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BIOLOGICAL INDICATORS IN HELSINKI AND TALLINN SEA AREAS

Report of the 4th Annual Knowledge Transfer Seminar
Tvärminne, December the 11-13th, 1996

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Ilkka Viitasalo
(Editors)

Helsinki - Tallinn
bioindicator project

Helsinki 1997

PREFACE

The distance between Helsinki and Tallinn is among of the shortest between two capitals of sovereign UN states. This geographical fact has raised many twinning activities between the cities. The biology of littoral, or coastal, aquatic zone in the vicinity of these cities, however, is not too well understood. These areas are more or less eutrophied by municipal wastewaters. Recreational activities of the citizens turn mostly to the same areas.

This report contains proceedings, minutes and conclusions of the fourth knowledge transfer seminar about water quality biomonitoring off the cities of Helsinki and Tallinn. Monitoring was initially based on brackish water macrophytes but along the years new parameters have been suggested. First attempts to intercalibrated observations of benthic animals, fecal bacteria and heavy metals in algal tissues were reported in the seminar.

The seminar pointed out that only long-term cooperation on permanent observation stations yields comparable results and conclusions. Good and established relationships support this progress on both sides of the Gulf.

Among the targets of the Gulf of Finland Year 1996 have been: To assess the state of the sea, to harmonize the monitoring methods and to support interaction between researchers and decision-makers. The Helsinki-Tallinn biomonitoring project has had similar goals from the very beginning and we think that our contribution may help the total process to advance to the same direction.

We credit the Finnish Ministry of the Environment and the Regional Environment Centre of Uusimaa for funding the project and the transfer seminar through the grants for regional cooperation as well as the skilful staff of the Tvärminne Zoological Station for practical arrangements.

Most of the papers in this report are manuscripts which are to be published elsewhere. It is therefore recommended not to cite the papers without prior reference to the authors.

On behalf of the Seminar Participants

Editors

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BIOLOGICAL INDICATORS IN HELSINKI AND TALLINN SEA AREAS

Meeting Report and Proceedings of the Knowledge Transfer Seminar
Tvärminne Zoological Station

December the 11-13th, 1996

OPENING ADDRESSES:

Dr **Pekka Kansanen**, Director, Environment Centre of the City of Helsinki:

Dr Pekka Kansanen welcomed both the Estonian and the Finnish colleagues and friends to the fifth Helsinki-Tallinn Bioindicator Seminar to Tvärminne Zoological Station. The initiative of the Bioindicator Monitoring Project was launched in 1992, when General Manager Aap Mumme and Director Pekka Kansanen had the very first appointment on the official level. The bilateral environmental cooperation decided to be started with monitoring coastal water areas of the cities Helsinki and Tallinn. This ongoing project has recieved very positive administrative attention and support by the authorities of the cities Helsinki and Tallinn as well as the ministries of both of the countries. After the last Lohusalu knowledge transfer seminar the economical support in the future was still open. Dr Kansanen believed that the cooperation will be continued in 1997, because this seminar now in late autumn 1996 appeared to be possible to arrange economically.

Dr **Ahto Järvik**, Director, Estonian Marine Institute:

First Dr Järvik wished on his behalf the Finnish and the Estonian participants warmly welcome to the beautiful Tvärminne Zoological Station. He wanted to remind everyboby that cooperation is succesful only when both parts involved in it are ready to work and struggle for it. This year 1996 has had a special issue, because it was named as the Gulf of Finland Year. This Helsinki-Tallinn Biomonitoring Transfer Seminar has an especially important meaning in this year because it belongs to those workshops of the theme year. Dr Järvik was convinced that the presentations of the Seminar will benefit everybody, both the authorities and the research scientists as well.

Dr **Aap Mumme**, General Manager, Environmental Board of the City of Tallinn:

Dr Mumme pointed out the importance of the bottom communities as the most objective tool in biomonitoring of the water quality of the coastal sea areas. During the last few years the water quality of the

Tallinn Bay has improved a lot. Tallinn City Government has contributed this kind of development which has lead the improved situation in coastal areas. In 1989 Tallinn Pulp and Paper Mill was closed, which affected on the water quality immediately in a positive way. During the last ten years the total amount of waste waters from the City of Tallinn has been 300 000 km3/d. Before closing the Tallinn Pulp and Paper Mill the organic BOD load to the Tallinn Bay was 60 tn/d. Then after closing the Mill the total BOD decreased to 40 tn/d.The next essential step in water protection measures happened in 1994, when the biological waste water treatment plant of the City of Tallinn was constructed. Then the BOD load decreased again, now to 6-8 tn/d. Authorities of the City of Tallinn are ready to continue supporting economically this kind of valuable cooperation project in 1997, as well as the Finnish authorities, too.

LECTURES

Director, **Kansanen, Pekka**, Environment Centre of the City of Helsinki:
MUNICIPAL ENVIRONMENTAL AUDITING OF THE BALTIC CITIES; AN EU-LIFE-PROJECT ACROSS HELSINKI, TURKU AND TALLINN, AND SOME OTHER ONGOING PROJECTS OF THE ENVIRONMENTAL CENTRE OF THE CITY OF HELSINKI

(APPENDIX 1)

Helsinki, Turku and Tallinn are the members of the Union of the Baltic Cities. MEA-project was launched in 1996, about a year ago, by this organization. The aim was to be published a manual 'How the environmental auditing should be done on the municipal level'. This manual will be finished in spring 1997. Dr Kansanen pointed out the importance of the international cooperation especially nowadays when there is no official obstacles in a political level anymore and direct contacts between the authorities and research scientists are possible. We had to remember also our global responsibility for the common environmental problems e.g. the present situation of the Gulf of Finland.

Professor, **Niemi, Åke**, University of Helsinki:
LITTORAL MONITORING OF THE GULF OF FINLAND; EXPERIENCES FROM THE GULF OF FINLAND YEAR 96

(APPENDIX 2)

The influence of polluted water from the land and of saline water rich in nutrients in connection with upwelling from the open sea on the littoral system are discussed. Input of nutrients causes a bottom-up effect in the littoral. The predatory effect of perch may strongly vary owing to year-to-year fluctuations in the abundance of certain year classes. Also the predatory cod may strongly diminish the perch populations in the littoral. Thus the littoral system is regulated both by bottom-up and top-down effects. Monitoring the littoral ecosystem in the outer archipelago requires considerable multidiciplinary research.

Dr **Kiirikki, Mikko**, University of Helsinki:
DYNAMICS OF MACROALGAL VEGETATION IN THE NORTHERN BALTIC SEA - EVALUATING THE EFFECTS OF WEATHER AND EUTROPHICATION

(APPENDIX 3)

The species composition and biomass production of rocky shore macroalgal vegetation have been considered to be possible good indicators of eutrophication. The main problem in utilising these indicators has been irregular variations in the abundance of several species. The present work shows that most of this irregularity can be attributed to processes primarily driven by weather conditions; winter weather effects on species composition among the short lived macroalgae and summer wind regimes on their biomass production.

It is evident that also the eutrophication of the Baltic Sea has a significant effect on the rocky shore macroalgal vegetation. However, practically all symptoms of eutrophication are connected to weather driven processes which makes their interpretation difficult and thus their indicator value low in routine monitoring studies.

Professor, **Kukk, Henn**, Estonian Marine Institute:
MONITORING OF THE STATE OF THE COASTAL SEA IN TALLINN AREA IN 1993-1996 BY LITTORAL MACROALGAE

(APPENDIX 4)

The results of the regular monitoring of the state of coastal sea by benthic algal communities in 1996 indicated a change, compared to the earlier situation. The borders of the mesosaprobic zone have also moved from the Viimsi peninsula towards the bottom of Tallinn Bay. The recolonization of *Fucus vesiculosus* was described in the areas close to the Pirita area and northwards along the shoreline of Viimsi peninsula. On the other hand the relative abundance of *Cladophora glomerata* has increased in whole sea area. The development of *Enteromorpha* species was somehow lower than in previous years.

Viitasalo, Ilkka, Environment Centre of the City of Helsinki:
THE STATE OF LITTORAL MACROPHYTES OFF VUOSAARI, THE FUTURE HARBOUR AREA OF HELSINKI

(APPENDIX 5)

The study area of 12 sampling sites in Vuosaari region has been visited regularily at interval of 4-5 years. Two of the sites were undisturbed, nine of them slightly disturbed and one disturbed. The latter one was characterized by dense mass occurence of *Enteromorpha intestinalis* and *E. prolifera*. *Fucus* was abundant in 1993 but now it has disappeared. The bay of Niinilahti suffers from releases of sand industry which releases high amounts of fine mineral particles to water. Settling of *Fucus* germlings on the stone surfaces may suffer. On the other hand, Maloxen had recovered from slightly disturbed to undisturbed. *Ahnfeldtia plicata*, which has never seen before in this area, was encountered from two locations.

Kotta, Ilmar and Kotta, Jonne, Estonian Marine Institute:
ZOOBENTHOS AROUND SEA-REGION OF VUOSAARI AND SEURASAARI

(APPENDIX 6)

The number of species in Vuosaari harbour area was quite small, and the total biomass and the number of individuals in all main groups were remarkable low compared to areas of Tallinn Bay. *Macoma balthica*, Polychaetes and Oligochaetes dominated in species composition. Measured values of biomass, numbers of individuals and species composition were typical only for Vuosaari region. Sedimentation rate was high, because wind or currents can not reach these isolated areas. Muddy sediments dominated in the studied area. Examinated macrozoobenthic samples showed that human impact has not caused dramatical changes to the eutrophication process of Vuosaari area.

Studies made in 1969 showed that inner part of Tallinn Bay was polysaprobic with absence of benthic animals. The samples taken in 1996 has not been examined yet, but it is clear that the benthic animals have returned to the Tallinn Bay.

Martin, Julia* and Kalso, Seija**
* Estonian Marine Institute
** Environment Centre of the City of Helsinki:
INTERCALIBRATION OF MICROBIOLOGICAL METHODS BETWEEN HELSINKI AND TALLINN

(APPENDIX 7)

The requirements and criteria for bacteria used as hygienic indicators of drinking water, swimming water and monitoring of sea area were discussed. Because these bacteria are used as an indicator of faecal pollution, they must be common inhabitants of human and animal feces. Especially the group of thermotolerant coliforms and *Escherichia coli* as indicators were considered.

Comparative studies between the laboratory of Estonian Marine Institute and the laboratory of Helsinki City Environment Centre were performed during the year 1996. Identical sea water samples were analyzed in both laboratories to get information about the reproducibility and also repeatability of the methods used.The first results were not promising. But it was seen necessary and important to go on the collaboration concerning the analysis of hygienic faecal indicators of sea water.

Martin, Julia, Estonian Marine Institute:
HYGIENIC STATE OF SEA WATER OFF TALLINN REGION

(APPENDIX 8)

Water sampling areas were situated both in Kopli Bay and Tallinn Bay in 1996. The hygienic state of sea water near the waste water outlet, in harbour area, on the beaches and in the outer parts of bay areas was examined and results were discussed in this paper, too.

Kalso, Seija and Pesonen, Lauri,
Environment Centre of the City of Helsinki:
HYGIENIC STATE OF SEA WATER OFF HELSINKI REGION

(APPENDIX 9)

The hygienic state of sea water on the 23 beaches of Helsinki was introduced. The quality of water on the beaches of more than 100 visitors a day are yearly reported to the European Comission. Thermotolerant coliform bacteria and faecal streptococci has been used as hygienic indicators up to the year 1996. Three categories of water quality has been used according to the quidelines: good, acceptable and poor.

The changes of the hygienic quality of bathing waters due to the improvement of waste water treatment systems were discussed.

Since 1.5.1996 the new requirements for hygienic indicators of bathing waters have been in use. Also other changes for instance in water sampling frequency in the settlement of Ministry for Social Affairs and Health etc. were discussed. The hygienic quality of the bathing water has been good. The report of European Comission of the quality of bathing water was introduced.

Sinervo, Tuija, Environment Centre of the City of Helsinki:
ACCREDITATION CRITERIA FOR LABORATORIES

(APPENDIX 10)

The quality assurance means all those planned and systematic measures by which a laboratory can show that its results fulfill the requirements of clients. The quality system contains all parts of the laboratory work: the quality policy, the organization and staff, the environment, the equipment and reagents, the methods, the quality assurence, the control of the quality system and documentation. This

system has to build on the base of international standards EN-45001 and ISO GUIDE 25 and be described in the quality handbook of the laboratory. Building of the quality system is a very time-consuming process and makes extra costs. The whole laboratory staff including the highest management must engage with this system before it can work. And it never comes ready. But it will pay itself back because there will be less mistakes, the staff will be more motivated and the clients will be satisfied.

Kalso, Seija, Environment Centre of the City of Helsinki:
ACCREDITATION OF THE MICROBIOLOGICAL LABORATORY OF HELSINKI ENVIRONMENTAL LABORATORY

(APPENDIX 11)

Altogether 32 microbiological methods were accreditated in the environmental laboratory. Standard methods for the examination of water samples are used and the methods for the most important hygienic indicators are accreditated. The quality system of the microbiological laboratory was introduced by giving examples of the general rules and procedures to ascertain the techiques used for conducting these examinations. Particular attention was paid to the quality system of preparation and sterilization of culture media and reagents. Calibration and every day control of equipment as the temperature control of incubators and autoclaves were introduced. Intercalibration of microbiological methods is performed three times a year. Also the principles of internal quality control systems such as testing the dispersion of parallel colony counts were discussed.

Lehvo, Annamaija, Finnish Environmental Institute:
COASTAL MONITORING GROUP: RESULTS AND RECOMMENDATIONS OF THE GULF OF FINLAND WORKSHOP: LITTORAL PHYTOBENTHOS MONITORING

(APPENDIX 12)

A lot of work is needed before the phytobenthos monitoring programme for baseline studies can be accepted by the all Baltic Sea countries. Some small useful pieces of programme are existing now. Supporting projects are needed, like biotope classification system and more research on ecological processes of phytobenthos. However, a small scale pilot monitoring project could be started already in summer 1998.

Viitasalo, Ilkka, Environment Centre of the City of Helsinki:
RESULTS AND RECOMMENDATIONS OF THE GULF OF FINLAND WORKSHOP: DEVELOPMENT OF THE SPACE-INDEPENDENT BIOINDICATION SYSTEM FOR EVALUATION OF EUTROPHICATION IN COASTAL AREAS OF THE GULF OF FINLAND

(APPENDIX 13)

There are vital biomonitoring programs going on around most of the big cities of the Gulf of Finland. In the following table main parameters and properties of the programs are presented.

	Helsinki A	Helsinki B	St.Petersburg	Tallinn
Monitoring area (sq.km)	110	110	1400	
Starting year	1974	1962	1982	1992
Prevailing salinity range (‰)	2-6	0-6	0-6	2-6
Organism groups	Macroalgae, phanerogams	Zoobenthos; macrofauna	Chironomidae, Oligochaeta, zoobenthos	Macroalgae, phanerogams
No of sampling sites	220	66	45	40
Present sampling interval	5 yrs	5 yrs	1-2	1-2
Classification method	Ecol.groups, abundance, biotic index	Biomass, ecol.groups	Abundance, biomass, species composition, ecol. groups, Integrated Index (Balushkina 1995)	Ecol.groups, saprobic system

Recommendations to future work (bioindication, in the vicinity of municipalities):

1. Work should concentrate upon **polluted or semi-polluted coastal areas**. Comparative studies between different areas should continue.
2. **One water area** shoul be selected to a **common pilot field**.
3. In 1997 a **planning workshop** is arranged in order to organize the field study and to introduce the different research teams to the selected area.
4. In 1998, **joint field and laboratory work** is conducted in the selected area with a **concluding seminar** in late autumn 1998.
5. It was considered that an ample pilot area could be the **Wyborg Bay**.

