 and 4). In the deeper samples the perennial red algae dominated (mainly *Polysiphonia nigrescens*). The animal biomass had equal amounts of herbivores, filter feeders and detritivores (Table 2). The highest animal biomass was found in the *Fucus* –belt (68 g dry weight m^{-2}) (Table 3).

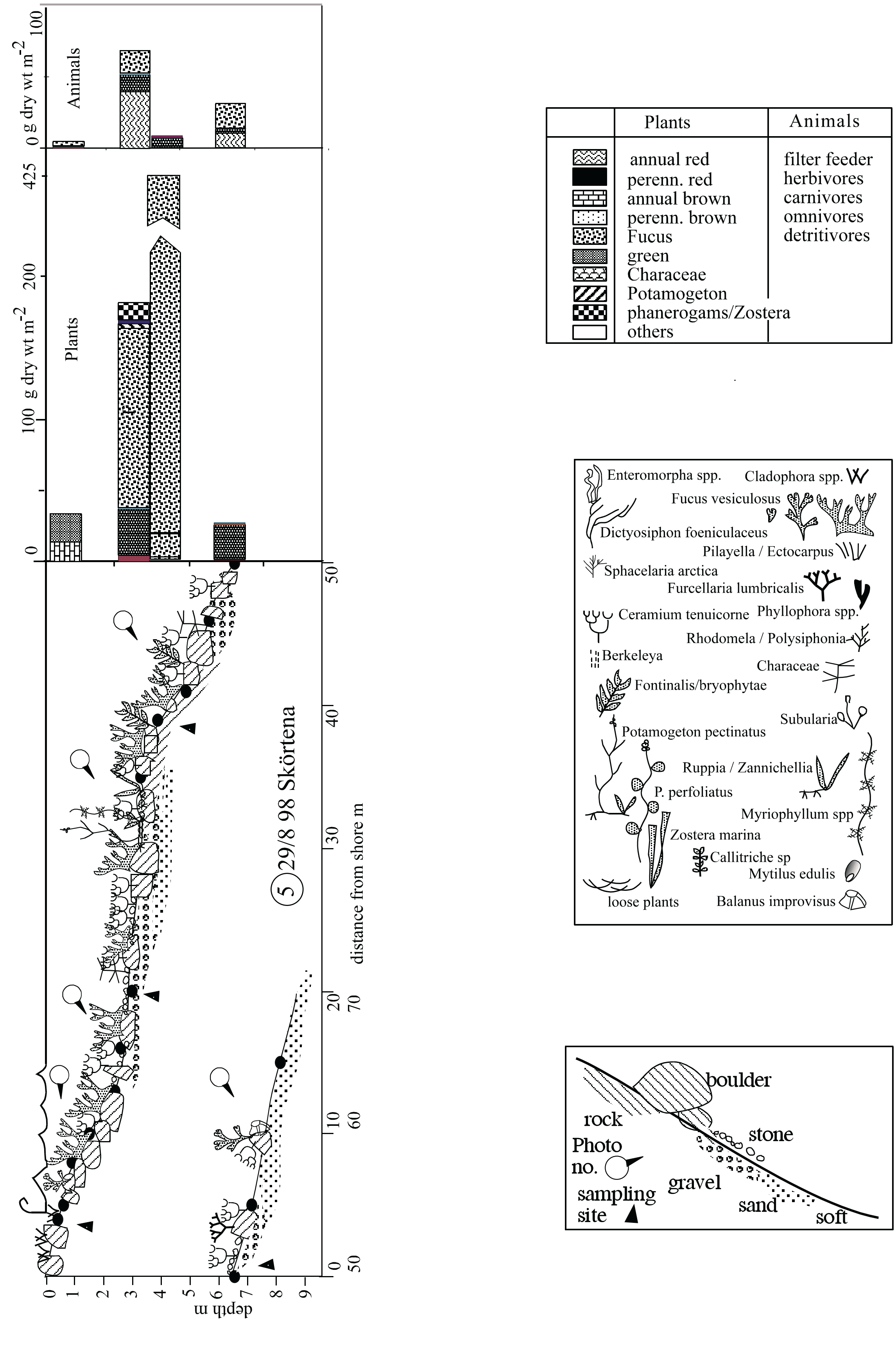


***Figure 6**. SFR, Forsmark 1998. Station 5. The depth distribution of the transect substrate and plant communities as well as plant and animal biomass.*

Station no. 6, 18-m depth

At this station the divers went down to 17.5 m depth, to a boulder rich sandy substrate. The sight was at a minimum at this sediment rich bottom. The boulders had trapped loose, partly decaying algae. On the sandy substrate, three sediment-cores were taken. The cores had decaying algae on the sediment surface. The redox cline was just below the surface (not measurable). The mean organic matter constituted 0.3 +-0.1% of dry weight (n=3) and the chlorophyll a content (uncorrected (Chl-a and for chlorophyll a (Chl_V-a and pheopigments (C_{feo}) was 6.4 ±3.4, 4.0±2 and 4.4±2 mg per g wet weight of sediment respectively (n=6) (standard deviation indicated).

