

02.09.2003

**The international evaluation of the
National Environmental Research Institute
(NERI)
2000-2003**

August 2003

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Executive summary

NERI is a large Danish government research institute focusing on research, monitoring and advisory activities regarding the environment and nature.

NERI is responsible for a considerable range of official responsibilities and specific tasks, to which are allocated approximately 70% of NERI's basic funding provided by the Danish government in 2002). This radically distinguishes NERI from other government research institutes. NERI has the comprehensive responsibility for the national monitoring of the environment and nature. The monitoring programmes are founded in national as well as international legal documents. This work has been entrusted to NERI on account of the need for cross-disciplinary priority-setting and because it relies on scientific insight to be carried out optimally.

NERI has about 400 employees, and its annual turnover in 2002 amounted to approximately DKK 255 million, up from DKK 100 million in 1989. The growth since 1989 is partly due to the additional new responsibilities and partly due to an increase in external financing from research programmes and consultancy activities, which increased from approximately DKK 20 million in 1989 to approximately DKK 103 million in 2002. The external financing of research programmes, which NERI has won in calls for tenders and proposals, was DKK 33 million in 2002. Of this amount, DKK 20 million was from international programmes, which required a corresponding self-financing. In 2002, the basic allocation amounted to DKK 152 million, as opposed to DKK 89.1 million in 1989, mainly due to assignment of additional official responsibilities over the years. Excluding these additional assignments, the basic funding base has remained unchanged since 1989.

NERI's operations are managed by a strategy and a Performance Contract (presently 2000-2003) between the Ministry of the Environment and NERI's Board. The strategy and the Performance Contract are based on the statutory order concerning NERI and are made concrete in annual work programmes that are subject to approval by the Board. The Performance Contract and the strategy covers the entire range of NERI's work, i.e. work financed from basic funding, and work funded from external sources.

About the evaluation

The evaluation was conducted in August 2003 upon request from the NERI Board of Governors as expressed in the Terms of Reference (see Annex 1). The Danish Research Councils appointed the Evaluation Panel comprising four Sub-Panels each addressing one of the four competence areas of NERI.

The Panel has received and worked with a number of summary reports and publications prepared by NERI for the review (see Annex 3) and the Panel has also upon request had access to NERI's publications as a basis for this evaluation. In addition the Panel has met with the directors, the departments and selected scientists at the headquarters in Roskilde and, via video links, the departments in Kalø and Silkeborg. Where appropriate, the Panel has also looked at web pages, followed database demonstrations, and visited laboratory facilities.

Within the resources and time available, the Panel has made much effort in obtaining a correct understanding and evaluation of the scope, operation and performance of NERI. In spite of this, the Panel does not claim to have an in-depth understanding of all aspects of NERI. In particular, the Panel has not been able to study in-depth NERI's activities on the Arctic Environment and on Risk Assessment. Nevertheless, the Panel believes that the general evaluation is reasonably correct and provides a balanced assessment of NERI's research and its associated activities including monitoring and consultancy.

Main observations regarding research quality and extent

In general, the panel finds the quality of the research performed by NERI to be good and fully satisfactory for meeting the objectives and tasks of NERI. The institute has within all the competence areas and departments specified its visions and goals. General management procedures are established and at project level management procedures are in the process of being established.

The research teams are in general experienced, have access to modern facilities and methods and interact well internally and with relevant research communities both at national and international level.

Research results are presented at international conferences and published in international journals. Furthermore, NERI's journal publications are in general cited at or above a level comparable to publication from other research groups in the same journals. NERI (including the institutions and laboratories that were merged to form NERI in 1989) has since 1981 published 1440 scientific journal publications yielding 13400 citations in total, of which 23% are self-citations.

The uniqueness of NERI is the combination of research, monitoring and advisory tasks. For maintaining and strengthening this uniqueness, the research activities must cover a wide range of topics and disciplines. NERI does cover such wide range of research. Given its status as a government research institute with several obligatory responsibilities, the Panel finds a wide spectrum of research, combined with a satisfactory quality standard of the research, preferable instead of focusing on top-class research in a more narrow spectrum of topics. Nevertheless, in its natural science fields, NERI has achieved an appropriate balance between a wide spectrum of research activities and highly respected specializations in a number of research areas. These are:

- Air quality monitoring and atmospheric modeling, in particular in the fields of mercury deposition in the arctic; ammonia dispersion, transformation and deposition; and street pollution
- Freshwater ecology, in particular the research on lakes.
- Marine ecology in particular monitoring and analysis activities in coastal waters and fjords
- Risk assessment on Genetically Modified Plants (GMPs)
- Soil eco-toxicology
- Monitoring, for example in arctic environments and in seabirds movements

NERI's competence area in policy analysis has recently expanded into environmental economics and environmental sociology. The Panel considers NERI's research on Environment and Society an important and necessary supplement to the natural science based competence areas. This field is multidisciplinary, and a substantial effort must be allocated to ensure a critical mass and common working concepts. Although the productivity in peer-reviewed scientific journals is not satisfactory, the Panel is convinced that the research activities within this area are sound and necessary, and that this competence area within a few years will reach a level comparable with the other competence areas in terms of coherence and outputs.

The Panel identified that many projects are interdepartmental, and many research projects are linked to monitoring. This is a strength that should be maintained and actively nurtured by NERI.

The research areas identified for the new contract period (2004-2007) are all considered by the Panel to be important. They build on NERI's existing expertise and target at contributing to solving problems, which the Panel anticipates to be important in future. Among others, the clear targeting to the implementation of the Water Framework and Habitat Directives is important for Denmark. However, in all areas of competence, even including the most successful ones, the need for continuously adjusting research focus and effort is eternal and the Sub-Panel reports (chapters 5-8) contain some suggestions on such adjustments. NERI should consider some of these for the coming Performance Contract.

Considering that in average 70 % of appropriation provided by the Danish Government is bound to tasks related to monitoring and specified services and the amount of external research contracts obtained (EU, research councils, etc.), the Panel finds the productivity of NERI in terms of research publication and reports fully satisfactory. The number of international scientific journal publications in the period 2000-2003 is, in the natural science competence areas, in the interval 1-1.6 per scientific staff per year. As mentioned previously, the department on policy analysis shows a lower productivity with respect to journal publications.

The researchers at NERI represent a broad spectrum of expertise and educational backgrounds and the interaction among these researchers is a good basis for performance of relevant research. The Panel, however, finds it important that NERI has significant expertise in statistical analysis and simulation modelling. This expertise is currently embedded within research departments. The increasing importance of this expertise across all NERI tasks suggests that expertise be increased and structured to cross departmental boundaries. The Panel feels that such a step will better ensure the maximum outcome from the monitoring programmes and successful synthesis of data and process understanding to create new knowledge (in contrast to just producing more data). Since the Panel believes that environmental issues in the future will be linked more to human health this may require association of such expertise to NERI.

Considering the constraints in budget in recent years, NERI has done well. However the announced budget cuts in the future leads to concerns of the panel on whether NERI is still able to maintain its present performance level and quality.

Main observations regarding relevance of research

The Panel finds it very important that the research performed by NERI is not only of good quality but also is of high relevance in order to contribute to the overall goal fulfilment of NERI. As already stated, the close relationship between research, monitoring and advisory activity covering the major issues related to environment and nature in Denmark and Greenland is the legality of NERI and should be given careful attention at the directors' level, the departmental level and in the public appearance of NERI.

The Panel finds that the current research activities are relevant and that the activities at NERI in many cases make very important contributions to Danish as well as to European initiatives and regulations regarding nature and environment. The reports on the specific competence areas provide several examples.

In addition, the Panel finds that the research activities planned for the next performance contract period also are relevant and very important for the Danish implementation of the new EU directives.

The Panel is of the opinion that in the future, more effort should be devoted to a more detailed specification of relevance at all levels in NERI. This recommendation is particularly important in the view of the basic appropriation becoming more tight, thus necessitating external funding from Danish and European bodies. Having the overall goal of NERI in mind, only project proposals relevant for high priority topics of NERI should be submitted for external funding

Relevance is largely defined by the future political/societal need for knowledge and data on the environment and nature. Predicting which needs will be most pressing in, for example five to ten years, is difficult because political priorities may change. The Panel suggests that NERI in addition to its contacts in the Danish central administration and the initiatives generated in-house might consider establishing one or more scientific advisory boards of high and international standing to help NERI foresee future needs.

With respect to relevance, the Panel also wishes to emphasise the need for a close and visible connection between research and monitoring. Research should lead to improved monitoring and interpretation of results and monitoring should also lead to identification of research needs.

Main observations regarding fulfilment of performance contract

The Performance Contract (PC) 2000-2003 between NERI and the Ministry of the Environment includes a total of 169 goals. At the time of the evaluation, less than 6 months remain in this contract period. NERI uses the PC as a guiding framework for the preparation of annual work programmes, for the ongoing prioritisation of tasks and resources, and for reporting progress to the Board of Governors.

NERI has made a preliminary assessment of the overall goal achievement based on annual results from 2000-2002 and preliminary judgements halfway through 2003. According to these, on average NERI will achieve 84% of the PC-goals, 9% are still uncertain, whereas 7% of the goals will only

be partly achieved or given up. NERI's main reasons for giving up goals are related to the unpredictable complexity of research, the lack of external funding and the prioritisation, which has been necessitated by budget restraints.

The Panel has not had the means to carefully scrutinize the fulfilment of the individual items of the PC. However, the Panel has no basis for questioning the information provided by NERI and finds that NERI has fulfilled the current performance contract to a satisfactory degree. The Panel suggests that future Performance Contracts contain fewer items, preferably with more flexibility to allow for unforeseen needs within the coming period.

According to the performance contract and in accordance with the statutory order, NERI should service the authorities with respect to advisory and contingency tasks. The Panel has had no possibility within the available time to scrutinize the satisfaction of the "customers" with regard to NERI's services. However, Kvistgaard Consult (see Annex 3) has in May and June 2003 undertaken a user satisfaction survey for NERI. The purpose was to find out whether NERI's objectives for implementation of their services have been met, whether the user needs have been considered, and to collect user suggestions for improving services provided by NERI. The study was made on the basis of 15 qualitative interviews with chosen key persons among the central users of NERI's services. The Kvistgaard survey concludes that all interviewed persons were satisfied with NERI's deliveries, but it also identified room for improvement, in particular that the NERI products must target and adapt to the concrete needs of individual users/authorities. It is relevant in this regard for NERI, when delivering advice and results, to adapt further to the reality of public administration, and thus to the needs of clients.

The Panel finds that NERI does deliver the services requested. But in the view of the diversity and complexity of NERI's research and service areas, the Panel suggests NERI make an effort to improve the transparency and availability of its competencies in order to substantiate the use of these competencies and also improve the actual services undertaken to increase user satisfaction.

Main observations regarding the management

The environmental and nature area is interdisciplinary within research, monitoring and consultancy, as also reflected in the diversity and complexity of NERI's activities. This puts high demands on the directors and department heads to keep NERI well-trimmed and adaptable to changes in expectation and political and economic conditions. The Panel has received information about the organisation and management procedures and has requested information about various specific issues and attitudes. It has not been possible for the Panel to assess the senior management in-depth, but in view of NERI's performance and quality of its activities over the last five years, the panel is confident that the management has obtained success and will continue to do so in the future. As mentioned in the Sub-Panel reports, there are things to improve, but the Panel is confident that the management will deal with these matters. However, as stated in earlier sections, the most challenging management issue is probably to maintain and further develop the uniqueness of NERI based on the combination of relevant research, monitoring and advisory services.

Main observations regarding collaboration with universities and other research institutes

In its research projects, NERI collaborates with a wide range of institutions in Denmark as well as abroad. The Sub-Panel reports contain details about this. The Panel appreciates NERI's involvement in collaborating with institutes which provides both supporting and complementary expertise.

NERI in many areas involves Ph.D. as well as Master students and offers educational activities to collaborating universities. NERI also participates in six Danish research schools.

The Panel appreciates NERI's dedication to collaboration, networking and education.

Main recommendations

The Panel is very satisfied with the overall performance of NERI. In general there is always a potential for improvement, and the Sub-Panel reports suggest such improvements. In addition to these competence-specific recommendations, the Panel presents the following general recommendations:

- NERI should maintain its wide spectrum of research topics and disciplines, thus maintaining its unique combination of research, monitoring and advisory tasks. The close inter-linking between research, monitoring and consultancy is the legality of NERI, and should continuously be given careful attention at all organizational levels and in the public appearance of NERI.
- NERI should carefully evaluate all research activities with respect to relevance in relation to the overall objective of NERI to performance monitoring and advisory to the public authorities.
- A proper balance between research financed by NERI's basic appropriation and externally funded research should be maintained, thus contributing to ensuring a continuous prioritization of research with high relevance for Danish and EU environmental policy.
- NERI should consider establishing one or more scientific advisory boards to help NERI foresee the needs for development in its competence areas in compliance with the future political trends.
- NERI should consider strengthening and better coordinating its in-house expertise regarding statistical issues and modelling in order to ensure the maximum outcome from the monitoring programmes and successful synthesis of data and process understanding to create new knowledge.
- NERI should continue its efforts and co-operation with universities concerning education of Ph.D. and Master Students.
- NERI should maintain its strong collaboration with relevant research organisations in Denmark and abroad. This contributes to NERI keeping up with state-of-the-art within its research fields and provides a large potential for using expertise complementary to NERI's own. NERI already exploits this opportunity, but the Panel sees potential for exploiting it further, e.g. in the Human Health area.

1. Introduction

This report presents the outcome of an evaluation of NERI's research, carried out in August 2003 by an independent, international Evaluation Panel.

Chapter 2 describes NERI and each of its four competence areas, which are:

- Atmospheric Environment
- Aquatic Environment
- Terrestrial Environment
- Environment and Society

The background and purpose of the evaluation, and the evaluation procedure are described in chapter 3. Chapter 4 contains the Panel's views regarding NERI as a whole, whereas chapter 5-8 present the Panel's findings regarding NERI's four competence areas, respectively. Each of these five chapters present, for the area in question, the Panel's assessments and recommendations related to the four reporting points indicated in the Terms of Reference, namely:

- The extent and scientific quality of NERI's research and its national and international position and impact, including strengths, weaknesses or deficiencies in the activities
- The relevance of NERI's research activities as a basis for Danish and international environmental policy and management
- The performance of NERI as a government research institute with respect to the tasks laid down in the government order regulating NERI and the management performance contract 2000-2003
- NERI's national and international collaboration with universities and other research institutes.

The Panel's assessments, conclusions and recommendations are summarised in the Executive Summary which is placed in the beginning of the evaluation report.

2. About NERI and its four competence areas

2.1 NERI as a whole

The National Environmental Research Institute (NERI) is a government research institute affiliated to the Danish Ministry of Environment. NERI was established in 1989 in order to enhance the coherence and consistency within the Danish environmental research. The establishment was partly in response to an international review of Danish environmental research initiated by the government of the time. The review included a number of laboratories which are now integrated in the departments of NERI.

The objective of NERI is to enhance, develop and disseminate knowledge relating to the structures, processes and relationships significant for the maintenance of nature and the environment in Denmark. NERI's role extends from the provision of specialist consultancy services and offering specialist advice to agencies, ministries, other public authorities, businesses, and private organisations, to monitoring, mapping, and data processing, etc. NERI is expected to undertake research and development tasks, report its findings, and make its knowledge and data holdings publicly available.

In the evaluation period (2000-2003), NERI's research, monitoring and consultancy activities are organised in six focus areas:

- Atmospheric Environment
- Aquatic Environment
- Terrestrial Environment
- Arctic and Global Environment
- Risk Assessment of Chemical Substances and Biotechnological Products
- Interdisciplinary Research.

From 2004 NERI intends to reduce these to five programme areas organised in the following four competence areas:

- Atmospheric Environment
- Aquatic Environment
- Terrestrial Environment
- Environment and Society

NERI is responsible for a considerable range of official responsibilities and specific tasks (approximately 70% of the basic funding in 2002), which radically distinguishes NERI from other government research institutes. In terms of monitoring, where the majority of work is conducted by the counties, NERI has the comprehensive responsibility for the national monitoring of the environment and nature. This task bears the character of an official responsibility otherwise to be undertaken by an authority. Failure to attend to this work would create significant political problems, nationally as well as internationally. This work has been entrusted to NERI on account of the need for cross-disciplinary priority-setting and because it relies on scientific insight to be carried out op-

timally.

In 2002, the basic allocation amounted to DKK 152 million, as opposed to DKK 89.1 million in 1989, mainly due to assignment of additional official responsibilities over the years. Excluding these additional assignments, the basic funding base has remained unchanged since 1989.

NERI's annual turnover in 2002 amounted to approximately DKK 255 million, up from DKK 100 million in 1989. The growth since 1989 is partly due to the additional new responsibilities and partly due to an increase in external financing from research programmes and consultancy activities, which increased from approximately DKK 20 million in 1989 to approximately DKK 103 million in 2002. The external financing of research programmes, which NERI has won in tenders, was DKK 33 million in 2002. Of this amount, DKK 20 million was from international programmes which required a corresponding self-financing.

Legislative foundation

NERI is subject to the Applied Research Act of 20 December 1995. Pursuant to section 2 of the act, NERI's tasks are determined in the "Bekendtgørelse om Danmarks Miljøundersøgelser" (statutory order concerning NERI - no. 1065, 18 December 1997, only available in Danish).

Furthermore, NERI is subject to the statutory order on the employment of scientific employees in sector research institutes ("Bekendtgørelse om ansættelse af videnskabelige medarbejdere ved sektorforskningsinstitutioner" - no. 664, 19.8.1997).

Organisation

NERI is headed by a board consisting of representatives from research, NERI's clients and employees. The Chairman of the NERI Board and a majority of the other members are independent of the Minister for the Environment.

NERI has eight research departments divided among three work-sites:

Roskilde: Department of Policy Analysis (SYS), Department of Marine Ecology (MAR), Department of Environmental Chemistry and Microbiology (MIMI), Department of Arctic Environment (AM), Department of Atmospheric Environment (ATMI).

Silkeborg: Department of Freshwater Ecology (FEVØ), Department of Terrestrial Ecology (TERI).

Kalø: Department of Wild Life Ecology and Bio-diversity (VIBI) . (Recently changed)

The management and administration are situated in Roskilde.

NERI's priority areas and the activities of the eight departments in the period 2000-2003 are shown below. Shading indicates the extent of the activity (dark grey being the highest level)

	SYS	ATMI	MAR	MIMI	AM	TERI	FEVØ	VIBI
Atmospheric environment	■	■				■		
Aquatic environment and nature		■	■			■	■	■
Terrestrial nature and environment		■			■	■		■
Arctic and global environment		■	■	■	■	■	■	
Risk assessment chemicals / biotech	■	■	■	■		■	■	■
Interdisciplinary analyses	■					■	■	■

NERI's performance contract and strategy

NERI's operations are managed by a strategy and a performance contract (presently 2000-2003) between the Ministry of the Environment and NERI's Board. The strategy and the performance contract are based on the statutory order concerning NERI and are made concrete in annual work programmes that are subject to approval by the Board. The Performance Contract and the strategy covers the entire range of NERI's work, i.e. work financed from basic funding, and work funded from external sources.

The fulfilment of NERI's objectives is assessed in the semi-annual status (Follow-up on the work programme) and annual reports or corporate accounts (Follow-up on the performance contract, Work programme, Institutional and Ministry Goals). In addition to the economic accounts, these also contain specific assessments of the degree to which the objectives have been attained and the "productivity". In addition to the routine follow-up, NERI's Board regularly carries out particular assessments of selected areas.

NERI's strategy is to contribute to and meet the Government's objectives for sustainable development in society and on minimising impacts on nature and the environment. NERI's contribution will be through the provision of the highest quality consultancy services and analyses of nature and the environment based on the most recent national, international, scientific, and technological advances.

In its Strategy in the evaluation period (2000-2003), NERI has placed special emphasis on the fol-

lowing four areas of strategic development:

- Accessibility – making results visible
- Quality assurance – safeguarding standards
- Know-how – maintaining a knowledge base
- Integration of knowledge – developing inter-disciplinary competence

NERI has established a number of institutional goals under each heading.

NERI's clients

NERI's primary clients are the Ministry of the Environment, particularly the Danish Environmental Policy Agency (EPA), the Danish Forest and Nature Agency, as well as the counties and municipalities in Denmark and the Greenland Home Rule. The associated tasks are transferred to NERI in accordance with section 6 of the Applied Research Act. The EU, the Ministry of Food, Agriculture and Fisheries, the Ministry for Traffic, agricultural interests, and the Danish Hunters' Association are also significant clients.

NERI's primary clients have described their needs for NERI's services in conjunction with an investigation of sector research institutes conducted by the Danish Council for Research .

The clients unanimously indicate that it is decisive for the official responsibilities pertaining to the environment and nature that there is a specialist resource with coherent expertise concerning the accumulation of data, monitoring, consultancy and research. Furthermore, the clients indicate that a body of expertise encompassing a broad range of issues pertaining to the environment is necessary to fulfil the official responsibilities, as opposed to the solution of individual tasks in isolated, discipline-specific environments.

2.2 Atmospheric Environment field

The competence area Atmospheric Environment encompasses NERI's activities concerning emission, dispersion, conversion, and deposition of air pollution as well as environmental impacts and human exposure.

The activities on air quality comprise special analyses of pollutants in air (e.g. pesticides and heavy metals) , routine measuring in connection with NERI's monitoring of air, and development and validation of air pollution models and models for exposure via air. The air pollution models link knowledge about emissions of pollutants with meteorological conditions, atmospheric transport, chemical processes in the atmosphere, and exchanges with land and marine areas. Models for human exposure are developed in co-operation with research groups within environmental medicine.

In addition, NERI prepares the official Danish statements describing emissions of harmful substances to the atmosphere. The inventories are based on an analysis of information about significant

sources of harmful substances such as the energy sector, industries, transport, and agriculture.

Specific responsibilities

NERI undertakes official responsibilities for the Ministry of the Environment and local authorities concerning air pollution. Regarding monitoring, the actual official responsibility is entrusted to NERI, including service to the minister and the political system.

The organisation carries out monitoring programmes for urban air and air quality in background areas in Denmark in accordance with current directives, conventions and rules. The monitoring is developed with a minimum of data collection and the maximum use of model calculations.

In addition, NERI collects, aggregates and disseminates the results of the monitoring, and is responsible for assuring their quality. The results are disseminated to the authorities and on the Internet, as well as in the form of prognoses for, and the warning of, air pollution.

NERI also carries out monitoring of long-range air pollution to the Arctic, including accumulation of heavy metals and organic compounds in ecosystems with particular containments on the highest tropic level and the exposure of humans. NERI assists Greenland in their participation in the international Arctic environmental partnership, including the Arctic Monitoring and Assessment Programme (AMAP). This sizeable monitoring programme is comprised of monitoring contaminants in air, soil, sediments and , etc., as well as transportation, occurrences and effects of pollutants (heavy metals, persistent organic compounds, etc.) in the Arctic.

Furthermore, NERI attends to Denmark's obligations to international efforts concerning the exchange of air quality data, the determination of critical thresholds, standardisation of models and methods of measurement. This partnership is grounded in conventions, directives and international agreements.

Research

NERI's research in the field of atmospheric environment comprises the following specific areas:

- Development and improvement of atmospheric air pollution transport models on local, regional and global scales with particular emphasis on atmospheric chemical conversion of the components of air pollution.
- Development of complex support systems for information and decisions for the calculation of scenarios, prognoses and warnings about air pollution.
- Research and development of measurement methods and models for air pollution from traffic.
- Evaluation of air quality in urban areas.
- Research and development of model systems for the population's exposure to particles harmful to health with coupling to health information with the help of advanced GIS and GPS technology.

- Research and development of models concerning the exchange of components of pollution between the air and surface of the sea, e.g. as part of the action plans for the aquatic environment (a significant portion of the strain on Danish marine areas by nutrients is via the air).
- Policy analyses concerning the effect on the Danish waters from Danish and European measures for the reduction of air pollution.
- Research and development of model systems that describe transportation, exposure and effects of trans-boundary air pollution, including ozone.
- Analyses of scenarios of the strain of air pollution, exceeding of critical loads and effects of limits on emissions on the Danish and European levels.
- Follow-up on national and international measures for reduction of air pollution.
- Prognosis models for extreme events (e.g. flooding in European river systems).
- Methods and models from emissions inventories
- Model development and calculation of the atmospheric transportation of pollution to the Arctic.
- Scenario calculation of CO₂ conversion (sea, air, land) is conducted for the northern hemisphere with high resolution for Europe. (This is utilised for the evaluation of Denmark's and EU's fulfilment of the Kyoto Protocol and the associated EU directives).

