Publications of the Academy of Finland 1/08

Water Research in Finland 2002–2006

International Evaluation

Academy of Finland
Research funding and expertise

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International Evaluation

Members of the Evaluation Panel

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Pictures: Sebastian Valanko and Jukka Aroviita
Page layout: DTPage Oy
ISBN 978-951-715-687-5 (print)
ISBN 978-951-715-688-2 (pdf)
Edita Prima, 2008

Contents

Description

Publisher	Academy of Finland	Date: March 2008
Author(s)	Evaluation panel	
Title	Water Research in Finland 2002–2006, International Evaluation	

Abstract

The report presents the evaluation of Finnish Water Sciences. The evaluation covered the activities of the organizations or their relevant parts in the field during 2002–2006. The Academy of Finland called an international evaluation panel to conduct the task. The Panel was asked to pay the attention to the scientific quality in aquatic research and training, research environment and organization, research system in Finland and finally to the outreach of aquatic research to society. The evaluation field was defined to cover the water cycle in the nature with substances and biota involved. Altogether 17 Units were evaluated at seven universities and research institutes.

The Panel found research, in the areas it reviewed, to have very high quality by international standards and was impressed by the amount and quality of the work done. The Panel presented 11 recommendations, which help to direct the aquatic research and allocation of funds in future.

According the Panel Finland should revise the balance of allocation of funds nationally to favour the area of water research (and of environmental issues in general), particularly because of Finland's immediate and substantial dependency on natural resources. Many recommendations by the Panel concerned the needs of career development and researcher training. The focus should be shifted from producing large numbers of PhD's to better support of PhD- studies, to post doc positions and support for career development in general and in particular of women.

The Panel recommended the founding of a School or Department of Aquatic Environmental Sciences to educate students who will be able successfully to integrate understanding in currently traditionally separate areas. It also underlined the need for more integration among predictive modelers and experimental scientists and better model validation than presently.

The Panel recommended that the proposal to disband the Finnish Institute of Marine Research and separate its physical and biological sciences between the Finnish Meteorological Institute and Finnish Environmental Institute be urgently reconsidered as not in the interests of promotion of internationally credible marine science nor of increased understanding of the Baltic Sea ecosystem.

The Panel recommended also that, there be an expansion of work on flowing waters, that work on experimental whole catchments including lakes and peatland should be encouraged. Also an inventory should be made of current long-term data sets, with an assessment of their reliability and security and potential usefulness in integrated models and that these data may be made freely available on the Internet.

Key words	water research, hydrology, limnology, hydrobiology, ecotoxicology, fish biology, environmental research, marine science, research organization, funding, evaluation
Name and number of series	Publication of the Academy of Finland 1/08
ISSN	0358-9153
ISBN	Print: 978-951-715-687-5 / Pdf: 978-951-715-688-2
Number of pages	92
Distributed by	Academy of Finland, POB 99, FI-00501 Helsinki, viestinta@aka.fi
Published by	Academy of Finland
Place and date of printing	Edita Prima, 2008
Other information	www.aka.fi/publications

Kuvailulehti

Julkaisija	Suomen Akatemia	Päivämäärä Maaliskuu 2008
Tekijä(t)	Arviointipaneeli	
Julkaisun nimi	Water Research in Finland 2002–2006, International Evaluation	
Tiivistelmä	Raportissa arvioidaan Suomessa tehtävää vesialan tutkimusta. Arvioinnin kohteena oli alan tutkimusta harjoittavien organisaatioiden tai niiden relevanttien osien toiminta vuosina 2002–2006. Suomen Akatemia kutsui kansainvälisen paneelin suorittamaan arvioinnin. Heidän tuli kiinnittää huomiota alan tutkimuksen tasoon, tutkijakoulutukseen, tutkimusympäristöön ja tutkimuksen organisoitumiseen, suomalaiseen tutkimusjärjestelmään yleensä sekä alan tutkimuksen yhteiskunnalliseen vaikuttavuuteen. Arvioinnin ala määriteltiin kattamaan veden kiertoon luonnossa sekä siihen liittyvään aineiden ja eliöiden tutkimukseen. Arviointiin osallistui 17 yksikköä seitsemässä yliopistossa sekä kahdeksassa tutkimuslaitoksessa. Paneeli totesi suomalaisen vesitutkimuksen olevan erittäin korkeaa kansainvälistä tasoa ja ilmaisi ihailunsa sen saavutuksista. Paneeli esitti 11 alaan liittyvää konkreettista suositusta, jotka auttavat alan tutkimuksen voimavarojen ja aihepiirien suuntaamisessa. Paneelin mukaan suomalaisten tulisi kiinnittää nykyistä enemmän huomiota ja varoja vesi- ja ympäristöalan tutkimukseen, koska luonnonvarat ovat Suomelle tärkeitä. Useat paneelin suositukset koskevat tutkijakoulutuksen ja tutkijauran kehittämisen tarpeita. Painopistettä tulisi siirtää tohtorikoulutuksesta post - doc- virkojen lisäämiseen sekä toisaalta tukea jatko-opintojen tehokasta ja nopeaa loppuun saattamista. Myös naistutkijoiden urakehitystä tulisi tukea. Paneeli suositteli myös erityisen poikkitieteellisen vesi- ja ympäristöalan koulun tai laitoksen perustamista alan eri tieteenhaarojen integroidun kokonaisuuden opettamista varten. Pnaeelistit korostivat myös kokeellisen tutkimuksen harjoittajien ja mallien soveltajien nykyistä läheisemmän yhteistyön tarvetta ja kiinnittivät huomiota mallien hyvään validointiin. Paneelin mukaan Merentutkimuslaitoksen toimintojen jakaminen Ilmatieteen laitoksen ja Suomen ympäristökeskuksen kesken tulisi kiireesti uudelleen arvioida, sillä se ei tukisi kansainvälisesti merkittävää merentutkimusta eikä lisäisi Itämeren ekosysteemin tuntemusta. Paneeli suositteli panostuksen lisäämistä virtavesitutkimukseen ja erityisesti myös valuma-aluemittakaavaisen tutkimuksen lisäämistä. Paneelin mukaan pitkien aikasarjojen suhteen olisi tehtävä inventointi, jossa huomioon otettaisiin niiden luottavuus, tarkkuus ja käyttökelpoisuus integroiduissa malleissa. Paneeli arvosti laitosten pyrkimystä julkaista havaintoaineistoa vapaasti käytettäväksi esim. internetin kautta.	
Asiasanat	vesitutkimus, hydrologia, limnologia, hydrobiologia, ekotoksikologia, kalabiologia, ympäristöntutkimus, meritiede, tutkimusorganisaatio, rahoitus, arviointi	
Julkaisusarjan nimi ja numero	Suomen Akatemian julkaisuja 1/08	
ISSN	0358-9153	
ISBN	Painetulle kirjalle annettu tunnus 978-951-715-687-5	Pdf-versiolle annettu tunnus 978-951-715-688-2
Sivumäärä	92	
Julkaisun jakaja	Suomen Akatemia, PL 99, 00501 Helsinki	
Julkaisun kustantaja	Suomen Akatemia	
Painopaikka ja -aika	Edita Prima, 2008	
Muut tiedot	www.aka.fi/julkaisut	

Preface

Water and the substances it carries play a crucial role for the well-being of all living organisms including human society. In terms of water supply and quality the Finnish society will face many challenges in the coming decades. Great efforts have been made to improve water purification and reduce diffuse load, yet the eutrophication of the Baltic Sea, and fresh water basins pose major environmental problems. Climate change will further affect the temporal and spatial distribution of rain fall, the length of season with snow and ice cover, as well as the thermal regime of Finnish lakes and the Baltic Sea. The fate and impact of new and old harmful chemicals as well as nutrients drained into natural waters raise additional concerns.

Researchers try to understand the very complex interactions between abiotic and biotic factors as well as the interactions among organisms both at the level of populations and communities, with the aim to find solutions to protect nature and society. Excellent science and scientists who foster well-trained researchers in environmental, and in particular aquatic sciences, are a prerequisite for the success of this endeavour. Scientific excellence can best be achieved by international collaboration both in research and education; in addition measures are also needed to put the available research results into practical application.