Comparison with other areas

In the vicinity of the Forsmark area quantitative data have been collected in the eastern Gräsö-Singö area in the 1940s (Waern, 1952) and at a revisit of Waerns stations in 1984 (Kautsky, 1989, Kautsky, et al., 1986). When comparing our results with the findings of the 1980s (Figure 7), the quantitative data from the Forsmark area (Figure 8) had somewhat lower max biomass between 2 and 4 m depth (580 g and 214 g respectively)

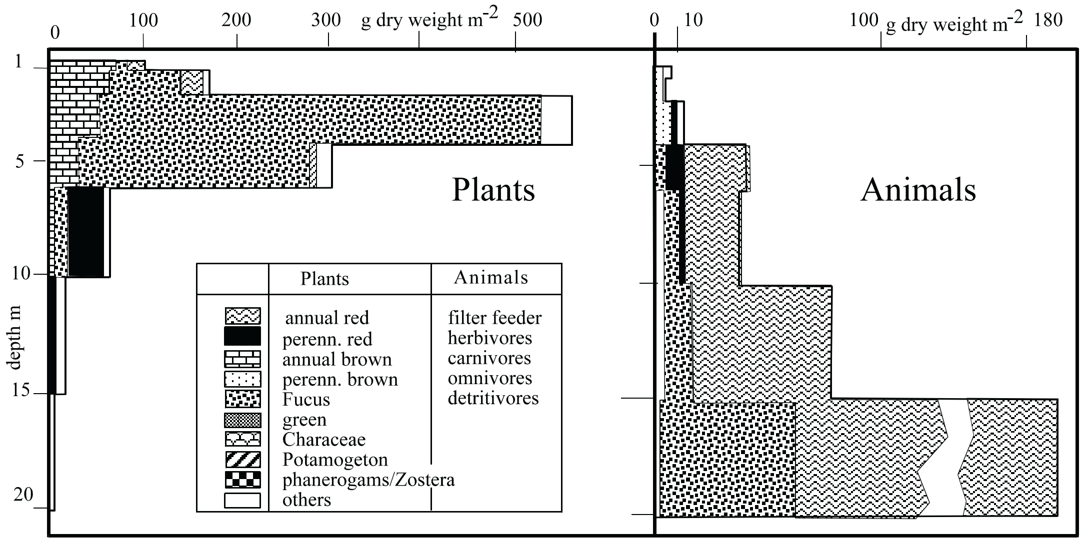


Figure 7. *The total plant and animal biomass depth distribution of the Gräsö-Singö area (from Kautsky 1989).*

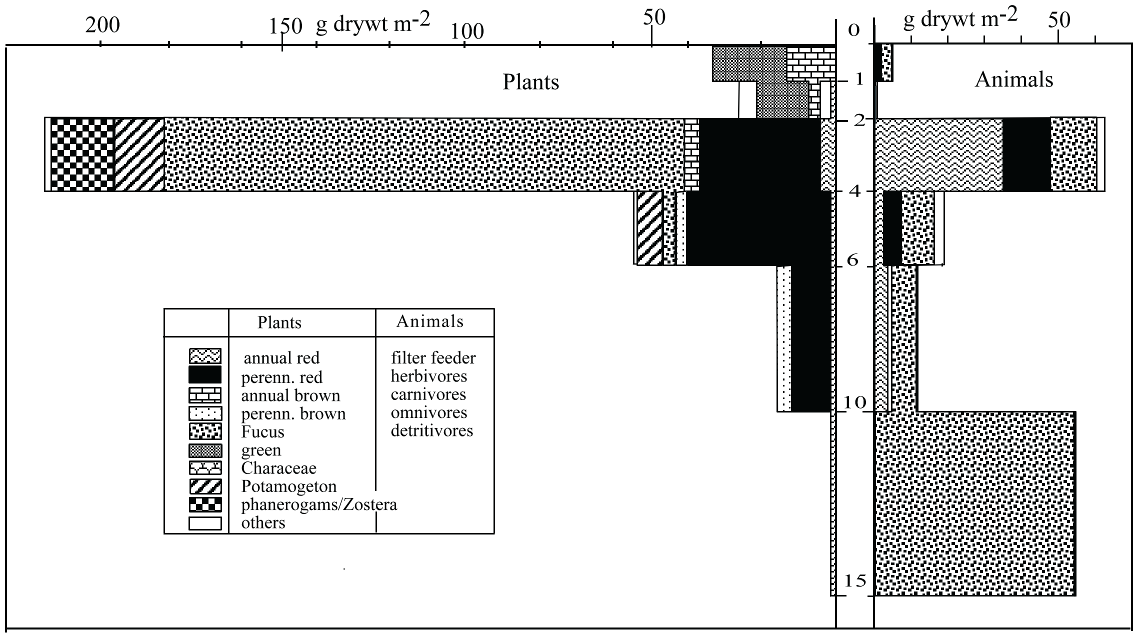


Figure 8. *SFR, Forsmark 1998. The total plant and animal biomass depth distribution of the investigated area.*

(Table 5). The main reason for this was the smaller amounts of *Fucus vesiculosus* in the Forsmak area, most probably due to the lack of suitable substrate in the area. Observations in the area partly indicate a rich growth of *Fucus* especially on hard substrates at the stations 1 and 5 (max. 624 g in one sample from station 5). However, the unstable substrates of stones, gravel and sand dominated in the area thus decreasing the mean biomass. Except for *Fucus*, in the Gräsö area the annual brown alga *Pilayella littoralis* (Figure 7) and in the Forsmark area the red algae (Figure 8) dominated between 1 and 6 m depth. This is mainly due to the difference in season of sampling, the Gräsö area was visited in June-July when annual brown algae are more common. The Forsmark area was visited in August when the annual brown algae usually have detached from the substrate and are replaced by green algae close to the surface and red algae deeper down. However, excluding *Fucus*, at given depths the overall plant biomass is similar in the two areas.