PLENARY SESSION, CONCLUSIONS abbreviated:

FUTURE ACTIVITIES AND RESEARCH PLAN IN 1997

Both Finnish and Estonian authorities promised economical support for the next year 1997

Phytobenthos, macrozoobenthos and hygienic indicator monitoring projects will continue

Phytobenthos monitoring:

In Tallinn this method works well because there are no big salinity differences in the area.

In Helsinki method works well, too, in the middle and outer archipelago. There has been some difficulties in the innermost bays where fresh water enters from rivers and brooks. Together with fresh water, high amounts of clay is transported to the same areas. This hampers settling of spores and germlings of macrophytes, prevents the penetration of light into water etc.

Sampling sites must be documented carefully to make sure they can be found by everyone in the future, too

The statistical handling of the results requires more attention.

Other biomonitoring:

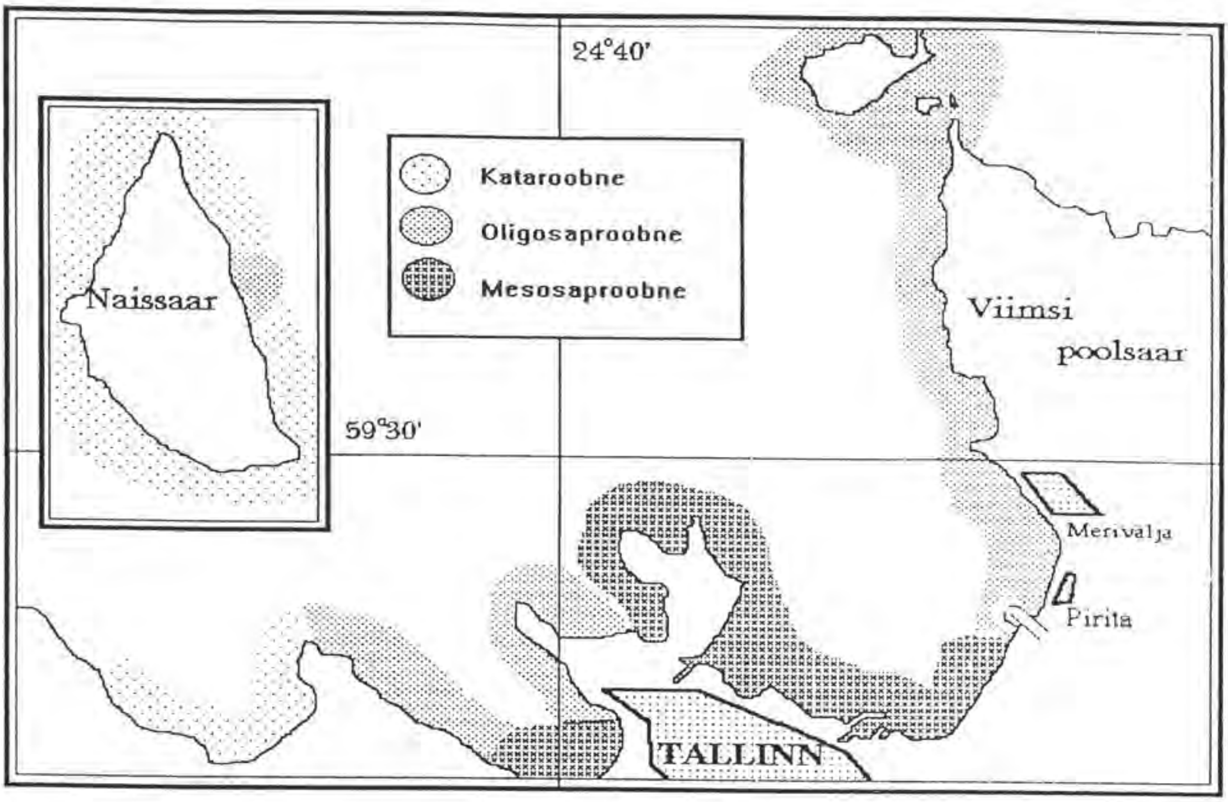
Soft bottom zoobenthos near the coastline was studied for the first time. The results must be evaluated carefully before the next season.

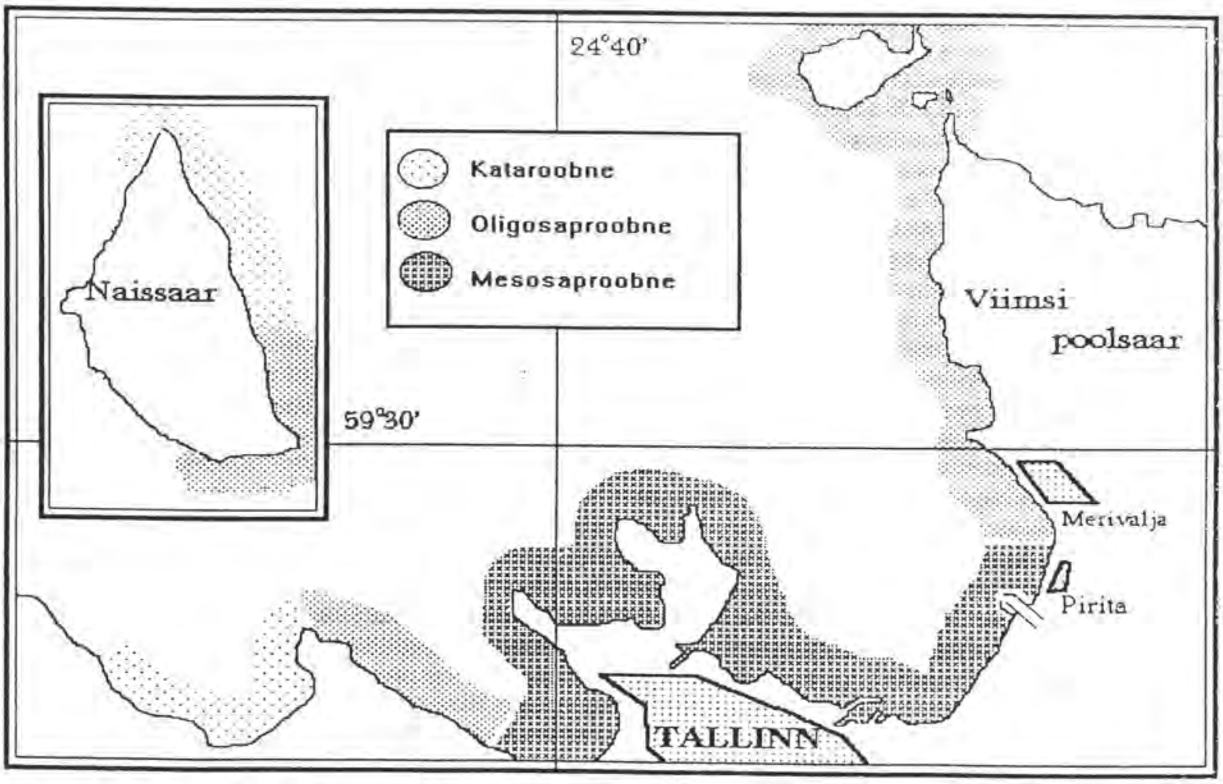
Taxonomical knowledge of certain taxa (Chironomidae, Oligochaeta) were of vital importance but is so far lacking

The invading of certain new alien species (Cercopages, Dreissena, Marenzelleria etc) must be followed.

Hygienical (bacterial) indices:

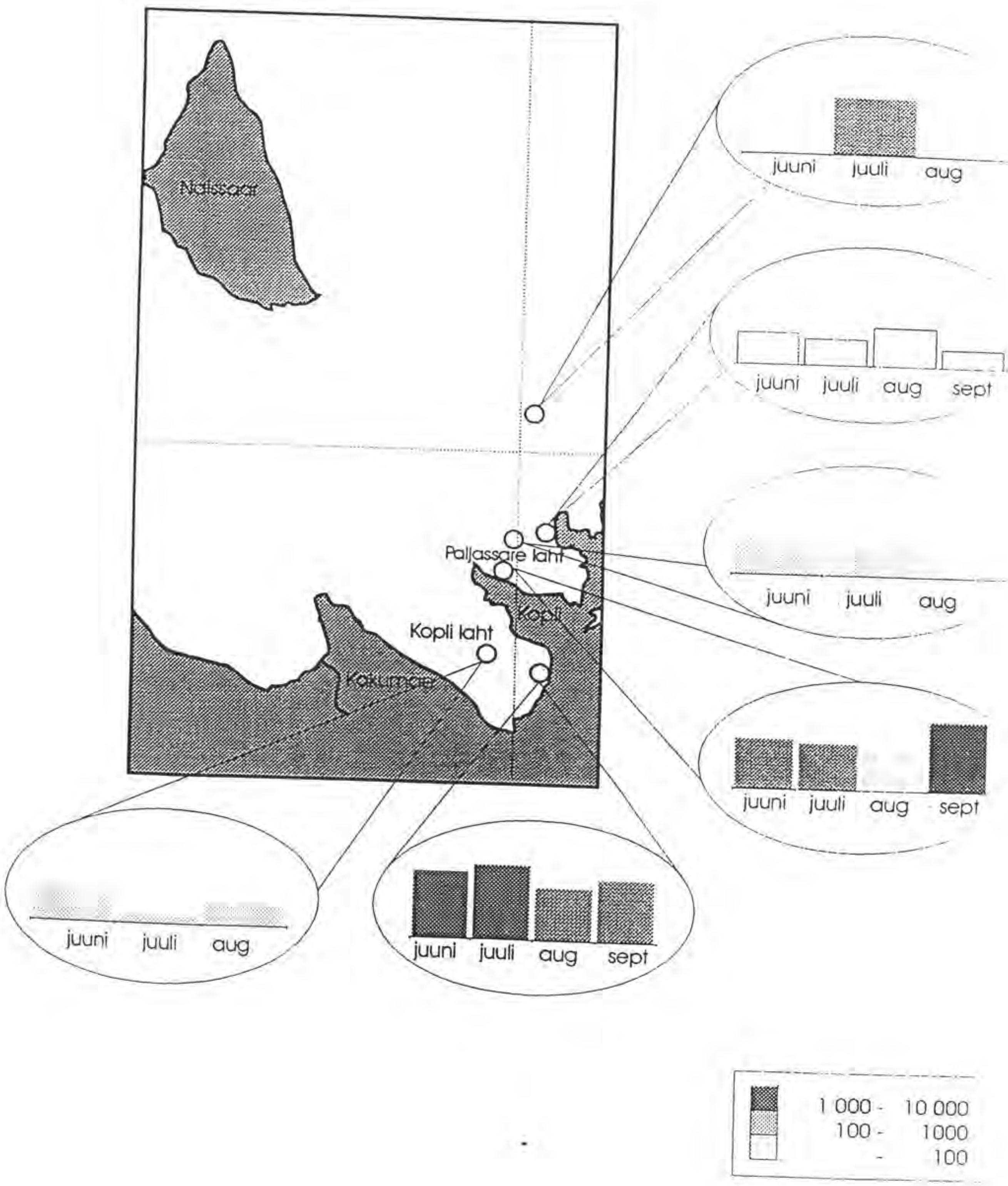
Cooperation between the microbiological laboratories in Helsinki and Tallinn will continue





Joonis 5. 2. 4. ja 5. 2. 5. erineva saproobsustüübiga taimestiku levik uurimispiirkonnas 1995 ja 1996 aastal.

Joonis 4. **Fekaalsete koli-laadsete organismide üldarvukus Kopli lahes 1996. aastal.**
(kol/100 ml)



Joonis 3. **Fekaalsete koli-laadsete organismide üldarvukus Tallinna lahes 1996. aastal.**
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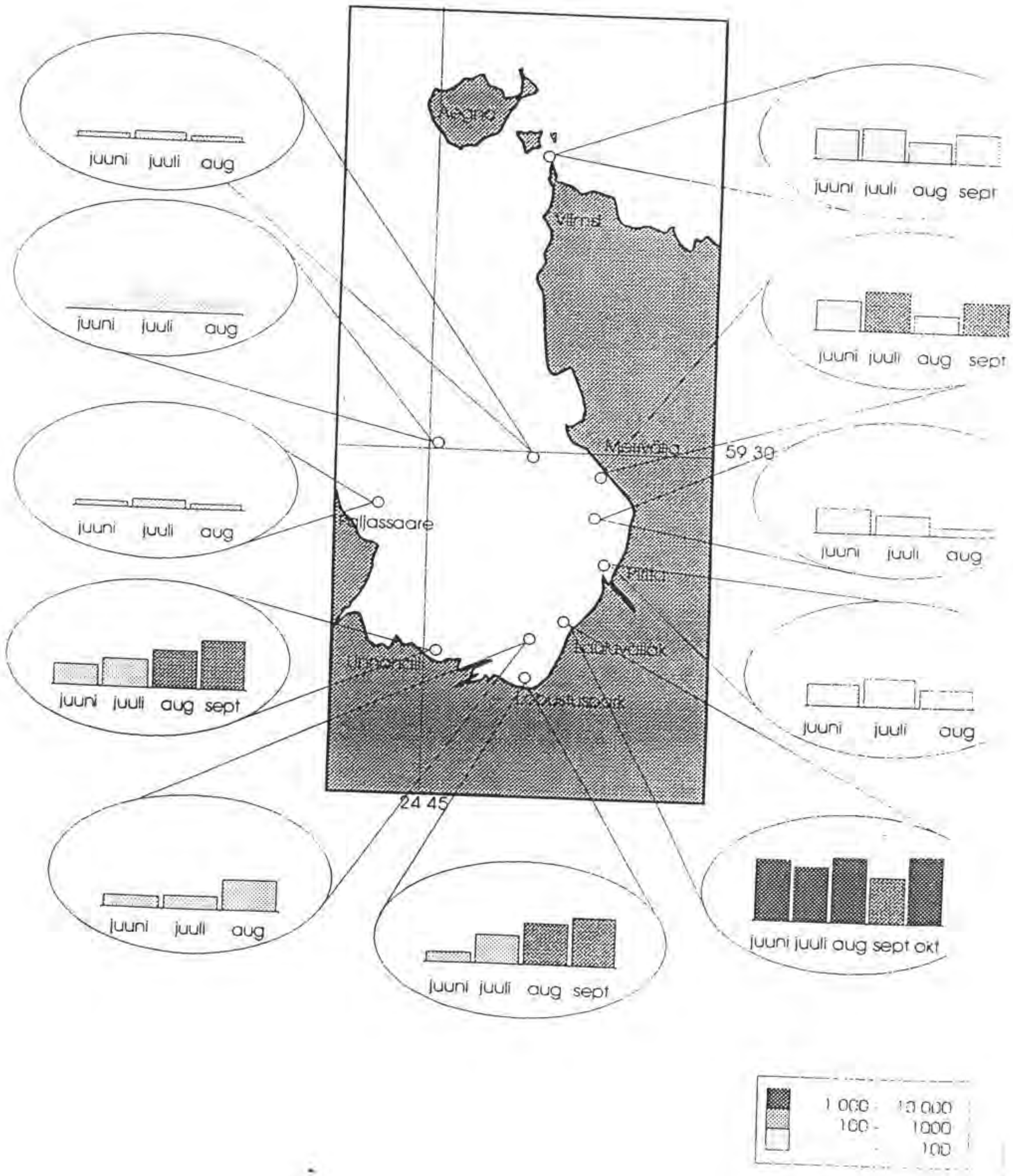

Heavy metals in biota:

The first draft of a litterature review of heavy metals in the Baltic Sea organisms was distributed in the seminar. The work is expected to be completed in spring. The rewiew does not contain litterature of heavy metals in sediments and water so far

Fucus-heavy metal standard is released in the nearest future

The work serves as a preparatory work for a large heavy metal project which starts in 1997 in the Helsinki sea area.