One of the tasks of the Academy of the Finland is to conduct periodical evaluations to assess the scientific level of research and researcher training in Finland. The Research Council for Biosciences and Environment decided to launch such an evaluation of aquatic research at a meeting on 26 September 2007. The previous evaluation of hydrobiology was conducted more than twenty years ago. In September 2007, as one of the first activities, the Council dispatched a questionnaire to map actors and their research focuses in the field of water science.

In December 2007 the Council appointed a Steering Group, chaired by the undersigned, to plan and support the execution of the evaluation. The goal set by the Steering Group was to assess the scientific quality of Finnish aquatic research, to evaluate the structural state of this field in Finland, and to obtain recommendations for the further development of aquatic research. The focus was on the field of water research in general, not on the quality of the individual units as such. The Steering Group decided to include in the evaluation such water research that focuses on natural water basins and life in these waters, while excluding fields related to human health and water usage. In order to avoid undue overlap with the recent evaluation of geosciences the Steering Group restricted this evaluation to research on surface waters, whereas research on groundwater was excluded.

In spring 2007, a second more detailed questionnaire was dispatched to the units considered to fall within the scope of the evaluation where the units were asked to conduct a self-analysis and submit information to be used for the evaluation by the panel. The Steering Group decided to apply a broad perspective, and the smallest units were asked to merge their information with larger units in the same institute. This also happened within several university faculties and within some institutes as well. The units within the focus of the evaluation comprised 17 different groups

based at seven universities and eight research institutes. The units were asked to return their completed questionnaires in May 2007.

In July 2007, the President of the Academy nominated an evaluation panel of seven members. The panel was chaired by Professor Brian Moss and represented all ten key research fields in aquatic sciences. The members of the panel were all internationally well-known and highly respected scientists. In the execution of the evaluation the panel was assisted by an evaluation team at the Academy and an expert secretary, Dr Timo Huttula.

The panel held its first meeting in Helsinki on 4 November 2007, together with members of the Steering Group. The purpose of this meeting was to provide the panel with an overview of the organisational structure within which Finnish research is conducted. During the following days, the panel met in parallel sessions both senior and student representatives of the 17 units. At the end of the week, the panel drafted the first version of the report now at hand.

I would like to take the opportunity to thank the panel members for their willingness to take on the task and carrying it out with such a professional stance and ability to provide constructive criticism.

Helsinki, March 2008

Academy of Finland

Liselotte Sundström, Chair of the Steering Group

Summary

In 2007 the Academy of Finland appointed a panel of seven working scientists from outside Finland to review the state of surface water research in Finland. Surface waters include atmospheric water, and that draining from the land into streams, rivers, wetlands and lakes and thence to estuaries and the seas and oceans. The review included the functioning of little-disturbed systems and those influenced by human activities. It encompassed all the physical and biological sciences but not social links. It also excluded ground waters and peatlands, water supply and wastewater technologies. The Panel found research, in the areas it reviewed, to have very high quality by international standards and was impressed by the amount and quality of the work done. It had a number of suggestions to make that could improve the system of funding and managing research and maintaining Finland's intellectual, practical and policy positions in this area. It has expressed them as recommendations in Chapter 8. The following is a summary of them.

1. **We recommend that there is a need for some revision in the balance of allocation of funds nationally to favour the area of water research (and of environmental issues in general), particularly because of Finland's immediate and substantial dependency on natural resources.**

2. **We recommend creation of a more secure career progression for post-doctoral scientists in the Universities, through establishment of many more permanent positions. We note that recent panels on Finnish Geosciences, Energy Research in Finland and Food Sciences and Related Research in Finland have made a similar recommendation. There is clearly a major systematic weakness in this aspect of the Finnish system compared with other countries. We also recommend redoubled efforts to achieve a similar proportion of women in senior academic and institute posts to the proportion achieving PhD degrees.**

3. **We recommend establishment of a scheme to ensure continued input of new approaches by making a condition of Academy post-doctoral fellowships that the initial 1–2 years of a four-year fellowship be spent in different laboratory, ideally overseas, from that in which the PhD was obtained.**

4. **We recommend an urgent reform of the system for allocating funds for PhD work so that the time taken for achievement of a PhD is not more than 3–4 years. We note that a similar recommendation has been made by recent panels on Finnish Geosciences and Energy Research in Finland. There is clearly a major systematic weakness in this aspect of the Finnish system compared with other countries.**

5. **We recommend the founding of a School or Department of Aquatic Environmental Sciences to educate students who will be able successfully to integrate understanding in currently traditionally separate areas.**

6. **We recommend that there be more integration among predictive modellers and experimental scientists so that models of physical processes, hydrological processes and biological processes can be linked together to gain greater environmental reality. It remains crucial that there be more rigorous validation from real data on natural processes.**

7. **We recommend that the proposal to disband the Finnish Institute of Marine Research and separate its physical and biological sciences between the Finnish Meteorological Institute and Finnish Environmental Institute be urgently reconsidered as not in the interests of promotion of internationally credible marine science nor of increased understanding of the Baltic Sea ecosystem.**

8. **We recommend that, in the area of freshwater ecology, hydrology and limnology, there be an expansion of work on flowing waters, that experimental whole catchment and lake approaches should be encouraged and that more attention be given to integrating peatland and wetland research into the wider field of freshwater. In all areas there is a continued need to understand the implications of climate change.**

9. **We recommend that an inventory be made, with suitable funding, of current data sets, with an assessment of their reliability and security and potential usefulness in integrated models and that these data may be made freely available on the Internet. We suggest that assured funding is also required for 'Long term ecological research' sites.**

10. **We recommend that attention be given for the setting up of a fund for replacement of expensive analytical instruments, and supercomputing facilities, that are used on a shared basis among different users. We acknowledge the very important role of the many field stations in supporting water research in Finland and the general area of the Baltic and would wish to see continued strong support for them.**

11. **We recommend that there should be continued positive encouragement of outreach to the wider community, through courses in popular communication for PhD students, a target of one item of popular communication per peer-reviewed paper, and reporting requirements of such efforts for research grants.**

1 The scope of water research

1.1 Wherever you look, what you see will be linked with water. It need not be the sea, a lake or a river. It may be a forest or a garden, a school or a street, a mouse or a person. Water will either dominate its composition or determine its structure, function, design or behaviour. Earth would be lifeless, human culture would not exist, had not the size of the planet, its distance from the sun and its initial chemical nature all combined to allow the existence of liquid water. It is both mother- and master-molecule.

1.2 Water research, however, must be more narrowly defined for it to be reviewed. The panel heard of a conversation between a Finnish terrestrial ecologist and a Finnish marine ecologist, in which the former said '*I am in love with the problem and you are in love with the sea*'. What was implied was that for many scientists who work in aquatic habitats, both marine and freshwater, the lure is very much the medium of the water, the sheer romance of the milieu. Solutions to abstract scientific problems are sought but there is an importance of the pervasiveness of the medium. That is not surprising for the medium obviously dominates aquatic habitats in an immediate way and allows an easy habitat-based definition of the scope of water research. It is that where the medium dominates the problem. There are fuzzy edges, but as the hydrological cycle turns, rain, snow and ice form the first of a series of stages on which the dramas of water research are played. Even as rain, the medium has acquired not only a physical structure, but also a complex chemical composition from dust, aerosols and dissolved gases and a biological nature from pollen grains and micro organisms transmitted through the atmosphere. Melting snow banks and the interface between sea ice and seawater both rapidly acquire an ecosystem of algae, bacteria and small animals that can be, especially for sea ice, the most productive community in the area.

1.3 Rain and snowmelt gather into rivulets and streams; water that has pervaded the soil joins the surface run-off and the chemical complexity of the former atmospheric droplets increases further. Headwater stream communities develop and immediately links are forged with the surrounding land, for leaf litter and woody matter fall in and contribute, indeed dominate the structure of the stream. There is a geological contribution too, for the water erodes the land. It moves particles, from clays to huge boulders, into positions that continually alter as spates of water create a habitat that changes in detail, yet stays basically constant in fundamental nature. Insects will fly in; other small animals will find their way from springs and wet soils. Understanding this system requires the mathematics of fluid dynamics, the measurements of hydrologists and geomorphologists, the sophisticated instrumentation of chemists, the identifications of taxonomists, and the experiments of ecologists. Because human activities have frequently altered the land surfaces through forestry or grazing, applied scientists will also be needed.

