Contents

INTRODUCTION

The Estonian Science Fund Council has instructed Estonian scientists in the field of Marine Science and Limnology to prepare reports concerning their research activities during the last 5 years. These reports were completed during the spring of 1991 and dealt with the following points:

- project leader(s)
- short description of the objectives
- summary of results
- summary of resources
- scientific staff and their qualifications
- list of publications
- dissertations
- scientific meetings organized
- prognosis of the future development of the project

In most cases the reports were accompanied by reprints of scientific publications written in English and Russian.

In July 1991 the reports were sent to NFR and during the autumn the evaluators received them. A site visit by two of the evaluators to the relevant Estonian research institutions was made in the period of March 31 - April 1, 1992. The physical oceanographer in the group was abroad in Canada for most of 1992 and could thus not participate in the site visits.

This report was drafted in August 1992 and was finally approved by the Evaluation Group in September. It became less comprehensive and more time-consuming than originally intended, due to some practical problems and administrative misunderstandings.

We were originally asked to review Estonian *marine* science and this was later extended to include also *limnology*. However, when we came to Estonia, our hosts were not aware of the intention to include limnology, and no arrangements had been made for site visits to the limnological laboratories. The evaluation of this subject is included in this report even though it is based entirely on the submitted material, without the deeper insights a site visit can give. Furthermore, our site visit programme included two marine laboratories from which we had received no study material before the visit. Luckily, the reports which these laboratories had submitted for review could be dublicated during our visit.

ACKNOWLEDGEMENTS

The above problems notwithstanding, we were very well taken care of during our visit in Estonia. In particular, we want to thank our guide during the visit, Dr Edgar Karofeld. We were impressed by the openness with which problems were discussed, and by the facility with which most of the scientists conversed in English, an until recently more or less forbidden language. We left with deep admiration for many of the scientists we had met, who have managed to produce good to excellent science under often extremely difficult practical and political circumstances.

GENERAL COMMENTS ON ESTONIAN MARINE SCIENCE AND LIMNOLOGY

A major problem in our evaluation was the enormous difference in available resources between research groups in Estonia during the Soviet occupation. Some groups managed to do good science in spite of great difficulties, while one group at the Baltic Department of the Institute of Thermo- and Electrophysics in Tallinn produced excellent results, but with almost unlimited resources - greater than available to any marine research group in Sweden. This distribution of resources has hardly been optimal, and it is very difficult to foresee how much the comparative productivity of such groups may change under a system of more even distribution of smaller resources. However, it would be extremely unfortunate if Estonia did not continue to support and maintain its only marine research group with a strong international reputation.

We realize that the creation and maintenance of a good research competence in aquatic sciences under the Soviet occupation has been an extremely difficult task, and that almost all the scientific leaders during this period must have faced many very difficult political decisions, in order to maintain and develop their institutions. Whether some of the decisions taken then were wrong, now making the persons who made them unacceptable in leading positions is clearly outside our evaluation. However, this was a question repeatedly touched upon during our visit.

We were impressed with the dedication and capability of several of the young scientists we met. One of the major tasks for Estonian science in the next few years clearly is to allow such young scientists to go abroad to learn and establish scientific contacts of their own - the old Soviet system of sending abroad mainly the older, politically safe institute leaders must be discarded. In the same vein, it is clearly important to establish in Estonia separate funding agencies for basic science, similar to the Natural Science Research Council in Sweden, where proposals are judged according to their merit, not by the formal standing of the proposer. This will be needed so that brilliant, young scientists returning from abroad have a real possibility of establishing their own research projects and groups. If this is not possible, the best young scientists will stay abroad.

The Soviet division of science between academy institutes, which carry out most of the research, and universities, which mainly teach, is counterproductive. The early exposure of bright young students to front-line science is of paramount importance for the long-term creation and maintenance of scientific excellence, and requires a better integration between university education and front-line research. The academy institutes should, in our opinion, be integrated with the university system, leaving the academies mainly as organs for international contacts, and national science policy discussions.

In the short-term, the quality of Estonian science is threatened by the difficulty of obtaining, and even of maintaining, modern scientific equipment, necessary for chemical analyses and modern oceanographic measurements. The unavailability of modern scientific literature is another pressing problem, made worse by the cutting of ties to Moscow, from where photocopies could earlier be obtained.

EVALUATION OF RESEARCH GROUPS

I. Institute of Ecology and Marine research, Tallinn (Head Prof J-M Punning)

- Physical Oceanography -

Materials

The basic material used for the evaluation of Physical Oceanography was the report, including lists of publications and some complements, and 14 scientific papers. The scientific papers were mainly proceeding papers (10), articles in international journals (2), and in books (2). The Curriculum Vitae of Dr Mati Kahru and some of his papers were also added.