At the deeper sites the animal biomass of the Gräsö-Singö area (Figure 7) is approximately three times higher than the Forsmark area (Figure 8). This is due to the almost complete lack of the blue mussel *Mytilus edulis* in the Forsmark area having a maximal mean biomass of 1 g dry weight m^{-2} (including shells) and a maximum of 14 g in one sample from station 2 (Table 5), which is low in comparison to what is usually found further south in the Baltic Sea. In the Gräsö-Singö area the Mytilus biomass is in the magnitude of 150 g and in the Askö area, Baltic proper on average over 200 g dry weight m^{-2} (with maxima well over 1000 g). The lack of larger amounts of *Mytilus edulis* might also be due to the low occurrence of hard, stable substrates. However, this is well in accordance with results from other areas in the Bothnian Sea (Kautsky, 1989, Kautsky, 1995). As this major filter feeder is lacking in the area and no other species takes its role in the ecosystem, the function is somewhat different in the area compared to the Baltic proper where the filter-feeders (i.e. *Mytilus*) constitute up to 90 % of the total animal biomass). The biomass of other animals is of the same magnitude as those found in the Gräsö-Singö area, e.g. the detritivore *Macoma balthica* has a biomass of around 50 g at the deepest sites.

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Appendix 1. Selected photos from the SAFE area

In the appandix a selected number of photogaphs taken in the area are presented. Under water the pictures were taken with a Nikkonos V and 15 mm Nikkor-lens.

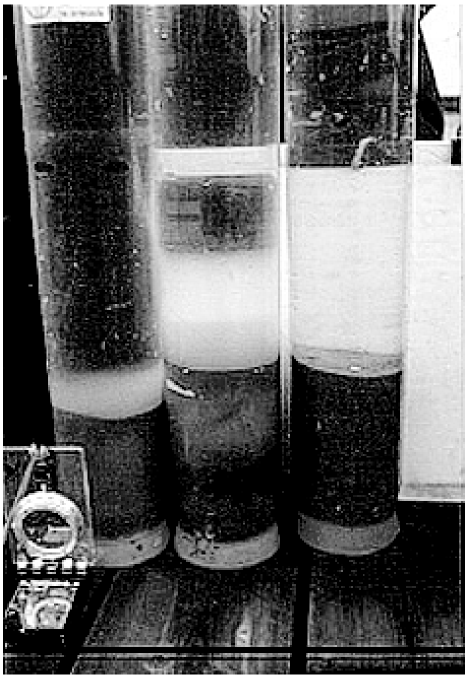

Photo no.1 Sediment cores from station no.3, 10.8 m depth. The redox-zone can be seen, especially in the middle core.

Photo no. 2. Sediment core from station no.6, 18 m depth. The redox-zone is just under the surface of the substrate. The black debris above the substrate is decaying, loose algae

Photo no. 3. Sediment core in situ at station no.3, collected on a sandy substrate at 10.8 m depth.

Photo no. 4.Station no. 4, 60 m from shore, at 10.5 m depth. Sandy substate with occasional stones and filamentous algae.

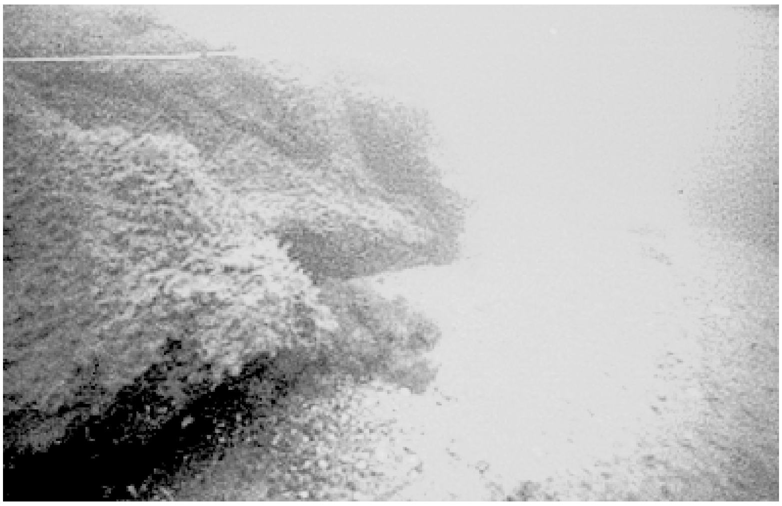

Photo no. 5. Station no. 3, 10 m from starting point, at 10.8 m depth. Boulder on sandy substrate. Loose algae catched by the boulder and filamentous algae growing on it.