1.4 From this stage in the hydrological cycle onwards we are dealing with exceptionally complex systems. No one has yet comprehensively understood the detailed movement of the water, or analysed the thousands of different chemical

compounds that the water will now have acquired, dissolved and suspended in it, or even listed all the organisms present. Increasingly, molecular methods of characterising living organisms, through the sequence of bases in their DNA, seem to indicate a biodiversity, especially of micro organisms, that is difficult to conceive. And as the water moves down the rivers to the floodplains, wetlands and lakes to the estuaries, seas and oceans, this complexity never decreases and the range of expertise needed to understand it continually increases.

1.5 As the network of river tributaries drains increasingly large catchment areas, a new dimension is added as fish move up from downstream or even from oceans thousands of kilometres distant. Salmonid fish bring nutrients such as nitrogen and phosphorus, as excreta or when they die and decompose, that they have accumulated from their growth in the ocean, to freshwaters that, although diverse in chemistry, may bear extremely small concentrations. Terrestrial litter, falling in, also contributes nutrients, as does the water draining through the catchment soils. But the forest and tundra vegetation also prize nutrients that are overall scarce, and have evolved mechanisms to hold these nutrients within themselves and minimise losses to the river system. To function, the river system has thus already acquired the three key features of pristine ecosystems: a parsimony of nutrients and a set of mechanisms to use these very efficiently; a characteristic structure, provided by geomorphologic, hydrological and biological features; and a connectivity that extends both upstream and downstream and sideways as well. Material falls in, but insects fly out as they emerge from their juvenile aquatic stages. Birds, bats and even large mammals like moose, wolves and bear either take food or contribute excreta to the river system.

1.6 We need not elaborate as the rivers widen, flood wetlands, fill lakes, and merge through estuaries with the coastal seas and eventually the deep oceans. The complexity, the connectedness, and the mutual interaction of the physico-chemical and biological components all increase in a sequence of dependency on systems upstream. Nothing gets simpler and the three-dimensional structures of lakes and seas, with stratification of temperature, light penetration and chemistry and the movements of large animals, add particularly expanded dimensions. Furthermore, throughout this sequence, there are both global and local influences, as might be expected from phenomena centred on a molecule that is so central to the workings of the planet.

1.7 To the natural complexity is added a social dimension. This planet existed, with self-regulating systems, in a dynamic but stable form, for many thousands of millions of years between the late Precambrian period and the recent, relative instant in time that has encompassed human evolution. It coped with geological events like the movements of the plates that bear the continents, major volcanic eruptions, and glaciations associated with cyclic changes in the relationship of the Earth to the Sun, with comparative aplomb. Its living systems combined to maintain an environment that was equable for the particular carbon and water-based biochemistry that evolved on Earth. It has met these challenges through a system of continual invention and testing that we call natural selection. It will undoubtedly continue to react to change. But what we do not know is the timing with which it will react to the changes being imposed by increasing human populations using increasing amounts of energy and material resources, and producing increasing amounts of toxic waste products with an

increasingly powerful technology. The problems are widely realised; the solutions are widely delayed or avoided. There has come about a socio-economic system that has its own considerable complexities but which has not yet successfully coupled itself to the natural system in a harmonious way that might allow the two to co-exist. At present the human system appears to be dominating. What we do not know is whether and when the natural systems will assert themselves. Ultimately research in the natural and social sciences squeezes itself into this uncomfortable zone.

1.8 We have powerful tools to examine natural systems. We have observations of increasing sophistication using aeroplanes and balloons to sample, and radar systems increasingly to follow, the dynamics of the atmosphere. We have hydro acoustic techniques for tracing fish and zooplankton in the vastness of the ocean. We can use automated monitoring and collection systems for the river waters, probes to determine the changing biological and chemical events in large rivers and lakes, even free-ranging 'gliders' to roam the seas sending back data, on physical and chemical and some biological conditions, of a quality and extent that were undreamt of only twenty years ago. Gas chromatography and mass spectrometry allow the analysis of such tiny concentrations of organic substances that the term 'undetectable' is becoming redundant and we can truly say 'absent'. Our molecular techniques improve extremely rapidly so that it is possible to trace individual activities of organisms, to discover their precise origins even when they appear in a tub in the fish market, and to reveal degrees of diversity and biogeochemical processes among communities and their differences. We have biochemical-molecular micro array techniques for measuring physiological status of organisms in response to alien substances and we can increasingly identify the activities of particular genes in ways that have revolutionised genetics and ecotoxicology.

1.9 We also have very complex statistical techniques to analyse enormous banks of data, to reveal subtle patterns, and to probe the uncertainties and apparently chance changes that are features of very complex systems. We have experimental techniques that can investigate, in laboratories, mesocosms, whole lakes and even whole catchments, mechanisms of how the systems operate. And where the systems are too big to be manipulated by experimentalists we can use predictive modelling to simulate them, and then subject them to experimentation in the computer. Our techniques to investigate socio-economic systems are less good, however. We behave as individuals as well as societies. Although biology and evolutionary psychology can determine that part of our behaviour concerned with simple biochemical survival, which we share with other vertebrates, the effects of the operation of the large cerebral hemispheres in our brains, which we do not share, are less certain. Social sciences, economics, politics, and cultural values all strongly influence our environment but the techniques for investigating them are far less developed than those that we use in the natural sciences. We might add, in the context of this review, that the assessment of research quality has elements that fall into this category!

1.10 On the other hand we have a very good grasp of the many ways in which human societies change natural systems. The list is very long. We start by discharging substances that alter the chemistry even of rain water. Sulphur oxides have been prominent but now are supplanted by nitrogen oxides, acidifying the water. Even more importantly, rises in concentrations of greenhouse gases are unanimously

accepted by the independent scientific community as responsible for accelerating global warming. In changing climate we change every aspect of the aquatic environment, from the survival of snow bank communities to the movements of the great ocean currents. The atmosphere transports a myriad of persistent organic pollutants that influence organisms, including health effects on ourselves. We alter land uses for animal husbandry, forestry, cultivation and urban settlement. This generally increases the loss of nutrients from the land that then eutrophicate aquatic systems downstream. We modify the patterns of discharge of water, with dams and hydroelectric plants, and bar the passage of migratory fish, and we engineer rivers, in the interests of agriculture and control of floods, where we have been unwise enough to build on floodplains that are naturally parts of river beds. We continually pollute our waters with new substances, often in small quantities but with proportionately high effects as the complexities of our lifestyle grow. We overfish on the one hand and import exotic species on the other. We also rehabilitate and remediate some of the damage we have caused and there is increasing interest in restoration of rivers and lakes. We are helped where the turnover of the water mass in the habitat is swift, as it is in the regional atmosphere, rivers and small lakes. But where it is slow, with bigger and bigger marine habitats and the global atmosphere, we run the risk that damage once caused will be irreversible for centuries and possibly millennia. Problems such as greenhouse gas accumulation and ocean acidification are profoundly serious.

1.11 Though there will always be much more to discover, our knowledge of the components of many of these systems is considerable. We frequently have well-founded instincts as to what should be done to preserve them as natural systems. What we most often lack is knowledge of how the parts fit together in a quantitative way, so that reliable calculations can be made of the complete consequences of existing and further damage, or degrees of management or remediation. Though environmental scientists have an instinctive grasp of the importance of variability and chance in complex systems, the general public and its representatives in government are more comfortable with a strong determinism, a solid and simple chain of cause and effect. To some extent predictive models can bridge this gap. We particularly lack good atmosphere-ice-water models, including integration of effects on biology and chemistry, and models linking land-use and hydrology in watersheds to dissolved and particulate components (nutrients, contaminants, suspended solids). We have only primitive models relating water inputs and consequent effects on coastal waters and the open sea, including an integrated approach to food web structure and dynamics and including fisheries, ecosystems, socio-economics, human behaviour and technology. Apart from physical atmosphere and ocean models, which are built on quantitative formulations of basic physical laws, models are only as good as the basic data available to them. Like computer programs, they cannot process what has not been incorporated into their design. Models need a background of observations and manipulated experiments as their raw material and if some key component is missing, the model may mislead. For example we heard a great deal about the two seal species of the Baltic Sea, but it was either in the context of seal as villain, in damage to fisheries, or of the seal as victim needing conservation. Natural selection is so powerful in determining the nature of ecosystems that we wondered whether the

question had ever been asked of what the essential role of the seals must have been, or still is, in determining the indefinite function of the Baltic Sea ecosystem.

