NIVA

REPORT SNO 4839-2004

Environmental assessment of Ranfjorden, northern Norway, 2003

Resipientundersøkelse i Ranfjorden 2003

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REPORT

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Title	Serial No.	Date
Environmental assessment of Ranfjorden, northern Norway, 2003 - *Resipientundersøkelse i Ranfjorden 2003*	4839-2004	2004.05.24
	Report No. 23205 Sub-No. 1-6	Pages 133 Price
Author(s): Walday, Mats; Helland, Aud; Magnusson, Jan; Moy, Frithjof; Rygg, Brage	Topic group: Marine Ecology	Distribution
	Geographical area: Nordland, Norway	Printed: NIVA

Client(s)	Client ref.
Rana kommune (Elisabeth Skei)	document ref. 02/00360 – 034

Abstract

The environmental quality of Ranfjorden is regarded as little affected by municipal sewage; the water quality normally varies between Very Good and Good (classes I-II). There are, however, evident effects from sewage at station 1 in the vicinity of the innermost outlet, Mjølanodden. This is regarded as a local problem and might be solved by changing the position of the outlet. The abundance of fast-growing algae in the littoral zone also gives evidence of elevated nutrient levels in the inner fjord. Oxygen-levels in the fjord are classified as Good to Very Good. The results from the benthic-fauna investigations indicate a need for remediation in order to obtain good environmental status (class II) throughout the inner fjord. However, it is not certain if the status can be improved merely by reducing the municipal sewage discharges. The observed decrease in concentrations of contaminants in sediments from 1992 to 2003 is probably related to the remediating action that has been taken in the area. The mining company Rana Gruber and the river Ranelva are supplying the fjord with large amounts of inorganic material. Variations in the input will have major influence on the concentration of pollutants in the sediments. The discharge of particulate matter from Rana Gruber have negative impact on both hard-bottom and soft-bottom communities. These effects might camouflage effects from eutrophication.

4 keywords, Norwegian	4 keywords, English
1. Ranfjorden	1. Ranfjorden, Norway
2. Eutrofi	2. Eutrophication
3. Sedimenter	3. Sediments
4. Miljøgifter	4. Micropollutants

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ISBN 82-577- 4521-9

Environmental assessment of Ranfjorden, northern Norway, 2003

Resipientundersøkelse i Ranfjorden 2003

Preface

The present report is produced by the Norwegian Institute for Water Research (NIVA) on behalf of Rana kommune. The main purpose of the study was to document the environmental quality of Ranfjorden, primarily according to eutrophication, so that local authorities of Rana obtained necessary decision basis on whether they should apply for exception from the EU-requirement of secondary treatment of sewage or not.

A contract regulating the task was signed between NIVA and Rana kommune in January 2003 (document ref. 02/00360 – 034). Elisabeth Skei has been representing Rana kommune during the work.

Roger Velvin at Akvaplan-niva was responsible for the sediment-sampling. Mona Gilstad Hials at Hydra-Vega performed the sampling in cooperation with Akvaplan-niva. She did also all the water-sampling.

Thermotolerant coliform bacteria in seawater was analysed by the local food control authorities in Mo i Rana.

Arild Sundfjord NIVA was responsible for the Hydrographical and hydrochemical part of the survey, assisted by Tone Kroglund NIVA. Jan Magnusson NIVA is author of the chapter on Hydrograpy and hydrochemistry. Analysis of water samples were done at NIVAs laboratory in Oslo.

Brage Rygg NIVA is author of, and responsible for the soft-bottom fauna investigations. Pirkko Rygg, NIVA assisted in the taxa identification.

Mats Walday NIVA is author of, and responsible for the investigations of hard bottom communities. He was assisted by Frithjof Moy (co-author) and Lise Tveiten, both NIVA.

Aud Helland NIVA is author of, and responsible for the investigation of micro pollutants in bottom sediments. Chemical analysis of sediments were done at NIVAs laboratory in Oslo.

Oslo, 24. May 2004

Mats Walday, project manager

Contents

Summary

The environmental quality of Ranfjorden in northern Norway was investigated in 2003. The investigations focused on effects from eutrophication. In addition, levels of micro pollutants in sediments were measured.

The main purpose of the study was to document the environmental quality of Ranfjorden, primarily according to eutrophication, so that local authorities of Rana obtained necessary decision basis on whether they should apply for exception from the EU-requirement of secondary treatment of sewage or not.

Surface observations of nutrients, phytoplankton biomass (chlorophyll-a) and oxygen in the deeper water masses, classifies the fjord generally as Very good to Good (class I-II) according to the Norwegian Classification System for eutrophication.

The exception from this is station 1, close to the town 'Mo i Rana' at the mouth of the river Ranelva, and in the vicinity of a sewage outlet. At this station there were elevated concentrations of phosphorus in the water, classifying the surface layer as Very poor to Poor (class IV-V) in summertime. There were also slightly elevated levels of ammonia (classified from Good (II) to Fair (III)).

The elevated concentrations of nutrients and the high number of thermotolerant coliform bacteria (TCB) that were found at station 1 indicate a local negative impact from sewage, probably from the closest sewage outlet (Mjølanodden) or from free overflows. The total local loads of nutrients and carbon to the fjord are dominated by the river Ranelva, except for phosphorous where sewage contributes with about 30-50%, depending on the (natural) variation in the river load. However, as nutrient source for phytoplankton growth, the phosphorous load from sewage can result in a modest production, roughly 1-20 % of the carbon load (TOC) from the river.

The relatively poor secchi-depth (water transparency) is a function of the discharges of (mineral or other non-marine) particles from the river or other sources, and can not be explained by the measured phytoplankton biomass.

The littoral zone of the inner fjord showed some indications of eutrophication, primarily increased abundances of fast-growing green-algae. These are probably caused by elevated nutrient levels in the surface-water, but is also a natural effect of increasing fresh-water influence towards the inner part of the fjord. The main negative influence on littoral and sublittoral flora and fauna on hard-bottom in the inner fjord is from sedimentation of inorganic particles, mainly originated from the activities of the Rana Gruber company, but also from river run-off. The sub-littoral reference station was heavily grazed from sea-urchins.

The soft-bottom communities in large areas of inner Ranfjorden showed Fair environmental status (class III). In some areas the status was classified as Good (class II). In the outer fjord the status was Good.

At many of the soft-bottom stations in inner Ranfjorden, the abundances of benthic animals were much higher than in outer Ranfjorden and also much higher than at the majority of soft-bottom stations in Norwegian fjords and coastal waters. The high abundances of animals at several stations in the inner fjord indicate high nutrient supply. This may be caused both by runoff from the river and surrounding land areas and by nutrient discharges from human activities. The most significant source is runoff from the river. Similar situations with high animal abundances have been observed in other estuarine and polluted areas in Norway (NIVA database).

In general, the sediments had low concentrations of TOC, but at some stations in the inner fjord, significant amounts of organic particles in the sediments were observed. They were mostly terrestrial and probably due to river runoff. The low TOC-concentrations in the fjord sediments are due to dilution by inorganic particles from the activities of Rana Gruber.

The area was not characterized by typical pollution-indicating species, except at two of the innermost stations, where the polychaete *Capitella capitata* occurred in moderate numbers. The fauna in inner Ranfjorden is probably influenced by several factors, including organic pollution and industrial pollution (inorganic particles from Rana Gruber, heavy metals, PAH and other substances).

There has been a significant reduction of total PAH and benzo(a)pyren in the sediments of Ranfjorden from 1992 to 2003. Only the innermost part of the fjord is markedly polluted by PAH, while the rest of the fjord is moderately polluted by PAH. The metal concentrations in the sediments have also decreased from 1992 to 2003. The fjord is in general moderately polluted by Cd, Cu, Pb and Zn, and insignificantly polluted by Hg.

Conclusions

The environmental quality of Ranfjorden is regarded as little affected by municipal sewage; the water quality in the fjord normally varies between Very Good and Good (classes I-II). An exception from this is the evident effects from sewage at station 1 in the vicinity of the innermost outlet, Mjølanodden. This is regarded as a local problem and might be solved by changing the position of the outlet.

Elevated concentrations of coliform bacteria at station 1 clearly indicates impact of fresh sewage when the submerged outlet breaks through the discontinuity layer. The abundance of fast-growing algae in the littoral zone also gives evidence of elevated nutrient levels in the surface waters of the inner fjord.

In spite of the relatively high supply of organic material by the river Ranelva are oxygen-levels in the fjord classified as Good to Very Good.

The results from the benthic-fauna investigations indicate a need for remediation in order to obtain good environmental status (class II) throughout the inner fjord. However, it will probably not be significantly improved merely by reducing the municipal sewage discharges.

The observed decrease in concentrations of contaminants in sediments from 1992 to 2003 is probably related to the diminishing supply of micro pollutants to the fjord, effected by the remediating action that has been taken in the area.

The project “Fylkesvise tiltaksplaner: Nordland (Olsson et al. 2003) has shown that current information on discharges of pollutants to the fjord is insufficient. It is therefore difficult to relate the decreasing sediment concentrations directly to decreases in discharges.

The mining company Rana Gruber and the river Ranelva are both supplying the fjord with large amounts of inorganic material. Variation in these sources will have major influence on the concentration of pollutants in the sediments. A large input of inorganic non polluted particulate matter will dilute the micro pollutant concentrations in the sediments.

The discharge of particulate matter from Rana Gruber has negative impact on both hard-bottom and soft-bottom communities. These effects might camouflage effects from eutrophication.

Sammendrag, konklusjoner og tilrådinger

Det er i 2003 gjennomført resipientundersøkelser i Ranfjorden på oppdrag av Rana kommune. Det overordnede formålet var å framskaffe data som gir Rana kommune grunnlag for å avgjøre om de vil søke om unntak fra det generelle kravet om sekundærrensing for de kommunale renseanleggene, hvor avløpsvannet nå gjennomgår primærrensing (sil). Videre skulle undersøkelsen være grunnlag for senere overvåking av fjordområdet. Avløpsdirektivet krever at oversikten over følsomme og mindre følsomme områder skal revideres minst hvert 4. år. Det var også et ønske at undersøkelsene skal være egnet til å danne grunnlag for vurdering av opphevelse av gjeldende kostholdsråd.

Undersøkelsene har omfattet innlagrings- og spredningsberegninger av kommunale utslipp (se vedlegg A), vurdering av ulike tilførselskilder relatert til eutrofi, undersøkelser av vannkvalitet, undersøkelser av bunnfauna på bløtbunn, undersøkelser av fastsittende alger og dyr på grunne hardbunnsområder (0-30 m dyp), samt innhold av miljøgifter i blåskjell og i bunnsedimenter. Det er fokusert på problemstillinger i forhold til kommunale avløp og eutrofieffekter. Metodikken er nærmere beskrevet i de enkelte fagkapitteler i rapporten. Miljøgiftanalysene av blåskjell rapporteres separat og vil bli brukt av kommunene ved en revurdering av de gjeldende kostholdsråd for Ranfjorden.

Resultatene fra undersøkelsene i Ranfjorden i 2003 er blitt sammenlignet med resultater fra tidligere undersøkelser i fjorden

<u>Vannkvalitet</u>
Det var gode oksygenforhold i hele fjorden. Klorofyll- og næringssaltmålingene i overflatelaget i de indre deler av Ranfjorden karakteriserer tilstanden generelt som God (Klasse II) til Meget God (Klasse I).

Klorofyllmålingene viste en Meget god tilstand i sommerhalvåret. Dette tyder på liten produksjon av planteplankton i denne delen av fjorden. I vårmånedene kan imidlertid klorofyllnivåene være høye under våroppblomstringen.

Unntaket fra dette er stasjon 1, nær Mo i Rana og munningen av Ranelva, samt i området hvor avløpet fra Mjølanodden renseanlegg slippes ut. På denne stasjonen var det forhøyede nivåer av fosfor, tilsvarende Dårlig (klasse IV) til Meget dårlig tilstand (klasse V) sommerstid. Det var også noe forhøyede nivåer av ammonium på stasjon 1, tilsvarende God til Mindre god tilstand (klasse III).

Når bobleanlegget ved munningen av Ranelva er i drift, vil kompensajonsstrømmen innover i fjorden øke og dermed bidra til en større inlagring av avløpsvann i det overliggende elvevannet.

De høye næringsalt- og bakterienivåer (TKB) som ble målt på stasjon 1 gir klare indikasjoner på en negativ påvirkning fra det kommunale utslippet ved Mjølanodden, og/eller fra overløp av kloakk. Den totale tilførsel av næringsalter og karbon til Ranfjorden er dominert av tilførslene via Ranelva. Dette gjelder ikke for fosfor hvor kloakken bidrar med 30-50%, andelen er avhengig av svingninger i tilførslene via elva. Som næringskilde til planteplanktonvekst er imidlertid bidraget fra fosfor fra kloakk ganske beskjedent; i størrelsesorden 1-20% av karbontilførselen fra elva.

Det relativt dårlige siktdypet i fjorden har ikke sin årsak i planteplanktonforekomster, men er en funksjon av mineralske- eller andre ikke-marine partikler som tilføres fjordvannet via elva og andre kilder.

Hardbunnsamfunn

Forholdene i fjæra var preget av nedslamming, primært av partikler fra Rana Gruber. Det var også indikasjoner på næringsaltbelastning, uttrykt ved forekomstene av hurtigvoksende grønnalger på stasjonene innenfor Bjørnebærvika, i indre del av Ranfjorden. Økende ferskvannspåvirkning fremmer også grønnalgevekst, slik at de observerte forekomster er en kombinasjon av disse to faktorene. Dette har vi også sett i andre fjorder. På hardbunn dypere ned, overskygget nedslammingen eventuelle effekter av næringsaltpåvirkning i indre deler av fjorden. På referansestasjonen var forholdene preget av kråkebollebeiting, som ofte er observert i nordnorske fjorder.

Bløtbunnsfauna

Bløtbunnsfaunaen i indre del av Ranfjorden hadde en mindre god tilstand (klasse III), men noen områder hadde også god fauna (klasse II). På de innerste stasjonene var det dårligst faunatilstand.

Bunnfaunaen i indre del av Ranfjorden hadde høy individtetthet, men lavere artsmangfold sammenlignet med ytre del. Individtettheten økte inn mot elva med høy dominans av noen få opportunistiske arter[1], og den var langt høyere enn normalt for norske fjorder og kystvann. Typiske forurensningsindikerende arter forekom på to av de innerste stasjonene i fjorden. Lignende tilfeller med høy tetthet av dyr er observert i estuarer og forurensede områder andre steder i Norge (NIVA database).

Faunasammensetningen på bløtbunn tyder på en rik tilgang på næring. Kilden til denne næringen kan være både planteplankton, terrestrisk organisk materiale og kommunale avløp. Tilførslene av TOC med Ranelva er så mye høyere enn fra kommunens utslipp av kloakk, at den hovedsaklige næringskilden for organismene i fjorden høyst sannsynlig er elva.

Bunnsedimenter

Bunnsedimentene hadde et relativt lavt organisk innhold, men i de innerste delene av fjorden ble det observert mye terrestrisk organisk materiale i sedimentene. Både denne og tidligere undersøkelser viser at hele Ranfjorden er påvirket av uorganiske partikler fra Rana Gruber, og spesielt innenfor Langneset var sedimentasjonen av partikler høy. Den høye sedimentasjonen av uorganisk materiale er årsaken til den relativt lave konsentrasjonen av organisk materiale i sedimentene. Økende TOC men avtagende totalfosfor i sedimentene utover fjorden tyder på en tilførsel av fosfor innerst i fjorden.

[1] Opportunistiske arter er arter som raskt kan utnytte endringer i miljøet, som f.eks økte næringssaltnivåer, til hurtig vekst og en høy produksjon av avkom. Langsomtvoksende flerårige arter vil i slike tilfeller kunne bli utkonkurert.

Konsentrasjonen av miljøgifter i bunnsedimentene var tydelig redusert siden 1992. Dette var tydeligst for total PAH og benso(a)pyren. Med unntak av den aller innerste delen av fjorden, er Ranfjorden nå Moderat forurenset (klasse II) av PAH. Sedimentene er Ubetydelig forurenset (klasse I) av kvikksølv og Moderat forurenset av metallene kadmium, kopper, bly og sink.

Konklusjon

Dagens miljøtilstand i fjorden vurderes som lite preget av de kommunale utslippene av kloakk, unntatt lokalt ved Mjølanodden. Tilstanden er mer preget av industriutslipp, og da særlig utslippene av uorganiske partikler.

Forhøyede nivåer av termotolerante koliforme bakterier (TKB) i sjøvannet på stasjon 1 gir klare indikasjoner på at avløpsskyen av kloakkvann tidvis bryter gjennom til fjordens overflate. Forekomsten av hurtigvoksende grønnalger i fjæra på de indre stasjonene er også indikator på forhøyede nivåer av næringssalter i fjordens overflatevann.

På tross av relativt stor tilførsel av organisk material til fjorden via Ranelva så er oksygennivåene i fjordvannet gode.

Det er registrert en nedgang i miljøgiftkonsentrasjonene i fjordens bunnsedimenter siden 1992. Dette er sannsynligvis et resultat av reduserte tilførsler av miljøgifter til fjorden, en følge av miljøtiltak som er gjennomført for fjorden og nedleggelse av forurensende industri.

Prosjektet "Fylkesvise tiltaksplaner: Nordland" (Olsson et al. 2003) har imidlertid vist at kunnskapen om utviklingen i tilførsler til Ranfjorden er utilstrekkelig. Av denne grunn er det vanskelig å påvise en direkte kobling mellom nedgangen i miljøgifter i fjorden og endringer i tilførsler til fjorden.

Store mengder uorganisk materiale tilføres Ranfjorden fra aktivitetene ved Rana Gruber og via Ranelva. Endringer i disse tilførslene vil ha stor betydning for konsentrasjonene av miljøgifter i bunnsedimentene; - store tilførsler av ikke-forurenset uorganisk materiale vil fortynne miljøgiftkonsentasjonene i sedimentene. Den registrerte nedgangen i miljøgift-konsentrasjoner sedimentene, og de reduserte utslippene fra Rana Gruber gir sammen gode indikasjoner på at tilførslene av miljøgifter til fjorden må være redusert.

Utslippene fra Rana Gruber har også negativ påvirkning på fjordens hardbunns- og bløtbunnssamfunn. Denne påvirkningen kan skjule en eventuell eutrofieffekt.

Undersøkelsene av fauna på bløtbunn indikerer et tiltaksbehov for å oppnå god miljøtilstand (klasse II) i hele indre fjord. Det er imidlertid usikkert hvorvidt dette kan oppnås ved å redusere kommunens kloakkutslipp.

Tilrådinger

Problemene ved Mjølanodden er både knyttet til den direkte tilførselen av næringssalter til kompensasjonsstrømmen og til den tidvise gjennomtrengningen av kloakkvann til overflaten. Problemet kan delvis løses ved å flytte utslippspunktet lenger ut i fjorden eller å dykke det til et dyp hvor faren for gjennomslag til overflaten er minimal. Sannsynligvis må man ned mot

50m dyp for å oppnå dette. Et annet alternativet er en kjemisk rensing av kloakken som vil redusere både bakterie, fosfor og miljøgiftinnhold i kloakkvannet.

Hvis kommunen vurderer å flytte utslippsdypet for Mjølanodden bør nye beregninger av optimalt dyp og sted for utslippet gjennomføres først.

Ved undersøkelsene i 2003 hadde kommunen tekniske problemer med renseanlegget ved Mjølanodden. Disse problemene har sannsynligvis påvirket resultatene for vannkvalitet ved stasjon 1. Vi anbefales derfor en fortsatt innsamling av vannprøver i dette området under normal drift av renseanlegget. En bør da inkludere prøver fra elvevann for å ekskludere at de forhøyede verdiene i fjorden kan være påvirkning fra overløp til elven. Undersøkelsene kan begrense til å inkludere parametrene TKB, ammonium og temperatur/salinitet i overflatelaget (0,5 m dyp).

Vi anbefaler fremtidige overvåkningsprogram til å inkludere undersøkelser av miljøgiftutslipp til fjorden. Kunnskap om tilførsler er avgjørende for å kunne vurdere effekter av forurensningsbegrensende tiltak. I dette ligger også behovet for kunnskap om eventuelle sesongavhengige endringer i tilførslene.

1. Introduction

The environmental quality of the inner parts of Ranfjorden, northern Norway, has been investigated several times. The fjord has throughout the 20th century been affected by human activities, mainly industrial effluents, but also discharges of sewage from the town Mo at the head of the fjord, and other scattered settlement along the shoreline.

It has been reported that the environmental status of the fjord is improving, but there are still dietetical restrictions based on the levels of micropollutants in blue mussels (*Mytilus edulis*). Contamination by micropollutants primarily PAH and heavy metals, is regarded as the major environmental problem in the fjord. In addition, the large spill of inorganic particles from mining is a significant impact that can be traced throughout the fjord. It has been estimated that 95% of the total supply of particles to the fjord is caused by mining activities (Helland et al. 1995).

Impoverished bottom fauna and high abundance of green algae on shallow water in 1992-1994 gave indications of eutrophication, especially the inner parts of the fjord (Green et al. 1995). Eutrophication refers to an increase in the rate of supply of organic matter to an ecosystem, which most commonly is related to nutrient enrichment enhancing the primary production in the system (Nixon 1995). Eutrophication of marine coastal waters has been in focus for the last three decades and is recognised as a main task to overcome, because negative changes from eutrophication are observed in coastal systems.

There are six sewage outlets larger than 300 p.e. (person equivalents) that discharges to the inner fjord. The main sewage outlet equals 18 900 p.e. (Mjølan) and the total discharge to the inner fjord equals 31 721 p.e. Sewage treatment today includes primary treatment (1 mm sieve). The main official requirement in EU Directive (1991/271/EEC and 1998/15/EEC) on urban waste water treatment is that member states shall ensure that urban waste water entering collecting systems before discharge shall be subject to secondary treatment, or an equivalent treatment for all discharges to sea from agglomerations of more than 10 000 p.e., and to estuaries from more than 2 000 p.e.

Urban waste water discharges from agglomerations of between 10 000 and 150 000 p.e. to coastal waters and those from agglomaterions of between 2 000 and 10 000 p.e. to estuaries may be subjected to treatment less stringent providing that:
- such discharges receive at least primary treatment,
- comprehensive studies indicate that such discharges will not adversely affect the environment, and the recipient be identified as a less sensitive area.

Member States shall provide the Commission with all relevant information concerning the above mentioned studies. Member States shall also ensure that the identification of less sensitive areas is reviewed at intervals of not more than four years.

The main purpose of this study is to document the environmental quality of Ranfjorden, primarily according to nutrients, so that local authorities of Rana obtains necessary decision basis on whether they should apply for exception from the EU-requirement of secondary treatment or not. Further to create the basis for future monitoring programs - the identification of less sensitive areas must be reviewed at intervals of not more than four years.

2. Hydrography and hydrochemistry

2.1 Fjord bathymetry.

Ranfjorden is a sill fjord, about 45 km long and over 500 meter deep, with the sill at about 100 meters depth (Figure 3 and Figure 4). The inner part of the fjord is about 26 km long and 5 km wide and with a surface area of $90*10^6 m^2$ (Figure 1). The main freshwater discharges are from the Dalselven (average yearly discharge 1930-60 was 8 m^3/s) and the Ranelva (174 m^3/s). From the Sørfjord there is a freshwater discharge of 95 m^3/s. In 2002 the run off was close to the averages (Ranelva 186 m^3/s, Dalselven 8 m^3/s and Sørfjord 93 m^3/s).

Figure 1. Ranfjorden, and main rivers discharging into the inner part of Ranfjorden. The outer boarder of inner part of Ranfjorden is marked with a blue line at Langnesodden. Chart from NVE. *Ranfjorden med større elver med utløp i indre del av fjorden. Det som her betegnes som indre del av fjorden er innenfor den blå linjen ved Langnesodden.*

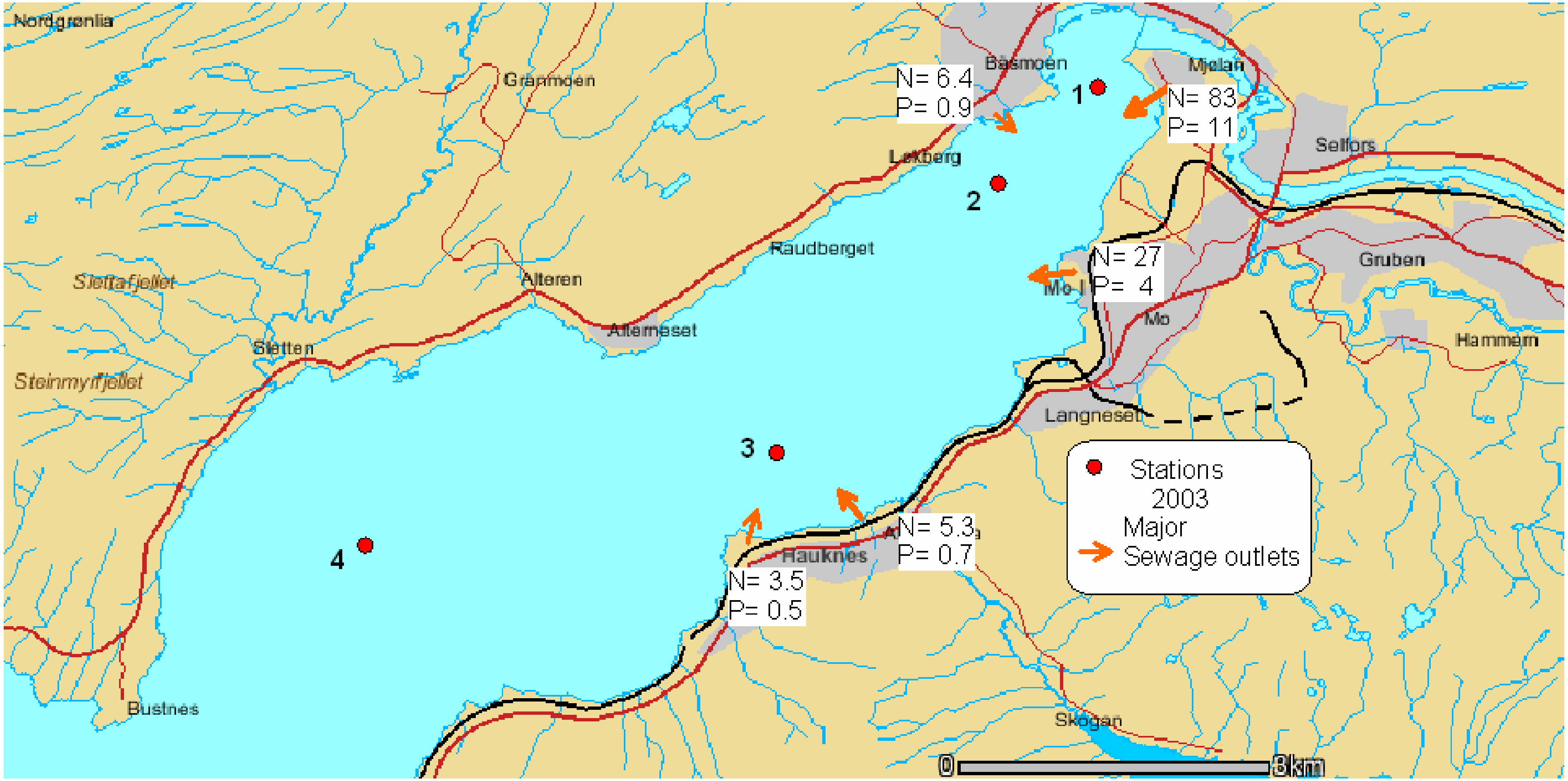


Figure 2. The inner part of Ranfjorden with hydrographic stations 2003 and major municipal sewage outlets. Load of nitrogen (N) and phosphorus (P) in tonnes pr. year (2002). Chart from NVE. *Indre del av Ranfjorden med hydrografiske stasjoner i 2003, samt større utslipp av avløpsvann, Nitrogen (N) og fosfor (P) i tonn pr. år (2002). Kart fra NVE.*

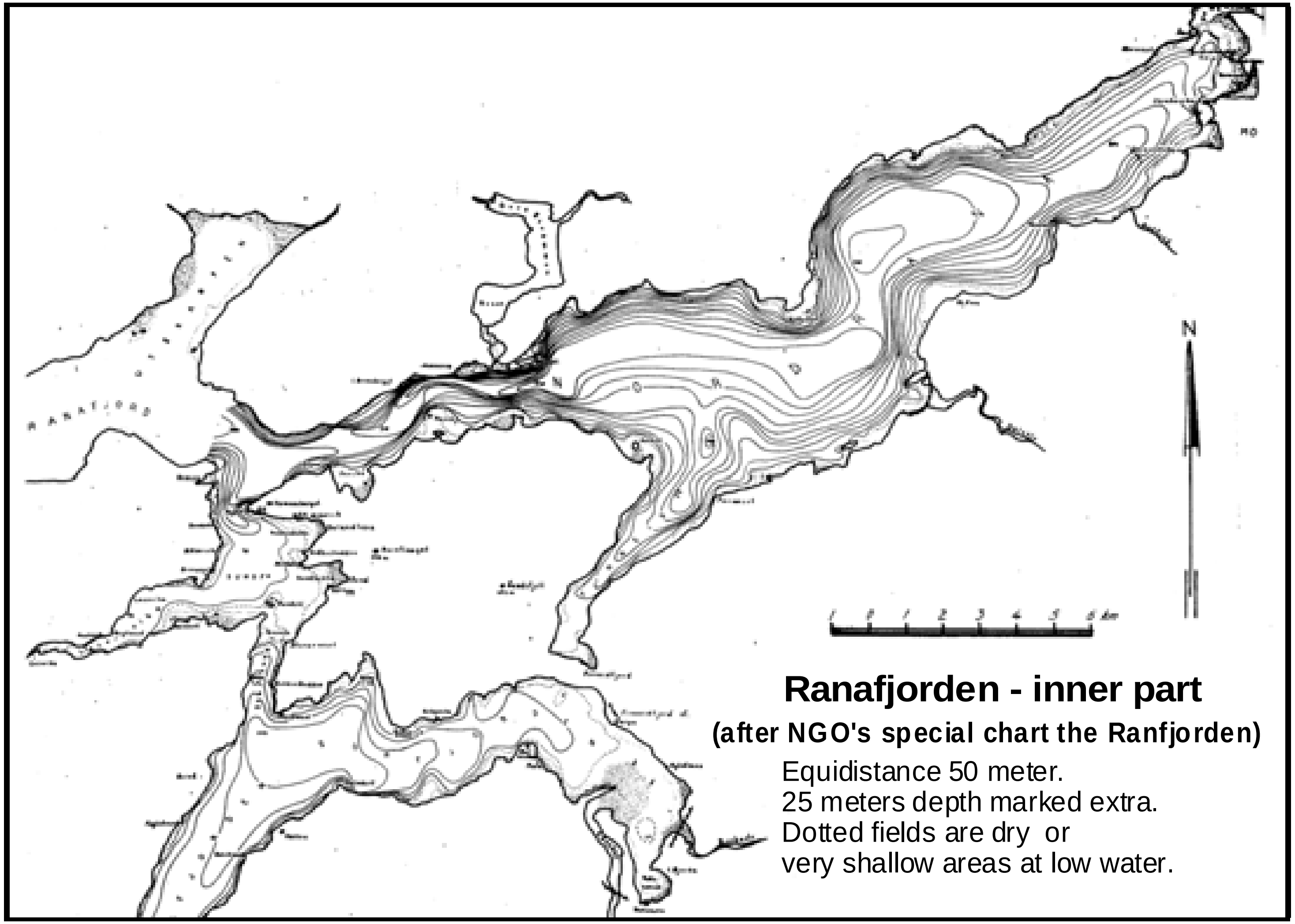


Figure 3. Topographic map of the inner Ranfjorden. *Dybdeforhold i indre deler av Ranfjorden.*

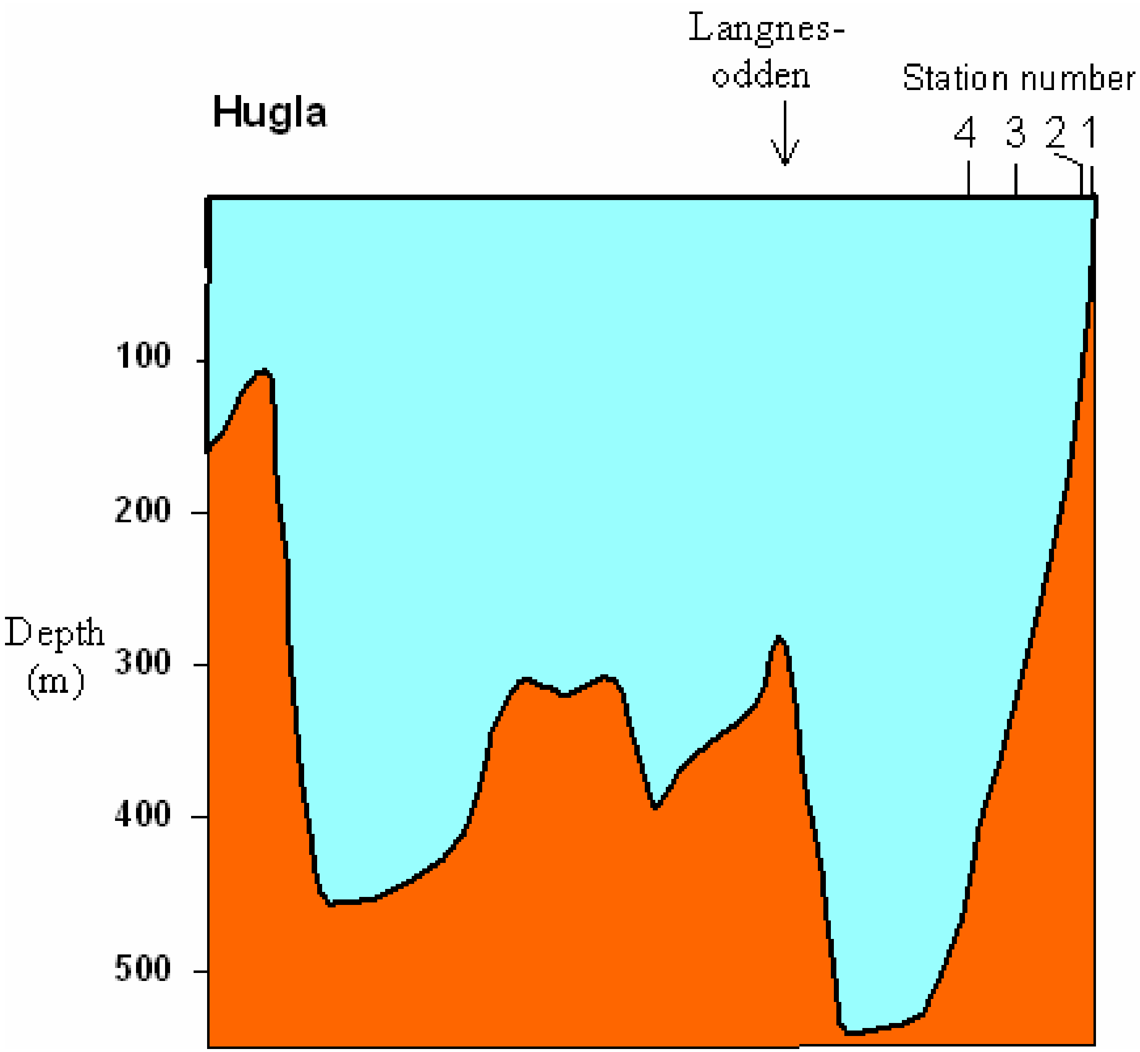


Figure 4. Schematic depth profile of Ranfjorden, with sampling stations in 2003-2004. *Skjematisk dybdeprofil av Ranfjorden med prøvetakingsstasjoner.*

2.2 Pollution loads.

The fjord is mainly polluted from industrial discharges in form of particles and micro pollutants. In this project, however, the main focus is on nutrients and possible effects from eutrophication.

The main sources of nutrients are from background and agriculture, mainly distributed to the fjord by the rivers (the Ranelva and the Dalselva).

The municipal discharges of N (nitrogen) and P (phosphorus) from Rana Kommune are calculated using standard values for converting p.e. (person equivalents) to amount of nutrients. According to EWPCA guidelines (EWPCA 1997), one p.e. without treatment equals 12 gN/day and 1.6 gP/day. The majority of the waste-water goes through the treatment facilities at Mjølanodden and Moskjæran (Figure 2), which both have 1 mm sieves. The rest of the discharges go through basic sludge removal processes. The dilution and spreading of waste-water from Mjølanodden and Moskjæran has been calculated, cf. Appendix A.

Based on experience and measurements from various treatment facilities of similar kind, NORVAR concludes that one can expect at least 15% reduction through use of 1mm screens and 10-15 % by sludge removal (Johansen & Holte 1996). We have therefore chosen to use an overall reduction factor of 15%, which gives the values for municipal discharges.

The background and agricultural loads are calculated from TEOTIL (Bratli & Tjomsland 1996). The different loads are given in Table 1.

Table 1. Nutrient loads to the inner part of Ranfjorden from different sources. *Tilførsler av næringsalter fra ulike kilder til indre del av Ranfjorden.*

Source	Nitrogen (as tot-N) tonn/year	Phosphorus (as tot-P) tonn/year
Background and agriculture	422	16
Sewage	118	16

Thus, about 20 % of the total nitrogen load and 50 % of the total phosphorus load are from sewage. The background load varies with the river runoff, thus calculated loads brought to the fjord by the river Ranelva was 480 tonnes nitrogen (tot-N) and 53 tonnes phosphorous (tot-P) in 2002 (Weideborg et.al. 2004). Assuming constant sewage loads, these contributed in 2002 with about 20 % for nitrogen and 30 % for phosphorous, which gives an estimate of the relative ratio between sewage load and other sources.

The load of carbon from different sources is compared in Table 2. The results are not directly comparable, but gives a roughly picture of the relatively contribution to the fjord from the different sources. The river Ranelva carried in 2000, 2001 and 2002 respectively 7.000, <3.800 and <3.300 tonnes of suspended particulate matter (SPM), 3.500, 8.600 and 3.800 tonnes of TOC (Weideborg et al. 2001, 2002 and 2004). Assuming a TOC load of 23 g/person/day, the total load by the sewage to the fjord from 21.000 person's (P.E) is estimated.

The nutrients (nitrogen and phosphorous) in the sewage is a potentially source for phytoplankton blooms. Using the average content for nutrients in phytoplankon (the Redfield ratio 41:7:1 (C:N:P)) a rough estimate of carbon from the load of phosphorous is made. As the N/P-relation is above 7:1 in the surface (0.5 m depth) in the inner part of Ranfjorden is higher or close to 7:1 in the upper 10 meter of the fjord, phosphorous can be used as a limiting nutrient in this context. As we use total phosphorus the calculation will overestimate the relative influence of the sewage, as well as it is assumed that the sewage phosphorous will contribute to phytoplankton growth the whole year, while the production season is limited to part of the year, when light conditions are satisfying (March-October).

The dominating source to the fjord is clearly the transport of carbon from the river Ranelva. The sewage contributes with between 20-10 %, depending if the load from the river is 3000 tonnes or 8000 tonnes. Thus the impact of the sewage to the total carbon load of the fjord is modest.

Table 2. Carbon loads (TOC) from different sources. *Karbontilførsler (TOC) fra ulike kilder til indre del av Ranfjorden.*

Source	TOC, tonnes pr year
The river Ranelva	3800
Sewage (direct load)	8
Sewage (estimated carbon from phosphorous limited plankton growth)	760

Some of the sewage outlets to the fjord are discharged to intermediate water depths – usually between 25-30 meters depth, where it rises towards the surface. The plumes are trapped where the surrounding waters have the same density as the seawater-diluted plume.

During winter, the effluent plumes from outfalls can be expected to be trapped around 13-17 m for "typical" flux rates and when the fjord water is significantly vertically stratified. Under conditions of weak stratification, and with high flux rates, the effluent plume is likely to protrude to the surface (Sundfjord 2003, cf Appendix).

Summer conditions will be similar; the plume will generally be trapped somewhat deeper (typically 15-19 meters depth), but there is still risk of breakthrough to the surface in periods with high flux rates and moderate vertical stratification (op-cit.).

2.3 Observations in 2003.

During 2003/2004 observations from 4 stations (figure 2) were sampled by Mona Gilstad (Hydra-Vega AS). Temperature and salinity were observed with mini-CTD (SAIV). Water samples were taken from a Niskin water sampler and the water was analysed for oxygen, tot-N, NO_3+NO_2-N, NH_4-N, tot-P, PO_4-P and chlorophyll-a. Secchi depth was observed with a white disc (25 cm in diameter). In addition, thermotolerant coliform bacteria (TCB) in the fjord water were analysed. Dates, depths and parameters are given in Table 3 and Table 4.