Other: Reporting: Annual reports to the Finnish and the Estonian authorities. Gulf of Finland year concluding seminar in March 1997, Baltic Marine Biologists Symposium, Mariehamn in June 1997.

The Estonian counterpart expressed the willing to arrange the next transfer seminar in Estonia, next year.

APPENDIX 1

Kansanen, Pekka
City of Helsinki
Environment Centre

MUNICIPAL ENVIRONMENTAL AUDITING OF THE BALTIC CITIES; AN EU-LIFE-PROJECT ACROSS HELSINKI, TURKU AND TALLINN, AND SOME OTHER ONGOING PROJECTS OF THE ENVIRONMENT CENTRE OF THE CITY OF HELSINKI

MUNICIPAL ENVIRONMENTAL AUDITING OF THE BALTIC CITIES; AN EU-LIFE-PROJECT ACROSS HELSINKI, TURKU AND TALLINN, AND SOME OTHER ONGOING PROJECTS OF THE ENVIRONMENT CENTRE OF THE CITY OF HELSINKI

Municipal Environmental Auditing (MEA) project

Helsinki, Turku and Tallinn are the members of the Union of the Baltic Cities. Mea-project was launched in 1996, about a year ago, by this organization. The aim was to be published a manual 'How to environmental auditing should be done on the municipal level'. Reseach scientist, M.Sc., Ilkka Viitasalo has been collecting material and data for this publication and this process is still going on. The final manual will be finished in the next spring 1997. The whole budget of this project is 2 million FMKs.

International cooperation nowadays

Political situation has dramatically changed during the last few years; USSR collapsed, Estonia is independent nation now and Finland got a membership of the EU. Earlier the official bureaucracy was in a main role in international relationships. Nowadays we have direct contacts to authorities of the foreign countries without any official protocol, which makes international cooperation much more easier. This international cooperation is needed to improve the state of the Gulf of Finland and it is essential in air pollution control too. The global responsibility of the environment oblige us to join these important international cooperation projects e.g. Local Agenda 21 sustainable development project of ICLE (International Council for Local Environmental Initiatives).

Ongoing EU-projects:

1. APHEA-project (finished already)
   - -WHO, EU and 15 cities of the Europe
   - -How air pollutions affect on the human health
2. Employment Path -project
   - -for creating jobs for e.g. environmental protection
3. Baltic Municipal Environmental Audit

Some other projects of the Environment Centre of the City of Helsinki

1. Harbour Net -(EU-)project
   - -Helsinki, Tallinn, Copenhagen, Gdansk, Pireus
   - -Water quality and pollution factor management of the harbour areas (including waste waters of ships)
2. Environmental experts in EU-projects and in FAO
3. Karolus-programme training
4. Traditional Scandinavian cooperation and communication

APPENDIX 2

Niemi, Åke
University of Helsinki

LITTORAL MONITORING OF THE GULF OF FINLAND; EXPERIENCES FROM THE GULF OF FINLAND YEAR 1996

Littoral monitoring of the Gulf of Finland

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Abstract

The influence of polluted water from the land and of saline water rich in nutrients in connection with upwelling from the open sea on the littoral system are discussed. Input of nutrients causes a bottom-up effect in the littoral. The predatory effect of perch may strongly vary owing to year-to-year fluctuations in the abundance of certain year classes. Also the predatory cod may strongly diminish the perch populations in the littoral. Thus the littoral system is regulated both by bottom-up and top-down effects. Monitoring the littoral ecosystem in the outer arcipelago requires considerable multidiscliplinary research.

Background

The structure of the phytal ecosystem gives a good idea of the trophic status of the water which for a time has washed the shore. The quality of the surface water off our great cities as Tallinn and Helsinki is well mirrored in the macrophytic vegetation of the hydrolittoral and upper sublittoral zone. Thus also the citizens are able to observe a deteriorating of their recreation areas and begin to bring pressure to bear upon decision makers.

The question is: How reliable are the structure of the phytal ecosystem as a criteria to be used when assessing the trophic status of our coastal waters?

The origin of nutrient loading

When discussing the input of nutrients to the sea area outside our capitals, one has to take two sources of loading into consideration:

1. The nutrient loading from cities, from the industry and from fish farming causing a eutrophication gradient going out from land.
2. The fluctuation in hydrodynamics of the open Gulf of Finland causing upwelling and changes in temperature, salinity and nutrient level influencing the structure and production of the phytal in the outer archipelago between the land and the sea zone.

The pollution gradient off the cities

In the inlets and the inner archipelago zone off the outfall points, a clear eutrophication gradient has been observed. Already Häyrén (1921,1944) used Kolkwitz and Marsson´s (1908) saproby system to describe the pollution gradient of the shores outside Helsinki. A survey of the litterature on the macrophytes to be used as critera on the degree of saproby or eutrophication were given by Hällfors et al.

(1987). The saproby system for classification of the pollution status of the coastal waters has much been used in Estonia wheras Finnish researchers have changed to the eutrophication classification from the 1960s (e.g. Lehmusluoto 1968). The salinity gradient parallel to the pollution gradient, however, makes difficult to use the structure of the phytal as citeria for eutrophication (Hällfors et al. 1987).

Since the early 1980s all the well purified sewage and waste waters from Helsinki and adjoining areas have been led out to the outer archipelago zone via long pipe lines. There the mixing and dilution are very effective. As a result the quality of water in the inlets and inner archipelago has markedly risen during the last decades (Pesonen 1996). However, the trophic status in the outer archipelago and sea zone off Helsinki, Espoo and Kirkkonummi seems to have decreased. This can easiest be observed as a stronger production of filamentous algae in the hydrolittoral and upper sublittoral belt, as more detritus sedimenting upon macrophytes and hard substrates and as a decreasing Secchi disc transparency. But what is the real background to these signs of eutrophication in the outer archipelago zone? Nutrients from the land or influence of the overall eutrophication of the open Baltic Sea?

Water masses of different trophic status and origin in the archipelago

The influence of different water masses can easily be observed in the archipelago area off Tvärminne at the entrance to the Gulf of Finland. On Tvärminne Storfjärd three water masses of different origin will influence the phytal ecosystem (Hällfors et al 1987).

1. In winter a 2-3-m thick surface outflow below the ice is characterized by low salinity (1-2 promille), high content of inorganic nitrogen but moderate phosphorus content, high humic content and turbidity. This layer vanishes after the break-up of ice.

2. In summer southern winds press surface water from the open Baltic into the archipelago. This warm water has a moderate salinity (5-5.5 promille) and is very poor in nutrients. This presents the normal summer situation in the outer archipelago.

3. Steady strong western-northwestern winds cause upwelling in the outer archipelago area (e.g. Sjöblom 1967, Niemi 1975, Haapala 1994). As a result the temperature of the surface water drops and the salinity may increase up to 7 promille and the concentration of nitrate and phosphate markedly rise to favour the primary production. Thus the meteorological fluctuations strongly influence the phytal environment.

Many studies have shown the effects of nutrient loading from the land on the aquatic ecosystems in the inner arcipelagos. On the other side, what is the influence of the fluctuations in temperature, salinity and nutrient levels on the phytal ecosystem in the outer archipelago zone and the sea zone? Shortly said, how does influence the changes in the open Baltic Sea the littoral ecosystems?

During the growing period, upwelling of cold, saline water from the level near the permanent halocline (Niemi 1975) brings a marked nutrient input to the euphotic layer. This results in summer often in blooms of blue-green algae (e.g.Niemi 1979). In the archipelago the nutrients are immediately used up and causes increasing production of filamentous algae in the phytal. Kiirikki and Blomster (1996) have shown how the phytal primary production is regulated by hydrodynamic processes in the open Gulf of Finland. Thus such a bottom-up effect is regulated by meteorological conditions. As

Kiirikki and Blomster pointed out, it is quite clear that production of filamentous algae in the phytal ecosystem varies apparently between years because they are coupled to fluctuations in the hydrodynamics of the open Gulf of Finland and meteorological conditions over the northern Europe.

Interactions in the phytal -- factors influencing the growth of the bladder-wrack and filamentous algae.

In the late 1970s and early 1980s the bladder-wrack deteriorated in the outer archipelago zone on less-exposed shores along the southern and south-western coast of Finland, in the same time as the growth of filamentous algae in the hydrolittoral and upper sublittoral zone strongly increased. Kangas et al.(1982) explained the phenomenon as a result of several synergistic factors (Fig. 1).

- The increased nutrient level favoured the growth of filamentous algae. The epifytic algae covered the bladder-wrack, competed effectively for nutrients and shadowed the bladder-wrack decreasing its assimilation capacity.

- The increased amount of seston, owing to increased phytoplankton production, has decreased the transparency of the water and raised the lower limit for the bladder-wrack with 3-4 m (Kautsky et al. 1986).

- The increased sedimentation of seston on hard substrates has prevented the oospores of the bladder-wrack from fixing on the hard substrate. Thus the reproduction of *Fucus* has failed.

- The increased production of filamentous algae has favoured the reproduction of littoral isopods and amphipods so vigorously that later on the herbivory has also directed on the bladder-wrack.

When this was pondered in the early 1980s, the top down-effect of littoral and pelagic fishes was not taken into consideration (Fig. 1).

In the outer archipelago off Tvärminne, strong fluctuations of year classes of perch occur. The area is characterized by strong upwelling phenomena connected to strong W-NW winds (e.g. Smith 1964, Niemi 1975, Haapala 1994). Especially in early summer the marked decrease in surface temperature may destroy the young perch larvae (Böhling et al. 1991, Lehtonen and Lappalainen 1995). As the perch is a strong predator on crustaceans in the phytal, in the *Fucus* belt, the disappearance of one or several year classes will markedly decrease the predatory pressure on the isopods and amphipods. This will result in a strong increase of the crustaceans which again increase the herbivory on filamentous algae and the bladder-wrack. Thus this top-down effect may also be the cause to the temporal disappearence of the bladder-wrack.

However, the disappearance of the bladder-wrack, which began ca. 20 years ago, probably is connected to the great inflows of saline water through the Danish Sounds in the 1970s. The successive temporal increase in salinity and oxygen concentrations in the Gotland Sea favoured the spawning of cod. Effective inflow of Baltic deep water to the SW coast of Finland brought a lot of young 1+ cods to our southwestern archipelago in the mid 1970s. Then the cod was abundant in the archipelago (own observations). They occurred even in the upper sublittoral as yellow-brown specimens taking the habitats of the pikes. Both perch and pike almost totally disapperaed, probably consumed by the cods. Only big pikes remained. The strong herbivory effect on the bladder-wrack (Kangas et al. 1882) was probably a result of the strongly increased population of crustaceans.

Thus the inflow of saline water into the Baltic can in the above-mentioned way influence the structure and energy flow in the phytal in the archipelago of the Gulf of Finland. An physical perturbation in the southern Baltic cause a top down-effect in the phytal in the Gulf of Finland. However, all the factors causing herbivore pressure on the bladder-wrack are not at all made clear. The problems are studied by Mikko Kiirikki´s research team in Tvärminne.

Which conclusions can be made considering using the phytal as a criteria of the water quality in the outer archipelago

The fluctuations of species composition and abundance in the hydrolittoral and upper sublittoral belt in the outer archipelago can be caused both by nutrient loading from the land and by upwelling of saline water rich in nutrients from the open Gulf of Finland. The effect may by a bottom-up effect cause an increase in the primary production as well as a top-down effect caused by changes in the predatory pressure influencing the herbivory effect on littoral algae. Thus the use of the phytal as a monitoring object in the outer archielago and the sea zone is problematic, because of the fact that different environmental and biotic factors may cause bottom-up and top-down effects, which origin is difficult to find out.

The cause to observed changes in species composition and abundance of littoral algae in the outer archipelago and the sea zone cannot be explained by temporal observations in the field. The interpretation needs as well field observations as meteorological and hydrographical observations from a long preceeding period as Kiirikki (1996) has shown. Because the predatory effects of fishes in the littoral may be decisive, also observations on the fish populations are important. Thus the interpretation of the causes to changes in the littoral ecosystem require considerable multidiscliplinary studies. The use of production and abundance of some species for monitoring the littoral cannot be recommended.

Both the open coastal waters off Tallinn and off Helsinki is temporarily influenced by hydrographic changes in the open Gulf of Finland, i.e. upwelling. When monitoring the littoral system one has to carefully consider if the influence comes from the coast or from the open sea and are the changes result of bottom-up or top-down effects.

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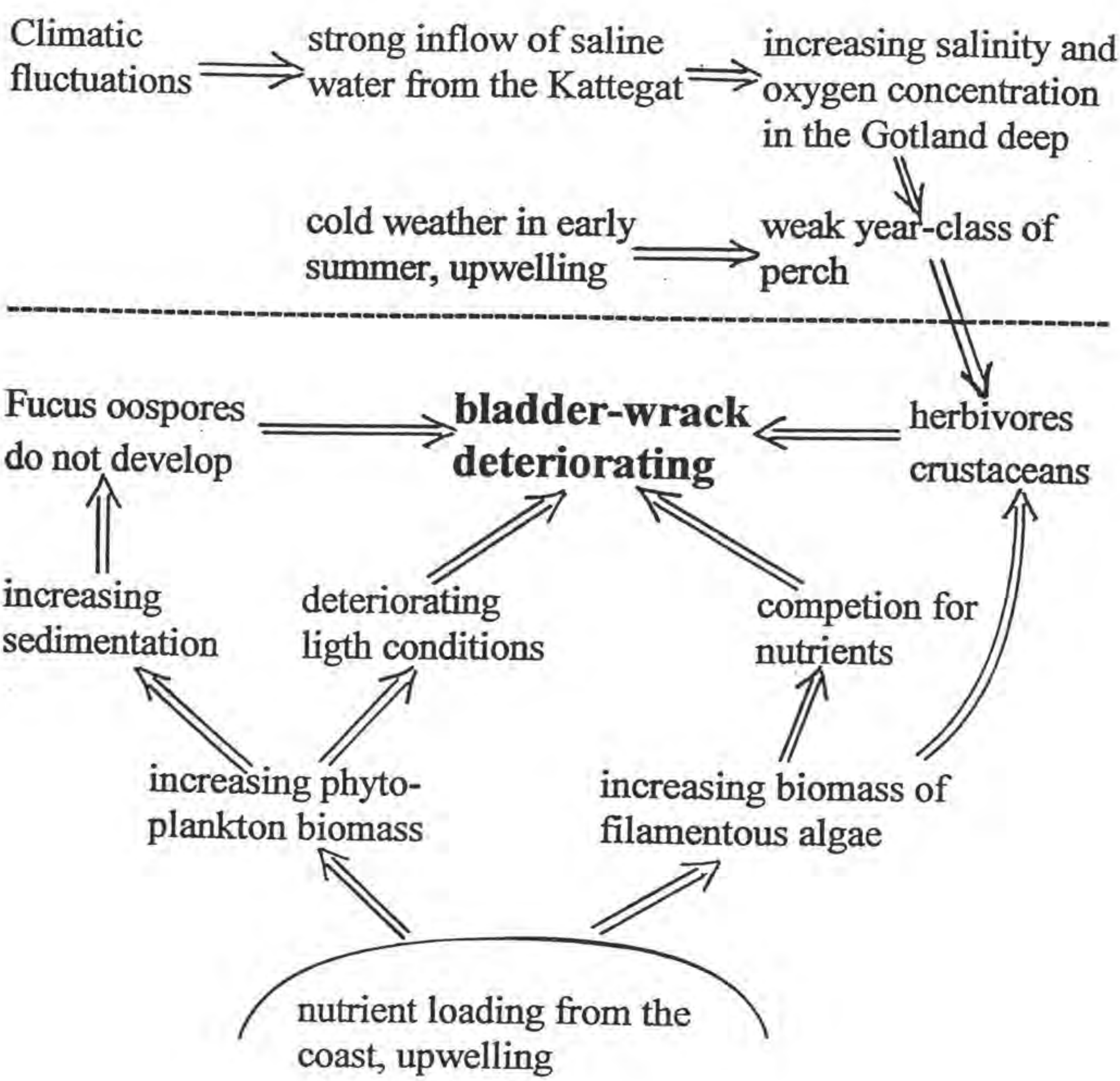
Legends

Fig. 1. Bottom-up and top-down effects causing deterioration of the bladder-wrack *Fucus vesiculosus*.