1.12 Within this nexus, we have sought to define and assess a slice of knowledge and research in Finland that has been designated 'water research'. Our terms of reference were clear. The field was to be surface water in Finland or as investigated by Finnish scientists. It was to include all the biology and ecology of habitats dominated by surface water, whether fresh, brackish or saline and the physico-chemical characteristics of such habitats. It was to be about the systems as a whole and how they function, including the effects of people in damaging them and in restoring them. Our terms of reference excluded some areas that were linked, but which would have involved a very large extension of the panel that might have been unwieldy. Thus we did not review groundwater, except insofar as the water that moves through the soil and surface rocks rapidly gets delivered to streams; we did not review the technology of water supply or waste water disposal, though we looked at research that investigated the nature of the raw water used for supply and the effects of the effluents resulting from wastewater disposal. We looked at the provision of water resources to society but not the specifically medical aspects of water-borne human disease, nor the social and policy research that investigates the consequences of the operation of our cerebral hemispheres. We did not look at aspects of peatland research that involve terrestrial ecologists and peat technologists. But these limitations did not greatly limit us. Although all things are connected by water, the definition of research areas was not difficult for it followed conventional divisions that have compartmentalised research for a century or more. This may be a limitation to the understanding and solution of the problems that face us, but it made the task of review easier.

1.13 In carrying out our task, we were greatly helped by a supporting team, Timo Huttula, Timo Kolu and Anneli Aitola, from the Academy of Finland, whose burden of organisation was very large. We are also grateful to all of the Universities and Institutes (often referred to here as 'Units'), who spent a great deal of time compiling the written evidence asked of them, and to those of their members who gave time to talk to us and make presentations. Among these we were especially impressed by the attention that a large number of PhD students gave to the process. In a sense our task is made easier by the nature of the scientific community. Almost universally its first loyalty is to discovering the truth of things as best it can. Its standards are inherently high for its values are absolute. What we are thus assessing is to a large extent the degree to which Society supports these values by provision of funds, facilities and encouragement, an endeavour crucial to any Society that lives beyond the present. And finally the chairperson is grateful to his large dog, Morgan, whose need for two hours of walking every day gave an opportunity for quiet reflection during the writing of the first draft.

2 The state of water research in Finland

2.1 The panel was asked to assess the relative quality and quantity of aquatic research in Finland. This posed inevitable problems of by what standards should these things be assessed. There are no absolute standards. There is no equivalent to a physical law that says that a population of x people should do y amount of research, and there is no equivalent to the accuracy and precision by which a scientist may measure a temperature, a concentration or the number of organisms. Secondly, the panel comprised seven people, each with particular expertise and specific interests and could not be expert in every detail of water research. There is always the danger that an area is undervalued because of ignorance. On the other hand the panel was asked to comment mostly on the generalities of research in Finland, from a shared background of many years of working in the scientific community, and in this it was appropriate and expert.

Quantity of research

2.2 Finland invests a high proportion (about 3.5%) of its gross domestic product (GDP) in research, and although GDP is a very biased measure of a country's performance, it is widely used. Precise figures vary from year to year and are not always strictly comparable, but Finland's investment is apparently lower than that of Sweden (4.0%) but much higher than those of the EU in general (<2.0%) or the USA (2.7%). We do not know, however, how this sum is divided among subject areas. Finnish government policy is first to promote economic activity in a country whose standard of living is high but in which there is an ageing population. The budget of Tekes, for technological research and development, is far higher than that of the Academy of Finland and in general research directed at wealth creation seems much better funded than that on understanding natural support systems. This is undoubtedly common practice in all countries and is based on the assumption of the primacy of human interests. Our current global experiment with the climate system, where we seem unable to control our activities in the best interest of our future survival, ought to trigger an urgent reappraisal of the balance of research funding.

2.3 The total number of people involved in water research in Finland, bearing in mind that its population is around 5 million (compared with the 5.5M in Denmark, 9.0 in Sweden, 61 in the UK, 82 in Germany, 303 in the USA and 1169 in India, the countries of origin of the panel members) seems in line with our perceptions for European countries, perhaps underrepresented compared with North America and hugely generous relative to India. Table 2.1 lists total staff investment in the Finnish Units reviewed and Table 2.2 the number of research active staff. These numbers include the number of PhD students and staff on both permanent and temporary contracts. Overall there have been between three and four hundred research active staff in post in water research during the period, with about a further one hundred administrative technical and other supporting staff. Of course there will be a number of supporting staff, in funding agencies outside the Units reviewed, which also contribute to the research effort, but it is not possible to quantify these. The ratio of

Table 2.1. Total number of staff involved with aquatic research in Finland. Values are in person-years.

Organisation	Faculty/department	2002	2003	2004	2005	2006	Total
UH	FAF	13,6	14,4	14,5	14,6	16,6	73,6
UH	FB	65,1	76,9	89,3	84,6	92,9	408,8
UH	FS	20,1	18,5	15,9	17,2	14,2	85,8
UJo	FB	32,1	33,7	30,8	33,1	35,3	165,0
UJ	DBE	40,3	37,9	36,0	36,2	36,3	186,7
UO	DB	8,4	10,6	17,3	15,8	14,2	66,3
UO	WREEL	7,8	7,8	9,0	11,0	15,0	50,5
UT	FMNS	21,8	23,3	25,9	25,2	29,4	126,5
ÅU	FMNS	27,5	29,2	28,2	32,8	37,1	154,7
HUT	LWRE	25,5	29,0	29,0	33,0	30,5	147,0
MTT		7,9	8,4	8,4	9,4	10,4	44,3
SYKE		50,7	60,2	60,9	57,2	56,7	285,7
FFRI		10,9	14,4	13,2	12,6	16,1	67,2
FGFRI		30,5	30,6	34,4	34,3	35,5	165,3
FIMR		47,8	48,1	50,0	45,5	42,8	234,2
FMI		7,6	8,6	12,1	13,3	20,8	62,3
KTL		3,9	3,9	4,1	3,9	3,4	19,2
Total		**421**	**455**	**479**	**480**	**507**	**2343**

Table 2.2. Number of research–active staff in aquatic research in Finland. Values are in person-years.

Organisation	Faculty/department	2002	2003	2004	2005	2006	Total
UH	FAF	12,1	12,9	13	12,9	14,9	65,7
UH	FB	56,4	68,3	80,7	76,7	84,9	367,0
UH	FS	15,3	14,6	13,8	15,1	12,1	70,8
UJo	FB	21,1	21,4	19,2	20,2	21,7	103,6
UJ	DBE	33,2	31,1	31,3	32,3	29,4	157,3
UO	DB	6,8	8,5	14,3	14,1	12,0	55,7
UO	WREEL	5,8	5,8	7,0	9,0	13,0	40,5
UT	FMNS	17,9	17,6	19,7	20,6	25,2	101,9
ÅU	FMNS	21,4	23,1	22,1	27,8	32,0	126,4
HUT	LWRE	18,5	21,0	21,0	24,0	22,5	107,0
MTT		6,3	6,8	6,8	7,8	8,8	36,3
SYKE		48,2	54,3	55,3	51,6	51,4	260,8
FFRI		4,3	3,5	4,3	5,8	6,0	23,9
FGFRI		18,3	18,3	22,1	22,0	22,0	102,7
FIMR		37,1	36,7	37,1	32,0	29,4	172,3
FMI		4,6	5,5	9,0	10,1	17,6	46,7
KTL		1,6	1,6	1,8	1,6	1,1	7,7
Total		**329**	**356**	**378**	**384**	**404**	**1846**

administrative staff to research active staff seems acceptable, though several Units commented on a lack of support in activities concerned with the raising of research funds and there was a view from within the panel that in general shortage of support staff in Scandinavia might undermine scientific productivity.

2.4 Funding of water research comes from two basic sources, the core grants given directly by the Finnish government to Universities and Research Institutes and the money raised by the efforts of their staff externally and almost always competitively. The average funding over the period has been about equally divided between these sources, amounting, in round figures, to between 11 and 12 million euro per year from each source. This represents a high dependency on external sources for a research area that is entirely in the interests of society in general and 'not for profit', but again is in line with our perceptions for European countries. It may be generously biased towards core funding in comparison with the USA.