Table 3. Observations of water quality in the inner part of Ranfjorden during 2003-2004. *Vannkvalitetsprøver i Ranfjorden 2003-2004.*

	January-March and October-December				April to September			
Station 1	Surface	5 m depth	10 m depth	15 m depth	Surface	5 m depth	10 m depth	15 m depth
Secchi Depth*								
Nutrients	x	x	x	x	x	x	x	x
Chl-a					x	x	x	x
Oxygen close bottom*								
TCB					x	x	x	x
Station 2								
Secchi depth								
Nutrients	x		x		x		x	
Chl-a	x		x		x		x	
Station 3								
Secchi depth*								
Nutrients	x		x		x		x	
Chl-a					x		x	
Station 4								
Secchi depth*								
Nutrients	x		x		x		x	
Chl-a	March only		March only		x		x	
Oxygen close bottom*								

*On all surveys.

Table 4. Date of observations. *Datoer for prøvetaking*

Date	Station	Remarks
19.02.2003	1, 2, 3, 4	Sewage to surface due to technical problems at Mjølnaodden (East of station 1). CTD malfunction, no data.
24.03.2003	1, 2, 3, 4	Technical problems at Mjølnaodden continued since February
28.04.2003	1, 2, 3, 4	Technical problems at Mjølnaodden continues
26.05.2003	1	Heavy weather stops the survey
01.06.2003	2, 3, 4	
29.06.2003	1, 2, 3, 4	
24.07.2003	1, 2, 3, 4	
04.09.2003	1, 2, 3, 4	
30.09.2003	1, 2, 3, 4	
30.10.2003	1, 2, 3, 4	
14.01.2004	1, 2, 3, 4	

2.3.1 Hydrography and water exchange.

Surface layer.

The main factors regulating the surface waters in the fjord are tides, freshwater discharges, wind and density variations in the coastal waters outside the fjord. The average differences in tidal height are about 170 cm. The river runoff mainly influences the surface layer through the year. In 1975-1976 a complete year of hydrographical observations (Kirkerud et al. 1977) illustrates the salinity variations in the upper layer of the fjord (Figure 6). Station 6 is situated in the mouth of the inner part of Ranfjorden and also influenced by low saline water from the Sørfjorden.

In 2003-2004 the salinity variations during the year are similar to the variation in 1975-1976 (Figure 6). Low salinity follows the local river discharge pattern - low river runoff mainly in December- April and high runoff during the summer months. There is a slight horisontal difference in surface salinity, with less saline water at station 1, which is closest to the river mouth. The depth of the surface layer varies about the same level during the year at the stations, as the constriction at the mouth of the inner part of Ranfjorden acts as a control on the water exchange.

Apart from the tides, the main water exchange of the surface layer is through the estuarine circulation. Fresh water from the rivers flows out the fjord, mixing with the deeper saline waters. Loss of saline water to the surface layer is compensated by a transport of saline water into the fjord under the outflowing brackish water (Figure 7). Wind and tides will on shorter time scales change this general out-transport, but over longer time-scales (weeks) the estuarine pattern will be prominent. The outflowing brackish-water transport increases with the distance from the main river (Ranelva). The freshwater retention time was calculated in 1975-76, defined as the relation between freshwater in the surface layer divided by the runoff. Table 5 gives the average results of 13 situations (6 from summer and 7 from winter). The depth of the surface layer varied between 2 and 8 meters, and the freshwater retention time between 2 and 11 days. The average seawater content in the surface layer was about 80 % in winter, while it was 20% in summer.

Table 5. Depth of surface layer, river runoff, brackish water transport and retention time for freshwater in the innermost part of Ranfjorden (Kirkerud et al. 1977). *Overflatelagets tykkelse, elveavløp, brakkvannstransport samt oppholdstid for ferskvann I den indre delen av Ranfjorden.*

Season	Depth of surface layer (m)	River runoff (m^3/s)	Brackish water transport (m^3/s)	Freshwater retention time (days)
Winter	4.7	140	820	6.6
Summer	3.6	750	1000	4.0

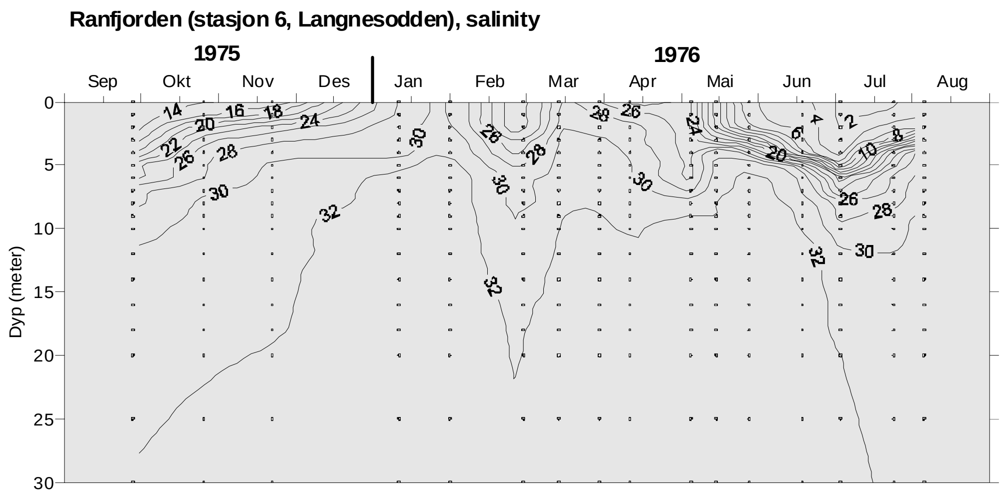
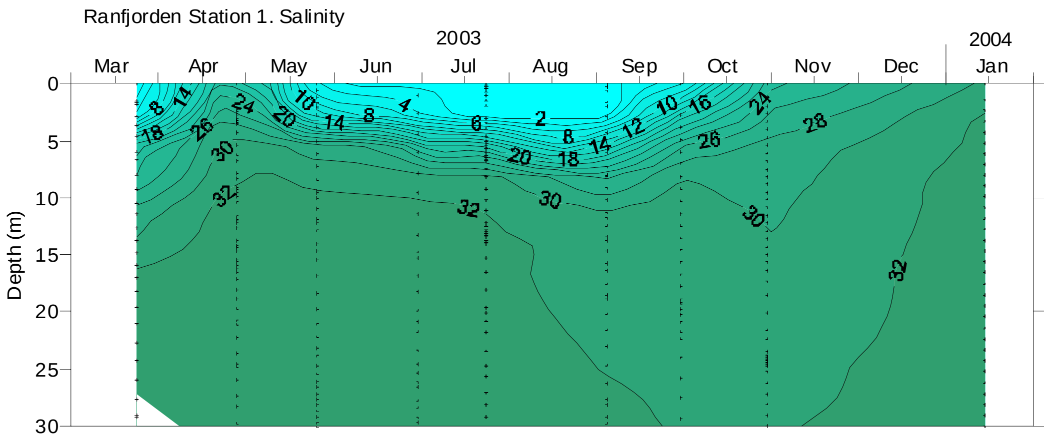


Figure 5. Salinity variations in the surface layer in the inner part of Ranfjorden (st. 6) in 1975-76 (Kirkerud et al. 1977). *Saltholdighetsvarisjonen i overflatelaget av indre del av Ranfjorden 1975-76.*



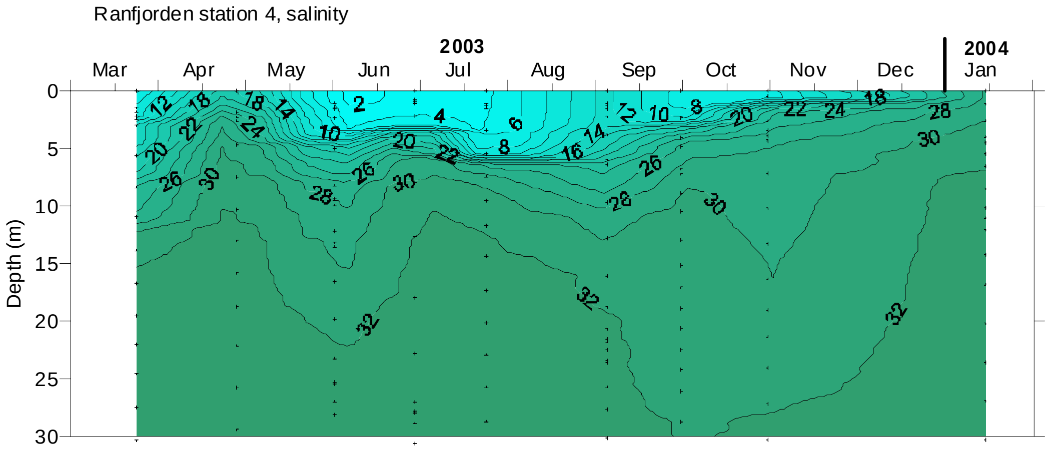


Figure 6. Salinity at station 1 and the upper 30 meters at station 4 in 2003-2004. *Saltholdighetsvariasjonen ved station 1 og 4 i de øvre 30 metrene.*

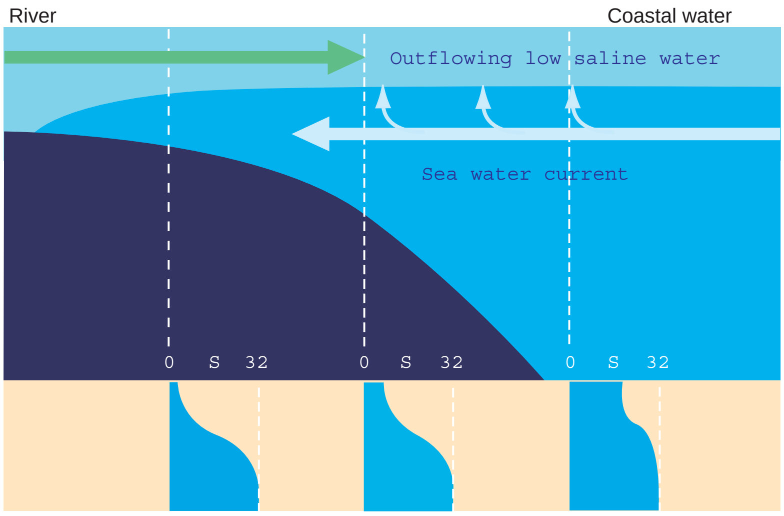


Figure 7. Estuarine circulation. The downstream increasing salinity in the upper outflowing layer is illustrated in the vertical profiles of salinity in the lower part of the figure. *Estuarin sirkulasjon. Økningen i saltholdighet i det utstrømmende laget illustreres nederst i figuren.*

2.3.2 Deeper water masses.

The water exchange in the intermediate water masses (above sill depth) is mainly driven by changes in stratification in the coastal water outside Ranfjorden. Haakstad (1984) has estimated the average exchange of these water masses (down to 100 meters depth) to several times during a year. The main water exchange is during winter and autumn. The amount of water from these water masses leaving the fjord through the eintrainment to the outflowing surface layer, was estimated to a volume corresponding to the volume of the intermediate water in winter time (6 months), and half the volume in summer time (6 months) (Haakstad 1984).

The deep water masses below fjord sill depth are mainly renewed during winter. Haakstad (1984) estimated the renewal to be 50 % in 1981 and 65 % in 1982.

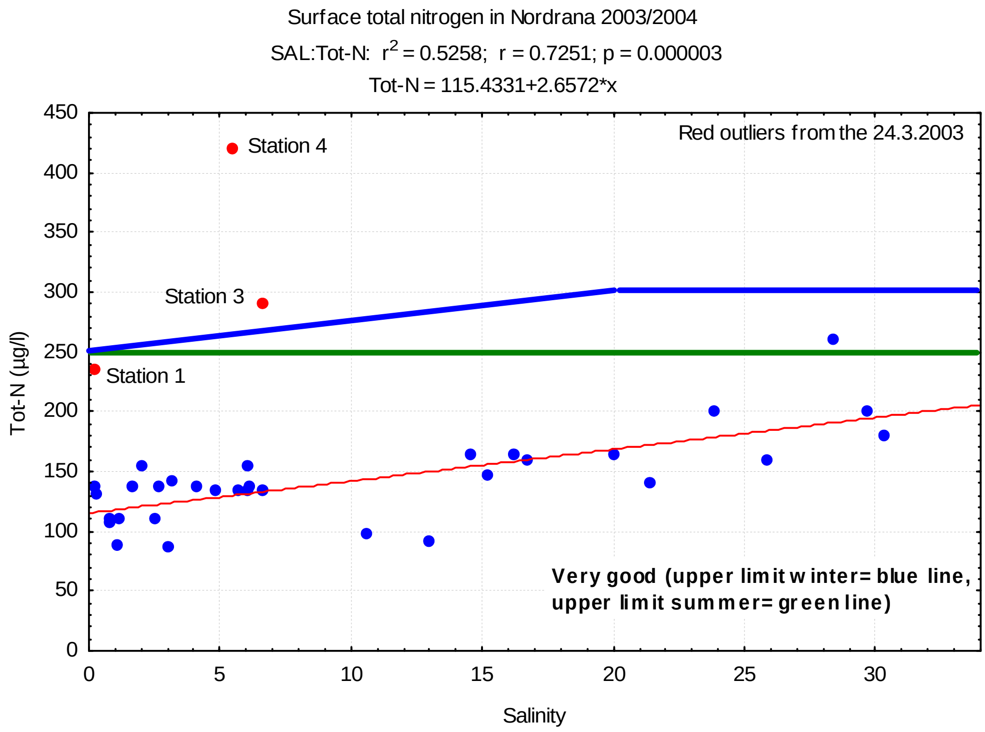
2.3.3 Nutrients.

The distribution of nutrient follows the salinity gradient – increasing with salinity (Figure 8). Normally the concentrations indicates a very good environmental condition, except for a few outliers (the outliers for nitrogen coincides with a longer period of technical problems at the purification plant close to station 1). Increasing concentrations with increasing salinity indicates that the underlying saltwater is an additional source of nutrients.

The Norwegian criteria for classification (NCS) of environmental quality in fjords and coastal waters (Molvær et al. 1997), developed for The Norwegian Pollution Control Authority, is used in this report to compare the water quality against known concentrations and environmental conditions. An overview of the system is given in Appendix B.

Average winter concentration of nutrients is compared to the Norwegian Classification System for eutrophication in Figure 9. The surface layer can generally be classified as Very good or Good. Typically, the nitrate concentrations are in a poorer class as an effect of the river runoff and eintrainment from seawater, while the most sewage sensitive parameters as ammonia (NH4-N) and phosphorus, indicates a slightly higher value at station 1, which is situated close to a major sewage outlet, which as mentioned earlier, had technical problems during the winter of 2003. Normally the outlet is at 30 meters depth, but during the technical problem period sewage was released to the surface layer. This can explain why station 1 is classified as good rather than very good for phosphorous, and the slightly higher levels of ammonium.

A



B

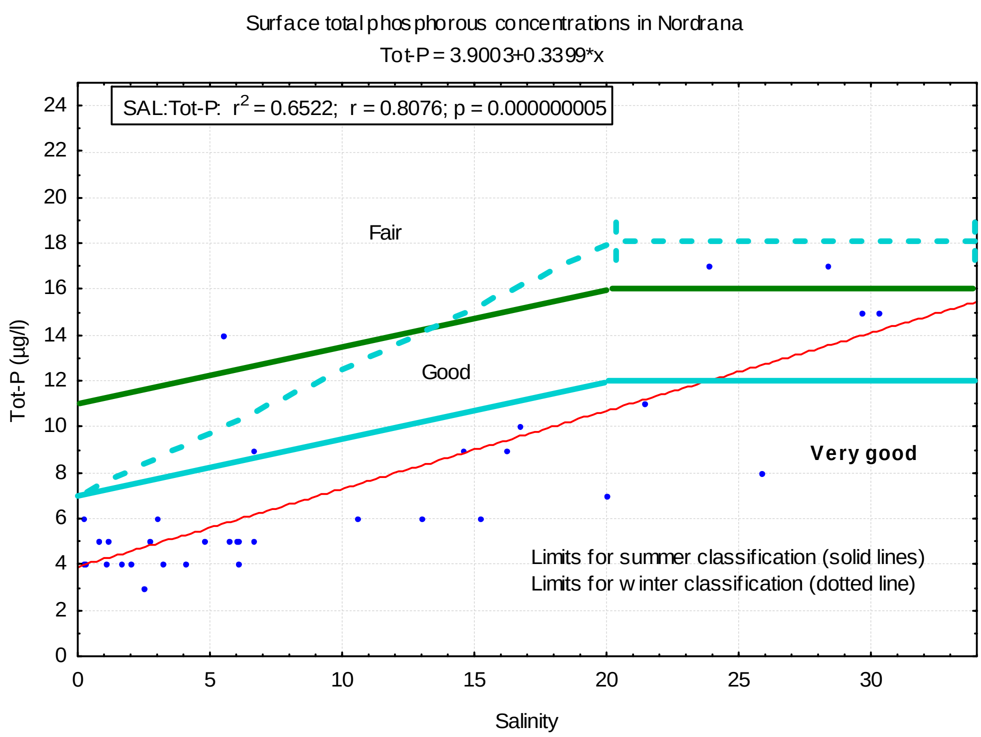


Figure 8. Inner Ranfjorden. Total nitrogen A) and total phosphorus B) from the surface (upper meter) and salinity – all observations from 2003. Regression line (red) does not include red dots. *Total nitrogen og total fosfor fra øvre meteren i indre del av Ranfjorden 2003. Regresjonslinjen (rød) inkluderer ikke røde markeringer.*

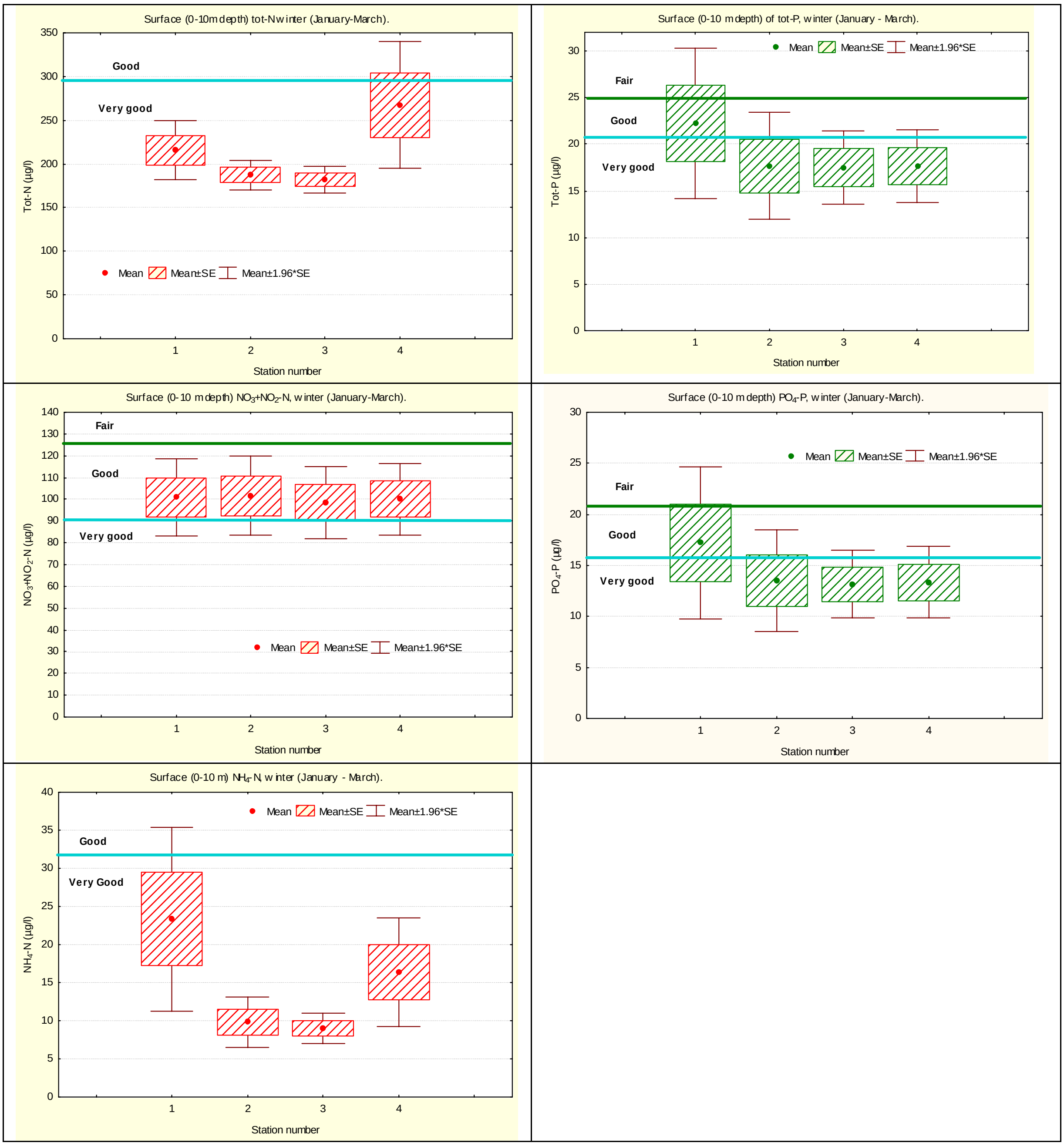


Figure 9. Surface (0 –10 m depth) winter (January –March) concentrations of nutrients. Classification according to the Norwegian Classification System for eutrophication, salinity above 20. Normally the winter period is between December-February, but according to Chlorophyll concentrations, observations from March 2003 can be included, as the spring bloom occured later. *Overflatekonsentrasjoner (0-10m) av næringssalter vinterstid (jan.-mars). Grenseverdier for den norske tilstandsklassifiseringen av miljøtilstand er angitt*

Average nutrient summer concentrations and phytoplankton biomass (as Chlorophyll-a) is compared to the Norwegian Classification System for eutrophication in Figure 10. As for the winter observations, the condition at most stations can be classified as Very good. However, the spring bloom can give a high chlorophyll-concentrations (highest observed concentration at station 2 and 4 was 18 µg/l at 10 meters depth). At station 1, close to a (submerged) sewage outlet, the most sensitive parameters as ammonium and phosphorus gives a clear signal of higher concentrations. For both tot-P and PO_4-P the surface water is classified as Poor to Very poor, and for ammonium it varies between Fair and Good, but with significant higher concentrations, compared to the other stations.

As there is a decrease in nitrate concentrations from station 1- 4, there is a slightly increase of phytoplankton biomass at station 4. There is a correlation between higher chlorophyll and lower nitrate concentrations, but the variation is poorly described (regression analyse).

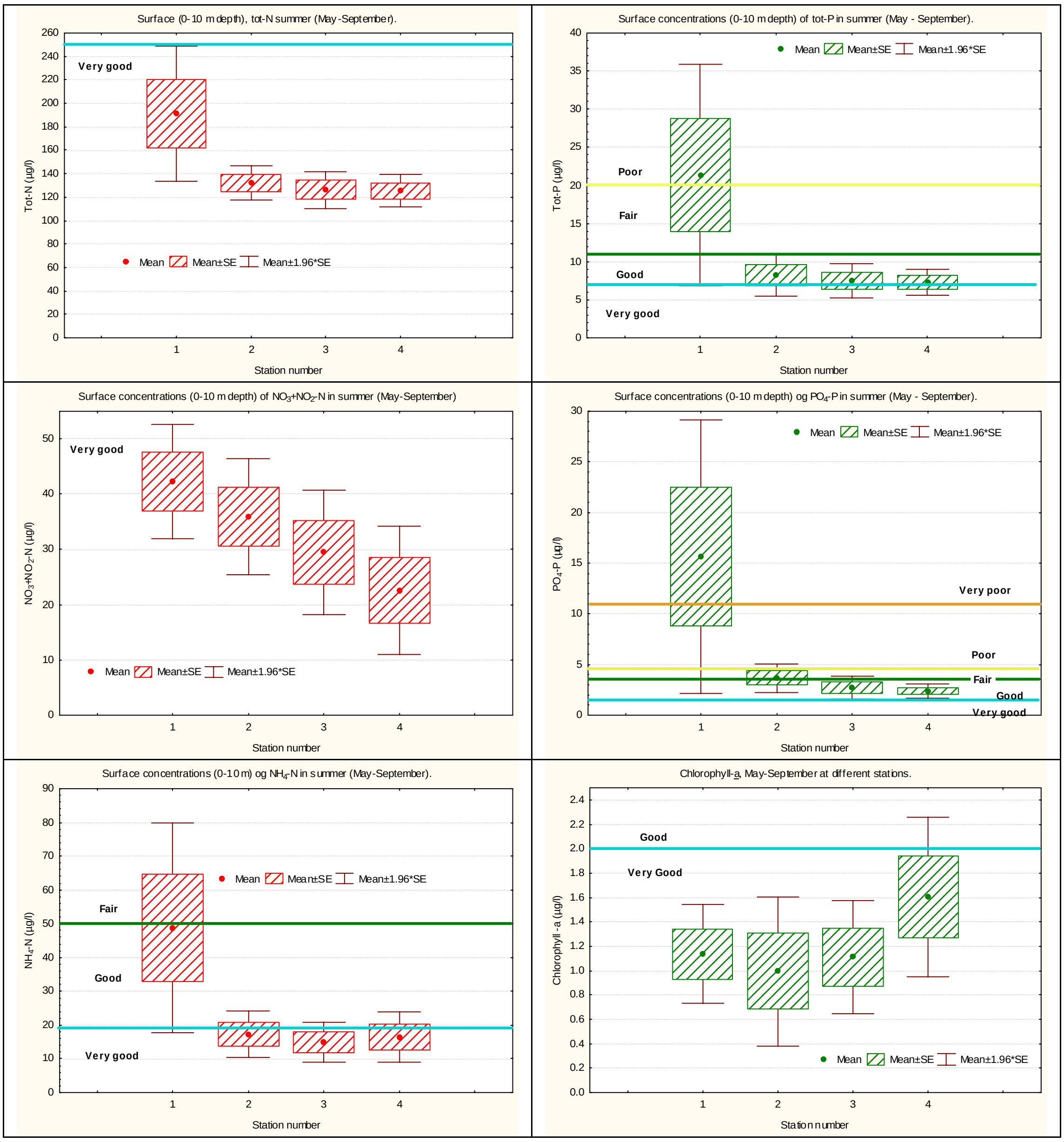


Figure 10. Surface (0 –10 m depth) summer (May – September) concentrations of nutrients. Classification according to the Norwegian Classification System for eutrophication, salinity below 20. *Overflatekonsentrasjoner (0-10m) av næringssalter sommerstid (mai-sept.). Grenseverdier for den norske tilstandsklassifiseringen av miljøtilstand er angitt.*

2.3.4 Thermotolerant coliform bacteria

Findings of thermotolerant coliform bacteria (TCB) in water indicates recent impact from sewage or fertilisers. Water-samples from 4 depths at station 1 in Ranfjorden were analysed for TCB by the local food control in Mo i Rana. The number of bacteria were high in several samples (Table 6) and gave indications on local impact from sewage in the vicinity of station 1.

Table 6. No. of thermotolerant coliform bacteria/100 ml water in water-samples from st. 1 at Mjølan in 2003. More than 100 bacteria indicates that the water is less suitable for swimming. *Antall termotolerante koliforme bakterier (TKB) pr. 100ml vann i prøver fra 4 dyp på stasjon 1 ved Mjølan i 2003. Ved et bakteriantall >100 er vannet mindre egnet for bading.*

Date/depth	0m	5m	10m	15m
28. april	51	>100	>100	6
26. may	46	15	>100	43
30. june	67	>100	>100	52
24. july	>100	>100	>100	>100
04. sep.	>100	19	>100	>100

2.3.5 Secchi depth – the transparency of the surface water.

Classification of the surface waters according to the Norwegian Classification system reveals that the average secci depth summertime only is in class Fair (Figure 11). The secchi depth increases with increasing salinity (Figure 11). Thus the relative poor secchi depth is related to low-saline or freshwater sources. As the average chlorophyll-a concentration during the summer period was about 1 (µg/l) at the inner stations, this could not explain the low secchi depths. In fact, in the inner Oslofjord, where summer concentrations of chlorophyll-a is about 3 (µg/l), this corresponds to a secchi depth about 6 meter. Thus, the secchi depth in Ranfjorden is mainly influenced by other (mineral) particles, as other investigations has shown (cf. Johnsen et al. 2004).

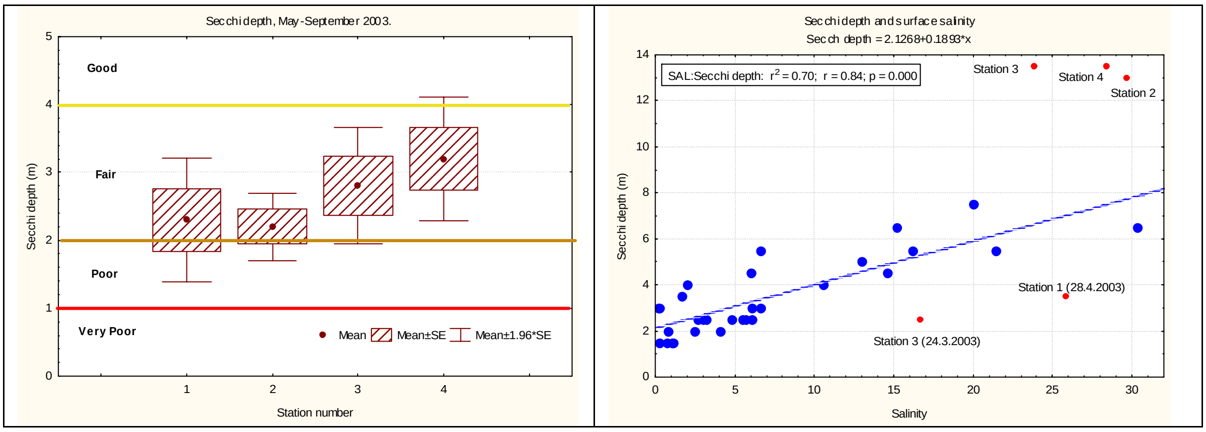


Figure 11. Secchi depth in summer (May – September). Classification according to the Norwegian Classification System for eutrophication, salinity below 20 (left figure). Secchi depth vs. surface salinity all observations (right figure). *Venstre: siktdyp sommerstid (mai-sept.). Grenseverdier for den norske tilstandsklassifiseringen av miljøtilstand er angitt. Høyre: siktdyp plottet mot saltholdighet.*

2.3.6 Oxygen.

According to the Norwegian Classification system, the oxygen concentration in the fjord is Good to Very Good (Figure 12). This confirms results from earlier investigations, where Haakstad (1984) observed oxygen at different depths 5 times during 1982. The oxygen concentration varied about 6 ml/l, slightly raised with water renewals, slightly decreasing in stagnant periods. Thus, the oxygen condition in the fjord is satisfying.

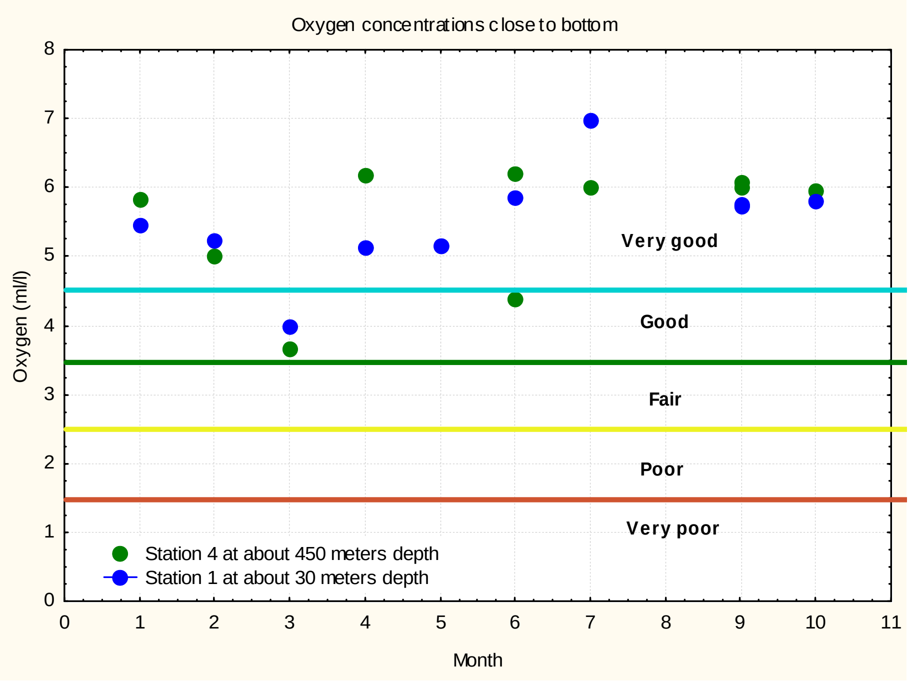


Figure 12. Oxygen concentration in 2003-2004 observed close to the bottom at station 1 and station 4. *Oksygennivåer i bunnvannet på stasjon 1 og 4*

2.4 Conclusions

Surface observations of nutrients, phytoplankton biomass (chlorophyll-a) and oxygen in the deeper water masses, classifies the fjord generally as Very good to Good (class I-II) according to the Norwegian Classification System for eutrophication.

The exception from this is station 1, close to the town Mo i Rana and at the mouth of the river Ranelva, and in the vicinity of a sewage outlet. At this station there are elevated concentrations of phosphorus, that classifies the surface layer as Very poor to Poor (class IV-V) in summertime, and slightly elevated levels of ammonia (classified from Good to Fair, class II-III).

The elevated concentrations of nutrients, and the high number of bacteria that were found, indicates a local negative impact from sewage, probably from the closest sewage outlet or from free overflows. The total local loads of nutrients and carbon to fjord are dominated by the river Ranelva, except for phosphorous from the sewage that contributes with about half the load, or down to 30 % depending on the (natural) variation in the river load. However, as a source for phytoplankton growth, the phosphorous load from sewage can roughly result in a production of about 1-20 % of the carbon load (TOC) from the river.

The relatively poor secchi depth is a function of suspended (mineral or other non-marine) particles, entering the fjord from the river or other sources, and can not be explained by the measured phytoplankton biomass.

3. Hard-bottom communities

3.1 Introduction

Surveys of macroalgae vegetation and sessile or slow moving animals on rocky shore are widely used to assess the environmental condition. The littoral organisms reflect the water quality of the surface layer. Except for sudden impacts, species composition change slowly in a fluctuating environment and reflect an integrated view of the environmental condition, in contrast to for instance a water sample. Nutrients are essential for macroalgae growth and a change in the nutrient supply change the conditions for growth. Changes in species composition may therefore indicate nutrient enrichment. With slight enrichment the diversity may increase and often growth of filamentous green and brown algae is enhanced. With stronger eutrophication the large seaweed species may be completely overgrown by epiphytes and dependent on the load, the large seaweed will disappear (Bokn 1978, Mathieson & Penniman 1991, Kautsky 1991, Bokn et al. 1992).

Increased growth and dominance of fast growing filamentous macroalgae is known as an eutrophication effect in shallow hard bottom areas. This often results in loss of macroalgae with their associated fauna, which further leads to a reduction in biodiversity and nursing areas for fish.

3.2 Environmental status on hard bottom in a previous survey, 1992-1993

The aim of the surveys in 1992-1993 was to

- update the knowledge on environmental status on hard bottom in Ranfjorden, with emphasis on possible positive effects from the close-down of some heavy industry in 1989-1990 (Råjernverket, Koksverket and Bergverkselskapet Nord-Norge).
- give local authorities better basis for the decision on further initiatives to reduce pollution to the fjord.
- create the basis for future monitoring programs.

It was found clear negative effects from sedimentation on hard bottom communities on all stations, especially st. B5 Moholmen in the mouth of the fjord. This was interpreted as a possible result of the large discharges of inorganic particles from Rana Gruber. In addition to sedimentation stress, particles also reduces light-penetration in the water and thereby indirectly affect the abundance of algae and some animals.

Grazing from sea-urchins was significant in the outer parts of the fjord (st.B15, Holmgalten and B14, Hinderå, 15 and 46 km from the town of Mo, respectively). Freshwater influence in the inner parts of the fjord was probably limiting the grazing in these areas.

High abundance of fast-growing green algae gave clear signs of eutrophication in the innermost parts of the fjord (st. B5 Moholmen). Less clear symptoms were found in the area further out, to station B16, Laukhella.

It was concluded that environmental conditions in Ranfjorden had improved significantly since the earlier surveys in 1980-81. The conclusion was based on the positive changes in the algal communities, including increase in diversity and number of taxa, and less difference in community composition between inner and outer parts of the fjord. There were signs of less effects from eutrophication compared to 1980-81, but reductions in contamination from micropollutants could also have tributed positively to the observations.

For the possibilities of further improvement in the fjord, Green et al. (1995) stated that reductions in the discharges of public sewage, and particles from Rana Gruber were necessary.

3.3 Methods

The littoral zone was surveyed at low-tide, by quantitative quadrat-analysis and semi-quantitative registrations, at nine stations. In addition, vertical hard bottom transects, from the surface down to about 30m, was surveyed by SCUBA diving at two of the stations in the same period. The methods are according to the Norwegian standard "Guidelines for marine biological investigations of littoral and sublittoral hard bottom" (NS 9424). The investigation was performed by a marine zoologist and a marine botanist and the survey was carried out in August 20-24 in 2003.

3.3.1 Stations

In 1992 and 1993 NIVA performed comparable investigations on hard bottom in the same area (Green et al. 1995). A selection of the same stations was revisited in 2003, in addition two new reference stations were established and investigated (B17, Langneset and B91, Hemnesberget). The position of the stations was documented photographically and with GPS (WGS-84). Data on the stations are given in Table 7. The distribution of stations are shown in the map in Figure 14.

Table 7. Hard bottom stations investigated in Ranfjorden in 2003. *Hardbunnsstasjoner undersøkt i Ranfjorden 2003.*

Stations in the expected influence area	Position	Direction	Littoral quadrats	Transects
B3 Laukberget	66° 19,450 14° 05,258	SE (115°)	x	
B5 Moholmen	66° 18,714 14° 07,545	SW (230°)	x	
B7 Raudberget	66° 18,972 14° 03,181	SE (130°)	x	
B9 Bjørnebærvika	66° 16,723 14° 02,011	W (265°) 320-340° (dive)	x	x
B12 Kalvhaugneset	66° 16,641 13° 54,676	SE (108°)	x	
B16 Laukella	66° 14,902 13° 39,922	SE (140°)	x	
Reference-stations				
B91 Hemnesberget (new)	66° 12,896 13° 37,793	NW (320°)	x	
B14 Hinderå	66° 12,581 13° 12,302	SE (130°) 140° (dive)	x	x
B17 Langneset (new)	66° 10,870 13° 11,360	NE (036°)	x	
No. of stations			9	2

3.3.2 Semi-quantitative registrations in the littoral zone

semi-quantitative registrations was done in the littoral-zone at low-tide, using the same semi-quantitative abundance scale as during the diver registrations of vertical transects (below). The taxa and amount of algae and animal within each dominating vegetation zone was recorded.

3.3.3 Quadrats

All attached algae and animals, also slow-moving animals, were recorded *in situ* in 4 parallel quadrats à 0,5 x 0,5 m (0,25m^2) in the Ascophyllum-zone (knotted wrack) and any other distinct vegetation-zone present at the stations (cf Appendix D). The quadrats are subdivided into 25 smaller squares (10 cm x 10 cm), each of which represents 4 % of the original grid to help quantifying total species cover within the square. The quantity of taxa was recorded in % coverage of the entire grid area. Larger solitary animals were recorded by number. The quadrats were also photographed. The width of the vegetation zones were measursed, and the type and slope of the substrate was noted.

3.3.4 Vertical transects

Registration of macroscopic (> 1 mm) benthic algae and invertebrates was done *in situ* along a fixed route (transect) from a maximum depth of 30m to the surface by the means of SCUBA-diving. Algae and invertebrates were recorded on separate dives by a marine botanist and zoologist, respectively. A diver had two-way audio communication with an assistant on shore who noted the observations. Species abundance was recorded for every second depth-meter using a semi-quantitative abundance scale from 1 to 4:

Abundance scale	Species abundance
1	Rare
2	Frequent
3	Common
4	Dominant

Organisms impossible to identify *in situ*, were sampled and identified in the laboratory the same day. A collection of reference species is kept at NIVA. Abiotic factors such as slope and type of substrate, degree of silt deposition, horizontal visibility etc., were also recorded during each dive.