Consultancy

Under this competence area, NERI continually provides the basis for decisions, consultancy and other advisory services regarding air pollution to the Ministry of the Environment, Ministry of Transport, Ministry of Health, the local environmental authorities, private clients and the EU. Concrete assessments for decisions in counties and municipalities concerning local air pollution, and for state authorities' international negotiations, decisions on the national level and follow-up on agreements and the like. NERI's expertise is also useful in connection with Danish and international development assistance.

Economy

The table below shows the budget 2002 of NERI's activities in the Atmospheric Environment competence area. The figures in the table are from the document "Analysis of NERI's core activities" regrouped to the competence area "Atmospheric environment" in NERI's Draft Strategy 2004-2010.

Budget 2002. Amounts in DKK million	Gross expenses	Income	Net expenses	Pct. Ext. financing
Atmospheric environment	42,6	15,9	26,8	37%

Education

Within the atmospheric science, NERI contributes to higher education at the University of Copenhagen, University of Southern Denmark and the Technical University of Denmark. In 2002 this involved two Ph.D. students, two Master's Degree students, lectures and service as external examiner in connection with external professorships at the University of Copenhagen.

As a part of international environmental assistance, NERI has developed a comprehensive educational module about monitoring systems for air pollution for use in universities and bodies of environmental administration in other countries.

Co-operation partners

NERI's primary co-operation partners on projects in the atmospheric environment area are Risø National Laboratory, University of Copenhagen, University of Aarhus, University of Southern Denmark, National Institute of Occupational Health, The Danish Transport Research Institute, DHI Water & Environment, COWI, Rambøll, Hanneman & Højlund, dk-TEKNIK Energy & Environment, HLU (The Municipality of Copenhagen's air pollution unit), the municipalities of Odense, Aalborg and Aarhus, Danish Meteorological Institute, Danish Road Directorate and Danish Institute of Agricultural Sciences.

In addition, NERI co-operates with the following foreign organisations: HELCOM, Finland; ISPRA, Italy; EMEP Meteorological Centre West, NILU Norsk Institut for Luftforskning and NMR Nordisk Ministerråd in Norway; OSPARCOM, Lancaster University, St. John's Institute of Dermatology, London, The Environment Agency, Uniliver UK Central Resources Ltd, and Universities of Reading, Cambridge, Bristol and Lancaster in UK; NASU, Ukraine; Desert Research Institute, EPA, Naval Research Laboratory, NCAR, NOAA, Oak Ridge National Laboratory, Purdue University, University of Florida and Woods Hole Oceanographic Institute in USA; and University of Belgrade, Yugoslavia.

The Technical University of Denmark is also a Danish actor in the atmospheric environment field.

2.3 Aquatic Environment field

The competence area Aquatic Environment is constituted by NERI's activities regarding marine ecology and fresh water ecology. The area extends to the impacts of eutrophication, xenobiotic substances, and climate change. In addition, NERI studies and monitors marine mammals in Danish waters, particularly in relation to human impacts, the impact of mass die-offs and population management.

NERI's competencies in marine ecology focus on the structure and function of marine ecosystems. The objective is to elucidate interactions with hydrographical conditions and human impacts, both at global level (climate changes) and national level (e.g. the impact of the Action Plans for the Aquatic Environment).

NERI's competencies in stream and lake ecology focus mainly on impacts on ecosystem structure and functions caused by changes in nutrient impacts as a result of the Action Plans for the Aquatic Environment, land use, methods of cultivation, and restoration measures.

Specific responsibilities

NERI attends to official responsibilities for the Ministry of the Environment and the counties regarding leaching from agricultural areas, environment and nature in water courses, lakes and the sea. It includes activities concerning eutrophication, oxygen depletion, state of the environment and nature, restoration of nature and administration thereof.

In the monitoring area, the authorities' responsibility is actually entrusted to NERI to service the minister and the political system. NERI thus co-ordinates a monitoring programme NOVA 2003 as a part of the Action Plan for the Aquatic Environment and carries out the monitoring of the marine environment for the open seas (the counties attend to the monitoring of coastal areas and freshwater). NERI attends to hydrometric monitoring tasks and monitoring in connection with the restoration of the River Skjern, Action Plan for the Aquatic Environment II and the EU's Habitat Directive. Currently, NERI is working on a new national programme for monitoring the environment and nature (NOVANA, 2004-2009) in collaboration with the Danish counties and the Ministry of the Environment.

In the field of aquatic environment, NERI also assists Greenland in the participation in the international Arctic environmental partnership, including the Arctic Monitoring and Assessment Programme (AMAP). In addition, the organisation has significant responsibilities as a scientific data centre in the aquatic area: development of guidelines and instruction for monitoring and collecting, comparison and evaluation of all monitoring results (from the counties, NERI itself and others). NERI annually reports at the national level on the state of the environment in watercourses, lakes and the sea. The massive body of data is made available to the public via the Internet together with warnings in the event of risks of oxygen depletion and the occurrence of poisonous algae.

Furthermore NERI contributes to the international reporting of the development of the state of the environment in accordance with Danish obligations and co-operates nationally and internationally on the standardisation of models, methods and the exchange of results.

NERI provides expertise to the Ministry of the Environment concerning analyses of chemical substances in environmental samples and assessments that involve impact on the flora and fauna in aquatic environments. This includes impacts from pesticides, including the mapping of their effects on animals, plants and biological systems in freshwater and on land. NERI is responsible for reference functions and conducts performance tests for ecology as the basis for the national monitoring programmes. NERI routinely provides "Fingerprint analyses" of oil in connection with oil pollution control.

Research

NERI's research concerning aquatic environment comprises the following specific areas:

- Research and development of cross-disciplinary models that describe the connections between environmental effects of nutrients, state of the environment, and effects from the catchment area via water courses and lakes to the sea.
- Research and development of oxygen depletion models and models for transportation and conversion of nutrient and carbon.
- Methods for calculation of impact from diffuse sources.
- Analyses of the interplay between the utilisation of space, loss of chemical substances from agriculture and effects on the aquatic environment.
- Research concerning eutrophication and poisonous algae.
- Tools for priority setting to describe the connection between intervention regarding nutrients and effects in fresh water and marine areas.
- Research in aquatic bio-diversity and the effect of human impact on the structure and function of aquatic (fresh and salt-water) ecosystems.
- Development of indicators, objectives and reference systems for the state of nature and the environment in water courses, lakes and the sea (e.g. the Water Framework Directive).
- Analyses of the interplay between water courses and catchment areas.
- Development of methods for the evaluation of the state of the environment and nature.
- Development of tools for the administration of nature and priority setting for nature-administration strategies for fresh and salt-water areas.
- Research and system development for the selection and evaluation of wetlands (Action Plan for the Aquatic Environment II).
- Environmental consequences of the exploitation of sand, pebbles and gravel resources in Danish waters.
- Research and the accumulation of knowledge concerning the impact of global climate change on Arctic marine and fresh water ecosystems, including changes in Arctic bio-diversity.
- Development of methods for analysis and sampling for the measurement of environmentally dangerous chemical substances in various matrices (e.g. water, biological materials). This includes chemical substances such as dioxins, pesticides, PAH, PCB and bromated flame retardants.
- Studies of the effects of biocides (e.g. hull paint) on marine life and develops markers for the effects of environmentally dangerous substances.

Consultancy

NERI continually provides the basis for decisions, consultancy and other advisory services regarding pollution and the quality in water courses, lakes and the sea to the Ministry of the Environment, the Ministry of Food, Agriculture and Fisheries, the counties in Denmark, the EU and private clients. In connection with the Action Plans for the Aquatic Environment, NERI provides evaluations to the Danish Parliament (Folketinget) about the effects of the political measures.

Economy

The table below shows the budget 2002 of NERI's activities in the Aquatic Environment competence area. The figures in the table are from the document "Analysis of NERI's core activities" re-grouped to the competence area "Aquatic environment and nature" in NERI's Draft Strategy 2004-2010.

Budget 2002. Amounts in DKK million	Gross ex-penses	Income	Net ex-penses	Pct. Ext. financing
Aquatic environment and nature	92,6	37,4	55,1	40%

Education

Within the aquatic environment field, NERI contributes to higher education at the University of Copenhagen, University of Aarhus, Roskilde University, Aalborg University, The Danish University of Pharmaceutical Sciences and the University of Southern Denmark. In 2002 this involved 20 Ph.D. students, approximately 30 Master's Degree students and a great number of lectures, e.g. in connection with external and assistant professorships. NERI employees often serve as external examiners in examinations on the Master's Degree level and in conjunction with Ph.D. defences at all the Danish universities (20-25 annually).

In addition, NERI participates in the management of a research school, SOAS, School of Aquatic Sciences, together with the University of Aarhus and University of Southern Denmark. The organisation also participates in research schools working with bio-diversity (University of Aarhus and the University of Copenhagen) and water resources (the University of Copenhagen). NERI has a contract with the University of Aarhus about teaching in aquatic eco-toxicology

Together with The Veterinary and Agricultural University, NERI participates in the management of the research school RECETO, Research School of Environmental Chemistry and Eco-toxicology. Furthermore, NERI participates in the drafting of establishment of a new research school in aquatic eco-toxicology together with Roskilde University and the University of Southern Denmark.

NERI has two research professors employed in co-operation with the University of Aarhus and the University of Copenhagen.

Co-operation partners

NERI's primary co-operation partners on aquatic environment are the University of Copenhagen, The Veterinary and Agricultural University, University of Southern Denmark, University of Aarhus, Roskilde University, Danish Institute for Fisheries Research, DHI Water & Environment, Danish Institute of Agricultural Sciences, Geological Survey of Denmark and Greenland, Risø National Laboratory, Miljøkemi A/S and a number of counties in Denmark. These organisations constitute, in fact, the actors in the aquatic environment field in Denmark.

In addition, NERI co-operates with a number of foreign universities and institutes, comprising University of Gent in Belgium; Department of Fisheries and Marine Research, Nicosia, Cyprus; University of Liverpool, OSPARCOM - River Restoration Project, and Universities of East Anglia, Newcastle, Ulster and Wales, UK; Estonia Marine Institute and University of Tartu, Estonia; University of Latvia; Finnish Environment Institute; Finnish Institute of Marine Research; HELCOM and University of Helsinki in Finland; CNRS and Commissariat à l'Energie Atomique in France; Bundesamt für Seeschifffahrt und Hydrographie; AWI, Common Wadden Sea Secretariat, EAWAG, Institute für Ostseeforschung, Multimar Wattforum and University J.W. Goethe and University of Constance in Germany. RUG, IBN-DLO, National Institute for Coastal & Marine Management/RIKZ, NIOZ, RIVM, RIVO-DLO, RIZA, Tauw Milieu BV, and Agricultural University Wageningen and Katholieke Universiteit Leuven in Holland; Institute of Marine Biology of Crete and National Centre for Marine Research (NCMR) in Greece; Trinity College, Ireland; NIVA Institut for Vandforskning, Norsk Havforskningsinstitut and University of Bergen in Norway; Institute of Meteorology and Water Management, University of Agriculture, Lublin, and Water Management Board in Poland; Instituto da Conservacao da Natureza and University of Algarve in Portugal; Consejo Superior de Investigaciones Científicas, Direccio General de Pesca, Institute Mediterraneo de Estudios Avanzados, Mallorca, and Universities of Barcelona, Santiago de Compostela, Granada, León and Valencia in Spain; SMHI, TMBL, UGOT and Universities of Gøteborg, Linköping, Lund, Uppsala and Stockholm in Sweden; Phuket Marinebiological Center, Thailand; Department of Fisheries and Oceans, Canada; and U.S. Naval Research Laboratory.

2.4 Terrestrial Environment field

The competence area Terrestrial Environment comprises bio-diversity and landscape ecology, game biology, and effects of chemicals, micro-organisms, and GMOs. This competence area also includes NERI's work on impacts of raw material activities in Greenland and parts of NERI's work on effects of climate changes in Arctic eco-systems.

NERI's competencies in bio-diversity and landscape ecology focus on the structure and function of terrestrial natural habitats with a view to elucidating interaction with human impacts at species levels, natural habitat level, and landscape level. Historical analyses contribute to understanding landscape development, and prospective analyses and tools form part of integrated analyses of regulation measures and consequences to nature and landscape.

NERI's competencies within the game biology field include population ecology among important water fowl and mammals. In recent years, these competencies have been supplemented by spatial modelling of populations in relation to significant human activities.

NERI's competencies include the dispersion, fate, and impacts of xenobiotic substances, micro-organisms, and GMOs in terrestrial systems. Within terrestrial eco-toxicology, NERI focuses on the effects of pesticides and other chemical substances. The significance of the climate and other physical variables to toxicity is one aspect in analyses of e.g. bio-availability and interaction between physical, chemical, and biological conditions. NERI possesses competencies as regards interaction between environmental factors and ecosystem organisms, and special competencies as regards the

assessment of spread and impact of GMOs and microbiological pesticides. NERI develops test protocols and quality assurance systems for studies of chemical substances, microbiological pesticides, and GMOs.

Specific responsibilities

NERI provides specific expertise to the Ministry of the Environment and the counties concerning bio-diversity and populations of plants and animals, administration of nature, sustainable hunting and the impact on nature of cultivating forms in agriculture, large operations, etc., as well as soil quality.

Pertaining to monitoring, the actual official responsibility is assigned to NERI to service the minister and the political system. NERI attends to the monitoring of species, habitats and the quality of nature in accordance with EU directives and national obligations. This task involves operations such as the monitoring of terrestrial birds and plants, beavers, cormorants and populations of waterfowl, types of nature and bird sanctuaries and the compilation and updating of Red Lists of threatened species. Mapping of soil contamination and integrated monitoring of the impact of air pollution on nature are also included in NERI's activities in the terrestrial competence area.

In addition, NERI acts as the scientific data centre concerning nature and bio-diversity in Denmark and has responsibility for the collection of data on Denmark's behalf in connection with international co-operation on the management of migratory water-bird populations.

NERI also provides expertise to the Ministry of the Environment concerning the use and analyses of chemical substances in environmental samples and risk assessments of chemical substances and genetically engineered micro-organisms and plants. NERI conducts assessments that involve impact on the flora and fauna in soil, in particular impacts from pesticides on plants and biological systems and the ecology of soils. NERI also conducts risk assessments as the basis for permits and conditions for the release of genetically modified organisms in the environment.

Research

NERI's research concerning terrestrial environment includes the following specific areas:

- Studies of the living conditions of mammals, birds, insects and plants as they are affected by mankind through agriculture, utilisation of space, habitat fragmentation, establishment of large nature conservation areas and nature conservation management.
- Development of models, support systems and monitoring mechanisms to underpin decisions concerning the effects of nature conservation management measures on animals, plants and bio-diversity, e.g. organic agriculture.
- Modelling population developments under differing scenarios by varying various factors that have an influence on the landscape.
- Development of criteria for the quality of nature and development of nature conservation objectives in connection with the Habitat Directive.

- Development of genetic tools for use in assessing population status and trajectories and in connection with maintaining bio-diversity.
- Studies of the quality of soil in relation to cultivation forms, e.g. organic agriculture.
- Development of soil quality criteria and integrated systems for the evaluation of the quality of the environment.
- Research in soil-dwelling animals' tolerance.
- Research and development of mechanisms to ensure the sustainability of hunting practice.
- Analyses of various stocks of game.
- Research concerning the effects of the injuring of game and evaluation of preventative measures.
- Development of tools regulating damage and injury caused by game animals.
- Research concerning the ecology of water-birds and the effects of activities related to recreation, commerce and nature conservation management on the distribution and abundance of populations.
- Development of models to determine the effects on water-birds using areas that are protected from hunting and other disturbances.
- Development of tools for environmental impact assessments (EIA).
- Development of indices and objectives for the quality of nature in wetlands in the coastal zones, EC-bird sanctuaries, Ramsar areas, and EU-habitat areas.
- Studies of the effects of offshore wind turbines on sea mammals and migratory birds.
- Development of methods for analysis and sampling for the measurement of environmentally dangerous chemical substances (such as dioxins, pesticides, PAH, PCB and bromated flame retardants) in soil and biological matrices.
- Identification of allergens in consumer products and methods for risk assessment affecting human health (in collaboration with the Allergies Know-how Centre (Astma – Allergi Forbundet))
- Development of tools for chemical and eco-toxicological risk analysis and criteria for soil quality
- Development of models of the fate and effects of chemical substances.
- Development of guidelines, concepts and test systems for the risk assessment of GMOs in agriculture
- Studies of the occurrence, diffusion and transfer of genes in microbial communities.
- Studies on the ecology of microbial communities and the effects of biological biocides, including the health risk associated with the transport of airborne pathogenic bacteria from manure
- Development of microbiologically-based indicators of soil health and microbial diversity, and the transfer of antibiotic resistance among bacteria.
- Development of technologies for the biological re-mediation of contaminated soil.

Consultancy

NERI continually provides the basis for decisions, consultancy and other advisory services regarding alterations in the landscape, nature and biodiversity, as well as the administration of nature and

game and quality of soil for the Ministry of the Environment, Ministry of Food, Agriculture and Fisheries, Ministry of Transport, Danish Ministry of Foreign Affairs, the counties, private clients and the EU.

In addition, within the terrestrial environment area, NERI continually provides consultancy and other advisory services relating to the diffusion and environmental effects arising from the utilisation of chemical substances and genetically modified bacteria and plants. This consultancy is provided to the Ministry of the Environment, Ministry of Food, Agriculture and Fisheries, the counties, private clients and the EU.

Economy

The table below shows the budget 2002 of NERI's activities in the Terrestrial Environment competence area. The figures in the table from the document "Analysis of NERI's core activities" re-grouped to the competence area "Terrestrial environment and nature" in NERI's Draft Strategy 2004-2010.

Budget 2002. Amounts in DKK million	Gross expenses	Income	Net expenses	Pct. Ext. financing
Terrestrial environment and nature	88,3	39,6	48,7	45%

Education

In the terrestrial environment area, NERI contributes to higher education at the University of Copenhagen, University of Aarhus, The Veterinary and Agricultural University, and Roskilde University. In 2002 this involved 16 Ph.D. students, approximately 30 Master's Degree students, lectures and service as external examiner at university examinations and Ph.D. defences (15-20 annually). NERI conducts a semester-long course in game biology at the University of Aarhus and courses for forest and landscape engineers. Furthermore, NERI participates in the further education and training of game consultants, county biologists and agricultural consultants.

Together with The Veterinary and Agricultural University, NERI participates in the management of a research school, SOAR, Research School for Organic Agriculture and Food Systems, and participates in a research school dealing with bio-diversity (ISOBIAS, University of Aarhus, University of Copenhagen). Within the terrestrial competence area, NERI also participates, together with The Veterinary and Agricultural University, in the management of the research school RECETO, Research School of Environmental Chemistry and Eco-toxicology.

In addition, in this competence area, NERI employs a research professor in co-operation with the University of Aarhus.

Co-operation partners

NERI's primary co-operation partners as regard terrestrial environment are the Danish Institute of Agricultural Sciences, University of Aarhus, University of Copenhagen, University of Southern Denmark, The Royal Veterinary and Agricultural University, The Technical University of Denmark, Danish Forest and Landscape Research Institute, Risø National Laboratory, Aalborg University, Roskilde University, Gentofte Hospital, Odense University Hospital, SOILREM (Biotechnisk Jordrens A/S), DHI Water & Environment, The Danish Veterinary and Food Administration, ORNIS Consult, Wetlands International (WI), Hedeselskabet, Danisco Seed-Holeby, COWI A/S, DK-Teknik A/S, Defence Command Denmark, Admiral Danish Fleet as well as a number of counties.

Other Danish actors within terrestrial environment are Danish Agricultural Advisory Service, Biotechnological Institute and Danish Pest Infestation Laboratory.

DEME Environmental Contractors (Belgium), Limburgs Universitair Centrum (Belgium), In the terrestrial area, NERI also cooperates with a number of foreign organisations, namely VITO - Vlaamse Instelling voor Technologische Ondersok, DEME Environmental Contractors, Limburgs Universitair Centrum, and Institute Nature Conservation and Katholieke Universiteit Leuven in Belgium; Miljø- og Levnedsmiddelstyrelsen, Faroe Islands; Icelandic National History Institute and Miljø- og Levnedsmiddelstyrelsen, Iceland; OECD, Centre Natural Resources Science, l'Institute Pasteur, Commisariat a l'Energie Atomique and CNRS in France; Max Planck Gesellschaft zur Förd, Bundesamt und Forschungszentrum für Landwirtschaft, Gesellschaft für Biotechnologische Forschung mbH, BSH, WCI Umwelttechnik, Common Wadden Sea Secretariat, UFZ Leipzig, Technical University of Munich, Universität Tübingen and University of Heidelberg in Germany; Grønlands Forundersøgelse, Grønlands Hjemmestyre, Grønlands Naturinstitut, and ASIAQ in Greenland; ALTERRA - Green World Research Centre, Wetlands International, ECE Coordination Centre for Effects, Dienst Landbouwkundig Onderzoek, Netherlands Energy Res. Foundation, Universities of Groningen and Vrije Amsterdam, Utrecht University, Agricultural University Wageningen and RIVM in Holland; University of Eotvos, Hungary; CESI - Centro Elettrotecnoc and Istituto di Ricerche Farmacologiche "Mario Negri" and Consiglio Naz. Delle Ricerche, University of Milano in Italy; AMAP Styringsgruppe, NINA Norsk Institut for Naturforskning, Norwegian Polar Institute, Centre for Soil and Environmental Research, NMR - Nordisk Ministerråd, Sintef, NTNU, and Universities of Tromsø and Oslo in Norway; Swedish Environmental Research Institute, Swedish Nat. Test. & Resources, Stockholm's Museum of Natural History and Universities of Gøteborg, Kalmar and Lund in Sweden; University of Bern, Switzerland and Swiss Federal Institute for Environmental Science and Technology; QUASIMEME, Centre for Ecology and Hydrology, Wildfowl & Wetlands Trust, the Macaulay Institute (Scotland), WRC and Universities of Reading, Sunderland and Edinburgh, UK; Bundes und Forschungszentrum für Landwirtschaft and Interuniversitäres Forschungsinstitut in Austria; Chinese Academy of Sciences; Environment Data Centre in Helsinki; Finnish Environment Institute and University of Oulu in Finland; University of Athens; Irish National Parks & Wildlife Service, Institute of Technology Carlow and University College Cork in Ireland; Centre d'Investigacio i Desenvolupament (CID), Centro de Astrobiología-Madrid, Consejo Superior de Investigaciones Científicas, Instituto de Recursos Naturales y Agrobiología, National Centre Biotechnology, and Universities of Autónomia de Madrid, Cadiz (UCA), and del Lleida in Spain; TRENT University, Environment Canada, and Canadian Wildlife Service, Canada; Rutgers University, Universities of Michigan, Missouri-Rolla and Connecticut, US EPA, Batelle, Naval Research Laboratory, Brookhaven National Laboratory and US Fish & Wildlife Services, USA; and Wuhan Institute of

Virology in China.

2.5 Environment and Policy field

The competence area Environment and Policy comprises NERI's activities on environmental economics, environmental sociology, and risk assessment.

The work with environmental economics relates to the need for environmental prioritisation tools in Denmark and internationally. NERI's competences comprise environmental economic analyses, welfare-economic assessment of environmental measures and responses, and development of methods of valuation.

Environmental sociology is a relatively new research discipline. It contributes to the understanding of the driving forces behind various environmental issues and the political and management-related opportunities for responding to them. NERI's environmental sociological studies analyse the attitudes and actions of population groups in relation to selected environmental problems with a view to describing the potential for changing people's behaviour. Analyses of public preferences are also used to value environmental benefits.