APPENDIX 3

Kiirikki, Mikko
University of Helsinki

DYNAMICS OF MACROALGAL VEGETATION IN THE NORTHERN BALTIC SEA - EVALUATING THE EFFECTS OF WEATHER AND EUTROPHICATION

The species composition and biomass production of rocky shore macroalgal vegetation have been considered to be possible good indicators of eutrophication. The main problem in utilising these indicators has been irregular variations in the abundance of several species. The present work shows that most of this irregularity can be attributed to processes primarily driven by weather conditions; winter weather effects on species composition among the short lived macroalgae and summer wind regimes on their biomass production.

It is evident that also the eutrophication of the Baltic Sea has a significant effect on the rocky shore macroalgal vegetation. However, practically all symptoms of eutrophication are connected to weather driven processes which makes their interpretation difficult and thus their indicator value low in routine monitoring studies.

Walter and Andrée de Nottbeck Foundation Scientific Reports No. 12

Dynamics of macroalgal vegetation in the northern Baltic Sea – evaluating the effects of weather and eutrophication

MIKKO KIIRIKKI

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CONTENTS

INTRODUCTION

The rocky shore macroalgal vegetation of the northern Baltic Sea shows variations in its biomass and species composition in three different time scales. The most predictable scale of temporal variation is seasonality. The short lived algae can be grouped into spring, summer and autumn species according to their timing of appearance and dominance in the vegetation (Wærn 1952, Wallentinus 1969, 1979, Jansson 1974, Laurola 1982). The second scale of variation is observed between growing seasons. The biomass of common species like *Pilayella littoralis* (L.) Kjellm. can be highly variable between successive years (Wallentinus 1974, 1976, Niemi 1975) and rare species like *Chorda tomentosa* Lyngb. can suddenly appear in masses (Hällfors & Heikkonen 1992). Only slight regularity has been observed in these fluctuations. Wærn (cited by Wallentinus 1974 and Kautsky 1989) has proposed that there might occur so called "green and brown algal years" according to the share of green or brown algal species among the short lived filamentous algae. Unfortunately, this phenomenon has never been reliably documented, neither has there been any explanation proposed for it.

The third scale of variation can be observed in the occurrence of perennial species in a perspective of several years. *Fucus vesiculosus* L. declined in the northern Baltic at the turn of 1970's and 1980's (Kangas et al. 1982, Mäkinen et al. 1984, Rönnberg 1984, Rönnberg et al. 1985). A similar phenomenon was also observed in the southern Baltic (Vogt & Schramm 1991). In some areas the decline was only temporary and recolonisation was observed during the 1980's (Rönnberg 1991). In addition to temporary variations in the occurrence of *Fucus*, the lower limit of the *Fucus* dominated zone has risen even several metres since the 1940's (Kautsky et al. 1986). *Fucus vesiculosus* is the largest algal species in the northern Baltic and therefore it is not surprising that changes in its occurrence have been widely documented. There may occur similar long term changes in other perennial algae, but as they are deep growing small species, they have been out of the scope of most studies.

Quite recently, the macroalgal vegetation has become a popular object for monitoring studies. The main idea behind these projects is that as a community growing fixed to a hard substrate, the macroalgal vegetation should be a more reliable indicator of changes in the environment than e.g. plankton, which moves with water masses (Blomster 1996). Macroalgal species have for a long time been classified according to their ability to withstand anthropogenic load. This use of macroalgae as indicators for water quality is reviewed by Wallentinus (1979) and Hällfors et al. (1987). The use of indicator species involves a hidden notion of the necessity of competition between the species, as the nutrient concentrations of most Baltic coastal areas can not directly be harmful to any macroalga. This hypothetical competition should be affected by the water quality and results should be seen as changes in the vegetation. However, there is no scientific evidence that there exists any competition between these indicator species. Therefore, it is possible that many results of these studies may be due to spatial and temporal variation in the physical environment, like wave exposure and weather conditions.

Studies on the macroalgal vegetation in the northern Baltic, especially those primarily aimed for local administrative use, are struggling in the jungle of this highly variable community. There is no clear information available on the sources of variation. To be able to interpret the observed changes, a basic understanding of the function of the community is urgently needed. In this thesis, studies on the dynamics of macroalgal vegetation on the south coast of Finland (papers I, II and III) and a three year monitoring study of rocky shore macroalgal vegetation in the Tvärminne Archipelago (papers V and IV) are summarised together with the previous literature. The main purpose of this paper is an attempt to separate the processes primarily governed by either weather or eutrophication, and to evaluate their influence on species composition and biomass of the macroalgal vegetation.

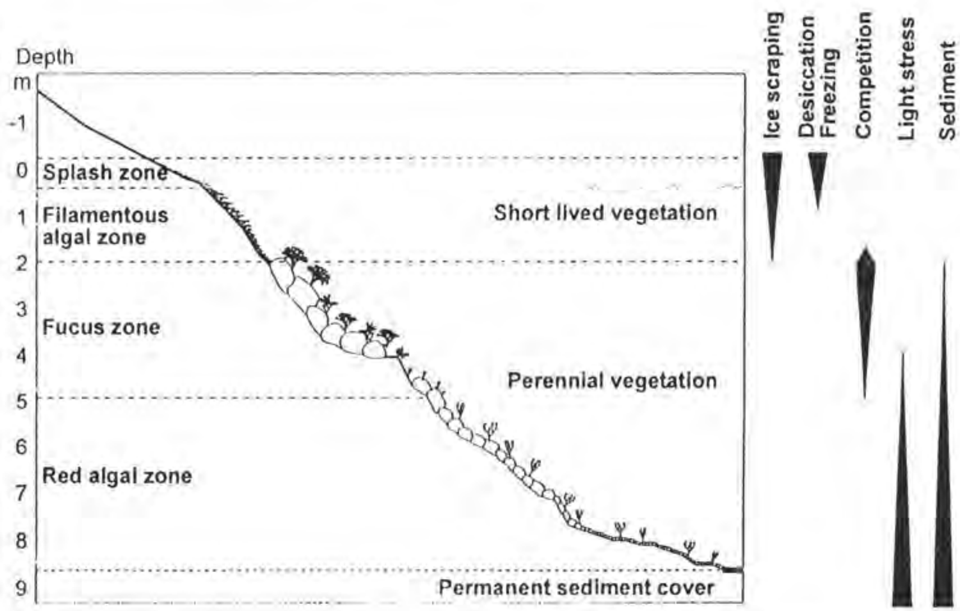

Fig. 1. Zonation of macroalgal vegetation on a wave exposed shore in the Tvärminne Archipelago, southern coast of Finland. The main factors affecting the zonation pattern are summarised (see references in text). See also the zonation terminology by Du Rietz (1930), Wærn (1952) and Hällfors et al. (1981).

MACROALGAL ZONATION

The main feature of rocky shore macroalgal vegetation is its vertical sequence of species, which results in distinct depth zones. In the tideless Baltic Sea, disturbances caused by ice scraping and irregular sea level fluctuations, divide the macroalgal vegetation into short lived and perennial parts (Fig. 1). The intensity of ice scraping decreases with depth creating a sequence of species of different scraping tolerances (paper II). Also the risk for desiccation decreases with depth. This downward gradient of decreasing frequency of disturbances can be seen in an increase in diversity (Johannesson 1989, Kautsky & Kautsky 1989).

The dominant perennial canopy species below the ice-scraped zone is *Fucus vesiculosus*. *Fucus* fronds are vulnerable to ice scraping, but the capacity of holdfasts for vegetative regeneration makes this limit determined by ice-scraping highly dynamic. Even small holdfast remnants left in the irregularities of the rock surface are able to support growth of new fronds during the following summer (paper I). *Fucus* is capable of removing potentially competing epiphytic and epilithic filamentous algae with the help of its wave induced thallus movements i.e. the whiplash effect. When *Fucus* is removed on exposed shores, the biomass of fast growing filamentous species may increase by as much as 5-fold (paper III).

The occurrence of *Fucus* divides the perennial vegetation into two parts. The deepest *Fucus* individuals grow nowadays at depths of 5-6 m (paper II) and thereafter smaller perennial red and brown algae inhabit the lowest part of the vegetation covered bottom. Perennial vegetation becomes more patchy with depth and the lowermost attached macroalgae are often found to grow on boulders and convex surfaces. These microhabitats may act as sediment free refuge habitats (Littler et al. 1983, paper II). The permanently sediment-covered bottom is often reached well above the expected lower depth limits of perennial macroalgae in sheltered archipelagos. Only on the most exposed shores, where rock surfaces are available at a great enough depth, physiological depth limits primarily caused by low light intensities may be found (Kautsky et al. 1986, paper II). The deepest growing filament like alga on the southern coast of Finland is *Sphacelaria arctica* Harv., which can be found at the depth of 17 m (paper II).

INFLUENCE OF WEATHER

The Fennoscandian climate is characterised by an alternation of oceanic and continental periods. In winter, low pressure activity and SW-winds bring warmer and moister air from the northern Atlantic causing periods of mild weather. When the continental high pressure and eastern or northern winds prevails, the weather is clear and cold. These weather phenomena last from a few days to a few weeks and the general climatic pattern is always a mixture of both oceanic and continental periods. The more frequently the continental periods occur, the colder the winter will be (Anonymous 1987). Winds and temperature control the formation of ice cover and the intensity of the scraping effect of ice (Palosuo et al. 1982, Seinä & Peltola 1991). Winds and atmospheric pressure govern the irregular sea level fluctuations in the Baltic (Lisitzin 1957). Furthermore, winds are the driving force of upwelling of nutrient rich water on the southern coast of Finland (Palmén 1930, Haapala 1994). The connection between weather and factors of direct importance for macroalgal vegetation is strong. The high variation shown by short lived filamentous and filament like algae can in most cases be traced back to these climatic factors.

Species composition in the filamentous algal zone

The species composition in the filamentous algal zone is primarily governed by two factors: the timing of disturbance caused by low sea level or ice scraping, and the reproductive seasonality of the species. This basic idea was first presented by Du Rietz (1922), but exact information on the timing of reproduction has not been available. Our present knowledge of the reproductive seasonality of the most abundant species (paper IV), is summarised in Fig. 2.

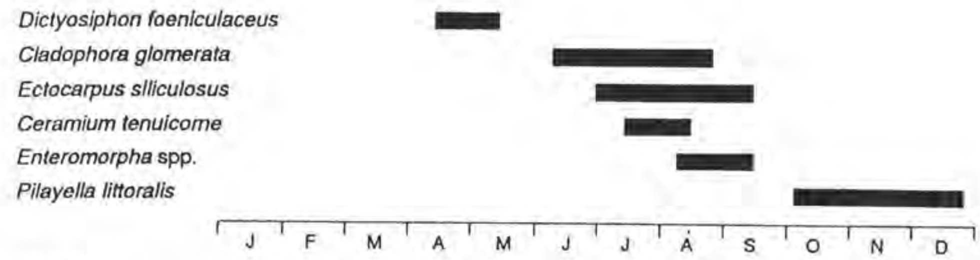

Fig. 2. Reproductive seasonality of the most abundant species of the filamentous algal zone in the Tvärminne Archipelago, southern coast of Finland. Drawn from data of paper IV.

In spring, the dominant species of the filamentous algal zone is *Pilayella littoralis*. Its propagules settle in late autumn and early winter. Disturbances occurring thereafter are of primary importance for the survival of these overwintering young plants. If the winter is mild and the scraping effect of ice is minimal, the chances for their successful overwintering are high. Furthermore, the sea level has to stay high enough to prevent lethal desiccation and freezing. A combination of these two factors is needed for successful overwintering and development of a high *Pilayella* cover in the filamentous algal zone. On the contrary, after a severe winter the filamentous algal zone is thoroughly scraped by ice and stays practically without algal cover until early summer (paper IV).

The strong influence of winter weather is still visible in the summer aspect of the filamentous algal zone (Fig. 3). *Cladophora glomerata* (L.) Kütz., the dominant species, is able to withstand moderate ice scraping in rock fissures with the help of its resting spores, akinetes (e.g. Rosemarin 1985). Therefore ice scraped surfaces are already in early summer covered by *Cladophora*, even though no reproduction has occurred in spring. When the intensity of ice scraping exceeds the level at which the akinetes are killed, the rock surfaces are free for new colonisation. This happens on exposed shores during severe winters. Free surfaces are also produced by low sea levels which kill the overwintering plants by desiccation (paper II). Low sea levels are generally connected to severe winters. All these free surfaces are available for *Dictyosiphon foeniculaceus* (Huds.) Grev., the first species having its propagules available in the water mass in spring. *Dictyosiphon* overwinters as a microthallus, which releases propagules when the ice cover breaks up (paper IV). The

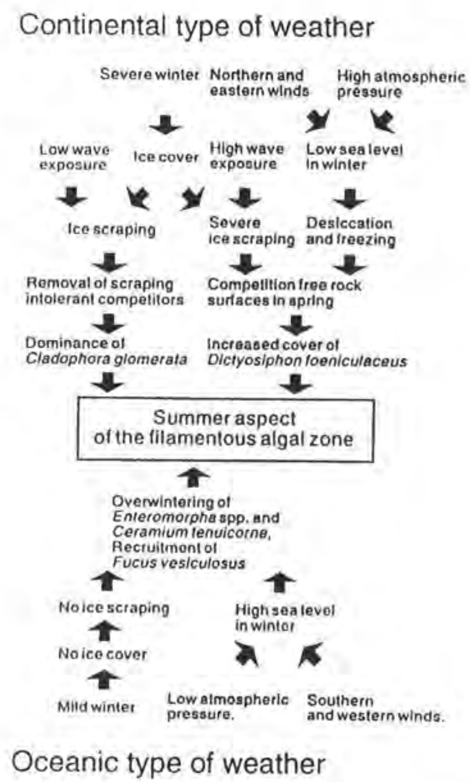

Fig. 3. Main factors proposed to affect the species composition in the summer aspect of filamentous algal zone (see references in text).

habitat of this microthallus is not known, but probably it overwinters below the regularly disturbed filamentous algal zone.

After a mild winter, the filamentous algal zone is first dominated by *Pilayella*, which degenerates and detaches before summer. In conditions of low ice scraping intensity, the overwintering of *Enteromorpha* spp. and *Ceramium tenuicorne* (Kütz.) Wærn seems to be successful and they appear in the filamentous algal zone in early summer together with *Cladophora* (paper IV). In the case of several successive ice free winters, the recruitment of *Fucus vesiculosus* is successful in the filamentous algal zone and the factor determining its upper limit is no longer ice scraping but periods of low sea level (Wallentinus 1979, Rönnberg, Östman & Ådjers 1992).

The influence of winter weather on the filamentous algal zone, is not evident in autumn. A group of species reproducing in summer: *Ectocarpus siliculosus* (Dillwyn) Lyngb., *Ceramium tenuicorne* and *Enteromorpha* spp. appear occasionally in the autumn aspect of the vegetation in addition to the dominant species *Cladophora glomerata*. Competition with *Cladophora* seems to be the most plausible explanation for this variation (paper IV). When the competitive ability of *Cladophora* declines, *Ectocarpus*, *Ceramium* and *Enteromorpha* increase their share in the vegetation. Factors which may cause the decline of the competitive ability of *Cladophora* are selective grazing and unsuccessful reproduction. The grazing pressure against filamentous algae increases towards autumn (Jansson 1974, Salemaa 1979, Anders & Möller 1983). The palatabilital differences between algal species are not known, but *Cladophora* seems often to be heavily grazed compared to *Ectocarpus*, *Ceramium* and *Enteromorpha*.