2.5 Table 2.3 gives the total funding per year per research–active staff member (including PhD students, post-doctorals and assistants as well as those permanently employed) and shows an investment of about 48,000 euro per year per person in aquatic research. There is some variation but this is inevitable given greater labour, overhead or equipment costs in some areas than others. This is specifically research investment and does not include teaching investment. Fifty thousand euro is a modest sum considering the costs of modern research equipment, the previous investment in training, the overhead institutional costs, and salaries paid to highly qualified people that are generally low compared with other professions and business.

2.6 It is possible to examine the investment in relation to research funding in Finland as a whole. In 2004, 5.25 billion euro were invested in research, but 70% of this came from private business and was likely to be in development of products rather than fundamental research. Very little of it was likely to be for further understanding of the environment. Table 2.4 shows research funding in the entire public sector and is taken from The Science and Technology Policy Council of

Table 2.3. Funding per person involved in aquatic research in Finland. Values are thousands of euro per person per year.

Organisation	Faculty/department	2002	2003	2004	2005	2006	Mean
UH	FAF	56	56	58	56	61	58
UH	FB	53	51	46	51	47	49
UH	FS	35	26	38	43	41	36
UJo	FB	32	33	48	41	42	39
UJ	DBE	46	48	47	46	47	47
UO	DB	42	45	52	52	51	50
UO	WREEL	65	62	56	41	32	48
UT	FMNS	43	50	50	52	51	49
ÅU	FMNS	36	42	51	39	30	39
HUT	LWRE	39	40	43	43	47	43
MTT		46	49	49	46	59	58
SYKE		49	48	41	47	50	47
FFRI		23	27	29	35	40	31
FGFRI		48	52	47	48	44	48
FIMR		72	74	71	66	67	70
FMI		15	19	27	28	21	22
KTL		89	81	59	79	74	76
Mean		**48**	**48**	**48**	**48**	**47**	**48**

Finland Report (2006), *Science, Technology, Innovation.* (ISBN 952-442-206-3). It shows a rise in real terms in funding with increases of +4.2% in 1991–1995, +24.3% in 1996–2000 and +6.7% in 2001–2006. The Academy of Finland benefited in particular from the general increase. However, the total funding for water research in 2005 was 23.1 million euro, of which only 11.3 million was core funding. Water research thus accounted for just under 0.7% of government research funding and only as much again was contributed through competitive funding. In view of the dependence of the Finnish economy on the resources of the Baltic Sea, the provision of water power through hydroelectric generation, the freshwater fisheries, and industries like forestry that have a major impact on water and water resources, this seems to us a low figure.

Table 2.4. Government research funding (1991–2005). Millions of euro adjusted to 2006 prices

	1991	1995	1996	2001	2005
Academy of Finland	75,6	77,1	84,4	153,8	223,5
Tekes	156,5	243,9	246,2	390,8	448,4
University core funding	226,3	220,4	258,6	346,4	416,7
Research institute core funding	209,9	194,6	196,1	215,8	259,4
Other research funding	131,5	158	153,4	189,1	248,7
Total	**799,8**	**894**	**938,7**	**1295,9**	**1596,7**

2.7 Research output can only be readily measured by the amount of publication. Publications are not standard units. They vary in length, content of new data, wealth of new ideas and impact on scientific thought, and the more important of these things are impossible to measure in any absolute way. We are thus reduced to considering mere numbers. Table 2.5 shows the number of publications divided into those in international and national journals.

2.8 A 1986 review of hydrobiology, (broadly the ecological part of our current remit), in Finland found that a high proportion of publications were then appearing in local journals and were relatively unavailable to the international community. This clearly has changed in response to the recommendation, made by that previous panel, that there should be much more emphasis on publication in international journals. Currently international publication accounts for the great majority of the output. Table 2.6 shows the total number of publications per research active staff member. Such statistics need careful handling for traditions of publication, including length of publication, vary greatly between fields. Rate of publication is generally between 1 and 2 per person per year with two above-average outliers in the Finnish Institute of Game and Fisheries and the Public Health Institute. There are no research Units obviously below the rest and 1–2 publications per year overall seems healthy. There can be no fixed standards but as a comparator, in the UK Research Assessment Exercise for Universities, the panels examine one publication per year for each full-time researcher and this may be taken as a reasonable expectation for publication rate. The reasons for the two upper outliers may be, in the case of the Finnish Institute for Game and Fisheries, a very wise policy of extensive collaboration outside the Institute plus a strong pressure to make its information available because of the social importance of fisheries. The rate for the Public Health Institute also is thought to reflect collaboration, particularly with the Finnish Environment Institute, and the role of the National Public Health Institute in chemical analyses of samples collected

Table 2.5. Total number of publications over the five-year review period that were peer-reviewed, produced in international and national journals by Finnish water research scientists.

Organisation	Faculty/ department	International journals	National journals	Total journal articles	International edited volumes	National edited volumes	Total articles in edited volumes
UH	FAF	55	1	56	2	4	6
UH	FB	349	6	355	92	14	106
UH	FS	74	11	85	18	4	22
UJo	FB	82	10	92	44	40	84
UJ	DBE	209	15	224	36	16	52
UO	DB	59	2	61	7	11	18
UO	WREEL	36	6	42	45	9	54
UT	FMNS	130	7	137	16	7	23
ÅU	FMNS	155	11	166	24	5	29
HUT	LWRE	52	30	82	86	11	97
MTT		17	4	21	2	0	2
SYKE		245	13	258	92	15	107
FFRI		17	2	19	28	17	45
FGFRI		217	35	252	28	0	28
FIMR		186	25	211	56	2	58
FMI		34	7	41	56	2	58
KTL		27	7	34	19	16	35
Total		**1944**	**192**	**2136**	**651**	**173**	**824**

Table 2.6. Number of publications produced per person per year in peer-reviewed international and national journals by Finnish water research scientists. Units are publications per person per year.

Organisation	Faculty/department	International ref. articles	National ref. articles	Total
UH	FAF	0,84	0,02	0,85
UH	FB	0,95	0,02	0,97
UH	FS	1,05	0,16	1,20
UJo	FB	0,79	0,10	0,89
UJ	DBE	1,33	0,10	1,42
UO	DB	1,06	0,04	1,10
UO	WREEL	0,89	0,15	1,04
UT	FMNS	1,28	0,07	1,34
ÅU	FMNS	1,23	0,09	1,31
HUT	LWRE	0,49	0,28	0,77
MTT		0,47	0,11	0,58
SYKE		0,94	0,05	0,99
FFRI		0,71	0,08	0,79
FGFRI		2,11	0,34	2,45
FIMR		1,08	0,15	1,22
FMI		0,73	0,15	0,88
KTL		3,51	0,91	4,42
Mean		**0,97**	**0,10**	**1,07**

by other Units. Costs per publication are also of passing interest so long as too much emphasis is not placed on them. Table 2.7 shows these to be on average 52,500 euro per publication, not far from the annual investment placed in each researcher and consistent with expectations elsewhere.

Table 2.7. Costs per publication of peer-reviewed articles produced by Finnish aquatic research scientists. Units are thousands of euro per publication.

Organisation	Faculty/department	Publication costs
UH	FAF	75,9
UH	FB	56,7
UH	FS	36,6
UJo	FB	70,2
UJ	DBE	39,0
UO	DB	53,9
UO	WREEL	57,6
UT	FMNS	45,2
ÅU	FMNS	36,4
HUT	LWRE	76,7
MTT		121,6
SYKE		52,1
FFRI		110,7
FGFRI		31,3
FIMR		77,7
FMI		33,9
KTL		43,1
Mean		**52,5**

Quality of research

2.9 Our overall view was that Finnish research in aquatic sciences is easily comparable in quality with that of other wealthy countries. The lists of publications that we examined contained many examples of papers in international journals for which standards and rejection rates are high. For many such journals the acceptance rate is now between 20 and 30%. Science progresses first from the provision of radical new ideas from a very few individuals, whom we may call the architects and then development and testing of these ideas by a small army of artisan bricklayers, carpenters, plumbers and plasterers. The architects are few anywhere and are recognised by high accolades. It would be invidious of us in this report to select particular names as examples. as we would do injustice to others whom we did not mention. Suffice it to say that Finland has a system of recognition through its Academy professors and its Centres of Excellence, and that we find the standards it imposes in giving this recognition to be comparable with those used elsewhere. We suggest that the funds available need boosting to recognise others of equal quality.