With interpolated values for the between registration depths, species abundance for every meter was stored in a database. The selected depth range for the present sublittoral analysis was 3-24m which avoided problems with comparable registrations at shallower depths due primarily to wave action and tide. The depths measured *in situ* during the dive-registrations were adjusted proportional to high-tide level in Ranfjorden.

Prior to analyses, abundances 1 to 4 were anti-log transformed (e^x) giving abundance values in the range of 3 to 55, that is more comparable with %-cover scale commonly used in hard bottom studies. Organisms difficult to distinguish *in situ* were consolidated into groups or higher taxa with common features (Table 2). For each consolidation the maximum abundance of species in the consolidation was calculated for each meter along the transect. Only species (or groups of species/taxa) with sum of abundance >20 (i.e. at least common at one depth or frequent at 3 depths or rare for at least 8 depths) was selected and sum of abundance of the infralittoral zone from 3 to 24m depth was calculated for each survey (station and year) and Bray-Curtis similarity was calculated.

3.3.5 Statistics

Statistical analyses were done by using the PRIMER v5.2.0 (2001). Non-metric Multiple Dimensional Scaling analysis (MDS), and cluster analyses was applied on group averages. Analysis of similarities between regions and years was done by a two-way crossed design with no replicates (PRIMER module ANOSIM2). The main species (or groups of species/taxa) that distinguished collections of samples were identified by using PRIMER module SIMPER. Species richness, d (Margalef) and biological diversity, H' (Shannon-Wiener) was calculated (Shannon & Weaver 1963).

3.4 Results

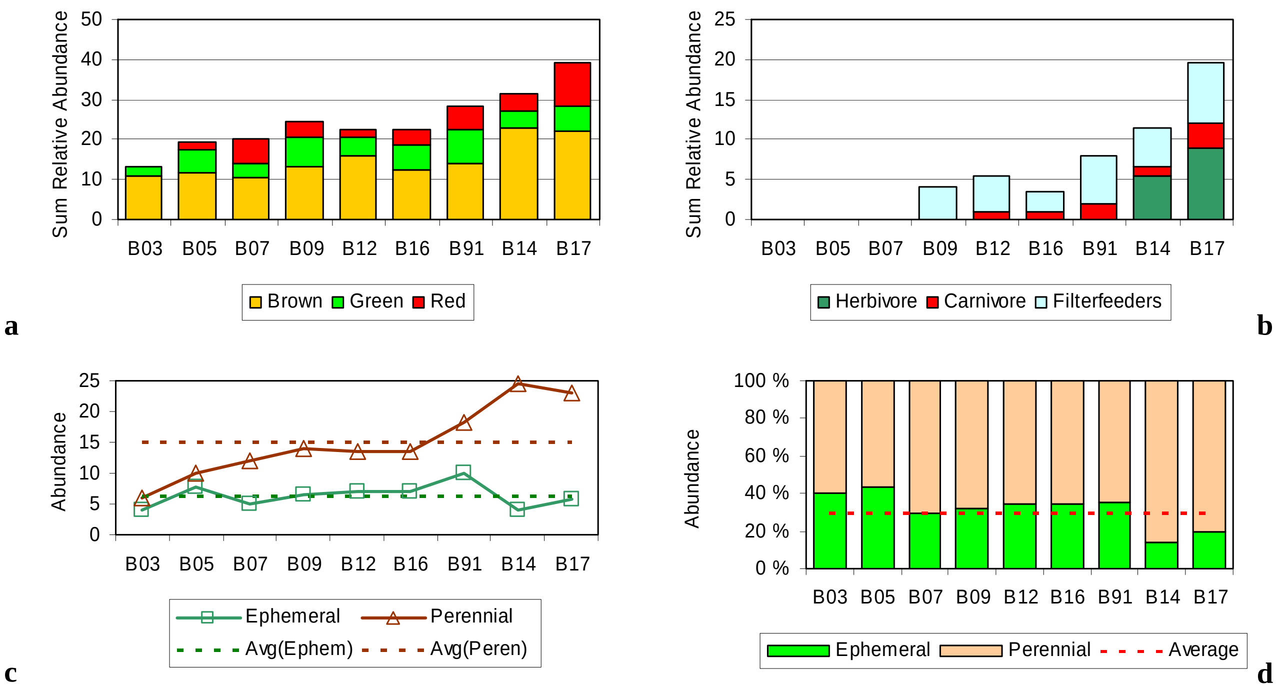
There was a well developed seaweed belt in the tidal zone on all stations, dominated by Bladderwrack and Knotted wrack. The abundance of animals was small, except at two of the reference stations (B14 and B17). The most common animal in the littoral zone was the blue mussel. The sub-littoral area on reference station B14 was heavily grazed from sea-urchins, while impact from sedimentation was high on B9. As a result, flora and fauna on both stations were reduced compared to a normal situation. Dominating organisms sublittorally were encrusting algae, the red seaweed *Phycodrys rubens* and Keelworm (*Pomatoceros triqueter*). Visibility was reduced during field-work (1-3m horizontally). This was due to a phytoplankton bloom in the surface-layer of the fjord.

3.4.1 Semi-quantitative registrations in the littoral zone

The benthic littoral community in the fjord had a significant growth of seaweed, while abundance of animals was low (Figure 13 a and b). It was found stone dust on the shore as far out as station B16. The particles probably originates from the activities of Rana Gruber (cf. Figure 22).

The number of species (cf. Appendix C) and the species abundance increased along a gradient from inner to outer fjord, with highest values on the reference stations. The abundance of ephemeral macroalgae did not change significantly, but there was a significant increase in the abundance of perennial species outwards the fjord (Figure 13 c and d). Presence of fast growing ephemeral species, such as many filamentous green and brown algae, may indicate stressful or polluted conditions while long lived slow growing perennials, like knotted wrack, generally are sensitive to disturbance. The ratio between them therefore indicates degree of disturbance.

The blue mussel *Mytilus edulis* and barnacle *Balanus balanoides* were the most common animals at the stations but at the three innermost stations no animals were observed in the littoral zone. Periwinkles (Littorinides) were only found at the two outermost reference stations B14 and B17 (Figure 13 e). These findings do indicate increased disturbance and detoriated littoral communities in the inner part of Ranfjorden. Low salinity and river discharge of particles are factors that naturally change species composition, and this might camouflage effects from municipal outlets. A complete list of species is shown in Appendix C.



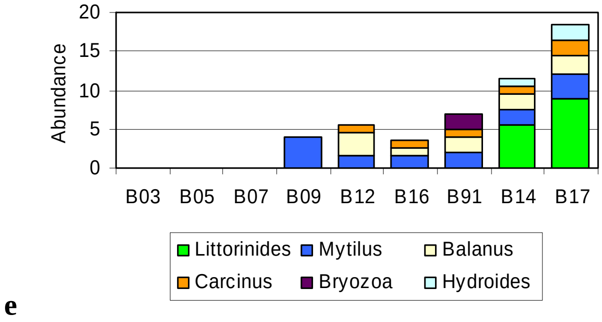


Figure 13. Abundance of a) macroalgae classes, b) animal feeding-cathegories, c) ephemeral and perennial macroalgae species, d) percentage of ephemeral and perennial macroalgae species and e) animal cathegories observed in the littoral zone. Stations are arranged according to distance from the town. *Forekomst av a) makroalgeklasser, b) ernærings-kategorier av dyr, c) forekomst av ettårige- og flerårige makroalger, d) %-fordeling av ettårige- og flerårige makroalger, e) taxa av dyr i littoralsonen. Stasjonene er arrangert etter økende avstand fra Mo i Rana.*

3.4.2 Quadrat registrations

Average species abundance/cover in the quadrat registrations in the littoral zone at 9 sites in Ranfjorden is shown in Table 8. The number of species/taxa in the quantitative registrations were highest on the reference stations (B17, B14 and B91) and lowest in the inner parts of the fjord (Table 9). The reference station south of Hemnesberget (B91) was more fresh-water influenced than the two other reference stations, and the littoral zone was completely dominated by knotted wrack which reduce the diversity compared to sites with more than one well-developed association. This is probably the reason for the lower community indexes at B91 in Table 9. Diversity (H) was highest at B14 and B17, while the third reference station (B91) was more similar to the stations in between the outer- and inner part of the fjord (B12 and B16) (cf. Figure 14).

Table 8. Percent cover of macroalgae and sessile animals (and other features) and number of mobile animals in quadrates in the littoral zone. Average value of 4 or 8 quadrates at each station. Stations are arranged according to distance from town. Main association seaweeds in bold. *Prosent dekningsgrad av makroalger og fastsittende dyr, og antall av bevegelige dyr i kvadratene i fjæra. Gjennomsnittsverdi for 4 eller 8 kvadrater pr. stasjon. Stasjonene er arrangert i økende avstand fra Mo i Rana. Dominerende tangsamfunn i fet skrift.*

Latin name	B3	B5	B7	B9	B12	B16	B91	B14	B17	Common name
Empty bivalve shell					0.6		0.2			empty bivalve shell
Cyanophycea indet								11	26	blue green algae
Chondrus crispus								0.1	2	carrageen
Hildenbrandia rubra		0.4	33	92	18	88	53	37	40	red coating on stone
Ascophyllum juv					1.3	2.7		2.8	0.8	juvenile knotted wrack
Ascophyllum nodosum				**100**	**54**	**68**	**100**	**50**	**50**	**knotted wrack**
Brown encrusting indet.	54		53						3.5	brown coating on stone
Ectocarpus sp.	18		5.5						0.5	brown filamentous
Fucus juv.					6.1	2.3			0.5	juvenile wrack
Fucus spiralis								7.5		spiral wrack
Fucus vesiculosus	**100**	**100**	**100**	**71**	**51**	**34**			**1**	**bladder wrack**
Pelvetia canaliculata								**32**	**21**	**channeled wrack**
Pelvetia juvenil								7.1	11	
Cladophora rupestris					4	8.5	28	10	8	green seaweed
Enteromorpha sp.		11								green gut weed
Green filametous indet.		11								green turf indet
Green encrust. indet.	11	50	9		0.6	6	9	0.8		green coating on stone
Dynamena pumila								0.1	0.5	hydroid
Littorina littorea								0.5		common periwinkle
Littorina obtusata								2.5	52	flat periwinkle
Littorina saxatilis								4	20	rough periwinkle
Littorina sp.								0.5	5.5	periwinkle
Nucella lapillus									0.5	dog whelk
Mytilus edulis					0.4	1	1.3	3.3	7.5	blue mussel
Mytilus edulis juv.				0.4						blue mussel juvenile
Balanus balanoides						0.1	6	6.3	12	barnacle
Carcinus maenas					0.5	0.5	2	1	0.5	shore crab
Bryozoa indet. (encrusting)							24			moss animal

Table 9. Community indexes calculated as average pr. quadrat at each station. *Samfunnsindekser beregnet etter gjennomsnittsverdien av kvadratregistreringer pr. stasjon.*

station	taxa	abundance	species richness (d)	species diversity (H)
B3	4	50	0,8	1,2
B5	5	44	1,1	1,1
B7	5	50	1,0	1,2
B9	4	66	0,7	1,1
B12	10	46	2,4	1,5
B16	10	64	2,2	1,5
B91 (reference)	9	59	2,0	1,6
B14 (reference)	17	89	3,6	2,1
B17 (reference)	19	125	3,7	2,4

The cluster analysis grouped the stations B3, B5 and B7 (Figure 15), indicating that these stations had similar community composition. These were stations situated in the areas dominated by Bladder wrack (*Fucus vesiculosus*) while the other group, containing the rest of the stations, were dominated by Knotted wrack (*Ascophyllum nodosum*). No animals were found at the three inner-most stations, except for amphipods on B3. Average dissimilarity in community composition between the two groups was high (80%), and the taxa contributing strongest to the difference are listed in Table 10.

The low abundance of knotted wrack in the inner parts of Ranfjorden is probably related to both pollution and decreasing salinity inwards the fjord. Bladderwreck is known to tolerate very low salinities and it is, as an example, a rather common species in the brackish Baltic Sea. Knotted wrack is believed to be more sensitive to pollution and as an example the inner growth border in the Oslofjord have changed with changing pollution load (Bokn et al. 1992). Reduced abundance of knotted wrack in polluted areas and close to outlets have been reported in several assessment studies (Holte et al. 1992, Oug et al. 1985, Oug et al. 1987). Bladder wrack is a fast growing seaweed compared to knotted wrack and it is able to rapidly recover (1-3 years) with improved conditions, while knotted wrack need more time, and also has to out-compete the bladder wrack to restore an association. The thin red encrusting algae *Hildenbrandia rubra* was common in the outer parts of the fjord, while brown encrusting algae were more abundant in the inner parts of the fjord. This was also the case in 1992-1993 but little is known of salinity requirements or sensitivity of these two encrusting species. There was a higher abundance of opportunistic filamentous algae like ‘green and brown turf’ at the stations in the inner fjord (B3-B9). This might indicate increased nutrient levels in this part of the fjord.

There was sign of impact from inorganic particles from Rana Gruber as far out as station B16. We suggest smothering from particles as main reason for the absence of animals in the littoral zone at the three innermost stations.

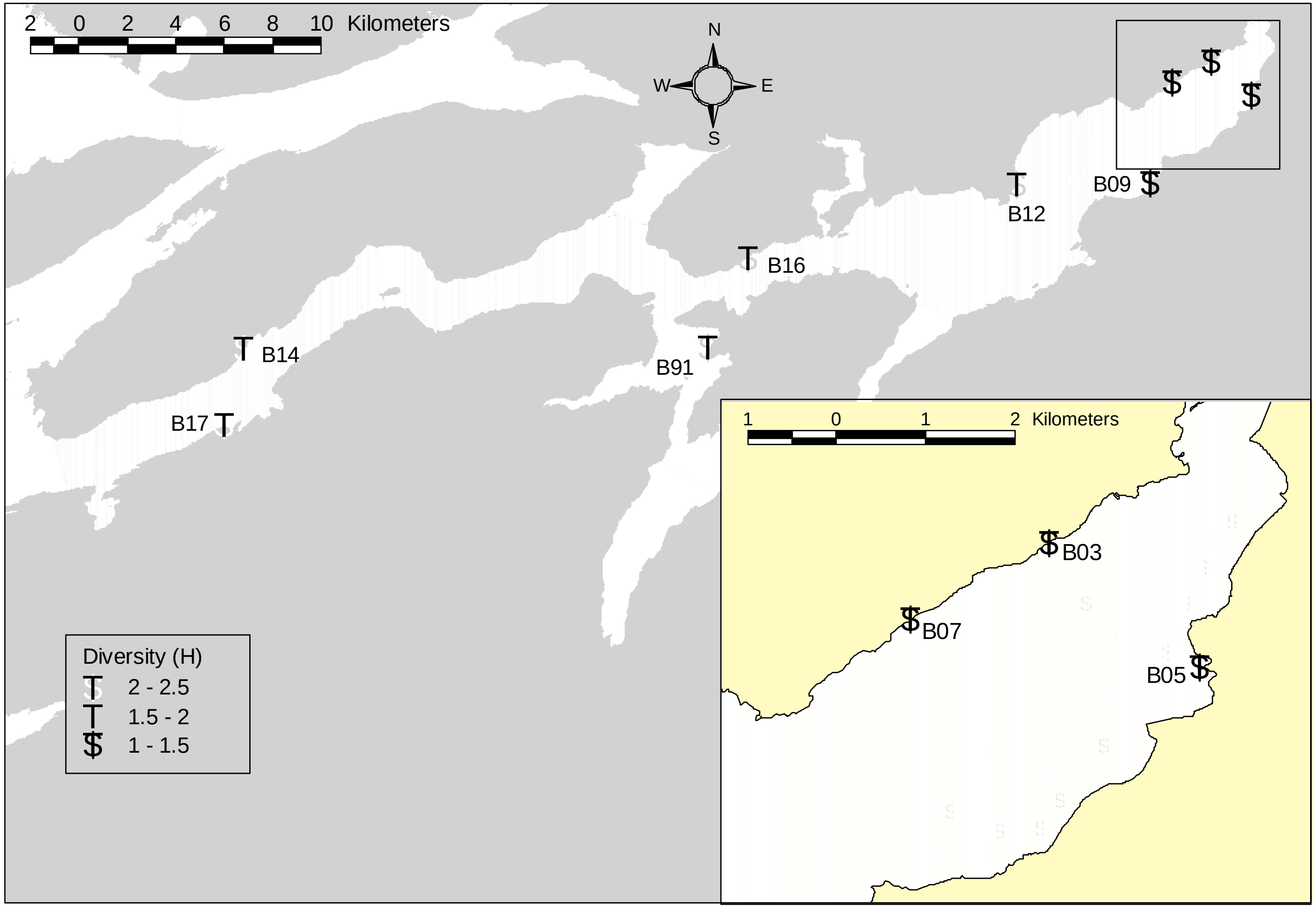


Figure 14. The map illustrates the gradient in biological diversity (H) in the littoral zone of Ranfjorden. *Kart som viser gradienten i diversitet (H) i fjæra utover fjorden.*

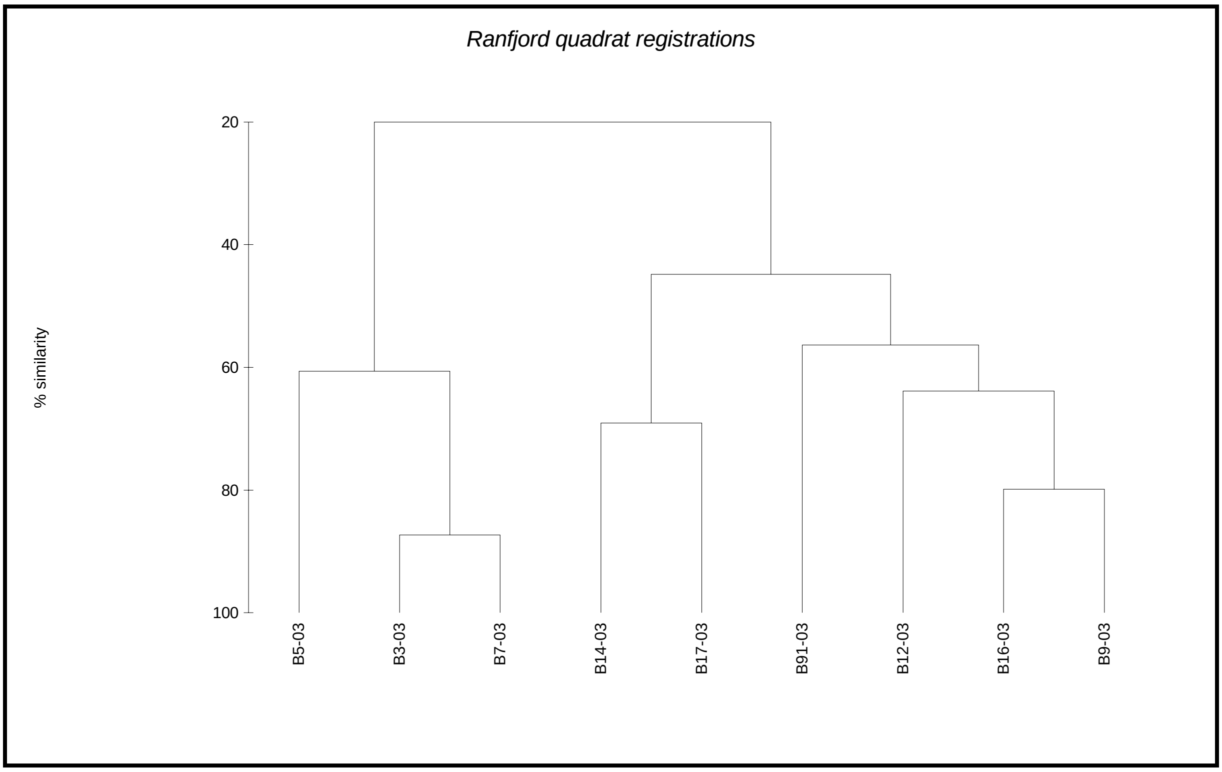


Figure 15. Similarity in community composition. Cluster analysis of data from quantitative quadrat registrations of animals and algae on hard bottom in the littoral zone in Ranfjorden. Results from station B3, B5, B7, B9, B12, B16 and reference station B14, B17 and B91 in 2003. *Likhet i samfunnstruktur. Klusteranalyse som viser gruppering av prøver fra fjæreregistreringene i 2003.*

Table 10. Taxa contributing to the difference between inner- (st. B3-B7) and outer parts (st. B9-B91) of the investigated littoral area (from the quadrat-registrations). Listed in decreasing statistical importance. Results from SIMPER. *Tabellen viser hvilken taxa som bidro sterkest til forskjellen mellom de indre (st. B3-B7) og ytre stasjoner (st. B9-B91) mht. registreringene i fjæra.*

Taxa	Common name / description	B3-B7 Avg. abundance	B9-B91 Avg. abundance	Contrib. %
Fucus vesiculosus	Bladderwrack	25.0	6.5	23.8
Ascophyllum nodosum	Knotted wrack	0	17.6	22.2
Hildenbrandia rubra	red encrusting algae	2.8	13.6	14.0
Brown encrusting algae	brown encrusting algae	8.9	0.2	11.2
‘green turf’	Green algae on stone, indet.	5.8	0.7	6.8
Cladophora rupestris	green seaweed	0	2.4	3.1
Pelvetia canaliculata	Channelled wrack	0	2.2	2.9
Littorina obtusata	Flat periwinkle	0	2.3	2.6
Ectocarpales	filamentous brown algae	2.0	0	2.5
Cyanophycae	blue green algae	0	1.5	1.9

3.4.3 Transect registrations

There were no indications of eutrophication at the two sublittoral stations B9 and B14 in 2003. The difference in community composition between the two stations was relatively high (average dissimilarity = 67%) in 2003, and the taxa contributing to the difference are listed in Table 11.

The similarity between transect samples was approximately 60%, except for the reference station B14 where similarity was ca. 80% between 1992 and 1993 (Figure 16). Biological diversity and species richness was reduced compared to the previous survey in 1992-1993 (Table 12). The lowest values were found on reference station B14 in 2003.

The major change in species composition on B14 between 1992-1993 and 2003 was due to increased grazing from sea-urchins, leading to a dramatic reduction in number of species on this station (Table 12).

Impact from sedimentation of inorganic particles was high on B9 in 2003, as it was in 1992-1993. The distribution of organisms was strongly influenced by the presence of sediments, reported as ”gold-sediment” (glittering) by the diving investigator. These sediments are probably origin from the activities of Rana Gruber.

Table 11. Taxa contributing to the difference between the sub-littoral community at B9 and the reference station B14 in 2003. Listed in decreasing statistical importance. Results from SIMPER. *Tabellen viser hvilken taxa som bidro sterkest til forskjellen mellom transektregistreringene på st. B9 og B14.*

Taxa	Common name	B9 Avg. abundance	B14 Avg. abundance	Contrib. %
Lithothamnion/Phymatolithon GROUP	red encrusting algae	155.4	975.6	17.6
Brown encrusting algae	brown encrusting algae	580.2	202.6	7.8
Phycodrys rubens	red seaweed	124.4	450.3	6.3
Pomatoceros triqueter	Keelworm	62.8	331.6	5.5
Camardonta GROUP	sea urchin	6.1	203.1	4.5
Modiolus modiolus	Horse mussel	25.8	138.7	2.5
Phyllophora truncata/pseudoceranoides	red seaweed	107.9	0	2.3
Ptilota/Plumaria GROUP	red seaweed	0.9	103.3	2.0
Enteromorpha spp.	Gut weed	87.7	4.9	1.8

Table 12. Community indexes calculated pr. transect (3-24m depth) 1992, 1993 and 2003. B14 is the reference station. *Samfunnsindekser beregnet pr. transekt (3-24m dyp). B14 er referansestasjon.*

station	taxa	abundance	species richness (d)	species diversity (H)
B9 -92	65	2752	8.1	3.6
B9 -93	66	3021	8.1	3.5
B9 -03	55	3326	6.7	3.1
B14 -92	80	4941	9.3	3.4
B14 -93	76	4735	8.9	3.4
B14 -03	39	2811	4.8	2.4

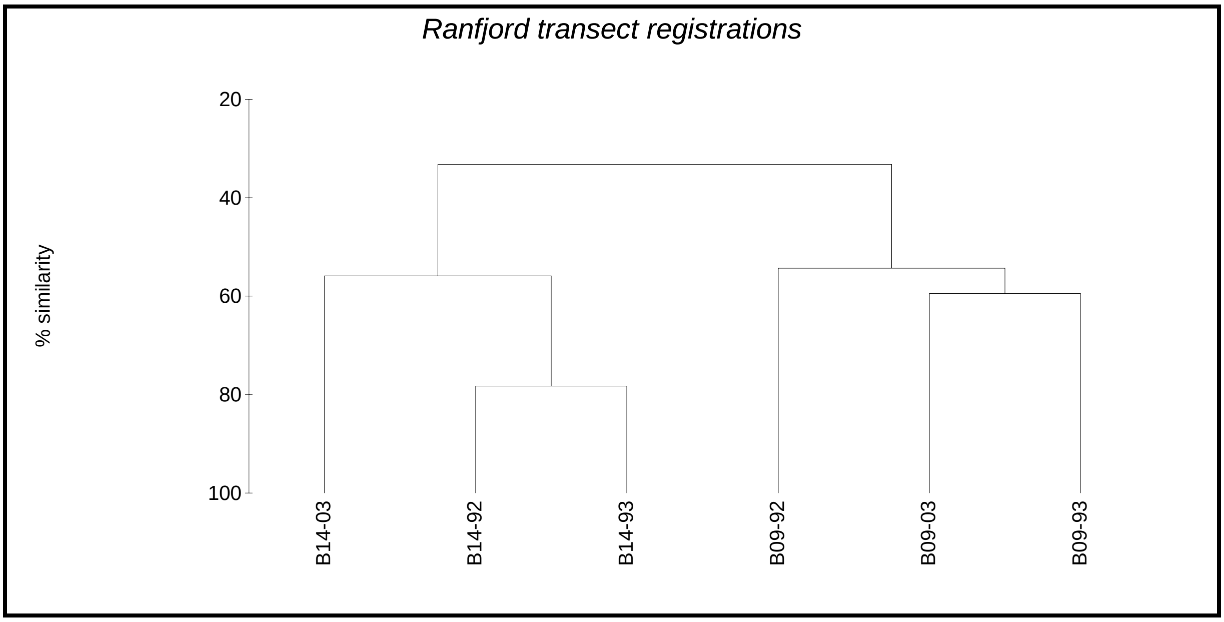


Figure 16. Similarity in community composition. Cluster analysis of data from semi-quantitative transect registrations of animals and algae on hard bottom on two stations (B9 and B14) in Ranfjorden. Registrations from 3-24m depths are included. *Likhet i samfunnstruktur. Klusteranalyse som viser gruppering av prøver fra transekregistreringene i 1992, 1993 og 2003.*

There were few sea-urchins on station B9, while they were common on the reference station. Two species were identified; the Northern sea-urchin (*Strongylocentrotus droebachiensis*) and the edible sea-urchin (*Echinus esculentus*), the former was the dominating species. Green et al. (1994) found indications of a negative correlation between the abundance of sea-urchins and siltation in 1992-1993. But also freshwater influence was mentioned as a limiting factor on grazing in the inner fjord. There is still an excessive discharge of inorganic particles from Rana Gruber to the inner part of the fjord. In the littoral zone there was sign of impact from Rana Gruber as far out in the fjord as station B16. We suggest smothering from inorganic particles as the main reason for the low abundance of animals in the littoral and sublittoral of station B9.

The main structural factor on hard bottom in outer parts of Ranfjorden is grazing from sea urchins. Where urchins occur at such high densities as in Ranfjorden, the result is destructive grazing that produces habitats devoid of seaweeds. These areas are often called "barren grounds". This phenomena is not exceptional for Ranfjorden, but very common along the coast of northern Norway. Thus, impact from other factors in the sublittoral is difficult to identify in the heavily grazed areas of the coast. The Northern sea urchin (*S. droebachiensis*) is one of the most widely distributed of all Echinoderms, with a circumpolar distribution It primarily grazes on seaweeds (kelp being its preferred food source), but will also consume a wide variety of organisms including mussels, barnacles, whelks, periwinkles, sponges, bryozoans etc.

3.4.4 Conclusions

Some of the changes in the littoral community composition from the outer to the inner part of Ranfjorden indicated elevated nutrient-levels. River discharges and decreasing salinity are contributing to the observerved changes, but the main negative impact is from particles, mainly inorganic particles origin from the activities of Rana Gruber. The highest negative impact on the littoral communities was observed at stations B3 – B5 in the innermost part of the fjord (Figure 14). A lesser degree of negative effects were observed on B9. The rest of the stations were little affected. The absence of animals at stations B3 – B5 is most probably caused by smothering from inorganic particles.

There were no indications of eutrophication at the two sublittoral stations. Main impact on sublittoral communities in Ranfjorden was grazing from sea-urchins on the reference station, and smothering from inorganic particles on station B9, Bjørnebærvika.

4. Soft-bottom fauna

4.1 Introduction

In marine areas the benthic fauna is widely used as an indicator of environmental status and has proven to be a useful tool for describing the ecological status at the locality.

Benthic animal communities are rich in species. Changes in the communities therefore reflect the integrated response of many species to pollutants or other disturbance. The communities are representative of the local environmental conditions and their fluctuations.

4.2 Methods

The collection and treatment of samples are carried out in accordance with the Norwegian Standard NS 9423 (1998): “Guidelines for quantitative investigations of sublittoral soft-bottom benthic fauna in the marine environment”.

At each station four parallel samples are obtained using a 0.1 m^2 vanVeen grab. Sediments are sieved through 1.0 mm sieves for removal of fine particles. Animals larger than 1 mm and other coarse material are retained by the sieves and conserved in 4-6% formaldehyde solution in sea water and kept for subsequent treatment in the laboratory, where animals are sorted out, identified to species (if possible) and counted. Based on species lists and number of individuals per species, diversity indices, species densities, abundance and a species indicator index based on the relative occurrence of species which are sensitive or tolerant to pollution.

Sediment samples are obtained for analyses of organic carbon and nitrogen. The fine fraction (the proportion of particles < 0.063 mm) is determined by wet sieving. The content of organic carbon (TOC) and nitrogen (TN) is analysed using an element analyser after the carbonates have been removed by hydrochloric acid. Usually only one sediment sample is analysed from each station.

4.2.1 Field work and treatment of samples

The field work was carried out by Akvaplan-niva 27 - 29 May 2003 using the ship “Hydra”.

Nine of the earlier benthic stations in Ranfjorden were sampled in 2003 (Table 13, Table 14) to assess present status and changes since the earlier investigations. The stations are situated more than 1 km away from the discharge points and at much greater depths. The stations represent areas of the ”main” recipient, and are supposed to integrate the influences of the different runoffs and discharges to the recipient.

In a supplementary investigation in a NIVA research project, grab samples were obtained from 14 separate stations in the inner, southeastern area of Ranfjorden (RE stations and RN2, Table 14), for analyses of soft-bottom fauna and heavy metals in the sediments. The aim was to describe fauna status along a gradient of polluted sediment. The fauna resultats from 10 of these stations are included in the present report.

Table 13. Sampling stations in previous years, with coordinates and depths, investigated in 2003. *Prøvetakingsstasjoner i tidligere år, med koordinater og dyp, undersøkt i 2003.*

Station	Previous samling years	East	North	Depth
RN3	1992, adjacent station RA3 in 1981	14°06,34	66°18,92	232
RN4	1992, 1994, 1996, adjacent station RA4 in 1981	14°05,82	66°19,10	215
RN5	1992, adjacent station RA8 in 1981	14°04,38	66°18,18	92
RN6	1992	14°03,83	66°17,82	365
RN8	1992	13°57,93	66°17,50	460
RN9	1992, 1994, 1996	13°56,21	66°16,60	491
19R	1992	13°36,50	66°14.13	319
24R	1992	13°23,00	66°13,84	300
26R	1992	13°02,04	66°09,84	455

Table 14. Stations list 2003 with observered positions and depths and analyses scheme at the separate stations. (The results for metals and PAH are presented in the chapter on sediments.) *Stasjonsliste 2003 med observerte posisjoner og dyp og analyseplan for de enkelte stasjonene. (Resultatene for metaller og PAH er vist i kapitlet om sedimenter.)*

Station	x_ddg	y_ddg	Longitude	Latitude	Depth	Area (fauna)	Fauna	Metals	PAH	TOC
RE01	14.13333	66.32667	14°08.00'E	66°19.60'N	90	0.1		x		x
RE02	14.12883	66.32500	14°07.73'E	66°19.50'N	91	0.1	x	x		x
RE04	14.12200	66.31833	14°07.32'E	66°19.10'N	70	0.1	x	x		x
RE05	14.11983	66.31500	14°07.19'E	66°18.90'N	150	0.1		x		x
RE06	14.11767	66.31333	14°07.06'E	66°18.80'N	180	0.1		x		x
RE07	14.11533	66.31167	14°06.92'E	66°18.70'N	150	0.1	x	x		x
RE08	14.11983	66.31117	14°07.19'E	66°18.67'N	141	0.1	x	x		x
RE09	14.10667	66.30700	14°06.40'E	66°18.42'N	57	0.1		x		X
RE10	14.10200	66.30383	14°06.12'E	66°18.23'N	29	0.1	x	x		X
RE11	14.09100	66.29833	14°05.46'E	66°17.90'N	84	0.1	x	x		X
RE12	14.08650	66.29533	14°05.19'E	66°17.72'N	80	0.1	x	x		X
RE13	14.07583	66.29500	14°04.55'E	66°17.70'N	174	0.1	x	x		X
RE14	14.07300	66.29300	14°04.38'E	66°17.58'N	90	0.1	x	x		X
RN2	14.12600	66.32200	14°07.56'E	66°19.32'N	93	0.1	x	x		X
RN3	14.10600	66.31500	14°06.36'E	66°18.90'N	220	0.4	x	x	x	X
RN4	14.09700	66.31817	14°05.82'E	66°19.09'N	212	0.4	x	x	x	X
RN5	14.07300	66.30300	14°04.38'E	66°18.18'N	310	0.4	x	x	x	X
RN6	14.06383	66.29700	14°03.83'E	66°17.82'N	365	0.4	x	x	x	X
RN8	13.96550	66.29167	13°57.93'E	66°17.50'N	455	0.4	x	x	x	X
RN9	13.93683	66.27667	13°56.21'E	66°16.60'N	483	0.4	x	x	x	X
19R	13.60833	66.23550	13°36.50'E	66°14.13'N	319	0.4	x	x	x	X
24R	13.38333	66.23067	13°23.00'E	66°13.84'N	298	0.4	x	x	x	X
26R	13.03400	66.16400	13°02.04'E	66°09.84'N	453	0.4	x	x	x	X

4.2.2 Data treatment and status assessment

Number of species and individuals are determined and the diversity calculated using the index H_{log2} (Shannon & Weaver 1963) and the Hurlbert index ES_{100} (Hurlbert 1971). The occurrence of pollution-sensitive species (species indicating good environmental conditions) are used to estimate the index ISI (Rygg 2002).

The results are assessed using the SFT system for classification of environmental status in fjords and coastal waters. The Norwegian classification system for soft-bottom fauna (see Molvær et al. 1997) is based on fauna diversity and sediment organic content (TOC). Classification based on the occurrence of sensitive and pollution-tolerant species (Rygg 2002) and number of species per bottom area (Lyche et al. 2003) are also applied to the data.

4.3 Results and conclusions

4.3.1 Sediments

The sediments were mainly silty. Some organic particles (mostly plant debris from the river and from land) were observed at the innermost stations. Field report and visual descriptions of the grab samples are shown in Appendix E.

Data for sediment parameters are shown in Table 15.

As in 1992, 1994 and 1996, in 2003 low levels of total organic carbon (TOC) were found in the sediments in inner Ranfjorden. The low levels most probably are caused by the discharges of inorganic particles (Johnsen et al. 2004). The mineral particles in the tailings dilute the organic material in the sediments.

Table 15. Sediment content of fine particles (silt and clay) and total organic carbon, as measured (TOC) and after normalization for fine particles content (TOC_{63}). * = unreliable analysis value. *Innhold av finpartikler og totalt organisk karbon (TOC) i sedimentene, normalisert mot* TOC_{63}.

Station	%<63µm	TOC (mg/g)	TOC_{63} (mg/g)
RE01	84	4.4	7.3
RE02	79	7.3	11.1
RE04	71	9.7	14.9
RE05	82	9.5	12.7
RE06	77	11.7	15.8
RE07	88	13.3	15.5
RE08	72	14.9	19.9
RE09	88	12.6	14.8
RE10	89	14.2	16.2
RE11	94	11.4	12.5
RE12	77	13.0	17.1
RE13	93	10.8	12.1
RE14	94	8.5	9.6
RN2	62	*	*
RN3	73	6.5	11.4
RN4	96	4.5	5.2
RN5	96	5.7	6.4
RN6	77	5.0	9.1
|RN8	92	5.2	6.6
RN9	90	7.2	9.0
19R	91	11.8	13.4
24R	72	9.8	14.8
26R	96	17.1	17.8

4.3.2 Fauna

The dominating species in the area were the polychaetes *Chaetozone setosa*, *Paramphinome jeffreysii*, *Spiophanes kroeyeri*, *Prionospio cirrifera*, *Scoloplos armiger* and *Heteromastus filiformis,* and the bivalves *Thyasira* spp, *Kelliella miliaris* and *Yoldiella* spp. The dominating species in the area were mostly the same in 2003 as in previous years (Johnsen et al. 2004). The pollution-indicating polychaete species *Capitella capitata* occurred in moderate numbers at stations RN2 and RN6 in the inner fjord, both in 1992 and 2003.

Table 16 shows fauna parameters per station. The table also shows status classification based on selected parameters. Fauna parameters per grab are shown in Appendix (Table 43).

Appendix F. (Table 42) shows the most abundant species and genera (or higher groups) at the stations in 2003. In some genera the identification of species proved difficult. For instance, many of the bivalves *Thyasira* og *Yoldiella* were small and had damaged shells. Complete lists of species (taxa) and their abundance are shown in Appendix H. (Table 44).

At many of the stations in inner Ranfjorden the abundances of benthic animals were much higher than in outer Ranfjorden and also much higher than at the majority of soft-bottom stations in Norwegian fjords and coastal waters (Table 16, Table 17, Figure 4). The high abundances of a few dominating species caused lowered diversity index values. The high abundances at several stations in the inner fjord indicate high nutrient supply. This may be caused both by runoff from the river and surrounding land areas and by nutrient discharges from human activities. Similar situations with high animal abundances have been observed in other estuarine and polluted areas in Norway (NIVA database).

In the inner fjord significant amounts of organic particles in the sediments were observed. They were mostly terrestrial and probably due to river runoff. The area was not characterized by typical pollution-indicating species, except at two of the inner stations, where the polychaete *Capitella capitata* occurred in moderate numbers.

The fauna in inner Ranfjorden is probably influenced by several factors, including organic pollution and industrial pollution (inorganic particles from Rana Gruber, heavy metals, PAH and other substances).

In the report from the investigations in 1992 (Helland et al. 1994) it was concluded that the soft-bottom fauna in Ranfjorden (especially the inner part of the fjord) was affected by particles from Rana Gruber.

In the maps in Figure 17 - Figure 19 status classifications of the stations in 2003, are shown, based on two diversity indices (H and ES_{100}) and the indicator species index (ISI).

The soft-bottom communities in extensive areas of inner Ranfjorden showed moderate environmental status (class III). In some areas the status was classified as good (class II). In the outer fjord the staus was good (class II).

The results from the benthic-fauna investigations indicate a need for remediation in order to obtain good environmental status (class II) throughout the inner fjord. However, it is not certain if the status can be improved merely by reducing the municipal sewage discharges.