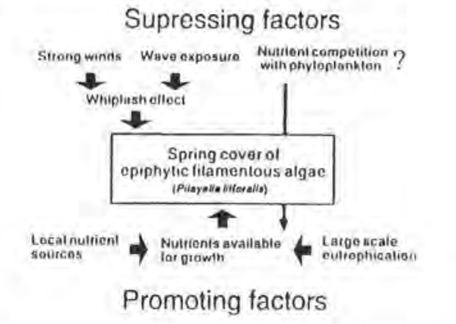

Fig. 4. Main factors proposed to a affect the spring cover of epiphytic filamentous algae (see references in text).

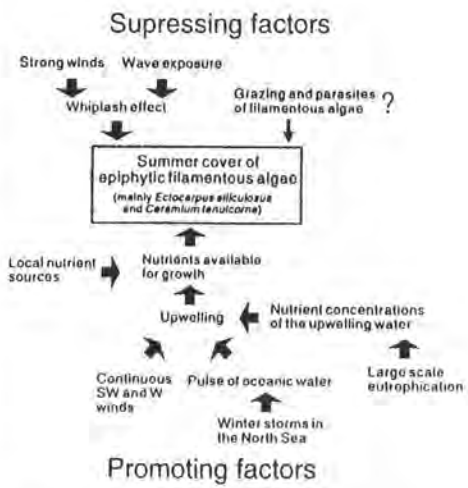

Fig. 5. Main factors proposed to a affect the summer cover of epiphytic filamentous algae (see references in text).

Epiphytes of perennial species

In spring, the perennial algal species are covered by epiphytic *Pilayella littoralis* (Fig 4). This mass occurrence of *Pilayella* was a regular phenomenon during the study period of three years (paper IV). *Pilayella* starts to grow early in spring utilising the high nutrient concentrations before the thermal stratification is formed, and the spring bloom of phytoplankton consumes the nutrients in the surface water. It has been proposed that there might occur nutrient competition between phytoplankton and macroalgae in spring (Wallentinus 1974, 1976, Niemi 1975), but this hypothesis has not been studied in detail.

In summer, the epiphyte cover of perennial species is highly variable (Fig. 5). Occasionally *Fucus* stands are covered by a thick layer of epiphytes, mainly *Ectocarpus siliculosus* and *Ceramium tenuicorne*, but this does not happen every summer (paper IV). Wind induced upwelling has been proposed to be the main reason for these mass occurrences (paper V). Even moderate SW and W winds lasting for 50 h are capable of inducing an upwelling event on the southern coast of Finland (Haapala 1994). Upwelling brings nutrient rich water to the surface, where it enhances the growth of algae. Upwelling events, on a larger scale, can also be induced by a pulse of oceanic water through the Danish Sounds. The driving force of these pulses are winter storms in the northern Atlantic (Matthäus & Franck 1988, Matthäus & Lass 1994). Increased epiphyte cover probably caused by this kind of large scale upwelling was observed in late 1970's (Kangas et al. 1982, Mäkinen et al. 1984, Rönnberg et al. 1985).

The species composition of these summer mass occurrences of epiphytic filamentous algae may be influenced by the life strategies of the species together with the weather conditions in winter (paper IV). The main summer epiphytes of *Fucus*; *Ectocarpus siliculosus* and *Ceramium tenuicorne* differ in their strategy of overwintering. *Ectocarpus* spends the whole winter hidden as an "microthallus" (see Russell 1983 for SEM images) growing at least partially endophytically in the thalli of *Fucus* (paper IV). *Ceramium* overwinters as macroscopic filaments. During winter these *Ceramium* filaments are vulnerable to storms and the whiplash effect of the *Fucus* thalli. Stormy winters may decrease the number of overwintering *Ceramium* individuals, whereas silent conditions under a long lasting ice cover may be optimal for their survival.

In autumn, the perennial algae are generally free of epiphytes even though the nutrient availability is high due to the weakening of thermal stratification and mixing of water layers. The reasons for the lack of epiphytes may be the high amount of grazers, whose feeding activity cuts the algal filaments. These partly grazed filamentous algae are probably efficiently wiped away by autumn storms with the help of the whiplash effect (papers III and V). Also low light may partly explain this decrease in epiphyte cover (Rönnberg & Ruokolahti 1986).

WHERE THE INFLUENCE OF EUTROPHICATION COULD BE SEEN ?

The Baltic Sea has steadily been in the process of eutrophication for the last decades (Elmgren 1989, Cederwall & Elmgren 1990). The nitrate-nitrogen concentration in the Gulf of Finland has increased on average by 4 % per year since 1965 in the waters of 0-50 m (Kahma & Voipio 1990). The increased availability of this generally limiting nutrient has obviously enhanced primary production. Unfortunately, direct evidence on this increase is not available due to the lack of a representative time series. The increased primary production can be seen indirectly as a decline in dissolved silicate (Niemi & Åström 1987, Rahm et al. 1996) used by diatom blooms and increase in the biomass of benthic macrofauna utilising the sedimentating plankton (Cederwall & Elmgren 1980). Also, the decreased depth penetration of *Fucus vesiculosus* (Kautsky et al. 1986) probably caused by decreased water clarity demonstrated by Launiainen et al. (1989) indicates the same phenomenon. In addition to the general process of eutrophication in the scale of the whole Baltic Sea, local nutrient sources influence the coastal ecosystems and may cause mass occurrences of short lived macroalgae. Increased production of macroalgae have been documented in estuaries of rivers originating from agricultural areas (Rosenberg 1990, Bäck et al. 1994, Pihl et al. 1996), in the vicinity of fish farms (Rönnberg, Ådjers et al. 1992) and outside industrial outlets (Kautsky 1982).

In early spring the influence of large scale eutrophication on macroalgal vegetation is direct. Nutrient reserves of the whole water column are available for algal growth due to the lack of thermal stratification (Fig 4). Therefore, regular spring mass occurrences of epiphytic *Pilayella littoralis* could be considered as a direct symptom of eutrophication. Unfortunately, the indicator value of the epiphytic *Pilayella* biomass can be disturbed at least by winds acting through the whiplash effect of *Fucus vesiculosus*. In summer, when the thermal stratification prevails, the influence of eutrophication can only be seen indirectly. The concentration of the limiting nutrient, nitrogen, is most of the time below the detection limit of conventional water analytical methods due to the high nutrient consumption by phytoplankton in the surface water. Only occasionally, when the wind condition are favourable, do upwelling events bring nutrient rich water to the surface. Mass occurrences of epiphytic filamentous algae can be observed after these upwelling events (paper V). When these mass occurrences detach due to e.g. heavy wave action, drifting filamentous algal carpets can be formed (Norkko & Bonsdorff 1996). The primary reason for summer mass occurrences is weather conditions, but the large scale eutrophication may effect indirectly by increasing the nutrient concentration of the upwelling water. This may be visible as an increased production of biomass within a single mass occurrence. The importance of this wind driven upwelling system is probably less in sheltered archipelagos near the coast, where the local anthropogenic nutrient sources may dominate.

In addition to the direct effect of the nutrient availability, the biomass produced in the planktonic community may affect macroalgae through the sediment cover over the rock surfaces. The highest biomass production of phytoplankton is concentrated within a short period in spring, the spring bloom. Most biomass produced during the spring bloom is not consumed in the water column and it sedimentates during early summer (Heiskanen & Leppänen 1996). This sedimentation maximum occurs simultaneously with the calmest period of the year. Especially the deeper parts of the vegetation covered bottoms remain more or less sediment covered until the stormy period of autumn and winter (paper IV). Long lasting sediment cover or rotting filamentous algal biomass, together with the microtopography of the substrate may increase the patchiness of the deeper parts of the macroalgal vegetation (paper II).

Even small amounts of sediment on a hard substrate greatly reduces the settlement success of macroalgal propagules (Devinny & Volse 1978, Norton 1978). Thus it has been proposed by Kangas et al. (1982) that there may be problems concerning the reproduction of *Fucus vesiculosus*, when sediment cover is abundant over the rocky surfaces. This seems highly probable as *Fucus* releases its propagules at midsummer (Bäck 1993, Andersson et al. 1994), when the sediment cover is abundant. An increase in the summertime sediment cover could induce changes in the composition of the whole macroalgal vegetation by benefiting species releasing their propagules during the stormy and sediment free period in late autumn and winter. A shift from summer reproducing *Fucus* dominated bottoms towards the dominance of winter reproducing *Pilayella* has already been reported by several authors (Rönnberg 1981, Hällfors et al. 1984, Mäkinen et al. 1984, Jumppanen 1992).

CONCLUSIONS

In a time scale of three years, the variations observed in the northern Baltic macroalgal vegetation were in most cases obviously induced by weather conditions. This differs clearly from the results of studies conducted on the oceanic coasts, where most of the processes in the littoral vegetation are biologically controlled and a direct connection to the physical environment is not clear (see Hawkins & Hartnoll 1983 for evaluation of monitoring studies). This disparity gives support to the hypothesis that the stressful physical environment of the Baltic Sea decreases the importance of biotic interactions in the sublittoral communities (Kautsky & Kautsky 1989, Kautsky & van der Maarel 1990).

The direct influence of eutrophication is difficult to observe in the macroalgal vegetation. Most plausible symptoms are spring mass occurrences of epiphytic *Pilayella littoralis*, increased patchiness of the perennial vegetation, a shift from summer reproducing to winter reproducing species and a rise in the lower limits of perennial species. However, the rocky shore macroalgal vegetation, as a whole, is in most cases a too complicated system to be used as an indicator of environmental changes, at least at the present level of our understanding.

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APPENDIX 4

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MONITORING OF THE STATE OF THE COASTAL SEA IN TALLINN AREA IN 1993-1996 BY LITTORAL MACROALGAE

Monitoring of the state of the coastal sea in Tallinn area in 1993-1996 by littoral macroalgae.

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Introduction:

The earliest data concerning the bottom vegetation of Tallinn Bay is available from the year 1849 published by E. Eichvald. In his work he mentioned the presence of red algae *Furcellaria fastigiata* = *F. lumbricalis, Polysiphonia nigrescens* and *Ceramium sp*. From the brown algae *Chorda filum* and from the marine phanerogarms *Zannichellia martima* = *Z. palustris* and *Potamogeton pectinatus* were mentioned. Chr. Gobi, a Russian professor of St. Petersburg (1874, 1977), was the next to study marine algae in Tallinn Bay. He described the benthic flora of Tallinn Bay and nearby bodies of water. E. Häyren (1929) collected data about species composition of the macrophytobenthos of this region from stranding on seashore. Thereafter the investigations came to a standstill until in 1975 they were revived by H.Kukk who collected samples of benthic algae from 127 stations all over Tallinn Bay. Besides, in 1976 he took samples from 35 stations. The obtained results were presented and long-term changes analysed (1979). In 1978, 19 samples were taken from this region and in 1984, 36 more samples were examined. All the data obtained were published in 1986. Already in 1984 certain changes became evident compared to earlier years. So in Kopli Bay *Zostera marina* had considerably expanded its distribution. The same pattern was registered for *Fucus vesiculosus*. Some species (*Sphacellaria arctica, Furcellaria lumbricalis, Coccotylus truncatus*), previously absolutely lacking in the bottom vegetation of the area, occurred in the bay. At the same time serious decline of *Fucus vesiculosus* was registered east of Tallinn Bay at the coast of the Viimsi Peninsula. The above changes were thought to be caused by starting of the new waste water purification system (Kukk 1986). During the last few years, since 1991, a regular monitoring has been carried out in the area. On the basis of this programme the bottom vegetation of the area is mapped each year and changes in the communities have been recorded (Kukk, et. al. 1994).

Material and Methods.

Material for the present study was collected during the field work in June-July of 1993, in July of 1994 and in August of 1995 and August of 1996. Each year 30 stations from Kopli, Paljassaare and Tallinn Bays were sampled. All samples were collected from a depth of 0.2 - 2 m by a special scraper. The character of substrate and depth were recorded at each location. The samples were preserved in Strasburger solution (45% alcohol, 30% glycerol and 25% formalin). In each sample the species composition and relative abundance (percentage of the wet weight of each species from the total wet weight of the sample) were studied. Relative abundance was later treated as a quantitative measure in statistical processing. The classification of benthic algal communities was established by cluster analyses using the MVSP package where the similarity measure was Squared Euclidean Distance.

Results and Discussion.

Out of the 21 taxa of macroalgae and phanerogarms identified in the samples of this area 7 species were PHAEOPHYTA, 4 species RHODOPHYTA, 5 species CHLOROPHYTA, 1 species CHAROPHYTA and 4 species MAGNOLIOPHYTA. The bottom vegetation of the Tallinn area is somewhat different from that of the Helsinki area. Comparison of the sampling results in 1993 showed that only 14 species of bottom vegetation occurred in both areas, while 24 species were found either in the Tallinn or in the Helsinki area. In the Tallinn area the share of CLOROPHYTA was the biggest in terms of biomass, whilein the Helsinki area the PAEOPHYTA was the most abundant group of bottom vegetation. These differences are caused most probably rather by the geomorphology of the coastline and the type of the substrate than by salinity conditions or the character of human impact.

To find out the regularity in the distribution pattern of the bottom vegetation in the Tallinn area the methods of classification by cluster analyses was applied. As a result, three groups of communities with a very specific structure of communities were determined. The figure shows the relative abundances of six main species of benthic algae in these communities. It is important to note that all six species are present in each of the three communities, but the in share is considerably different. In the first group of vegetation communities the green algae *Cladophora glomerata* is hardly dominating the vegetation while the abundances of other species are very low. The second group of vegetation communities is characterized by codominance of four key species *Cl. glomerata, Enteromorpha intestinalis, Ceramium tenuicorne* and *Pilayella littoralis*. The third group of communities is dominated by the brown algae *Fucus vesiculosus*. On the basis of the structure of the communities, these three groups could be classified to three different trophic levels of the coastal sea water in the area. The first group of communities inhabits the areas with the highest trophic level of the coastal environment. The second group is characterizing the moderate trophic level of the coastal sea. The third group, dominated by the bladder wrack with its epiphytes, is representing the areas of the coastal sea with natural background trophic conditions not influenced by human activities. According to the distribution of these three groups of benthic algal communities the areal classification of the coastal sea in the Tallinn area was established. The validity of this classification is proved also by the distribution of the dominant species of bottom vegetation along the coast of the Tallinn area. It is obvious that the urban area of the coastal sea in the Tallinn region is surrounded from the east and west by the benthic communities dominated by bladder wrack (*F. vesiculosus*). These communities inhabit the areas west of Kopli Bay, the coastal sea of Naissaar Island and the waters east of the Viimsi Peninsula. The inner part of the urban area is dominated mostly by two species of green algae *Cladophora glomerata* and *Enteromorpha intestinalis*. The abundant occurrence of *E. intestinalis* is recorded for the most polluted coastal areas of the Paljassaare Peninsula and harbour region of Tallinn Bay.

The results of regular monitoring of the state of coastal sea by benthic algal communities in the region show some dynamics of the distribution of the tropic level of the coastal sea. In 1993, the inner part of the coastal sea of the Tallinn urban area was covered by mesosaprobic vegetation. By 1995 the mesosaprobic zone had diminished considerably; being replaced, for the most part, by the oligosaprobic vegetation, it had preserved only in the areas close to the Paljassaare Peninsula and the innermost part of Kopli Bay. The area of distribution of katarobic vegetation has not changed much since 1993. This phenomenon could be explained by the effect of introducing modern waste water treatment system at the Tallinn Waste Water Treatment Plant in 1994.