After the site visit to Tallinn, 13 further publications, mainly oriented towards marine optics and laser measurements, were added.

Principal activities

The marine research in Estonia is today mainly organized through the Institute of Ecology and Marine Research, a governmental institute founded in 1990. Research in the field of Physical Oceanography has been carried out in the Baltic Sea as well as in the Northern and Tropical Atlantic Oceans. Work in connection with international interdisciplinary experiments, as for example PEX-86 and SKAGEX-90, has also been carried out.

Estonian Physical Oceanography has been oriented to investigation of dynamics and interaction of processes at different scales, and estimation of their role for the marine environment. The researchers in this field have also built up a large data base of CTD and current measurements, which allows detailed studies of the dynamics.

Within the Institute of Ecology and Marine Research, three different departments are related to Physical Oceanography; these are:

1. Department of Marine Physics, with Cand. of Phys.-Math. Sci. Juri Elken acting as the head. In the group about 8 graduates and 8 undergraduates are working.

2. Department of Marine Optics and Remote Sensing, with Cand. of Phys.-Math. Sci. Helgi Arst acting as the head. In the group about 5 graduates and 8 undergraduates are working.

3. Department of the Modelling of Marine Ecosystems, with Dr Phys.-Math. Rein Tamsalu acting as the head. In the group about 4 graduates and 1 undergraduate are working.

The scientific potential also consists of the research ship RV Livoonia (Arnold Veimer), with quite advanced instrumentation, and one field station in Pärnu.

For the years 1991-1994 studies at the Institute of Ecology and Marine Research will follow two general themes:

1. Structural and functional organization of land ecosystems and their anthropogenic dynamics

2. Study of the Baltic Sea ecosystem and living resources aimed at elaboration of a scientific basis for their usage and protection

More detailed comments on the different groups are given in the next section.

A. DEPARTMENT OF MARINE PHYSICS (Head of Dept Juri Elken)

Evaluation

No Curriculum Vitae for Cand. of Phys.-Math. Sci. Juri Elken was included in the material. In the list of publications were found papers which were mainly oriented towards the understanding of density structure, synoptic eddies and currents, and also a paper on the PEX-86 experiment and on intrusive lenses in the Baltic Sea. The papers were published mainly in proceedings.

A considerably large data base of CTD and current measurements (about 8 900 CTD casts, 8 200 miles of towed CTD transects, 3 500 days moored current records, 4 000 current velocity profilings) has been created during several cruises. The data base is expected to give important information about different dynamic and physical processes in the Baltic Sea and the Atlantic.

The research has mainly been devoted to the investigation of synoptic, meso- and small scale processes. The aim of coming research is to go through the experimental data collected and to develop methods for diagnosis and prognosis of the synoptic scale anomalies. Also some theoretical model investigations are planned.

Within a group of the department, theoretical and numerical investigations of processes at different scales have been made. Studies on turbulence processes in the ocean and the development of new ideas about rotationally anisotropic turbulence have been made as well as studies on nonlinear interactions of synoptic-scale processes.

For the future development in Physical Oceanography the following areas were also outlined:

1. Collection of information should be improved

2. Special attention should be paid to data processing and generalization of the results

3. Effective international cooperation should be organized

Recommendations

The scientific level of the group is good and the scientific value of the measuring programmes is high. However, more efforts should be oriented towards analysis of the data, for use in the development of models for the Baltic Sea. Problems such as internal exchange within the Baltic Sea subbasins, up- and downwelling in the coastal zone, fronts, halocline ventilation, lenses and synoptic eddies should be in focus. The development of new ideas about rotationally anisotropic turbulence seems interesting but one can ask whether this will be applicable to the ocean or not. Work should also be invested in making the database easy to use and open for international cooperation. Exchange with the ICES data base should also be considered.

B. DEPARTMENT OF MARINE OPTICS AND REMOTE SENSING (Head of Dept Helgi Arst)

Evaluation

No Curriculum Vitae for Cand. of Phys.-Math. Sci. Helgi Arst was included in the material. In the list of publications 10 papers, mainly proceedings and technical papers, were found. The main fields of activity were marine optics in the Baltic Sea, solar heating and temperature profiles, radiation, attenuation and transparency.

Series of measurements of the radiance factor of the sea, the beam and diffuse attenuation coefficient, solar irradiance, chlorophyll concentration etc. have been carried out. Both the technique and the methods for the active remote sensing in the Baltic Sea have been developed. The physical control of phytoplankton growth in the Baltic Sea has also been studied.