2.10 The panel divided the research being carried out into several coherent areas so as to give some indication of its strengths and gaps in its coverage. Thus we provide overviews of hydrology and water resources: limnology and freshwater ecology;

marine science; and ecotoxicology. These areas are determined largely by the Panel's particular expertise, and a traditional organisation of subject areas that may no longer be entirely in line with modern understanding of the interlinking and connectedness of many phenomena, but we shall have more to say of this in subsequent Chapters.

Finnish research on hydrology and water resources

2.11 Generally, research on hydrology and water resources (which we treat, for convenience in this section, as excluding ecological and limnological aspects) in Finland is internationally competitive with a sufficient publication rate in international scientific journals. Although the main part of the research effort is devoted to national problems, the generality of methods and approaches ensures international recognition. Some sub-disciplines are more advanced than others, but altogether the level is satisfactory. The coordination of the efforts is in general adequate, despite examples where unnecessary duplication and lack of coordination can be seen. An open graduate school that would allow all supervisors and PhD students interested in hydrology and water resources to participate might be an instrument for improved coordination and mutual exchange of research results.

2.12 At all institutions there is a strong focus on direct measurement and acquisition of new data. This implies less emphasis on mathematical model development than seen in some other countries, but for the chosen focal areas of research it seems well justified. Nevertheless, there is a challenge in applying new modelling approaches, including use of GIS, assimilation of remote sensing data, and application of geophysical measurements, in future research efforts. Up- and down-scaling of forcing variables, modelling grids, effective parameters, and process description are research fields of great importance, where more efforts are needed at hydrological scales. The same applies to assessment of model uncertainty, which presently is a very active theme of research internationally.

2.13 Radar techniques have been introduced to obtain better estimates of areal precipitation. Although a routine monitoring network is in practical use in Finland, ongoing research is important for improving the precision and credibility of radar-based precipitation data. Snow and ice studies are crucial elements in hydrology focused on northern conditions. Detailed process knowledge is procured on variability in accumulation, melting, reflection and emission, and progress is ongoing in synthesising the results.

2.14 Catchment processes like runoff, evapotranspiration, infiltration, percolation, and exchange between surface and groundwater are carried out as basic research themes for understanding and modelling natural as well as human-influenced catchment processes. In particular, transport and transformation of nutrients conditioned by agricultural activity is an area of great concern. Pathways are explored by means of tracers, and methods for reducing the nutrient load of rivers and lakes are being investigated. Monitoring and modelling of lake eutrophication is an important element in these efforts. Finland has a leading position in this regard. Also studies of lake physics including hydrodynamics, lake ice and lake optics have resulted in international recognition.

2.15 The natural hydrological system has to a great extent been modified by human activity. Drainage of catchments is heavily modified, water is being abstracted

for water supply, and urbanisation is taking place at an increasing rate. By today's standards crude channelisation of rivers, uncritical loading of rivers and lakes by waste water, drying-up of wetlands, and peatland mining without land re-establishment are no longer acceptable, and there is a strong need for restoration efforts. This is an active research field where Finland has a prominent role. Urban hydrology was previously completely dominated by stormwater design, but now new ecological concepts are being introduced, and Finland is an active player in these activities. Generally, ecohydrology, linking hydrology and ecology, is an emerging discipline where Finland is in a good position to become an important player.

2.16 Hydrology related to development of hydropower is not a particularly active research area at present. This may change as important questions related to optimisation of the hydropower potential as well as real-time management of hydropower plants are being posed. Modern optimisation tools have recently been introduced, which may lead to considerable economic gains. Due to the impact of climate change, a need for reconsideration of reservoir safety may emerge in the future, which again will lead to more focus on hydropower-related hydrology.

2.17 Climate change impact studies are carried out by running regional climate models generated from general circulation models. Finland has been active in developing coupled atmospheric-oceanographic models. Exchange of water, energy and other substances between land and atmosphere is still modelled by simplified land-surface schemes. By running regional climate models under different future scenarios, large-scale assessments of climate change impacts can be obtained. Further, by forcing hydrological models with regional climate model outputs more detailed information on the impact on the water balance and ecosystems can be obtained. Ideally, more detailed hydrological models should replace the land-surface schemes, but so far, scaling problems and excessive computer requirements have prevented this. Finland is in a good position to explore the possibilities for overcoming the current limitations. Other global change effects caused by human activity, and possible mitigating interventions, can be taken into account as well. The effects on ecosystems are extremely important to assess, and flood risk is another particular concern in the light of climate change expectations. The modifying effects of flood plains should be analysed in detail, and flood protection and mitigation measures must be analysed according to safety requirements. Finland is actively contributing to all these research efforts.

2.18 Integrated water resources management (IWRM), where all water uses are seen in the context of the needs for both socio-economic development and ecosystem protection, is a growing area for applied research. Nationally the development is being pushed by the EU Water Framework Directive. The introduction of IWRM principles in developing countries may, however, be seen as even more important. Exploring the trade-offs between the different water uses through application of hydro-economic analysis techniques, introduction of demand-management policies, empowerment of institutions, and stakeholder involvement are all elements in the overall efforts. Food security and poverty reduction are major drivers to be balanced against ecosystem needs. Sustainable development is a multi-faceted concept. Sustainable water use is an inherent and extremely important element that must be ensured now and in the future, where increased urbanisation and climate change effects make the problem even more complex. Finnish research has made a strong contribution to the development and implementation of IWRM principles in developing countries.

Finnish research on limnology and freshwater ecology

2.19 Nothing exists in tight compartments and freshwater ecology and limnology in Finland are no exceptions. Substantial parts of the Baltic Sea are freshwater or of such low salinity that they would come under the compass of freshwater scientists in many countries rather than marine scientists. Salmonid fish and eels also bridge the artificial divide between fresh and salt water. For this review, however, we have chosen to allocate all Baltic Sea research to marine science, and migratory fish to freshwaters. We have also separated hydrological and water resource aspects and ecotoxicology though they too are ultimately inseparable from biological phenomena. Fig. 2.1 shows a survey of activity as a basis for discussion.

Fig. 2.1. Classification of research in freshwater ecology and limnology in Finland. Red box shows areas in which there is relatively small activity, orange box, moderate activity and green box, high activity. Institutions where the research is carried out are shown but indications of activity are for Finland as a whole and are not reflections of the specific activity within these institutions, which is generally high. Abbreviations in appendix G.

	Whole catchment	Rivers and streams	Lakes
Nutrient processes	FFRI, MTT, HUT/LWRE	SYKE	UJ/DBE
Organism-orientated (physiology, evolution, genetics)	Not relevant	FGFRI, UO/DB, SYKE	FGFRI, UH /FAF, UJ/DBE, UH/FB, UT/FMNS
Process-based and community research	SYKE	SYKE, UO/DB	UJ/DB, UH/FB UT/FMNS
Whole ecosystem based research including palaeolimnology	UJo/FB, UJ/DBE,UH/FB,UH/FS , SYKE	No activity	UJo/FB,UT/FMNS, UJ/DB, UH/FB

2.20 Whole catchment research is largely founded in palaeolimnology, there being very little, as far as we can see (there may be some in Geography departments that were not included in our terms of reference) GIS based research seeking to understand how land management is changing with its implications on water quality. There are excellent studies on field lysimeters and forest sections that give good data on the sub-catchment scale. Palaeolimnology has long been strongly covered in Finland and remains a high quality area. The other 'green' category is organism-based research, which has benefited from current interest in the use of new molecular techniques. There are excellent groups in this area, which is well represented, particularly where cyanobacteria, and fish and their parasites, are concerned. 'Orange' and particularly 'red' areas need further strengthening. Surprisingly, in view of the importance of the Water Framework Directive, nutrient work is confined to two institutes and has a relatively minor role in one University. Similarly, process-based work is limited throughout and work on rivers and streams is confined to one location, except where it is specifically directed to fisheries management. Given that

rivers are as important a component of the freshwater network as lakes and of equal importance for both fisheries and for the Water Framework Directive, this is a major gap. Expansion of work on flowing waters is desirable.