In 1996 the situation has changed also. The borders of the mesosaprobic zone have also moved from the Viimsi peninsula towards the bottom of Tallinn bay. The recolonisation by *Fucus vesiculosus* was described in the areas close to the Pirita area and northwards along the shoreline of Viimsi peninsula. On the other hand the relative abundance of *Cladophora glomerata* has increased in whole sea area. The development of *Enteromorpha species* was somehow lower than in previous years.

APPENDIX 5

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THE STATE OF LITTORAL MACROPHYTES OFF VUOSAARI, THE FUTURE HARBOUR AREA OF HELSINKI

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THE STATE OF LITTORAL MACROPHYTES OFF VUOSAARI, THE FUTURE HARBOUR AREA OF HELSINKI

The growth of macrophytes is dependent on different environmental parameters. Tide is almost absent in the Baltic Sea. Sea level varies according to the cyclonic activity and runoff; the lowest water levels occur mainly in spring and early summer. Salinity is affected by runoff, upwelling and irregular movements of water layers. Wave exposure, ice shearing and the quality of substrate are the most important local abiotic factors to macrophytes. Growth period is limited by ice cover, temperature and solar radiation; most of the primary production taking place in June-September. Perennial macrophytes inhabit the sublittoral zone under 1,0 - 1,5 m depth because of ice shear. Annual macrophytes; mainly green and brown algae, colonize the eulittoral zone from 0 to 1-3 meters depth. If ice period is delayed, some of them inhabit the uppermost water line in the dark season, too. Due to low water temperature, secondary production is slow. Thus they are able to stay in the waterline without being decomposed by grazer organisms or bacteria.

Besides the above-mentioned factors, inorganic nutrients are essential growth promoters for macrophytes. Plankton algae compete directly with them by using the same nutrients and indirectly by shading deeper water layers. The riverine and human input of nutrients is remarkable in the Gulf of Finland. Even if the Gulf is open towards the Baltic proper, local high concentrations of nutrients, mainly nitrogen anf phosphorus, are frequently recorded along the coastline.

The study was concentrated to the upper (eu)littoral zone which is mainly populated by annual green algae and phanerogams. The uppermost part of the *Fucus* belt (down to 2.0 - 2.5 m depth) was included, too.

Samples were taken in August when the annual algae have reached full length but before they begin to cease, decompose and detach from the substrate. Sampling took place from a outboarder boat with a shaft rake, equipped with a cutting edge and a net bag. Sample sites were 3-5 m broad strips of the eulittoral zone. Prior to sampling, the site was viewed and documented for substrate type and vegetation cover. By raking several times from one site a representative collection of the macrophyte cover was obtained. The sample was preliminary surveyed onboard and different algal groups or species were subsampled to an one liter plastic container with the ambient sea water. The subsamples were preserved (fixed) with Strassburger solution for later microscopy in the laboratory. Sampling took place on both sides of the Gulf by the same crew. Laboratory work was made by the same personnel, too.

Besides taxonomical determinations, different physiological parameters were recorded for *Cladophora glomerata* and *Fucus vesiculosus*. A compilation of the parameters is presented in Table 1.

Cladophora glomerata	Height	1-12 cm 10-30 cm
	Abundance of epiphytes (3 classes, visual observation)	Class 0 (no epiph.) Class 1-2 Class 3 (abundant)
Fucus vesiculosus	Height Gas vacuoles Fertility *Elachista* as an epiphyte[1]	(cm) (y/n) (y/n) (y/n)
	Hydrozooic epiphytes[2]	<10 % of surface >10 % of surface

Remarks: (1) The most common obligate epiphyte on *Fucus* in the Baltic.
(2) Mainly *Membranipora crustulenta* and *Balanus improvisus*.

Table 1. Physiological and vegetative properties recorded in this study.

The macrophyte groups off Helsinki

The most extensive field work in Helsinki and adjacent areas was conducted in 1993. 225 sample sites were visited in two weeks at the end of July (Viitasalo et al. 1994).

The taxons and their physiological properties were clustered into groups which occur most likely together in same samples. The clustering process used a correlation matrix with Pearson's product moment coefficient and utilized weighted pairing of groups in building the dendrogram (Kowach 1993, Lance and Williams 1966). Some of the taxa were rare and their clustering affinities were not clear. The following groups of taxa, their properties and functions were detected, however (see FIGURE 1):

A. Group of the outermost archipelago (s=-2):

Fertile *Fucus* with *Elachista* but few zooic epiphytes.
Cladophora with few (diatomic) epiphytes.
Pilayella and *Dictyosiphon chordaria* near the surface.
Ceramium, Cladophora rupestris and *Furcellaria* under *Fucus*.

B. Group of the middle archipelago (s=-1):

Sterile *Fucus*; mainly without *Elachista* and older parts of the thallus covered by epiphytes.
Ectocarpus siliculosus, Polysiphonia violacea on stones, *Dictyosiphon foeniculaceus* also on *Fucus*.
Chorda filum, Ranunculus baudotii in more sheltered localities.

C. Group of inner archipelago without wastewater load or convalescent areas (s=+1)

Constant occurrence of small amounts of *Enteromorpha sp.* (abundance under 2 %).
Enteromorpha compressa.
Constant growth of *Cladophora* in different forms.
Rich populations of phanerogams; *Potamogeton pectinatus, P.perfoliatus, Ceratophyllum sp, Myriophyllum sp.*
Zannichellia.

D. Group of inner archipelago with wastewater or stormwater load (s=+2):

More than one species of *Enteromorpha* or mass occurrence (abundance > 60 % in the sample) of *Enteromorpha sp.*
Most frequent species were *E. prolifera, E. ahlneriana, E. intestinalis.*
Sterile *Ectocarpus* with long hairy branches (*Ectocarpus confervoides* typus *fluviatilis*, sensu Waern 1952, p.116).

Remarks on the groups:

Cladophora glomerata occurred frequently in the groups A and D, too. The clustering process can "sell" one taxon only once into a group with the highest affinity. Thus an ubiquitous species like *Cladophora* suffers from this type of grouping method.

Many rare species confuse the clustering tree rather than show any indication properties. Further work is needed to evaluate whether or not they deserve attention in respect to eutrophication.

The overall nutrient concentrations are well documented in the area. Different clusters (and taxa inside them) are supposed to display different ecological factors, one of them being the availability to nutrients (eutrophication). All taxa in a certain cluster were assigned with integer values which were called s-values (s-indicator values). These values are not necessarily connected to eutrophication in the outer fringe of the archipelago.

The information of different taxa, their abundances and s-values from one sample were collected into a sample biotic index ("S-index") according:

$$S = \frac{\sum (s \times a_{100}^{1/3})}{\sum (a_{100}^{1/3})}$$

where S = sample S-index
s = taxon s-value
$a_{100}^{1/3}$ cubic root of the abundance of a taxon in a sample.

Comment: Taxa with s = 0 were excluded.

Because the S-index is an average-like function of all taxa in a sample, it is less sensitive against local variation than the observations of individual taxa alone. The abundances were handled by cubic root transformation. It favours small-sized species with permanently low abundances, which, however, may be as important indicators as the big ones (Williams and Stephenson 1973).

There are many different biotic indices. The present method is based mainly on Pantle and Buck (1955), Chutter (1972) and Sladecek (1961). All of them have suggested indices where the abundances are weighed by different subjective quality values of the same taxa. As is well known, the distribution of algae species is mainly dependent on natural environmental variables (salinity, light, temperature etc). Thus care must be taken when conclusions of their reactions against eutrophication are drawn.

After the calculation of the sample S values, the sample sites were classified into four classes and a map of different ecological zones was drawn (FIGURE 2).

The question arises, to which extent the sample S values alone mirror eutrophication. Man-induced effects upon an ecological association are always hard to separate from the natural variety of circumstances and localities. Long-lasting monitoring of the same areas with identical methods, however, may help to detect and explain the changes.

The Vuosaari sea area is located on the eastern border of Helsinki. It belongs to the inner and middle archipelago. It is characterized by shallow bays and semi-enclosed water basins between the mainland and islands. Besides local brooks and ditches, no freshwater is entering to the area. Salinity varies between 5 and 6 per mille. Water temperature rises up to 20 oC during the growth period. During the last few years the summer thermocline has been extraordinarily faint; thus water has been able to mix through the whole water column. The growth period 1996 was exceptionally cold and windy from June to July. Warm calm season from August released mass occurrence of blue-green algae. Ice cover prevails from mid-December-Januaray to the end of April, thickness being from 30 to 60 cm. Water currents move irregularily or according to wind; the zero resultant being slightly from north-east to south-west; along the mainland coastline.

No wastewater is released to the are today. Earlier it served as a recipient for treated municipal wastewater from 100.000 inhabitants. The location of the future harbour and the new channel are depicted in Fig. 1.

The study area has been visited regularily at 4-5 year´s interval . During this survey, 12 sampling sites were visited during the week 30, in 1996.

Results

Main results are depicted in Fig. 2. Two of the sites were undisturbed, nine of them slightly disturbed and one disturbed. The latter one was characterized by dense mass occurrence of *Enteromorpha intestinalis* and *E. prolifera*. *Fucus* was abundant in 1993 but now it had disappeared. The bay of Niinilahti suffers from releases from sand industry which releases high amounts of fine mineral particles to water. Settling of *Fucus* germlings on the stone surfaces may suffer. On the other hand, Maloxen, south og Granö, had recovered from slightly disturbed to undisturbed. *Ahnfeldtia plicata* was encountered from two locations; Maloxen (7 meters) and Fästningen (1,5 m). *Ahnfeldtia* has never been encountered by the present author from these areas.

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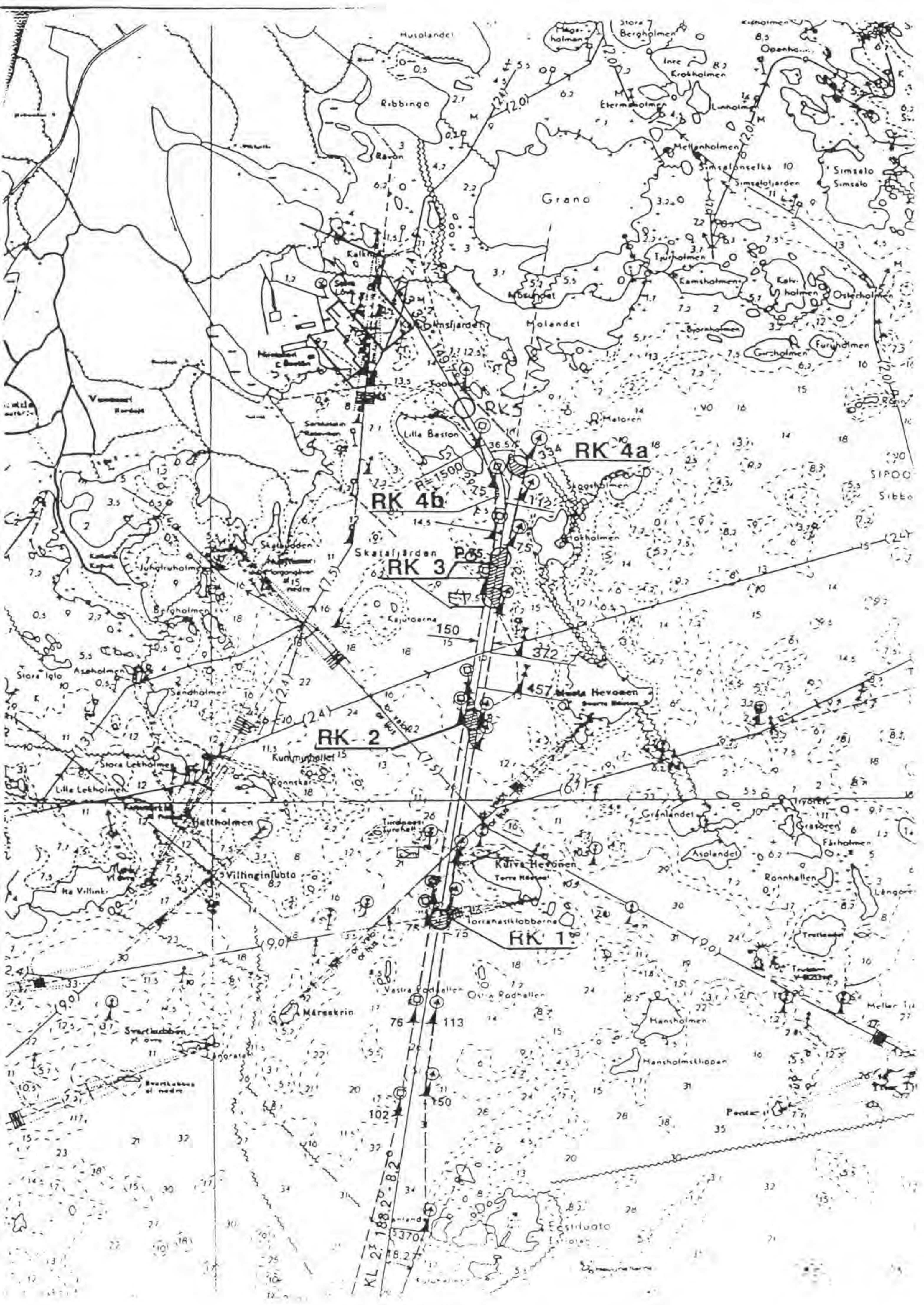
Husolandet
Ribbinge
Grano
Simsalo
Simsalonselka
Mellanholmen
Krokholmen
Bergholmen
Kalvholmen
Österholmen
Furuholmen
Molandet
Lilla Beston
Malören
RK 5
RK 4a
RK 4b
RK 3
RK 2
RK 1
R=1500
36.5
Skatafjärden
Kajuterna
Bergholmen
Stora Iglo
Aseholmen
Sandholmen
Stora Lekholmen
Lilla Lekholmen
Hettholmen
Kuiva Hevonen
Grönlandet
Asolandet
Ronnhallen
Trollandet
Vastra Rodhallen
Östra Rodhallen
Måraskrin
Svartkobben
Hansholmen
Hansholmsklippan
SIPOO
Sibbo
150
372
457
76
113
102
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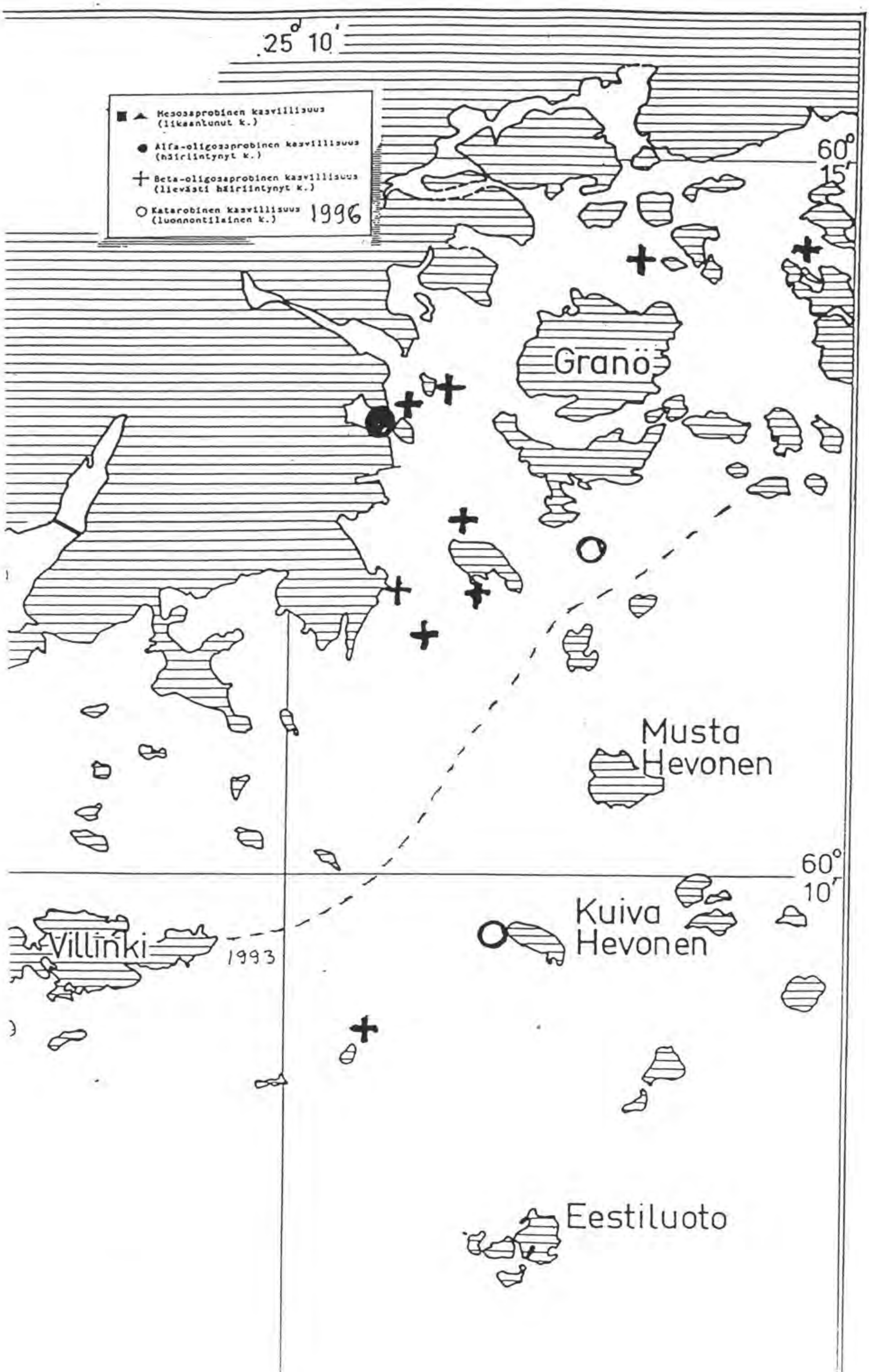
1996