A laser remote sensing method and instruments have also been developed by Dr Babichenko and co-workers. This is an active remote sensing method (compared to passive methods) and from the use of selective light signals, different chemical compositions of water can be determined. This opens up the possibility to produce spectral signal catalogues for different substances, for example different oil products, dissolved organic matter and phytoplankton pigments. The method and instrument have been tested aboard ships, but could also be applied to aircrafts.

The laser remote sensing method is interesting and offers the possibility for more rapid monitoring programmes for some water quality aspects in the upper layer of the sea.

Dr Mati Kahru is a leading scientist in the Department of Marine Optics and Remote Sensing. In 1982 he got his PhD degree in marine ecology and he has published about 20 papers in internationally refereed journals, partly on applying remote sensing data to oceanography. At the same time he has been on several scientific cruises and has good international experience from work and studies in the USA, Germany and Sweden.

The aim is now to continue research on optical remote and contact measurements, to determine the optical, radiative and biological characteristics of the Baltic Sea and the Estonian inland waters.

Recommendations

The scientific level of the group is good. Marine optics and remote sensing are important areas for Baltic Sea research. However, facilities for satellite remote sensing seem to be missing. The development of proper algorithms for the Baltic Sea also requires the development of in-situ measurements for the calibration and validation of the remote sensing data. The combination of facilities for satellite remote sensing, in-situ measurements and international cooperation should be important steps to take in the development of marine optics and remote sensing in Estonia. This should also be a strong support for the verification of models applied to the Baltic Sea.

Dr Kahru is a most creative and capable scientist. His experience in using satellite data in oceanography and his international contacts are important contributions to the marine research in Estonia. We recommend that some arrangements should be made in order to ensure Dr Kahru a strong research position in Estonia.

C. DEPARTMENT OF THE MODELLING OF MARINE ECOSYSTEMS (Head of Dept Rein Tamsalu)

Evaluation

Dr Rein Tamsalu is an internationally known scientist with a list of publications of more than 50 papers in different journals, proceedings and books. The main part of the papers is written in Russian and in proceedings, some papers are found in international journals. The main field of activity is modelling of the Baltic Sea. The modelling of the baroclinic three-dimensional circulation started in the early 1970's by Kullas and Tamsalu. Later more simplified models were studied, and the idea that the vertical structure in the ocean could be treated using universal non-dimensional structures was developed in cooperation with scientists in Finland. Work together with Finnish researchers on two-dimensional modelling of the Gulf of Finland has also been performed. Close co-operation with Prof Zilitinkevich in S:t Petersburg on boundary layer problems has resulted in some further model elements.

The state, dynamics and prognoses of the Baltic Sea marine environment is one main project, others are prognoses of long-term changes in the ecosystems of the Gulf of Finland and the Gulf of Riga. The ecosystem model FINEST, developed by the Estonian and Finnish scientists in cooperation, will be applied and a data base will be developed.

Recommendations

The scientific level of the group is good and the direction of work is promising. There is a great need for the development of diagnostic as well as prognostic models for eddies, circulation, and exchange studies in the Baltic Sea. The importance of development of these physical models is stressed. The modelling work should be closely connected to the analysis of the database. As it is today, quite little is done about the development of models for eddies, circulation and exchange studies in the Baltic Sea, this could therefore be a most important area to develop in Estonia. The work should be done in close contact with the international research community and analysis of the data should be one main starting point.

Summary recommendations on Estonian Physical Oceanography

The general scientific level in physical oceanography in Estonia is high, with a quite satisfactory technical base for marine research. However, there seems to be a need for more well-focused research plans. There is also a need for increased international cooperation and increased effort in publishing in international journals.

It seems that research and teaching within physical oceanography at the universities are missing at the present time. This is, of course, also a drawback for the evolution of the subject, and efforts to introduce physical oceanography at one university are recommended.

We recommend:

1. The formulation of more well-focused national research plans
2. An increase in modelling of physical processes in close contact with the analysis of current and CTD data bases
3. Introduction of facilities for satellite remote sensing in the marine research
4. Some arrangements should be taken in order to ensure Dr Kahru a strong research position in Estonia
5. An increase of international cooperation, particularly within modelling and satellite remote sensing
6. An increase of the number of papers published in international journals
7. Introduction of physical oceanography at the university level, with research as well as teaching obligations

- Marine Biology and Chemistry -

Investigation of Biota in the Baltic Sea and Elaboration of Scientific Basis of its Management (H Kukk)

Materials

The evaluation is based on a 13 page report and a publication list covering 1986-1990 and comprising 83 titles. Of these 58 are in 'congress language', published in proceedings (35), international journals (17) and books (4). Of the above mentioned publications 10 reprints were submitted for evaluation. The evaluation committee spent half a day talking to the senior scientists at the institute.