Table 16. Fauna parameters and status classifications in 2003, shown per station (0.1 or 0.4 m^2). Number of species (S), abundance (N), diversity (H and ES_{100}) and indicator species index (ISI). Class = overall classification. Classes for H and ES_{100} according to SFT (Molvær et al. 1997). Classes for ISI as suggested by Rygg (2002). S_{01} = Number of species in 1 grab sample (0.1 m^2). S_{04} = Number of species in 4 grab samples (0.4 m^2) (classes suggested by Lyche et al. 2003). The classes are indicated by colour symbols. *Faunaparametre og statusklassifisering i 2003, vist pr. stasjon (0.1 eller 0.4 m^2). Artstall (S), individtall (N), artsmangfold (H og ES_{100}) og indikatorartsindeks (ISI). Class = samlet klassifisering. Klassene for H og ES_{100} ifølge SFT (Molvær et al. 1997). Klassene for ISI som foreslått av Rygg (2002). S_{01} = Artstall i 1 grabbprøve (0.1 m^2). S_{04} = Artstall i 4 grabbprøver (0.4 m^2) (klasser foreslått av Lyche et al. 2003). Klassene er indikert med fargesymboler.*

Station	Depth	Area	N	N/m²	S01	S04	H	ES_{100}	ISI		Class
RE02	91	0.1	1666	16660	34		3.19	14.82	7.85		III
RE04	70	0.1	1835	18350	50		3.65	18.81	7.61		II
RE07	150	0.1	759	7590	35		2.79	15.64	8.31		III
RE08	141	0.1	1072	10720	49		3.79	19.81	7.51		II
RE10	29	0.1	329	3290	40		4.01	24.82	7.25		II
RE11	84	0.1	372	3720	31		3.63	19.76	8.60		II
RE12	80	0.1	570	5700	43		3.78	20.99	7.99		II
RE13	174	0.1	98	980	22		3.47	22.00	8.63		II
RE14	90	0.1	130	1300	21		3.53	19.84	8.13		II
RN2	93	0.1	2120	21200	31		2.29	10.46	7.72		III
RN3	220	0.4	3316	8290	33	52	3.88	19.51	8.31		II
RN4	212	0.4	2177	5443	28	45	3.61	19.47	8.91		II
RN5	310	0.4	3270	8175	26	42	3.03	14.38	8.47		III
RN6	365	0.4	2389	5973	25	45	3.10	14.74	7.34		III
RN8	455	0.4	1340	3350	14	26	2.62	11.61	7.76		III
RN9	483	0.4	1730	4325	24	38	3.21	15.74	8.24		III
19R	319	0.4	1304	3260	30	53	3.51	19.62	9.71		II
24R	298	0.4	1983	4958	36	63	3.13	18.94	9.76		II
26R	453	0.4	642	1605	24	40	3.39	20.65	9.49		II

Status	S04	H	ES_{100}	ISI
Class I - High	>58	>4	>26	>8.75
Class II - Good	36-58	3-4	18-26	7.5-8.75
Class III - Moderate	17-36	2-3	11-18	6-7.5
Class IV - Poor	7-17	1-2	6-11	4-6
Class V - Bad	0-7	<1	<6	<4

Abundance (N), species numbers (S), diversity (H and ES_{100}) and indicator species index (ISI) in Ranfjorden in 2003 and earlier years at the same stations are shown in Table 17. All data from the fjord are presented in Table 45 in Appendix H. Some improvements in fauna status seem to have occurred from 1981 to the1990-ies and 2003. The status is mainly class III (moderate) in the inner fjord area and class II (good) in the outer fjord area in the 1990-ies and 2003.

Table 17. Fauna parameters and status classification spanning inner to outer Ranfjorden in 1992-2003. *Faunaparametre og statusklassifisering fra indre til ytre Ranfjorden i 1992-2003.*

Station	Year	Depth	Area	IND	IND/m^2	S01	S	H	ES_{100}	ISI
Inner Ranfjord										
RN2	1992	92	0,2	5176	25880	41	63	2,95	16,8	7,76
RN2	2003	93	0,1	2120	21200	31	31	2,29	10,5	7,72
RN3	1992	232	0,2	3168	15840	34	45	3,57	16,1	8,09
RN3	2003	220	0,4	3316	8290	33	52	3,88	19,5	8,31
RN4	1992	213	0,2	2436	12180	37	45	3,23	16,3	8,19
RN4	1994	215	0,2	1670	8350	36	48	3,55	18,6	8,85
RN4	1996	215	0,2	2347	11735	34	43	3,44	18,1	8,47
RN4	2003	212	0,4	2177	5443	28	45	3,61	19,5	8,91
RN5	1992	310	0,2	2025	10125	29	33	2,76	15,1	8,22
RN5	2003	310	0,4	3270	8175	26	42	3,03	14,4	8,47
RN6	1992	365	0,2	739	3695	13	18	2,47	9,9	6,72
RN6	2003	365	0,4	2389	5973	26	45	3,10	14,7	7,34
RN8	1992	460	0,2	903	4515	21	29	2,90	14,7	7,62
RN8	2003	455	0,4	1340	3350	15	26	2,62	11,6	7,76
RN9	1992	486	0,2	931	4655	21	31	3,26	14,2	7,32
RN9	1994	491	0,2	1056	5280	22	31	2,58	13,6	7,71
RN9	1996	491	0,2	415	2075	19	24	3,45	15,8	8,11
RN9	2003	483	0,4	1730	4325	24	38	3,21	15,7	8,24
Outer Ranfjord										
19R	1992	319	0,2	709	3545	34	43	3,70	21,6	9,00
19R	2003	319	0,4	1304	3260	30	53	3,51	19,6	9,71
24R	1992	300	0,2	866	4330	40	53	3,77	21,6	9,11
24R	2003	298	0,4	1983	4958	36	63	3,13	18,9	9,76
26R	1992	455	0,2	436	2180	33	43	4,12	25,8	9,09
26R	2003	453	0,4	642	1605	24	40	3,39	20,7	9,49

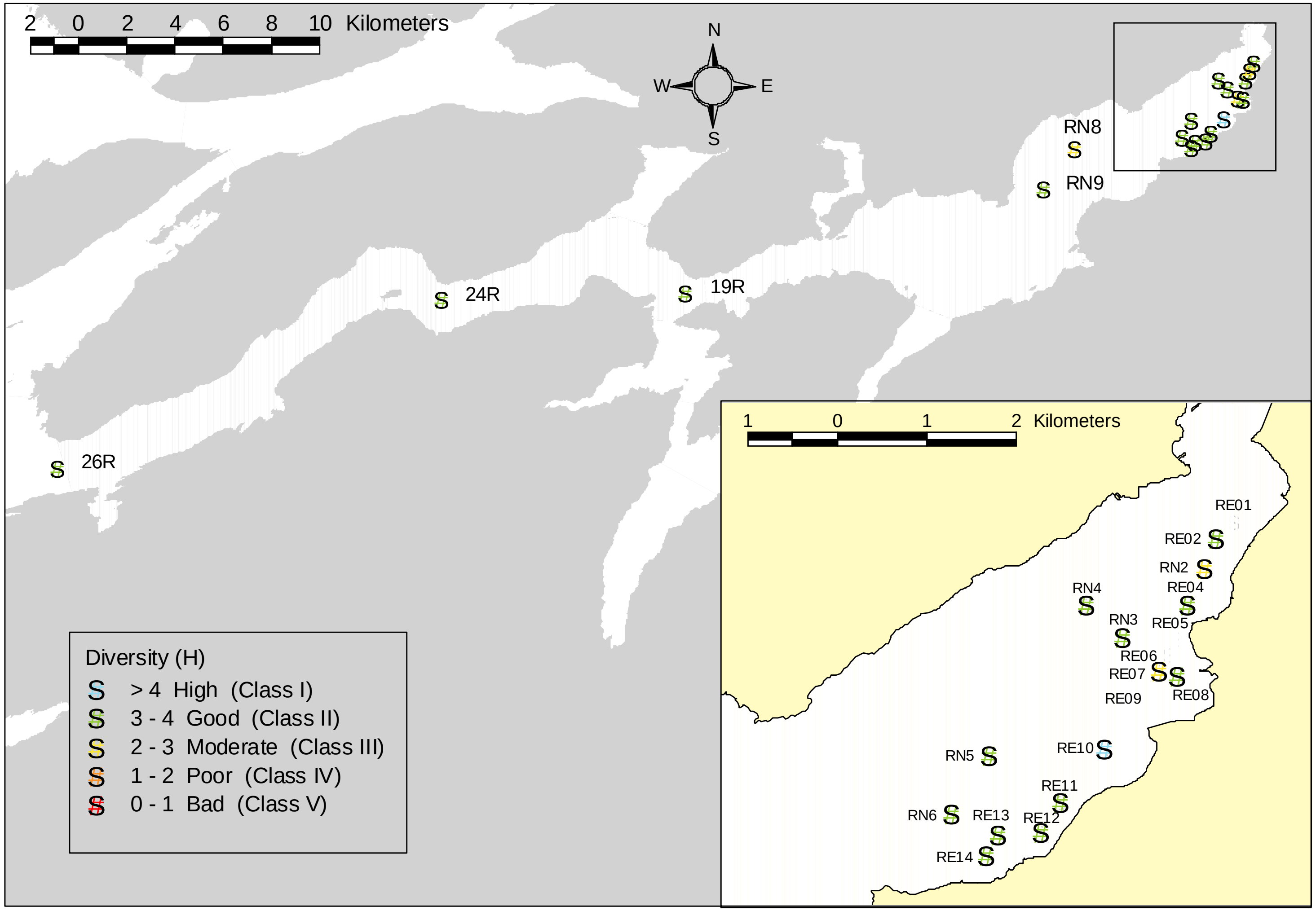


Figure 17. Diversity (H) 2003. *Artsmangfold (H) 2003.*

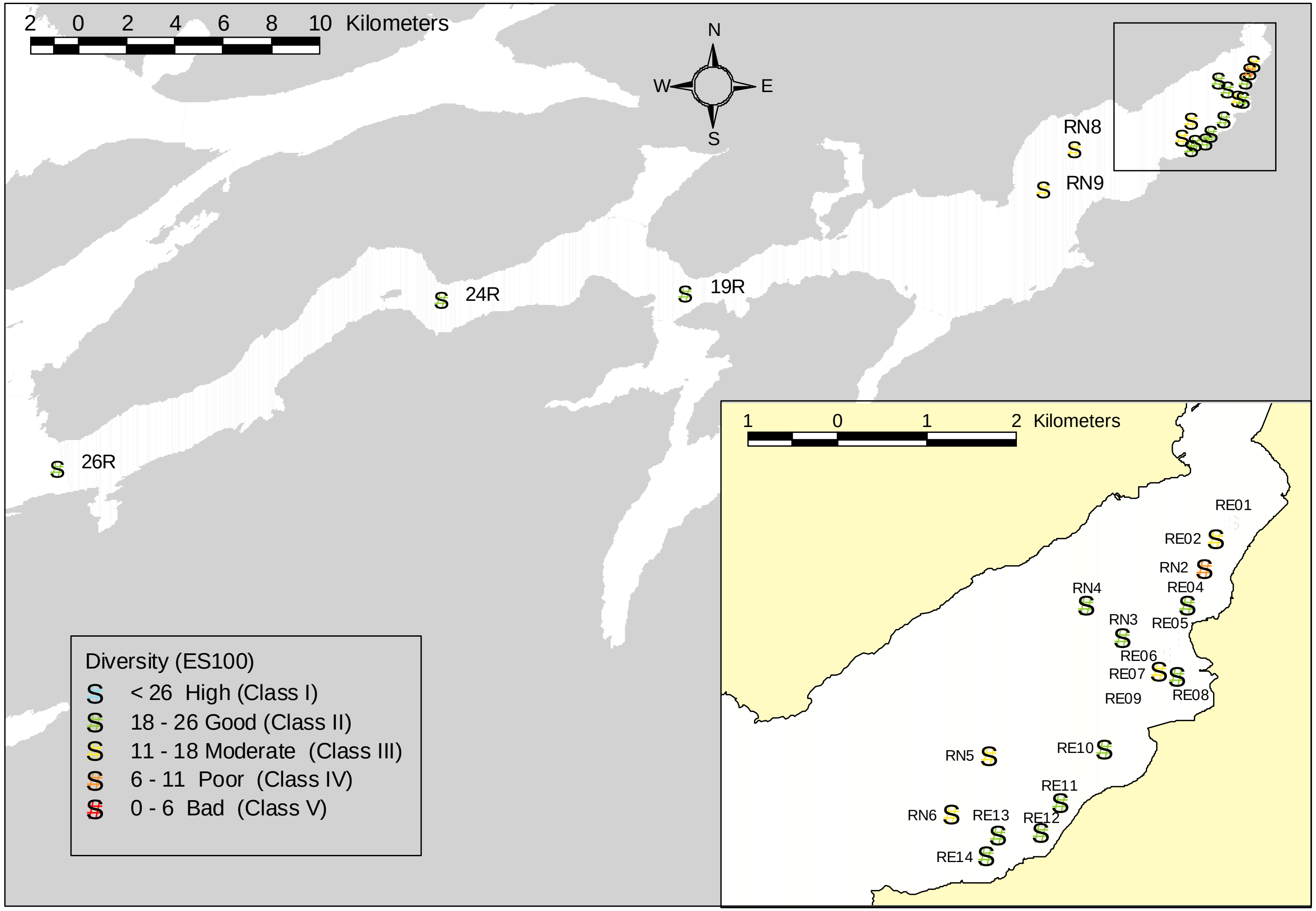


Figure 18. Diversity (ES_{100}) 2003. *Artsmangfold (ES_{100}) 2003.*

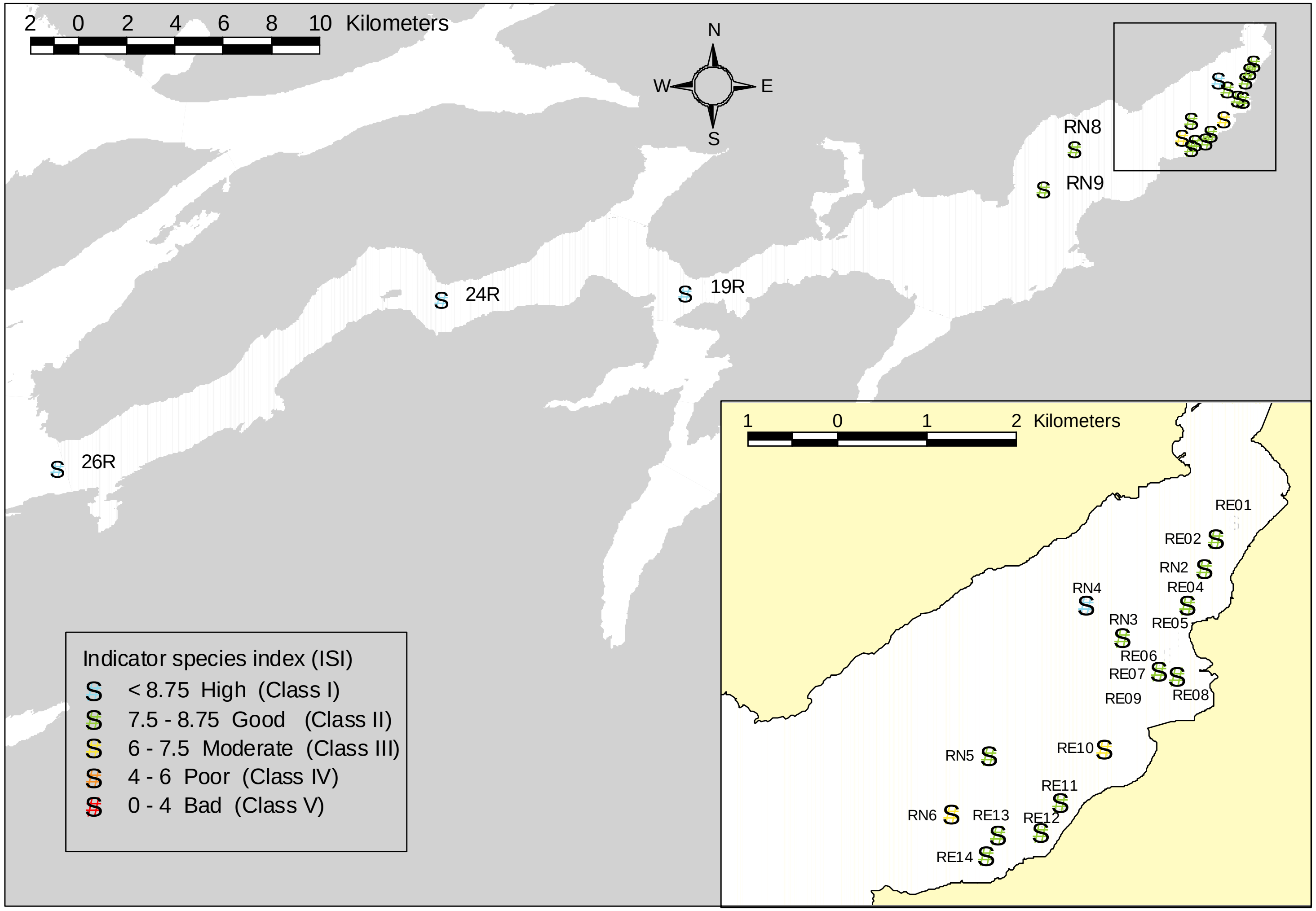


Figure 19. Indicator species index (ISI) 2003. *Indikatorartsindeks (ISI).*

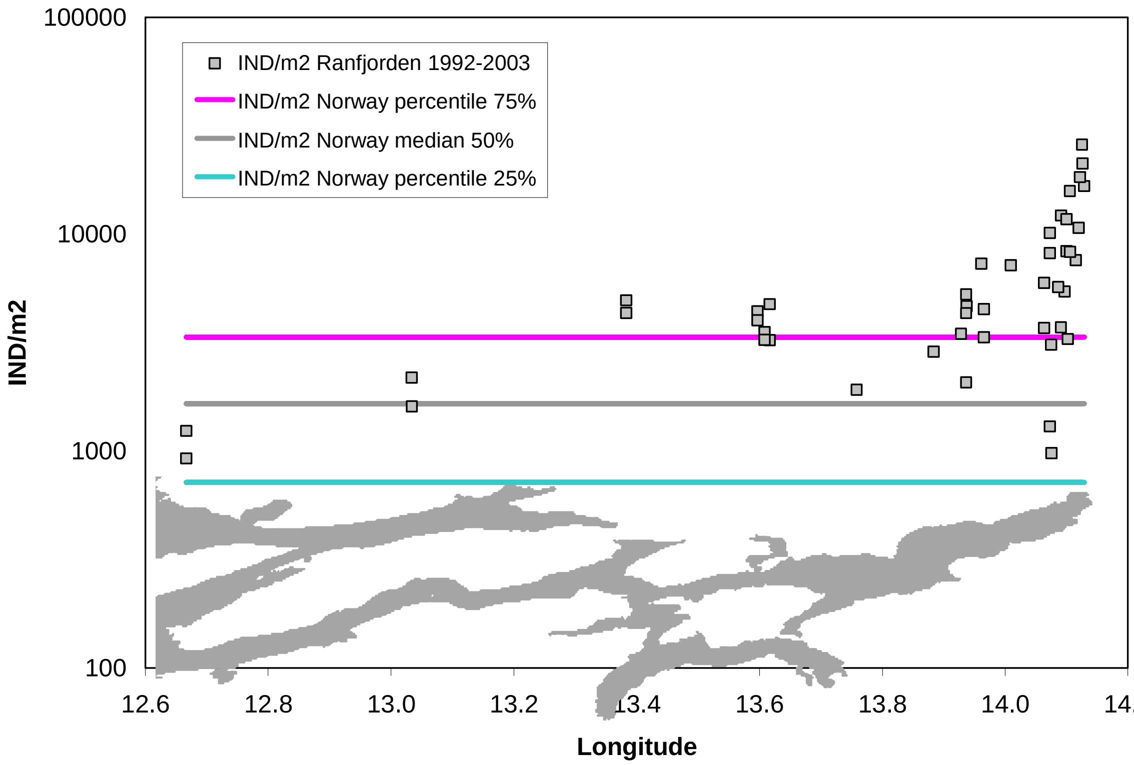


Figure 4. Plot of abundance (IND/m2, logaritmic scale) at the stations in Ranfjorden 1992-2003. The grey area is a map of Ranfjorden and the dots in the plot corresponds to the east-west position in the fjord. *Plott av individtetthet (IND/m2, logaritmisk skala) på stasjoner i Ranfjorden 1992-2003. Punktene i plottet korresponderer med øst-vest plassering av stasjonene.*

5. Bottom sediments

5.1 Introduction

Micro pollutants reaching a fjord environment will deposit along with the bottom sediments. Provided stable sedimentation conditions, sediment cores from accumulation areas display a chronological history of the micro pollutant supply to the fjord. Bottom sediments are therefore utilised as an indicator of both status and development of environmental conditions in coastal areas.

Bottom sediments in Ranfjorden have been subject to monitoring by the Environmental Authorities (SFT) since the 1970ies. The latest comprehensive monitoring was performed in 1989 and 1992. At that time the sediments were severely polluted by PAH all the way out to Hemnesberget. However there was a significant decease in the PAH pollution from 1989 to 1992 in the inner part of the fjord from 1989 to 1992 (Helland et al. 1994). The reasons for the PAH pollution were local industrial outlets. Outlets from mining activity, causing siltation, have also been marked in the inner part of the fjord. It has not been focused on effects of sewage on sediments in earlier investigations.

The main purpose of the sediment investigations in 2003 is to describe the environmental quality of the sediment surface according to SFTs environmental quality criteria of pollutants (SFT:97). Further, to find out if there have been any changes in sediment contamination from 1992 to 2003. These investigations will make basis for future sediment monitoring.

The sediment data will also be used in the overall assessment related to the challenge of secondary sewage treatment.

5.2 Field work

Sediment sampling was performed by Akvaplan-niva from 27 - 29 May 2003 from the ship “Hydra”. The sampling was co-ordinated with the soft bottom fauna sampling. The sediment sampling stations had the same geographical positions as in 1989 and 1992.

5.3 Methods

Samples of the upper 0-1 cm of the sediments were collected by use of a vanVeen grab. The samples were transferred to incinerated tin foil by use of a stainless steel spoon. The samples were frozen shortly after sampling and kept frozen until analytical treatment at NIVAs laboratory in Oslo.

The samples were analysed for total amount of solids (TTS), copper (Cu), lead (Pb), iron (Fe), zinc (Zn), total amount of organic carbon (TOC), total amount of nitrogen (TN), phosphorous (P), polycyclic aromatic hydrocarbons (PAH) and tributyltin (TBT). The methods used are shortly described in Table 18.

Table 18. Analytical methods and instrumentation for sediment analyses. *Analysemetoder ved sedimentanalysene.*

Element	Analytical method and instrumentation
TTS	A known amount of sample is dried at 105 °C in a Thermaks 4115 hot cabinet, the remaining is weighed on a Sartorius R 200 D. The measured uncertainty between parallel samples is 3.2% deviation from the average, with a standard deviation of 5.2%
TOC, TN	Homogenise sample (>0.5mg) weight in tin capsules is combustion catalytic at ca. 1800 °C in oxygen saturated helium gas. Cu removes excess oxygen at ca 650 °C, whereby also nitrogen oxides are reduced to N_2 gases. The flue gases passes a chromatographic column, N_2 and CO_2 are detected by a hot wire detector in a Carlo Erba Elementanalysator 1106. Measured uncertainty: N=84, average = 41.66% C, 16.37% N from theoretic value 41.84% C and 16.27% N, std. = 0.22% C, 0.37% N.
Cd, Pb, Fe, Zn	< 200 mg freeze-dried homogenised sample, accurately weight in a teflon bomb, aqua regia and hydrofluoric acid added. The bomb is tightened and the sample is digested in a microwave oven, closed system. An excess of boric acid is added to the cold sample, then diluted by deionizen water. The clear water phase is analysed for metals by atomic absorption, flame or furnace.
Hg	0.5 g freeze-dried homogenised sediment accurately weight is digested by nitric acid. The water phase is analysed by cold vapour atomic absorption spectrophotometer, Perkin Elmer FIMS-400 (NS 4768). 7 measurements of MESS-2 (sediment) 0,092 ± 0,009 µg/g, gave 0,086 and 0,003 µg/g.
P	0.5 g freeze-dried homogenised sediment accurately weight is digested by nitric acid. The water phase is introduced to a Perkin-Elmer Optima 4300 DV by a peristaltic pump coupled to a nebulizer where the sample is atomised. The fine aerosols are transported to argon plasma. The plasma emission is separated in a spectrophotometer and measure by a CCD detector, which has a linear area of 5 – 6 decades from the detection limit.
PAH	Internal standards are added to the samples, then extracted in Soxhlet with dichloromethane. The extract is cleaned in several steps to remove disturbing substances, finally the extract is analyses by a GC/MDS. (Hewlett Packard modell 5890 Series II, with column injector and HP auto sampler 7673. Equipped with HD model 5970 B mass selective detector and column HP-5 MS 30 m x 0,25 mm i.d. x 0,25 µm.) The identifications are based on retention time and the molecular ions of the PAHs. The quantification is based on the added internal standards, according to Grimmer & Bøhnke 1975.
TBT	Internal standards are added to the samples, and extracted by alcoholic lye. After pH adjustment and derivatisation the organic tin compounds are further extracted by organic solvents cleaned by gel permeation chromatography and concentrated. The samples are analysed by gas chromatography and atom emission detection, GC-AED. The different compounds are identified by time of retention, and quantified by the internal standard after the method of Følsvik 1997. The instrumentation is a Hewlett Packard 5890 Series II gas chromatograph with HP 7673 auto injector and HP 5921 A atomic emissions-detector.

The environmental quality of the sediments is evaluated by comparing the concentrations obtained from the chemical analyses with the SFTs environmental quality criteria (SFT:97, Molvær et al. 1997). The current environmental parameters are presented in Table 19.

Table 19. Classification according to SFTs environmental quality criteria (Molvær et al. 1997). *Klassifisering av miljøtilstand i hht. SFTs miljøkvalitetskriterier (Molvær et al. 1997).*

Variable		Environmental classes				
		I Insignificantly polluted	**II Moderately polluted**	**III Markedly polluted**	**IV Severely polluted**	**V Extremely polluted**
Sediments (dry weight)	Lead (mg Pb/kg)	< 30	30 – 120	120 – 600	600 – 1500	> 1500
	Cadmium (mg Cd/kg)	< 0,25	0,25 – 1	1 – 5	5 – 10	> 10
	Copper (mg Cu/kg)	< 35	35 – 150	150 – 700	700 – 1500	> 1500
	Mercury (mg Hg/kg)	< 0,15	0,15 – 0,6	0,6 – 3	3 – 5	>5
	Zinc (mg Zn/kg)	<150	150-700	700-3000	3000-10000	>10000
	TBT (µg/kg)	< 1	1 – 5	5 – 20	20 – 100	> 100
	Σ PAH (µg/kg) 1)	< 300	300 – 2000	2000 – 6000	6000 – 20000	> 20000
	Σ PCB_7 (µg/kg) 2)	< 5	5 – 25	25 – 100	100 – 300	>300
	HCB (µg/kg) 3)	<0,5	0,5-2,5	2,5-10	10-50	>50

1) Σ PAH: Sum of 19 tri- to heksacyclic compunds. Including the 16 compunds from EPA journal 8310 minus naftalen (dicyclic). All CPAH are included.
2) Σ PCB_7 : Sum of the compounds no. 28, 52, 101, 118, 138, 153 and 180.
3) HCB: Hexachlorobenzene

5.4 Results and discussion

A complete set of results is presented in 0

5.4.1 Sediment description

The sediments in Ranfjorden generally consist of silty clay, with the exception of the inner fjord, at station RN2 (Table 20). This station has a higher content of coarse material, sand and gravel, brought in by the river Ranelva. The influence of the river is also reflected by the higher concentrations of organic carbon TOC (2.3%), probably terrestrial organic material, than in sediments further out the fjord (Figure 20). Typically, this is the only station with significantly different TOC concentration from 1992 to 2003. Bottom sediments in river mouths may change through the year and from one year to another, due to varying input from the river (Helland et al. 2003). In general the organic carbon concentration in the fjord sediments is about 1%. In coastal areas this is regarded as a low concentration. The low concentrations are probably related to the high input of inorganic tailings from the mining industry (Johnsen et al. 1994), which also explain the low nitrogen concentrations in the sediments (concentrations were below detection limit < 1.0 mg/g).

The concentrations of phosphorus varied between 1.0 to 2.5 gP/kg sediment (Figure 21). Except for the two inner stations (RN2, RN3), the concentrations decreased seaward. There were low concentrations in the inner part of the fjord and this is probably because of high input of inorganic particles from Rana Gruber, and also high input of material from the river. See discussion below.

Table 20. Description of sampling stations and sediment from the survey 27. and 28. of May 2003 in Ranfjorden. *Stasjons- og sedimentbeskrivelse fra prøvetakingen 27-28 mai 2003.*

Station no.	Position	Depth (m)	% silt & clay	Sediment description
RN2	66°19.32'N 14°07.56'E	93	62	Sandy silt with gravel, olive green surface, dark grey below. Terrestrial material. Some smell (organic metallic?? Not H_2S) Bristle worms, brittle stars.
RN3	66°18.90'N 14°06.36'E	220	73	Silty, homogeneous olive green colour whole sediment. No smell. Bristle worms.
RN4	66°19.09'N 14°05.82'E	212	96	Silty, homogeneous dark olive green colour whole sediment. No smell. Bristle worms.
RN5	66°18.18'N 14°04.38'E	310	96	Silty, homogeneous dark olive green colour whole sediment. No smell. Bristle worms, brittle stars
RN6	66°17.82'N 14°03.83'E	365	77	Sandy silt, dark olive green surface, nearly black below, some terrestrial material. No smell. Bristle worms, mussels
RN8	66°17.50'N 13°57.93'E	455	92	Silty, dark olive green sediment, some terrestrial material. No smell, Bristle worms
RN9	66°16.60'N 13°56.21'E	483	90	Silty, olive green surface, nearly black below. No smell.
19R	66°14.13'N 13°36.50'E	319	91	Silty, olive green surface, grey below. No smell.
24R	66°13.84'N 13°23.00'E	298	72	Silty, olive green surface, darker below. No smell. Bristle worms, amfipodes Ophiurider Ctenodiscus,
26R	66°09.84'N 13°02.04'E	453	96	Silty, olive green surface, darker below. No smell. Bristle worms, amfipodes , Ctenodiscus, Pectinaria and Brisaster?

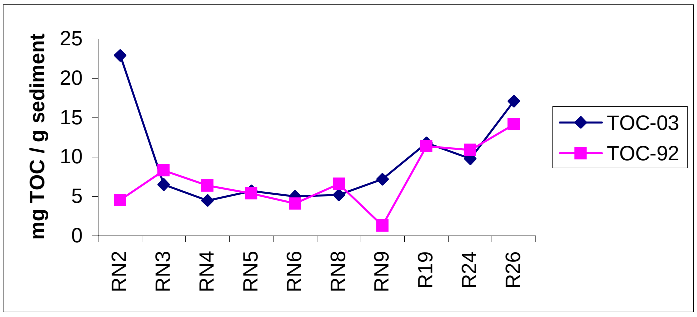


Figure 20. Total organic carbon (TOC) in surface sediment (0-1cm) from Ranfjorden in 2003 and (0-2 cm) in 1992. *Total organisk karbon (TOC) i overflatesedimenter (0-1cm) fra Ranfjorden i 2003 og (0-2cm) i 1992*

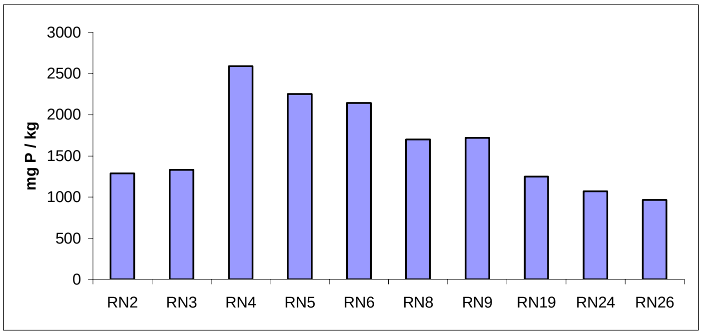


Figure 21. Phosphorous (P) in surface sediment (0-1cm) from Ranfjorden 2003. *Fosfor (P) i overflatesedimenter (0-1cm) fra Ranfjorden i 2003.*

5.4.2 Metals and organic micro pollutants

The concentration of the metals Cd, Hg and Zn is low throughout the fjord (class I, insignificantly polluted). A slightly elevated concentration of Zn was detected at station RN19 (class II, moderately polluted). The concentrations of Zn and Cd was in general lower in 2003 than in 1992 (compare Table 21 and Table 22). The concentrations of Hg were well below the limit for class I sediments, both in 2003 and 1992.

Fe is not included in the environmental quality criteria because there is a natural varying concentration of Fe in sediments, depending on the surrounding geology. As expected the Fe concentration decreased seaward, probably because of decreasing amount of mining tailings in the sediments. There was a significantly negative correlation between Fe and TOC in the sediments at the 90% confidence level (corr.coef. = -0,6), when excluding the innermost station (RN2). This confirms what stated above, that high discharge of inorganic particles probably dilute the TOC concentrations in the sediments. However, the moderately strong relationship between the variables indicates that there are other factors, besides Fe, that influence on the TOC concentration, probably river born material and sewage.

The river Ranelva carried in 2000 and 2001 respectively 7.000 and <3.800 tonnes of suspended particulate matter (SPM), 3.500 and 8.600 tonnes of TOC (Weideborg et al. 2001 and 2002). This is a small amount of SPM compared to the discharge of inorganic particles from Rana Gruber AS, which was more than 500.000 tonnes annually in these two years (Figure 22).

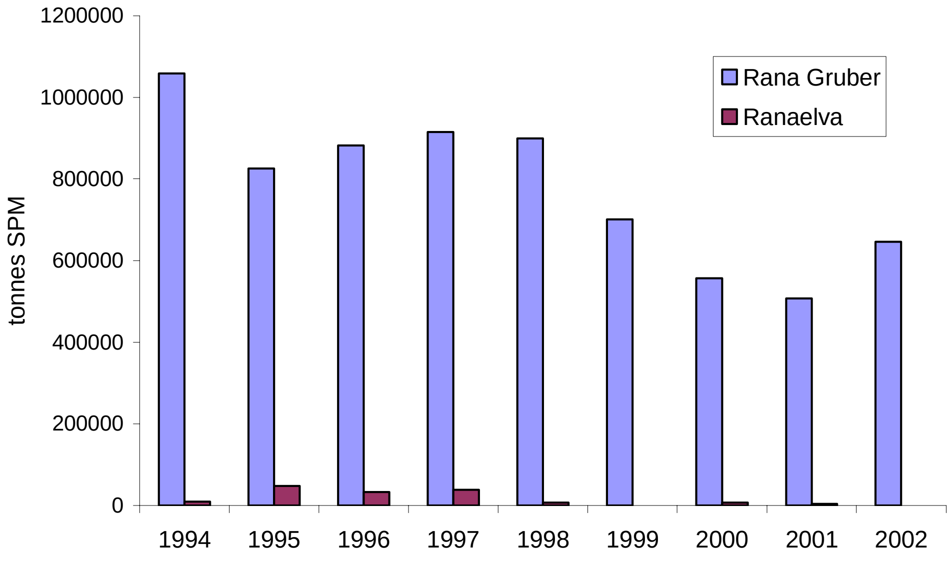


Figure 22. Discharge of suspended particulate matter (SPM) to Ranfjorden from Rana Gruber AS, and from the river Ranelva. Data for Ranelva 1999 and 2002 is lacking. *Tilførsler av partikler (suspendert materiale) til Ranfjorden fra Rana Gruber og fra Ranelva. Data fra 1999 og 2002 mangler for Ranelva.*

The concentration of P decreased seaward, from more than 2500 mg total P/kg to about 1000 mg total P/kg in the outer fjord (Figure 21). An exception was the two innermost stations, RN2 and RN3. The lower concentrations on these two stations is probably influence be the river Ranelva and also inorganic particles from Rana Gruber. There is a statistical negative correlation between P and TOC at the 95% confidence level (cor.coef. = -0,7), which also indicate a source of phosphorous in the inner fjord.

There was a general decrease in the concentrations of PAH and (a)pyren from 1992 to 2003 (compare Table 21 and Table 22). Only the inner station was severely polluted (class IV) by (a)pyren in 2003, while three stations were in 1992. In the outer fjord the sediments could be classified as moderately polluted (class II) from (a)pyren, while they were markedly polluted (class III) in 1992. It was only the inner station RN2 that was markedly polluted (class III) in 2003, while rest of the fjord could be classified as moderately polluted (class II).