25° 10'
Mesosaprobinen kasvillisuus
(likaantunut k.)
Alfa-oligosaprobinen kasvillisuus
(häiriintynyt k.)
Beta-oligosaprobinen kasvillisuus
(lievästi häiriintynyt k.)
Katarobinen kasvillisuus
(luonnontilainen k.)
1996
60° 15'
Granö
Musta Hevonen
60° 10'
Kuiva Hevonen
Villinki
1993
Eestiluoto

APPENDIX 6

Kotta, Ilmar and Kotta, Jonne
Estonian Marine Institute

ZOOBENTHOS AROUND SEA-REGION OF VUOSAARI AND SEURASAARI

Zoobenthos around sea-region of Vuosaari and Seurasaari

I. Kotta J. Kotta

Estonian Marine Institute, Lai 32 Str., Tallinn EE0001, Estonia

Samples were collected by a modified Petersen bottom grab (0.017 m^2) in 1995 and Ekman-Lenz bottom sampler (0.04 m^2) in 1996. Sediments were washed through a 0.25 mm mesh (nylon net bag) and the samples were preserved in 4 % buffered formaldehyde solution. In the laboratory, animals were counted under the stereo dissecting microscope. Total wet weight for each taxa were found to the nearest 0.5 mg.

The zoobenthos of Vuosaari and Seurasaari sea-area is characterized by

1. low species diversity (especially if crustacean are taken into account). The following taxa were found in the study area: *Marenzelleria viridis, Turbellaria, Oligochaeta, Nereis diversicolor, Halicryptus spinulosus, Gammarus spp., Jaera albifrons, Saduria entomon, Chironomidae larvae, Diptera larvae, Macoma balthica, Cerastoderma lamarcki, Hydrobia spp.*
2. low biomass and abundance values (< 5000 ind m^{-2}, 100 g m^{-2}), especially true for crustacean (Table 1, Table 2)
3. high proportion of sessile benthos (usually *Macoma balthica* comprises more than 90% of the total biomass and abundance)
4. high percentage of occurrence of insecta larvae and worms but their abundance and biomass values are low.

The zoobenthos of this type is rarely observed in the southern coast of the Gulf of Finland: as the examples Paldiski, Ihasalu and Eru Bays could be mentioned. In Estonian waters such communities are observed in Väinameri Archipelago and southern coast of Saaremaa Island. These areas do not encounter any bigger pollution inputs and the development of the communities are determined by eutrophication rate. We may conclude that zoobenthos in Vuosaari and Seurasaari Islands is typical to eutrophicated sea-areas but the influence of the source pollution of Helsinki City may be considered rather unimportant. It is possible that the communities of Vuosaari and Seurasaari have overcome similar changes in last 20 years as that of Saaremaa Island (Kotta, I., Kotta J. in press) i.e.:

1. the decrease of species diversity caused by the impoverishment of benthic macroalgal communities
2. abundance and biomass of zoobenthos decrease
3. sessile molluscs (such as *Macoma balthica*) become more abundant in zoobenthic communities.

Table 1. Abundances of different groups of macrobenthos (ind m^{-2}) in Vuosaari and Seurasaari areas in 1995-1996.

PIIRKOND	*total*	*vermes*	*crustacea*	*insecta larvae*	*mollusca*
Malören	150	0	25	0	125
Särkkaniemi	225	50	0	0	175
Miimisaari	300	300	0	0	0
Niimisaari	225	75	0	75	75
Kajutaluonto	325	125	25	0	175
Lehtisaari	225	75	0	0	150
Simsalö	450	450	0	0	0
Madasaari	475	150	0	0	325
Etermaholmen	450	450	0	0	0
Fästningör	250	100	0	0	150
Vuosaari mean	**308**	**178**	**5**	**8**	**118**
Conf. int.	**71**	**102**	**7**	**15**	**64**
G (169)	1450	870	0	348	232
186	986	464	0	58	464
180	1392	1218	0	0	174
G (169)	2958	174	0	1624	1160
E (166)	3016	2668	58	116	174
189 A	3712	696	0	2146	870
185	1044	928	0	0	116
170 A	986	174	0	812	0
182	2378	812	0	1566	0
184	1392	928	0	58	406
187	1276	1044	0	0	232
111	928	0	0	812	116
F (168)	928	58	58	812	0
170	232	58	0	58	116
Seurasaari mean	**1620**	**721**	**8**	**601**	**290**
Conf. int.	**523**	**365**	**11**	**378**	**179**

Table 2. Biomasses of different groups of macrobenthos (g m^{-2}) in Vuosaari and Seurasaari areas in 1995-1996.

Area	*total*	*worms*	*crustacean*	*insecta larvae*	*mollusca*
Malören	30,6	0,0	6,0	0,0	24,6
Särkkaniemi	3,0	0,1	0,0	0,0	2,9
Miimisaari	0,2	0,2	0,0	0,0	0,0
Niimisaari	16,1	0,1	0,0	0,1	15,9
Kajutaluonto	0,8	0,2	0,1	0,0	0,5
Lehtisaari	16,9	0,2	0,0	0,0	16,7
Simsalö	0,2	0,2	0,0	0,0	0,0
Madasaari	84,7	0,3	0,0	0,0	84,4
Etermaholmen	0,5	0,5	0,0	0,0	0,0
Fästningör	0,4	0,2	0,0	0,0	0,2
Vuosaari mean	**15,3**	**0,2**	**0,6**	**0,0**	**14,5**
Conf. Int	**16,4**	**0,1**	**1,2**	**0,0**	**16,2**
G (169)	20,0	2,2	0,0	0,4	17,4
186	211,2	1,3	0,0	0,0	209,9
180	1,4	1,3	0,0	0,0	0,1
G (169)	146,1	0,4	0,0	2,0	143,7
E (166)	3,2	2,7	0,0	0,0	0,5
189 A	113,1	1,5	0,0	3,1	108,5
185	12,0	0,3	0,0	0,0	11,7
170 A	0,9	0,1	0,0	0,8	0,0
182	9,3	0,4	0,0	8,9	0,0
184	51,6	0,8	0,0	0,0	50,8
187	6,8	0,5	0,0	0,0	6,2
111	54,1	0,0	0,0	1,5	52,5
F (168)	1,3	0,0	0,0	1,2	0,0
170	13,4	0,0	0,0	0,0	13,3
Seurasaari mean	**46,0**	**0,8**	**0,0**	**1,3**	**43,9**
Conf. Int.	**34,2**	**0,4**	**0,0**	**1,3**	**34,2**

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APPENDIX 7

Martin, Julia* and Kalso, Seija**
* Estonian Marine Institute
** City of Helsinki, Environment Centre

INTERCALIBRATION OF MICROBIOLOGICAL METHODS BETWEEN HELSINKI AND TALLINN

INTERCALIBRATION OF MICROBIOLOGICAL METHODS BETWEEN HELSINKI AND TALLINN

M.Sc. Julia Martin, Estonian Marine Institute
M.Sc. Seija Kalso, Helsinki City Environment Centre

The requirements and criteria for bacteria used as hygienic indicators of drinking water, swimming water and monitoring of sea area were discussed. Because these bacteria are used as an indicator of faecal pollution, they must be common inhabitants of human and animal feces.

The value of different groups of bacteria as hygienic indicator of sea water was discussed. Especially the group of thermotolerant coliforms and *Escherichia coli* as indicators were considered.

In the knowledge transfer seminar of Lohusalo the analyse of thermotolerant coliforms as an indicator of faecal pollution in Estonian sea waters was decided to be developed.

Comparative studies between the laboratory of Estonian Marine Institute and the laboratory of Helsinki City Environment Centre were performed during the year 1996. Altogether 65 identical sea water samples were analyzed in both laboratories to get information about the reproducibility and also repeatability of the methods used. Only a difference of no importance in the medium used was between the methods of the two laboratories.

The first results were not promising. The reason for differences in test results were discussed. Storage problems of samples and the use of inaccurate incubator in Tallinn shoud be taken into consideration.

When identical samples of sea water were analyzed with different methods in the same laboratory, the reproducibility expressed as Poison index of distribution of parallel colony counts was regonized.

This was the situation in both laboratories: with the same technical equipment no method-related differences in colony counts were observed.

Some non-typical strains of bacteria were grown especially on the medium used in the laboratory of Helsinki, but also on the medium used in Tallinn. This was observed when parallel samples of very turbid samples with a lot of backgroud flora were analyzed in Tallinn. Identification of these strains approved that they were not typical thermotolerant coliforms. The reason for non-typical growth of bacteria was discussed and the calibration of the thermometer in the laboratory of Estonian Marine Institute is planned to be performed in the near future. Also there is a need to improve the quality of the laboratory water used in the Estonian Marine Institute.

It was seen necessary and important to go on the collaboration concerning the analysis of hygienic faecal indicators of sea water.

APPENDIX 8

Martin, Julia
Estonian Marine Institute

HYGIENIC STATE OF SEA WATER OFF TALLINN REGION

Water sampling areas were situated both in Kopli Bay and Tallinn Bay in 1996. The hygienic state of sea water near the waste water outlet, in harbour area, on the beaches and in the outer part of bay areas was examined and results were introduced in this paper, too.

APPENDIX 9

Kalso, Seija and Pesonen, Lauri
City of Helsinki
Environment Centre

HYGIENIC STATE OF SEA WATER OFF HELSINKI REGION

HYGIENIC STATE OF SEA WATER OFF HELSINKI REGION

M.Sc. Seija Kalso
Helsinki City Environment Centre

The hygienic state of sea water on the 23 beaches of Helsinki was introduced (Figure 1). The quality of water on the beaches of more than 100 visitors a day are yearly reported to the European Comission.

The quality of the bathing waters in Helsinki has regularly been studied since 1958.

Thermotolerant coliform bacteria and faecal streptococci has been used as hygienic indicators up to the year 1996 (Figure 2). Three categories of water quality has been used according to the quidelines: good, acceptable and poor.

The changes the hygienic quality of bathing waters due to the improving of waste water treatment systems was discussed.

Since 1.5.1996 the new requirements for hygienic indicators of bathing waters have been in use. Also other changes for instance in water sampling frequency in the settlement of Ministry for Social Affairs and Health etc. were discussed.

Altogether 260 swimming water samples from the beaches of Helsinki in 1996 has been studied. The hygienic quality of the bathing water has been good.

The raport of European Comission of the quality of bathing water was introduced.