Principal activities

The project has four foci; the structure of the Baltic Sea plankton and bottom communities, mainly the Finnish Bay and Estonian waters and especially algal communities (leader Cand. Biol. H. Kukk); the spatial and temporal distribution of phytoplankton in relation to strong gradients in temperature and salinity (leader Dr M. Kahru); population structure of fish especially herring in relation to environment gradients (leader Dr E. Ojaveer); estimation of the state of the Baltic ecosystems using chemical and biological variables (leader Cand. Chem. H. Jankovski).

Evaluation

Within the Soviet-Finnish bilateral cooperation programme intercalibration of phytoplankton determinations was carried out, defining critical taxa. Likewise the macrophytes have been subjected to collaborative revision of previous data. Most of the research has been devoted to a survey of the marine vegetation of the southern coasts of the Gulf of Finland and the west Estonian waters. The different associations of macrophytes were mapped by SCUBA diving and classified as typical for undisturbed, moderately eutrophied and strongly eutrophied waters. Together with semiquantitative data on biomasses and per cent coverage this constitutes a valuable data bank now open for comparison with the conditions in other parts of the Baltic. Long-term changes of the flora, based on comparisons with data back to the 1800's, show the typical features valid also for other parts of the Baltic: increase of filamentous green and brown algae and decrease of the large brown alga *Fucus vesiculosus*. In an international perspective these investigations are good and would have merited publication with richer illustrations, including maps, in widespread international journals. The work of monitoring of macrobenthos, which shows a decrease of the fauna, has also comprised identification of bioindicators of pollution. This is good work by experienced scientists.

The field of phytoplankton/hydrodynamics (Kahru, Nömmann, Talpsepp et al.) is an important coupling between physical oceanography and biology, where the Tallinn group has made very good, often excellent, original contributions published in respected, international journals. The physical side is reported on separately, here can be stressed the ecological results, which in principal show the growth and aggregation of phytoplankton in fronts, paralleled by

higher concentrations of both zooplankton and herring larvae. S. Nömmann, who spent half a year at Stockholm University summarizing his results within this field, defended his thesis there in autumn 1990.

The studies of zooplankton incorporate a long-term study which started in 1963 at the Estonian coast in the Gulf of Finland. The proportions of the different taxa of the freshwater dominated fauna clearly show the changes of the environmental variables, particularly of salinity and temperature. The general decrease of copepod abundance corresponds to a decrease in individual weight of young herring. Although somewhat primitive in methods the results and their interpretation are of good quality and of great interest for an international forum.

The fisheries research has been directed by Dr E. Ojaveer. The studies are concentrated to herring and sprat. They concern the population differences in the herring stock both in Riga Bay and the open Baltic as answers to the different environmental conditions. However, inhomogeneities and changed migration patterns occur, probably due to impaired feeding conditions. Consequently the stock assessment should be based on local populations and not on territories, and the fish should be treated as a part of the ecosystem. A highly speculative paper predicts favourable conditions for the marine, boreal fauna including cod and herring, for the 90's and the first decade of the 2000's, based on previous patterns in river discharge, ice cover, wind directions and solar activity. Dr Ojaveer is an internationally well-known fisheries expert and the scientific production is good to very good, showing a deep knowledge especially of the herring and sprat in the Baltic.

The Department of Chemistry (head H. Jankovski) has been deeply involved in the HELCOM-assessment of the state of the Baltic in relation to toxic substances and in GESPA-working groups. Extensive studies of heavy metals in the Baltic basin have been carried out, including temporal changes. Bioindication of heavy metals has been delt with in depth and suitable indicators among macrophytes (*Fucus*, *Cladophora*, *Enteromorpha*), and benthic invertebrates have been pointed out. Trends of PCBs and DDTs have been investigated and higher concentrations of the former in open Baltic zooplankton compared to populations in the Gulf of Finland have been registered. The papers presented are of good quality and the department gives a dynamic impression.

The Pärnu Department comprises a field station on the Gulf of Riga which we were not able to visit. The research programme of the station is concentrated on phytoplankton and primary production. The time series during the last 30 years show the typical Baltic features; increase of primary production and sedimentation, decrease of lower depth limit of brown algae and of spawning grounds of fish and decrease of clear water fish species.

Recommendations

Based on the good descriptive studies of the macrophyte group we recommend support to initiate ecophysiological process studies and quantifications of primary production and respiration.

We most strongly recommend continued strong support for the "bio-hydrodynamical" group, as an important and qualitatively outstanding group. As stated in the physical oceanography section Dr Kahru's permanence in the group should be secured.