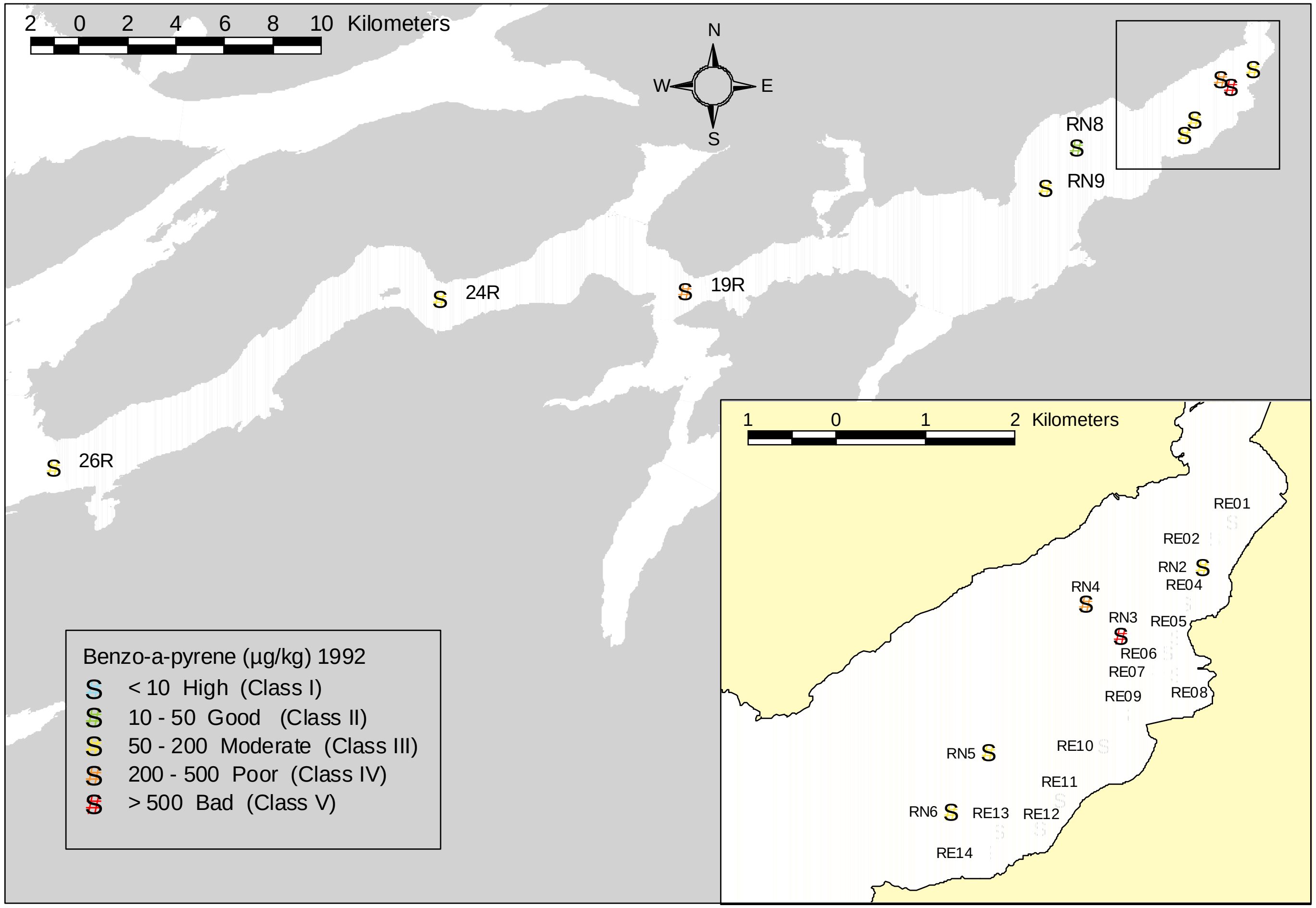


Figure 23. Classification of Ranfjord-sediments according to BaP in 1992. *Tilstand hos Ranfjordsedimenter mht. BaP i 1992.*

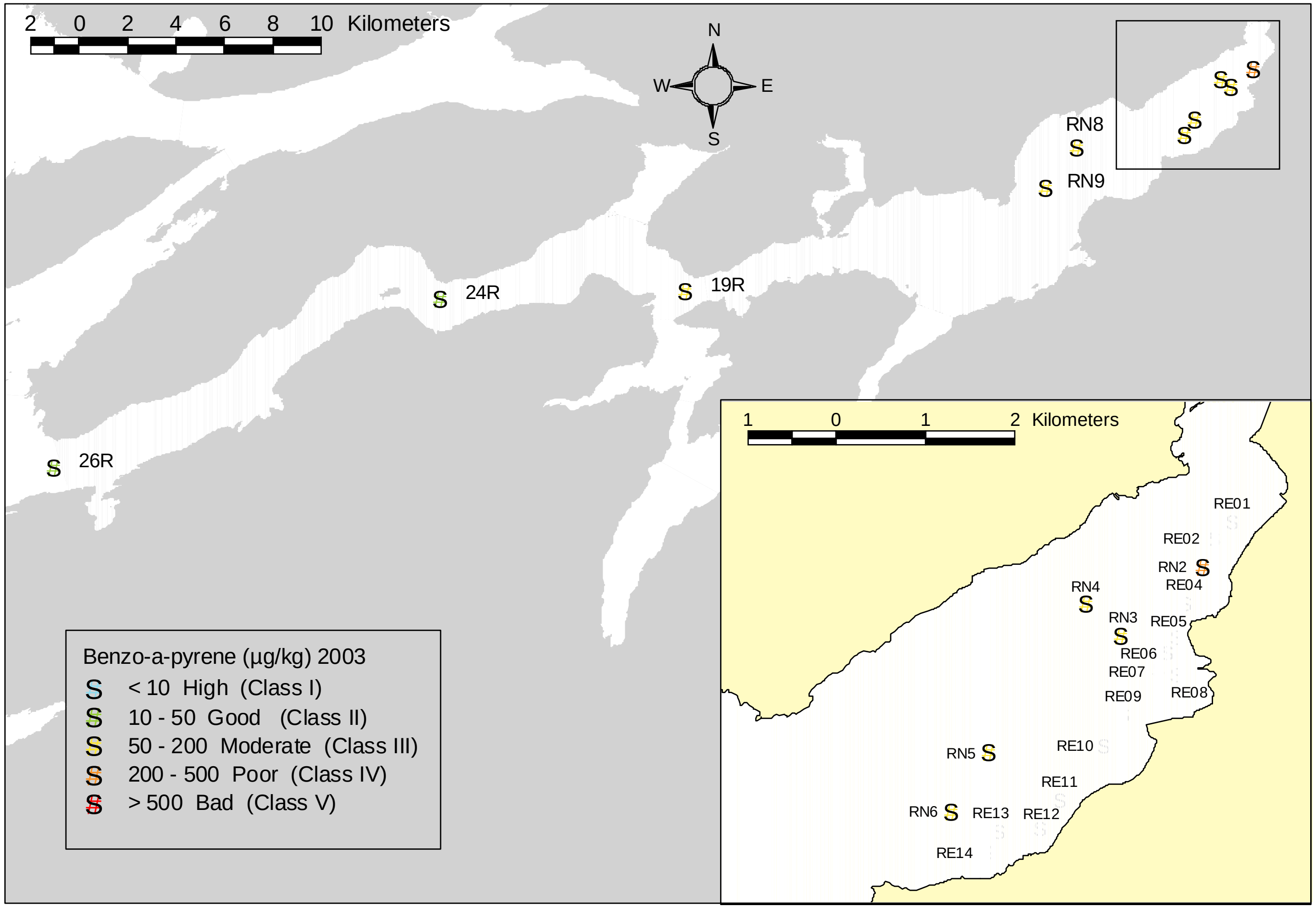


Figure 24. Classification of Ranfjord-sediments according to BaP in 2003. *Tilstand hos sedimenter fra Ranfjorden mht. BaP i 2003.*

Table 21. Metals in sediments (mg/kg d.w., Fe in %) and (a)pyren, sumPAH and TBT (in µg/kg d.w.) from Ranfjorden 2003. The colour code in the table refers to the environmental quality criteria given by SFT:97 (Molvær et al. 1997, cf. Figure 24). Fe is not included in the criteria. *Metaller i sedimenter (mg/kg, Fe er i %) fra Ranfjorden 2003. Fargekoder er i hht. SFTs miljøkvalitetskriterier (Molvær et al. 1997). Fe er ikke inkludert i SFTs miljøkvalitets-kriterier.*

	Fe	Cd	Hg	Cu	Pb	Zn	(a) pyren	Sum PAH	TBT
RN2	8,94	0,14	0,016	64,2	20	96	348	4420,0	<1,22
RN3	5,21	0,11	0,015	39,0	20	100	100	1010,5	
RN4	6,95	0,10	0,019	48,2	30	100	98	956,2	<1,22
RN5	7,23	0,12	0,017	48,3	35	130	71	1034,0	<1,22
RN6	5,87	0,20	0,012	38,4	30	120	82	751,2	<1,22
RN8	5,89	0,10	0,016	37,5	30	130	107	1154,0	
RN9	5,94	0,18	0,025	44,5	30	140	69	767,2	5,3
RN19	5,86	0,12	0,060	40,4	70	194	123	1875,7	
RN24	4,04	0,08	0,038	22,0	30	120	49	981,4	
RN26	4,75	0,10	0,052	28,0	40	140	21	444,2	

Table 22. Metals in sediments (mg(kg, Fe in %) from Ranfjorden 1992. The colour code in the table refers to the environmental quality criteria given by SFT:97 (Molvær et al. 1997, cf. Figure 24). Fe is not included in the criteria. *Metaller i sedimenter (mg/kg, Fe er i %) fra Ranfjorden 1992.*

	Fe	Cd	Hg	Cu	Pb	Zn	(a)pyren	Sum PAH
RN2	7,53	0,26	n.d.	86,5	24,3	139,0	148	1530
RN3	7,03	0,25	n.d.	66,8	77,5	201,0	517	6300
RN4	7,63	0,17	n.d.	63,8	72,5	173,5	406	4410
RN5	7,10	0,22	0,04	49,0	42,0	149,0	194	2710
RN9	5,43	0,21	n.d.	34,5	28,0	105,5	165	1530
RN6	6,60	0,22	n.d.	33,5	22,5	104,0	121	1540
RN8	5,30	0,16	n.d.	26,5	22,5	71,0	17	250
RN19	6,03	0,21	n.d.	50,3	105,0	223,5	238	3310
RN24	5,40	0,11	0,04	37,0	93,0	179,0	180	2900
RN26	4,90	0,16	n.d.	34,3	67,5	164,5	118	1580

n.d. no data

5.4.3 Conclusions

There has been a significantly reduction of PAH and Benzo(a)pyren in Ranfjorden from 1992 to 2003. Only the innermost part of the fjord (RN2) is markedly polluted by PAH, while the rest of the fjord is moderately polluted by PAH. The metal concentrations in the sediments have also decreased from 1992 to 2003. The fjord is for the most moderately polluted by Cd, Cu, Pb and Zn, and insignificantly polluted by Hg.

The fjord sediments are characterised by inorganic particles discharged by Rana Gruber, and this is partly indicated by the low concentrations of TOC.

6. Overall conclusions

The softbottom fauna of the inner part of Ranfjorden (the proximal area of Ranfjorden) was characterized as Fair (Class III) or Good (Class II) in the Norwegian Pollution Control Authority's (SFT) environmental quality classification system. The fauna composition at the stations closest to the head of the fjord were in a poorer condition than further out. The innermost part of Ranfjorden had higher density of individuals and lower diversity than the outer part of the fjord. The density increased towards the river (Ranelva) with a dominance of opportunistic species. Indicator species of pollution were numerous at two of the stations in the inner part.

The oxygen conditions were good for the investigated area of the fjord. The total organic content (TOC) of bottom sediments are commonly low in Ranfjorden, with lower content towards the head of the fjord. Sediments of the innermost part of Ranfjorden were characterised by material of terrestrial origin. Both this and earlier investigations have shown that Ranfjorden, especially the inner part, is markedly affected by inorganic particles discharged by Rana Gruber. The generally low organic content is attributed to the relatively large deposition of inorganic particles. An increasing TOC and decreasing total phorphorus gradient in the sediment from inner to the outer part of the fjord indicated that the inner part is exposed to a higher discharge of phosphorus.

The content of chlorophyll in the surface layer of the inner part of Ranfjorden during the summer half of the year showed a Very good condition (Class I in the SFT system), indicating low production of planktonic algae. However, during spring blooms chlorophyll production can be high. The environmental quality of Ranfjorden is regarded as little affected by municipal sewage; water-quality in the fjord normally varies between Very Good and Good. The exception from this are the evident effects from sewage at station 1 in the vicinity of the innermost outlet, Mjølanodden, but this can be looked upon as a local problem.

Elevated concentrations of thermotolerant coliform bacteria (TCB) at station 1 clearly indicate impact of fresh sewage when the submerged outlet breaks through the discontinuity layer. The abundance of fast-growing algae in the littoral also gives evidence of elevated nutrient levels in the surface waters of the inner fjord. However, the normal trapping depth for the diluted sewage is estimated to between 13-21 meters (Appendix A). The general estuarine circulation brings the diluted sewage to the north, towards the river Ranelva, as part of the compensation current of incoming seawater (cf. Figure 7). The following entrainment of this water into the surface water, gives further dilution by the river water, and the by this time strongly diluted sewage is finally brought out of the fjord in the surface.

The harbour in Mo i Rana is kept ice-free during winter by releasing air from a certain depth to the surface. This process increases the compensation-current and, thus, the transport of nutrients to the river-water.

In spite of the relatively high supply of organic material through the river Ranelva, are oxygen-levels in the fjord classified as Good to Very Good.

The fauna composition of the soft bottom indicated an ample supply of nourishment, probably from phytoplankton, terrestrial organic material and municipal sewage effluents. The TOC discharge from Ranelva is much higher than the municipal sewage effluents. Taking this into consideration, and the generally low phytoplankton production, the river is probably the main source of food for the softbottom fauna of the inner part of Ranfjorden.

The composition of the benthic fauna on hard bottom showed signs of being negatively affected by sedimentation, mainly from inorganic particles. The impact decreased outward the fjord. There were also indications of exposure to elevated levels of nutrients in the littoral zone, shown by the incidence of fast-growing green algae at stations in the innermost part of Ranfjorden. The effect of freshwater is, however, more predominant here and will enhance the occurrence of green algae. The effect of sedimentation on benthic hardbottom fauna in sub-surface waters presumably masked the possible effect of the nutrient load in the inner part of the fjord. The reference station (in the outer Ranfjorden) was heavily grazed by sea urchins, a common phenomena in many northern Norwegian fjords.

The concentration of contaminants in the bottom sediments were much lower than in 1992. This was most evident for PAH. With the exception of the innermost part of Ranfjorden, the fjord is now only Moderately polluted (Class II in the SFT system) for PAH and Insignificantly polluted (Class I) when considering metals.

The observed decrease in concentrations of contaminants in sediments from 1992 to 2003 is probably related to the diminishing supply of micro-pollutants to the fjord. Several initiatives have been taken to reduce the discharges to the fjord, and some industry with large discharges has closed down. Koksverktomta has been an area characterised by heavy pollution, and in 1989 – 1992 several sites were remediated when polluted soil was removed.

The project "Fylkesvise tiltaksplaner: Nordland (Olsson et al. 2003) has, however, shown that existing information on trends in input of contaminants to the fjord is insufficient. The discharge of PAH from industrial sewage is estimated to vary between 12 and 300 kg annually, while the river Mobekken transport about 12 kg annually. It is therefore difficult to relate the decreasing sediment concentrations directly to decreases in discharges.

Rana Gruber and the river Ranelva are both supplying the fjord with large amounts of inorganic material. Variation in these sources will have major influence on the concentration of pollutants in the sediments. A large input of inorganic non polluted particulate matter will dilute the micro pollutant concentrations in the sediments. The discharge of particulate matter from Rana Gruber is much higher than the supply from the river Ranelva, but it has decreased since 1994. If the supply of micro pollutants was stable through the same period, an increase in micro pollutant concentrations in the fjord sediments would have been expected. This has not been observed, and thus, the results indicate a decrease in the supply of micro pollutants to the fjord.

6.1 Suggestions

The problem with the outlet at Mjølanodden is both the time it contaminates the surface water directly, and the load itself to the compensation current. The problem can partly be solved by moving the sewage outlet, either outwards the fjord or to a depth where chances of break-through to the surface-water is minimized. This implies an outlet water depth of perhaps 50 meters. Another solution is chemical treatment of the sewage, which reduces bacteria content as well as phosphorus and micro pollutants.

During the investigations, there were technical problems at the plant at Mjølanodden and this probably contributes to the achieved water quality results. Thus, it is recommended to collect further water-samples in the area during normal conditions, and to include observations in the river to exclude the possibility of impact on the results from free overfalls in the river area. The observations can be limited to TCB, ammonia and temperature/salinity from the surface layer (0.5 m depth).

If a new outlet depth for the sewage is considered for Mjølanodden, new calculations of optimal outlet depth is recommended.

The soft-bottom fauna investigations indicate a need for remediation in order to obtain good environmental status (class II) throughout the inner fjord. However, it is not certain if the status can be improved merely by reducing the municipal sewage discharges.

NIVA recommends future monitoring programs in Ranfjorden to include measurements of discharges of micro pollutants to the fjord. Knowledge about the different sources is essential in order to document effects of remediation actions. Monitoring programs must also take into account the natural variation of discharges throughout the year.

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Appendix A.

Effluent discharge – dilution and spreading by Arild Sundfjord. Memo 1.4.2003.

To ensure that the water sampling program will cover the most likely depth interval of plumes from the two largest effluent outfalls, a series of computer simulations were run with the numerical model US EPA Visual Plumes (Ref). This model uses outfall characteristics (pipe depth and diameter, flow rates and effluent density) and ambient conditions in the receiving water body (hydrographic profiles and water currents) as input for the simulations. Information about the outfall was supplied by Rana Kommune, and table 1 shows typical values for periods of low and high flux rates in addition to median and average numbers. For Moskjæran, the median and average values were combined into a "typical" rate of 3750 m^3/day. The outer pipe diameter is given as 500 mm for Mjølanodden and 560 mm for Moskjæran. Assuming a pipe thickness of 20 mm, inner diameters of 460 and 520 mm, respectively, were used in the simulations.

Data on effluent temperature were not available. Since a large part of the effluent stems from natural run-off it is assumed that temperatures will be comparable to those found in the fjord surface water. Average values of 3 °C for winter and 8 °C for summer[2] were used, based on the available hydrographic data.

Water current velocities were based on measurements made in 1994 (Ref TMJ). Average velocities of 3.1 cm/s at 10 m depth and 1.0 cm/s at 25 m depth were used in the near-field model simulations, while the 10 m value of 3.1 cm/s was used for the far-field dispersion, regardless of final plume depth (from Station 1, Jan-Feb 1994). Seven hydrographic profiles spanning most of a one-year cycle were used (St. 1, 15.12.1994, 22.01, 22.03, 26.04, ("winter" profiles) 21.06, 26.08 og 18.09.1995 (summer)).

Table 1. Flow [m^3/day] used for the model simulations at the two outfall sites. *Vannføring (m^3/dag) som ble brukt i modellsimuleringene av de to utløpene.*

	Mjølanodden	Moskjæran
Low	900	1500
Median	1676	3619
Average	3100	3863
Extreme	15000	10000

Results

Winter

As an example, trapping depth (the depth where the effluent is diluted to achieve neutral buoyancy) for the outfall at Mjølanodden is given in table 2. The plume will rise to the surface under conditions of very weak stratification (Jan 22) and when the flux/initial velocity is high (“extreme” flux case). Otherwise, the effluent plume will be trapped around 13-17 m depth.

Table 2. Neutral depth [m)] for Mjølanodden outfall for four winter profiles. *Innlagringsdyp I meter for Mjølanodden ved fire vintersituasjoner*.

	12/15/1994	1/22/1995	3/22/1995	4/26/1995
Low flow	17.4	~ 10.0/surface	17.0	15.5
Median flow	15.6	~ 3.7/surface	16.1	14.7
Average flow	14.8	~ 3.5/surface	14.8	13.7
Extreme flow	surface	surface	surface	surface

Neutral depth is found at a horizontal distance of 4-8 m from the end of pipe (with the given ambient current velocity). Horizontal plume width at this stage is in the order of 10-20 m. Dilution when neutral depth is reached is typically between 150 and 400 times for the low and typical flux cases, and 55-100 times for the maximum flux scenarios when surface is reached. It should be noted that for the “extreme” case with very large flux, the effluent would be diluted about 10 times before it is discharged, compared with the median flux case.

The outfall at Moskjæran has very similar characteristics. The outfall pipe is somewhat wider. With equal effluent flux this gives a somewhat lower exit velocity, which implies slightly less effective initial mixing. At the same time the fluxes are typically more stable at this site, with fewer periods with extremely large or small flux values. The model results indicate typical trap levels for the Moskjæran to be in the same depth interval as Mjølanodden (13-16 m depth), with the same risk of surface breakthrough for given stability and flux conditions.

Summer

For the three hydrographic profiles from summer, the outfall at Mjølanodden will reach neutral depth at 14-21 m (average 16.9 m) for the median and average flux rates. For minimum flow values the plume will be centered about two meters deeper whereas the scenarios with extremely high fluxes the plume will reach the surface two out of three times (average depth for center of plume for the extreme flow cases is 12.7 m – with or without surface contact).

Moskjæran is similar; the typical trapping depth is around 13.5-19 m (average 15.4). For low flux rates the plumes are trapped two meters deeper and two of three high-flux cases break the surface. Summer dilution rates are generally smaller than those for winter. For Mjølanodden dilution rates are around 80-250 when final depth is reached.

Simulations for “typical” flux scenarios were performed to evaluate the sensitivity to different temperatures in the effluent water. Water density decreases with increasing temperature and the plume buoyancy increases. Simulations for summer with effluent temperature of 15 °C showed that the plume would be trapped 0.1-0.5 m shallower than with the 7.4 °C used previously.

The above calculations were performed using average current velocities from existing measurements. Current velocities will vary in strength and direction due to wind, tides and estuarine circulation drive by freshwater run-off. To investigate the effect of stronger or weaker background water currents, a series of simulations for average flux rates were done for a limited number of hydrographical profiles. Stronger currents would lead to more efficient dilution and consequently deeper trapping of the plume. With 10 cm/s current in the whole water column, the plume would typically be trapped 2-3 m deeper than under the average conditions as specified above. With a horizontal current of 1.0 cm/s the effect would be opposite, with surface breakthroughs occurring more frequently and otherwise ~2 m shallower plume trapping.

Conclusions

During winter, the effluent plumes from both outfalls can be expected to be trapped around 13-17 m for “typical” flux rates when the fjord water is significantly vertically stratified. Under conditions of weak stratification and with high flux rates the effluent plume is likely to protrude to the surface.

Summer conditions will be similar; the plume will generally be trapped somewhat deeper (typically 15-19 meters depth), but there is still risk of breakthrough to the surface in periods with high flux rates and moderate vertical stratification.

To make sure that the depth interval most susceptible to eutrophication is covered in the sampling series, the depths 0, 5, 10 and 15 m are recommended to use throughout the program. The plume will most often be centered at the greater of these depths but may also be trapped more shallowly, or rise all the way to the surface. Trapping may occur at depths down to about 20 m under special combinations of flux rates and stratification, but it is judged that it is more important to ensure that the more vulnerable euphotic layer is survey.

It should be noted that all trapping depths refer to centre of the plume. The effluent plume will however have a vertical extent of several meters above and below this depth, and this should be kept in mind when considering the results of modelling and sample analysis.

Appendix B.

Table 1. Norwegian classification criteria for nutrients, chlorophyll *a*, secchi depth and oxygen. For surface water criteria for summer and winter is included. Oxygen saturation refers to a water mass with temperature 6^o and salinity 33. *Norske vannkvalitetskriterier for næringssalter, klorofyll-a, siktdyp, og oksygeninnhold (ved 6^o og saltholdighet på 33).*

		Classes				
	Parameters	**I Very Good**	**II Good**	**III Fair**	**IV Bad**	**V Very bad**
Surface layer Summer (June-August)	Total phosphorus (µg P/l)	<12	12-16	16-29	29-60	>60
	Phosphate (µg P/l)	<4	4-7	7-16	16-50	>50
	Total nitrogen (µg N/l)	<250	250-330	330-500	500-800	>800
	Nitrate (µg N/l)	<12	12-23	23-65	65-250	>250
	Ammonium (µg N/l)	<19	19-50	50-200	200-325	>325
	Chlorophyll *a* (µg/l)	<2	2-3.5	3.5-7	7-20	>20
	Secchi depth (m)	>7.5	7.5-6	6-4.5	4.5-2.5	<2.5
Surface layer Winter (December-February)	Total phosphorus (µg P/l)	<21	21-25	25-42	42-60	>60
	Phosphate(µg P/l)	<16	16-21	21-34	34-50	>50
	Total nitrogen (µg N/l)	<295	295-380	380-560	560-1300	>1300
	Nitrate (µg N/l)	<90	90-125	125-225	225-350	>350
	Ammonium (µg N/l)	<33	33-75	75-155	155-325	>325
Deep water	Oxygen (ml O_2/l)	>4.5	4.5-3.5	3.5-2.5	2.5-1.5	<1.5
	Oxygen saturation (%)	>65	65-50	50-35	35-20	<20

Table 2. Norwegian classification criteria for nutrients and secchi depth for salinity in the 0-20 range. *Norske vannkvalitetskriterier for næringssalter og siktdyp, ved saltholdighet på 0-20.*

Surface layer	**Parameter**	**Salinity**	**Classes**				
			I Very good	**II Good**	**III Less good**	**IV Poor**	**V Very Poor**
Summer:	Total phosphorus (µgP/l)	0	<7	7-11	11-20	20-50	>50
		20	<12	12-16	16-29	29-60	>60
(June-August)	Phosphate (µgP/l)	0	<1.5	1.5-2.5	2.5-4.5	4.5-11	>11
		20	<4	4-7	7-16	16-50	>50
	Total nitrogen (µgN/l)	0	<250	250-400	400-550	550-800	>800
		20	<250	250-330	330-500	500-800	>800
	Nitrate (µgN/l)	0	<125	125-200	200-275	275-400	>400
		20	<12	12-23	23-65	65-250	>250
	Secchi depth (m)	0	>7	4-7	2-4	1-2	<1
		20	>7.5	6.2-7.5	4.5-6.2	2.5-4.5	<2.5
Winter:	Total phosphorus (µgP/l)	0	<7	7-11	11-20	20-50	>50
		20	<21	21-25	25-42	42-60	>60
(December-February)	Phosphate (µgP/l)	0	<4	4-5	6-10	10-25	>25
		20	<16	16-21	21-34	34-50	>50
	Total nitrogen (µNg/l)	0	<250	250-400	400-550	550-800	>800
		20	<295	295-380	380-560	560-800	>800
	Nitrate (µgN/l)	0	<160	160-260	260-360	360-520	>520
		20	<90	90-125	125-225	225-350	>350

Appendix C.

Table 23. Abundance of benthic macroalgae and macro invertebrates registrated in the littoral (L) and the sublittoral zone (S). R = rare, F = frequent, C = common, D = dominating. Sublittoral number = sum relative abundance throughout the transect. *Forekomst av bunnlevende alger og bunnlevende makroevertebrater i fjæra (L) og sjøsonen (S). R= sjelden, F = spredt, C = vanlig, D = dominerende. I sjøsonen (S) er relativ forekomst gjennom hele transektet angitt.*

LATIN name	B3 L	B5 L	B7 L	B9 L	B9 S	B12 L	B14 L	B14 S	B16 L	B17 L	B91 L
Verrucaria maura											D
Cyanophycea div. Indet			F	C			D			C	C
RED MACROALGAE											
Audouinella spp.											F
Aglaothamnion sp.					2						
Callophyllis cristata					8						
Chondrus crispus					2		F			F	
Cruoria pellita					29			1			
Delesseria sanguinea								4			
Dilsea carnosa					2						
Furcellaria lumbricalis					7						
Hildenbrandia rubra		F	D	D	14	F	C	4	D	C	D
Lithothamnion sp.					46			100			
Odonthalia dentata					6						
Palmaria palmata					2			3		F	
Phycodrys rubens					25			32			
Phyllophora truncata					14						
cf. *Polyides rotundus*					2						
Polysiphonia lanosa										F	
Polysiphonia urceolata					27			4			
Porphyra sp.								6			
Porphyra umbilicalis										F	
Ptilota plumosa								5			
Scagelia pylaisaei					2						
Spermothamnion repens					11						
Bonnemaisonia hamifera: sporoph.					16						
Rhodomela confervoides			F								
BROWN MACROALGAE											
Ascophyllum juvenile				F		R	R		R	R	
Ascophyllum nodosum	F	F	F	D	16	C	D	8	C	D	D
Brown encrusting algae	C		C		74			60		F	
Chordaria flagelliformis								4			
Chorda tomentosa								3			
Ectocarpus sp.	F	F	F	F	17	F	C	13	F	F	
Elachista fucicola		F			8		F	3		C	
Eudesme virescens								2			
Fucus juvenile				F		R			R	R	
Fucus spiralis							C				
Fucus serratus		F			4	C	F	4	C	C	C
Fucus vesiculosus	D	D	D	C	10	D	D		C	C	C
Laminaria hyperborea					1						
Laminaria cf. *hyperborea*					3						
Laminaria saccharina					2						
Pelvetia canaliculata							D			D	F
cf. *Pilayella littoralis*						F					F
Sphacelaria plumosa					20						
Sphacelaria radicans					6						
cf. *Spongonema tomentosum*					7			4			
GREEN MACROALGAE											
Chaetomorpha melagonium					2						
Cladophora sp.					7				F		F

LATIN name	B3 L	B5 L	B7 L	B9 L	B9 S	B12 L	B14 L	B14 S	B16 L	B17 L	B91 L
Cladophora rupestris				C	17	F	C	4	R	F	C
Enteromorpha sp.		C	R	F	10	F		4	F	D	F
cf. *Rhizoclonium implexum*					8						
Green algae on stone, indet.	F	D	D	C		R	R		R		F
SPONGES											
Haliclona urceolus					1						
Leucosolenia coriacea					5						
HYDROIDES											
Bougainvillia sp.								5			
Corymorpha nutans					1			1			
cf. *Laomedea geniculata*								2			
Laomedea cf. *longissima*					2						
Laomedea sp.								6			
Dynamena pumila							R			F	
ANEMONES											
Actiniaria indet.					9						
Gonactinia prolifera					4						
Hormathia digitata								2			
Urticina eques					18			11			
cf. *Urticina eques*								1			
Urticina felina								2			
WORMS											
Arenicola marina					16						
Chaetopterus variopedatus					19			1			
Hydroides norvegica					4			1			
Placostegus tridentatus								2			
Pomatoceros triqueter					30			60			
Sabella penicillus					45						
Serpula vermicularis					8			1			
Spirorbis borealis								4			
Spirorbis cf. *borealis*					2						
Spirorbis sp.					4						
SNAIL											
Buccinum undatum					2			14			
Calliostoma zizyphinum								5			
Gibbula sp.					19			3			
Littorina littorea							R	10		F	
Littorina obtusata							F			C	
Littorina saxatilis							F			F	
Littorina sp.							R			F	
Nucella lapillus										F	
Polyplacophora indet.					17			10			
MUSSELS											
Anomoniidae indet.					3						
Chlamys cf. *striata*					1						
Hiatella arctica					1						
Modiolus modiolus					2			48			
Mytilus edulis				F	16	F	F	20	F	C	F
Mytilus edulis juvenile				F							
SEA SPIDERS											
Nymphon gracile					2						
Pycnogonidea indet.								4			
CRUSTACEANS											
Balanus balanoides						R	F	17	R	C	F
Balanus improvisus						F					
Balanus balanus					39			8			
Galathea strigosa								2			
Hyas sp.					1						
Pagurus bernhardus								7			
Pagurus sp.					27			17			
Carcinus maenas						R	R		R	R	F
Amphipoda	F								R		
MOSS ANIMALS											
Bryozoa indet. encrusting					2						F
Parasmittina trispinosa								8			
Dendrobeania murrayana								6			
Scrupocellaria scabra					6						

LATIN name	B3 L	B5 L	B7 L	B9 L	B9 S	B12 L	B14 L	B14 S	B16 L	B17 L	B91 L
BRACHIOPODA											
Crania anomala					21						
ECHINODERMS											
Asterias rubens					16			6			
Ceramaster granularis								1			
Leptasterias mulleri								1			
Marthasterias glacialis								5			
Solaster endeca								3			
Stichastrella rosea								3			
Ophiopholis aculeata								1			
Ophiura albida					1						
Echinus esculentus					1			24			
Echinoidea indet.					1			1			
Strongylocentrotus droebachiensis					3			56			
Cucumaria frondosa								9			
Antedon petasus								1			
ASCIDIANS											
Ascidia virginea					2						
Ciona intestinalis					17			13			
Corella cf. *parallelogramma*					1						

Appendix D.

Description of Littoral sites in alfanumeric order.
The description include:

- Picture of the sites
- Profile of the littoral zone and placement of quadrats
- Zonation and common species
- Quantitative quadrates composition

Beskrivelse av fjærestasjonene i alfanumerisk rekkefølge.
Beskrivelsen omfatter:

- *Stasjonsbilde*
- *Profil av fjæresonen med plassering av kvadrater*
- *Biologiske soner og de vanligste arter*
- *Artsforekomster i kvadratene*

STATION B3 LAUKBERGET

a b

Photo 1 a) Overview and b) close-up of the littoral zone. *Stasjonsbilder*. (photo: NIVA).

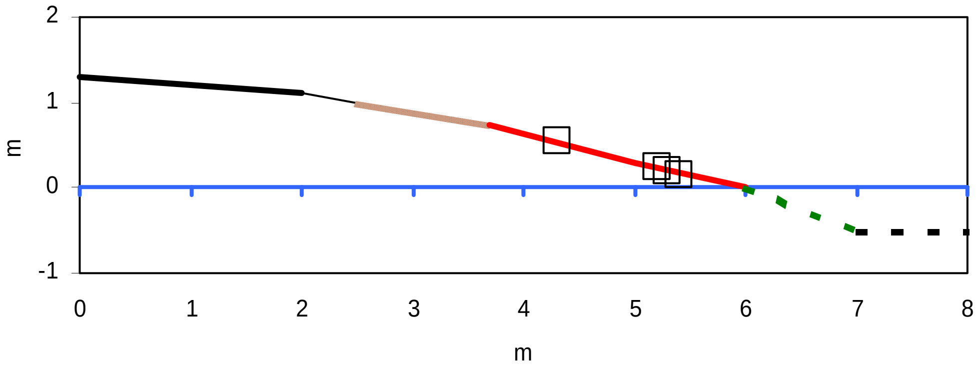


Figure 25 Profile of the littoral zone and placement of the quadrates. Zonation indicated by colour. *Profil av fjæresonen med plassering av kvadrater.*

4 zones were identified at station B3. Uppermost a supra littoral zone dominated by blue green algae, then a band with a thick sediment layer deposited by the river. Then bladder wrack (*Fucus vesiculosus*) formed an association and below that a mixed association of bladderwack and more scarcely knotted wrack (*Ascophyllum nodosum*). The seaweeds were overgrown by filamentous brown algae. No animals were observed except for a few amphipods swimming among the seaweeds. The littoral communities are clearly influenced by discharges from the river.

The quantitative quadrates were randomly placed in the *Fucus* association.

Table 24 Zonation and species composition. B=brown, G=green and, R=red algae. Zonation: SUPRA=Supra-littoral, SEDIM=Sediment layer, FUCVE=Bladder wrack, MIX=Mixed association with Bladder wrack and Knotted wrack. *Biologiske soner og artssammensetning. B=brun, G=grønn og, R=rødalger. Sonering: SUPRA=Supra-littoral, SEDIM=Sediment lager, FUCVE=blæretang, MIX=blandet samfunn med blæretang og grisetang.*

B3	**Laukberget**	**1**	**2**	**3**	**4**	
	Zone	SUPRA	SEDIM	FUCVE	MIX	
	Width of zone, m	3.7		2.3	1	
	Cyanophyceae	s				
B	*Fucus vesiculosus*, Bladder wrack			d	v	
G	Green algae indet.			s		
B	Brown encrusting indet.			v		
B	Ectocarpales			s		
B	*Ascophyllum nodosum*, Knotted wrack				s	
	Animals					
	Amphipods			s	s	

Table 25 Species composition registered in quantitative quadrates (R1-R4) and average abundance (Avg) of the zone based on 4 quadrates. StDev=Standard deviation. B=brown, G=green and R=red algae. Bladder wrack zone. *Artsforekomst registrert i kvadratene (R1-R4) i blæretangsonen, med gjennomsnitt mengde (Avg.) av 4 kvadrater. StDev=standardavvik. B=brun, G=grønn og R=rødalger.*

B3	FUCVE zone	R1	R2	R3	R4	Avg	StDev
B	Brown encrusting indet.	100	60	40	16	54.0	35.6
B	*Ectocarpus* sp.	0.8	0	48	24	18.2	22.8
B	*Fucus vesiculosus*	100	100	100	100	100.0	0.0
G	Green algae indet.	0	4	0	40	11.0	19.4

STATION B5 MOHOLMEN

a  b

Photo 2   a) Overview and b) close-up of the littoral zone. *Stasjonsbilder*. (photo: NIVA).

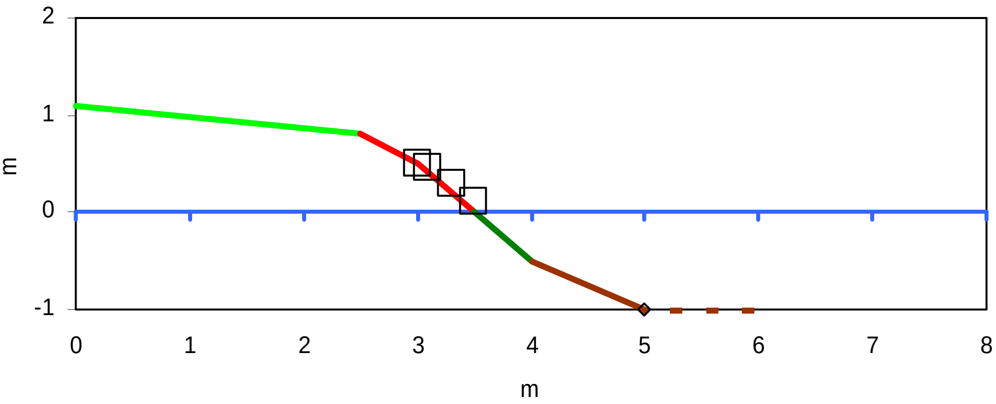


Figure 26 Profile of the littoral zone and placement of the quadrates. Zonation indicated by colour. *Profil av fjæresonen med plassering av kvadrater.*

Moholmen was a small rock which covers and uncovers with the tide in the vicinity of the town. The top of the rock was dominated by green algae mainly gut weed. A dense bladder wrack association of small (young) plants dominated below the green algae association. Deeper and below sea level at the time of the investigation, knotted wrack and toothed wrack was observed. 4 zones were identified. The sea area around the rock was shallow. The turbidity of the water was high.
No animal was found.
High amount of green alga and young wrack individuals indicate high stress and easy available nutrients. Nutrients may be supplied by outlets, run-off from land, by the river and by sea gull droppings.

Table 26 Zonation and species composition. B=brown, G=green and R=red algae. Zonation: GREEN=Green algae/Gut weed, FUCVE=Bladder wrack, ASCNO=Knotted wrack, FUCSE=Toothed wrack. *Biologiske soner og artssammensetning. B=brun, G=grønn og, R=rødalger. Sonering: GREEN=grønnalger/tarmgrønske, FUCVE=blæretang, ASCNO=grisetang, FUCSE=sagtang.*

B5	**Moholmen**	**1**	**2**	**3**	**4**	
	Zone	GREEN	FUCVE	ASCNO	FUCSE	
	Width of zone, m	2	1	0.5	0.5	
G	*Enteromorpha* spp.	d	s	v	s	
B	*Fucus vesiculosus*, bladder wrack		d	s	s	
R	*Hildenbrandia rubra*		s			
B	*Ascophyllum nodosum*, knotted wrack			s		
B	Ectocarpales			s	s	
B	*Elachista fucicola*			s	e	
B	*Fucus serratus*, toothed wrack				s	

Table 27 Species composition registered in quantitative quadrates (R1- R4) and average abundance (Avg) of the zone based on 4 quadrates. StDev=Standard deviation. B=brown algae, G=green algae, R=red algae. Bladder wrack zone. *Artsforekomst registrert i kvadratene (R1-R4) i blæretangsonen, med gjennomsnitt mengde (Avg.) av 4 kvadrater. StDev=standardavvik. B=brun, G=grønn og R=rødalger.*

	FUCVE zone	R1	R2	R3	R4	Avg	StDev
R	*Hildenbrandia rubra*	0.4	0.4	0.4	0.4	0.4	0.0
B	*Fucus vesiculosus*, bladder wrack	100	100	100	100	100.0	0.0
G	*Enteromorpha* sp., gut weed	2	20	20	0	10.5	11.0
G	Green algae indet.	4	20	4	16	11.0	8.2
G	Green algae on stone	40	40	40	80	50.0	20.0

STATION B7 RAUDBERGET

a b

Photo 3 a) Overview and b) close-up of the littoral zone. Sediment layer above the seaweed was conspicuous (b). *Stasjonsbilder, det var et markant sedimentlag på fjellet over tangbeltet (b)*. (photo: NIVA).

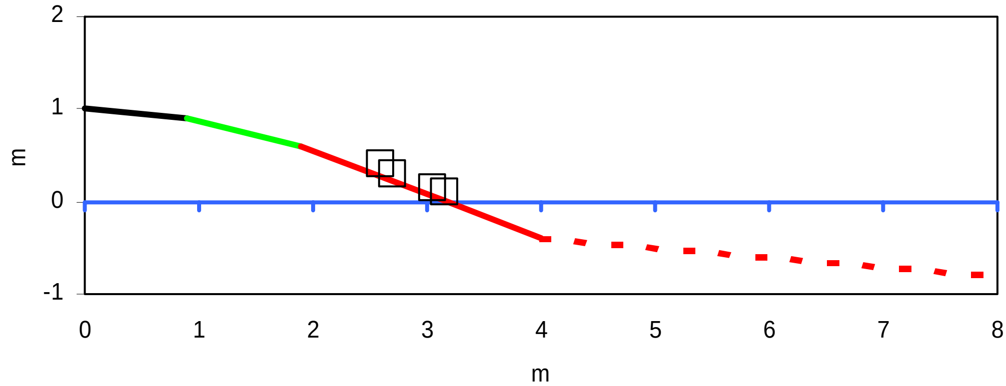


Figure 27 Profile of the littoral zone and placement of the quadrates. Zonation indicated by colour. *Profil av fjæresonen med plassering av kvadrater.*

3 zones of algal associations were identified at B7. Above these zones there was a band of *Verrucaria maura* (lichen) and *Calothrix* (blue-green algae). Several mm thick layer of sediment deposited by the river was conspicuous and clearly prevented algae growth and animal distribution.

High on the shore a green association was observed including several green and blue-green algae species not identified mixed with sediment. The quadrates were randomly placed in the bladder wrack association. Below this zone and below sea level at the time of the investigation, scattered individuals of knotted wrack was observed in the bladder wrack dominated mixed zone.

No animals were found.

Sedimentation reduce the diversity. The amount of fast growing green and filamentous brown algae species indicate slight nutrient enrichment.