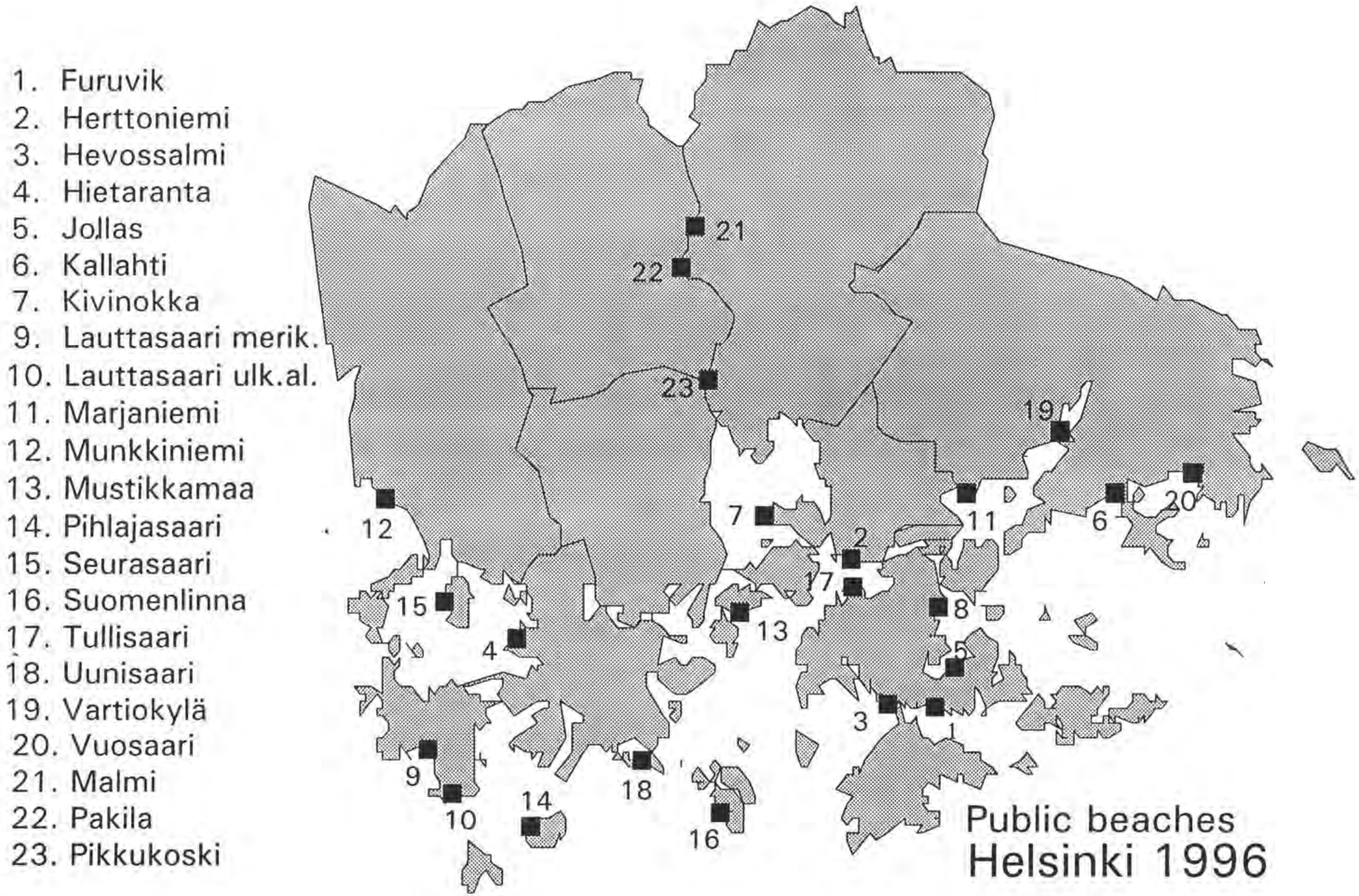

Fig. 1. Public beaches in Helsinki in 1996

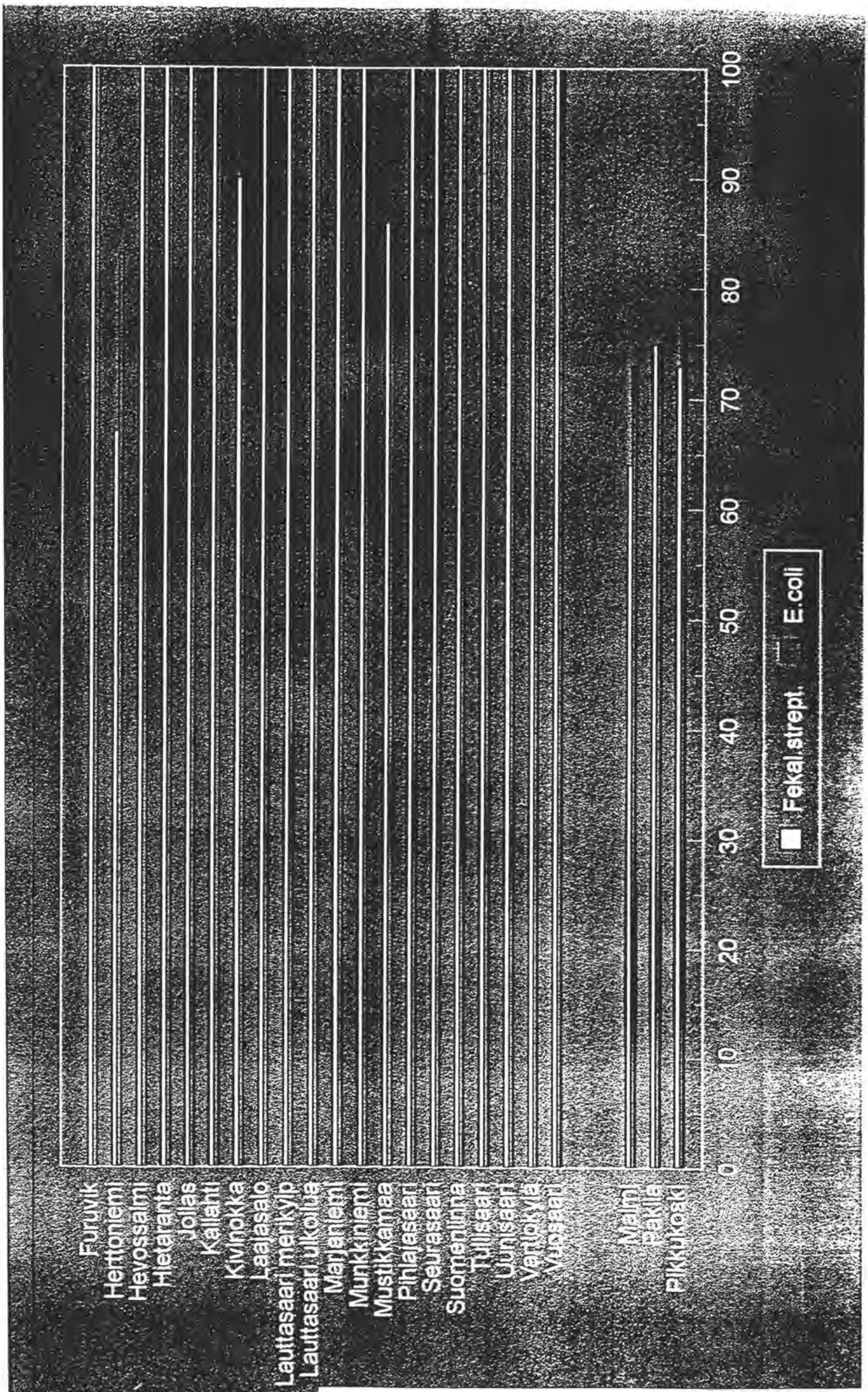

Fig 2. Hygienic quality of the public beaches of Helsinki in summer 1996

APPENDIX 10

Sinervo, Tuija
City of Helsinki
Environment Centre

ACCREDITATION CRITERIA FOR LABORATORIES

ACCREDITATION CRITERIA FOR LABORATORIES

Tuija Sinervo
City of Helsinki
Environment Centre

The high quality of laboratory results has always been very important to laboratories, but during the last five years it has become the most important issue when these laboratories develope their operations. To convince the client about the high quality of the analyse results laboratory needs well documented quality system where all the quality assurence measures are described.

The quality assurance means all those planned and systematical measures by which a laboratory can show that its results fulfill the clients requirements. The quality system contains all parts of the laboratory work: the quality policy, the organization and staff, the environment, the equipment and reagents, the methods, the quality assurence, the control of the quality system and documentation. The quality system has to be based on the international standards EN-45001 and ISO GUIDE 25 and described in the quality handbook of the laboratory.

The accreditation is the formal statement of the competence of the laboratory to make certain tests. The accreditation covers only certain tests and is made by the independent accreditation body. This accreditation criteria for the laboratory means that the laboratory must have the well documented quality system based on the international standards. The quality system should include all those parts which has been listed earlier in this paper.

The laboratory should have a clear opinion what are the most important facts in its quality policy. The laboratory must be independent and unbiassed. The responsibilities of the staff must be spesified. The laboratory must have a quality manager, who ensures that the quality system works. All staff should be well educated and competent and the laboratory must take care of the adequate training. The environment in laboratory must be clean and well organized. All the instruments must be calibrated and the calibrations should be controlled. All the other equipment should be suitable for use and reagents must have the right purity. Standard methods should be used if they are available. If the laboratory use their own methods they must be validated. Used tests must work well and the continuous quality control must be arranged (Including using of reference materials, to take apart to intercalibration tests and to control the repeatibility and reproducibility of the analysis). The quality system should also be controlled by arranging internal quality audits and management reviews. The laboratory must document all its work starting from data sampling and raw results to the analysis reports in a permanent way with date and personal signature.

Building the quality system is a very time-consuming process and it makes extra costs. The whole staff in laboratory including the highest management must engage with this quality system process before it can work. And it never comes ready. But this system will pay itself back because there will be less errors and mistakes, the staff will be more motivated and the clients will be more satisfied.

APPENDIX 11

Kalso, Seija
City of Helsinki
Environment Centre

ACCREDITATION OF THE MICROBIOLOGICAL LABORATORY OF HELSINKI ENVIRONMENTAL LABORATORY

ACCREDITATION OF THE MICROBIOLOGICAL LABORATORY OF HELSINKI ENVIRONMENTAL LABORATORY

M.Sc. Seija Kalso
Helsinki City Environment Centre

Altogether 32 microbiological methods were accreditated in the environmental laboratory. Standard methods for the examination of water samples are used and the methods for the most important hygienic indicators are accreditated.

The quality system of the microbiological laboratory was introduced by giving examples of the general rules and procedures to ascertain the techiques used for conducting these examinations.

Particular attention was paid on the quality system of preparation and sterilization of culture media and reagents.

Calibration and every day control of equipment as the temperature control of incubators and autoclaves were introduced.

Intercalibration of microbiological methods is performed three times a year. Also the principles of internal quality control systems such as testing the dispersion of parallel colony counts were discussed.

APPENDIX 12

Lehvo, Annamaija
Finnish Environmental Institute

COASTAL MONITORING GROUP: RESULTS AND RECOMMENDATIONS OF THE GULF OF FINLAND WORKSHOP: LITTORAL PHYTOBENTHOS MONITORING

Development of phytobenthos guidelines
Pentti Kangas and Annamaija Lehvo
Finnish Environment Institute, 5 Dec., 1996

Report from a **PHYTOBENTHOS MONITORING WORKSHOP** held in Finland in 18-21 November, 1996.

This report presents the results of the Phytobenthos Monitoring Workshop held at Tvärminne, Finland in November 18-21, 1996.

Participants

Estonia: Henn Kukk & Georg Martin, Finland: Jan Ekebom, Pentti Kangas (chairman), Annamaija Lehvo, Anita Mäkinen & Pentti Välipakka, Lithuania: Vytautas Labanauskas & Sergej Olenin, Poland: Eugeniusz Andrulewicz, Russia: Alexander Antsulevich, Yuri B. Okolodkov, Vadim E. Panov & Irena V. Telesh

Background

The workshop was financed by The Finnish Ministry of the Environment (Gulf of Finland year 1996) and the International EMECS Center (Environmental Management of Enclosed Coastal Seas). The original task was to discuss on and plan a phytobenthos monitoring programme for the Gulf of Finland. However, an extra financiation from EMECS gave an opportunity to enlarge the workshop to southeastern part of the Baltic Sea, in order to promote the task of EC MON/CMP-project to develop Guidelines for phytobenthos monitoring in the Baltic Sea. Depending on financial facilities, the western Baltic Sea countries will be included in the work after this workshop.

Aims and realization

Important matters to discuss were:
- Present situation of phytobenthos monitoring and related studies
- Concepts for creating a phytobenthos monitoring strategy for the Baltic Sea
- Concepts for selecting monitoring areas and stations, monitoring methods and parametres
- Optimal and obligatory level of monitoring
- National needs and resources

Firstly, the participating countries informed on the present situation of phytobenthos monitoring and research activities. Secondly, general principles of monitoring guidelines were discussed. Thirdly, three work groups were formed on the basis of different phytobenthos bottom types: hard bottom areas, sandy areas and sheltered soft-bottom areas.

Results

By common consent it was stated that a lot of work is needed before the phytobenthos monitoring programme can be useful and accepted by all the Baltic Sea countries. Only some small useful pieces of programme are existing now. Supporting projects are needed, like a biotope classification system and more research on ecological processes of phytobenthos. However, a small scale pilot monitoring project could be started already in summer 1998.

The experiences of phytobenthos monitoring are quite variating in different countries. However, some long-term phytobenthos research has been done in all countries, but only Estonia has a phytobenthos monitoring programme financed by the government.

It was also stated that the emphasis of monitoring should be at relative clean areas, while polluted areas are of national concern. HELCOM BSPA-areas are in the first place to be considered. Methods were discussed in quite general level. Most important method will be SCUBA-diving together with underwater video, when fine resolution is needed. Also remote sensing is necessary especially in shallow soft-bottom areas. Biotic and also abiotic environmental parameters for monitoring were suggested in priority order. Optimal and obligatory level of monitoring were discussed. Detailed results of the workshop are under preparation, and will be available for distribution in the beginning of 1997.

Suggested time schedule for the work (depends on financial resources):

Outlines of the phytobenthos monitoring programme on the basis of the 1st workshop (Nov 1996)	February 1997
2nd Workshop including the western Baltic Sea countries	March 1997
Recommendations to EC MON	May 1997
Presenting the proposal to BMB phytobenthos wg	June 1997
Distribution of the proposal for comments	September 1997
3rd Workshop /preparation for a first draft of the programme	December 1997
Draft of the phytobenthos monitoring programme	Beg. of 1998
Realization of a pilot monitoring programme	Summer 1998

APPENDIX 13

Viitasalo, Ilkka
City of Helsinki
Environment Centre

RESULTS AND RECOMMENDATIONS OF THE GULF OF FINLAND WORKSHOP: DEVELOPMENT OF THE SPACE-INDEPENDENT BIOINDICATION SYSTEM FOR EVALUATION OF EUTROPHICATION IN COASTAL AREAS OF THE GULF OF FINLAND

Ilkka Viitasalo: Report from the seminar:

DEVELOPMENT OF A SPACE-INDEPENDENT BIOINDICATION SYSTEM FOR EVALUATION OF EUTROPHICATION IN COASTAL AREAS OF THE GULF OF FINLAND

Tvärminne Zoological Station, FINLAND
November the 25-27th, 1996

Plenum Summary and the Recommendations of the Seminar

All the participants agreed on the importance of this Seminar especially as a channel in creating international biological "language", which in this case means bioindex system for the coastal polluted areas of the Gulf of Finland. This indicator project was launched in 1996, and this meeting was the very first one. Now the ideas were presented and the development process is started. The following conclusions and the future plans were made during the Seminar:

A. Present situation:

There are vital biomonitoring programs going on around most of the big cities of the Gulf of Finland. In the following table main parameters and properties of the programs are presented:

	Helsinki A	Helsinki B	St.Petersburg	Tallinn
Monitoring area (sq.km)	110	110	1400	
Starting year	1974	1962	1982	1992
Prevailing salinity range (‰)	2-6	0-6	0-6	2-6
Organism groups	Macroalgae, phanerogams	Zoobenthos; macrofauna	Chironomidae, Oligochaeta, zoobenthos	Macroalgae, phanerogams
No of sampling sites	220	66	45	40
Present sampling interval	5 yrs	5 yrs	1-2	1-2
Classification method	Ecol.groups, abundance, biotic index	Biomass, ecol.groups	Abundance, biomass, species composition, ecol. groups, Integrated Index (Balushkina 1995)	Ecol.groups, saprobic system

Fruitful cooperation between Helsinki and Tallinn has been practiced since 1992. Macrophyte communities have been surveyed on both sea areas with identical sampling and laboratory methods. It has been observed that macrophytes suit well for monitoring purposes (Kukk, Viitasalo and Martin 1995). So far experience is collected from species and communities which need and/or tolerate brackish water. Freshwater communities need further consideration because they mainly receive nutrients both from the sediment and surrounding water. An attempt is underway to analyze heavy metal content of brackish water macrophytes, too.

In St.Petersburg it has been proved that information from different ecological (zoobenthos) groups can be combined into an integrated biotic index. This encourages to employ this method to other areas. Because of the strong spatial and temporal differences of the environmental variables (hydrography, pollution types, salinity, exposition, ice cover etc), additional comparative research is needed between the different polluted areas of the Gulf of Finland.

B. Overall topics:

It is essential to create a "common language" and make an exact definition of terms

Continue intensive research work on a local level

Parameters should be selected carefully e.g. among these presented ones:

Relationship between production and respiration and Shannon Index H'
Relationship between Biomass Min/Biomass Max and H'
Relationship between BOD tot/BOD soluble and H'
Carbon flow versus energy flow
Community indices
Integrated indices
Chemical parameters in biota: Heavy metals, tot-P, tot-N and their relationships

Sessile organism groups, e.g. zoobenthos and phytobenthos were recommended. On the other hand new biotic integrated indices may allow combination of phytoplakton, zooplankton and possibly some chemical parameters

In spite of their importance, fish indicators were not considered in this seminar

Methods should be simple and based on the existing theories. Special character of polluted and semi-polluted water bodies must be taken into consideration.

Results must be presented either as time series or zonation maps.

Filing and reconstruction of historical primary data was considered important. At the same time it was considered that it is time-consuming and contains many sources to errors or misintepretations (methods and units have changed, pollution data is scanty or lacking etc).

It was recognized that the rebirth of the biodiversity concept has revealed gaps in the taxonomy of certain organism groups as well as regrettable shortage in the taxonomical skills of the scientists. International taxonomy courses to younger scientists were recommended.

Old practice of international exchange of sample specimens between expert groups or scientists was encouraged.

C. Recommendations to future work (bioindication, in the vicinity of municipalities):

1. This work should concentrate upon **polluted or semi-polluted coastal areas**. Comparative studies between different areas should continue.

2. **One water area** shoul be selected to a **common pilot field**.

3. In 1997 a **planning workshop** is arranged in order to organize the field study and to introduce the different research teams to the selected area.

4. In 1998, **joint field and laboratory work** is conducted in the selected area with a **concluding seminar** in late autumn 1998.

5. It was considered that an ample pilot area could be the **Wyborg Bay**.