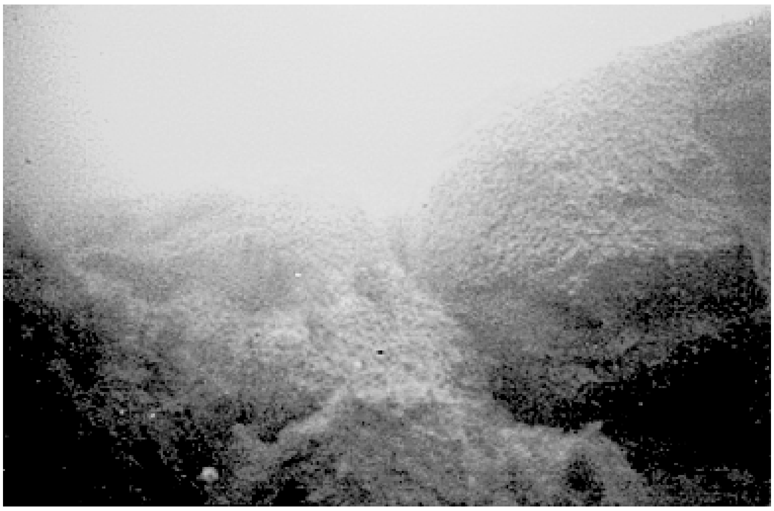

Photo no. 6. Station no. 2, 110 m from starting point, at 9 m depth. Large boulders covered by filamentous algae (e.g. ***Polysiphonia nigrescens****)*

Photo no. 7. Station no. 2, 74 m from starting point, at 4.8 m depth. Luxuriant growth of bladder wrack **(Fucus vesiculosus)** *covering 100 % of the boulder-substrate.*

Photo no. 8. Station no. 1, 29 m from starting point, at 3.6 m depth. **Chara**-*communities on mixed substrates.*

Photo no. 9. Station no. 5, 35 m from shore, at 3.5 m depth. A mixed substrate with mixed growth of phanerogames (mainly **Potamogeton** *spp.) and bladder wrack (***Fucus vesiculosus***).*

Photo no. 10. Station no. 4, 27 m from shore, 2.7 m depth. The moss ***Fontinalis dalecarlica*** *growing on top of a* ***Ceramium****-covered boulder.*

Photo no. 11. Station no. 2, at starting point, 2.4 m depth. Diver collecting quantitative samples from boulders covered (100 %) by ***Ceramium tenuicorne.***

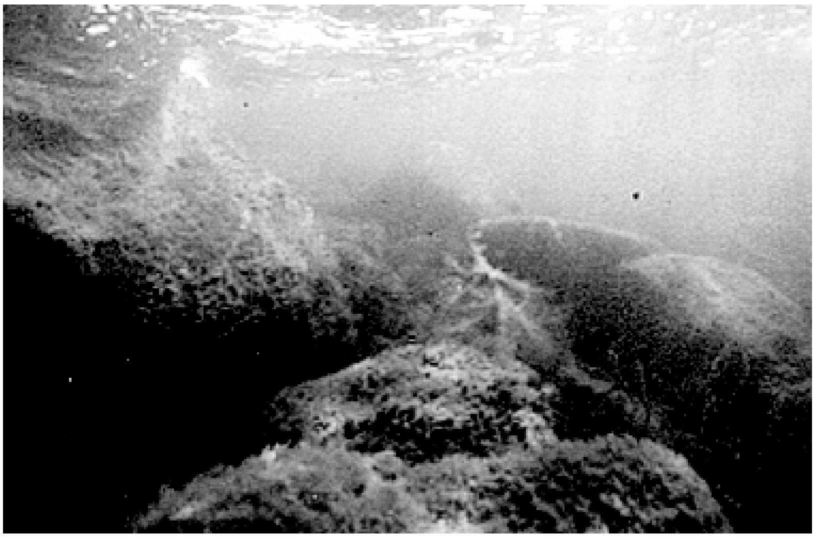

Photo no. 12. Station no. 5, 5 m from shore, at 0.5 m depth. The green algae ***Cladophora glomerata*** *covering the last 0.5 m of depth.*

Appendix 2. Copy of the divers protocols

The following is a direct copy of the protocol the divers wrote below the water surface. It is in Swedish.

Dykprotokoll slutförvaret (SFR) augusti 1998, primärprotokoll, dykprofiler.