Table 28 Zonation and species composition. B=brown, G=green and R=red algae. Zonation: GREEN=Green algae/Gut weed, FUCVE=Bladder wrack, MIX=Mixed association with Bladder wrack and Knotted wrack. *Biologiske soner og artssammensetning. B=brun, G=grønn og, R=rødalger. Sonering: GREEN=grønnalger/tarmgrønske, FUCVE=blæretang, MIX= blæretang og grisetang.*

B7	**Raudberget**	**1**	**2**	**3**	
	Zone	GREEN	FUCVE	MIX	
	Width of zone, m	1	2.1	4	
G	cf. Ulothrix /Urospora	d			
	Cyanophyceae	s			
G	*Enteromorpha* spp., gut weed	s			
G	Green algae indet.	s	v-s		
B	*Fucus vesiculosus*, bladder wrack		d	d	
R	*Hildenbrandia rubra*		d	d	
B	Ectocarpales		s-e	s	
B	*Ascophyllum nodosum*, knotted wrack			s	
R	*Rhodomela confervoides*			s	

Table 29 Species composition registrated in quantitative quadrates (R1- R4) and average abundance (Avg) of the zone based on 4 quadrates. StDev=Standard deviation. B=brown algae, G=green algae, R=red algae. *Artsforekomst registrert i kvadratene (R1-R4) i blæretangsonen, med gjennomsnitt mengde (Avg.) av 4 kvadrater. StDev=standardavvik. B=brun, G=grønn og R=rødalger.*

B7	FUCVE zone	R1	R2	R3	R4	Avg	StDev
R	*Hildenbrandia rubra*	12	68	48	4	33.0	30.2
B	Brown encrusting indet.	72	20	40	80	53.0	28.0
B	*Ectocarpus* sp.	2	4	12	4	5.5	4.4
B	*Fucus vesiculosus*, bladder wrack	100	100	100	100	100.0	0.0
G	Green algae indet. på fjell	12	8	8	8	9.0	2.0

STATION B9 BJØRNEBÆRVIKA

a   b

c 

Photo 4 a) Overview and b) close-up of the littoral zone. c) Sea pen at 10 m depth (photo: NIVA). *Stasjonsbilder. Bilde c) viser nesledyret liten piperenser (cf* Virgularia mirabilis*) på 10m dyp.*

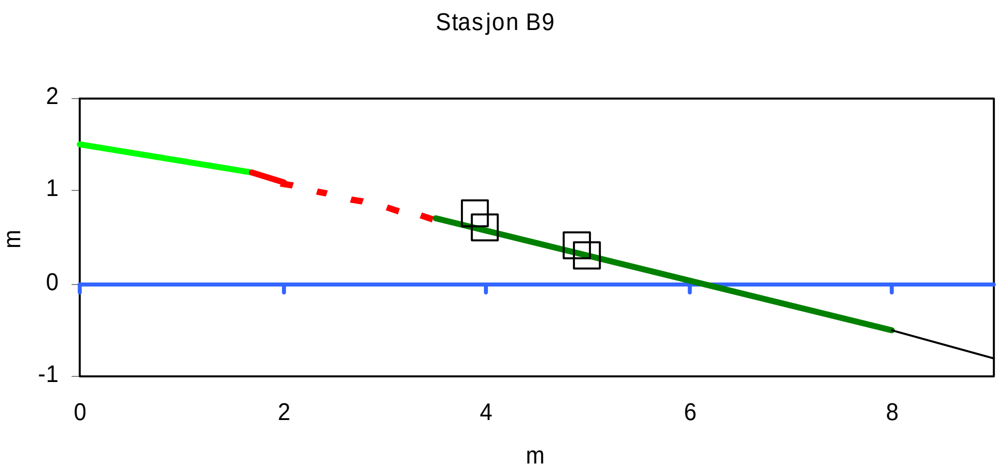


Figure 28 Profile of the littoral zone and placement of the quadrates. Zonation indicated by colour. *Profil av fjæresonen med plassering av kvadrater.*

The littoral zone overall dominated by knotted wrack was divided into 4 zones. Highest on the shore there was a large area of scattered abundance of lichen, blue-green and green algae species. Below this green zone, bladder wrack formed a narrow band of 'mono culture' that changed to a mixed culture with knotted wrack growing from below. A broad band of knotted wrack dominated the lower intertidal and upper sub littoral zone. The common green weed *Cladophora rupestris* dominated the understory vegetation and the encrusting red algae *Hildenbrandia rubra* dominated the primary surface.
Algae growth indicate high availability of nutrient, but absence of common littoral animals also is responsible for deviation from expected composition.
Scattered abundance of the blue mussel *Mytilus edulis* was found in the lower littoral zone.
4 quadrates was randomly placed in the knotted wrack zone.

Besides investigation of the littoral communities SCUBA diving along a sub littoral transect was performed to register species composition and assess the sub littoral condition. The sublittoral communities were clearly influenced by a heavy sedimentation of mineral particles. Most of the sub littoral bottom was soft bottom and only on vertical rocks or walls hard bottom organisms could survive but the species composition was poor with low abundance and low diversity. A large field with sea pens were observed around 10-15 m depth (photo c).

Table 30 Zonation and species composition. B=brown, G=green and R=red algae. L=lichen, C=Blue-green algae, A=Animals. Zonations: GREEN=Green algae/Gut weed, FUCVE=Bladder wrack, MIX=Mixed association with Bladder wrack and Knotted wrack, ASCNO=Knotted wrack. *Biologiske soner og artssammensetning. L=lav, C=blågrønnalger, B=brun, G=grønn og, R=rødalger. Sonering: GREEN=grønnalger/tarmgrønske, FUCVE=blæretang, MIX=blæretang og grisetang, ASCNO=grisetang.*

B9	**Bjørnebærviken**	1	4	2	3	
	Zone	GREEN	FUCVE	MIX	ASCNO	
	Width of zone, m	4	0.3	1.5	4.5	
L	*Verrucaria maura*	s				
C	Cyanophyceae	v	s			
G	Green algae indet.	v	s			
G	*Enteromorpha* spp., gut weed	s				
R	*Hildenbrandia rubra*	e	v	d	d	
B	*Fucus vesiculosus*, bladder wrack		e	v	s-e	
B	Fucus juvenil			s		
B	*Ascophyllum nodosum,* knotted wrack		e	v-d	d	
B	*Ascophyllum nodosum* juv			s	s	
G	*Cladophora rupestris*		s	v	d	
B	Ectocarpales				s	
A	*Mytilus edulis* juvenil		s	s	s	
A	*Mytilus edulis*				s	

Table 31 Species composition registrated in quantitative quadrates (R1- R4) and average abundance (Avg) of the zone based on 4 quadrates. StDev=Standard deviation. B=brown algae, R=red algae. *Artsforekomst registrert i kvadratene (R1-R4) i grisetangsonen, med gjennomsnitt mengde (Avg.) av 4 kvadrater. StDev=standardavvik. B=brun, G=grønn og R=rødalger.*

	ASCNO zone	R1	R2	R3	R4	Avg	StDev
R	*Hildenbrandia rubra*	96	92	96	84	92.0	5.7
B	*Ascophyllum nodosum*, knotted wrack	100	100	100	100	100.0	0.0
B	*Fucus vesiculosus*, bladder wrack	60	64	68	92	71.0	14.4
A	*Mytilus edulis* juv., blue mussel	0.4	0.4	0.4	0.4	0.4	0.0

STATIONS B12 KALVHAUGNESET

a  b

Photo 5 a) Overview of the littoral zone and b) shallow sublittoral zone. *Stasjonsbilder.* (photo: NIVA).

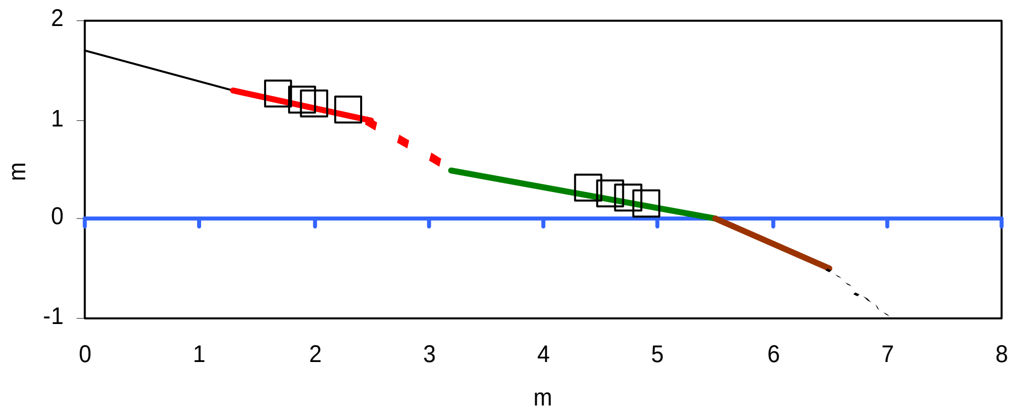


Figure 29 Profile of the littoral zone and placement of the quadrates. Zonation indicated by colour. *Profil av fjæresonen med plassering av kvadrater.*

The dominating seaweed species bladder wrack, knotted wrack and toothed wrack formed 3 distinct zones. Between the two main littoral zones there was a narrow mixed. The sub littoral toothed wrack zone also had a mixed composition of all three main seaweeds.
A black band of Verrucaria and Calothrix formed the supra littoral zone and scattered spots of green algae was observed as well.
The bladder wrack formed a dense association with some green algae as understory vegetation. In the knotted wrack association common green weed was the main understory specimen. Epiphytic growing filamentous brown algae was common on the seaweed.
B12 was the innermost station were barnacles was found as well as the common shore crab. This indicate a change in the environment to better conditions for marine species.
Sublittorally the seaweed and the bottom was overgrown by several filamentous green and brown algae, diatoms and bacteria indicating a heavily disturbed community.

Nutrient enrichment, fresh water and particle loading are factors boosting the this kind of development. A larger number of species and especially animal species indicate lower impact of mineral particles that prevented survival and growth at the innermost stations.

4 quadrates were randomly placed in the bladder wrack zone and 4 quadrates was placed in the knotted wrack zone.

Table 32 Zonation and species composition. B=brown, G=green and R=red algae. A=Animals. L=lichen, C=Blue-green algae. Zonation: SUPRA=supra littoral, FUCVE=Bladder wrack, MIX=Mixed association with Bladder wrack and Knotted wrack ASCNO=Knotted wrack, FUCSE=Toothed wrack. *Biologiske soner og artssammensetning. L=lav, C=blågrønnalger, B=brun, G=grønn og, R=rødalger. Sonering: SUPRA=sprøytesonen, FUCVE=blæretang, MIX=blæretang og grisetang, ASCNO=grisetang, FUCSE=sagtang.*

B12	**Kalvhaugneset**	**1**	**2**	**3**	**4**	**5**
	Zone	SUPRA	FUCVE	MIX	ASCNO	FUCSE
	Width of zone, m	1.3	1.2	0.7	2.3	0.75
L/C	Verrucaria /Calothrix	v				
G	Green algae indet.	e				
B	*Fucus vesiculosus*, bladder wrack		d	v	s	v
G	*Blidingia minima*		s			
G	*Enteromorpha* spp., gut weed		s			
R	*Hildenbrandia rubra*		e	s	s	
G	*Cladophora rupestris*			e	s	
B	Ectocarpales				s	s
B	*Pilayella littoralis*				s	s
B	*Ascophyllum nodosum*, knotted wrack			s	d	s
B	*Fucus serratus*, toothed wrack					v
B	*Filamentous indet*					d
A	*Mytilus edulis*, blue mussel		e		s	
A	*Carcinus maenas*, shore crab				e	
A	*Balanus balanoides*, barnacle				e	
A	*Littorina littorea*, common periwinkle					s
-	Empty bivalve shell		e		e	

Table 33 Species composition registrated in quantitative quadrates (R1- R8) and average abundance (Avg) of the zone based on 4 quadrates. StDev=Standard deviation. B=brown, G=green and R=red algae.A=Animal. *Artsforekomst registrert i kvadratene (R1-R4) i blæretangsonen og i grisetangsonen, med gjennomsnitt mengde (Avg.) av 4 kvadrater. StDev=standardavvik. B=brun, G=grønn og R=rødalger.*

B12	Fucus vesiculosus zone	R1	R2	R3	R4	Avg	StDev
R	*Hildenbrandia rubra*	0.8	4	0	60	16.2	29.3
B	*Ascophyllum* juv	0	0.8	0	0	0.2	0.4
B	*Ascophyllum nodosum*, knotted wrack	8	24	0	0	8.0	11.3
B	*Fucus* juv.	0.4	8	32	8	12.1	13.7
B	*Fucus vesiculosus*, bladder wrack	100	100	100	100	100.0	0.0
G	Green algae indet. på fjell	0.4	0.4	2	2	1.2	0.9
A	*Mytilus edulis*, blue mussel	0.4	0.4	0.4	0.4	0.4	0.0
-	Empty bivalve shell	0	0	0.4	0	0.1	0.2
	Ascophyllum nodosum zone	R5	R6	R7	R8	Avg	StDev
R	*Hildenbrandia rubra*	4	28	32	16	20.0	12.6
B	*Ascophyllum* juv	0.8	4	0.8	4	2.4	1.8
B	*Ascophyllum nodosum*, knotted wrack	100	100	100	100	100.0	0.0
B	*Fucus vesiculosus*, bladder wrack	4	0	0	0	1.0	2.0
G	*Cladophora rupestris*	4	8	8	12	8.0	3.3
A	*Mytilus edulis*, blue mussel	0.4	0.4	0.4	0	0.3	0.2
A	*Carcinus maenas*, shore crab	0	4	0	0	1.0	2.0
-	Empty bivalve shell	0	0	0	4	1.0	2.0

STATIONS B14 HINDERÅ


a


b

Photo 6 a) Overview and b) close-up of the littoral zone. *Stasjonsbilder*. (photo: NIVA).

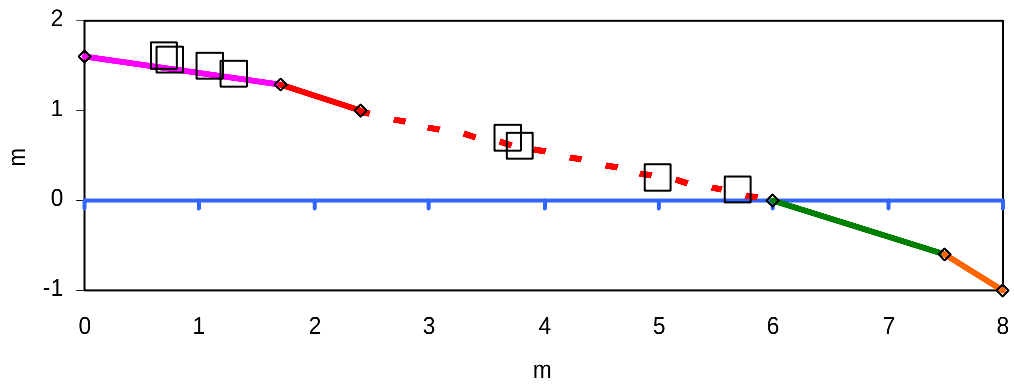


Figure 30 Profile of the littoral zone and placement of the quadrates. Zonation indicated by colour. *Profil av fjæresonen med plassering av kvadrater.*

The littoral zone at station B14 was flat with a very wide zone dominated by knotted wrack. B14 was the innermost station for many littoral species in Ranfjorden. Among new species are:

- channelled wrack that formed a distinct association in the upper littoral zone
- spiral wrack that formed an association between the channelled and knotted wrack and
- the three littorinides: Common, rough and flat periwinkle.

The species composition indicated good environmental conditions.

4 quadrates were randomly placed in the channelled wrack association and 4 quadrates were randomly placed in the knotted wrack association.

Table 34 Zonation and species composition. B=brown, G=green and R=red algae. A=Animals, L=lichen, C=blue-green algae. Zonation: SUPRA=supralittoral, PELCA=Channelled wrack, FUCSP=Spiral wrack, ASCNO=Knotted wrack, FUCVE=Bladder wrack. *Biologiske soner og artssammensetning. L=lav, C=blågrønnalger, B=brun, G=grønn og, R=rødalger. Sonering: SUPRA=sprøytesonen, PELCA=sauetang, FUCSP=spiraltang, ASCNO=grisetang, FUCVE=blæretang.*

B14	**Hinderå**	1	2	3	4	5
	Zone	SUPRA	PELCA	FUCSP	ASCNO	FUCVE
	Width of zone, m					
L	*Verrucaria maura*	s				
C	Cyanophyceae	v	v	v		
B	*Pelvetia caniculata*, chanelled wrack		d			
B	*Fucus spiralis*, spiral wrack		s	d		
R	*Hildenbrandia rubra*		s	s	d	d
B	*Ascophyllum nodosum*, knotted wrack				d	
C	Cyanophyceae type 2				s	
G	*Cladophora rupestris*				v	v
R	*Chondrus crispus*				e	s
B	*Fucus vesiculosus*, bladder wrack					d
B	*Ectocarpales* epi					v
B	*Elachista fucicola*					s
B	*Fucus serratus*, toothed wrack					s
A	*Balanus balanoides*, barnacle		-	s	s	
A	*Littorina saxatilis*, rough periwinkle		-	s	e	
A	*Littorina littorea*, common periwinkle		-	e	e	
A	*Littorina obtusata*, flat periwinkle		-		s	
A	*Mytilus edulis*, blue mussel		-		s	
A	*Carcinus maenas*, shore crab		-		e	

Table 35 Species composition registrated in quantitative quadrates (R1- R8) and average abundance (Avg) of the zone based on 4 quadrates. StDev=Standard deviation. *Artsforekomst registrert i kvadratene (R1-R4) i sauetangsonen og i grisetangsonen, med gjennomsnitt mengde (Avg.) av 4 kvadrater. StDev=standardavvik. B=brun, G=grønn og R=rødalger.*

B14	PELCA zone	R1	R2	R3	R4	Avg	StDev
C	Cyanophyceae	20	4	40	16	20.0	15.0
R	*Hildenbrandia rubra*	20	4	0	0.8	6.2	9.4
B	*Fucus spiralis*, spiral wrack	60	0	0	0	15.0	30.0
B	*Pelvetia canaliculata*, chanelled wrack	32	36	92	92	63.0	33.5
B	*Pelvetia canaliculata* juvenil	4	48	4	0.8	14.2	22.6
A	*Balanus balanoides*	2	0	0	0	0.5	1.0
	ASCNO zone	R5	R6	R7	R8	Avg	StDev
C	Cyanophyceae	0	4	0	4	2.0	2.3
R	*Chondrus crispus*	0.8	0	0	0	0.2	0.4
R	*Hildenbrandia rubra*	52	52	84	80	67.0	17.4
B	*Ascophyllum* juv	0	2	0	20	5.5	9.7
B	*Ascophyllum nodosum*, knotted wrack	100	100	100	100	100.0	0.0
G	*Cladophora rupestris*	2	24	52	2	20.0	23.7
G	Green algae indet. på fjell	4	0	0	2	1.5	1.9
A	*Dynamena pumila*	0	0	0	0.4	0.1	0.2
A	*Littorina littorea*, common periwinkle	4	0	0	0	1.0	2.0
A	*Littorina obtusata*, flat periwinkle	8	0	8	4	5.0	3.8
A	*Littorina saxatilis*, rough periwinkle	20	8	4	0	8.0	8.6
A	*Littorina* sp.	0	0	4	0	1.0	2.0
A	*Mytilus edulis*, blue mussel	12	4	8	2	6.5	4.4
A	*Balanus balanoides*, barnacle	16	12	12	8	12.0	3.3
A	*Carcinus maenas*, shore crab	4	4	0	0	2.0	2.3

STATION B16 LAUKELIA

a   b

Photo 7   a) Overview and b) close-up of the littoral zone. *Stasjonsbilder* (photo: NIVA).

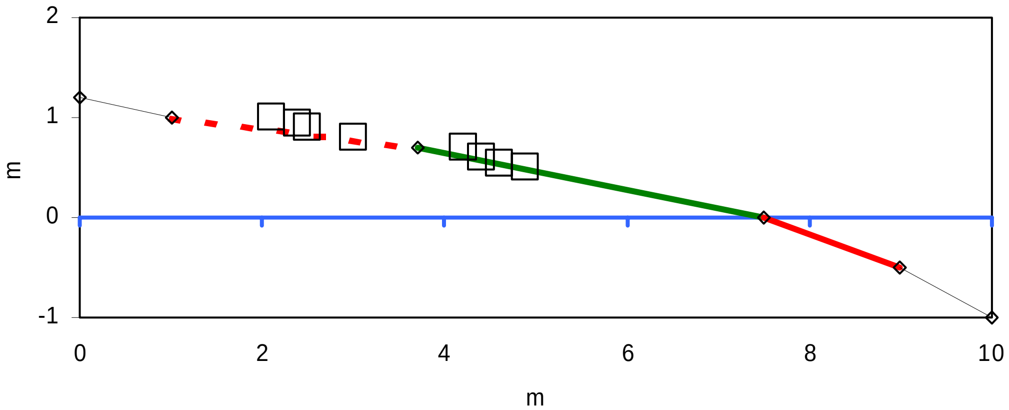


Figure 31 Profile of the littoral zone and placement of the quadrates. Zonation indicated by colour. *Profil av fjæresonen med plassering av kvadrater.*

A flat slope gave a wide band dominated by knotted wrack. The uppermost part of this zone was mixed with bladder wrack. 4 quadrates were randomly placed in the mixed association and 4 quadrates were randomly placed in the knotted wrack association. Below surface toothed wrack was common and scattered to common populations of the three kelp species was observed.

The littoral seaweed was clean and strong indicating good environmental conditions.

Table 36 Zonation and species composition. B=brown, G=green and R=red algae. A=Animals, L=lichen, C=blue-green algae. Zonation: SUPRA=supralittoral, MIX=Mixed association with Bladder wrack and Knotted wrack, ASCNO=Knotted wrack, FUCSE=Toothed wrack. SUBLIT=Sublittoral. *Biologiske soner og artssammensetning. L=lav, C=blågrønnalger, B=brun, G=grønn og, R=rødalger. Sonering: SUPRA=sprøytesonen, MIX=blæretang og grisetang, ASCNO=grisetang, FUCSE=sagtang, SUBLIT=sjøsonen.*

B16	**Laukelia**	1	2	3	4	5
	Zone	SUPRA	MIX	ASCNO	FUCSE	SUBLIT
	Width of zone, m	1	2.3	3.8		
L/C	Verrucaria / Calothrix	d				
B	*Fucus vesiculosus*, bladder wrack		d		v	
B	*Fucus juvenil*		s			
R	*Hildenbrandia rubra*		d	d		
G	Green algae on stone		e	s		
G	*Cladophora rupestris*		e	s		
B	Ectocarpales			s		
B	*Ascophyllum nodosum*, knotted wrack		s	s		
G	*Enteromorpha* spp., gut weed			s		
G	*Cladophora* spp.			s	s	s
B	*Fucus serratus*, toothed wrack				v	s
B	*Laminaria* cf. *digitata*, oarweed					s
B	*Laminaria saccharina*, sugar kelp					e
B	*Laminaria hyperborea*, cuvie					v
A	*Mytilus edulis*, blue mussel			s	e	
A	*Balanus balanoides*, barnacle			e		
A	*Carcinus maenas*, shore crab			e		
A	Amphipoda			e		

Table 37 Species composition registrated in quantitative quadrates (R1- R8) and average abundance (Avg) of the zone based on 4 quadrates. StDev=Standard deviation. B=brown, G=green and R=red algae.A=Animals. *Artsforekomst registrert i kvadratene (R1-R4) i grisetang-/blæretangsonen og i grisetangsonen, med gjennomsnitt mengde (Avg.) av 4 kvadrater. StDev=standardavvik. B=brun, G=grønn og R=rødalger.*

B16	MIX zone	R1	R2	R3	R4	Avg	StDev
R	*Hildenbrandia rubra*	80	60	96	96	83.0	17.1
B	*Ascophyllum* juv	2	0	8	8	4.5	4.1
B	*Ascophyllum nodosum*, knotted wrack	24	40	60	16	35.0	19.4
B	*Fucus* juv.	16	0	0	2	4.5	7.7
B	*Fucus vesiculosus*, bladder wrack	80	60	40	88	67.0	21.5
G	*Cladophora rupestris*	8	2	8	20	9.5	7.5
G	Green algae indet. på fjell	4	4	4	4	4.0	0.0
A	*Mytilus edulis*, blue mussel	0.4	0.4	0.4	0.4	0.4	0.0
	ASCNO zone	R5	R6	R7	R8	Avg	StDev
R	*Hildenbrandia rubra*	92	96	92	92	93.0	2.0
B	*Ascophyllum* juv	0.4	2	0.4	0.4	0.8	0.8
B	*Ascophyllum nodosum*, knotted wrack	100	100	100	100	100.0	0.0
G	*Cladophora rupestris*	16	0	12	2	7.5	7.7
G	Green algae indet. på fjell	8	8	8	8	8.0	0.0
A	*Mytilus edulis*, blue mussel	2	0.4	2	2	1.6	0.8
A	*Balanus balanoides*, barnacle	0	0	0	0.4	0.1	0.2
A	*Carcinus maenas*, shore crab	0	0	4	0	1.0	2.0

STATION B17 LANGNESET

a  b

Photo 8 a) Overview and b) close-up of the littoral zone. *Stasjonsbilder* (photo: NIVA).

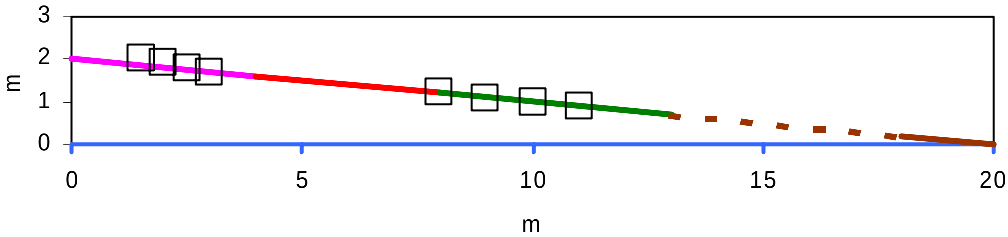


Figure 32 Profile of the littoral zone and placement of the quadrates. Zonation indicated by colour. *Profil av fjæresonen med plassering av kvadrater.*

The station B17 was established during this investigation as a reference. The site was in a sheltered shallow bay at the exposed outer part of Ranfjorden. The slop was flat and knotted wrack dominated the station. 4 quadrates were randomly placed in the mixed association and 4 quadrates were randomly placed in the knotted wrack association.
Channelled wrack dominated the upper seaweed association above a band dominated by bladder wrack growing above the knotted wrack association. The upper sublittoral zone was a mixed zone with bladder, knotted and toothed wrack as common species. The bottom of the upper sublittoral zone was a mixture of hard bottom, rocks in several sizes, shell sand and soft sediments producing a high variety of sub littoral habitats (not included in the littoral investigation).
The species composition indicated good environmental conditions.

Table 38 Zonation and species composition. B=brown, G=green and R=red algae. A=Animals, L=lichen, C=blue-green algae. Zonation: SUPRA=supralittoral, PELCA=Channelled wrack, FUCVE=Bladder wrack, ASCNO=Knotted wrack, MIX=Mixed association with Bladder wrack and Knotted wrack. *Biologiske soner og artssammensetning. L=lav, C=blågrønnalger, B=brun, G=grønn og, R=rødalger. Sonering: SUPRA=sprøytesonen, PELCA=sauetang, FUCVE=blæretang , ASCNO=grisetang, MIX=blæretang og grisetang.*

B17	**Langneset**	1	2	3	4	5
	Zone	SUPRA	PELCA	FUCVE	ASCNO	MIX
	Width of zone, m					
L/C	Verucaria / Cyanophyceae	s				
B	*Pelvetia caniculata*, channelled wrack		d			
B	*Fucus vesiculosus*, bladder wrack		s	d	s	d
G	*Enteromorpha* spp., gut weed		s			s
B	*Pelvetia caniculata* juv.		s			
R	*Hildenbrandia rubra*		e	v	d	d
B	*Ascophyllum nodosum*, knotted wrack			e	d	v
C	Cyanophyceae		v	v		
G	*Cladophora rupestris*				s	s
R	*Chondrus crispus*				s	s
B	Ectocarpales				e	s
B	*Fucus serratus*, toothed wrack					s
R	*Palmaria palmata*					s
R	*Polysiphonia lanosa*					s
R	*Porphyra umbilicalis*					s
B	*Elachista fucicola*					s
A	*Mytilus edulis*, blue mussel				v	
A	*Balanus balanoides*, barnacle		s		v	
A	*Dynamena pumila*				s	
A	*Littorina obtusata*, flat periwinkle				v	
A	*Littorina saxatillis*, rough periwinkle		s		s	
A	*Littorina* sp.		s		s	
A	*Littorina littorea*, common periwinkle				s	
A	*Nucella lapillus*, dogwhelk				s	

Table 39 Species composition registrated in quantitative quadrates (R1- R8) and average abundance (Avg) of the zone based on 4 quadrates. StDev=Standard deviation. B=brown, G=green, R=red algae. *Artsforekomst registrert i kvadratene (R1-R4) i sauetangsonen og i grisetangsonen, med gjennomsnitt mengde (Avg.) av 4 kvadrater. StDev=standardavvik. B=brun, G=grønn og R=rødalger.*

B17	PELCA zone	R1	R2	R3	R4	Avg	StDev
C	Cyanophycea indet	8	48	72	80	52.0	32.3
R	*Hildenbrandia rubra*	12	4	0	0	4.0	5.7
B	Brown encrusting indet.	28	0	0	0	7.0	14.0
B	*Pelvetia canaliculata*, channelled wrack	60	48	52	8	42.0	23.2
B	*Pelvetia canaliculata* juvenil	8	12	4	60	21.0	26.2
A	*Littorina saxatilis*, rough periwinkle	0	92	24	4	30.0	42.6
A	*Littorina* sp.	0	12	0	4	4.0	5.7
A	*Balanus balanoides*, barnacle	4	0	0	16	5.0	7.6
	ASCNO zone	R5	R6	R7	R8	Avg	StDev
R	*Chondrus crispus*	0	8	4	4	4.0	3.3
R	*Hildenbrandia rubra*	96	84	40	80	75.0	24.3
B	*Ascophyllum* juv	0	0	4	2	1.5	1.9
B	*Ascophyllum nodosum*, knotted wrack	100	100	100	100	100.0	0.0
B	*Ectocarpus* sp.	0	0	2	2	1.0	1.2
B	*Fucus juv.*	0	0	4	0	1.0	2.0
B	*Fucus vesiculosus*, bladder wrack	0	0	8	0	2.0	4.0
G	*Cladophora rupestris*	0	36	12	16	16.0	15.0
A	*Dynamena pumila*	2	0.8	0.8	0.4	1.0	0.7
A	*Littorina obtusata*, flat periwinkle	72	108	104	128	103.0	23.2
A	*Littorina saxatilis*, rough periwinkle	20	0	8	8	9.0	8.2
A	*Littorina* sp.	12	0	16	0	7.0	8.2
A	*Nucella lapillus*, dogwhelk	0	0	4	0	1.0	2.0
A	*Mytilus edulis*, blue mussel	24	4	20	12	15.0	8.9
A	*Balanus balanoides*, barnacle	16	16	28	16	19.0	6.0
A	*Carcinus maenas*, shore crab	0	4	0	0	1.0	2.0

STATION B91 HEMNES

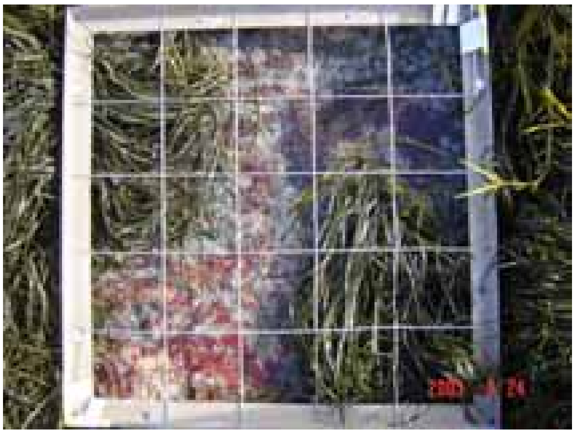
a   b

Photo 9 a) Overview and b) close-up of the littoral zone. *Stasjonsbilder* (photo: NIVA).

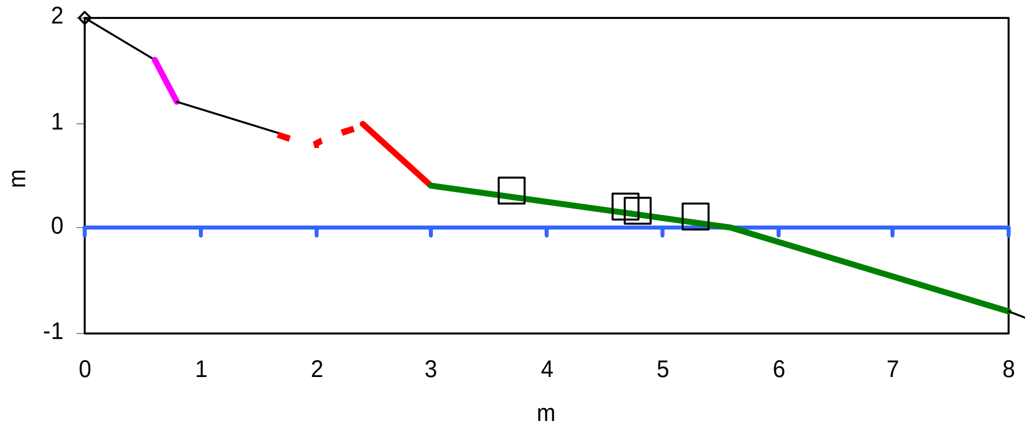


Figure 33 Profile of the littoral zone and placement of the quadrates. Zonation indicated by colour. *Profil av fjæresonen med plassering av kvadrater.*

The station B91 was established as a reference station during this investigation. The site was in a sheltered shallow bay in Sørfjorden, a lateral branch of Ranfjorden. As for the innermost stations in Ranfjorden, B91 is influenced by fresh water.

The slop was moderate, but varied in the upper part and sustained patchiness. The supralittoral zone was dominated by lichen and blue-green algae. Channelled wrack dominated the upper seaweed association above a band with mixed associations of bladder wrack and knotted wrack. A narrow band was completely dominated by bladder wrack above a wide zone of knotted wrack.
4 quadrates were randomly placed in the knotted wrack association.

The species composition indicated good environmental conditions.

Table 40 Zonation and species composition. B=brown, G=green and R=red algae. A=Animals, L=lichen, C=blue-green algae. Zonation: SUPRA=supralittoral, PELCA=Channelled wrack (Pelvetia caniculata), MIX=Mixed association with Bladder wrack and Knotted wrack, FUCVE=Bladder wrack, ASCNO=Knotted wrack. *Biologiske soner og artssammensetning. L=lav, C=blågrønnalger, B=brun, G=grønn og, R=rødalger. Sonering: SUPRA=sprøytesonen, PELCA=sauetang, MIX=blæretang og grisetang, FUCVE=blæretang, ASCNO=grisetang.*

B91	Hemnes	1	2	3	4	5
	Zone name	SUPRA	PELCA	MIX	FUCVE	ASCNO
	Width of zone, m	0.6	0.2	1.6	0.6	5
L	*Verrucaria maura*	d				
C	Blue-green algae	v	v	s		
	Macroalgae					
B	*Pelvetia caniculata*, channelled wrack		s			
B	*Fucus vesiculosus*, bladder wrack			v	d	
R	*Hildebrandia rubra*			v	d	d
G	*Enteromorpha* spp, gut weed			s		
G	*Cladophora* spp			s		
B	*Ascophyllum nodosum*, knotted wrack			v		d
G	*Cladophora rupestris*				s	v
R	Red fur on stone indet.					s
B	*Pilayela littoralis*					s
G	Green fur on stone indet.				s	s
B	*Fucus serratus*, toothed wrack					
	Animals					
A	*Carcinus maenas*, shore crab					s
A	Bryozoa indet. encrusting					s
A	*Balanus balanoides*, barnacle					e
A	*Mytilus edulis*, blue mussel					s
-	Empty bivalve shell					e

Table 41 Species composition registrated in quantitative quadrates (R1- R4) and average abundance (Avg) of the zone based on 4 quadrates. StDev=Standard deviation. B=brown algae, G=green algae, R=red algae.A=Animals. *Artsforekomst registrert i kvadratene (R1-R4) i grisetangsonen, med gjennomsnitt mengde (Avg.) av 4 kvadrater. StDev=standardavvik. B=brun, G=grønn og R=rødalger.*

B91	ASCNO zone	R1	R2	R3	R4	Avg	Stdev
R	*Hildenbrandia rubra*	56	48	60	48	53.0	6.0
B	*Ascophyllum nodosum*, knotted wrack	100	100	100	100	100.0	0.0
G	*Cladophora rupestris*	16	32	24	40	28.0	10.3
G	Green algae indet. på fjell	4	0	16	16	9.0	8.2
A	*Mytilus edulis*, blue mussel	4	0.4	0.4	0.4	1.3	1.8
A	*Balanus balanoides*, barnacle	16	4	0	4	6.0	6.9
A	*Carcinus maenas*, shore crab	0	8	0	0	2.0	4.0
A	Bryozoa indet. encrusting	28	32	20	16	24.0	7.3
	Empty bivalve shell	0	0	0.4	0.4	0.2	0.2

Appendix E.

Field survey notes – sediment and softbottom fauna sampling 2003

NOTAT

fra / from:	*Akvaplan-niva*
til / to:	*Brage Rygg og Aud Helland*
kopi til / copy to:	*Mats Walday*
dato / date:	*05.09.05*
prosj nr / proj nr:	*2695 Ranfjorden 2003*
sak / subject:	*Feltlogg*

☒ til orientering / for your information
☐ vennligst kommenter / please comment
☐ svar innen / please answer before

Feltarbeidet ble utført mellom 27. og 29. mai 2003.
Vind fra sørøst varierte mellom bris og liten kuling in kastene, litt regn.
Ranelven var flomstor under feltarbeidet.

Stasjons nr.	Posisjon	Dyp	Dato	Sedimentbeskrivelse
26R	66°09.84'N 13°02.04'E	453	27.05.03	Siltig, olivengrønn overflate mørkere farge under. Ingen lukt. Børstemakk, amfipoder, Ctenodiscus, Pectinaria og Brisaster?
24R	66°13.84'N 13°23.00'E	298	27.05.03	Siltig, olivengrønn overflate mørkere farge under. Ingen lukt. Børstemakk, amfipoder, Ophiurider Ctenodiscus,
19R	66°14.13'N 13°36.50'E	319	27.05.03	Siltig, olivengrønn overflate grålig farge under. Ingen lukt
RN9	66°16.60'N 13°56.21'E	483	27.05.03	Siltig, olivengrønn overflate nesten svartfarge under. Ingen lukt
RN8	66°17.50'N 13°57.93'E	455	28.05.03	Siltig, mørk olivengrønn sediment, noe terrestrisk materiale. Ingen lukt Børstemakk
RN6	66°17.82'N 14°03.83'E	365	28.05.03	Sandig silt, mørk olivengrønn overflate nesten svart under, litt terrestrisk materiale Ingen lukt Børstemakk, muslinger
RN5	66°18.18'N 14°04.38'E	310	28.05.03	Siltig, mørk olivengrønn farge in hele sedimentet Ingen lukt Børstemakk, slangestjerner
RE14	66°17.58'N 14°04.38'E	90	28.05.03	Siltig, brun overflate, mørk grå til svart under Ingen lukt
RE13	66°17.70'N 14°04.55'E	174	28.05.03	Siltig, brunlig litt løs overflate Ingen lukt Sjømus (3 stk)
RE12	66°17.72'N 14°05.19'E	80	28.05.03	Siltig, brunlig til olivengrønn overflate, mørk grå under. Terrestrisk materiale Ingen lukt Børstemakk, sjøstjerner og slangestjerner

Stasjons nr.	Posisjon	Dyp	Dato	Sedimentbeskrivelse
RE11	66°17.90'N 14°05.46'E	84	28.05.03	Siltig, brunlig til olivengrønn overflate, mørk grå under. Terrestrisk materiale Ingen lukt Børstemakk, sjøstjerner og slangestjerner
RN4	66°19.09'N 14°05.82'E	212	28.05.03	Siltig, mørk olivengrønn farge in hele sedimentet Ingen lukt Børstemakk
RN3	66°18.90'N 14°06.36'E	220	28.05.03	Siltig, olivengrønn farge in hele sedimentet Ingen lukt Børstemakk
RN2	66°19.32'N 14°07.56'E	93	29.05.03	Sandig silt med grus, olivengrønn overflate, mørk grå under. Terrestrisk materiale Litt lukt (organisk metallisk?? ikke H_2S) Børstemakk, slangestjerne
RE01	66°19.60'N 14°08.00'E	90	29.05.03	"Koksverk" silt med grus, mørk grå hele sedimentet. Terrestrisk materiale Ingen lukt Amfipoder
RE02	66°19.50'N 14°07.73'E	91	29.05.03	Siltig, olivengrønn overflate, mørk grå under. Terrestrisk materiale Ingen lukt Børstemakk
RE04	66°19.10'N 14°07.32'E	70	29.05.03	Siltig, olivengrønn overflate, mørk grå under. Terrestrisk materiale Ingen lukt Børstemakk
RE05	66°18.90'N 14°07.19'E	150	29.05.03	Siltig, olivengrønn overflate, mørk grå under. Terrestrisk materiale Ingen lukt Børstemakk
RE06	66°18.80'N 14°07.06'E	180	29.05.03	Siltig, olivengrønn hele sedimentet med svarte områder. Terrestrisk materiale Litt svak H_2S lukt Børstemakk, sjømus
RE07	66°18.70'N 14°06.92'E	150	29.05.03	Siltig, olivengrønn hele sedimentet. Terrestrisk materiale Ingen lukt Børstemakk, sjømus, reke, Macoma
RE08	66°18.67'N 14°07.19'E	141	29.05.03	Siltig, olivengrønn hele sedimentet. Terrestrisk materiale (Greiner ++) Ingen lukt Børstemakk, gullmus
RE09	66°18.42'N 14°06.40'E	57	29.05.03	Siltig, olivengrønn overflate, mørk grå under. Terrestrisk materiale Ingen lukt Børstemakk, Pectinaria, musling
RE10	66°18.23'N 14°06.12'E	29	29.05.03	Siltig, olivengrønn overflate, mørk grå under. Terrestrisk materiale Ingen lukt Børstemakk, Pectinaria, Ophiura, musling

Appendix F.