2.21 Lake studies are currently relatively well represented, but we were told that one University will withdraw from this area within a few years and that activity is likely to be reduced at another. We are strongly in favour of the consolidation that is going on at the University of Jyväskylä and are well aware of the strengths of the University of Helsinki, at Viikki, Lahti and Lammi, but think that a third centre should be encouraged also, to maintain an alternative creative outlook. Since most research is concentrated in southern Finland, where human impacts are greatest, there are arguments for a centre in the north where near-pristine systems can be studied. The Water Framework Directive places emphasis on reference standards that are pristine, though most countries in Europe have none of these. Finland is an exception and should exploit this. There is also, apparently, a lack of wetland (floodplain function, mire dynamics) research, although this may have been left from our remit by exclusion of peatland work. Again a northern location would provide excellent sites, and further development at Oulu would be appropriate.

2.22 The approaches used in Finnish freshwater research are largely accepted and conventional. New techniques (molecular, stable isotope) are used and becoming widespread, but often the approach tends to be conventional. There is a need for large-scale ecosystem studies using macrocosms, whole lakes and experimental catchments that are manipulated to reveal mechanisms of operation. The concept of an experimental lakes area close to Jyväskylä is a very good one and we hope that the aquarium and pond facilities built by the Game and Fisheries Research Institute at Kainuu will be widely used. We were especially impressed by the outward looking policies of this Institute. A real need everywhere, however, is for experimental manipulations of land use on whole catchment areas containing lake and river systems. It is likely that these will provide really new insights that cannot be obtained from simply putting together results from small components of the system.

2.23 Restoration ecology is also an area that needs strengthening. Finland has suffered perhaps less structural damage to its rivers than other lowland European countries but damage is widespread in the south. River restoration techniques, pioneered especially in Denmark, which include re-establishment of floodplains and natural channels can be applied but Finnish work on these is very rare and still subject to a compromise that favours conventional engineering. Nonetheless we were heartened by the more ecological approaches being taken by Helsinki University of Technology where urban rivers are concerned. Lake restoration receives an adequate amount of attention, has flagship projects at Lahti, and shares approaches with studies on the Baltic Sea. Many restoration attempts do not go entirely to plan and need close scientific monitoring to improve predictability for future projects. Continued support of this area is needed.

2.24 Finland hosted, at Lahti in 2004, the Triennial Congress of the International Society for Limnology. This was extremely well-organised and marks the esteem with which Finnish limnology and freshwater ecology is held on the world stage. Its publications and influence are strong. There are gaps in coverage, particularly for rivers (other than perhaps, river fish, where there is extensive work) and always some danger that the area in general may be disfavoured as commercially applicable biology

commands more funds. The use of freshwaters as relatively inexpensive models for studying processes that are crucial on global scales and of key importance to human survival should not be underestimated.

Finnish research on marine science

2.25 There is a strong societal need for integrated scientific research to provide predictive capacity for the fast and large-scale environmental changes (climate change, eutrophication, pollution) that take place in coastal waters, continental seas and the oceans. Well-founded and credible scenarios and models for decision-support-systems rely on high-quality scientific data, both experimental and from long-term monitoring. Examples of research areas that are currently at the forefront of integration on a world-scale include: atmosphere-ice-water models including integration of effects on biology and chemistry, linking land-use and hydrology in watersheds to dissolved and particulate (nutrients, contaminants, suspended solids) and water inputs and consequent effects on coastal waters and the open sea; integrated approach to food web structure and dynamics including fisheries, ecosystems and society (socio-economics, human behaviour). Finnish research on marine science covers a wide range of disciplines and subject areas, including most of the areas noted above. Continued strengthening of the linkages and integration of the science should be strongly encouraged. More than 90% of Finnish marine research is conducted in the Baltic Sea, with a small contribution to polar research. There is no significant contribution to deep-water oceanographic research.

2.26 A recent analysis of ISI ranked world-wide Baltic Sea publications, including 1975 papers published in international journals in 2002–2006 (carried out within the BONUS programme, www.bonusportal.com), shows that Finland was involved in 433 (22%) of these papers. In 2004, overall, 882 Baltic Sea research projects were funded with 52 million euro. Relative to other Baltic Sea countries, Finland had very little 2002–2006 EU funding, whilst the proportion of core funding was comparatively high in Finland, when assessed in 2004. We would encourage greater collaboration in EU programmes. The major Units involved in Baltic Sea research in Finland are the Institute of Marine Research, Environment Institute and Game and Fisheries Research Institute, Åbo Akademi University and the Universities of Helsinki and Turku. All six Units have considerable international cooperation and national cooperation is outstanding. The structure supports this as the government institutes and universities have been much integrated with shared professorships, PhD students, shared infrastructure, data sharing, complementarity of expertise, and proximity of buildings.

2.27 Based on the number of ISI ranked publications addressing Baltic Sea research, the main fields of study are ecology and physiology (47%), followed by physics (15%), and toxicology (12%). Basic research comprises 41%, while subjects of applied research are mainly fish biology and fisheries (19%), contaminants (10%), eutrophication (9%), and cyanotoxins (7%). The number of Finnish papers on climate change, introduced species, and biodiversity is relatively low, similar to the emphasis in other countries contributing to Baltic Sea research. Research on socio-economy, administration and legislation development as well as network and capacity building is low throughout the Baltic Sea Research and needs strengthening.

2.28 Sea ice (both physical and community aspects), cyanobacteria, and animal physiology from a molecular perspective, are three of the strongest areas of marine research in Finland. There is high international recognition for contributions to the advancement of science in these areas. Sea ice and cyanobacteria are also issues of high societal importance for Finland. Research in all these areas is being conducted jointly at universities and government institutes. However, we should emphasize that the wide diversity of marine research by Finnish scientists in other areas is important and, in an international perspective, of high quality. This includes, for example, benthic ecology and effects of eutrophication on changes in food web structure and function.

2.29 Not unexpectedly, the large institutes are more diverse, whilst the smaller Units are more focused. In terms of the emphasis among the different scientific disciplines, Finland is very similar to pan-Baltic research. There is a higher percentage of publications in fishery research in Finland than in the other pan-Baltic countries. Fish have high societal importance for Finland. Microbial ecology and biogeochemistry are very active fields of marine research in other European and North American institutions/universities. However, overall microbiology (bacteria and viruses) including microbial ecology and their biogeochemistry is less well represented in Finland. In contrast, cyanobacterial research is overall stronger. There is a strong emphasis on applied research in Finland, especially in the fields of fish biology and fisheries, cyanotoxins, and combined human impacts.

2.30 Research collaboration within the Baltic Sea area is very good but we would encourage additional collaborations. Combining and integrating the Finnish long-term data sets with those of other Baltic Sea countries into a modelling framework to maximize the understanding of ecosystem processes for management services would have widespread benefits, as would increased cooperation with research groups on coupled physical-biological processes in the Baltic. There is some investment in Arctic Sea research (Institute of Marine Research) but Finland's Antarctic Programme appears to contain almost no aquatic research.

2.31 Some increase in research sites outside the Baltic region would be beneficial for expanding international contacts/interactions, for interpreting the Baltic research within a wider context, broadening the approaches and questions, and in providing additional opportunities for training. We would also encourage continued research on the combined effects of multiple human impacts (multiple stressors) on ecosystems.

2.32 There is a clear recognition of the importance of modelling in Finnish water research. Models are mentioned in many of the research descriptions of the different Units and refer to a wide spectrum of approaches, ranging from simple statistical models in lakes, bio-energetic models of fish to describe responses of fish growth to toxins, up to full three dimensional circulation models with coupled biogeochemistry components.

A particular successful sector of this field in Finland is ice modelling, which comprises both applications, e.g. for ship routing in ice covered areas such as in the Gulf of Bothnia, and basic research on ice physics and thermodynamics of sea ice. Enhanced understanding will improve descriptions of ice dynamics in models. There is a well established cooperation between the Division of Geophysics of the University of Helsinki and the Finnish Institute of Marine Research.