Lokal 1, 18.8, SV hörn av Slutförvar, 10° dykriktning, N60° 24.774' E 18° 13.138' skattare HK, kamera Fo2, film 9816:1–36.
95: 4.5 (3.7) småblockig botten med sten grus , Fucus 25, Ceramium 75, Furcellaria 5, Fontinalis 5, Ruppia 5, Tolypella, Zannichellia 5, ca 5 Fo.
90:4.5 **ram 30**: Ceram 75, småblock, **ram 31**: Ceram 75, Ruppia, **ram 32**: Ceram 75, på grus.
Fucus delvis smalbålig, delvis bred, på sina håll upp till 50, mkt Macoma.skal hel del Theodoxus.
82: 4.8 (3.9) (10° C) 2Fo på bred och smal Fucus på block, annars s.o.
80:4.8 delvis mer stenigt, sandig, Fucus 10-5, Chorda Fo mkt Macoma -skal
74:4.5 blockigt igen som ovan, P.pectinaus +, Fucus 10, Ceram 75, Tolypella 5, Furcellaria 5, delvis halv m^2 ytor med grus tämligen kal,
50: 4.2 3 Fo grusigt med block, Zannich, Ruppia mm. även Fucus , Ceramium etc s.o.
ram 33 grus, Ruppia 50, **ram 34** grus 50, block, Ceram 50, Zannich 5, Fucus i hörn
ram 35 på block, Ceram 75, Fontinal 10.
48:3.6 (2.8) P.pect ökar 10 % i fläck 2Fo, Ceram 75, Fucus 10-25, Fontin 5, Entero och en hel del Rivularia som delv växer invävd i övriga finådiga alger.
block blir större
35:3.6 Fo på bred och smal Fucus på block,
3Fo på Micke och stort block (pyramidformat) med Fucus
29:3.6 3Fo på Chara på sand påse 57.
25: 3.3 **ram 37** Fucus 75 på sten, Myriophyllum, **ram 38** Ceram 75, Ruppia/Poamogeton pectinatus 25, **ram 36** Fucus 25, Pot.pect10, Ceram 50.
20:3.0 P.pectin och Ruppia tillsammans 50 % på småsandig grusig botten med block, på block Fucus tot. 25-50, Fontinalis 5, Ceram 25, Chorda 5, Chara 5 ökande, mycket Rivularia, Myriophyllum 5, Fo.
0:2.4 Fo s.o.
Fo **ram 27** block, grus, Chara 5, P.pectin -Ruppia 75.
ram 28 Ceram/Cladoph, Rivul, Ruppia.
ram 29 Fucus 10, Myriophyll, Ruppia.

Lokal 2, 19/8 NE -hörn vid grynnan (slutförvar) 245°, N E
110: 9.0 (9.2) grusbotten med sten och block (mkt block-dominerande).
Polysiph 50, kort ludd, sed 3, Cladoph rupestris (påse 3) Furcellaria 5, Macoma-skal.
ram 20 litet block, kort Poysiph 25 2Fo, **ram 22** grus sen röda 25, **ram 24** på block Furcell 10.
100:9.0 del lösa alger, s.o. Fo.
90:8.0 (8.0) Polysiph 25-50, Clad. rupestr 5, Fontinalis +-5 Fo, Furcell 5.
80:6.9 (6.9) häll N om lina, under lina block, grus.
på häll: Polysiph 75-100, Furcell 10, Fontinal 10,
vid 6.3 m djup (6.3) Fucus
77:6.0 (6.0) på häll: **ram 25**, Ceram 75 (Polysiph??) Fontin 5
ram 26 Ceram 100, Fucus 5,
ram 27 Ceram 100, Fontinal 10, Furcell 10
76: 5.7 häll börjar även under linan, Fucus 10, hel del småplantor, Polysiph. 100-75

Fucus ökar snabb
74:4.8 häll planar ut, Fucus 50, Poly 50-75 (delvis renspolad häll av whiplash) Fucus ökar till 100-75 vis 73:4.5 3Fo delvis några smalbåliga och ferila dels bredbåliga och krusia.
70:4.2 (skiss:bottnen planar ut ännu mer) Fucus 75-50, kort Pilayella under, kannål, gobider, finns ett fåtal fertila Fucus (både smal och bred, mest smal).
60:3.9 (3.9) häll slut, block Polysiph 75-100, Fucus 25, Fontinalis 5.
Fo på block med bred och smala ind av Fucus.
delvis stora (mkt stora ca. 1-2 m) , mellan block delvis kal grus
50:4.8 (4.6) grus 25, block med Pilayella 75, Fontinalis 5, Fucus 5.
46:4.5 (4.5) ram 28 på block Polysiph 100, font 5.
ram 29 block grus, Polysiph 75.
ram 30, block, ontinal 5, Fucus 5, Polysiph 5 Fo
2 Fo på finkrusig Fucus på topp av block.
40:3.8 Polysiph 75, Fucus 10-25, Font 5, Pilayella.
31:3.3 (3.2) 2Fo på Fontinalis, Fo på Fucus och Fontinalis, småblockigt , s.o. även stora block.
20: 2.9 (2.9) mest små Fucus (ngra år) 5-10 %, Fontinalis 5, Cladophora.
15:3.5 skiss: block sen dal (3.5 m djup) mest grus sten sen block igen).
10:2.6 2Fo hel de små Fucus men även några stora, mångåriga,
0:3.0 stora block 2 Fo s.o.,
ram 31 block Ceram 100, **ram 32** block Ceram 100-75, **ram 33** block Ceram 100.

Lokal 3 19/8 98 NV-hörn Slutförvar 90o, N 60 25.024 E 18 12.995.
25: 10.5 (10.5) finsandig botten, plan, hård, 3Fo.
Macoma-skal, lösa alger, spår av Mesidothea (?), enstaka mindre block med Sphacelaria och Poly/Rhod., block högst 5 %, sed 3.
20: 10.8 (10.6) 2Fo på block och sandbotten.

ram 30: på block, alger 25 %, **ram 31** på sand, inget, **ram 32** på sand, inget.
15:1.8 Fo på spår i sanden, på ett block Mytilus +
10:10.8 (10.6) fler block i litet område, täcking som ovan Fo, gobid
lösa alger fastnar kring foten av blocken
5:10.5à på toppen av ett block las 2 ramar:

ram 34 algludd 75, **ram 33** alger 75, Fo efer skrap, **ram 35** på grus, tomt
på sidan av block Balanus