NERI's activities on risk assessment focus on the development of model tools to carry out risk assessment of chemical substances based on their structure and physical-chemical properties.,

Specific responsibilities

NERI provides specific resources for the Ministry of the Environment in questions pertaining to environmental regulation. This includes environmental economics, projections, cross-disciplinary environmental evaluations and priority-setting, as well as the co-ordination of environmental monitoring in Denmark.

NERI also produces the Danish report on the national state of nature and the environment ("SOE") and develops cross-disciplinary indicator systems regarding sustainability, nature and the environment.

Research

In the Environment and Policy competence area, data, knowledge and tools are broadly acquired from NERI's other priority areas and are supplemented with knowledge and data from the social sciences in cross-disciplinary analyses. NERI's research concerning environment and policy includes the following specific areas:

- Analyses and comparison of data, knowledge and models on an aggregated level, describing

the connection between discharge, transport and transformation of pollutants and other environmental impacts, as well as the effect of regulatory measures.

- Systems analyses, including issues and questions pertaining to the use of chemical substances, land-use, agriculture, nature management and energy.
- Methods and models from environmental economics, environmental sociological analyses, and GIS (Geographical Information Systems). Issues that are presently being worked with include discounting, benefit transfer, valuation and economic priority-setting methods. In environmental sociology, the scientific themes are agricultural sociology, transport behaviour, and consumer involvement and public participation.

Consultancy

NERI continually provides information forming the basis for decisions, consultancy and other advisory services concerning environmental economics and valuation, regulation, cross-disciplinary priority-setting, scenario analyses, indicator systems,. This consultancy is provided to the Ministry of the Environment, Ministry of Food, Agriculture and Fisheries, Ministry of Transport, The Danish Ministry of Finance, the EU, the EEA, the Danish counties and private clients.

Economy

The table the budget 2002 for NERI's activities in the Environment and Policy competence area. The figures from the document "Analysis of NERI's core activities" regrouped to the competence area "Environmental economics and sociology and risk assessment" in NERI's Draft Strategy 2004-2010.

Budget 2002. Amounts in DKK million	Gross expenses	Income	Net expenses	Pct. Ext. financing
Environmental economics, sociology and risk assessment	26,3	10,8	15,5	41%

Education

NERI contributes to higher education at the University of Copenhagen, University of Aarhus, The Royal Veterinary and Agricultural University, Copenhagen Business School, Roskilde University and Aalborg University. In 2002 this involved seven Ph.D. students together with a long number of lectures and service as external examiner in conjunction with examinations.

NERI has employed a research professor in the area in collaboration with the University of Aarhus.

Co-operation partners

NERI's most important co-operation partners as regards environment and policy are Risø National Laboratory, Institute of Local Government Studies - Denmark, Copenhagen Business School, Statistics Denmark, Danish Institute of Agricultural Sciences, Danish Research Institute of Food Economics, University of Copenhagen, Aalborg University, Roskilde University, Danish Forest and Landscape Research Institute, dk-TEKNIK Energy & Environment, the Geological Survey of Denmark and Greenland, the Danish EPA, Danish Forest and Nature Agency.

NERI has no formal collaboration agreement with the new Danish Environmental Assessment Institute. However, NERI has provided the institute with a presentation of the expertise found at NERI and has hitherto provided data, knowledge and scientific commentary for some of the institute's reports on an ad hoc basis. NERI will continue the alliance according to these guidelines.

Other Danish actors within the field of environment and policy are The Aarhus School of Business and University of Southern Denmark.

NERI's foreign collaboration partners in this area are: SYKE - Finnish Environmental Institute, MTT Economic Research, University of Helsinki - Faculty of Agriculture and Forestry and University of Joensuu - Faculty of Forestry in Finland; NIJOS - Norwegian Institute of Land Inventory, NILU - Norwegian Institute for Atmospheric Research and ECON - Centre for Economic Analysis in Norway; IVL - Institute for Vatten och Luftforskning and Göteborg University in Sweden; University of Iceland; Laboratory Glaciologic and Geophysical Environment and INRA - Institut National de la Recherche Agronomique in France; UFZ - Centre for Environmental Research, ZALF - Centre for Agricultural Landscape & Land Use Research, Hamburg Weltwirtschaftlicher Universität, German Institute of Freshwater Ecology and Fisheries, and GSF - National Research Centre for Environment and Health in Germany. RIVM - National Institute of Public Health and the Environment, RIZA - National Institute for Inland Water Management and Waste Water Treatment, and DLO - Agricultural Economics Research Institute in Holland; UNEP/Grid Arendal, International Centre for Integrative Studies, ALTERRA - Green World Research Centre, ECNC - European Centre for Nature Conservation and Universities Wageningen and Nijmegen in Holland; CEH - Centre for Ecology and Hydrology, London School of Economics, and Manchester and Durham Universities in UK; CAU - Czech Academy of Sciences-Prague, Czech Agricultural University in Czech Republic; IECB - Institute of Ecology & Conserv. Biology in Austria; UWH - University of Western Hungary; IMAR - University of Evora/Universidade de Coimbra in Portugal; WSL - Swiss Institute of Forest, Snow & Landscape in Switzerland; INB - Instituut voor Natuurbehoud., Belgium; Panteion University of Social and Political Sciences, Athens; Vanderbilt University - Institute for Public Policy Studies and Massachusetts Institute of Technology in USA; and Kyoto University, Japan.

3. Evaluation procedure

3.1 Background and purpose of the evaluation

The starting point of NERI, when established in 1989, was an international review of Danish environmental research. The review included a number of the present departments of NERI. During the following years additional reviews of NERI's research areas were carried out, most recently in 1997 when NERI's aquatic research was evaluated as part of an international evaluation of public Danish fisheries research, and in spring 2003 where NERI's research on marine eutrophication was evaluated.

In view of the time elapsed, and since the latest reviews comprise only a few specific parts of NERI's activities, NERI's Board of Governors decided in the summer 2003 to initiate a general evaluation of the institute and its research. This evaluation of NERI is based on the Terms of Reference of June 2003 (annex 1) set up by The Danish Research Agency and The Danish Natural Science Research Council.

In the Terms of Reference, the scope of the evaluation is indicated as follows:

“The review shall evaluate the scientific quality of NERI's research and provide guidance on the research strategy. In addition, the review must evaluate the general performance of the institute and provide recommendations for the management.”

3.2 Panel and procedure

The evaluation was carried out in August 2003 by an Evaluation Panel composed of leading international scientific experts with experience in NERI's research areas. The Panel members, which were appointed by the Danish research councils, include persons with management experience, and several of them are able to read reports published in Danish.

The Evaluation Panel was structured in four Sub-Panels comprising the following members:

Atmospheric Environment

Dr. Kjetil Tørseth (Sub-Panel Chairman)
Norwegian Institute for Air Research (NILU)
Norway

Dr. Timothy J. Wallington
Chemistry Department
Ford Motor Company
USA

Professor Karl H. Becker
University Wuppertal
Department of Physical Chemistry
Germany

Aquatic Environment

Dr. Robert S. Carney
Louisiana State University's
Coastal Ecology Institute
USA

Professor Richard Burrows (Sub-Panel Chairman)
University of Liverpool
Department of Civil Engineering
UK

Associated Professor Bente Aagaard Lomstein
Department for Microbial Ecology
University of Aarhus
Denmark

Terrestrial Environment

Professor Thomas H. Christensen (Panel Chairman)
Technical University, Denmark
E&R - Environment and resources
Denmark

Professor Donald. A. Davidson (Sub-Panel Chairman)
University of Stirling, Scotland
School of Biological and Environmental Sciences
Department of Environmental Science
UK

Professor Nico M. van Straalen
Vrije Universiteit
Department of Animal Ecology
The Netherlands

Environment and Society

Professor Petter Næss (Sub-Panel Chairman)

Aalborg University
Department of Development and Planning
Denmark

Professor Per-Olov Johansson
Stockholm School of Economics
Department of Economics
Center for Health Economics
Sweden

Professor Philippe Grandjean
University of Southern Denmark
IST – Environmental Medicine
Denmark

Professor Thomas H. Christensen, who was also member of the Terrestrial Environment Sub-Panel, was the overall Panel Chairman. M.Sc.Eng. Pia Jørnø, independent consultant, served as academic secretary for the Panel.

The basic principle of the evaluation was peer review of NERI's research activities, as judged by the tasks assigned to NERI in the government order regulating NERI and NERI's management performance contract 2000-2003.

18-21 August 2003 the Evaluation Panel visited NERI and had meetings with the senior management, department management and researchers of NERI. The schedule for the Panel's assembly and meetings is enclosed as Annex 2.

In advance of the visit, the Panel reviewed documents supplied by NERI. A reference list, indicating the background documents, is enclosed as Annex 3.

In the Terms of Reference, the Evaluation Panel was asked to prepare a report including considerations and conclusions about:

- The extent and scientific quality of NERI's research and its national and international position and impact. This point should also include an evaluation of whether there are professional or quality-related strengths, weaknesses or deficiencies in the activities.
- The relevance of NERI's research activities as a basis for Danish and international environmental policy and management. This point should also include an evaluation of NERI's application of scientific results in the institute's monitoring and advisory activities.
- The performance of NERI as a government research institute with respect to the tasks laid down in the government order regulating NERI and the management performance contract 2000-2003.
- NERI's national and international collaboration with universities and other research institutes.

4. The Panel's assessments and recommendations regarding NERI as a whole

NERI is a large national institute (about 400 employees, annual budget: 250 million DKK, 1000 publications annually including 200 international journal publications) focusing on research, monitoring and advisory activities regarding the environment and nature.

The Panel has received and worked with a number of summary reports and publications prepared by NERI for the review (see Annex 3) and the Panel has also upon request had access to public publications by NERI as a basis for this evaluation. In addition the Panel has met with the directors, the departments and selected scientist at the headquarters in Roskilde and, via video links, the departments in Kalø and Silkeborg. Where appropriate, the Panel has also looked at web pages, followed database demonstrations, and visited laboratory facilities.

Within the resources and time available, the Panel has made much effort in obtaining a correct understanding and evaluation of the scope, operation and performance of NERI. In spite of this, the Panel does not claim to have an in-depth understanding of all aspects of NERI. In particular, the Panel has not been able to study in-depth NERI's activities on the Arctic Environment and on Risk Assessment. Nevertheless, the Panel believes that the general evaluation is reasonably correct and provides a balanced assessment of NERI's research and its associated activities including monitoring and consultancy.

This chapter presents the Panel's overall evaluation of NERI, while the Panel's specific evaluation of each of the four competence areas are found in the following chapters.

4.1 Extent and scientific quality of NERI's research and its position and impact

In general, the panel finds the quality of the research performed by NERI to be good and fully satisfactory for meeting the objectives and tasks of NERI. The institute has within all the competence areas and departments specified its visions and goals. Management procedures are established or in the process of being established, using the method "Logical Framework Approach" in order to drive and monitor progress at project level.

The research teams are in general experienced, have access to modern facilities and methods and interact well internally and with relevant research communities both at national and international level.

Research results are presented at international conferences and published in international journals. Furthermore, the journal publications are in general cited at or above a level comparable to publication from other research groups. NERI (including the institutions and laboratories that were merged to form NERI in 1989) has since 1981 published 1440 scientific journal publications which have had 13400 citations in total, of which 23% are self-citations. Considering the journals containing the published articles and their average citation ratio as established by the Institute of Scientific Information, the number of citations is 22 % above the average number of citations in the respective

journals.

The uniqueness of NERI is the combination of research, monitoring and advisory tasks. For maintaining and strengthening this uniqueness, the research activities must cover a wide range of topics and disciplines. NERI does cover such wide range of research, and given its status as a government research institute with several obligatory responsibilities, the Panel finds a wide spectrum of research, combined with a satisfactory quality standard of the research, preferable instead of focusing on top-class research in a more narrow spectrum of topics. Nevertheless, in its natural science fields, NERI has achieved an appropriate balance between a wide spectrum of research activities and highly respected specializations in a number of research areas. These are:

- Air quality monitoring and atmospheric modeling, in particular in the fields of mercury deposition in the arctic; ammonia dispersion, transformation and deposition; and street pollution
- Freshwater ecology, in particular the research on lakes.
- Marine ecology in particular monitoring and analysis activities in coastal waters and fjords
- Risk assessment on Genetically Modified Plants (GMPs)
- Soil eco-toxicology
- Monitoring, for example in arctic environments and in seabirds movements

NERI's competence area in policy analysis has recently expanded into environmental economics and environmental sociology. The Panel considers NERI's research on Environment and Society an important and necessary supplement to the original natural science based competence areas. This field is multidisciplinary, and a substantial effort must be allocated to ensure a critical mass and common working concepts. Although the productivity in peer-reviewed scientific journals is not satisfactory, the Panel is convinced that the research activities within this area are sound and necessary, and that this competence area within a few years will reach a level comparable with the other competence areas in terms of coherence and outputs.

The Panel identified that many projects are interdepartmental, and many research projects are linked to monitoring. This is a strength that should be maintained and actively nurtured by NERI.

The research areas identified for the new contract period (2004-2007) are all considered by the Panel to be important. They build on NERI's existing expertise and target at contributing to solving problems, which the Panel anticipates to be important in future. Among others, the clear targeting to the implementation of the Water Framework and Habitat Directives is important for Denmark. However, in all areas of competence, even including the most successful ones, the need for continuously adjusting research focus and effort is eternal and the Sub-Panel reports contain some suggestions on such adjustments. NERI should consider some of these for the coming Performance Contract.

Considering that in average 70 % of appropriation provided by the Danish Government is bound to tasks related to monitoring and specified services and the amount of external research contracts obtained (EU, research council, etc.), the Panel finds the productivity of NERI in terms of research

publication and reports fully satisfactory. As hinted in the table below, the number of international scientific journal publications in the period 2000-2003 is, in the natural science competence areas, in the interval 1-1.6 per scientific staff per year. As mentioned previously, the department on policy analysis shows a lower productivity with respect to journal publications.

The researchers at NERI represent a broad spectrum of expertise and educational backgrounds and the interaction among these researchers is a good basis for performance of relevant research. The Panel, however, finds that significant expertise in statistical analysis and simulation modeling is now embedded within research departments. The increasing importance of these specialties across all NERI tasks suggests that expertise be increased and structured to cross departmental boundaries. Creating a department of statistics and modelling might not work, but some mechanism that assures more co-operation is needed. The Panel feels that such a step will better ensure the maximum outcome from the monitoring programmes and successful synthesis of data and process understanding to create new knowledge (in contrast to just producing more data). Since the Panel believes that environmental issues in the future will be linked more to human health this may require association of such expertise to NERI.

Resources and Outputs Year 2002	Dept. of Arctic Environment (AM)	Dept. of Atmospheric Environment (ATMI)	Dept. of Freshwater Ecology (FEVØ)	Department of Coastal Zone Ecology (KYST)	Dept. of Landscape Ecology (LAND)	Dept. of Marine Ecology (MAR)	Dept. of Environmental Chemistry and Microbiology (MIMI)	Dept. of Policy Analysis (SYS)	Dept. of Terrestrial Ecology (TERI)
Total funding (m DKK)	17,2	33,3	28,2	14,4	12,5	30,6	17,8	18,2	17,7
Human resources (person- years)									
Scientific academic staff	15,9	24,1	14,8	9,6	13,4	29,5	16,9	25,9	14,9
Total staff	22,2	66,5	61,8	25,2	24,6	61,6	41,4	35,0	38,4
Products									
International journal publications	15	39	25	15	14	52	24	20	21
Other scientific publications	37	76	61	35	27	81	29	57	44
Technical reports	59	77	64	53	34	78	34	51	113
Popular publications	17	8	5	11	15	10	2	13	2

4.2 The relevance of NERI's research activities as a basis for Danish and

international environmental policy and management

The Panel finds it very important that the research performed by NERI is not only of good quality but also is of high relevance in order to contribute to the overall goal fulfilment of NERI. As already stated, the close relationship between research, monitoring and advisory activity covering the major issues related to environment and nature in Denmark and Greenland is the legality of NERI and should be given careful attention at the directors' level, the departmental level and in the public appearance of NERI.

The Panel finds that the current research activities are relevant and that the activities at NERI in many cases make very important contributions to Danish as well as to European initiatives and regulations regarding nature and environment. The reports on the specific competence areas provide several examples.

In addition, the Panel finds that the research activities planned for the next performance contract period also are relevant and very important for the Danish implementation of the new EU directives.

Considering the constraints in budget in recent years, NERI has done well. However the announced budget cuts in the future leads to concerns of the panel on whether NERI is still able to maintain its present performance level and quality.

The Panel is of the opinion that in the future, more effort should be devoted to a more detailed specification of relevance at all levels in NERI. This recommendation is particularly important in the view of the basic appropriation becoming more tight, thus necessitating external funding from Danish and European bodies. Having the overall goal of NERI in mind, only project proposals relevant for high priority topics of NERI should be submitted for external funding. However, externally funded projects will often require internal co-funding and thereby indirectly remove resources from other maybe even more important (i.e. relevant) projects. This situation is not easy to control and may result in a less optimal project portfolio. This negative effect should be met by keeping a proper balance between basic appropriation and external financing, obtained via a clear focus on relevance, while at the same time drawing on external complementary expertise to the largest possible extent.

Relevance is largely defined by the future political/societal need for knowledge and data on the environment and nature. Predicting which needs will be most pressing in, for example five to ten years, is difficult because political priorities may change. The Panel suggests that NERI in addition to its contacts in the Danish central administration and the initiatives generated in-house might consider establishing one or more scientific advisory boards of high and international standing to help NERI foresee future needs.

With respect to relevance, the Panel also wishes to emphasise the need for a close and visible connection between research and monitoring. Research should lead to improved monitoring and interpretation of results and monitoring should also lead to identification of research needs. In this context we find that high-level statistical approaches and integrated modelling must play a crucial role. These issues are involved in some research areas, but the Panel suggests that the consistency and general integration of these elements be carefully evaluated in all project areas.

The panel is impressed by the number and range of popular publications as well as with the increasing availability of information on the Web. These dissemination activities contribute to the public's awareness and knowledge on environmental matters.

4.3 The performance of NERI as a government research institute with respect to the tasks laid down in the performance contract 2000-2003 and the government order

The Performance Contract (PC) 2000-2003 between NERI and the Ministry of the Environment includes a total of 169 goals. At the time of the evaluation, less than 6 months remain in this contract period. NERI uses the PC as a guiding framework for the preparation of annual work programmes, for the ongoing prioritisation of tasks and resources, and for reporting progress to the Board of Governors.

NERI has made a preliminary assessment of the overall goal achievement based on annual results from 2000-2002 and preliminary judgements halfway through 2003. According to these, on average NERI will achieve 84% of the PC-goals, 9% are still uncertain, whereas 7% of the goals will only be partly achieved or given up. NERI's main reasons for giving up goals are related to the unpredictable complexity of research, the lack of external funding and the prioritisation, which has been necessitated by budget restraints.

According to NERI's own assessments, senior management, being responsible for crosscutting activities and administration, has achieved about 72% of the crosscutting and administrative goals. 16% are still uncertain, whereas 12% will not be fully met. The need for a comprehensive GIS expertise within NERI was met by the inclusion of the National Survey and Cadastre in the Ministry of Environment in 2001/2002. The integration of project management tools into Resources and Results Management System (goal 148) has been postponed. Formal co-operation with organisations from industry, agriculture and NGOs has been only partly successful. In addition, co-operation with universities has been strengthened, especially through Ph.D. schools.

The Panel has not had the means to carefully scrutinize the fulfilment of the individual items of the PC. However, the Panel has no basis for questioning the information provided by NERI and finds that NERI has fulfilled the current performance contract to a satisfactory degree. The Panel suggests that future Performance Contracts contain fewer items, preferably with more flexibility to allow for unforeseen needs within the coming period.

According to the performance contract and in accordance with the statutory order, NERI should service the authorities with respect to advisory and contingency tasks. The Panel has had no possibility within the available time to scrutinize the satisfaction of the "customers" with regard to NERI's services. However, Kvistgaard Consult (se Annex 3) has in May and June 2003 undertaken a user satisfaction survey for NERI. The purpose was to find out whether NERI's objectives for implementation of their services have been met, whether the user needs have been considered, and to collect user suggestions for improving services provided by NERI. The study was made on the

basis of 15 qualitative interviews with chosen key persons among the central users of NERI's services.

The Kvistgaard survey concludes that all interviewed persons were satisfied with NERI's deliveries. They all agree that there is a high level of professionalism within NERI. A concrete comparison of the users' expressions of expectations and the level of satisfaction showed that the expectations of the costumers are generally higher than the level of satisfaction. The conclusion is therefore, that for several criteria, there is room for improvement from a level of satisfaction below average for certain criteria to an average level for others. Especially one criterion calls for improvement, namely that the NERI products must target and adapt to the concrete needs of individual users/authorities. It is relevant in this regard for NERI, when delivering advice and results, to adapt further to the reality of public administration, and thus to the needs of clients.

The Panel finds that NERI does deliver the services requested. But in the view of the diversity and complexity of NERI's research and service areas, the Panel suggests NERI make an effort to improve the transparency and availability of its competencies in order to substantiate the use of these competencies and also improve the actual services undertaken to increase user satisfaction.

The environmental and nature area is interdisciplinary within research, monitoring and consultancy, as also reflected in the diversity and complexity of NERI's activities. This also puts high demands on the directors and department heads to keep NERI well-trimmed and adaptable to changes in expectation and political and economic conditions. The Panel has received information about the organisation and management procedures and has requested information about various specific issues and attitudes. It has not been possible for the Panel to assess the senior management in-depth, but in view of NERI's performance and quality of its activities over the last five years, the panel is confident that the management has obtained success and will continue to do so in the future. As mentioned in the competence area chapters, there are things to improve, but the Panel is confident that the management will deal with these matters. However, as stated in earlier sections, the most challenging management issue is probably to maintain and further develop the uniqueness of NERI based on the combination of relevant research, monitoring and advisory services.

4.4 NERI's national and international collaboration with universities and other research institutes

In its research projects NERI collaborates with a wide range of institutions in Denmark as well as abroad. The Sub-Panel reports contain details about this. The Panel appreciates NERI's involvement in collaborating with institutes which provides both supporting and complementary expertise.

NERI in many areas involves Ph.D. as well as Master students and offers educational activities to collaborating universities. NERI also participates in six Danish research schools covering a wide spectrum of topics.

The Panel appreciates NERI's dedication to collaboration, networking and education.

4.5 The Panel's general recommendations

The Panel is very satisfied with the overall performance of NERI. In general there is always a potential for improvement, and the chapters on the Panel's specific evaluation of NERI's competence area suggest such improvements. In addition to these competence-specific recommendations, the Panel wishes to present the following general recommendations:

- NERI should maintain its wide spectrum of research topics and disciplines, thus maintaining its unique combination of research, monitoring and advisory tasks. The close inter-linking between research, monitoring and consultancy is the legality of NERI, and should continuously be given careful attention at all organizational levels and in the public appearance of NERI.
- NERI should carefully evaluate all research activities with respect to relevance in relation to the overall objective of NERI to performance monitoring and advisory to the public authorities.
- A proper balance between research financed by NERI's basic appropriation and externally funded research should be maintained, thus contributing to ensuring a continuous prioritization of research with high relevance for Danish and EU environmental policy.
- NERI should consider establishing one or more scientific advisory board to help NERI foresee the needs for development in its competence areas in compliance with the future political trends.
- NERI should consider strengthening and better coordinating its in-house expertise regarding statistical issues and modelling in order to ensure the maximum outcome from the monitoring programmes and successful synthesis of data and process understanding to create new knowledge.
- NERI should continue its efforts and co-operation with universities concerning education of Ph.D. and Master Students.
- NERI should maintain its strong collaboration with relevant research organisations in Denmark and abroad. Besides contributing to NERI keeping up with state-of-the-art within its research fields, the collaboration provides a large potential for using expertise complementary to NERI's own. NERI already exploits this opportunity, but the Panel sees a potential for exploiting it further, e.g. in the Human Health area.

5. NERI's activities concerning the atmospheric environment. Assessments and recommendations

This chapter concerns the Panel's assessments and recommendations as regards NERI's activities within the Atmospheric Environment Competence Area. NERI has conducted research and development on air pollution issues and application of air pollution systems in relation to monitoring, field studies, and modeling of air pollution for more than 20 years. Today, these activities are mainly carried out by the Department of Atmospheric Environment (ATMI), but the Department of Policy Analysis (SYS) also works within the atmospheric environment competence area. Overall, the Panel finds that NERI has unique expertise and capabilities in these fields on both a Danish and international level.