Table 42. The ten most abundant species/taxons at each station (average number per 0.1 m^2).
De ti vanligste artene (evt. høyere gruppe) på hver stasjon (gjennomsnittlig antall pr. 0.1 m^2).

Station	Group	Family	Genus	Number pr. 0.1 m^2
RE02	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	509
RE02	BIVALVIA	Thyasiridae	*Thyasira*	401
RE02	POLYCHAETA	Spionidae	*Prionospio cirrifera*	270
RE02	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	147
RE02	POLYCHAETA	Spionidae	*Spiophanes kroeyeri*	112
RE02	POLYCHAETA	Lumbrineridae	*Lumbrineris*	48
RE02	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	27
RE02	POLYCHAETA	Opheliidae	*Ophelina cf. modesta*	26
RE02	BIVALVIA	Scrobiculariidae	*Abra nitida*	20
RE02	ANTHOZOA	Edwardsiidae	Edwardsiidae	17
RE04	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	476
RE04	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	349
RE04	BIVALVIA	Thyasiridae	*Thyasira*	188
RE04	BIVALVIA	Kelliellidae	*Kelliella miliaris*	184
RE04	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	129
RE04	POLYCHAETA	Lumbrineridae	*Lumbrineris*	77
RE04	POLYCHAETA	Orbiniidae	*Scoloplos armiger*	71
RE04	POLYCHAETA	Sigalionidae	*Pholoe minuta*	70
RE04	POLYCHAETA	Spionidae	*Prionospio cirrifera*	65
RE04	POLYCHAETA	Cossuridae	*Cossura longocirrata*	47
RE07	POLYCHAETA	Spionidae	*Spiophanes kroeyeri*	382
RE07	BIVALVIA	Thyasiridae	*Thyasira*	101
RE07	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	79
RE07	POLYCHAETA	Syllidae	*Typosyllis cornuta*	37
RE07	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	29
RE07	POLYCHAETA	Sabellidae	Fabriciinae	26
RE07	SIPUNCULIDA		*Golfingia*	23
RE07	BIVALVIA	Kelliellidae	*Kelliella miliaris*	15
RE07	POLYCHAETA	Orbiniidae	*Scoloplos armiger*	9
RE07	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	8
RE08	POLYCHAETA	Spionidae	*Spiophanes kroeyeri*	212
RE08	POLYCHAETA	Spionidae	*Prionospio cirrifera*	164
RE08	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	131
RE08	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	118
RE08	POLYCHAETA	Orbiniidae	*Scoloplos armiger*	106
RE08	BIVALVIA	Thyasiridae	*Thyasira*	88
RE08	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	42
RE08	POLYCHAETA	Lumbrineridae	*Lumbrineris*	32
RE08	POLYCHAETA	Sabellidae	Sabellidae	28
RE08	POLYCHAETA	Syllidae	*Typosyllis cornuta*	20
RE10	POLYCHAETA	Spionidae	*Prionospio cirrifera*	81
RE10	POLYCHAETA	Sternaspiidae	*Sternaspis scutata*	55

Station	Group	Family	Genus	Number pr. 0.1 m^2
RE10	BIVALVIA	Thyasiridae	*Thyasira*	30
RE10	POLYCHAETA	Spionidae	*Pseudopolydora*	24
RE10	POLYCHAETA	Orbiniidae	*Scoloplos armiger*	16
RE10	POLYCHAETA	Oweniidae	*Owenia fusiformis*	14
RE10	POLYCHAETA	Oweniidae	*Myriochele*	14
RE10	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	13
RE10	BIVALVIA	Cardiidae	*Parvicardium minimum*	11
RE10	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	11
RE11	BIVALVIA	Kelliellidae	*Kelliella miliaris*	90
RE11	BIVALVIA	Thyasiridae	*Thyasira*	70
RE11	BIVALVIA	Nuculanidae	*Yoldiella*	69
RE11	POLYCHAETA	Oweniidae	*Myriochele*	37
RE11	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	30
RE11	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	12
RE11	SIPUNCULIDA		*Golfingia*	12
RE11	CUMACEA	Leuconidae	*Leucon nasica*	7
RE11	POLYCHAETA	Orbiniidae	*Scoloplos armiger*	6
RE11	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	5
RE12	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	105
RE12	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	102
RE12	POLYCHAETA	Cossuridae	*Cossura longocirrata*	102
RE12	POLYCHAETA	Spionidae	*Prionospio cirrifera*	43
RE12	BIVALVIA	Nuculanidae	*Yoldiella*	35
RE12	BIVALVIA	Kelliellidae	*Kelliella miliaris*	27
RE12	BIVALVIA	Thyasiridae	*Thyasira*	24
RE12	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	21
RE12	POLYCHAETA	Lumbrineridae	*Lumbrineris*	18
RE12	POLYCHAETA	Sigalionidae	*Pholoe minuta*	13
RE13	BIVALVIA	Nuculanidae	*Yoldiella*	27
RE13	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	19
RE13	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	8
RE13	NEMERTINEA		Nemertea	7
RE13	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	7
RE13	POLYCHAETA	Lumbrineridae	*Lumbrineris*	6
RE13	POLYCHAETA	Spionidae	*Spiophanes kroeyeri*	4
RE13	BIVALVIA	Thyasiridae	*Thyasira*	4
RE13	POLYCHAETA	Spionidae	*Prionospio cirrifera*	2
RE13	CUMACEA	Diastylidae	*Diastyloides serrata*	2
RE14	BIVALVIA	Nuculanidae	*Yoldiella*	38
RE14	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	20
RE14	BIVALVIA	Thyasiridae	*Thyasira*	13
RE14	CUMACEA	Leuconidae	*Leucon nasica*	10
RE14	POLYCHAETA	Spionidae	*Prionospio cirrifera*	8
RE14	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	6
RE14	POLYCHAETA	Cirratulidae	*Tharyx*	4
RE14	SIPUNCULIDA		*Golfingia*	3
RE14	NEMERTINEA		Nemertea	3
RE14	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	3

Station	Group	Family	Genus	Number pr. 0.1 m^2
RN2	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	1170
RN2	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	295
RN2	POLYCHAETA	Spionidae	*Prionospio cirrifera*	205
RN2	POLYCHAETA	Orbiniidae	*Scoloplos armiger*	171
RN2	POLYCHAETA	Lumbrineridae	*Lumbrineris*	87
RN2	POLYCHAETA	Cossuridae	*Cossura longocirrata*	61
RN2	POLYCHAETA	Syllidae	*Typosyllis cornuta*	40
RN2	POLYCHAETA	Sigalionidae	*Pholoe minuta*	15
RN2	POLYCHAETA	Opheliidae	*Ophelina* cf. *modesta*	12
RN2	POLYCHAETA	Capitellidae	*Capitella capitata*	10
RN3	BIVALVIA	Thyasiridae	*Thyasira*	280
RN3	POLYCHAETA	Spionidae	*Spiophanes kroeyeri*	157
RN3	POLYCHAETA	Spionidae	*Prionospio cirrifera*	77
RN3	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	70
RN3	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	67
RN3	BIVALVIA	Scrobiculariidae	*Abra nitida*	40
RN3	BIVALVIA	Kelliellidae	*Kelliella miliaris*	23
RN3	SIPUNCULIDA		*Golfingia*	16
RN3	POLYCHAETA	Oweniidae	*Myriochele*	14
RN3	POLYCHAETA	Syllidae	*Typosyllis cornuta*	11
RN4	POLYCHAETA	Spionidae	*Spiophanes kroeyeri*	137
RN4	BIVALVIA	Kelliellidae	*Kelliella miliaris*	129
RN4	BIVALVIA	Thyasiridae	*Thyasira*	119
RN4	BIVALVIA	Nuculanidae	*Yoldiella*	62
RN4	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	16
RN4	POLYCHAETA	Syllidae	*Typosyllis cornuta*	13
RN4	ANTHOZOA	Edwardsiidae	Edwardsiidae	13
RN4	ANTHOZOA	Edwardsiidae	*Edwardsia*	7
RN4	NEMERTINEA		Nemertea	7
RN4	AMPHIPODA	Phoxocephalidae	*Harpinia pectinata*	5
RN5	BIVALVIA	Thyasiridae	*Thyasira*	259
RN5	BIVALVIA	Kelliellidae	*Kelliella miliaris*	233
RN5	POLYCHAETA	Spionidae	*Spiophanes kroeyeri*	106
RN5	BIVALVIA	Nuculanidae	*Yoldiella*	66
RN5	BIVALVIA	Pectinidae	*Delectopecten vitreus*	42
RN5	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	35
RN5	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	16
RN5	ANTHOZOA	Edwardsiidae	*Edwardsia*	13
RN5	POLYCHAETA	Syllidae	*Typosyllis cornuta*	8
RN5	NEMERTINEA		Nemertea	6
RN6	BIVALVIA	Thyasiridae	*Thyasira*	179
RN6	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	153
RN6	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	143
RN6	POLYCHAETA	Opheliidae	*Ophelina* cf. *modesta*	48
RN6	POLYCHAETA	Spionidae	*Prionospio cirrifera*	14
RN6	POLYCHAETA	Capitellidae	*Capitella capitata*	12
RN6	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	9
RN6	POLYCHAETA	Cossuridae	*Cossura longocirrata*	5
RN6	BIVALVIA	Tellinidae	*Macoma calcarea*	5

Station	Group	Family	Genus	Number pr. 0.1 m^2
RN6	POLYCHAETA	Sigalionidae	*Leanira tetragona*	4
RN8	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	160
RN8	BIVALVIA	Thyasiridae	*Thyasira*	71
RN8	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	42
RN8	POLYCHAETA	Spionidae	*Prionospio cirrifera*	22
RN8	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	17
RN8	POLYCHAETA	Sigalionidae	*Leanira tetragona*	7
RN8	BIVALVIA	Scrobiculariidae	*Abra nitida*	5
RN8	NEMERTINEA		Nemertea	3
RN8	BIVALVIA	Tellinidae	*Macoma calcarea*	2
RN8	POLYCHAETA	Cirratulidae	*Tharyx*	2
RN9	BIVALVIA	Thyasiridae	*Thyasira*	241
RN9	POLYCHAETA	Cirratulidae	*Chaetozone setosa*	35
RN9	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	32
RN9	BIVALVIA	Kelliellidae	*Kelliella miliaris*	31
RN9	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	23
RN9	POLYCHAETA	Opheliidae	*Ophelina cf. modesta*	17
RN9	POLYCHAETA	Spionidae	*Prionospio cirrifera*	14
RN9	BIVALVIA	Nuculanidae	*Yoldiella*	8
RN9	POLYCHAETA	Chaetopteridae	*Spiochaetopterus typicus*	7
RN9	BIVALVIA	Scrobiculariidae	*Abra nitida*	6
19R	BIVALVIA	Kelliellidae	*Kelliella miliaris*	105
19R	BIVALVIA	Thyasiridae	*Thyasira*	79
19R	POLYCHAETA	Oweniidae	*Myriochele*	29
19R	BIVALVIA	Nuculanidae	*Yoldiella*	28
19R	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	15
19R	POLYCHAETA	Cirratulidae	*Tharyx*	14
19R	OPHIUROIDEA	Ophiuridae	*Ophiocten sericeum*	9
19R	BIVALVIA	Nuculidae	*Nucula*	6
19R	POLYCHAETA	Arabellidae	*Drilonereis filum*	5
19R	AMPHIPODA	Melitidae	*Eriopisa elongata*	4
24R	BIVALVIA	Kelliellidae	*Kelliella miliaris*	245
24R	BIVALVIA	Thyasiridae	*Thyasira*	74
24R	BIVALVIA	Nuculanidae	*Yoldiella*	55
24R	POLYCHAETA	Oweniidae	*Myriochele*	34
24R	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	16
24R	BIVALVIA	Scrobiculariidae	*Abra nitida*	9
24R	AMPHIPODA	Phoxocephalidae	*Harpinia pectinata*	8
24R	OPHIUROIDEA	Ophiuridae	*Ophiocten sericeum*	7
24R	HOLOTHUROIDEA	Synaptidae	*Labidoplax buskii*	4
24R	BIVALVIA	Nuculidae	*Nucula*	4
26R	POLYCHAETA	Oweniidae	*Myriochele*	61
26R	BIVALVIA	Thyasiridae	*Thyasira*	29
26R	BIVALVIA	Nuculanidae	*Yoldiella*	16
26R	BIVALVIA	Kelliellidae	*Kelliella miliaris*	10
26R	POLYCHAETA	Capitellidae	*Heteromastus filiformis*	7
26R	AMPHIPODA	Melitidae	*Eriopisa elongata*	5
26R	POLYCHAETA	Orbiniidae	*Orbinia norvegica*	4

Station	Group	Family	Genus	Number pr. 0.1 m^2
26R	POLYCHAETA	Maldanidae	Euclymeninae	3
26R	AMPHIPODA	Phoxocephalidae	*Harpinia pectinata*	3
26R	POLYCHAETA	Amphinomidae	*Paramphinome jeffreysii*	3

Appendix G.

Table 43. Fauna parameters per grab. *Faunaparametre pr. grabb (S = artstall; N = individtall; H og ES100 = indekser for artsmangfold; ISI = indikatorartsindeks).*

Station	Grabb	S	N	H	ES_{100}	ISI
RE02	G1	34	1666	3.19	14.82	7.85
RE04	G1	50	1835	3.65	18.81	7.61
RE07	G1	35	759	2.79	15.64	8.31
RE08	G1	49	1072	3.79	19.81	7.51
RE10	G1	40	329	4.01	24.82	7.25
RE11	G1	31	372	3.63	19.76	8.60
RE12	G1	43	570	3.78	20.99	7.99
RE13	G1	22	98	3.47	22.10	8.63
RE14	G1	21	130	3.53	19.84	8.13
RN2	G1	31	2120	2.29	10.46	7.72
RN3	G1	42	906	3.62	18.76	8.18
RN3	G2	31	822	3.30	16.50	7.82
RN3	G3	33	856	3.20	15.75	7.84
RN3	G4	25	732	3.05	15.37	7.78
RN4	G1	32	473	3.20	18.40	8.42
RN4	G2	27	566	3.11	15.94	8.12
RN4	G3	24	568	3.20	15.01	9.28
RN4	G4	30	570	3.45	17.25	8.42
RN5	G1	28	742	3.03	14.35	8.50
RN5	G2	23	713	2.72	12.72	8.08
RN5	G3	26	833	2.95	14.25	7.35
RN5	G4	28	982	3.02	14.07	7.68
RN6	G1	20	378	2.76	13.00	6.50
RN6	G2	27	771	2.57	10.81	6.99
RN6	G3	30	711	3.07	14.92	7.14
RN6	G4	25	529	2.78	13.17	7.03
RN8	G1	13	234	2.21	9.37	7.02
RN8	G2	15	289	2.12	9.58	6.80
RN8	G3	16	554	2.39	10.03	6.90
RN8	G4	14	263	2.46	10.72	7.03
RN9	G1	18	173	3.13	14.90	7.74
RN9	G2	29	329	3.25	17.02	8.33
RN9	G3	24	242	3.19	17.17	7.50
RN9	G4	25	986	2.07	11.99	7.88
19R	G1	23	237	3.19	17.94	9.78
19R	G2	36	326	3.63	22.13	9.71
19R	G3	30	413	2.69	16.40	9.78
19R	G4	31	328	3.72	20.04	10.07
24R	G1	43	513	3.17	19.16	10.03
24R	G2	35	491	2.71	17.76	9.02
24R	G3	35	512	2.87	17.74	10.00
24R	G4	32	467	3.28	18.71	9.74
26R	G1	25	164	3.16	19.57	10.21

Station	Grabb	S	N	H	ES_{100}	ISI
26R	G2	24	177	3.35	19.98	9.70
26R	G3	21	195	2.31	15.20	8.28
26R	G4	26	106	3.83	25.37	9.28

Appendix H.

Table 44. Species and numbers in the grab samples. *Arter og deres individtall i grabbprøvene*

Station RE02

Gruppe	Familie	Art/Takson	G1
ANTHOZOA	Edwardsiidae	Edwardsiidae indet	17
NEMERTINEA		Nemertinea indet	11
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	509
POLYCHAETA	Polynoidae	Harmothoe sp	1
POLYCHAETA	Sigalionidae	Leanira tetragona	2
POLYCHAETA	Sigalionidae	Pholoe minuta	8
POLYCHAETA	Phyllodocidae	Eteone sp	3
POLYCHAETA	Syllidae	Typosyllis cornuta	16
POLYCHAETA	Nereidae	Ceratocephale loveni	3
POLYCHAETA	Glyceridae	Glycera sp	1
POLYCHAETA	Lumbrineridae	Lumbrineris sp	48
POLYCHAETA	Orbiniidae	Scoloplos armiger	7
POLYCHAETA	Spionidae	Prionospio cirrifera	270
POLYCHAETA	Spionidae	Scolelepis foliosa	2
POLYCHAETA	Spionidae	Spiophanes kroeyeri	112
POLYCHAETA	Cirratulidae	Chaetozone setosa	147
POLYCHAETA	Cossuridae	Cossura longocirrata	9
POLYCHAETA	Opheliidae	Ophelina sp	26
POLYCHAETA	Capitellidae	Heteromastus filiformis	27
POLYCHAETA	Oweniidae	Myriochele oculata	1
POLYCHAETA	Terebellidae	Lanassa nordenskioeldi	1
POLYCHAETA	Terebellidae	Laphania boecki	1
CAUDOFOVEATA		Caudofoveata indet	2
BIVALVIA	Nuculanidae	Yoldiella fraterna	2
BIVALVIA	Thyasiridae	Thyasira equalis	131
BIVALVIA	Thyasiridae	Thyasira pygmaea	10
BIVALVIA	Thyasiridae	Thyasira sp	260
BIVALVIA	Tellinidae	Macoma calcarea	6
BIVALVIA	Scrobiculariidae	Abra nitida	20
BIVALVIA	Cuspidariidae	Cuspidaria obesa	1
AMPHIPODA	Oedicerotidae	Paroediceros propinquus	2
SIPUNCULIDA		Golfingia sp	6
SIPUNCULIDA		Phascolion strombi	1
HOLOTHUROIDEA	Synaptidae	Labidoplax buski	3

Station RE04

Gruppe	Familie	Art/Takson	G1
ANTHOZOA	Edwardsiidae	Edwardsiidae indet	1
NEMERTINEA		Nemertinea indet	12
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	349
POLYCHAETA	Polynoidae	Harmothoe sp	2
POLYCHAETA	Sigalionidae	Pholoe minuta	70

POLYCHAETA	Phyllodocidae	Eteone sp	1
POLYCHAETA	Phyllodocidae	Phyllodoce groenlandica	1
POLYCHAETA	Phyllodocidae	Phyllodocidae indet	1
POLYCHAETA	Hesionidae	Nereimyra punctata	1
POLYCHAETA	Syllidae	Typosyllis cornuta	36
POLYCHAETA	Nereidae	Ceratocephale loveni	2
POLYCHAETA	Glyceridae	Glycera cf. lapidum	1
POLYCHAETA	Glyceridae	Glycera lapidum	4
POLYCHAETA	Goniadidae	Goniada maculata	1
POLYCHAETA	Lumbrineridae	Lumbrineris sp	77
POLYCHAETA	Orbiniidae	Scoloplos armiger	71
POLYCHAETA	Spionidae	Prionospio cirrifera	65
POLYCHAETA	Spionidae	Pseudopolydora sp	27
POLYCHAETA	Spionidae	Scolelepis foliosa	1
POLYCHAETA	Spionidae	Spio cf. filicornis	1
POLYCHAETA	Spionidae	Spiophanes kroeyeri	1
POLYCHAETA	Cirratulidae	Chaetozone setosa	476
POLYCHAETA	Cirratulidae	Cirratulidae indet	1
POLYCHAETA	Cirratulidae	Tharyx sp	16
POLYCHAETA	Cossuridae	Cossura longocirrata	47
POLYCHAETA	Flabelligeridae	Diplocirrus glaucus	1
POLYCHAETA	Opheliidae	Ophelina modesta	3
POLYCHAETA	Opheliidae	Ophelina sp	1
POLYCHAETA	Capitellidae	Capitella capitata	1
POLYCHAETA	Capitellidae	Heteromastus filiformis	129
POLYCHAETA	Maldanidae	Euclymeninae indet	3
POLYCHAETA	Ampharetidae	Ampharete sp	1
POLYCHAETA	Terebellidae	Proclea cf. malmgreni	1
POLYCHAETA	Terebellidae	Streblosoma intestinalis	6
POLYCHAETA	Sabellidae	Sabellidae indet	5
PROSOBRANCHIA	Naticidae	Lunatia montagui	2
PROSOBRANCHIA	Buccinidae	Buccinum undatum	1
CAUDOFOVEATA		Caudofoveata indet	18
BIVALVIA	Nuculanidae	Yoldiella lenticula	1
BIVALVIA	Thyasiridae	Thyasira cf. orbiculata	75
BIVALVIA	Thyasiridae	Thyasira equalis	14
BIVALVIA	Thyasiridae	Thyasira pygmaea	17
BIVALVIA	Thyasiridae	Thyasira sp	82
BIVALVIA	Tellinidae	Macoma calcarea	14
BIVALVIA	Scrobiculariidae	Abra nitida	6
BIVALVIA	Kelliellidae	Kelliella miliaris	184
CUMACEA	Leuconidae	Eudorella emarginata	2
SIPUNCULIDA		Golfingia sp	1
SIPUNCULIDA		Phascolion strombi	1
OPHIUROIDEA	Ophiuridae	Ophiura sp	1

Station RE07

Gruppe	Familie	Art/Takson	G1
NEMERTINEA		Nemertinea indet	7
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	79
POLYCHAETA	Polynoidae	Harmothoe sp	1
POLYCHAETA	Phyllodocidae	Chaetoparia nilssoni	1
POLYCHAETA	Syllidae	Typosyllis cornuta	37
POLYCHAETA	Nereidae	Ceratocephale loveni	2
POLYCHAETA	Lumbrineridae	Lumbrineris sp	6
POLYCHAETA	Orbiniidae	Scoloplos armiger	9
POLYCHAETA	Spionidae	Prionospio cirrifera	2
POLYCHAETA	Spionidae	Spiophanes kroeyeri	382
POLYCHAETA	Cirratulidae	Chaetozone setosa	29
POLYCHAETA	Cirratulidae	Tharyx sp	6
POLYCHAETA	Cossuridae	Cossura longocirrata	2
POLYCHAETA	Opheliidae	Ophelina modesta	5
POLYCHAETA	Capitellidae	Heteromastus filiformis	8
POLYCHAETA	Maldanidae	Euclymeninae indet	1
POLYCHAETA	Oweniidae	Myriochele oculata	1
POLYCHAETA	Ampharetidae	Amphicteis gunneri	2
POLYCHAETA	Terebellidae	Laphania boecki	1
POLYCHAETA	Sabellidae	Fabriciinae indet	26
PROSOBRANCHIA	Naticidae	Lunatia montagui	1
BIVALVIA	Nuculanidae	Yoldiella fraterna	1
BIVALVIA	Nuculanidae	Yoldiella lenticula	1
BIVALVIA	Nuculanidae	Yoldiella lucida	1
BIVALVIA	Thyasiridae	Thyasira equalis	90
BIVALVIA	Thyasiridae	Thyasira pygmaea	1
BIVALVIA	Thyasiridae	Thyasira sp	10
BIVALVIA	Tellinidae	Macoma calcarea	1
BIVALVIA	Scrobiculariidae	Abra nitida	4
BIVALVIA	Kelliellidae	Kelliella miliaris	15
AMPHIPODA	Oedicerotidae	Paroediceros propinquus	1
SIPUNCULIDA		Golfingia sp	23
SIPUNCULIDA		Phascolion strombi	1
ASTEROIDEA	Goniopectinidae	Ctenodiscus crispatus	1
ECHINOIDEA	Schizasteridae	Brisaster fragilis	1

Station RE08

Gruppe	Familie	Art/Takson	G1
ANTHOZOA	Edwardsiidae	Edwardsiidae indet	1
NEMERTINEA		Nemertinea indet	5
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	118
POLYCHAETA	Aphroditidae	Aphrodita aculeata	1
POLYCHAETA	Polynoidae	Harmothoe sp	4
POLYCHAETA	Sigalionidae	Pholoe minuta	19
POLYCHAETA	Phyllodocidae	Eteone sp	9
POLYCHAETA	Phyllodocidae	Phyllodoce sp	1
POLYCHAETA	Hesionidae	Nereimyra punctata	3

POLYCHAETA	Syllidae	Typosyllis cornuta	20
POLYCHAETA	Nereidae	Ceratocephale loveni	1
POLYCHAETA	Nephtyidae	Nephtys hombergii	1
POLYCHAETA	Glyceridae	Glycera lapidum	1
POLYCHAETA	Goniadidae	Goniada maculata	1
POLYCHAETA	Lumbrineridae	Lumbrineris sp	32
POLYCHAETA	Dorvilleidae	Schistomeringos caeca	1
POLYCHAETA	Orbiniidae	Scoloplos armiger	106
POLYCHAETA	Paraonidae	Levinsenia gracilis	2
POLYCHAETA	Spionidae	Prionospio cirrifera	164
POLYCHAETA	Spionidae	Pseudopolydora sp	1
POLYCHAETA	Spionidae	Spiophanes kroeyeri	212
POLYCHAETA	Cirratulidae	Chaetozone setosa	42
POLYCHAETA	Cirratulidae	Tharyx sp	4
POLYCHAETA	Cossuridae	Cossura longocirrata	8
POLYCHAETA	Opheliidae	Ophelina modesta	18
POLYCHAETA	Capitellidae	Capitella capitata	5
POLYCHAETA	Capitellidae	Heteromastus filiformis	131
POLYCHAETA	Maldanidae	Euclymeninae indet	2
POLYCHAETA	Oweniidae	Owenia fusiformis	1
POLYCHAETA	Ampharetidae	Amphicteis gunneri	1
POLYCHAETA	Ampharetidae	Mugga wahrbergi	1
POLYCHAETA	Terebellidae	Lanassa venusta	3
POLYCHAETA	Terebellidae	Proclea graffii	1
POLYCHAETA	Sabellidae	Sabellidae indet	28
PROSOBRANCHIA	Naticidae	Lunatia montagui	1
OPISTOBRANCHIA		Tectibranchia indet	1
CAUDOFOVEATA		Caudofoveata indet	1
BIVALVIA	Thyasiridae	Thyasira cf. orbiculata	70
BIVALVIA	Thyasiridae	Thyasira equalis	5
BIVALVIA	Thyasiridae	Thyasira pygmaea	13
BIVALVIA	Lasaeidae	Mysella bidentata	7
BIVALVIA	Tellinidae	Macoma calcarea	1
BIVALVIA	Scrobiculariidae	Abra nitida	4
BIVALVIA	Kelliellidae	Kelliella miliaris	12
BIVALVIA	Pholadidae	Xylophaga sp	1
ISOPODA	Parasellidae	Eurycope cornuta	1
AMPHIPODA	Lysianassidae	Hoplonyx sp	1
OPHIUROIDEA	Ophiuridae	Ophiura sp	5
HOLOTHUROIDEA	Synaptidae	Labidoplax buski	1

Station RE10

Gruppe	Familie	Art/Takson	G1
NEMERTINEA		Nemertinea indet	1
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	1
POLYCHAETA	Sigalionidae	Pholoe minuta	5
POLYCHAETA	Sigalionidae	Sthenelais sp	1
POLYCHAETA	Hesionidae	Nereimyra punctata	1
POLYCHAETA	Syllidae	Typosyllis cornuta	1
POLYCHAETA	Nereidae	Ceratocephale loveni	2
POLYCHAETA	Nephtyidae	Nephtys ciliata	1
POLYCHAETA	Sphaerodoridae	Sphaerodorum flavum	1
POLYCHAETA	Lumbrineridae	Lumbrineris sp	3
POLYCHAETA	Orbiniidae	Scoloplos armiger	16
POLYCHAETA	Spionidae	Prionospio cirrifera	81
POLYCHAETA	Spionidae	Pseudopolydora sp	24
POLYCHAETA	Spionidae	Spio filicornis	1
POLYCHAETA	Spionidae	Spiophanes kroeyeri	2
POLYCHAETA	Cirratulidae	Chaetozone setosa	13
POLYCHAETA	Cossuridae	Cossura longocirrata	1
POLYCHAETA	Flabelligeridae	Diplocirrus glaucus	2
POLYCHAETA	Scalibregmidae	Scalibregma inflatum	2
POLYCHAETA	Capitellidae	Heteromastus filiformis	11
POLYCHAETA	Oweniidae	Myriochele oculata	14
POLYCHAETA	Oweniidae	Owenia fusiformis	14
POLYCHAETA	Sternaspiidae	Sternaspis scutata	55
POLYCHAETA	Ampharetidae	Melinna cristata	1
POLYCHAETA	Ampharetidae	Sabellides borealis	3
POLYCHAETA	Sabellidae	Sabellidae indet	3
PROSOBRANCHIA	Naticidae	Lunatia montagui	1
OPISTOBRANCHIA	Philinidae	Philine scabra	2
CAUDOFOVEATA		Caudofoveata indet	3
BIVALVIA	Nuculanidae	Yoldiella lenticula	3
BIVALVIA	Thyasiridae	Thyasira cf. sarsi	15
BIVALVIA	Thyasiridae	Thyasira equalis	14
BIVALVIA	Thyasiridae	Thyasira pygmaea	1
BIVALVIA	Lasaeidae	Mysella bidentata	1
BIVALVIA	Cardiidae	Parvicardium minimum	11
BIVALVIA	Tellinidae	Macoma calcarea	2
BIVALVIA	Scrobiculariidae	Abra nitida	8
BIVALVIA	Kelliellidae	Kelliella miliaris	3
CUMACEA	Leuconidae	Eudorella cf. truncatula	1
OPHIUROIDEA	Ophiuridae	Ophiura sp	4

Station RE11

Gruppe	Familie	Art/Takson	G1
NEMERTINEA		Nemertinea indet	3
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	30
POLYCHAETA	Syllidae	Typosyllis cornuta	4
POLYCHAETA	Lumbrineridae	Lumbrineris sp	4
POLYCHAETA	Orbiniidae	Scoloplos armiger	6
POLYCHAETA	Spionidae	Prionospio cirrifera	2
POLYCHAETA	Spionidae	Pseudopolydora sp	1
POLYCHAETA	Cirratulidae	Chaetozone setosa	5
POLYCHAETA	Cirratulidae	Tharyx sp	2
POLYCHAETA	Scalibregmidae	Polyphysia crassa	1
POLYCHAETA	Capitellidae	Heteromastus filiformis	12
POLYCHAETA	Capitellidae	Notomastus latericeus	1
POLYCHAETA	Maldanidae	Asychis biceps	1
POLYCHAETA	Oweniidae	Myriochele oculata	37
POLYCHAETA	Ampharetidae	Melinna cristata	1
POLYCHAETA	Terebellidae	Streblosoma intestinalis	2
CAUDOFOVEATA		Caudofoveata indet	3
BIVALVIA	Nuculanidae	Yoldiella fraterna	10
BIVALVIA	Nuculanidae	Yoldiella lenticula	59
BIVALVIA	Thyasiridae	Thyasira cf. pygmaea	19
BIVALVIA	Thyasiridae	Thyasira equalis	4
BIVALVIA	Thyasiridae	Thyasira sp	47
BIVALVIA	Kelliellidae	Kelliella miliaris	90
CUMACEA	Leuconidae	Leucon nasica	7
CUMACEA	Diastylidae	Diastylis scorpioides	1
AMPHIPODA	Lysianassidae	Onesimus plautus	1
AMPHIPODA	Oedicerotidae	Arrhis phyllonx	1
SIPUNCULIDA		Golfingia sp	12
ASTEROIDEA	Goniopectinidae	Ctenodiscus crispatus	2
OPHIUROIDEA	Ophiuridae	Ophiura sp	2
VARIA		Vermiformis indet	2

Station RE12

Gruppe	Familie	Art/Takson	G1
NEMERTINEA		Nemertinea indet	12
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	21
POLYCHAETA	Polynoidae	Harmothoe sp	1
POLYCHAETA	Sigalionidae	Pholoe minuta	13
POLYCHAETA	Phyllodocidae	Eteone sp	2
POLYCHAETA	Syllidae	Typosyllis cornuta	1
POLYCHAETA	Nereidae	Ceratocephale loveni	5
POLYCHAETA	Glyceridae	Glycera lapidum	5
POLYCHAETA	Lumbrineridae	Lumbrineris sp	18
POLYCHAETA	Dorvilleidae	Ophryotrocha sp	1
POLYCHAETA	Orbiniidae	Scoloplos armiger	4
POLYCHAETA	Spionidae	Prionospio cirrifera	43
POLYCHAETA	Cirratulidae	Chaetozone setosa	102
POLYCHAETA	Cirratulidae	Tharyx sp	3
POLYCHAETA	Cossuridae	Cossura longocirrata	102
POLYCHAETA	Scalibregmidae	Scalibregma inflatum	1
POLYCHAETA	Opheliidae	Ophelina modesta	7
POLYCHAETA	Capitellidae	Heteromastus filiformis	105
POLYCHAETA	Maldanidae	Euclymeninae indet	1
POLYCHAETA	Terebellidae	Laphania boecki	1
POLYCHAETA	Sabellidae	Sabellidae indet	1
OLIGOCHAETA		Oligochaeta indet	2
CAUDOFOVEATA		Caudofoveata indet	4
BIVALVIA	Nuculanidae	Yoldiella fraterna	2
BIVALVIA	Nuculanidae	Yoldiella lenticula	33
BIVALVIA	Pectinidae	Delectopecten vitreus	2
BIVALVIA	Thyasiridae	Thyasira equalis	23
BIVALVIA	Thyasiridae	Thyasira pygmaea	1
BIVALVIA	Tellinidae	Macoma calcarea	1
BIVALVIA	Kelliellidae	Kelliella miliaris	27
BIVALVIA	Cuspidariidae	Cuspidaria obesa	1
CUMACEA	Leuconidae	Leucon nasica	5
CUMACEA	Nannastacidae	Campylaspis rubicunda	1
CUMACEA	Diastylidae	Diastyloides serrata	1
TANAIDACEA	Parathanidae	Tanaidacea indet	1
ISOPODA	Gnathidae	Gnathia maxillaris	3
AMPHIPODA	Oedicerotidae	Arrhis phyllonx	2
AMPHIPODA	Oedicerotidae	Paroediceros propinquus	1
SIPUNCULIDA		Golfingia sp	1
SIPUNCULIDA		Sipunculida indet	1
ASTEROIDEA	Goniopectinidae	Ctenodiscus crispatus	1
OPHIUROIDEA		Ophiuroidea indet	4
OPHIUROIDEA	Ophiuridae	Ophiura sp	4

Station RE13

Gruppe	Familie	Art/Takson	G1
NEMERTINEA		Nemertinea indet	7
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	19
POLYCHAETA	Pilargiidae	Synelmis klatti	1
POLYCHAETA	Lumbrineridae	Lumbrineris sp	6
POLYCHAETA	Spionidae	Prionospio cirrifera	2
POLYCHAETA	Spionidae	Spiophanes kroeyeri	4
POLYCHAETA	Cirratulidae	Chaetozone setosa	7
POLYCHAETA	Cirratulidae	Tharyx sp	1
POLYCHAETA	Opheliidae	Ophelina sp	1
POLYCHAETA	Capitellidae	Heteromastus filiformis	8
POLYCHAETA	Ampharetidae	Ampharete sp	1
POLYCHAETA	Ampharetidae	Ampharetidae indet	1
POLYCHAETA	Ampharetidae	Melinna cristata	1
POLYCHAETA	Ampharetidae	Mugga wahrbergi	1
POLYCHAETA	Trichobranchidae	Terebellides stroemi	1
CAUDOFOVEATA		Caudofoveata indet	1
BIVALVIA	Nuculanidae	Yoldiella fraterna	27
BIVALVIA	Pectinidae	Delectopecten vitreus	1
BIVALVIA	Thyasiridae	Thyasira equalis	4
CUMACEA	Diastylidae	Diastyloides serrata	2
AMPHIPODA	Oedicerotidae	Monoculodes sp	1
ECHINOIDEA	Schizasteridae	Brisaster fragilis	1

Station RE14

Gruppe	Familie	Art/Takson	G1
NEMERTINEA		Nemertinea indet	3
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	20
POLYCHAETA	Syllidae	Typosyllis cornuta	2
POLYCHAETA	Lumbrineridae	Lumbrineris sp	3
POLYCHAETA	Spionidae	Prionospio cirrifera	8
POLYCHAETA	Cirratulidae	Chaetozone setosa	6
POLYCHAETA	Cirratulidae	Tharyx sp	4
POLYCHAETA	Opheliidae	Ophelina modesta	1
POLYCHAETA	Capitellidae	Heteromastus filiformis	3
POLYCHAETA	Ampharetidae	Amphicteis gunneri	1
POLYCHAETA	Terebellidae	Laphania boecki	3
CAUDOFOVEATA		Caudofoveata indet	3
BIVALVIA	Nuculanidae	Yoldiella lenticula	38
BIVALVIA	Thyasiridae	Thyasira equalis	13
BIVALVIA	Tellinidae	Macoma calcarea	1
BIVALVIA	Kelliellidae	Kelliella miliaris	2
CUMACEA	Leuconidae	Leucon nasica	10
CUMACEA	Diastylidae	Diastyloides serrata	3
AMPHIPODA	Oedicerotidae	Arrhis phyllonx	1
SIPUNCULIDA		Golfingia sp	3
SIPUNCULIDA		Phascolion strombi	2

Station RN2

Gruppe	Familie	Art/Takson	G1
NEMERTINEA		Nemertinea indet	9
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	295
POLYCHAETA	Sigalionidae	Pholoe minuta	15
POLYCHAETA	Phyllodocidae	Eteone sp	2
POLYCHAETA	Syllidae	Typosyllis cornuta	40
POLYCHAETA	Nereidae	Ceratocephale loveni	5
POLYCHAETA	Glyceridae	Glycera lapidum	1
POLYCHAETA	Lumbrineridae	Lumbrineris sp	87
POLYCHAETA	Orbiniidae	Scoloplos armiger	171
POLYCHAETA	Spionidae	Prionospio cirrifera	205
POLYCHAETA	Spionidae	Pseudopolydora sp	3
POLYCHAETA	Spionidae	Scolelepis foliosa	2
POLYCHAETA	Spionidae	Spiophanes kroeyeri	9
POLYCHAETA	Cirratulidae	Chaetozone setosa	1170
POLYCHAETA	Cirratulidae	Tharyx sp	1
POLYCHAETA	Cossuridae	Cossura longocirrata	61
POLYCHAETA	Opheliidae	Ophelina cf. modesta	12
POLYCHAETA	Capitellidae	Capitella capitata	10
POLYCHAETA	Capitellidae	Heteromastus filiformis	4
POLYCHAETA	Ampharetidae	Ampharete sp	1
POLYCHAETA	Ampharetidae	Sabellides borealis	1
POLYCHAETA	Terebellidae	Lanassa venusta	1
POLYCHAETA	Terebellidae	Streblosoma intestinalis	1
POLYCHAETA	Trichobranchidae	Terebellides stroemi	1
PROSOBRANCHIA	Naticidae	Lunatia montagui	2
OPISTOBRANCHIA	Philinidae	Philine scabra	1
CAUDOFOVEATA		Caudofoveata indet	1
BIVALVIA	Thyasiridae	Thyasira pygmaea	1
BIVALVIA	Kelliellidae	Kelliella miliaris	1
AMPHIPODA	Oedicerotidae	Monoculodes packardi	1
OPHIUROIDEA	Ophiuridae	Ophiura sp	6