Lokal 4 18.8 Smultrongrundet, 345°, N 60° 24.657 E 18° 14.685
61:10.5 (10.1) sandig grusbotten, hel del Macoma skal, Mesidothea + (ser flera ind) , lösa alger (?) på grus delvis mycket löst fastsittande, mytilus + 2Fo.
ram 28 alger 10
ram 29 alger 10
ram 37 alger 10-25
56: 10.2 block börjar lite.på block uderlig Phyllophora (smalat i påse 3), Sphacelaria 10-25.
51:9.9 (9,6) skiss sandbotten slutar i brantare blockbottnen som lutar uppåt, Fo.
hel del Balanus på sidan av block
45: 8.1 ram 25 Ceram 25 på block.
ram 27 kort ludd 50
ram 26 Ceram 10, kor ludd
Ceram (Polysiph??) ökar raskt på toppar av block.
40:6.9 Fontinalis 5, Ceram 50, Balanus p sidan av block.
3Fo(h) sista med block zonering (skiss:) Font i topp, sen Ceram och sist Balan. nere
Ceramium ökar till 100.
35.5.1 Fucus 5 , ceram 100, fontinal 5–10, (Fucus ökar på 5.5 m djup).

ram 20 eram 100 på block
ram 22 Ceram 100 på block
ram 24 Ceram 100, Fontinalis 5 på block
33:4.2 (3.6) skiss: blockbotten planar ut) Fo Ceram 100, Fucus 10.
30:3.6 (3.0) grusinslag men även mycke tflacka block sora (häll??), på blockbotten Ceram 75-100, fucus 10-25, Fontinal 5-+, Fo.
Ceram glesnar mer mycket Rivularia, Chorda+.
27:2.7(2.1) Fontinalis 10 2Fo på Font., Ceram kort, mycket rivularia, Fucus 5 Fo, Chorda 10 ökar till 25, Ceram delvis ersatt av Cladophora.
20:2.4 flack, småblock, sedine´menrik botten, block med lite och smått, hel del Chorda, Fucus 5
15:2.7 (de är liksom en flavck dal som gör ett grått inryck).
10:2.4 grus och block sprit, Fucus 10, Chorda 25, Ceram/Pilayella 50 kort, Fucus har delvis cladophora som epifyt.
5: 1.8 **ram 34** på block Cadoph 75, **ram 35** på block Cladoph 75, Rivularia Fo, **ram 36** på block Cladoph, Fontinal.
sen kort ludd mot ytan, nära 0.5 m förekommer delvis rikligt i fläckar Dictyosiphon (samlat)

Lokal 5, 29.8 98, Skörtena 220o , N 60o 25.77 E 18o 14.127.
65:8.2 (8.3) sand 2Fo enstaka Macoma,-skal, lite spår av Mesidiothea och bet-gropar från fisk.
på block Ceram 50, Furcell 25 och på topp 7.5 m djup:Fucus , sidan av block Balanus och Electra Fo.
55: 7.2 (7.2) sand slut, sten småbock, lite sand, Polysiph (Cer) 75-50, Furcell, ser lite Fucus-grodd, Fucus 5-10 Fo.
50:6.6 (6.5) s.o. Fo, **ram 27** på block Poly 50, Fontinalis, **ram 28** sten sand, alger 50, **ram 29** sten sand alger 25.
botten grus med …….(?) block, tämligen brant uppåt
46:5.7 s.o. Tolypella 10,, Myriophyllum, Fo på Tolypella.
häll börjar S om lina med Fucus 50, Furcell. 5, Fontinal 5, Polysiph 50, ”större” block under linan
41:4.8 häll Fucus 50, Furcell, Polysiph s.o., Balanus på sidor Fo.
39:3.9 (skiss: blockig botten planar ut)hällarat) Fucus 75-50, tämligen lite under Fucus, Fontinalis 2 Fo.
ram 33 Fucus 75, Fo, **ram 34** sten Fucu s10, Furcell 25, **ram 35** block Fucus 100
35:3.3 (3.3) blockigt tät botten (?) Ruppia.
Fucus 50 till 75 ibland, Zannichellia, Ruppia och Tolypella växer i grus sandfläckar, Myriophyllum och P.pectinatus 10, även Chara (påse 53) 4 Fo.
inslag av sand ökar och även kärlväxter
20: 3.0 (3.0) Fo på alla: **ram 30** sten Fucus 25, Chara, **ram 31** sten, sand P.pectin 10, Fucus 10, **ram 32** sten Fucus 75, P.pectin.
hel del Mysider och några gobider
16:2.6 (2.6) 2Fo Fucus 75, Zannichellia, P.pectinatus i klutt.
Pilayella 75, Ceram
13:2.4 (skiss: brant uppåt block) Fucus 75, ceram 75,Chorda, Fontinalis 5, lite P.pectin, Zannichell i början, men sen bara Fucus och Ceram, hel del Rivularia, flera Fo
10:1.5 (1.4) Fo på Peter i bakgrunden s.o.
8:0.9 Fucus avtar till 10, Cladophora på topp av block, (3Fo mot ytan) kraftig Chorda, Enteromorph och Rivular 3 Fo.
4:0.4 **ram 38** Cladoph 100, 50 % kvar).
5:0.6 **ram 37** Cladoph 100, **ram36** Dictyosiphon 50, Cladoph dyktid 1h20’.