5.1 Extent and scientific quality of the research in the field of atmospheric environment and its position and impact

NERI has developed a concept for "integrated monitoring" combining measurements and modeling for application in management and assessment of air quality. The Panel believes that NERI has expertise in operational integrated air quality modeling and forecasting on all spatial scales from hemispheric scale down to street canyon scale. In recent years this expertise and capabilities have been extended to particles and human exposure and in co-operation with the health sector to assessment of effects on human health.

The Atmospheric Department's expertise in monitoring, field studies, and modeling is also being used in the Arctic area particularly in relation to long-range transport and deposition of air pollution in the Arctic. The Panel is convinced that the department has developed state-of-the-art capabilities in relation to assessing deposition amounts and the governing transport pathways of mercury to the Arctic.

In addition, the Panel finds the department's methods and equipment appropriate. These are being improved continuously, and new technologies are being implemented to maintain a high international level. NERI is required to carry out urban, rural and Arctic integrated air quality monitoring programs in compliance with international conventions and EU-directives on air pollution. NERI has accreditation for most sampling and analytical methods used in the monitoring programs according to ISO 17025 and appropriate quality control is carried out at all levels. New methods are being developed and implemented for special purposes (e.g. ammonia analysis with low detection limits and with high temporal resolution). Further, the Panel finds that the air pollution models, particle measurements, and measuring techniques for mercury in the Arctic are state-of-the-art.

Integrated air quality monitoring

NERI has developed an advanced integrated air monitoring system combining high quality measurements and air quality models for assessment of the air quality as a tool for management of the Danish air quality. An appropriate QA/QC system is in operation.

The monitoring system delivers actual and historical data to the public, the local authorities, the ministries and other decision-makers. The monitoring programs appear to fulfil the Danish obligations in relation to the EU and other international requirements within the allocated budgets. The programs have been through several optimization processes to get cost-effective monitoring. This is mainly obtained by optimal siting of the monitoring stations and by the combined application of measurements and models. The Panel finds that this approach is cost efficient, reducing the number of monitoring stations compared to other European countries. However, further reduction will probably lead to programs which may not fulfil the Danish obligations in relation to international requirements.

NERI has been active in connection with development of the EU ambient air quality directives, and many of the elements of the Danish strategy have been implemented in the directives. However, the Panel assesses that at present, NERI only has little impact on the future European strategy. Since NERI holds valuable expertise in this area the Panel recommends that Denmark prioritise and strengthen further co-operation with the EU in relation to air pollution.

Monitoring of volatile organic compounds is very limited in the Danish monitoring programmes and more focus on organic compounds especially VOCs are recommended by the Panel.

The Panel considers the monitoring activities to form a very important platform for many of NERI's research projects, e.g. in relation to particles, ammonia, deposition of pollutants to land and sea areas and mercury, and they form basis for general model developments both with respect to long range transport modeling and urban modeling.

Integrated Operational Modeling

The Panel finds that NERI has a high international profile in research, development and application of advanced atmospheric dispersion models and integrated model systems for operational modeling, management and assessment of air quality. The model suite consists of comprehensive state of the art models, including a long-range 3-D Eulerian transport model covering the Northern Hemisphere and/or Europe, an urban background model, and a street canyon model. NERI is in a unique position in covering all these spatial scales in the same department and in integrating all the scales in an operational system, which is used for 3-day forecasts, scenarios, management and assessment of air quality. The level of integration of air quality models coupling hemispheric, regional, urban background and urban street scales is world class.

Especially three modeling areas are unique:

- Integrated modeling at different spatial scales. Since the early eighties, NERI has developed models covering different scales and applications. In 1998 the integration of the weather and air

pollution models in one operational and automatic system was carried out. The system is unique with respect to the level of integration of scales (regional scale, urban background scale and street scale).

- The street canyon model (Operational Street Pollution Model) is a benchmark for similar models in Europe.
- A two-way nested regional transport model (DEHM) with presently up to three domains covering the Northern Hemisphere, Europe and Northern Europe including higher and higher resolution for the domains over Europe. The model is capable of long-term calculations (more than 10 years), covering a large area and at the same time maintaining a high resolution over important areas. Model versions exist including 1) gas-phase chemistry and particles (total of 60 compounds), 2) mercury chemistry, 3) persistent organic pollutants (POPs), and 4) a CO₂ version applicable for assessing the carbon balance over Europe in compliance with the Kyoto protocol.

The NERI modeling research team (8 scientists, 3 Ph.D. and 2 Master students) has expertise in modeling, meteorology, physics, mathematics, atmospheric chemistry, numerical methods and computer sciences. In the view of the Panel, the size of the team is appropriate in relation to its activities.

In addition, the model team has during the years shown a high production of publications in reviewed scientific journals with high impact and has a highly active participation in international relevant conferences.

Particles

It is the Panel's impression that NERI conducts advanced particle studies of size distribution and chemical composition leading to source apportionment and development of modeling tools for assessment of particle exposure of the population. Measurements of size distributions are carried out using advanced techniques like DMPS and high volume impactor samplers. The chemical analyses comprises inorganic as well as some organic components (in different size fractions). The field studies of particles are carried out in close connection with the monitoring activities. NERI has developed techniques for source-receptor modeling and inverse modeling for determination of emission factors especially for the actual car fleet. The Institute has also implemented particles in models on scales from regional scale, urban background and down to street scale.

The particle group consists of 4 scientists, 2 Ph.D. students and 2 technicians.

The Panel appreciates that many papers in international and conference contributions have been prepared. In addition, reports were prepared for the decision-makers, i.e. ministries and local authorities.

Human health

Human health is a major issue in relation to air pollution. The Panel realizes that NERI does not

have responsibility for expertise on human health studies, but acknowledges its close co-operation with health experts at the universities in Copenhagen, Århus and Odense. A number of joint projects has been initiated, to ensure that air pollution studies is relevant to and co-ordinated with the studies of the effects of air pollution on human health.

In addition, NERI has for the last decade developed a very high expertise on assessment of human exposure to air pollution. This expertise includes the development and application of state-of-the-art geographical information system (GIS) based model systems for assessment of human exposure to air pollution with emphasis on pollution from traffic. This area is strongly linked to the research on atmospheric particles in the department. Currently NERI's exposure models are being applied for assessment of exposure of a number of cohorts in historical and ongoing epidemiological studies in Denmark for the assessment of possible links between health outcomes e.g. cancer, cardiovascular illnesses and various airway diseases.

The funding of the exposure assessments are ensured to the end of 2004, but a number of applications are either submitted or in process of being submitted for e.g. the Danish research councils, but also for the health effects institute (HEI) in the U.S. So far, the work has mainly obtained national funding but in the Panel's view, the group has the strength to take a significant position in European research in this area and funding from EU and eventually the American HEI should be a possibility for the group.

The work includes analysis of the appropriateness of monitoring data for exposure assessment, personal exposure monitoring as well as development and application of human exposure models. For the latter, NERI has developed a unique GIS based system for generating needed input parameters for calculations with state-of-the-art models for urban and street scale air pollution. The models can perform calculations along routes of individuals obtained from GPS data, drawn maps and information in questionnaires. The exposure models are currently being applied in a series of Danish historical and ongoing epidemiological studies. The tools as well as current assessments of human exposure coupled to biomarkers in blood and urine (carried out by researcher at Copenhagen University) have been published in a series of peer reviewed international journal articles.

The work on exposure assessment includes a research group of 3 researchers, 1 guest researcher, and 1 Master student.

Ammonia

NERI performs field studies on dispersion, transformation and deposition of ammonia in Danish terrestrial and marine ecosystems. The Panel believes that the field studies include important process studies, including advanced measurement with low detection limit and high temporal resolution and flux measurements. Results from these studies are used together with monitoring data in the development and testing of a new advanced modeling system for assessment of the nitrogen loads in the surroundings of agricultural sources like larger pig farms.

An advanced description of the seasonal variation in ammonia emissions based on local agricultural practice has been developed and implemented into the model system. The ammonia research has

been published in several peer review papers. High resolution local area model system consists of nesting of a regional model with a local scale deposition model with resolution down to 100 m x 100 m. The model is directed towards regulatory purposes and the research area has high public and political attention.

The ammonia research area is carried out by 5 scientists and 1 student with support from technicians.

AMAP

NERI takes part in the AMAP assessments and work as directed by the Arctic Council and supported by DEPA. This involves cross-departmental work including modeling of pollutant transport scenarios to the Arctic. The Panel believes that the contribution of NERI to AMAP is very valuable.

Mercury

The Panel finds that NERI has state-of-the-art monitoring, field studies and modeling in the Arctic region. The monitoring program includes measurements of e.g. nitrogen oxides, ozone and mercury at a fixed monitoring station near Nuuk in Greenland. Until recently monitoring was carried out at station North in the north-eastern remote region of Greenland. To study the accumulation of mercury in the Arctic, NERI conducts field studies of concentrations and depositions as well as chemical reactions during polar sunrise. The field studies of governing processes have now been moved from station North to Point Barrow in Canada and are performed in close co-operation with American researchers.

The knowledge obtained from the process studies and time series is used as basis for the development of a high quality physical/chemical 3D Eulerian hemispheric model for assessment of mercury and persistent organic compounds. The research has been published in several peer reviewed international journals and NERI has taken the lead in establishing a national mercury research center.

Research on atmospheric mercury at NERI is conducted by 2 senior scientists and 1 technician.

Atmospheric loads of marine and terrestrial ecosystems

Based on data from field campaigns, analysis of time series from monitoring programs and application of transport-chemistry models, NERI assesses atmospheric loads of marine and terrestrial ecosystems. Model tools and monitoring techniques are continuously being updated when new knowledge and new techniques are available, and the Panel finds this work to be of good quality. NERI has carried out assessments of nitrogen loads to Danish terrestrial and marine ecosystems, to the entire Baltic Sea and to the entire North Sea area. Assessments of atmospheric loads have been published in a series of peer reviewed international journal articles.

This area involves 6 researchers (part time), 1 student, and several technicians.

Emission inventories group at the Department of Policy Analysis (SYS)

The emission inventory group provides regularly the official Danish emission data. This involves collection of data from many institutions, up-dating of emission factors, improvement in emission modeling, and critical evaluation. The data from the agricultural sector requires expert assessment and sophisticated treatment. In particular, the ammonia emission data were obtained by using an emission model that makes use of comprehensive and detailed information and with potential for use also in other countries.

Conclusions regarding quality and extent

Air quality monitoring and atmospheric modeling are core activities of the Atmospheric Environment Department (ATMI). The Panel has observed that the monitoring and modeling work is of high quality and is internationally recognized. In addition, the methodologies employed are considered state-of-the-art in relation to the objectives. The Panel provides some suggestions for future development (see recommendations below).

The Panel considers that ATMI's research on mercury in the Arctic is innovative, of high quality, and promises to provide a new picture of input of substances into the Arctic region. Work on ammonia is of high quality and is particularly relevant for Danish environmental issues. The street canyon model (Operational Street Pollution Model) is a benchmark for similar models in Europe. The analytical chemistry facilities are excellent. The experience gained in the analysis of pesticides could be used to study other persistent organic pollutants (e.g., fluorinated compounds) in the future.

ATMI's research on atmospheric fine particles and the methods developed at ATMI can be considered to be of high quality and leading in Europe. It would be of interest to extend such measurements to indoor environments. Exposure research work with respect to human health is very interesting; however, since NERI does not have responsibility for expertise on human health studies, the department lacks expertise in environmental medicine. The Panel believes that NERI's exposure research should be carried out in close collaboration with other institutes, and acknowledges its close co-operation with health experts at the universities in Copenhagen, Århus and Odense.

A similar statement can be made for the work on consumer products. In this case expertise in ecotoxicology is necessary and has to be provided by collaborations with external organizations. The coupling of atmospheric modeling and measurements in Greenland provides NERI with a unique capability to provide insight into global transport of air pollutants. The Panel considers that this capability could be exploited in the future. Intercontinental long-range transport of air pollution is an important emerging international research activity for the coming years.

5.2 The relevance of the research activities on atmospheric environment as a basis for Danish and international environmental policy and management

Relevance and impact

The main mission of the ATMI is to carry out research, development and monitoring at an international level, on air pollution, which add value to the objectives of the Danish and European administrative system. The relevance for policy formulation needs to be assured when research strategies are defined. The Panel has observed that the process by which relevance is assured includes regular discussions in NERI's research and management groups. The management discusses research strategies with directors of NERI, relevant agencies (e.g. the Danish Environmental Protection Agency (EPA)), local authorities, and NGOs.

NERI seems to have a proper knowledge of likely future political trends and international research activities. This information is used for internal evaluation in relation to NERI's expertise and capabilities. As most funding for research projects comes from external sources like Danish research programs and EU projects this means that most projects also undergo independent international evaluation before approval.

The core activities undertaken at ATMI appear to have high relevance and to have a significant impact on the policy formulation. They include for example the results and reports from the monitoring programs carried out by NERI which forms an important basis for government policies on regulation of air pollution in relation to EU legislation, international conventions and national action plans (e.g. the Aquatic action plan).

Besides the results from monitoring programs, models and reports, NERI have contributed to the regulation of lead and benzene in gasoline, emissions from industry and farming, and the government plan on particles. Further, NERIs models are used for regulatory purposes e.g. an OML model developed for the Danish EPA for regulatory purpose of industry in local areas. The model is also extended to handle odour problems e.g., regulation of smell from pig farms. Furthermore, the local authorities and private consultants make use of the model which is commercially available.

NERI's particle report based on the latest studies of particles and human exposure was the base for the governments new "particle plan". NERI's expertise on ammonia plays a significant role for the Danish actions towards protection of natural ecosystems against eutrophication. The department's concept of integrated monitoring has been incorporated in EU-directives on air pollution. The Panel sees the Atmospheric Department's long-term contribution to the international AMAP program as an important input to upcoming global policies for emissions reduction. The department's work with consumer products have contributed to regulation at the EU-level, e.g., contribution to EU and EPA to the regulation of phthalates in children toys and contribution to the EU Cosmetic Directive concerning regulation of fragrance material.

Mechanisms used to ensure relevance and quality

It is the Panel's view that the mechanisms employed for identifying relevant research fields can be considered as appropriate. Within the atmospheric environment field these include the continuous study of international research papers, participation in relevant conferences and discussions with colleagues throughout the world, close contact and co-operation with end-users (e.g., the Ministry of Environment, EPA, counties, cities, human health sectors, ecosystem sectors and the public).

NERI's long-term strategic planning of research is formulated in its four yearly Performance Contracts. The Atmospheric Department and the different groups within the department have formulated short- and long-term strategies covering their research fields .

One of NERI's challenges is to formulate proposals and obtain funding to support the activities identified in the long term strategic planning. The balance between research activities relevant for Danish and EU policy and externally funded research is difficult. It seems NERI has been able to achieve balance so far, but significant reductions in the basic appropriation may make this more difficult to achieve in the future.

NERI's research strategies and plans are periodically adjusted according to the priorities in the Danish environmental policy and regulation. The Panel finds that the strategies are properly based on, and closely connected to, the monitoring programs, both with respect to identifying new research areas, to support existing strategies and specific projects, and with respect to developing new methods and technologies combining measurements and modelling. In addition, the research, monitoring and advisory activities seem to be closely integrated and the same scientific staff is typically involved in all three activities. Most of the research work (e.g., mercury in the Arctic, particles, ammonia, model development, air quality forecasting, model integration, management and assessment of air quality) is closely coupled with the monitoring programs. NERI has thus shown a sound capability to adjust strategic research planning and goals to comply with new actions and new priorities in the Danish environmental policy and regulation.

However, the Evaluation Panel is of the opinion that the research activities in relation to monitoring could be further strengthened. Of particular importance is the ability to be in the forefront with respect to developing new techniques and methods, which in the future can improve the basis for policy formulation in the atmospheric environment field. NERI has, however, proven such capabilities in the field of particulate matter measurements, ammonia and of mercury deposition in the Arctic. It is the Panel's view that the initiation of VOC measurements would strengthen NERI's capabilities in this field further.

It is the impression of the Panel that the Atmospheric Environment Department performs internal reviews to ensure quality control in the project design phase, including the phase of deciding on or selecting projects. In most projects funded by the EU, the EPA and others, periodic reporting and reviewing are being made. Project selection and planning are carried out in close co-operation between the individual scientists, the research groups and the overall management. The Panel considers these measures to be appropriate.

Furthermore, the Panel considers NERI's research pro-active in addressing short- and long-term

trends in the effects and consequences of air pollution and new knowledge of problems in atmospheric environment. NERI has however no systematic procedure for ensuring this..

To a large extent, it is a basic assignment of NERI to address the trends in the fields of e.g. exposure on human health, marine and terrestrial ecosystems, information and warning of the authorities and the public. NERI also has a responsibility to address problems and trends within the area of global change. NERI does however not include climate models in the strategic research, but it is pro-active in addressing effects of global change on the atmospheric environment and vice versa with respect to environmental, societal and political trends.

Data analysis, synthesis and dissemination

Results from the monitoring and modelling activities are reported and synthesised in quarterly and annual reports and both original data as well as processed information is made available on the Internet. NERI operates a public forecasting system of 3-day air quality forecasts at regional scale for 60 chemical compounds (including ozone and nitrogen-dioxides) and at urban background scale and urban street scale for ozone, nitrogen dioxides, carbon monoxide, and benzene. NERI is at the moment including particles in the forecast system and is furthermore working on obtaining funding for establishing a pollen forecast system applicable for people with asthma. The Panel finds that the modelling systems operated for these purposes are state-of-the-art and provide a very good and user-friendly interface for the general public. It is the Panels view that the services provided by NERI in this field is of great societal value.

Conclusions regarding relevance

In order to continuously ensure the relevance of the research, the Panel has the following specific recommendations to the Atmospheric Environment Department (ATMI):

- Increase research related to the monitoring program, with the aim to maintain and further develop the analytical capabilities and competence on advanced measurement techniques.
- To complement the existing atmospheric monitoring efforts and obtain a more complete understanding of polluted air masses it is strongly suggested to include VOC-measurement (including biogenics) in the network. Inclusion of VOC data (besides BTEX) will facilitate testing modeling results, provide information concerning emission reductions, and serve to evaluation of emission inventories. VOC data are also of importance to estimate the formation of secondary organic aerosols (SOA). The organic laboratory of ATMI offers an excellent possibility for VOC measurements.
- To strengthen the process understanding within the modeling and interpretation of the model results requires deeper knowledge of the chemistry in the model. Information concerning updated chemical mechanisms can be obtained through co-operation with an institution having competence in physical chemistry.
- Study global transport of air pollutants using the monitoring and modeling facilities of ATMI associated with their facilities in Greenland.

- Expand monitoring and modeling efforts associated with fine particles to indoor environments.
- Strengthen the research in relation to chemical composition of particulate matter (i.e. on the organic composition).
- NERI provides extensive exposure assessment data in regard to key pollutants in various media (particularly air and water). This information may be used for risk assessment purposes and for observational studies of the environmental impacts of the pollutants. However, because NERI focuses on the descriptive data and has limited capacity in toxicology and no epidemiological expertise, the use of these highly valuable data is hampered. It is recommended that NERI seek formal, long-term collaboration with institutions that can provide toxicology and epidemiological expertise.

In addition, the Panel recommends the Policy Analysis Department to put more effort in the task to obtain special VOC emission data, in particular from non-traffic sources. VOC emissions from the biosphere, though considered of low importance for photo-oxidant formation in Denmark, should be included in the inventory because of their potential to form organic aerosols (SOA).

5.3 The performance regarding the atmospheric environment in relation to the tasks laid down in the performance contract 2000-2003 and the government order

According to NERI's own assessments, 96% of the performance contracts goals will be met. The only problem is related to goal nr. 83, i.e. it has not been possible to establish scenarios of emissions, which take into account cleaner technology. This is also related to the reduced ambition regarding System Analysis on Industry and the Environment following budget restraints in 2001.

The Panel has observed that the monitoring programs have been carried out as planned and the knowledge and expertise have been updated and maintained. Information to the public has been considerably upgraded during the contract period and real time data from the monitoring programmes are available on both text TV and the Internet together with three-day forecast of air pollution from European to street level. An integrated system for policy analyses for use in assessing effects of reduction in emissions in Europe (the THOR-system) has been established. European co-operation has been extended through several EU-projects, technical assistance has been delivered to e.g. Romania and Latvia.

In addition, the planned pesticide activities appear to have been carried out and recommendation for including pesticides in NOVANA has been made. Considerable efforts and resources have been used on particle studies, human exposure and health effects financed by new research programmes (SMP) and special government funding. New knowledge has been acquired with the EU air/sea exchange projects on the significance of aerosols and particles for air/sea exchange in collaboration with Risø and European partners. The commitments with respect to the AMAP program has been carried out in accordance with the Performance Contract. A new monitoring site has been established on Greenland's west coast, close to Nuuk, replacing the previous site at Station Nord.

The Panel also finds that the goals on identification and quantification of source areas and atmospheric transport routes as well as the required modeling results have all been reached.

Furthermore, the obligations towards the Danish EPA in relation to the Chemical Substance and Products Act as well as the control campaigns on active ingredient and additives in pesticide products have been fulfilled. Knowledge building and models to predict the risk of introgression and invasivity of GMOs have been achieved.

From the documentation and information provided, we consider the fulfillment of the Performance Contract goals to be very satisfactory.

5.4 National and international collaboration with universities and other research institutes in the field of atmospheric environment

The Panel finds that the internal co-operation within NERI in the field of Atmospheric Environment is comprehensive and includes interaction Between the Atmospheric and the Policy Departments on emissions inventories and economical analysis. The Atmospheric Department also collaborates closely with the Department of Marine Ecology (MAR) on the development of and integration of sea and air pollution model for e.g. eutrophication of Danish waters, with the Terrestrial Environment Department (TERI) on the effects of nature, deposition of ammonia and spreading of GMOs, and with the Department of Arctic Environment (AM) in relation to mercury and persistent organic pollutants (POPs). These activities feed into the common NERI strategy on cycle of air pollution from sources to natural and human recipients.

The Panel has observed that NERI has a broad national and international co-operation with universities, research institutes, and public and private institutions. Nationally, the Atmospheric Department collaborates with a large number of other national research institutes, universities and several Ph.D. schools. Two scientists at ATMI hold external professorships, and ATMI actively recruits Ph.D. and Master students. ATMI also regularly hosts visiting scientist and foreign students for shorter or longer periods. NERI is also directly involved in several international conventions and EU bodies (e.g. CLRTAP, HELCOM, IPCC, AMAP, CAFÉ and others).

The extent and relevance of the collaborations in which NERI is involved is considered by the Panel to be very satisfactory.

5.5 General observations and recommendations concerning the atmospheric research at NERI

The Panel has the following general observations as regards the research in the Atmospheric Environment field undertaken by the Atmospheric and the Policy Department (ATMI and SYS):

- It is the Panel's view that the extent and quality of the scientific work, as well as its

relevance and impact in relation to policy formulation can be considered as very good.

- The Panel is impressed with the research expertise in the fields of integrated monitoring, its modeling activities and its research on mercury in the Arctic and on ammonia in Denmark.
- Of particular importance is the ability to be in the forefront with respect to developing new techniques and methods, which in the future can improve the basis for policy formulation in the atmospheric environment field. NERI has proven such capabilities in the fields of particulate matter measurements, ammonia and of mercury deposition in the Arctic, but this kind of research activities could be strengthened further within other of NERI's research topics.
- The Panel is also impressed with the dissemination of results from its monitoring and modeling activities combining state-of-the-art science and user-friendly interface for the general public (Internet etc.).
- The work obviously benefits from good internal collaboration as well as a large external scientific network and participation in relevant bodies and organizations, nationally as well as internationally.
- NERI has been active in connection with development of the EU ambient air quality directives, but at present, NERI only has little impact on the future European strategy, although it holds valuable expertise in this area.