As suggested by Dr Ojaveer the fish species should be studied as part of their ecosystem. Dr Ojaveers opinion concerning the great importance of local herring population is somewhat controversial and needs confirmation by population genetical studies.

The comprehensive autecological knowledge, the presence of good physical oceanographers and modellers at the institute and the logistically favourable Gulf of Riga constitute excellent possibilities for studies on the ecosystem level, including the main fish species. We recommend that the current synthesis of previous studies of the Gulf should be given high priority and strong support. For the chemistry department we recommend support for Dr Jankovski's proposals at the interview, to start more process-oriented research centered around the biogeochemical cycles. We also feel his laboratory has an important role to play in continued chemical monitoring of the Baltic Sea.

Without a site visit, it is difficult to evaluate the Pärnu field station. Estonian marine science definitely needs a field station, but whether the Pärnu station, with its location in a rather polluted town area, is well suited for this task in the long run is doubtful. We definitely recommend, however, that it be maintained until an alternative station in less polluted surroundings has been created.

II. Water Protection Laboratory, Tallinn Technical University, Tallinn

Materials

The available information which formed the basis for the evaluation consisted of a ten-page report of the structure and projects of the laboratory and a 13 page list of publications during the past 5 years, comprising 124 titles, whereof 42 in congress languages, including 30 contributions to proceedings, 9 technical reports, 1 book chapter and 2 articles in international journals. No reprints were available. During the site visit to Estonia one afternoon was spent at the laboratory on discussions with the project leader, the head and the senior scientists.

Principal activities

The responsibility of the laboratory is to carry out investigations of environmental engineering problems concerning the reduction and control of the pollution load to the Baltic Sea, the atmosphere and the surface waters of Estonia. The initiator and project leader from the start in 1963 is Prof Harald Velner, well-known to the Baltic scientific community as one of the former Director Generals of the Helsinki Commission. The present head of the laboratory is Dr Aleksander Toompuu, geophysicist, who together with 3 subproject leaders and 21 scientists coordinates the activities of the laboratory. These comprise:

1. Technological investigations, aiming at limiting the use of freshwater by major industries, like oil shale and food industry, and their waste production

2. Studies of water quality formation of surface waters

3. Elaboration of principles and methods for pollution load evaluation including monitoring

4. Estimation of pollution flows between land, sea and atmosphere

5. Assessment of inland, coastal and sea water quality, elaboration of water quality criteria

The role of the laboratory as the national body for water quality control, also of the Baltic Sea, stresses the importance of collaboration with other Baltic nations. This is mainly channeled through the Helsinki Commission and its different international activities, where good connections exist largely due to Prof Velners active past in the Commission. A close scientific cooperation with Finland on the problems of the Gulf of Finland has yielded a series of scientific publications.

Evaluation

The absence of available publications restricts the comments to the number and scope of the titles, which are numerous, indicating a good publication rate. The topics cover for example; assessment of the state of the Baltic; mathematical modelling of pollutants from food industry and farming; probabilistic models of water quality; simulation of river basin management, modelling

turbulence and contaminants; microbiological investigation and monitoring; atomspheric fallout of phosphorus and nitrogen; pollution load of the Gulf of Finland; exchange of phosphorus between river water and bottom; PCB and chlorinated pesticides in plankton fish and man.

The titles cover a rich field of topics, all relevant for the objectives of the laboratory. The interview with the senior scientists displayed a staff with good to very good competence, and good international contacts, although mostly within the Baltic area. The technical quality of the chemical work of the laboratory is top ranked within the Baltic scientific community. The reputation of Prof Harald Velner and the high scientific standards of the head of the Laboratory Dr Alexander Toompuu are good guarantees for future success. The brief account of the past history of Estonian pollution policies brought into relief the assiduous struggle to keep up with international standards, from the motto "(Finnish) Bay must be clean for sailors" (during the Moscow Olympic regatta) to the present problems of sewage outlets and storm water incidents. Investigations in the coastal area and suggestions of new technique were mentioned as foci for the future. An interesting project of retaining nutrients from land runoff by stimulation of reed belt growth was reported from Matsalu Bay on the Estonian mainland east of the island of Hiumaa.

Recommendations

We recommend continued support for this laboratory, which clearly has very good competence in the water resource management field, including the basic scientific background. In addition to routine tasks, which have to be performed by a modern water protection laboratory, the existing research on material flows between land-atmosphere, sea-atmosphere, land-sea and bottom sediments-water column should be maintained and strengthened. In particular we noted the important work on estimating nutrient transport by Estonian rivers, which must be continued. The healthy connection to basic research, apparent for example in the studies of water turbulence and distribution of contaminants, is important and should be nourished.