Lokal 6 20/8 98 18m-hålet, N 60o 25.336 E 18o 14.803
17.5 m djup blockskravel, simmar omkring i obefintlig sikt tar 3 proppar ca 10 m från nedstigningen.

Appendix 3. Primary data, mean of sampling depth

Primary data from quantitative sampling. Biomass given in g dry weight per m²

Mean per sampling depth																		
Profile no.	1	1	1	1	2	2	2	2	3	3	4	4	4	4	5	5	5	5
Depth	2.4	3.3	4.2	4.5	3	4.5	6	9	10.5	10.8	1.8	5.1	8.1	10.5	0.4-0.6	3	3.9	6.6
PLANTS																		
Rivularia	0.00033333	0.00033333	0.02666667	0.027	0	0.06333333	0	0	0	0	2.19308333	0	0	0	0	0.00033333	0	0
RED																		
Phyllophora sp	0.00033333	0	0.02866667	0	0	0	0	0	0	0	0	0	0.00033333	0	0	0	0	0
Phyllophora truncata	0.15158333	0.03258333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllophora pseudoceranoi	0	0	0	0.00033333	0	0	0	0	0	0	0	0	0	0.00033333	0	0	0	0
Furcellaria lumbricalis	1.19675	5.37683333	0.4525	3.90666667	0	0	5.23666667	2.44975	0	0	0	0	0	0.01691667	0	0.05733333	9.10141667	2.3
Ceramium rubrum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00033333
Ceramium tenuicorne	10.462875	2.16883333	0.07216667	1.031125	1.81841667	0.26330833	1.975425	0.15233333	0.37225	0.0815	2.11308333	5.83083333	2.13616667	0.03475	0.0545	2.33120833	1.903	0.54575
Polysiphonia spp.	11.1533333	17.9408333	10.6425	0	0	0	9.04583333	0	0	0	0	0	0	0	0	0	0	0
Polysiphonia nigrescens	13.3197083	16.379	13.6733333	43.338875	52.9352083	49.26855	16.271375	1.78375	0.3995	0.326	0.0425	40.4175	3.61616667	0.48391667	0.15333333	32.3917083	6.58616667	21.8779167
Polysiphonia violacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.261875	0.18616667	0.00033333
BROWN (filamenteous)																		
Dichtyosiphon foenic	0.6825	0	0	0.18916667	0	0	0	0	0	0	0	0	0	0	4.76691667	0	0.04916667	0.0325
Dichtyosiphon/Stictyo	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ectocarpus siliqulosus	0	0	0	1.545	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pilayella/Ectocarpus	8.61916667	4.2685	6.32416667	0.215	0	8.75083333	0	0.269125	0	0	3.0525	0.05333333	0.035	0	8.13291667	0.2295	0.75833333	0.03533333
Sphacelaria arctica	0.03916667	8.624	0	0.55416667	0	0.02741667	0	4.20508333	2.04933333	0.41833333	0	0.085	6.08183333	0.74608333	0	0.00033333	0.00033333	0.02366667
Chorda filum	0	0	0.0325	0	0	0	0	0	0	0	0	0	0	0	0.70825	0	0	0
Fucus vesiculosus	37.2356083	135.021667	1.37833333	3.59866667	0	11.7041667	0.13416667	0	0	0	0.42083333	0.18	0	0	0.12416667	126.458333	404.810833	0.52333333
GREEN (filamenteous)	0	0	0	0	0.44	0	0	0	0	0	0	0	0	0	0	0	0	0
Enteromorpha spp.	0.185	0	0	0.02466667	0	0.12416667	0	0	0	0	0.27333333	0	0	0	1.1775	0.12366667	0.00033333	0.00033333
Cladophora sp.	4.41025	0.29	4.74333333	0.28391667	0	0.12666667	0	0	0	0	13.505	0	0	0	18.3481667	0	0.05058333	0.00033333
Cladophora glomerata	0	0	0	0	0	0.065	0	0	0	0	0	0	0	0	0	0	0	0
Cladophora rupestris	0	0	0	0	0	0	0	0.00033333	0	0	0	0	0	0	0	0	0	0
Vaucheria dichotoma	0	0	0	0	0	0	0	0	0	0	0	0.0075	0	0	0	0.05	0	0
Tolypella nidifica	0.48552917	0.595	0.95916667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.019
Chara spp.	0.05166667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.82916667	0	0
Fontinalis dalecarlia	1.0838625	0.59925	1.2725	0.19916667	0	3.883225	2.51975	0	0	0	4.6125	0.13333333	0	0	0.01625	0.055	0.04616667	1.27516667
Myriophyllum spicatum	2.57416667	10.6333333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ruppia spiralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11.5125	0	0
Ruppia marina	48.0661667	12.2258333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zannichellia	0	0	0.8725	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potamogeton filiformis	41.6051667	5.3625	23.5766667	0.12075	0	0	0	0	0	0	0	0	0	0	0	3.17166667	0	0
Potamogeton pectinatus	0	7.12833333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

appendix 3, cont.