Based on its evaluation, the Panel has the following general recommendations to NERI's research within the atmospheric competence area:

- The Panel notes a need to maintain and further strengthen research activities in relation to the monitoring activities, in particular with respect to developing new monitoring techniques and methods, in order to be in the forefront with respect to analytical and measurement capabilities. It is the Panel's view that the initiation of VOC measurements would strengthen NERI's capabilities in this field further.
- The Panel recommends to maintain and further strengthen the scientific quality and production through publication in peer reviewed literature.
- The Panel recommends that NERI priorities and strengthens further co-operation with the EU in relation to air pollution.

6. NERI's activities concerning the aquatic environment. Assessments and recommendations

This chapter concerns the Panel's assessments and recommendations as regards NERI's activities within the Aquatic Environment Competence Area. The activities in this area are carried out by two of the largest programs at NERI, the Department of Marine Ecology (MAR) and the Department of Freshwater Ecology (FEVØ), and the much smaller, newer marine mammals sub-component of the Department of Arctic Environment (AM).

6.1 Extent and scientific quality of the research and its national and international position and impact

It is the impression of the Panel that the large Marine Ecology and Freshwater Ecology Departments undertake a broad range of research in support of their environmental monitoring and synthesis functions. Both departments carry out research of a type that can be categorized as systems ecology. The research is characterized by the effort to understand the whole system by identifying the components and studying the most critical interactions. Research in the Freshwater Ecology area follows the traditional effective division according to hydrological function (catchment area, stream/river, riparian zone, lake, etc.). Marine Ecology Department ecology follows a traditional mixed subdivision based upon hydrology (inshore, fjord, estuary, offshore, etc.) and ecological subdivisions (nekton, plankton, benthos, etc.). Effective systems ecology can be very broad since new understanding requires frequent revision of the components and interaction under study. Such breadth and change are indications of high quality, effective research. The Panel finds that NERI programs show such quality and breadth. The Panel also finds that the smaller marine mammal component of the Arctic Department is new, but has made an effective start on projects directed at Danish waters.

Marine and freshwater ecology

The Freshwater Ecology Department's scientific activities can be grouped into the following five main areas:

- Integrated catchment management
- Impact of land use on streams and riparian areas
- Eutrophication of freshwater ecology and brackish lakes
- Presence and effects of xenobiotics (manmade compounds exhibiting biotic activities) in freshwater ecosystems
- Impact of climatic change on freshwater ecosystems

The Marine Ecology Department's scientific activities can be grouped into the following four main areas:

- Biogeochemical cycles and organic matter dynamics in the water column.
- Benthic communities and biogeochemical processes.
- Presence and effects of xenobiotics in marine systems.
- Impact of climate change on marine ecosystems.

The Panel finds that the number of high quality projects is consistent with the staff sizes of the two departments. At the time of the review, Freshwater Ecology had a total of 45 research projects and Marine Ecology Department had 61. Most projects for both departments focus upon the continental Danish environment and Greenland. Both departments participate in European and other international research applying NERI expertise to analogous and contrasting ecosystems.

The Panel finds that evidence of NERI's present quality can be found in staff expertise and active research nationally and internationally recognised as on the cutting edge of science. The Panel finds that long-term research quality is reflected in several criteria. Citation by fellow scientists provides a good indication of the usefulness of the ideas generated, but is a criterion that becomes most reliable after several years of productivity.

The Panel finds that Freshwater Ecology and Marine Ecology Department have impressive publication records indicating that their research compares very favorably to university-based programmes. Both publish in high quality international journals. Between 1998 and 2002, Freshwater Ecology published at a rate of 1.7 publications per researcher per year. Marine Ecology Department published at a rate of 1.2 for the same period. Much of the difference was due to the exceptional productivity of the lake ecology program. The citation rate for publications from both departments was greater than expected according to an ISI conducted study. The Panel commends both departments for this record.

The Panel finds that scientific staff of both departments consists of effective, highly qualified senior and young researchers. The Marine Ecology Department is distinguished by a staff mixture that is based in science but includes applied statistical and environmental policy experts. Freshwater Ecology staff reflects a combination of a scientific personnel and senior consultants that participate in a science advisory and policy related function.

The Panel finds that Freshwater Ecology has an appropriate mix of staff expertise. The Department co-ordinates closely with County programs for monitoring data. The resulting large databases containing data from the national monitoring programme are managed by the department's IT and GIS employees. The national monitoring programme, which was initiated in 1989, will from 2003 include chemical and biological data from more than 1,000 streams and 700 lakes in Denmark. Analysis of data and development of models rely in part on the skills of the department's senior statistician and a newly employed senior modeller. The Freshwater Ecology department's expertise is strengthened by wide-ranging co-operation with strong research groups from all over the world and the close co-operation with local and national water authorities.

The Panel finds that the Marine Ecology Department has an appropriate mix of staff expertise. The department is responsible for the national marine database – MADS. The Marine Ecology Department actively collects monitoring data beyond the responsibilities of county programs. Data

collected within the national Marine Ecology Department monitoring program as well as data from regional monitoring programs and research projects are stored in the national database for Marine Ecology Department Data (MADS). Two Marine Ecology Department academics are responsible for the daily management and quality of MADS operations.

Future plans on marine and freshwater ecology

Both large departments have identified gaps in their research activity relative to their perceived environmental needs of Denmark.

Freshwater Ecology has effectively identified three areas in which to increase future emphasis: (i) Greater activity in effects of climatic changes on land use and Freshwater Ecology ecosystems, (ii) Biocomplexity in streams and riparian areas, and (iii) Rehabilitation.

The Panel agrees with the Freshwater Ecology Department's assessment that the results of climate changes will expectedly have a significant influence on both the hydrological cycle, as well as on the transport of nutrients and dissolved organic matter to groundwater, streams, lakes and fjords. Also temperature-conditioned changes in biological communities and interactions will occur. Climate scenarios predict increased nutrient runoff in Denmark. The trophic structure and function of streams, lakes and fjords will change in response to this increased runoff of nutrients and dissolved phosphorus and increased temperatures. Scenario predictions reveal that climate changes will counteract or neutralise the actions taken so far to improve the environmental state of the aquatic environment via the nation-wide action plans.

The Marine Ecology Department has identified four areas for increased emphasis: (i) the transport and effects of contaminants on marine organisms, (ii) research in fish ecology which is not covered by other organizations, (iii) interactions between cell research and individual species in relation, (iv) research in microbial decomposition and phytoplankton assimilation of organic nitrogen, to obtain a more accurate estimate of bio-available nitrogen. This strengthened focus follows from the recent Marine Eutrophication review.

The Panel finds that Marine Ecology's plans are well justified, but very broad and ambitious. It will be hard to maintain the current high level of quality across an increasingly broad systems integration. Consideration must be given to setting priorities and, as suggested by the Marine Ecology Department, to carrying out some research in collaboration with other institutions rather than hiring additional NERI staff.

Marine Mammals

The Panel finds that the marine mammal working group is correct in considering itself as having an internationally leading position with regard to satellite tracking of small cetaceans and seals; new methods and instruments for detailed positioning and dive depth recordings are developed with industry. Tracking combined with genetic analyses have provided new insight to the migration, site use and population deliniation of harbour porpoises and seals.

NERI has developed a concept for offshore environmental impact assessment with regard to marine mammals (by means of a combination of visual, camera and web based surveys and acoustic detection of porpoise activity). The new methods are currently tested in two Danish demonstration wind farm projects and further developed in a project in the Netherlands.

The staff of the marine mammal working group is composed of all biologists: 1 senior researcher, 1 researcher, 2 research assistants, 1 Ph.D. student and 3 M.Sc. student projects in 2003. Staff members regularly give contributions to international conferences or symposia in their specific field. Statistical advice is provided by the Marine Ecology Department. GIS-analyses are made by staff members and by external consultants. The Group currently lacks spatial modelling expertise (see also the input from the Dept. of Arctic Environment).

Monitoring of progress of project work is done by regularly keeping track of milestones and deadline of outputs in the annual work programme, regular follow-up meetings between the director of department and project groups (at approximately 3-monthly intervals) and annual personal interviews. The marine mammal working group is scientifically young (work started in 2000) and, hence, has not yet a long publication record. So far, mainly project reports have been produced, but scientific papers are now emerging, and a very promising list of manuscripts appears to be in the pipeline.

It is the group's ambition to further strengthen the work with regard to spatial modelling with the aim to be better able to identify critical habitats and areas and with regard to monitoring techniques for small cetaceans. The Panel supports this aspiration.

The Panel finds the working group strong in:

- Application of new technologies in tracking of Marine mammals.
- Developing new techniques for survey of Marine mammals by visual and acoustic means.
- Developing environmental impact assessment for Marine mammals

Currently, the Panel considers it a deficiency that the group does not have sufficient expertise to analyse and model spatial and population data. The Working Group only has external funding presently which makes the research strategy vulnerable.

6.2 The relevance of the research activities on aquatic environment as a basis for Danish and international environmental policy and management

The Panel found that both the Marine Ecology and Freshwater Ecology Departments have effective means of assuring the relevance of research and monitoring activities to Danish and international environmental policy. The two departments operate somewhat differently. Freshwater Ecology takes greater advantage of its close interaction with the counties, while Marine Ecology interacts more with government agencies. Both collaborations appear effective to the Panel. At the EU level, two directives are viewed by the Panel as being especially important in directing activities for

both departments, the Water Framework Directive and the Habitat Directive.

Marine Ecology

In the Marine Ecology Department the Panel sees a clear and well-defined coupling between the relevant actors. The mechanism is a strong dialogue between the Ministry of Environment, activities in the international conventions (HELCOM, OSPAR, ICES), the international directives (Nitrate Directive, Biocide Directive, Habitat Directive and Water Framework Directive), EEA, the national action plans, work on governmental committees and regional and local activities.

In addition, the ongoing and future strategic research activities in the Marine Ecology Department provide a strong foundation to manage and improve NOVANA activities for the next 6 years. The revised NOVANA programme, to be launched in January 2004, represents a comprehensive integration of the Marine Ecology Department's research and monitoring activities. Effective interaction with the counties is through NERI's Marine Topic Centre. The counties are responsible for the inshore part of the marine monitoring and assessment programme.

The Panel finds that appropriate evaluation of the methods, some derived by NERI, are applied into the monitoring activities. All methods for sampling and analysis are described in the "Technical Guidelines", in accordance with the methods agreed within HELCOM, OSPAR and ICES. The guidelines include description of quality control procedures. There is clear documentation in refereed journals before methods and approaches are included in the monitoring programme.

The Panel assesses that the Marine Ecology Department staff maintain appropriate levels of participation in working groups, workshops, and conferences. Results from research and monitoring activities represent an important part of Marine Ecology Department's teaching activities at the Danish Universities.

The Panel also finds that there is an effective feedback among advisory, monitoring and research. Strong evidence of this is the incorporation of monitoring data in 15% of recent peer-reviewed publications. The coupling between research and monitoring has been a fundamental issue in the Marine Ecology Department's strategic plan since 1996. During the period 1998 to 2003, there have been a number of activities demonstrating a mutual exchange of knowledge between the research activities and the Marine Ecology Department monitoring and assessment programme. Specific examples are: increasing incorporation of monitoring data in scientific publication, carrying out of research within EU directives, and educational dissemination through the international research school, the "Center for Research and Monitoring of the Marine Environment" which has been established for European Ph.D. students.

The opinion was expressed by the Marine Ecology Department that the overall balance among monitoring, advisory, research, and education is inappropriate under the current budget situation. The advisory function to authorities and the political system is seen as being undervalued. Rather, too much emphasis is placed on collecting data and too little time to analyse and synthesise the data into conclusions that are operational for management purposes. The Panel can only partially agree to these views.

The Marine Ecology Department is to be complimented in its staffing choice to add statistical/modelling efforts and the addition of a policy expert. This represents a confidence in Marine Ecology Department's existing and developing ecosystem models and the conviction that they are now ready to be increasingly applied to public needs. The Panel is aware, though, that this balance may not be appropriate for other NERI departments.

The Panel was advised that the Marine Ecology Department is currently optimizing its reporting on the occurrence and distribution of harmful algae and periods and areas with oxygen deficit. Specific plans are in operation for this optimization. In addition the following activities will be integrated in the work: (1) the role and potential effects of invasive species when relevant, (2) effects of oil spills and other uncontrolled accidents, (3) harmful algae in relation to shellfish production and aquaculture. The Panel feels that these are appropriate steps and are consistent with the recommendations of the recent Marine Eutrophication Review.

Freshwater Ecology

In Freshwater Ecology there is a clear and well-defined coupling between the relevant actors. The Panel commends the strong synergy obtained during the last 15 years between research, management and planning due to unique co-operation between the department and the Danish regional authorities (counties). The Danish Counties are largely responsible for the regional monitoring and planning. Mutual benefits are obtained through many joint projects and workshops that ensure fast transfer of research knowledge from strategic science to local authorities. In return the department benefits from data exchange, field information, and experience. Due to NERI's combination of monitoring and research, the department has facilitated information exchange between university researchers and the managers in the authorities.

The Freshwater Ecology department was the responsible partner for the preparation and evaluation of the Governmental Action Plan II and is now deeply involved in the preparation of the Governmental Action Plan III. The department has also contributed to the Governmental Action Plan on Pesticides. The need for relevant tools for implementing EU directives (the Water Framework Directive, the Habitat Directive) has generated new research projects in NERI at both national and EU level.

Furthermore the Panel considers that the Freshwater Ecology staff maintain appropriate levels of participation in working groups, workshops, and conferences. Results from research and monitoring activities represent an important part of Freshwater Ecology's teaching activities at the Danish Universities.

The Panel finds that there is an effective feedback among advisory activities, monitoring and research. Strong evidence of this is the incorporation of monitoring data in about 50% of recent peer-reviewed publications. The synergy between monitoring and research has yielded extremely successful results. New knowledge achieved from research projects has been implemented successively in the monitoring programmes. The coming stream and riparian area monitoring programme will include a suite of new biological elements. The programme changes made are

based on the department's research and the new monitoring programme will provide an unprecedented opportunity, within a Danish context, to test hypotheses on a large number of stream sites covering a range of spatio-temporal scales. The monitoring programme is based on state-of-the-art methods and complies with the demands of the Water Framework Directive.

The Department's research and monitoring activities are very closely linked and cross-fertilise each other, this facilitating research projects to arise, for example from a gap of knowledge becoming evident in the monitoring results, and scientific project results may thus improve the monitoring strategy. Research projects are also initiated according to the departmental strategic plans and international initiatives within the fields covered. Project proposals are, prior to initiation, reviewed by a scientific committee of key scientific personnel and the Director of Research. Specific examples are: increasing incorporation of monitoring data in scientific publication, carrying out of research within EU directives, and educational dissemination through SOAS (School of Aquatic Sciences) University Aarhus established for Danish and international Ph.D. students.

During the evaluation the Freshwater Ecology Department expressed concern that the present balance of activities resulted in too much time being allocated to proposal applications writing, due to the need to carry out too many short-term projects of limited scientific scope. Such a limited allocation of time is creating stress among staff members due to the current funding constraints. The department strategy aims at focusing also on new environmental problems and the strategy has been revised to meet the challenges of changes in climate and agricultural practices that are likely to strongly influence the Danish freshwater ecosystems in the future. The Panel found this strategy was carefully planned and is appropriate for the Freshwater Ecology Department.

Marine Mammals

The programmes funded by the wind farm electricity companies are selected and evaluated by an independent Board and by an international scientific Evaluation Panel. NERI has no influence on that process. Projects are evaluated at an annual basis. In the marine mammals group relevant research ideas are discussed and developed at annual strategy seminars and within the working group. The monitoring of marine mammals is part of the NOVANA programme. The development of new survey techniques is seen by the Panel to be beneficial to the group's planning of future monitoring. Furthermore, the current impact assessment work is beneficial for the advice provided to the National Forest and Nature Agency.

The group's quality control on wind farm projects is taken care of by an independent Advisory Board. Internally in the Department of Arctic Environment (AM) quality control in the strategy phase is dealt with at strategy seminars, work plan meetings. Ad hoc proposals are discussed in a dialogue between project proposers and the director of department. Projects are prioritised according to the NERI strategy and AM strategy. All projects are approved by the director of department. At the current level of activity this is considered appropriate by the Panel.

The development of new survey techniques are used in the planning of the national and international marine mammal surveys. The most important feedback comes from the creation of time series which can be used for time series analyses, analyses of seasonal or geographic

variability, input to modelling etc. Members of the working group are official scientific advisers to the Danish Forest and Nature Agency regarding national and international management and conservation of marine mammals. The group is currently involved in the preparation of designation of offshore areas of special conservation interest. Monitoring data on seals is used by the group in scientific publications, e.g., to describe the impact of the mass death of seals which took place in 2002.

6.3 The performance regarding the aquatic environment in relation to the tasks laid down in the performance contract 2000-2003 and the government order

According to NERI's own assessment, 79% of the Performance Contract (PC) goals in the 2000-2003 Aquatic Competence area will be met, 15% are uncertain, and 6% are given up as unobtainable. NERI has specified that delays have been encountered in the objectives of finalizing development of indicators of aquatic environmental quality (goals 31, 34, and 36). Natural complexity of Freshwater Ecology systems has prevented identification of simple summary indicators. Other goals which have not been fully met concern modelling of highly complex aquatic systems (goals 22,26,34, and 42).

The Panel finds that NERI's overall meeting of the PC-goals in this area is highly satisfactory, especially given the recent budget reductions. Difficulties in dealing with complex systems are to be expected, and are common in advanced ecosystems research.

6.4 National and international collaboration with universities and other research institutes

The Panel finds that the Marine Ecology and Freshwater Ecology departments are heavily involved in national and international collaboration. This level of collaboration greatly benefits NERI and Danish environmental science through inclusion of international experts (often at little cost) in the Danish research community. It also reinforces the Panel's finding that both departments contain international centers of excellence.

Marine Ecology

The majority of the national research projects are carried out together with scientists from the universities, government research institutes (Geological Survey of Denmark and Greenland, Danish Institute for Fisheries Research), private research institutes (DHI Water & Environment), counties, Danish Meteorological Institute and with other NERI departments. The collaboration with the Danish universities also includes teaching and supervising Master and PhD students.

NERI's 15 ongoing EU contracts within the Aquatic Competence area include collaboration with a large number of European universities and research institutes. In addition, a number of research

subjects are carried out in collaboration with a substantial number of international universities and research institutes. Examples of particular importance are: Greenland and Canadian Arctic research, intensive joint research (US, Germany, Sweden, New Zealand, and Australia) modelling sediment processes, fate and effects of dissolved organic matter (Canada, US, Sweden, France, UK, and New Zealand), nutrient budgets (US, France, Norway, Spain, and Finland), and nitrogen cycling (Costa Rica, U.S.A., and Holland).

The importance of the international collaboration activities can be measured as the number of publications with contributions from international authors and as exchange of scientist from other countries and/or Marine Ecology Department scientist working in other countries. The numbers of scientific publications with foreign authors corresponded to 46% in 1998-2002. Twenty foreign scientists have been visiting investigators at the Marine Ecology Department since 1998 for periods up to one year and from countries as far away as Thailand.

Furthermore, the department is a partner of the EU "CREAM" project involving exchange of Ph.D. students between European countries. The research professor and the two external professors in the Marine Ecology Department participate in teaching and student guidance and research management at the universities of Roskilde, Aarhus and Southern Denmark.

Freshwater Ecology

Most research projects of the Department of Freshwater Ecology are undertaken in co-operation with researchers from universities and sectorial research institutes in Denmark, the EU and other international collaborators. The department participates in projects involving co-operation with more than 100 international research institutes, many linked to the EU's 5th Framework programme.

In the future, the department's co-operation on model development and catchment management will expectedly be strengthened within the frameworks of the network of the European Freshwater Ecology Organisations "EURAQUA" and the Partnership for European Environmental Research "PEER". In the view of the Panel, the recent approved EU project "REBECCA" in which the department is a key partner (development of methods in relation to the Water Framework Directive) is, a significant step forward to strengthen the co-operation between the institutions of "EURAQUA".

The co-operation on xenobiotics in Freshwater Ecology environments involves the universities of Odense and Copenhagen, DHI and NERI's departments of Terrestrial Ecology, Atmospheric Environment and Policy Analysis. The department is a partner of the EU "CREAM" project involving exchange of PhD students between European countries.

In 2003, the department hosts 5 long-term visiting junior and senior researchers, staying in total 19 months. In addition, 11 researchers have been on short-term visits in 2003. Apparently, the department is highly attractive, as the majority of visiting researchers are paid by their home countries. The numbers of visiting researchers on longer stay is growing and is expected by NERI to increase further in the future.

The senior scientists are frequently invited to perform as keynote speakers at international conferences and are lecturing at universities in Europe, USA, Canada, South America, China and Japan. The scientists participate with oral and poster contributions at numerous international conferences.

The research professor of the department participates in the teaching, student guidance and research management at Aarhus University and has been the originator of several joint research projects. In addition, he is frequently lecturing at universities in Europe, USA and South America. The department is one of the partners of "ALFA" – a European-South American co-operation on the education of PhD students.

During the past 6 years, one of the department's senior scientists has functioned as external lecturer on stream ecology at the University of Aarhus. Several NERI researchers are teaching at Aarhus University and Copenhagen University in Denmark, and at Lund University in Sweden.

The department's researchers function as tutors for M.Sc. and Ph.D. students and act as external examiners at all Danish universities. Four Ph.D. theses were awarded in 2003 to students who have worked at NERI and 4 new Ph.D. studies have been initiated in 2003. In 2002, 9 NERI associated M.Sc.s graduated and the department has 15 M.Sc. students in 2003.

The director of the Department of Freshwater Ecology is member of the board and the executive committee of the "SOAS" research school (School of Aquatic Sciences). SOAS was founded in 2001 and Freshwater Ecology is one of the external partners in the collaboration with the universities of Aarhus and Southern Denmark and the Danish Institute for Fisheries Research (DIFRES).

The Department has taken many initiatives to conferences and workshop in the past, including the initiation of the now recurrent conference on shallow lakes. In 2003, the department has and will organise four international workshops. Two special volumes of international journals (Freshwater Biology and Hydrobiologia) will be the outcome of these activities. Leading researchers from all over the world have accepted the invitations, thus demonstrating a strong scientific interest in co-operating with the Department.

Marine Mammals

The group carries out collaborative projects with almost all the other single scientists at other institutes in Denmark. On the international scene, collaborative projects are carried out with research institutions in Sweden, Germany and The Netherlands. Currently, the group participates in the planning of a North European survey of small cetaceans in cooperation with all North Sea range states. Group members are also involved in Marine mammal research in Greenland and have a wide network of collaborators in Greenland, Canada, Norway and USA. Four M.Sc. projects connected to the group have been carried out during 2000-2003. Members of staff act as external examiners in connection with M.Sc. and Ph.D. theses defences.

On the basis of the above activities the Panel finds collaborative activities to be impressive across the full range of aquatic studies at NERI.

6.5 General observations and recommendations concerning the aquatic research at NERI

The Panel has the following general observations on NERI's activities concerned with aquatic environment:

- The Marine Ecology and Freshwater Ecology Departments have developed effective programs of advisory and monitoring and research activities, and they undertake a broad range of research in support of their monitoring and synthesis functions, characterised by the effort to understand the whole systems by identifying the components and studying the most critical interactions.
- The Marine Mammals group is new and small, but has nevertheless an internationally leading position within a number of research topics, including new techniques for tracking and survey of marine mammals, and development of environmental impact assessments for marine mammals.
- It is a deficiency of the Marine Mammals group that it does not have sufficient expertise to analyse and model spatial and population data.
- The groups within the aquatic environment field contribute well to education through inclusion of graduate students in projects and teaching at Danish universities.
- Their transmission of results to the scientific community, the public, and policy organizations is presently effective and is rightly considered a high priority.
- Evidence of NERI's present quality can be found in staff expertise and active research nationally and internationally recognised as on the cutting edge of science. The high quality and effectiveness of these departments should be maintained.
- The aquatic competence area at NERI contains centers of scientific excellence. Shallow-lake research and nutrient/organic matter dynamics in coastal zones are primary examples. Other research components may not have reached similar levels but are of high quality and can be expected to increase in prestige unless hampered by budget reductions.
- The Panel sought guidance from the recently completed and favorable international review in Marine Eutrophication. It was reassured to find that recommendations had been well received and appropriate actions taken.
- Aquatic activities at NERI are highly responsive to Danish needs and scientific advances.