III. Department of Hydrobiology, Institute of Zoology and Botany, Estonian Academy of Sciences, Tartu

- Marine Research -

Biota of the Baltic Sea Ecosystem: Variability of the Plankton and Benthos, Bioindication of the State of the Ecosystem, and Eutrophication

Materials

Our evaluation is based on a 19 page report on the research group, its previous work and future plans for research in the Baltic Sea, plus a list of 47 publications from the past 5 years (11 in English, 7 of which were published abroad, 17 in Russian, 1 in Finnish and the rest in Estonian). This was made available to us during the site visit, as were reprints of the published articles. During the site visit, which lasted several hours, we had the opportunity to speak to most of the members of the research group.

Principal activities

The research of the group has been centered on describing the variability and ecological state of the part of the Baltic Sea that adjoins Estonia. A large biological data base has been assembled, including some long-time series on zoobenthos, phytobenthos, phytoplankton, zooplankton and the concentrations of nutrients and chlorophyll in the Baltic Sea.

Evaluation

The research has been directed more towards describing the effects of pollution, including eutrophication, than at understanding ecological mechanisms. This is natural, given the location of the group at an inland university without a suitable field station at the Baltic Sea. In an international perspective the work in general is good and the faunistic parts very good. Only a minor part of the submitted publications was published in English and very little in international fora with a referee system. In recent years there has been a commendable effort to publish in the English language, and several of the publications we have seen are of high quality, and could most probably have been published internationally.

The Head of the group, Dr Arvi Järvekülg is an internationally well known and highly respected specialist in the biogeography and ecology of benthic invertebrates of fresh and brackish waters, particularly in the Baltic Sea. Dr Tiiu Trei is likewise an internationally well known expert on Baltic macrophytobenthos. We were impressed with the the obvious dedication to science shown by the group, as well as by the facility with which most of the group members expressed themselves in English. Overall, the competence of the group is very good and the faunistic competence excellent. However, the quality of the published work has been lessened by very meager resources and by the isolation of Estonian science.

The evaluated research project has recently been terminated, and the "Laboratory of Marine Biology" has been renamed the "Research Group of River Bilogy". The Research Group of River Biology plans to continue to work in the Baltic Sea, but intends to devote most of its efforts to the so far little studied running waters of Estonia. The new Baltic Sea project which will be carried out in cooperation with the Institute of Ecology and Marine Research, is of applied nature and involves work of a type that the group is well trained for. We deem the proposed Baltic Sea research to be of good quality, and needed for monitoring of Baltic water quality. The newly started research on rivers was not described in detail in the submitted material, but was discussed at some length during our site visit. Detailed studies on the biology and water quality of Estonian rivers and lakes will be of the greatest importance for future protection of both freshwater and coastal marine environments in Estonia. We consider these future plans very good.

Recommendations

The very meager material resources available for this group have meant a major limitation to the quality of their research. For example, plankton research has been conducted for years without the most basic instrument for such work, an inverted plankton microscope. We most strongly recommend increased materials support in the future, since the competence of the research group clearly warrants improved working conditions. In the future, the group is strongly recommended increasingly to use statistical methods to evaluate the results, and also to develop experimental approaches to test ecological hypotheses. For example, even though eutrophication is a major environmental problem in the areas under study, there was little discussion of limiting nutrients. To identify the limiting nutrient(s) should be of top priority in studies aiming at proposing ways of managing eutrophication problems. Likewise where the effects of a specific pollution source are under study, experimental confirmation that discharges from this source are indeed toxic, and likely to have caused the observed environmental changes, is desirable, and often required abroad. When specific pollutants, that can be determined analytically with sufficient precision, are studied, mass balance calculations are likely to be an important element in management schemes. To accomplish this, the group will need to cooperate with groups with hydrodynamic expertise. An increased effort to publish in refereed international scientific journals is also strongly recommended.

- Freshwater Research - (Vörtsjärv Limnological Station)

Materials

As there was no site visit to see the freshwater research at this department (except, incidentally, to the Group of River Biology), the evaluation is based entirely on the written material submitted. This consists of a 20 page report on previous research and the structure and staff of the station, plus a list of about 190 publications from the last 5 years. Of the publications, 18 are in English, whereof 5 published outside Estonia, including only 2 in refereed international journals. Of the other publications one is in Finnish, and the rest about equally divided between Russian and Estonian. Many are short notes or abstracts.

A. RESEARCH GROUP OF LAKE BIOLOGY

Principal activities

The research of the group has been centered on the two major lakes of Estonia Lakes Vörtsjärv and Peipus, and in particular on eutrophication and fisheries management. A massive biological data base has been assembled, including some remarkably long time series on phytoplankton, zooplankton, benthos and fish. Work on the chemistry of the lakes has started more recently.