ANIMALS																		
Laomedea spp.	0	0	0	0	0	0	0	0	0.0055	0	0	0	0	0	0	0	0	0
Dendrocelum lacteum	0	0	0	0	0.04166667	0	0	0	0	0	0	0	0	0	0	0	0	0
Prostoma obscurum	0.00066667	0.00033333	0.04266667	0.015	0.2375	0.105	0	0	0	0	0	0.00033333	0.00066667	0	0.00125	0	0.00033333	0
NEMATODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0055	0	0	0	0
ANNELIDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00319333	0	0	0
POLYCHAETAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0	0	0	0
Nereis diversicolor	0	0	0.32733333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00033333
Piscicola geometra	0	0.00033333	0	0.00033333	0	0	0	0	0	0	0.01833333	0	0	0	0	0.00033333	0	0
MOLLUSCA																		
Limapontia capitata	0	0	0	0	0.00066667	0	0	0	0	0.00033333	0	0	0	0	0	0	0	0
Hydrobia spp.	2.56	2.29833333	8.45666667	0.94883333	2.4125	0.97583333	2.14708333	1.33204167	0.24533333	0.325	0	1.1375	0.07083333	0.80666667	2.81083333	12.1966667	1.13366667	6.53666667
Theodoxus fluviatilis	17.5908333	14.6883333	12.0083333	4.62083333	4.77583333	3.71083333	1.41729167	0.00033333	0	0	0.11033333	1.08666667	0.08333333	0	0.9075	8.54416667	5.745	2.49166667
Bithynia tentaculata	0.9025	1.04	0.59833333	0.25366667	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lymnaea peregra	2.80866667	1.0975	0	0	0	0	0.03604167	0	0	0	0.055	0.40416667	0	0	0.26625	3.14416667	0.66783333	0.12916667
Mytilus edulis	0.72094167	0	0	0.10083333	4.98333333	1.56666667	0.27416667	0	0	0	0	0.1875	0	0	0	0.31333333	0.1005	0
Cardium sp.	92.22	42.2016667	5.88	4.43333333	0	0	0	0	0	0	0	0.23166667	0	2.01	0	39.4658333	0	9.96083333
Macoma baltica	15.6348917	21.6208333	28.6028333	3.075	0	0.10333333	0.36875	1.79166667	47.0041667	12.1666667	0	0.01916667	0.00033333	98.2225	0.08875	3.32833333	0	8.755
CRUSTACEA																		
Balanus improvisus	0	0	0	1.42416667	0	0	1.0625	0	0	0	0	0.21583333	0.2625	0	0	0	0	0.13916667
Idothea spp.	0.26166667	0.26166667	0.1875	0.07990833	0.02699833	0.14583333	0.00575	0	0	0	0	0.0525	0	0	0.009582	0.04583333	0.04386667	0.09033333
Idothea baltica	0	0	0	0	0	0	0	0	0	0	0.023	0.02666667	0	0	0.01	0.03291667	0	0
Idothea viridis	0	0	0	0	0	0	0	0	0	0	0	0.03116667	0.009375	0	0	0.004875	0	0
Jaera spp.	0.00066667	0.01233333	0.00933333	0.005625	0	0.00033333	0.00033333	0.017	0.01220202	0.00033333	0.00033333	0	0.00645833	0.00308333	0	0.00033333	0.02966667	0
Mesidothea entomon	0	0	0.53583333	0.02333333	0	0	0.10925	0.10229167	0.88916667	0.03333333	0	0	0	0	0	0	0	1.545
Gammarus spp.	1.20083333	1.53916667	0.40583333	0.50666667	1.22550167	0.1875	4.85654167	0.16616667	0.06237879	0.00868923	0.36466667	0.99333333	0.13623633	0.06125	0.62083333	1.1125	0.61666667	0.5825
Corophium volutator	0	0	0	0	0	0	0	0.03583333	0.20059091	0.06216667	0	0	0.05209667	0.23133333	0	0	0	0.0575
MYSIDAE	0	0.01416667	0	0.03855	0	0	0	0	0.00386364	0.01333333	0	0	0.02220833	0	0.0125	0.03666667	0.00033333	0.00033333
INSECTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00638887	0	0	0
Chironomidae	0.00033333	0.00333333	0.001	0.001875	0	0	0	0.00033333	0.00033333	0	0.01916667	0.00033333	0.01195833	0.01416667	0.00125	0	0.00033333	0
Diptera	0.00033333	0	0	0	0	0	0	0	0	0	0.04166667	0	0	0.00033333	0	0	0	0
Trichoptera	2.54433333	1.15916667	0.93166667	0.12905	0.63333333	0	0	0.2375	0	0.04	0.19166667	0.09333333	0.17166667	0.02	0	0	0	0
PISCES	0.10666667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.045
Gobidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0
sum plants	*181.323167*	*226.686833*	*64.055*	*55.0345*	*55.193625*	*74.2766667*	*35.1832167*	*8.860375*	*2.82108333*	*0.82583333*	*26.2128333*	*46.7075*	*11.8695*	*1.282*	*33.482*	*181.472625*	*423.4925*	*26.634*
sum animals	*136.553333*	*85.9371667*	*57.9873333*	*15.6570083*	*14.3373333*	*6.79533333*	*10.2777083*	*3.68316667*	*48.4235354*	*12.6498559*	*0.82416667*	*4.48016667*	*0.82766633*	*101.524833*	*4.78833087*	*68.2259583*	*8.3382*	*30.3335*