They have developed appropriate strategies that increase program breadth. Although intended to maintain balance through increased external funding, national and international decline in available funds may negate these plans and cause a decrease in effectiveness.

- Activities in the Departments are also responding to scientific trends that emphasize research along disciplinary boundaries (cross-cutting research). Addition of staff to pursue such topics or to carry out such research within NERI are hindered by a lack of funds. EU requirements for inter-European collaboration may also act to weaken internal cooperation within NERI.
- Both of the major departments have been forced to adjust staff and program balance through recent reorganizations

The Panel makes the following recommendations based on its evaluation:

- The Marine Ecology and Freshwater Ecology Departments have adopted two primary criteria for quality: peer reviewed publication and effectiveness in winning external funding. Faced with budgetary threat to overall effectiveness, these same criteria should continue to be applied to maintain the present level of quality.
- The Marine Ecology and Freshwater Ecology Departments have survived and remained effective through re-organizations and budget reductions by ad hoc changes of staff and program balance. It is the view of the Panel that both departments would benefit from increased use of long-term planned and reviewed programme strategies approved at Institute level. In this connection, consideration should be given to setting priorities and further carrying out research in collaboration with other institutions rather than hiring additional staff in NERI.
- The Panel recommends that marine mammal research be carried out in coordination with the systems ecology modelling being conducted by the Marine Ecology Department such that expertise need not be duplicated.

7. NERI's activities concerning the terrestrial environment. Assessments and recommendations

This chapter presents the Panel's assessments and recommendations as regards NERI's activities within the Terrestrial Environment Competence Area. The activities in this area are carried out by the Department of Terrestrial Ecology (TERI), the Department of Environmental Chemistry and Microbiology (MIMI), the Department of Wildlife Ecology and Biodiversity (VIBI) and the Department of Arctic Environment (AM).

7.1 Extent and scientific quality of the research in the field of terrestrial environment and its national and international position and impact

Department of Terrestrial Ecology (TERI)

The Department of Terrestrial Ecology comprises 36 permanent staff members at the time of evaluation. The research programme covers a great variety of issues, all related to soil/plant/invertebrate interactions. The Panel recognises the unique expertise in soil ecotoxicology, which is well established at the European level. There are strong collaborative links with many other European groups as well as outside Europe. Two areas of current research that showed clear evidence of excellence particularly impressed the panel. These are (1) risk assessment of genetically modified plants, (2) soil fauna ecotoxicology and ecophysiology.

The Panel finds that the work on genetically modified plants (GMPs) is unique because of the combination of risk assessment and greenhouse experiments. TERI has facilities for doing both laboratory and greenhouse studies. The strength is on applied ecology, mathematical modelling and the development of new concepts and methods for ecological risk assessment of GMPs. The focus is on closing gaps of knowledge in relation to the EU Directive 2000/18 on deliberate release of genetically modified organisms in the environment. The work supports the Danish Forest and Nature Agency in the regulation of GMPs, and the results have been used extensively in EU-round table discussions, and in an EU working group on herbicide tolerant plants.

In terrestrial ecology, the Panel recognises that the work on cold and drought stress and the interaction with chemical stress is of outstanding quality. In this field, the research team has developed a series of test methods for the laboratory, and keeps cultures of indigenous soil animals from Denmark and the Arctic. Many of these protocols have been used and referred to in a number of national and international protocols and frameworks for ecological risk assessment of chemicals and contaminated soils. Within this area the laboratories work according to the OECD Good Laboratory Practice.

In the near future, the Department will be involved in a programme of systematic monitoring of terrestrial habitats and species. The Panel stresses the importance of this latter activity because it will strengthen the link between research and monitoring, which is one of the main pillars of the institute as a whole.

The academic staff of TERI comprises plant ecologists, zoologists, biochemists, a geologist and a mathematical modeller. Staff members are specialised in ecotoxicology, genetics, risk assessment and monitoring. At present, the staff consists of 1 Director, 2 heads of sections (also acting as senior scientists), 9 senior scientists, 3 senior advisors, 3 other academics, 1 scientist, 14 laboratory staff members, 3 secretaries, 4 Ph.D. students, 13 M.Sc. students, 4 visiting scientists, 1 trainee (laboratory) and 2 student assistants. The size of the Department has been stable for some years leading to a lack of recruitment of young scientists. However, 3 – 4 Ph.D. students, 10 – 15 Master students, and short-term, temporary scientific assistants compensate for the skewed age distribution of the teams.

An analysis of NERI publications shows that the number of TERI's articles mentioned in the Journal Citation Reports database (JCR) is around the average for NERI, and the Journal Impact Factor (JIF) shows an average of 1.31, slightly above the NERI average. The total number of international publications per capita for scientific academic staff is 1.79. Some publications from TERI appear in high quality international journals, such as Science, Genetics, Conservation Biology, Ecology, Oikos and Environmental Toxicology and Chemistry. The majority of TERI publications have a higher impact than the journal average. The Panel concludes that the publication output of the Department accords with expectations.

The Panel has a very good impression of the motivation and dedication of the younger staff of which a small sample was interviewed. The working atmosphere was described as very stimulating. Some of the staff felt that their performance was not optimal due to time constraints associated with finishing project work. Time reserved for writing up manuscripts for scientific publications was easily used for other purposes and this was limiting the output of some staff. Consequently, the scientific output follows a skewed distribution, some staff being very productive in terms of scientific publications, and others providing little publications. The Panel felt that this unequal distribution needs to be addressed and that an action plan needs to be designed to avoid that the scientific output becomes too much dependent on a few individual staff.

The Department members are very active in sharing results at scientific conferences. Conferences on environmental chemistry and toxicology, on soil ecology, as well as workshops on risk assessment are often visited. Staff members felt that they were given sufficient freedom to participate in national and international meetings. The conferences are seen as an important opportunity for networking and for exploring key hypotheses. It is the explicit strategy of TERI to maintain a level of expertise in research and advisory activities related to genetically modified plants, pesticides and other chemicals, and anthropogenic factors affecting natural and semi-natural terrestrial ecosystems.

Department of Environmental Chemistry and Microbiology (MIMI)

This Department had been created as a recent merger of two other Departments. Panel was impressed by the enthusiasm expressed by the research leaders about the merged new Department and its mission. The possibilities for synergy between environmental chemistry and microbiology, although maybe not yet fully exploited at this stage, were clearly felt by the Department leadership.

Future areas of interaction between the two fields could be found in the measurement of organic substances in soil and in the rhizosphere (plant secondary metabolites, compounds involved in disease suppression, toxins released by pathogenic microorganisms, etc). Another area of interaction could be the construction of microbial bioreporter systems for environmental contaminants, which could be linked to determinations of bioavailability using analytical tools. In the field of bioremediation of polluted soils, the challenge is to match microbial degradation with bioavailability of the pollutants.

The current research concentrates on environmental chemistry and environmental microbiology, with the primary goal of abating chemical and microbiological problems that arise from human impacts on the environment. The Department specializes in the characterization of chemical, biochemical, and ecological processes that affect and moderate chemicals and microorganisms and in the implementation of monitoring programmes. In addition, high-resolution analytical methods (e.g. molecular analyses and mass spectral chemical analysis) are deployed to understand ecological processes that affect the distribution and fate of chemicals and biotechnological products. The Department takes an active role in the development of new sustainable and safe environmental technologies (i.e. bioremediation and microbial pest control agents), and in the development of analytical methods for assessing the distribution and fate of organic pollutants in the environment.

The Panel recognised several fields in which the Department has achieved a status of international excellence: (i) fate and effects of biotechnological products (micro-organisms and plants), (ii) analysis of trace organic chemicals (e.g. dioxins) in soil, sediment, water and biota, (iii) environmental fate and monitoring studies in Denmark and Greenland, (iv) forensic environmental chemistry to track sources of pollution (e.g. mineral oil), and (v) development and application of environmental biotechnology.

The Panel gives credit to the Department for applying a great variety of up-to-date technologies and methods, such as FISH, sequencing, DGGE, reporter systems (lux, gfp), high-resolution GC-MS technology, and equilibrium sampling devices to determine contaminant availability and activity.

The scientific staff consists of one senior research coordinator (environmental chemistry/microbiology/biotechnology), nine senior scientists (four chemists and five microbiologists), one scientist (chemist) and two PhD-students. The technical staff consists of 14 technicians (five working in microbiology/biotechnology, nine working in analytical chemistry), one technician-student) and two laboratory assistants.

The Panel view is that the Department has achieved outstanding quality in both environmental chemistry and microbiology and this high quality is testified by excellent publications in journals such as Environmental Science and Technology and Applied and Environmental Microbiology. The Department authored and co-authored 25 internationally refereed publications in 2002. Twenty publications are anticipated for 2003 (11 are currently published). In addition, 11 consultancy reports/popular articles were published in 2002. The relative Journal Impact Factor (JIF) for the 1998-2002 publications is 1.21, i.e. the papers are cited more frequently than the average within the categories.

The work in microbiology is moving into the direction of genomics; for example, in the strategic document 2003 – 2005 developed by the Department, the use of microarrays to analyse prokaryotes in the gut of earthworms is foreseen. The Panel was impressed by the creativeness reflected in the strategic document of the Department and suggests that further steps be taken to realise a significant part of the plans.

Department of Wildlife Ecology and Biodiversity (VIBI)

The Department of Wildlife Ecology and Biodiversity (VIBI), situated at Kalø, Eastern Jutland, was integrated into NERI in 1990 and has overall responsibilities for a knowledge base on nature monitoring, conservation and biodiversity. In May 2003 it was formed from the previous Departments of Landscape Ecology and Coastal Ecology.

Research strengths identified by the Panel are in the areas of waterfowl ecology, landscape ecological modelling and vegetation science. Of particular note is the development of innovative techniques using GPS and GIS to monitor the movement of birds in the areas of wind farms. This Danish research is well known internationally. Such work is of direct importance to environmental impact assessments. The Department has benefited from consultancy income from off-shore power companies. One downside of this is that staff with such expertise can be attracted into private consultancy.

The Panel is convinced that the Department uses approaches and methods that are state-of-the-art within its field, exemplified by the use of satellite and radio-telemetry, stable isotopes, and DNA-markers. In addition, innovative methodology has been developed in certain cases to tackle specific problems, e.g. automated GPS-systems for achieving spatial accuracy in aerial counts of waterfowl. VIBI has to undertake significant monitoring activities (involves 70 – 80% of the Departmental resource) which has an impact on publication output as expressed in papers in international journals. Between 1998 and 2002, between 32 and 58 scientific papers have been published per year in appropriate journals. As examples of quality research, publications dealing with modelling the loss of genetic diversity in vole populations and the prediction of habitat quality using ordination and neural networks can be highlighted. The Department has produced commendable output expressed in user-related scientific reports, conference papers and popular articles.

On the average, VIBI scientists have published 1.7 international scientific papers per year over the years 1998 to 2002. VIBI's publications have appeared in journals including Nature. The average Journal Impact Factor (JIF) of these publications was 1.17 for the years 1998-2002. This level of citation roughly corresponds to the average for the respective journals.

The panel commends VIBI for the provision of data on the web. A brief demonstration provided to the Panel illustrated the effectiveness of the system. Further developments are envisaged on simulating animal movements across landscapes (ALMass), a topic of great importance in evaluating, for example, the effects of new motorways or changes in habitat patterns.

VIBI's staff are 23 scientists and 9 other academic staff. The scientific staff comprises 1 research professor, 8 senior researchers, 5 senior advisors, and 9 junior researchers, Ph.D. students and

research assistants. All staff are involved in research, monitoring and providing advice though inevitable there are differences in emphases. Potential concerns about the work being too client driven have been recently addressed by the appointment of a Research Professor who will assume a key role in fostering research.

As a general rule, VIBI scientists participate in about 50 conferences annually, mostly in Europe, but also a few overseas. In addition, VIBI organises and hosts international conferences and workshops regularly itself, typically one per year. The latest large conference was a European one (80 participants) on impacts of offshore windfarms on waterfowl.

The Department has only recently been formed and thus it is early to provide an evaluation. The Panel's view is that greater focus on more limited areas needs to be considered, such as on waterfowl and landscape ecology. Innovative projects involving the integration of spatial modelling and monitoring offer opportunities for collaboration with other groups within NERI, for example the Department of Arctic Environment, and there are also other opportunities for wider international collaboration. The Panel notes that the major terrestrial topics covered by the Department seem particularly diverse. The implications of any further focus on research activities need to be considered in relation to the advisory responsibilities of the Department.

The Panel considers that there is a need to invest in new research students to support, in particular, the Research Professor. Consideration should be given to greater focus on research areas, but with due regard also to the needs of fulfilling the advisory role. Ways need to be found to further support staff in writing scientific papers. This will become an increasing issue as staff are expected to derive more income from external sources. The Panel took positive note of the action already taken to reduce administrative pressures on some staff.

Department of Arctic Environment (AM)

The Greenland Environment Research Institute was merged with NERI in 1995 to form the Department of Arctic Environment. Core funding of the Department is provided for the provision of environmental advice to the Bureau of Minerals and Petroleum in Greenland. Since the mid 1990s, activities have increased to include the Arctic Monitoring and Assessment Programme (AMAP) and a biological monitoring programme in Zackenberg in NE Greenland. The overall result has been the evolution of the Department from one primarily concerned with providing advice to one with a focus on research and monitoring.

The intention of fostering the integration of models of population dynamics with spatial modelling is to be commended and there is scope for this to be supported through collaboration with other Departments within NERI. Issues associated with climatic change and its impacts on arctic environments have been identified for future priority. Increased emphasis on climatic change would also encourage integration of the various monitoring programmes in order to build models for predicting, for example, changes of ranges in plants and animals under different climatic scenarios. The Panel considers that such research has to be paralleled with investigations to provide a deeper understanding of the physical processes underlying climatic change.

The Department has the following staff: 8 senior researchers/advisors, 6 research assistants, 4 fulltime Ph.D. students, plus 3 externally funded Ph.D. students who receive supervision from AM staff, 2 laboratory technicians, 3 clerical staff, and 1 database technician, totalling 29 members of staff. AM has expertise regarding statistical analysis, trace metal analyses, GIS/satellite image interpretation. Additional statistical and GIS-support is provided by other Departments (on a project basis). AM currently lacks modelling expertise, especially in the field of spatial modelling. A position has been advertised in 2003, but will have to be re-opened in early 2004.

In 2002 18 papers were published in scientific journals, 40 conference presentations were given and 11 other scientific papers/reports were completed. The scientific papers are in appropriate, albeit diverse journals. The Panel observes that the uniqueness of research is expressed in terms of the datasets from monitoring and this has also involved the development of innovative satellite tracking techniques, e.g. for eiderducks. Of particular note in terms of publications are two special issues in *The Science of the Total Environment* (2000 and 2004) and an impressive report on Arctic Pollution 2002, a product of the Arctic Monitoring and Assessment Programme (AMAP).

AM plans to synthesise data and to develop models for evaluating distributions of animal populations in relation to biotic and abiotic conditions. The panel finds this important for the identification of critical and sensitive areas and for the prediction of effects of changes in conditions, e.g. due to raw material activities or climatic change.

Integrated studies of selected contaminants (such as mercury), their transport, and effects in the Arctic ecosystems have been initiated in 2003 in co-operation with other NERI Departments and external partners. This research will provide an important input to the AMAP monitoring programme.

With regard to climate change, emphasis will be placed on multidisciplinary work to establish models for the effects on climate changes in Greenland, with particular emphasis on the High Arctic. This will involve the integration of terrestrial and marine research regarding carbon balance, biodiversity, and impacts on society.

Trace metal analyses have so far been carried out using AAS. The Panel supports the intention to replace this instrument with ICP-MS to allow analysis of a full spectrum of metals with a higher cost-effectiveness. The new instrument will be operated jointly by all three NERI Departments presently involved in element analyses.

7.2. The relevance of the research activities on terrestrial environment as a basis for Danish and international environmental policy and management

Department of Terrestrial Ecology (TERI)

The panel recognised that the research conducted by the Terrestrial Ecology Department is of a strategic nature and addresses timely concerns in society and regulatory authorities, for example the

risks associated with genetically modified plants, the effectiveness of organic farming and the use of pesticides. The involvement in the new monitoring programme NOVANA will strengthen the position of the Department in NERI's general strategic goals related to the maintenance of a strong link between research and monitoring.

TERI aims to apply its current knowledge in the several advisory activities. The best example is the work concerning Genetically Modified Plants. These research results have been implemented in a range of national and international activities:

- Papers on risk characterisation, which have been used in a review of the potential risk of GMOs requested by the European Commission.
- A research project about the effect of herbicide-tolerant fodder beet on biodiversity, which led to participation in the EU expert group on herbicide-tolerance.
- Research projects on co-existence of GMPs and conventional or organic farming, which led to participation in several scientific advisory groups supporting national and international authorities.
- Departmental expertise has led to requests from the government of Thailand to support the country in constructing a regulatory framework for GMPs; advice has also been given to the authorities in the Baltic countries.
- Suggestions on how to monitor GMPs were incorporated in the EU Directive 2000/18.

The Panel likes to point out that in terrestrial ecotoxicology, NERI's Department of Terrestrial Ecology has contributed greatly to the development of guidelines for maximum acceptable concentrations of potentially toxic substances in soil. A cut-off criterion for linear alkyl benzene sulphonates (LAS) in sewage sludge was derived from this work. After that, the need arose for refinement of the LAS criterion and led to a project commissioned by detergent companies. This NERI research resulted in substantial improvement of data for risk assessment of LAS in soils.

Another example is the work on the fate and effects of drugs in the environment, which led to activities in the second Danish Environmental Research programme. NERI participated in one of the successful applications within that programme covering research on fate and environmental effects of antibiotics. Previous research on the biogeochemistry of sensitive terrestrial ecosystems, in particular on nitrogen cycling, forms the basis for the new monitoring programme NOVANA.

Department of Environmental Chemistry and Microbiology (MIMI)

The Panel recognises that the Chemistry and Microbiology Department's research programme is clearly directed towards needs in society and regulation. The microbiological work is going to develop a link with human health by collaboration with the University of Aarhus and the National Serum Institute. The Panel supports the development of links between environmental and human health within NERI, since this issue is achieving more and more attention in society and there does not seem to be an institute in the Danish infrastructure that can fulfil the role of centre of expertise in this respect.

Three mechanisms are used by the Department to identify new and relevant research. One is to meet the Environmental Protection Agency and the Forest and Nature Agency on a periodical basis and discuss problems and concerns. From these discussions research plans and priorities are developed. Secondly, a variety of tools (newsletters, special bulletins, internet, meetings, etc.) are used for disseminating research results in addition to scientific publications. This provides extensive feedback that can also be the basis for setting research priorities. Thirdly, the Danish Research Councils biannually call for research proposals reflecting needs and relevance.

Examples of relevant research/monitoring activities that formed the basis for Danish and international policy management are:

- Biotechnology risk assessments and studies on the spread of antibiotic resistance.
- Early warning microbial indicators of soil health.
- Development of safe microbial pest control agents with no virulence determinants.
- Use of microorganisms and plants to clean-up contaminated soil and water (e.g. phytoremediation and degradation of methyl tertiary-butyl ether).
- Fate studies of organic pollutants including assessment of sources, transport and transformation of contaminants.
- Implementation of new sampling methods to determine contaminant availability
- Development of analytical methods for the determination of new priority contaminants in various matrices.
- Development of improved oil spill identification methodologies as part of the Danish Maritime Oil Spill Preparedness and Response strategy.

Department of Wildlife Ecology and Biodiversity (VIBI)

The Panel appreciates the fact that the results of monitoring activities by the Department provide essential inputs to the implementation in Denmark of the Habitats Directive. Habitat monitoring data as gathered in collaboration with TERI are used to develop criteria for the identification of Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) and also to guide formulation of policy regarding Biodiversity Action Plans. The game bag statistics are used to guide decisions on permitted hunting periods. Such important monitoring data along with the research on the impact of wind farms contribute to NERI's monitoring responsibilities and must be retained. Every opportunity should be taken to advertise the availability of such data on the web.

Examples of impacts of VIBI's research on political decision making are:

- The establishment of some 50 so-called 'hunting free core areas' within the Danish Special Protection Areas (SPAs) 1996-2000.
- The implementation of a national action plan to reduce the degree of crippling game
- Regulation of hunting seasons.
- Positioning and definition of maximum acceptable impacts of offshore wind parks
- Specification of criteria for conservation designation of habitat types and species in the context of the Habitats Directive and the Bird Protection Directive.

- Supporting counties' policies for implementing the Water Framework, Habitat, and Bird Protection Directives.

Department of Arctic Environments (AM)

Monitoring is of crucial importance with regard to the management of arctic environments. The Panel likes to point out that data sets held by AM are of considerable international significance given their uniqueness and the range of organisations concerned with arctic environments. Areas of particular importance are impacts of mining on contamination as well as on animal populations and environmental assessment associated with oil exploration and exploitation. Of considerable importance also is the archive dating back to the 1970s of biological materials as well as materials concerning marine mammals from Denmark. Much co-ordination of monitoring is evident, expressed in dissemination of data and inter-laboratory comparisons through AMAP.

The Department has no direct influence on the selection process for monitoring programmes. An independent Advisory Board together with the Environmental Protection Agency (EPA) and the Greenland Home Rule select the programmes funded by the Environmental Support Programme for the Arctic (administered by EPA). AM staff are key experts within the AMAP Framework, and provide the international AMAP board with research recommendations. The Environmental Support Programme reflects the AMAP recommendations. At the project level, AM submits proposals or applications to the Environmental Support Programme for the Arctic in open competition. The Advisory Board and the administrations select the projects, based on a combination of scientific evaluation and administrative needs / relevance. Internally, relevant research ideas are discussed and developed at annual strategy seminars. Similarly, AM arranges annual cross-departmental strategy meetings to develop Arctic research ideas and initiatives.

7.3 The performance regarding the terrestrial environment in relation to the tasks laid down in the performance contract 2000-2003 and the government order

According to NERI's own assessments, 83% of the goals set out in the Performance Contract (PC) will be met, 7% are still uncertain and 10% have been given up. Problems have been encountered with the impact of ammonia on natural habitats (PC nos. 46 & 48), as well as the creation of integrated coastal zone management systems (PC nos. 63 & 65). Part of the problem is related to rather high expectations concerning the development and use of simplified indicators of environmental quality. For example, there is frequent reference to the importance of soil quality, which is usually taken to refer to the ability of soils to support a range of physical, chemical and biological functions. However, in the context of the document as provided by NERI, soil quality is interpreted on a more limited basis, for example, judging the significance of soil contamination.

The Panel has had no chance in any detail to check the fulfillment of the goals set in the Performance Contract. In general terms, the Panel finds that the Performance Contract has been

used seriously in managing the activities within the terrestrial environment and that the degree of fulfillment is satisfactory.

7.4 National and international collaboration with universities and other research institutes on research and monitoring in the terrestrial environment field

Department of Terrestrial Ecology (TERI)

The Panel notes that TERI collaborates with a number of research institutions and universities in Denmark and internationally in research programmes. Partners are selected to fill gaps in expertise not covered by NERI. TERI has project collaboration with the following Danish universities: Copenhagen, Aarhus, Odense, Roskilde, the Royal Veterinary and Agricultural University and the Danish University of Pharmaceutical Sciences. The national collaboration furthermore includes several research institutions. TERI is involved in several EU projects, and projects with industry. TERI co-ordinates two EU projects, ECOGEN and LIBERATION, which both have about 10 participants in European countries. At present TERI is also involved in international development assistance in Africa: the International Institute of Tropical Agriculture (IITA), Benin and the AGRHYMET Centre, Niamey, Niger and in Bangladesh. Biomarkers are developed in collaboration with the University of Montpellier I, and TERI has a close collaboration with Environment Canada.

In the period 1992-1998 TERI held the secretariat for the European network SERAS (Soil Ecological Risk Assessment System), which took a leading role in the development of terrestrial ecotoxicology in Europe. In the PEER network (Partnership for European Environmental Research) the Department organises the research on contaminated environments, risk assessment and remediation strategies. The variety of international contacts, according to the Panel, reflects the good international position of the Department.

On the average one Ph.D. thesis from TERI is defended each year. The Ph.D. projects are conducted in collaboration with Danish and foreign universities. 10-15 Master students are working on their theses each year.