Evaluation

So far, the research has been directed more towards describing the process of eutrophication than at understanding what drives it. There are no attempts at mass-balances, and very little experimental work in the submitted material, only a very small fraction of which has been published in international fora. However, in recent years there has been a commendable effort to publish in the English language. This is a necessary first step in establishing international connections, but not enough in the long run. Overall (including the Groups of Hydrochemistry and Biometry) the quality of the work is good, and the systematic/biogeographic work of Dr Timm very good.

The Head of the group, Dr T. Timm, is an internationally well known and highly respected specialist in the taxonomy, biogeography and biology of aquatic oligochaetes. His long-term culture work is unique, and has the potential to develop into high quality experimental ecology. Both his systematics and ecology would benefit from increased international contacts. The specialty of Dr Timm seems to be somewhat isolated from the rest of the work of the group.

Recommendations

We recommend the group to develop experiment approaches for testing ecological hypotheses, and to use statistical methods for evaluating the results. The taxonomic work of Dr Timm would benefit from and be greatly facilitated by access to a research microscope of international standard. We recommend that funds for such a microscope be made available.

B. RESEARCH GROUP OF HYDROCHEMISTRY

Principal activities

The research of this group, which is responsible mainly for various types of chemical analyses, seems to have been integrated with that of the group of Lake Biology.

Evaluation

There is little foundation in the submitted material for evaluating the quality of the comparatively simple chemical analyses made. There seems to be little development of methods of analysis or of basic hydrochemistry, and we can see little need for having a separate group of hydrochemistry just for carrying out the chemical measurements needed for the ecological studies on lakes. The quality of the science cannot be separately evaluated from that of the group of Lake Biology.

Recommendations

We recommend that this group be integrated with the Group of Lake Biology, since its activity seems to be an integral part of the lake eutrophication studies of that group. We noted that total nitrogen and phosphorus had been analyzed, but that analyses also of nitrate, nitrite, ammonia and phosphate will be needed, in order to draw even tentative conclusions from water chemistry as to the limiting nutrient for phytoplankton. We recommend that these inorganic nutrients be measured in the lake water at the end of winter, just before the onset of the spring phytoplankton bloom, not only during the summer period.

C. RESEARCH GROUP OF ICHTHYOLOGY

Principal activities

The research seems to have been entirely directed towards the needs of fisheries management, and to have had some success in increasing the catch values for Lakes Peipus and Vörtsjärv.

Evaluation

The research of this group is not easy to evaluate without knowledge of the Estonian and Russian languages, since very little of the work of the group has been published in English, and only a couple of papers in international fora. Little of the work we have seen is of real ecological interest, and results seem to be judged more in terms of practical results than in terms of scientific hypothesis testing and statistical significance. We cannot rate it higher than fair. Without a site visit we find it hard separately to assess the competence of the group.

Recommendations

The work of this group should be classified and funded as practical fisheries investigations, rather than as ecological research. Thus we recommend no further funding within the science budget.

D. RESEARCH GROUP OF RIVER BIOLOGY

Principal activities

This group was earlier concerned with Baltic Sea research, and has therefore been evaluated separately under the heading Marine Research. The river biology research has started with an ambitious descriptive survey of Estonian rivers.

Evaluation

The river biology research of the group is quite new, and there was little basis for evaluating this separately from the Baltic Sea research. The plans for future river biology research we found very good and important.

Recommendations

We strongly recommend that support be given to the river biology group either through strengthening the Group for River Biology, or through appropriate co-operation. The future research should include work on nutrient concentrations in, and transports by, Estonian rivers.

E. RESEARCH GROUP OF BIOMETRICS

Principal activities

This group has used new statistical methods for describing Estonian lakes, and the eutrophication of Lake Peipus in particular.

Evaluation

This research has been useful, but very little has been published internationally. We cannot judge the basic methodological aspects of the work, and the practical results must be evaluated together with the Group for Lake Biology.

Recommendations

For the future, we strongly recommend that the main thrust be towards understanding, not description. There will be a need to supply other groups with

advice on experimental design, such as statistical evaluation of experimental designs to test ecological hypotheses, and models of lake biogeochemistry. Mass balance models are likely to be far more useful for future eutrophication research than descriptive models, however refined.