Station RN3

Gruppe	Familie	Art/Takson	G1	G2	G3	G4	Sum
ANTHOZOA		Anthozoa indet	4				4
ANTHOZOA	Edwardsiidae	Edwardsia sp	4	3	2		9
NEMERTINEA		Nemertinea indet	7	9	6	9	31
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	79	69	72	48	268
POLYCHAETA	Sigalionidae	Leanira tetragona	5	1	2	2	10
POLYCHAETA	Sigalionidae	Pholoe minuta	2	2	2	1	7
POLYCHAETA	Phyllodocidae	Chaetoparia nilssoni	1				1
POLYCHAETA	Pilargiidae	Synelmis klatti	2		1		3
POLYCHAETA	Syllidae	Typosyllis cornuta	9	23	3	10	45
POLYCHAETA	Nereidae	Ceratocephale loveni	6				6
POLYCHAETA	Glyceridae	Glycera lapidum	3		1		4
POLYCHAETA	Lumbrineridae	Lumbrineris sp	4	1	6	6	17

POLYCHAETA	Orbiniidae	Scoloplos armiger		1	1	3	5
POLYCHAETA	Paraonidae	Cirrophorus cf. lyra			1		1
POLYCHAETA	Spionidae	Prionospio cirrifera	65	36	130	75	306
POLYCHAETA	Spionidae	Spiophanes kroeyeri	107	184	177	159	627
POLYCHAETA	Chaetopteridae	Spiochaetopterus typicus	1		1		2
POLYCHAETA	Cirratulidae	Chaetozone setosa	101	50	66	62	279
POLYCHAETA	Cirratulidae	Tharyx sp		4			4
POLYCHAETA	Cossuridae	Cossura longocirrata	8	1	9	7	25
POLYCHAETA	Flabelligeridae	Diplocirrus glaucus			1		1
POLYCHAETA	Scalibregmidae	Polyphysia crassa	2	1	2		5
POLYCHAETA	Opheliidae	Ophelina modesta	6	3	9	4	22
POLYCHAETA	Capitellidae	Heteromastus filiformis	8	8	11	2	29
POLYCHAETA	Oweniidae	Myriochele oculata	26	20	8		54
POLYCHAETA	Ampharetidae	Amphicteis gunneri	1	1		1	3
POLYCHAETA	Sabellidae	Sabellidae indet	2	9	7	19	37
OLIGOCHAETA		Oligochaeta indet	3			3	6
CAUDOFOVEATA		Caudofoveata indet		4			4
BIVALVIA	Nuculanidae	Yoldiella fraterna	6	8		12	26
BIVALVIA	Nuculanidae	Yoldiella lenticula	2			2	4
BIVALVIA	Nuculanidae	Yoldiella lucida	1		1		2
BIVALVIA	Thyasiridae	Thyasira cf. equalis	252	246	248	255	1001
BIVALVIA	Thyasiridae	Thyasira cf. obsoleta				2	2
BIVALVIA	Thyasiridae	Thyasira pygmaea	74	10	20	12	116
BIVALVIA	Tellinidae	Macoma calcarea	2	4	2		8
BIVALVIA	Scrobiculariidae	Abra nitida	61	55	26	19	161
BIVALVIA	Kelliellidae	Kelliella miliaris	22	51	8	12	93
BIVALVIA	Cuspidariidae	Cuspidaria obesa	2	2			4
OSTRACODA	Cypridinidae	Philomedes globosus	1				1
TANAIDACEA	Parathanidae	Tanaidacea indet	1		1	4	6
ISOPODA	Parasellidae	Munnopsis typica	1				1
AMPHIPODA	Lysianassidae	Lysianassidae indet	1				1
AMPHIPODA	Oedicerotidae	Paroediceros propinquus	2	1			3
AMPHIPODA	Phoxocephalidae	Harpinia pectinata		1	1		2
SIPUNCULIDA		Golfingia sp	19	13	27	3	62
ASTEROIDEA	Goniopectinidae	Ctenodiscus crispatus	1				1
OPHIUROIDEA	Ophiuridae	Ophiocten sericeum	1	1	2		4
ECHINOIDEA	Schizasteridae	Brisaster fragilis			2		2
VARIA		Ubestemt indet	1				1

Station RN4

Gruppe	Familie	Art/Takson	G1	G2	G3	G4	Sum
ANTHOZOA	Edwardsiidae	Edwardsia sp	10	2	11	5	28
ANTHOZOA	Edwardsiidae	Edwardsiidae indet		24	9	17	50
NEMERTINEA		Nemertinea indet	6	6	6	9	27
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	23	8	7	25	63
POLYCHAETA	Aphroditidae	Aphrodita aculeata			1		1
POLYCHAETA	Sigalionidae	Leanira tetragona	4		3	1	8
POLYCHAETA	Sigalionidae	Pholoe minuta	2				2
POLYCHAETA	Phyllodocidae	Chaetoparia nilssoni	1			1	2
POLYCHAETA	Syllidae	Typosyllis cornuta	17	14	13	9	53
POLYCHAETA	Nephtyidae	Nephtys paradoxa		1			1
POLYCHAETA	Sphaerodoridae	Sphaerodoridium philippi		1			1
POLYCHAETA	Lumbrineridae	Lumbrineris sp	4	3			7
POLYCHAETA	Paraonidae	Cirrophorus cf. lyra	2	6		4	12
POLYCHAETA	Paraonidae	Levinsenia gracilis			2		2
POLYCHAETA	Spionidae	Prionospio cirrifera	2	3			5
POLYCHAETA	Spionidae	Spiophanes kroeyeri	185	147	103	111	546
POLYCHAETA	Chaetopteridae	Spiochaetopterus typicus		1			1
POLYCHAETA	Cirratulidae	Chaetozone setosa	8	6	3	2	19
POLYCHAETA	Cirratulidae	Tharyx sp	2			1	3
POLYCHAETA	Scalibregmidae	Polyphysia crassa	2	5		3	10
POLYCHAETA	Opheliidae	Ophelina cf. modesta	1	1	1	1	4
POLYCHAETA	Capitellidae	Heteromastus filiformis	5	5		1	11
POLYCHAETA	Oweniidae	Myriochele oculata	1				1
POLYCHAETA	Ampharetidae	Ampharete sp	1		1	1	3
POLYCHAETA	Ampharetidae	Amphicteis gunneri		1		1	2
POLYCHAETA	Ampharetidae	Sosanopsis wireni	1				1
BIVALVIA	Nuculanidae	Yoldiella fraterna	23		49	49	121
BIVALVIA	Nuculanidae	Yoldiella lenticula	10	26	28	38	102
BIVALVIA	Nuculanidae	Yoldiella lucida	3	4	8	9	24
BIVALVIA	Pectinidae	Delectopecten vitreus		4	2	3	9
BIVALVIA	Thyasiridae	Thyasira cf. equalis	70	72	93	88	323
BIVALVIA	Thyasiridae	Thyasira cf. obsoleta	6				6
BIVALVIA	Thyasiridae	Thyasira pygmaea	8	47	53	37	145
BIVALVIA	Scrobiculariidae	Abra nitida	2	3	8	7	20
BIVALVIA	Kelliellidae	Kelliella miliaris	64	165	156	130	515
BIVALVIA	Cuspidariidae	Cuspidaria obesa		2	1	5	8
CUMACEA	Leuconidae	Eudorella emarginata	1			3	4
CUMACEA	Diastylidae	Diastyloides serrata	1				1
AMPHIPODA	Phoxocephalidae	Harpinia pectinata	1	8	8	4	21
DECAPODA		Zoealarve				1	1
SIPUNCULIDA		Golfingia sp			1		1
ASTEROIDEA	Goniopectinidae	Ctenodiscus crispatus	1				1
OPHIUROIDEA	Ophiuridae	Ophiocten sericeum	6	1	1	4	12

Station RN5

Gruppe	Familie	Art/Takson	G1	G2	G3	G4	Sum
ANTHOZOA	Edwardsiidae	Edwardsia sp	4	11	20	17	52
ANTHOZOA	Edwardsiidae	Edwardsiidae indet	4	5	3	10	22
NEMERTINEA		Nemertinea indet	7	1	6	9	23
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	34	49	22	36	141
POLYCHAETA	Polynoidae	Harmothoe sp	1		1	2	4
POLYCHAETA	Sigalionidae	Leanira tetragona			5	6	11
POLYCHAETA	Sigalionidae	Pholoe minuta			4		4
POLYCHAETA	Pilargiidae	Synelmis klatti	1				1
POLYCHAETA	Syllidae	Typosyllis cornuta	5	7	9	9	30
POLYCHAETA	Lumbrineridae	Lumbrineris sp		2	1	1	4
POLYCHAETA	Paraonidae	Cirrophorus cf. lyra	3		1	3	7
POLYCHAETA	Spionidae	Prionospio cirrifera	1	1	2	4	8
POLYCHAETA	Spionidae	Spiophanes kroeyeri	112	102	101	109	424
POLYCHAETA	Cirratulidae	Chaetozone setosa	6	20	24	13	63
POLYCHAETA	Cirratulidae	Tharyx sp				1	1
POLYCHAETA	Scalibregmidae	Polyphysia crassa	4	1	1	3	9
POLYCHAETA	Opheliidae	Ophelina cf. modesta	1				1
POLYCHAETA	Opheliidae	Ophelina modesta			5	2	7
POLYCHAETA	Capitellidae	Heteromastus filiformis	3	3	5		11
POLYCHAETA	Oweniidae	Myriochele oculata	6	3	8	4	21
POLYCHAETA	Ampharetidae	Ampharete sp	1	1			2
POLYCHAETA	Ampharetidae	Amphicteis gunneri				1	1
POLYCHAETA	Ampharetidae	Mugga wahrbergi	1				1
BIVALVIA	Nuculidae	Nucula tumidula		1			1
BIVALVIA	Nuculanidae	Yoldiella fraterna	18	15			33
BIVALVIA	Nuculanidae	Yoldiella lenticula	30	13	73	102	218
BIVALVIA	Nuculanidae	Yoldiella lucida	2	1	2	5	10
BIVALVIA	Nuculanidae	Yoldiella sp				1	1
BIVALVIA	Pectinidae	Delectopecten vitreus	47	13	35	73	168
BIVALVIA	Thyasiridae	Thyasira cf. equalis	172	194	310	257	933
BIVALVIA	Thyasiridae	Thyasira pygmaea	38	16	22	25	101
BIVALVIA	Scrobiculariidae	Abra nitida	1	2	3	5	11
BIVALVIA	Kelliellidae	Kelliella miliaris	232	251	168	281	932
BIVALVIA	Cuspidariidae	Cuspidaria obesa	2				2
OSTRACODA	Conchoeciidae	Conchoecia elegans				1	1
CUMACEA	Leuconidae	Leucon nasica			1		1
ISOPODA	Parasellidae	Munnopsis typica				1	1
AMPHIPODA	Oedicerotidae	Bathymedon saussurei			1		1
DECAPODA		Zoealarve		1			1
DECAPODA	Pandalidae	Pandalus borealis	1				1
SIPUNCULIDA		Golfingia sp	5				5
OPHIUROIDEA	Ophiuridae	Ophiocten sericeum				1	1

Station RN6

Gruppe	Familie	Art/Takson	G1	G2	G3	G4	Sum
ANTHOZOA	Edwardsiidae	Edwardsia sp		1	4	1	6
PLATYHELMINTHES		Platyhelminthes indet			1		1
NEMERTINEA		Nemertinea indet	4	2	6	3	15
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	108	236	122	106	572
POLYCHAETA	Sigalionidae	Leanira tetragona	2	3	5	6	16
POLYCHAETA	Sigalionidae	Pholoe minuta	2	1	2	2	7
POLYCHAETA	Phyllodocidae	Eteone sp		1	1		2
POLYCHAETA	Pilargiidae	Synelmis klatti				1	1
POLYCHAETA	Syllidae	Exogone sp		1			1
POLYCHAETA	Syllidae	Syllinae indet		1			1
POLYCHAETA	Syllidae	Typosyllis cornuta	2		3		5
POLYCHAETA	Nereidae	Ceratocephale loveni	1		4		5
POLYCHAETA	Nephtyidae	Nephtys ciliata	1				1
POLYCHAETA	Glyceridae	Glycera lapidum			1		1
POLYCHAETA	Orbiniidae	Scoloplos armiger				3	3
POLYCHAETA	Paraonidae	Levinsenia gracilis		1			1
POLYCHAETA	Spionidae	Prionospio cirrifera	10	5	24	15	54
POLYCHAETA	Spionidae	Spiophanes kroeyeri		1	1		2
POLYCHAETA	Spionidae	Spiophanes sp	2				2
POLYCHAETA	Cirratulidae	Chaetozone setosa	45	235	192	141	613
POLYCHAETA	Cirratulidae	Tharyx sp		2			2
POLYCHAETA	Cossuridae	Cossura longocirrata	3	8	5	4	20
POLYCHAETA	Opheliidae	Ophelina cf. modesta	38	57	67	31	193
POLYCHAETA	Capitellidae	Capitella capitata	4	11	17	17	49
POLYCHAETA	Capitellidae	Heteromastus filiformis	1	14	15	4	34
POLYCHAETA	Oweniidae	Myriochele oculata				1	1
POLYCHAETA	Sabellidae	Sabellidae indet			1		1
OLIGOCHAETA		Oligochaeta indet				1	1
CAUDOFOVEATA		Caudofoveata indet			1		1
BIVALVIA	Nuculanidae	Yoldiella fraterna			3		3
BIVALVIA	Thyasiridae	Thyasira cf. equalis	136	181	211	179	707
BIVALVIA	Thyasiridae	Thyasira pygmaea	2	2	4	1	9
BIVALVIA	Tellinidae	Macoma calcarea	12	1	3	3	19
BIVALVIA	Scrobiculariidae	Abra nitida	4	1	4	2	11
BIVALVIA	Kelliellidae	Kelliella miliaris		1	2	1	4
ISOPODA	Parasellidae	Munnopsis typica				2	2
AMPHIPODA	Oedicerotidae	Bathymedon saussurei		1	1	1	3
AMPHIPODA	Phoxocephalidae	Harpinia pectinata		2	9	3	14
SIPUNCULIDA		Golfingia sp				1	1
PRIAPULIDA		Priapulus caudatus			1		1
OPHIUROIDEA	Ophiuridae	Ophiocten sericeum	1	1	1		3
ECHINOIDEA	Schizasteridae	Brisaster fragilis		1			1

Station RN8

Gruppe	Familie	Art/Takson	G1	G2	G3	G4	Sum
ANTHOZOA	Edwardsiidae	Edwardsia sp			1		1
ANTHOZOA	Edwardsiidae	Edwardsiidae indet		1			1
NEMERTINEA		Nemertinea indet	1	3	4	4	12
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	17	26	88	37	168
POLYCHAETA	Sigalionidae	Leanira tetragona	8	4	8	8	28
POLYCHAETA	Nephtyidae	Nephtys paradoxa		1		1	2
POLYCHAETA	Glyceridae	Glycera cf. lapidum		1			1
POLYCHAETA	Lumbrineridae	Lumbrineris sp		1			1
POLYCHAETA	Orbiniidae	Orbinia norvegica	1				1
POLYCHAETA	Spionidae	Prionospio cirrifera	25	21	29	11	86
POLYCHAETA	Spionidae	Spiophanes kroeyeri	1		1		2
POLYCHAETA	Chaetopteridae	Spiochaetopterus typicus	2	1		2	5
POLYCHAETA	Cirratulidae	Chaetozone setosa	105	139	267	127	638
POLYCHAETA	Cirratulidae	Tharyx sp	2	4	2		8
POLYCHAETA	Scalibregmidae	Polyphysia crassa				1	1
POLYCHAETA	Opheliidae	Ophelina cf. modesta			2		2
POLYCHAETA	Capitellidae	Heteromastus filiformis	1	2	61	3	67
POLYCHAETA	Ampharetidae	Amphicteis gunneri	1				1
POLYCHAETA	Ampharetidae	Mugga wahrbergi				1	1
BIVALVIA	Thyasiridae	Thyasira cf. equalis	66	82	77	58	283
BIVALVIA	Thyasiridae	Thyasira pygmaea			1		1
BIVALVIA	Tellinidae	Macoma calcarea		2	6	1	9
BIVALVIA	Scrobiculariidae	Abra nitida	4	1	6	9	20
OPHIUROIDEA	Ophiuridae	Ophiocten sericeum			1		1

Station RN9

Gruppe	Familie	Art/Takson	G1	G2	G3	G4	Sum
ANTHOZOA	Edwardsiidae	Edwardsia sp		2			2
NEMERTINEA		Nemertinea indet		1	3	3	7
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	21	16	12	43	92
POLYCHAETA	Sigalionidae	Leanira tetragona	2	1	3	3	9
POLYCHAETA	Sigalionidae	Pholoe minuta			1		1
POLYCHAETA	Pilargiidae	Synelmis klatti		1		2	3
POLYCHAETA	Syllidae	Typosyllis cornuta				2	2
POLYCHAETA	Nereidae	Ceratocephale loveni		1	1		2
POLYCHAETA	Nephtyidae	Nephtys paradoxa	2			1	3
POLYCHAETA	Glyceridae	Glycera lapidum			1		1
POLYCHAETA	Glyceridae	Glycera sp				1	1
POLYCHAETA	Lumbrineridae	Lumbrineris sp			1	1	2
POLYCHAETA	Orbiniidae	Orbinia norvegica		1			1
POLYCHAETA	Spionidae	Prionospio cirrifera	9	13	20	13	55
POLYCHAETA	Spionidae	Spiophanes kroeyeri			1	1	2
POLYCHAETA	Chaetopteridae	Spiochaetopterus typicus	3	6	16	3	28
POLYCHAETA	Cirratulidae	Caulleriella sp		1			1
POLYCHAETA	Cirratulidae	Chaetozone setosa	25	36	26	52	139
POLYCHAETA	Cirratulidae	Tharyx sp	2	3	1	4	10
POLYCHAETA	Cossuridae	Cossura longocirrata	1	5	4	7	17
POLYCHAETA	Opheliidae	Ophelina cf. modesta			7	56	63
POLYCHAETA	Opheliidae	Ophelina modesta	1	3			4
POLYCHAETA	Capitellidae	Heteromastus filiformis	23	14	18	71	126
POLYCHAETA	Ampharetidae	Mugga wahrbergi		1			1
PROSOBRANCHIA	Naticidae	Lunatia montagui		1			1
CAUDOFOVEATA		Caudofoveata indet		1			1
BIVALVIA	Nuculanidae	Yoldiella fraterna	2	7		14	23
BIVALVIA	Nuculanidae	Yoldiella lucida		2	3	2	7
BIVALVIA	Thyasiridae	Thyasira cf. equalis	45	100	98	655	898
BIVALVIA	Thyasiridae	Thyasira pygmaea	1	39	7	19	66
BIVALVIA	Tellinidae	Macoma calcarea	1	1			2
BIVALVIA	Scrobiculariidae	Abra nitida	2	4	3	13	22
BIVALVIA	Kelliellidae	Kelliella miliaris	28	66	13	18	125
BIVALVIA	Cuspidariidae	Cuspidaria obesa		1			1
CUMACEA	Diastylidae	Diastyloides serrata			1		1
AMPHIPODA	Oedicerotidae	Bathymedon saussurei	1	1	1	1	4
OPHIUROIDEA	Ophiuridae	Ophiocten sericeum	4	1	1	1	7

Station 19R

Gruppe	Familie	Art/Takson	G1	G2	G3	G4	Sum
NEMERTINEA		Nemertinea indet	4	2	1	1	8
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	2	3	2	8	15
POLYCHAETA	Sigalionidae	Pholoe minuta		1			1
POLYCHAETA	Lumbrineridae	Lumbrineris sp				2	2
POLYCHAETA	Arabellidae	Drilonereis filum	4	9	4	4	21
POLYCHAETA	Orbiniidae	Orbinia norvegica	1	5	2	2	10

POLYCHAETA	Cirratulidae	Tharyx sp	11	10	14	20	55
POLYCHAETA	Cossuridae	Cossura longocirrata	1				1
POLYCHAETA	Scalibregmidae	Polyphysia crassa		1			1
POLYCHAETA	Scalibregmidae	Scalibregmidae indet			1		1
POLYCHAETA	Opheliidae	Ophelina cf. modesta			2		2
POLYCHAETA	Capitellidae	Heteromastus filiformis	17	16	5	22	60
POLYCHAETA	Capitellidae	Notomastus latericeus		2			2
POLYCHAETA	Maldanidae	Asychis biceps		1			1
POLYCHAETA	Maldanidae	Maldane sarsi		2	1		3
POLYCHAETA	Oweniidae	Myriochele cf. heeri	46	31		38	115
POLYCHAETA	Ampharetidae	Ampharete sp			1		1
POLYCHAETA	Ampharetidae	Sabellides borealis		1			1
POLYCHAETA	Ampharetidae	Sabellides octocirrata			1	1	2
POLYCHAETA	Trichobranchidae	Terebellides stroemi		1			1
OLIGOCHAETA		Oligochaeta indet		1			1
PROSOBRANCHIA	Naticidae	Lunatia clausa				2	2
PROSOBRANCHIA	Naticidae	Lunatia montagui			2	2	4
PROSOBRANCHIA	Eulimidae	Eulimella scillae			1	2	3
OPISTOBRANCHIA	Scaphandridae	Cylichna alba		1	1	1	3
CAUDOFOVEATA		Caudofoveata indet	5	3	3	1	12
BIVALVIA	Nuculidae	Nucula cf. tumidula		1			1
BIVALVIA	Nuculidae	Nucula nitidosa	1	5	5	6	17
BIVALVIA	Nuculidae	Nucula tumidula	2		2	3	7
BIVALVIA	Nuculidae	Nuculoma corticata				3	3
BIVALVIA	Nuculanidae	Yoldiella fraterna	14	21	30	28	93
BIVALVIA	Nuculanidae	Yoldiella lucida	2	6	5	5	18
BIVALVIA	Mytilidae	Modiolus modiolus				1	1
BIVALVIA	Thyasiridae	Thyasira equalis	9	14	10	35	68
BIVALVIA	Thyasiridae	Thyasira obsoleta		1			1
BIVALVIA	Thyasiridae	Thyasira pygmaea	9	92	99	46	246
BIVALVIA	Scrobiculariidae	Abra nitida		1	3	1	5
BIVALVIA	Kelliellidae	Kelliella miliaris	88	68	193	71	420
BIVALVIA	Cuspidariidae	Cuspidaria obesa	1				1
OSTRACODA	Cypridinidae	Philomedes globosus	2	2	1	1	6
OSTRACODA	Cypridinidae	Philomedes lilljeborgi	2			2	4
CUMACEA	Nannastacidae	Campylaspis verrucosa		2			2
CUMACEA	Diastylidae	Diastylis rathkei				1	1
ISOPODA	Parasellidae	Munnopsis typica		1			1
AMPHIPODA	Ampeliscidae	Ampelisca aequicornis		2		1	3
AMPHIPODA	Ampeliscidae	Haploops tubicola		1			1
AMPHIPODA	Melitidae	Eriopisa elongata	4	4	5	3	16
AMPHIPODA	Phoxocephalidae	Harpinia pectinata	2	3	5	4	14
DECAPODA	Crangonidae	Pontophilus norvegicus		1			1
ASTEROIDEA	Goniopectinidae	Ctenodiscus crispatus			1		1
OPHIUROIDEA	Ophiuridae	Ophiocten sericeum	8	5	10	11	34
HOLOTHUROIDEA		Holothuroidea indet			1		1
HOLOTHUROIDEA	Synaptidae	Synaptidae indet	2	6	2		10

Station 24R

Gruppe	Familie	Art/Takson	G1	G2	G3	G4	Sum
ANTHOZOA	Edwardsiidae	Edwardsia sp		1			1
NEMERTINEA		Nemertinea indet	3	1		1	5
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	2	1	4	2	9
POLYCHAETA	Sigalionidae	Leanira tetragona	1				1
POLYCHAETA	Sigalionidae	Neoleanira tetragona			1		1
POLYCHAETA	Nephtyidae	Nephtys cf. cirrosa		1			1
POLYCHAETA	Nephtyidae	Nephtys paradoxa	1				1
POLYCHAETA	Lumbrineridae	Lumbrineris sp		2		1	3
POLYCHAETA	Arabellidae	Drilonereis filum	2	4	3	5	14
POLYCHAETA	Orbiniidae	Orbinia norvegica	3	5	4	3	15
POLYCHAETA	Orbiniidae	Scoloplos armiger			2		2
POLYCHAETA	Paraonidae	Levinsenia gracilis	2	1			3
POLYCHAETA	Chaetopteridae	Spiochaetopterus typicus				1	1
POLYCHAETA	Cirratulidae	Aphelochaeta sp			6		6
POLYCHAETA	Cirratulidae	Chaetozone setosa		1			1
POLYCHAETA	Cirratulidae	Tharyx sp	6	4		5	15
POLYCHAETA	Cossuridae	Cossura longocirrata	1	2			3
POLYCHAETA	Flabelligeridae	Diplocirrus glaucus	1			2	3
POLYCHAETA	Scalibregmidae	Polyphysia crassa	1	2	1		4
POLYCHAETA	Opheliidae	Ophelina cf. modesta	1				1
POLYCHAETA	Capitellidae	Heteromastus filiformis	30	13	3	18	64
POLYCHAETA	Maldanidae	Maldane sarsi			1		1
POLYCHAETA	Oweniidae	Myriochele cf. heeri	26	11	6	32	75
POLYCHAETA	Oweniidae	Myriochele oculata	12	8	17	24	61
POLYCHAETA	Oweniidae	Myriochele sp		1			1
POLYCHAETA	Ampharetidae	Amage auricula	1				1
POLYCHAETA	Ampharetidae	Ampharete sp				1	1
POLYCHAETA	Ampharetidae	Melinna cristata	1	3	2	4	10
POLYCHAETA	Ampharetidae	Sabellides octocirrata	1				1
POLYCHAETA	Trichobranchidae	Terebellides stroemi	1				1
PROSOBRANCHIA	Naticidae	Lunatia montagui	1	1	1		3
PROSOBRANCHIA	Eulimidae	Eulima bilineata			1		1
PROSOBRANCHIA	Eulimidae	Eulimella scillae			1		1
OPISTOBRANCHIA	Scaphandridae	Cylichna alba		2	1	1	4
CAUDOFOVEATA		Caudofoveata indet	1		1	1	3
BIVALVIA		Bivalvia indet	1				1
BIVALVIA	Nuculidae	Nucula cf. tumidula				4	4
BIVALVIA	Nuculidae	Nucula nitidosa	1	2	1	3	7
BIVALVIA	Nuculidae	Nucula tumidula	4	1	1		6
BIVALVIA	Nuculidae	Nuculoma corticata	2	1			3
BIVALVIA	Nuculanidae	Yoldiella fraterna	53	32	38	27	150
BIVALVIA	Nuculanidae	Yoldiella lucida	24	15	16	15	70
BIVALVIA	Thyasiridae	Thyasira equalis	16	36	30	35	117
BIVALVIA	Thyasiridae	Thyasira ferruginea	1				1
BIVALVIA	Thyasiridae	Thyasira obsoleta			12		12
BIVALVIA	Thyasiridae	Thyasira pygmaea	41	31	59	33	164
BIVALVIA	Cardiidae	Parvicardium minimum				1	1
BIVALVIA	Scrobiculariidae	Abra nitida	8	3	8	18	37

BIVALVIA	Kelliellidae	Kelliella miliaris	236	281	264	200	981
BIVALVIA	Cuspidariidae	Cuspidaria obesa	1	1	1		3
BIVALVIA	Cuspidariidae	Tropidomya abbreviata	1				1
OSTRACODA	Cypridinidae	Philomedes lilljeborgi	2			1	3
AMPHIPODA	Ampeliscidae	Ampelisca aequicornis	1		1	1	3
AMPHIPODA	Ampeliscidae	Haploops tubicola	1		1		2
AMPHIPODA	Melitidae	Eriopisa elongata	4	4	5	3	16
AMPHIPODA	Oedicerotidae	Arrhis phyllonx			1		1
AMPHIPODA	Phoxocephalidae	Harpinia pectinata	11	8	8	5	32
SIPUNCULIDA		Golfingia sp	1				1
SIPUNCULIDA		Onchnesoma steenstrupi	1				1
ASTEROIDEA	Goniopectinidae	Ctenodiscus crispatus		1	1	1	3
OPHIUROIDEA	Ophiuridae	Ophiocten sericeum	3	7	5	11	26
HOLOTHUROIDEA	Synaptidae	Labidoplax buski	2	3	5	7	17
HOLOTHUROIDEA	Synaptidae	Synaptidae indet		1		1	2

Station 26R

Gruppe	Familie	Art/Takson	G1	G2	G3	G4	Sum
NEMERTINEA		Nemertinea indet	1	2	1	2	6
POLYCHAETA	Amphinomidae	Paramphinome jeffreysii	1	3	3	3	10
POLYCHAETA	Sigalionidae	Leanira tetragona	1			1	2
POLYCHAETA	Lumbrineridae	Lumbrineris sp			1		1
POLYCHAETA	Arabellidae	Drilonereis filum		2		2	4
POLYCHAETA	Orbiniidae	Orbinia norvegica	6	3	6	1	16
POLYCHAETA	Paraonidae	Levinsenia gracilis				1	1
POLYCHAETA	Spionidae	Spiophanes kroeyeri			1	3	4
POLYCHAETA	Chaetopteridae	Spiochaetopterus typicus	1		3		4
POLYCHAETA	Cirratulidae	Aphelochaeta sp	3				3
POLYCHAETA	Cirratulidae	Tharyx sp		2			2
POLYCHAETA	Scalibregmidae	Polyphysia crassa			1	1	2
POLYCHAETA	Opheliidae	Ophelina cf. modesta	2			1	3
POLYCHAETA	Capitellidae	Heteromastus filiformis	11	8	5	5	29
POLYCHAETA	Maldanidae	Euclymeninae indet	1	5		6	12
POLYCHAETA	Maldanidae	Maldane sarsi			1		1
POLYCHAETA	Oweniidae	Myriochele cf. heeri	56	62	121	5	244
POLYCHAETA	Ampharetidae	Ampharete sp		1	1	1	3
POLYCHAETA	Ampharetidae	Anobothrus gracilis		1			1
POLYCHAETA	Ampharetidae	Melinna cristata		1	1	1	3
POLYCHAETA	Ampharetidae	Samytha sexcirrata	1				1
PROSOBRANCHIA	Eulimidae	Eulima cf. stenostoma	2				2
PROSOBRANCHIA	Eulimidae	Eulima stenostoma		1			1
CAUDOFOVEATA		Caudofoveata indet	3		4	3	10
BIVALVIA	Nuculidae	Nucula tumidula	1				1
BIVALVIA	Nuculanidae	Yoldiella fraterna	17	16	17	11	61
BIVALVIA	Nuculanidae	Yoldiella lucida	1	2		1	4
BIVALVIA	Thyasiridae	Thyasira cf. orbiculata		1	1		2
BIVALVIA	Thyasiridae	Thyasira equalis	38	31	8	30	107
BIVALVIA	Thyasiridae	Thyasira pygmaea	2	6			8
BIVALVIA	Scrobiculariidae	Abra nitida		2		1	3
BIVALVIA	Kelliellidae	Kelliella miliaris	2	11	14	11	38
OSTRACODA	Cypridinidae	Philomedes globosus	1	3		3	7
AMPHIPODA	Melitidae	Eriopisa elongata	4	6	3	6	19
AMPHIPODA	Phoxocephalidae	Harpinia pectinata	6	5		1	12
AMPHIPODA	Phoxocephalidae	Paraphoxus oculatus	1	2	1	2	6
SIPUNCULIDA		Golfingia sp	1				1
ASTEROIDEA	Goniopectinidae	Ctenodiscus crispatus	1	1		3	5
ECHINOIDEA	Schizasteridae	Brisaster fragilis			1		1
HOLOTHUROIDEA	Synaptidae	Labidoplax buski			1	1	2

Table 45. Fauna parameters and status classification spanning inner to outer Ranfjorden in 1981-2003. *Faunaparametre og statusklassifisering fra indre til ytre Ranfjorden i 1981-2003.*

Station	Year	Depth	Area	IND	IND/m^2	S01	S	H	ES$_{100}$	ISI
Inner Ranfjord										
RN2	1992	92	0.2	5176	25880	41	63	2.95	16.8	7.76
RN2	2003	93	0.1	2120	21200	31	31	2.29	10.5	7.72
RA1	1981	142	0.4	1028	2570		24	3.13	13.4	6.55
RA2	1981	175	0.4	78	195		10	2.37	11.1	6.79
RA3	1981	218	0.4	43	108		7	1.39	<11	6.18
RN3	1992	232	0.2	3168	15840	34	45	3.57	16.1	8.09
RN3	2003	220	0.4	3316	8290	33	52	3.88	19.5	8.31
RA4	1981	238	0.3	219	730		24	3.14	17.7	7.65
RN4	1992	213	0.2	2436	12180	37	45	3.23	16.3	8.19
RN4	1994	215	0.2	1670	8350	36	48	3.55	18.6	8.85
RN4	1996	215	0.2	2347	11735	34	43	3.44	18.1	8.47
RN4	2003	212	0.4	2177	5443	28	45	3.61	19.5	8.91
RA5	1981	252	0.4	204	510		25	3.01	17.7	8.03
RA6	1981	320	0.4	1276	3190		17	2.03	8.4	7.00
RA7	1981	323	0.3	150	500		10	1.35	9.0	6.02
RB7	1992	325	0.2	619	3095	20	29	2.44	13.7	7.05
RN5	1992	310	0.2	2025	10125	29	33	2.76	15.1	8.22
RN5	2003	310	0.4	3270	8175	26	42	3.03	14.4	8.47
RA8	1981	321	0.4	2345	5863		23	1.94	9.3	6.82
RN6	1992	365	0.2	739	3695	13	18	2.47	9.9	6.72
RN6	2003	365	0.4	2389	5973	26	45	3.10	14.7	7.34
RA9	1981	284	0.4	187	468		21	3.21	17.1	7.24
RA0	1981	339	0.4	120	300		15	2.56	14.0	8.70
RN7	1992	425	0.2	1438	7190	32	38	3.56	17.4	7.92
R11	1981	439	0.4	412	1030		29	3.21	18.1	8.35
R12	1981	445	0.4	592	1480		26	2.39	12.7	7.44
RN8	1992	460	0.2	903	4515	21	29	2.90	14.7	7.62
RN8	2003	455	0.4	1340	3350	15	26	2.62	11.6	7.76
R13	1981	455	0.3	99	330		12	1.68	12.0	5.92
13B	1992	454	0.2	1464	7320	21	26	2.93	12.6	7.48
RN9	1992	486	0.2	931	4655	21	31	3.26	14.2	7.32
RN9	1994	491	0.2	1056	5280	22	31	2.58	13.6	7.71
RN9	1996	491	0.2	415	2075	19	24	3.45	15.8	8.11
RN9	2003	483	0.4	1730	4325	24	38	3.21	15.7	8.24
10R	1992	375	0.2	695	3475	24	33	2.88	15.4	8.68
11R	1992	517	0.2	575	2875	24	31	2.91	15.5	8.38
R15	1981	229	0.4	207	518		33	3.69	23.6	8.97
R14	1981	539	0.4	659	1648		29	3.13	14.3	8.91
17R	1992	530	0.2	383	1915	31	40	3.92	23.3	8.75
Outer Ranfjord										
19R	1992	319	0.2	709	3545	34	43	3.70	21.6	9.00
19R	2003	319	0.4	1304	3260	30	53	3.51	19.6	9.71
21R	1994	72	0.2	882	4410	51	69	3.85	25.5	9.15
21R	1996	72	0.2	803	4015	62	85	4.68	32.6	9.90
22R	1994	205	0.2	951	4755	29	39	2.99	16.9	9.21
22R	1996	205	0.2	650	3250	36	47	3.89	22.2	8.98
24R	1992	300	0.2	866	4330	40	53	3.77	21.6	9.11
24R	2003	298	0.4	1983	4958	36	63	3.13	18.9	9.76
26R	1992	455	0.2	436	2180	33	43	4.12	25.8	9.09
26R	2003	453	0.4	642	1605	24	40	3.39	20.7	9.49
27R	1994	303	0.2	248	1240	28	38	3.96	26.2	10.72
27R	1996	303	0.2	185	925	21	28	3.20	22.8	10.27

Appendix I.

Sediment data from Ranfjord 2003 (all data on dry weight)

Dry weight (TTS), grain size <63µm (GRAIN), total nitrogen (TN), total organic carbon (TOC), phosphorous (P) and metals.

Station	TTS	GRAIN<63µm	TN	TOC	P	Cd	Hg	Cu	Fe	Pb	Zn
	g/kg	% t.v.	µg/mg	µg/mg	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
RN2	639	62	<1,0	43,9	1290	0,14	0,016	64,2	89400	20	96
RN3	652	73	<1,0	6,5	1330	0,11	0,015	39	52100	20	100
RN4	552	96	<1,0	4,5	2590	0,1	0,019	48,2	69500	30	100
RN5	588	96	<1,0	5,7	2250	0,12	0,017	48,3	72300	35	130
RN6	658	77	<1,0	5	2140	0,2	0,012	38,4	58700	30	120
RN8	609	92	<1,0	5,2	1700	0,1	0,016	37,5	58900	30	130
RN9	550	90	<1,0	7,2	1720	0,18	0,025	44,5	59400	30	140
RN19	442	91	<1,0	11,8	1250	0,12	0,06	40,4	58600	70	194
RN24	455	72	<1,0	9,8	1070	0,08	0,038	22	40400	30	120
RN26	367	96	<1,0	17,1	965	0,1	0,052	28	47500	40	140

Tin (Sn) in tin-organic compounds.

Station	MBT	DBT	TBT	MPhT	DPhT	TPhT
	µgSn/kg	µgSn/kg	µgSn/kg	µgSn/kg	µgSn/kg	µgSn/kg
RN2						
RN3	<0,7	<0,6	<0,5	m	m	<0,4
RN4						
RN5	<0,7	<0,6	<0,5	m	m	<0,4
RN6	<0,7	<0,6	<0,5	m	m	<0,4
RN8	<0,7	<0,6	<0,5	m	m	<0,4
RN9						
RN19	1,69	1,02	2,17	m	m	<0,4
RN24						
RN26						

Polycyclic aromatic hydrocarbon compounds (explanation of abbreviation given below)

Station	NAP µg/kg	ACNLE µg/kg	ACNE µg/kg	FLE µg/kg	PA µg/kg	ANT µg/kg	FLU µg/kg	PYR µg/kg	BAA µg/kg	CHRTR µg/kg
RN2	294	45	80	118	401	143	600	411	504	327
RN3	23	8,5	11	12	70	25	121	96	95	74
RN4	22	8,2	11	12	66	23	113	93	82	69
RN5	21	15	11	18	128	37	174	143	78	63
RN6	14	4,2	7	7	45	16	72	57	61	69
RN8	26	8	12	14	88	28	136	111	97	79
RN9	16	5,8	8,3	8,1	56	17	91	78	54	52
RN19	23	8,3	10	9,4	110	24	265	229	170	142
RN24	8,2	10	7,2	13	122	15	184	150	56	52
RN26	7,3	<3,0	7,2	3,9	39	6,4	59	49	18	24

Station	BBF µg/kg	BKF µg/kg	BAP µg/kg	ICDP µg/kg	DBA3A µg/kg	BGHIP µg/kg	Sum PAH µg/kg	Sum KPAH µg/kg	Sum NPD µg/kg
RN2	486	143	348	234	59	227	4420	1774	695
RN3	132	44	100	87	21	91	1010,5	479	93
RN4	135	47	98	77	19	81	956,2	458	88
RN5	97	32	71	66	14	66	1034	358	149
RN6	127	43	82	62	17	68	751,2	392	59
RN8	155	54	107	101	25	113	1154	539	114
RN9	108	40	69	70	17	77	767,2	358	72
RN19	245	89	123	193	43	192	1875,7	863	133
RN24	101	36	49	79	16	83	981,4	337	130,2
RN26	69	25	21	49	9,4	57	444,2	191,4	46,3

Abbreviations used for the PAH compounds

NAP	Naftalen	**FLU**	Fluoranten	**BAP**	Benzo(a)pyren*1 (µg/kg v.v.)
ACNLE	Acenaftylen	**PYR**	Pyren	**ICDP**	Indeno(1,2,3cd)pyren
ACNE	Acenaften	**BAA**	Benz(a)antracen	**DBA3A**	Dibenz(a,c/a,h)ant
FLE	Fluoren	**CHRTR**	Chrysen+trifenylen	**BGHIP**	Benzo(ghi)perylen
PA	Fenantren	**BBF**	Benzo(b)flu		
ANT	Antracen	**BKF**	Benzo(k)flu		