TERI takes an active part in four Ph.D. schools: 1) RECETO in environmental chemistry and ecotoxicology, which was established this year at the Royal Veterinary and Agriculture University, 2) COGCI, the Copenhagen Global Change Initiative, at the University of Copenhagen, 3) SOAR, the Research School for Organic Agriculture and Food Systems, and 4) GESS, in Environmental Stress Research with participation from the universities in Roskilde, Aarhus and University of Southern Denmark.

Department of Environmental Chemistry and Microbiology (MIMI)

The panel has observed that MIMI has extensive collaboration and networking with numerous

national and international research institutions, universities, regulatory offices, and private industries. Most of these collaborative efforts are the direct results of joint research projects.

The large number of national and international contacts is clear evidence of the excellent scientific network maintained by the Department.

During the Performance Contract period from 2000-2003, MIMI has trained eight candidates at the Ph.D. level and nine at the Master level. Presently, two Ph.D.-students are working on their dissertation (1-2 new students will be hired within the next year), while three are working on their Master theses. In addition to the direct supervision of students, MIMI staff frequently give lectures at the universities and act as censors. Finally, MIMI plays an active role as board member in the newly formed research school of environmental chemistry and toxicology (RECETO).

Department of Wildlife Ecology and Biodiversity (VIBI)

On a national level, co-operation takes place with Copenhagen University (bio-diversity, bird ringing population ecology) and Aarhus University (vertebrate ecology, population genetics). Links also exist with the Universities of Odense and Roskilde. International linkages within waterfowl ecology involves regular collaboration with many countries including Italy, Spain, Ireland, the UK, France, the Netherlands, Germany, Sweden, Norway, Iceland and the Baltic states. There is further scope for international collaboration on this topic given the priority of increasing renewable energy in many countries. In addition, the Department maintains international contacts through participation in such organisations as the scientific advisory board (the Bonn Convention for migratory species), the EU Ornis Committee, the Nordic College for Wildlife Research, the IUCN Otter Specialist group and the ICES Seabird Ecology Group.

Department of the Arctic Environment (AM)

The Panel was impressed by the Department's important role in circum-arctic research involving ecosystems in the US, Canada, Norway and the Russian Federation. AM's most important external partner is the Greenland Institute of Natural Resources in Nuuk. A formal agreement has been signed on project co-operation, data exchange, staff exchange, and chartering of research ships. The scope of the co-operation primarily centres on marine birds, marine and terrestrial mammals, and collection of environmental samples. AM also co-operates with the Canadian Wildlife Service, the Icelandic Institute for Nature Conservation and the Norwegian Polar Institute on research on and monitoring of Arctic birds and marine mammals.

Mapping of sensitive coastal areas is carried out in collaboration with the Geological Survey of Denmark and Greenland (GEUS), the Greenland National Archives, the Greenland Institute of Natural Resources, and others. A formal co-operation agreement has been signed between the Department of Arctic Environment, the Department of Atmospheric Environment (NERI), and the Institute of Environmental Medicine at the University of Aarhus. The objective of this agreement is to expand the scope of co-operation and to work towards an integration of the biological/chemical

and the human health disciplines within the AMAP initiatives. The Arctic Monitoring and Assessment Programme also involves co-operation with Environment Canada, the Norwegian Polar Institute, Risø National Laboratory in Denmark, and others.

Research and monitoring in Zackenberg is carried out in close collaboration with the Institute of Population Biology and the Institute of Geography (University of Copenhagen), ASIAQ (Greenland), the Department of Marine Ecology (NERI) and the Danish Polar Center. AM has entered into a formal co-operation agreement with the Institute of Geography at the University of Copenhagen on the abiotic monitoring programme (GeoBasis) in Zackenberg. This will help promote better integration between the individual sub-programmes.

Other climate related research is carried out in co-operation with the Norwegian Institute for Nature Research (NINA), the Institute of Nature Conservation (Belgium), the Netherlands Institute of Ecology, the Wildfowl and Wetlands Trust (UK), UNIS (Svalbard), University of Groningen (the Netherlands), and others.

Studies of marine mammals in Denmark are carried out in co-operation with Hedeselskabet (a consultancy firm), the University of Southern Denmark, the Danish Institute for Fisheries Research, the Danish Fisheries and Maritime Museum, Stockholm's Museum of Natural History, the University of Gothenburg in Sweden, Alterra (the Netherlands), and others.

In 2003, AE staff will act as external study directors for five PhD students (two from the University of Copenhagen, two from the Royal Veterinary and Agricultural University (KVL), and one from the Technical University of Denmark (DTU) and six undergraduate students working on their M.Sc. theses (from the University of Copenhagen, University of Southern Denmark and the Royal Veterinary and Agricultural University). AM takes active part in the PhD school COGCI, the Copenhagen Global Change Initiative at the University of Copenhagen. During 1998-2003, AE has successfully finalised nine M.Sc. and seven PhD projects in collaboration with various universities.

7.5 General observations and recommendations concerning NERI's terrestrial research

The Panel makes the following general observations on the activities concerned with terrestrial environments within the Departments of Terrestrial Ecology (TERI), Wildlife Ecology and Biodiversity (VIBI), Environmental Chemistry and Microbiology (MIMI) and Arctic Environment (AM):

- The Panel is impressed by the internationally recognised quality of the research, with the dissemination of data from monitoring programmes to inform environmental management and to assist with the initiation of new research, and the provision of advice based on scientific understanding.
- The Panel notes the Departments' extensive national and international research links.

- There is a high staff morale and commitment despite substantial re-structuring in recent years. The Panel is also impressed with the supportive and collegial work environments.
- The Panel is impressed with research expertise at the international level in such areas as risk assessment of genetically modified plants, soil ecotoxicology, chemical analysis of organic compounds, rhizosphere ecology, monitoring in a range of contexts (e.g. bird movements, habitat distribution), and the unique resources associated with monitoring arctic environments.
- Close relationships are evident between monitoring/research and environmental policy/implementation, for example, inputs to implementing the Habitats Directive.
- The Panel notes the extent to which research is orientated towards the needs of regulatory authorities. Effective management structures are in place to ensure that staff are well informed of new research opportunities.

The Panel makes the following recommendations based on its evaluation:

- The Panel notes a considerable diversity in terms of research areas within some Departments working with the Terrestrial Competence Area and also between departments, and thus recommends consideration be given to whether greater focus can be achieved.
- The Panel notes the increasing emphasis being given within the four different Departments to spatial modelling and the Panel recommends that this be encouraged given the benefits of fostering exchange of experience and integration between different groups.
- The Panel endorses the practice of appointing Research Professors and recommends that these are supported by new research studentships.
- The Panel has concern that some staff have difficulty in finding time to write scientific papers at the end of projects and thus recommends that ways are found to address this issue.
- The Panel recommends that in some cases, greater emphasis be given to publishing in top international journals.
- The Panel is impressed by the extent of multidisciplinary input in support of environmental policy formulation and implementation and the Panel recommends that emphasis is given to further enhancement of this core activity.
- The Panel is impressed with the dissemination of results from monitoring programmes using reports and the Internet. The Panel identifies the web as crucial in this role and thus recommends that ways are found to further strengthen this area.

- The Panel recommends that further opportunities be explored to achieve linking of environmental issues to human health, e.g. in collaboration with external expertise.

8. NERI's activities concerning Environment and Society and Arctic Environment. Assessments and recommendations

This chapter presents the Panel's assessments and recommendations as regards NERI's Competence Area Environment and Society, which is primarily conducted by the Department of Policy Analysis. In addition, the chapter includes an evaluation of NERI's research on the Arctic Environment, as this research, although not focusing specifically on relationships between society and the environment goes across the discipline-oriented themes of the three preceding chapters of the report.

The research within the Department of Policy Analysis focuses on increased understanding of the relations between the activities of society and environmental problems and on improving the basis for environmental decision making by analyzing driving forces, pressures and possible responses. This is a cross-disciplinary area drawing on natural and well as social science competencies.

The Department of Policy Analysis started at a low level in 1989 and increased over a 10-year period to 25 employees. During the last four years a further increase has taken place, and the department now comprises about 40 employees. The Department works within a number of disciplines within social and natural science (numbers in brackets show the number of researchers within the field): Economics (5), policy analysis (7), agroeconomics (2), agronomy (2), geography (4), biology (2), chemistry (2), sociology (2), engineering (11). About 15 staff members are researchers and senior researchers, 6 are senior advisors and 12 are PhD-students and research assistants. The rest belongs to the category 'other academic staff'.

8.1 Extent and scientific quality of the research in the fields of Environment and Society and Arctic Environment and its national and international position and impact

Environment and Society

According to the Policy Analysis Department, the quality of the research carried out is assured by either international publication of results or by internal and/or external review of research reports. The latter reviews are at present carried out mainly within the Danish research community. All reports will at least go through internal review by a colleague and the Research Director.

A culture and research tradition of international publication in peer reviewed publication has been emphasized stronger during the last 3-4 years. The number of papers 'in the pipeline', which have been submitted or are ready to be submitted within the next month, is over 20.

Quality assurance of advisory reports is carried out by internal and/or external reviews and by the review procedures undertaken by the client. This often includes the use of steering committees consisting of other national experts (including e.g. university professors) within the area. Products

like the Danish State of the Environment Report goes through a hearing process involving national expertise mainly from other research institutes. The methodology applied for the emission inventories goes through a hearing process, which activates the specific expertise within the relevant sector ministries/research institutes. The emission inventory itself is subject to an international review process, which is believed to be further developed in the future along with the implementation of the Kyoto Protocol.

The Panel finds it more difficult to assess the quality of the research within the sub-field of Environment and Society than of the three other competence areas of the evaluation. One reason for this difficulty is that the researchers within this field have been less active in publishing peer-reviewed international scientific articles than is the case within the other sub-fields. This is different from the situation within the other three competence areas, where a high number of peer-reviewed articles may indicate an overall high research quality.

An assessment of research quality within the Department of Policy Analysis must therefore be based on a broader range of publications. The diverse activities within the Department of Policy Analysis justify an approach that does not merely examine standard scientific publications, the impact factors of the journals, and the citation rates of the individual papers themselves. Because of the obligations to produce inventories, overview documents, and technical evaluations, efforts should be considered in regard to these requirements, with formal scientific publication as one of several aspects. Thus, the overall impact includes the citation impact of such papers, but it also includes the impact from other publications, some of which are available at the NERI website.

It is the clear impression of the Panel that the quality of each type of product is satisfactory. Given the time constraints of the evaluation, the Panel has only had the possibility to look quite superficially at a few indicative reports and books published in the department. These publications seem to hold a decent quality, compared to current research practice within their respective fields.

A particular category of reports is the national State of the Environment reports produced each fourth year by the group on Integrated Analyses. These reports contain a comprehensive compilation and presentation of environmental data by means of relevant indicators and indices. This is both a massive effort and an important task that the Panel would expect an institute like NERI to undertake. It obviously detracts resources from activities that could result in journal articles, but produces valuable output for decision-makers and the general public. The Panel considers this activity to be of high policy relevance as well as of a high information value for the public at large. While full documentation should be made accessible to the public, the selection of data for highlighting in popular reports should be made after careful analysis of whether they are representative and whether they may have policy implications or impact on individual behavior and risk perception. This consideration deserves further attention from a research angle.

The Department of Policy Analysis has relatively few publications in international referee-journals. Only 60 international journal articles have been published during the period 1998 - 2002 by researchers belonging to the Department of Policy Analysis, and less than half of these articles were published in JCR journals. In the period 1998-2002 the number has varied between 2 and 12, with the highest number in 2002. Since the department has around 15 senior-level researchers, on average a researcher publishes far less than one peer-reviewed article per year. This is far below the

numbers for the other departments of NERI.

Admittedly, there has been an increase in the publishing rate during the latest 2 years, where the annual number of published articles in each of the two categories (JCR and non-JCR) is twice as high as in the preceding three-year period. However, some of this increase is an artifact of the inclusion of researchers within the field of risk assessment and chemicals. These researchers had already a higher publication rate than the average among the original staff of the Department of Policy Analysis. Among the latter, there has been a certain increase in the rate of international journal publication, particularly due to a relatively high number of articles written by the researchers within the fields of Environmental Economics and Rural Analyses.

The Department of Policy Analysis admits that the publication rate is lower than what is seen for research within natural science and pure discipline-oriented science. According to the department, the publication rate is increasing as a result of a strategy to increase the publication in international journals to some extent at the expense of producing national research reports. However, the department does not consider it possible to make a total shift since the users of the policy-oriented research are national authorities/administration. According to the department, one of the main difficulties of environmental policy-oriented research, which is subject to a demand to provide applied research results for the environmental administration, is to assure a sufficient publication of results in international journals.

The Panel acknowledges these difficulties and observes that most of the researchers of the Policy Analysis Department have mainly published their work as research reports (published by NERI itself or by governmental agencies), conference papers and in some cases as Danish-language books. The department has a proportionally high output of conference papers, which include posters and abstracts of oral presentations. However, given that the research is carried through to presentation at scientific meetings, the Panel is surprised by the comparatively few formal publications in peer-reviewed scientific journals. One possible reason is that the projects did not lead to results of international relevance, but an additional explanation is that resources are not available for pursuing such publication, which involves potentially laborious stages, such as condensation in English and response to peer review.

The recent recruitment of a research professor in systems analysis and environmental economics has clearly improved the record of scientific publication, and hopefully this development will continue. It is the Panel's opinion that extent of international scientific publications needs to be improved as part of the overall need to secure a high quality level and a firm scientific standing.

To this must be added that the Panel is aware that the tradition for publishing a high number of scientific articles is perhaps not equally strong within the socio-economic disciplines as in natural science. The length of the typical article may differ across scientific fields, and the number of co-authors is also often higher within natural science. Moreover, tight budgets and a high workload from tasks mentioned in the performance contract put limitations on the scope for allocating time to writing scientific articles. Nevertheless, in the Panel's opinion, a better balance between the high number of conference papers and the low number of scientific journal articles should still be possible within existing resource limits. A further measure to increase the number of peer-reviewed journal articles published could be to earmark some of the time resources provided by the basic

appropriation to article publishing. Such an incentive is probably necessary in order to change the existing culture within parts of the department, where publishing peer-reviewed international articles is seen as a desirable, but not necessary activity.

The Department has also developed manual-like reports with valuation techniques for the assessment of environmental projects. The Panel considers this another important and applied research task for the improvement of decision-making. An institute like NERI is an ideal candidate for this type of task.

Lately, the Environmental Economics group has introduced reviews by external peers as a routine for reports written by its members, but among the remaining part of the department no such routine has been practiced. It is the Panel's opinion that the introduction of similar routines as a general practice in the Policy Department might be beneficial. For example, reports might be reviewed by external reviewers, and not accepted for publication until properly revised. This would force researchers to be careful in their choice of models, methods and data, and in their analyses. Ideally, such a step could contribute to making the Department of Policy Analysis an even more academic workplace than currently.

Conclusively, considering the various types of publications altogether, the Panel has the clear impression that the productivity of the Department of Policy Analysis is reasonable, regarding the manpower and resources available. Only a small amount of non-obligated research is funded by internal budgets, but especially the new activities in environmental economics are leading to a range of new initiatives that involve related basic and strategic research.

In the view of the Panel, the establishment of more systematic routines to ensure the quality of the research design of projects (methodology, choice of theoretical perspective(s), data sources etc.) might be desirable. For projects financed by the research councils or other funding authorities subjecting the applications to peer review, an additional, NERI-internal quality control of research design is probably unnecessary. However, for other projects, including Ministry-financed projects and projects financed by the basic appropriation, the Panel finds that routines ensuring a more thorough scrutinizing of research design quality could be a helpful tool in order to improve the validity and reliability of the findings. The Panel therefore recommends that the introduction of such routines be considered.

As a supplement to formal scientific publishing in peer-review journals, the department might consider introducing an electronic Working Paper series (after external review).

Arctic Environment

Most of the arctic projects are multidisciplinary, and they target specific issues that are of critical importance in regard to environmental problems in Greenland and elsewhere in the arctic, and to some extent also in regard to global problems. The Panel is aware that the projects conducted on vulnerability of arctic animal populations in regard to raw materials exploitation are costly and complex, but finds them nonetheless rather extensive and of high quality. Likewise, the projects on long-range transport of key pollutants, such as mercury and POP compounds, are targeted and

conducted at a high quality level. These projects provide descriptive data that are useful for decision-making as such, but some also include assessment of toxicity to specific arctic animal species, studies of physiological adaptation mechanisms, and human exposure assessments.

As a separate component, the department also conducts baseline studies in a remote area in northeastern Greenland, where the impacts of climate changes are studied. The Panel considers this ecological data-gathering and -treatment effort a highly appropriate complement to other descriptive NERI efforts, and it will in the long range become an extremely valuable source for obtaining unbiased, prospective information on ecological key indicators.

Originating from the circumstances of NERI's agreements with the authorities involved, the Panel sees an important weakness (in the sense of scientific quality) in the fact that this research is carried out in accordance to definitions that are not based on science but on administrative responsibilities. The department benefits from collaborations within NERI (e.g., on atmospheric pollution), and it has wisely secured agreements with institutions that are responsible for research on Greenland mammals and on human health. The results are published in appropriate scientific journals and by other means, e.g., as web documents including making maps of marine areas vulnerable to oil spills. The extent, the content, and the quality of these publications are in accordance with the Panel's expectations for the department.

8.2 The relevance of the research activities on Environment and Society, and Arctic Environment as a basis for Danish and international environmental policy and management

Environment and Society

According to the Department of Policy Analysis, one of its strengths is the broad knowledge and overview, which is unique at NERI level and in Denmark. The competencies on environmental economics, environmental sociology, ranking order methods for risk assessment and coupling of ecological and economic modeling are unique in Denmark and at the same scientific level as what is found in research communities in Europe. This is for instance clearly demonstrated by the fact that these areas participate actively in the respective scientific networks in Europe and are seen as a competent partner in European research co-operation and awarded European research projects. The Panel shares these views and overall finds the activities of the Department of Policy Analysis to be relevant and important.

In addition, according to the department, relevant research is identified via a dialogue with the Ministry, though inspiration by international literature, by attending international conferences and by participation in the environmental debate in Denmark at seminars, workshops and conferences and through discussions at both Institution (NERI) and Department level. The main criteria for selection of research areas are:

- The area is involved with an important environmental problem in Denmark.

- There is a need for research results in the field at the administrative level, i.e. for policy development
- There is a need for knowledge and research
- There is competence within the Department to undertake this kind of research i.e. to continuously increase and improve the standing in scientific terms
- The research is cross-disciplinary drawing on the width of knowledge and overview that is found in the Department.

The Panel finds these criteria reasonable, but in our judgement, the existing competence within the Department should not be considered a fixed parameter, but be subject to strategic discussions, notably in the planning processes in connection with the updating of NERI's research strategy.

It is the opinion of the Panel that the Department of Policy Analysis plays a key role in NERI. The research topics are to a large extent closely related to priority topics within Danish environmental policy and regulation. The department provides the link between the natural science Departments within NERI and the government, other policy-making units and the general public. The natural science departments provide, for example, estimations of the deposition of harmful particles in the environment, while Department of Policy Analysis provides estimates of the associated damage costs to society and suggests policy instruments that reduces/eliminates the damage.

In particular, the recent recruitment of researchers dealing with environmental aspects of sociology and economics is highly praiseworthy. These fields provide important inputs to studies of social impacts of environmental policies, and the economic and social feasibility of such policies. In the view of the Panel, the department plays an important role for decision-making as well as for improving the general public's understanding of environmental problems and their consequences.

The Department has identified two topics of priority by the Ministry of Environment presently not covered by substantial research activities, namely the flexible mechanisms under the Kyoto Protocol and the Precautionary Principle.

Organisational matters

The research within the Department of Policy Analysis is divided into sections, which interact and also collaborate with other departments. The research portfolio is quite heterogeneous. To the Panel it is not always obvious what strategic considerations are behind the composition of research areas. However, it seems that a major reason for the heterogeneity is organizational changes within NERI and between NERI and other research institutions. Currently, the department has six research areas (environmental economics, environmental sociology, risk assessment and chemicals, integrated analyses, rural analyses, and air emission inventories) covering a number of different academic disciplines. Still, the different groups have a quite high level of mutual cooperation. The group responsible for integrated analyses has particular, mandated documentation reports as their most important output.

Except for two quite large groups (environmental economics and rural analyses), many of the groups are quite small, perhaps too small to constitute the necessary "critical mass". For example, the group on environmental sociology includes only 2 senior researchers and 2 Ph.D. students. The Department of Policy Analysis is aware of the need for "critical mass" within each area and tries to

ensure this by increasing the size of the staff within the smallest fields (although this may be difficult due to the current reductions in funding), and through matrix-organized groups where the members of the smallest groups also participate in projects anchored in other groups.

One of the main rationales for locating research tasks within different fields and disciplines together under one roof is to gain synergy effects through interdisciplinary cooperation and integration. There are several examples of other departments (notably the departments of Atmospheric Environment, Terrestrial Environment, and Microorganisms and Chemicals) feeding results from their monitoring and research activities into the Department of Policy Analyses where further elaboration and analyses of these data take place.

However, the Panel finds that in some cases such cooperation is hampered as a result of the need to establish international rather than local research teams in order to obtain research funding from the European Union. For example, in a research consortium recently established on the initiative of the Atmospheric Environment Department it was decided to include Slovenian environmental economists instead of the expertise available in the group of Environmental Economics within the Department of Policy Analysis. Given the fact that EU-funded projects are supposed to make up an increasing part of the research carried out at NERI (as a result of reduced basic appropriation in combination with reduced funding sources in the Danish Research Councils and increased competition for these funds), this mechanism may give rise to some concern. If NERI researchers are increasingly forced to choose external instead of internal cooperation partners in interdisciplinary projects, the very idea of concentrating various types of environment-related expertise within one governmental research institute might be jeopardized.

The research carried out by the Department of Policy Analysis is partly geared at identifying environmental problems (their nature, extent and geographical distribution), and partly at evaluating environmental policies (ex-post as well as ex-ante). By communicating research results to decision-makers (notably the Ministry of the Environment and its agencies) and to the public at large, the department also contributes to raise the awareness about and acknowledgement of environmental problems.

The Department of Policy Analysis has chosen not to give primary focus on the processes through which problem acknowledgement eventually result in policy formulation, nor the processes leading from policy formulation to policy implementation (or non-implementation). An inclusion of the latter type of research issues might be desirable. The Panel still considers the possibility for carrying out more fundamental research into the mechanisms through which social conditions produce environmental problems to be higher at the universities than at a governmental research institute like NERI.

Rural Analysis

The group working with Rural Analysis is quite large. The team combines competencies within economics, sociology, landscape ecology, agronomy and includes a solid GIS expertise. Its topics include integrated impact assessments of land use and landscape changes at national, regional and local level; landscape ecological/biotope models, geographical and sociological analyses of organic farming, and analyses of landscape development. Scenario analyses coupling ecological modeling of agriculture, environment and nature makes up an important part of the project work. The group

also develops support tools and spatial modeling of land use changes relevant to sustainable development. This group incorporates researchers from several disciplines. It is the Panel's impression that it comprises a suitable team for solving the tasks mentioned. The topics appear to be highly relevant to policy-making. Some of the issues are also topics in another governmental research institute (the Danish Institute for Forest and Landscape). However, the coupling of rural and landscape issues with sociological and economic aspects seems to be unique for the group at NERI.

The group on Rural Analyses appears to be the most interdisciplinary one within the Department of Policy Analysis - and probably also within NERI as a whole. A considerable contribution of basic and applied research is involved in the group's activities.

Environmental Economics

The group on Environmental Economics includes competencies on economics, policy analysis and agro-economics. The area of law is not included, and this subject is not at present part of the activities. In the view of the Panel, the team appears to be a dynamic and productive group and represents an important asset of the Department of Policy Analyses. The group has an applied touch, but is focused on improving methods and publishing in an international context. It seems to have reached the size of or possibly beyond the critical mass size that is so essential in research. A further development of this research field should be encouraged.