General comments on the Department of Hydrobiology

We find that the subdivision of the Department of Hydrobiology into research groups follows academic disciplines, rather than the scientific problems under study. Even though there is evidence of extensive cooperation between research groups, we suspect that this organization hampers the interdisciplinary co-operation needed, and recommend that it be reconsidered. The Department of Hydrobiology now works almost entirely with fresh water, and might be better renamed Department of Freshwater Ecology, or Department of Limnology. The different research groups can be merged, or divided into one working on eutrophication problems, and another on fisheries management (if retained). The Group of River Biology may also be usefully kept separate, as a Group of River Ecology, due to the distinctive nature of its study objects.

IV. Tallinn Botanical Garden, Estonian Academy of Sciences, Tallinn

Antarctic Limnology (Enn Kaupp, A. Loopmann)

Material

As there was no site visit to this group, the evaluation is based entirely on the written material submitted. This included a written report of 20 pages, plus a list of 20 publications from the last 5 years (post-1985). Of these publications, 11 are in English, published within eastern Europe, 5 are in German and 4 in Russian. The publications in English and German were all received for inspection.

Principal activities

Lakes in the ice-free so called 'Oases' in East Antarctica have been studied during at least three expeditions (1976/77, 1983/84 and 1987). Physical and chemical conditions in the lakes have been described, and phytoplankton productivity measured. Some of the lakes studied are among the clearest known, and one has the lowest annual phytoplankton production ever estimated. Some of the lakes, which are permanently covered by 2-3 metres of ice, show high oxygen supersaturation, in spite of very low chlorophyll concentrations and primary productivity in the water.

Evaluation

The results so far achieved are primarily descriptive, but very interesting and of good quality. Based entirely on the published material, we estimate the competence of the group to be good to very good.

Recommendations

This programme requires access to Antarctic lakes, and it is strongly recommended that future plans move beyond the descriptive phase, to more experimental work, for example using the extreme Antarctic lakes to test general limnological theories. Whether this will be possible depends largely on practical matters - can frequent enough access to Antarctic lakes be guaranteed, through international cooperation and/or Estonian expeditions, for an Estonian group specialized in Antarctic limnology to be viable? If not, the able researchers in this group are recommended to turn their attention to scientific problems that can be studied closer to home.

Long Term Changes and Local Extremal Environmental situations in the Baltic Sea, Especially in Estonian Coastal Areas, and their Forecast as a Problem of Interaction of Different Scale Ecological, Hydrophysical and Biological Processes (prof Ain Aitsam)

Principal activities

Prof Aitsam was long the head of the Department of the Baltic Sea, Institute of Thermo- and Electrophysics, in Tallinn, which later became the basis of the marine part of the Institute of Ecology and Marine Research. He has had a distinguished scientific career, with a long list of scientific publications, also in the leading international journals of his field. He is a well-known and highly respected scientist in international committees and working groups.

Evaluation

Professor Aitsam's proposal builds on the main strength of previous Estonian marine research. It rightly identifies the interaction of physical processes and the biological primary production process as the field in which Estonian marine science has given its most valuable and original contributions to basic ecological understanding of the Baltic sea. Altogether, this has been an excellent achievement, in which prof Aitsam has played a leading part. On the other hand, it is also clear that this approach has largely failed to produce results directly useful in protecting the Baltic Sea environment. To achieve this will in the future require greater attention to higher trophic levels, benthic-pelagic coupling and toxic pollutants.

Recommendations

Professor Aitsam's scientific record is excellent, as is his achievement of creating the leading marine research institute of Estonia. We have only partial information on the reasons for Prof Aitsam's present isolated position in Estonian science, and thus can give no recommendation either for or against his reinstatement to a leading position. However, it would be a waste of high competence not to offer Prof Aitsam employment in a scientific capacity. Concerning his specific proposal, we believe that the clear demarcation he makes between two future alternative research strategies - fishery or pollution control - to be misguided, since higher trophic levels are important also in pollution control. Furthermore, his proposal is so inclusive as to give little concrete guidance for future research. Thus we do not recommend its full implementation even though it contains many interesting subproposals.

APPENDIX

Background of Evaluators

Ragnar Elmgren

Professor of Brackish Water Ecology at the Department of Systems Ecology, Stockholm University. He has worked on benthic ecology, ecosystem ecology, oil pollution and eutrophication in Sweden and USA.

Bengt-Owe Jansson

Director of the Stockholm Centre for Marine Research and professor of Marine Ecology at the Department of Systems Ecology, Stockholm University. He pioneered the systems approach to Baltic ecology, and led the Askö Laboratory from its foundation in 1961 to its incorporation in the Stockholm Centre for Marine Research in 1990.

Anders Omstedt

Associate Professor, presently at the Swedish Meteorological and Hydrological Institute. His research interests concern the dynamics and thermodynamics of the Baltic Sea. His research is mainly aimed towards modelling the atmosphere - ocean interaction in partly ice covered seas.