The group's research activities include cost-benefit and cost-effectiveness studies. These studies are mainly carried out within a mainstream, neoclassical paradigm. This approach has recently been supplemented by a project focusing on ethics and discounting. Given the long-term, global and irreversible character of certain environmental problems (notably the impacts of greenhouse gas emissions), it is the impression of the Panel that further methodological reflection within this field would be valuable in order to facilitate improved analyses of policies addressing the latter type of environmental problems. Possibly, this could be done in co-operation with other research institutes. Such a widening of the scope seems to be necessary in order to meet future challenges in relation to, e.g., the following-up of the Kyoto protocol. In this context, the above-mentioned project on ethics and discounting might preferentially be supplemented by a more extensive research effort into the different views on how (and whether) to discount projects that affect, roughly speaking, generations living now and projects that have positive or negative consequences far in the future, respectively.

Econometrics

The econometric competence at NERI seems quite weak. However, the Panel doubts that a central statistical function for NERI is the best way to improve the econometric competence since the needs vary so much both between and within departments. Instead, we encourage the Department of Policy Analysis to analyze how to strengthen its econometric/statistical competence paying proper attention to already existing expertise within NERI.

Environmental Sociology

The group on Environmental Sociology includes classical sociologists, engineers with Ph.D. training in societal aspects of technology and until recently also a psychologist. This group should ideally play an important role in the Department of Policy Analysis. It is important to acquire more knowledge about people's perceptions of (environmental) risks, and the factors governing our

attitudes to the environment. However, the group is currently too small, i.e. below the level of critical mass. The Panel considers this field important and recommends that it be strengthened, also encompassing psychological aspects of risk perception and environmental valuation.

One of the main fields addressed by this group is mobility sociology. Earlier, this research was integrated with other transport research activities in the Department of Policy Analysis. These transport researchers were, however, moved to another governmental research institute (the Danish Transport Institute) in 2001 when the latter institute was established. Today, the field of mobility sociology is quite isolated from the other research fields of NERI. The other research fields within the group of environmental sociology seem to be better integrated with the other research activities of the department. One solution might be to shift the focus from mobility sociology to sociological studies related to risk assessment. As mentioned above, such studies are presently missing at NERI.

Integrated Analysis

The group on Integrated Analyses includes biologists, economist and engineers. Solid general knowledge of water topics and the terrestrial environment is covered. The research activities within Integrated Analyses feed into assisting the Ministry concerning development and use of indicators, e.g. sustainability indicators and common indicator products.

The team carries out the important work of compiling data for and writing the four-annual State of the Environment report. As mentioned previously, this report is a crucial link between NERI's monitoring activities and policy-making, and it also plays an important role in the general enlightening of the public about environmental issues. Another important field within this group is the work on environmental indicators and indices. The activities of the group on Integrated Analyses are highly relevant to policy-making and make up a necessary part of the provision of a scientific base for environmental policy-making.

Risk Assessment and Air Emission Inventories

The Panel finds the two remaining groups (Risk Assessment and Chemicals, and Air Emission Inventories) more difficult to assess, if viewed as parts of the Department of Policy Analysis. They both perform essential tasks in that they collect the basic input data needed in assessments of environment's status. What is less obvious, however, is why they are located within a policy department. If the field of risk assessment is integrated to a higher extent with other fields of research within the department (notably environmental sociology and environmental economics), the Panel still believes that the present location of the risk analysis group may be favorable. We are more doubtful about the group on Air Emission Inventories (consisting of engineers) being located within the Department of Policy Analysis. If we are interested in knowing where airborne emissions are deposited, we must go to a different department within NERI. The Panel has the impression that it might be rewarding to reconsider the organizational location of the inventories of emissions.

The group on Risk assessment and Chemicals includes chemists and engineers with a strong background in mathematical modeling and statistical analyses. This group deals with natural science-based analyses of risks related to chemicals in the environment, and can so far hardly be said to be fully "environment and society" oriented, as long as it does not include topics like effects of exposures on human health, ethical aspects of risks, or the attitudes of the population to different types of risk. This group was moved to the Department of Policy Analyses from the former Chemistry Department one and a half year ago, and may not yet be fully integrated in its new

department. According to the head of the Department of Policy Analyses, a stronger integration of Risk analyses with, in particular, Environmental Economics and Environmental Sociology is planned in the future. The Panel agrees in this plan and recommends that the necessary resources for these tasks be allocated, if necessary by earmarking a part of the basic appropriation for these activities.

The risk assessment efforts must, in the Panel's opinion, be considered from its cross-departmental organization, where the modeling part is nested within the Department of Policy Analysis. The Panel sees risk assessment of GMOs as a major challenge, and NERI has made the right decision to build the expertise at a very high level in this field. In our view, a clear disadvantage regarding risk assessment (and arctic research too) is that exposure assessments carried out at NERI cannot provide a complete basis for human health risk assessment in the absence of dose-response relationships.

Human health

Presently, internally in NERI, no linking appears to exist between NERI's analyses of exposure to pollutants and environmental quality, and the effects on human health. This link is central to a policy-oriented department like the Department of Policy Analysis. In the view of the Panel, the health effects of emissions are both important and tricky to estimate. There are both ethical and methodological considerations involved; and nationally and internationally there is quite an intensive research going on, involving health economists, psychologists and researchers from other disciplines. Utilizing the results from such studies, the Department of Policy Analysis could play an important role in developing national standards for how to design and undertake cost-effectiveness/cost-utility and cost-benefit analysis of projects affecting morbidity as well as mortality rates.

Prioritization of research tasks

The senior researchers of the department have clear visions on research needs, and these are translated into priorities where financial prospects and feasibility must be taken into account. Although the priorities appear highly appropriate, projects not considered due to lack of funds sometimes seem as important as projects that are pursued. Such limitations on non-obligated research can potentially lead to inertia and inefficiency. While the addition of a research professor in environmental economics and system analysis has clearly provided fresh blood to the department, the Panel sees a remaining risk of inertia and delayed response to research developments in other fields and new environmental problems. The Panel therefore recommends that advice from external peers be sought when evaluating projects and developing research strategies.

Arctic Environment

NERI's research on arctic environment primarily aims at advising the Greenland government, as agreed with the authorities. The Panel finds that the relevance of the arctic research in this regard is undisputed. However, a potential that ought to be further explored is the relevance of this research in regard to environmental policy in Denmark, the EU and internationally. For example, most of the

POP contamination must originate from elsewhere, since Greenland emissions of these toxicants are miniscule.

Thus, the research on arctic environment may provide indicators of environmental health also on a global scale, since the combined worldwide pollution of certain compounds may elicit adverse effects in the vulnerable arctic environment before they create problems elsewhere. In this regard, the arctic research deserves a more prominent place in the application of the NERI research activities.

The Panel considers that NERI's research within the Arctic Environment Department is generally highly relevant to policy analysis. As mentioned previously, this department was reviewed in connection with the Department of Policy Analysis due to the multidisciplinary nature of these activities. Although defined in accordance with an agreement with the Greenland government, several arctic projects are crucial to policy development, because of the unique vulnerability of arctic animal populations and ecosystems, because long-range transport mechanisms result in accumulation of certain toxicants in arctic food chains, and because of the potential of abrupt climate changes as a result of anthropogenic pollutant emissions. Because the Greenland government has the responsibility for local animal populations, the topics of the NERI projects must necessarily (and do) respect this division, although it may not always be scientifically appropriate (collaboration, e.g. with the Greenland Nature Institute compensates for this problem).

8.3 The performance regarding Environment and Society and Arctic Environment in relation to the tasks laid down in the performance contract 2002-2003 and the government order

According to NERI's own assessments, 89% of the Performance Contract (PC) goals regarding Environment and Society will be met, 6% are still uncertain, whereas another 6% have been given up. Problems are related to the legal constraints on releasing GMOs in field experiments as well as methodological problems (108, 111 & 115). A group of goals centered on the environmental impacts of industry (127, 128 and 129) were removed from the contract (see Annex 2 of the PC) mainly due to budget restraints. Goals dealing with transport issues were also removed (e.g. 117) or given a lower priority when the Danish Transport Institute was established in 2001/2002 (see Annex 2 of the PC).

The Panel finds that the research activities at the Department of Policy Analysis are well in accordance with the Performance Contract. A high percentage of the goals in the contract have been fulfilled. One item deserves special consideration. In regard to the Precautionary Principle, NERI is required to carry out research on the importance of different types of uncertainty. Important projects in this field focus on ranking order methodology, modeling of environmental fate, and quantitative structure-activity models. Still, in regard to the Precautionary Principle, these efforts only target limited aspects of the issues involved.

The Precautionary Principle is too often mentioned in political decisions, and almost always when a

decision on pollution abatement or prevention has been made. However, when decisions on not preventing or abating are made, no indication is made why the Precautionary Principle would not apply.

In the view of the Panel, NERI could play a more pro-active role in suggesting threshold values indicating when precaution should lead to a decision on prevention. Thus, this crucial principle should be carefully examined to determine how it could be applied as guidance for decision-making. In the Panel's opinion, making the principle operational and assessing proper thresholds are clearly research issues that would comply with the overall NERI mandate.

The Panel finds that the research on arctic environment constitutes reasonable research contributions to providing highly useful documentation, improved understanding and new insight into a key scientific area of high societal importance. Given the limited size of the department, the projects currently under way are obviously a selection from a larger number of potential projects that could have been initiated, had the funding been available. The current choice of projects is based on a reasonable balance that includes personnel skills, feasibility, and requests from external funding sources.

8.4 National and international collaboration with universities and other research institutes on research and monitoring within the fields of Environment and Society and Arctic Environment

Department of Policy Analysis

The collaboration of the Department of Policy Analysis with universities is formalized by means of participation in research schools or general co-operation agreements. This collaboration includes agreements with University of Roskilde, the Royal Veterinary and Agricultural University, University of Copenhagen, Aarhus University, Aalborg University and the Technical University of Denmark.

The Department hosts the Center for Social Science Research on the Environment (CESAM), which is a collaboration that involves Aarhus and Aalborg University and which is supported by the Strategic Environmental Research Program. The department is also involved in several networks with other Danish governmental research institutes and research networks at a European scale. A joint Center for Analysis of Society and Environment (CASE) has been established with the Risoe National Laboratory.

As far as can be judged from the overview given of national and international collaboration, the general impression of the Panel is that the extent and nature of such collaboration is satisfactory. NERI collaborates with institutions that measure health data, e.g. airway function or childhood cancer incidences, so that joint projects can elucidate the possible contribution of air pollution to important health problems. However, due to the lack of large-scale funding for research in the environmental medicine field, only scattered collaborations of limited duration have materialized.

Previously, in section 8.2, the cooperation with partners in other countries was mentioned as a potential problem for the internal interdisciplinary cooperation within NERI. However, international research cooperation is important in order to provide new perspectives on the research - also for a governmental research institute like NERI. Ideally, the foreign research partners should be chosen within areas where NERI does not itself cover the relevant competency. The same of course applies to cooperation with domestic universities or other Danish governmental research institutes in joint applications to Danish research-funding authorities.

Arctic Department

Due to the circumstances outlined above, the department of arctic environment must necessarily collaborate with the Greenland Nature Institute, institutions involved in AMAP projects and other institutions that in some way have formal roles in this regard. In addition, the arctic environment researchers have actively sought out collaborators nationally and internationally, with whom the researchers may benefit from synergy. Greenland constitutes a highly valuable source for scientific information, and Denmark has a responsibility for ensuring that these potentials are explored and utilized internationally, to the benefit of Greenland, Denmark, and the international community. Given these highly important issues, the department should seek support for expanded efforts to create, e.g., biobanks with arctic tissue samples, and to generate databases on arctic environmental indicators for the use of researchers elsewhere.

8.5 General observations and recommendations on the fields of Environment and Society

As regards the Environment and Society Competence Area, the Panel has the following general observations:

- The research areas within the Department of Policy Analysis include 6 topics: Rural analyses, Risk assessment and chemicals, Integrated analyses, Environmental Economics, Environmental sociology and Air emission inventories. The staff most often contributes to and participates in two or more of these research areas. The Panel finds that this structure emphasizes, on the one hand, the importance of enhancing the cross-disciplinary character of the research, and on the other hand secures forums for method and disciplinary oriented discussions and development (e.g. within environmental sociology, environmental economics, risk assessment and chemicals).
- NERI's competence area in policy analysis has recently been expanded into environmental economics and environmental sociology. The Panel considers NERI's research on Environment and Society a necessary supplement to the original natural science based competence areas. This field is multidisciplinary, and a substantial effort must be allocated to ensure a critical mass and common working concepts.

- Although the productivity within this competence area in peer-reviewed scientific journals could be improved, the Panel is convinced that the research activities within this area are sound and necessary, and that field within a few years will reach a level comparable to the other competence areas in terms of coherence and outputs.
- Within the Department of Policy Analysis, the groups on risk assessment and atmospheric inventories represent approaches rooted more in natural science and engineering-based approach than the other research fields. The first mentioned group, emphasizing development of models for prediction of environmental fate of chemicals and relative toxicity using ranking order methodologies, was moved to the Department of Policy Analysis one and a half year ago from the Chemistry Department, which was dissolved and integrated into three NERI departments.

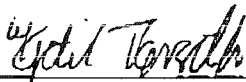
Within the competence area Environment & Society the Panel recommends that the following issues be considered as a follow-up of the evaluation:

- A strategic discussion of the competencies that NERI should cover within the field of Environment & Society should be carried out, involving NERI's directors, the board, and Ministry representatives. This discussion should focus on the division of labor between NERI and external research environments (universities as well as governmental research institutes), with a particular focus on any positive synergy effects from co-locating different competencies at NERI. Given the heterogeneity of the Department of Policy Analysis, the discussion should also consider the possibility of forming one or more Scientific Advisory Boards comprising experts with experience from applied and policy oriented work within strategic fields. Structural changes, such as moving the group on atmospheric inventories to another department, should also be considered.
- In the Department of Policy Analysis, a higher rate of publishing in peer-reviewed, international scientific journals should be actively encouraged. The Panel is aware that efforts have been made in order to increase the awareness of this issue within the department. However, in the Panel's opinion, substantial improvements will probably require stronger incentives than those at work today. The department should consider earmarking part of the time-resources provided through the Basic Appropriation to preparation and completing peer-reviewed scientific articles.
- The research on environmental sociology needs to be strengthened in order to reach a critical mass. The Panel is aware of the present difficulties in attracting external funding to this field. In this situation, increased allocation of resources from the basic appropriation should be considered. The focus within this field should also to a higher extent be directed towards issues dealt with in the other groups of the Department of Policy Analysis, notably sociological studies related to risk assessment (including risk perception).
- The Precautionary Principle should be considered a key topic of the research on risk assessment. Risk assessment efforts should include adverse effects as well as exposure assessments. Closer co-operation with public health research (including social sciences) needs to be established.
- A methodological discussion should be encouraged within the field of Environmental

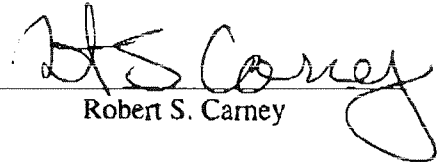
Economics in order to facilitate improved analyses of policies addressing long-term, global and irreversible environmental problems. The statistical/econometric competence should be strengthened, and the Panel appreciates NERI's attempts to recruit a professor within this field.

- The department needs to strengthen its internal process for ensuring high quality of its research projects. This has already been done within the field of Environmental Economics, and should preferentially be extended to the other groups as well. As a supplement to formal scientific publishing in peer-review journals, the department should consider introducing an electronic, externally reviewed Working Paper series.
- Foreign research partners should primarily be chosen within areas where NERI does not itself cover the relevant competency. The Panel is aware of the need to increase the proportion of internationally funded projects due to reduced basic appropriation and other national funding possibilities. However, if NERI researchers are increasingly forced to choose external instead of internal cooperation partners in interdisciplinary projects, the very idea of concentrating various types of environment-related expertise within one governmental research institute might be jeopardized.

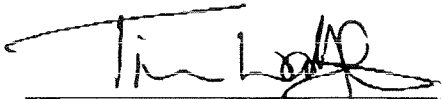
Roskilde, 21 August 2003,



Kjetil Tørseth



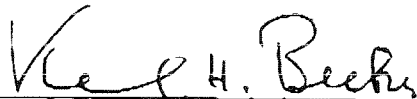
Robert S. Carney



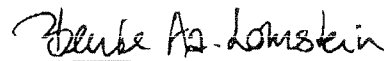
Timothy J. Wallington



Richard Burrows



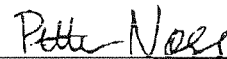
Karl Becker



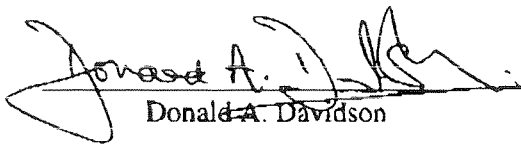
Bente Aagaard Lomstein



Thomas H. Christensen



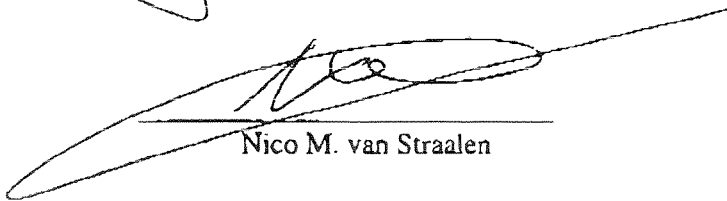
Petter Næss



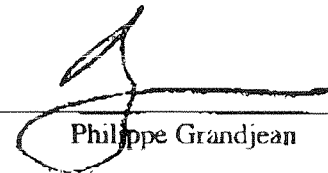
Donald A. Davidson



Per-Olov Johansson



Nico M. van Straalen



Philippe Grandjean

National Environmental Research Institute
Ministry of the Environment June 2003

**Terms of reference
for an international evaluation of The National Environmental Research
Institute (NERI)**

Background

NERI is a government research institute under Denmark's Ministry of the Environment. NERI's mission is to provide scientifically based monitoring and advice for decisions related to environmental policy and management. NERI's research, monitoring and consultancy are organised in six programme areas: Atmospheric Environment; Aquatic Environment; Terrestrial Environment; Arctic and Global Environment; Risk Assessment of Chemical Substances and Biotechnological Products; Interdisciplinary Research. NERI's activities are regulated in a government order and guided by four-year management performance contracts with the Ministry of the Environment.

NERI was established in 1989 following an international review of Danish environmental research. The review included a number of the present departments of NERI. During the following years additional reviews of NERI's research areas were carried out, most recently in 1997 when NERI's aquatic research was evaluated as part of an international evaluation of public Danish fisheries research. In view of the time elapsed since these reviews NERI's Board of Governors has decided to initiate a general evaluation of the institute and its research.

NERI is facing scientific as well as financial challenges, which are to be met in a new research strategy and management performance contract starting January 1st 2004. The evaluation shall provide advice on the strategy and contract.

Scope

The review shall evaluate the scientific quality of NERI's research and provide guidance on the research strategy. In addition, the review must evaluate the general performance of the institute and provide recommendations for the management.

Evaluation form and panel

The basic principle of the evaluation will be a peer review of NERI's research activities, as judged by the tasks assigned to NERI in the government order regulating NERI and NERI's management performance contract 2000-2003.

The evaluation will be carried out by an evaluation panel composed of leading international scientific experts with experience in NERI's research areas. The panel must include member(s) with management experience. It is also required that at least one of the panel members can read reports published in Danish.

The panel members are appointed by the Danish research councils.

NERI will supply the necessary background material and arrange visits to the research departments of NERI. Background material and a plan for the visits should be adopted by the panel well in advance.

Main tasks

The evaluation panel will prepare a report including considerations and conclusions about:

- The extend and scientific quality of NERI's research and its national and international position and impact. This point should also include an evaluation of whether there are professional or quality-related strengths, weaknesses or deficiencies in the activities.
- The relevance of NERI's research activities as a basis for Danish and international environmental policy and management. This point should also include an evaluation of NERI's application of scientific results in the institute's monitoring and advisory activities.
- The performance of NERI as a government research institute with respect to the tasks laid down in the government order regulating NERI and the management performance contract 2000-2003.
- NERI's national and international collaboration with universities and other research institutes.

Procedure

The Danish Research Councils appoint the chairman and members of the evaluation panel.

NERI will arrange the visit for the panel to NERI and supply practical assistance to support the evaluation, including travel arrangements and accommodation of the panel members.

Time schedule

The evaluation panel will be nominated and notified by the end of May 2003.

Background material and plan for visit to NERI will be forwarded to the panel in June 2003.

The evaluation report has to be completed by August 31st 2003.

Annex 2

National Environmental Research Institute
Ministry of the Environment June 2003

International Evaluation of National Environmental Research Institute, August 2003

Programme for site visit

August 18 – 21, 2003

Monday, August 18

9.00 – 9.30 Plenary	Welcome by Professor Hans Zeuthen, Chairman of NERI's Board of Governors			
9.30 – 10.15 Plenary	Briefing by the Management of NERI			
10.15 – 11.00 Plenary	General discussion, questions to NERI's management			
11.00 – 12.00 Plenary	Organisation of the Panel's work			
12.00 – 13.00	Lunch			
13.00 – 17.00 Sub-panels	Sub-panels meet research departments			
	Atmospheric	Aquatic	Terrestrial	Policy Analysis
13.00 – 14.00	ATMI	FEVØ	TERI	SYS
14.00 – 15.00		MAR	VIBI	TERI, MIMI (risk assessment)
15.00 – 16.00	SYS (emission)		AM	
16.00 – 17.00		AM (Marine mammals)	MIMI	ATMI (health)
17.00 – 18.30	Exchange of views after first meeting with research departments			
19.00 – 21.00 Plenary	Dinner with the Management and Directors of Research Departments			

Tuesday, August 19

9.00 – 10.00 Plenary	Exchange of views after day one			
10.00 – 12.00 Sub-panels	Atmospheric	Aquatic	Terrestrial	Policy Analysis
10.00 – 12.00	Follow up on interviews with research departments (Detailed planning Monday evening)			
12.00 – 13.00	Lunch			
13.00 – 14.00 Plenary	Exchange of views on reporting			
14.00 – 17.00	Follow up on interviews with research departments (continued) (Detailed planning Monday evening)			
19.00 – 21.00	Dinner			

Wednesday, August 20

9.00 – 9.30 Plenary	General discussion
9.30 – 12.00	Report drafting
12.00 – 13.00	Lunch
13.00 – 17.00	Report drafting
17.00 – 18.00	General briefing
19.00 – 21.00	Dinner.
21.00 -	Final report drafting

Thursday, August 21

9.00 – 10.00 Planary	Presentation of report to the Chairman of the Board of Governors, the Management, and Directors of research departments
10.00 – 12.00	Report finalisation. Chairman and Subpanel Chairmen
12.00 – 13.00	Lunch
13.00 – 15.00	Report finalisation, Chairman and Subpanel Chairmen
15.00 – 15.30 Panel chairman and sub-panel chairmen	Presentation of final report to the Chairman of NERI's board of governors and the Management.
16.00 -	Departure. Chairman and Subpanel Chairmen

Chairman of the Board of Governos of NERI

Prof. Hans E. Zeuthen

The Management of NERI

Director General Henrik Sandbech, M.Sc.

Deputy Director General: Peter Koefoed Bjørnsen, Ph.D.

Deputy Director General: Torben Moth Iversen, M.Sc.

Directors of Research Departments of NERI

Department of Policy Analysis

Director of Research Department: Hanne Bach, M.Sc.

Department of Marine Ecology

Director of Research Department: Bo Riemann, D.Sc., Professor

Department of Environmental Chemistry and Microbiology

Director of Research Department: Niels Kroer, Ph.D.

Department of Arctic Environment

Director of Research Department: Jesper Madsen, D.Sc.

Department of Terrestrial Ecology

Director of Research Department: Hans Løkke, Ph.D.

Department of Freshwater Ecology

Director of Research Department: Kurt Nielsen, M.Sc.

Department of Wildlife Biology and Biodiversity

Director of Research Department: Henning Noer, Ph.D.

Department of Atmospheric Environment

Director of Research Department: Lars Moseholm, Ph.D.

Resource persons from NERI

Terrestrial Environment: M.Sc. Mogens Bahn
Environment and Society: M.Sc. Hans Christensen
Aquatic Environment: M.Sc. Povl Frich
Atmospheric Environment: M.Sc. N. H. Bastholm

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