2.33 Hydrodynamic models are important for research on freshwater and marine systems, and are available in several versions. Apart from models developed in

Finland, in particular in the Institute of Marine Research, there are also implementations of community models, which are freely available as public domain software. Among the important applications for public services is oil spill prediction, providing predictions of how an initial distribution will spread over the next few days. There are also attempts to include biogeochemical model components into ocean circulation models. A particular important issue is the modelling of the development and spreading of cyanobacterial blooms. A pre-operational model was implemented at the Institute of Marine Research and is already in use. A strong role in modelling is played by the Finnish Meteorological Institute, which has a large research department supporting further development of and improvements to atmospheric models. The Finnish Meteorological Institute plays an important role in ocean and lake modelling by providing forcing data and cooperates with ocean modelling and hydrologic groups aiming to couple water cycle processes in comprehensive model systems. Research at the Finnish Meteorological Institute, in cooperation with the Finnish Institute of Marine Research is also considering the coupling of ocean-atmosphere models on event scales to increase accuracy of predictions e.g. during episodes of cold water upwelling. The supercomputing power in the Finnish Meteorological Institute is, to a certain extent, also available for other research Units. Further cooperation among the Finnish Meteorological Institute, the Finnish Environment Institute, and other smaller Units, concerns the study of future changes in the Baltic and in the Finnish lakes by downscaling climate scenarios and providing forcing data for regional and local models.

2.34 In principle, there exists in Finland the potential for system modelling covering the full water cycle, from water in the atmosphere, transferred through precipitation to the land, storage in soils, leaking to ground waters, and flow through small streams to rivers, lakes and estuaries until it enters the coastal zone and eventually the open sea, but this potential has not yet been realised. We heard that there is a wish to chain such models from representatives of several Institutes. A further modelling issue for lakes, the Baltic Sea and oceanic regions, is the connection of physical circulation models and biogeochemical or biological population models. Although some progress has been made during the last decade, the development of new generations of coupled models is a vast future research field with large potential in basic research and applications. An example is the vision of full food web models bridging the gap between biogeochemical and fish models. A further challenge concerns the next step, the development of concepts connecting these models with socio-economic models.

2.35 We suggest the development of modelling initiatives, where scientists working on models have a forum to exchange ideas and information, connecting different competences, and to join forces to develop a national concept on modelling aquatic systems. The challenges posed by future modelling perspectives mean a need for new, more intense education and training in theory and modelling skills. Currently, a central educational role is assigned to physicists and physical oceanographers, teaching at the University of Helsinki. These are university professors, adjunct professors from the Institute of Marine Research and also at the Meteorological Institute. This group is relatively small and not primarily focusing its teaching on models. Moreover, any such training does not, in general, reach the other disciplines relevant for aquatic chemistry and biology. A new approach could be the development of curricula addressing modelling issues particularly aimed at those who

intend to work primarily with experimentation or the collection of field data. This could help to develop a common language and foster an intense interaction of theory and experiment. This might be fostered by establishment of at least one School of Aquatic Sciences.

Finnish research on environmental toxicology and ecotoxicology

2.36 The intersection of toxicology research and water research in Finland addresses problems of chemical contaminants in the Baltic, as well as in freshwater systems. Science in general in Finland is very strong, with high quality and productivity. Similarly, research involving chemical contaminants and natural toxins in aquatic systems, and their effects, is characterized by high quality and productivity. These qualities reflect the essential role that aquatic resources play in Finnish society and economy and the threat to those resources or to humans from natural and anthropogenic contaminants in marine and freshwaters. Research in environmental- or eco- toxicology is broadly based, with research ongoing at a majority of the Finnish universities and Research Institutes that were evaluated. The Units and the general areas of research at those Units are listed in Fig. 2.2.

Fig. 2.2. Distribution and emphasis of environmental toxicology and eco-toxicology aquatic research in Finland Abbreviations: BFR – Brominated flame retardents, DLC – Dioxin-like compounds including polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF) and polychlorinated biphenyls (PCB); PBDE – polybrominated diphenyl ethers; NP, nonylphenols; BPA – bisphenol A; OC – organochlorines; PAH – polycyclic aromatic hydrocarbons; Cyanotoxins – Cyanobacterial toxins

Unit	Substances studied	Research focus
UH/FB	Cyanotoxins, DLCs, petroleum	Distribution, environmental levels
UH/FAF	Cyanotoxins	Synthetic pathways, mechanisms of effect, genetics
UJ/DBE	DLCs, PAH, pulp mill effluents	Bioaccumulation, biological responses, photoactivation
UT/FMNS	Copper, other metals, hypoxia, oxidative stress, DLCs	Molecular mechanisms, stressor interactions
ÅU/FMNS	Cyanotoxins, copper, pesticides, DLCs	Detection, analytical chemistry, impacts
UJo/FB	PAH, DLCs, BPA, NP, Pesticides	Toxicogenomics, bioavailibity, mechanisms
FIMR	Cyanotoxins, marine pollutants, DLCs, PAH, metals	Distribution, environmental levels, trophic transfer, biomarkers
SYKE	DLCs, methyl mercury, PBDE, BFR	Environmental exposures, metabolism and effects
FGFRI	DLCs, PAH, PBDEs, organotins, pesticides, environmental changes, cyanotoxins	Exposures and environmental levels, reproductive effects in fish and seals, bioaccumulation
KTL	DLCs organotins, methyl mercury	Analytical chemistry, epidemiology

2.37 The spectrum of investigation ranges from factors governing the bioavailability of sediment contaminants, biotransformation, and food web transfer, to aquatic animal exposure, animal health and reproductive effects, as well as human exposure from fisheries products and human health. The toxicants or toxic agents include chemicals of long-standing concern, i.e., heavy metals, organometalics, polynuclear aromatic hydrocarbons (PAH), persistent organic pollutants including polychlorinated dioxins (PCDDs), dibenzofurans (PCDFS) and biphenyls (PCBs), as well as chemicals or potentially toxic substances that have been more recently identified in the aquatic environment or more recently determined to be of potential health concern. These latter substances include polybrominated flame retardants (e.g. polybrominated diphenyl ethers), nanoparticles, as well as chemicals from pharmaceuticals and personal care products. The natural toxins include important cyanobacterial and dinoflagellate toxins, especially the hepatoxin nodularin (from *Nodularia spumigena*). Finland has a leading role in research on cyanotoxins in the Baltic Sea; Finnish scientists were involved in 30 out of 41 research papers published in international journals between 2002 and 2006. New concerns also have arisen with the first finding of the dinoflagellate *Alexandrium* sp., which produces a fatal neurotoxin saxatoxin, in the Baltic Sea. While all the areas are strong and recognized internationally, the studies on dioxins and dioxin-like compounds as well as cyanobacterial toxins are particularly strong, in the scale of this work worldwide.

2.38 The studies include basic research on mechanisms of action, reproductive and developmental toxicology, development and application of biomarkers, and xenobiotic metabolism, and human health. The cyanobacterial toxin synthetic pathway has been identified, facilitating studies of toxin production. Approaches involve the methods of chemistry, microbiology, biochemistry, molecular biology, and epidemiology. Collectively, the programmes in toxicology represent a substantial and impressive effort to identify, understand, and protect against health risks from environmental chemical hazards in Finnish waters. The research has basic mechanistic as well as very practical public and ecological health importance.

2.39 There are a number of issues and opportunities for environmental toxicology that arose in discussions during the evaluation. First, there is some concern that instrumentation adequate to the analyses required may not be sufficient to the needs of all the Units and in that respect collaboration should be strengthened in highly-specialized analytical facilities in environmental research. Secondly, it appears to this Panel that some structure to facilitate and encourage interaction among the toxicologists in the different Units could enhance the research in all, by assisting in sharing methods and expertise, as well as identifying specific research collaborations that may enhance progress toward the collective goals. There is, for example, a great strength in Finnish toxicology research on mammalian systems. Facilitating interactions between all groups pursuing toxicology could enhance the total product of this research in the country. And thirdly, some such structure could aid the training of PhD students as well as post-docs, in research, as well as perhaps in identifying and articulating specific societal impacts of their research.

3 The research system and the state of research organisation for water research in Finland

3.1 The basic organisation of research in Finland is similar to that of many other countries. First there are institutions of two basic kinds. The Universities have a dual role in teaching undergraduates as well as in postgraduate teaching and research and the Government research institutes have a dual role in advising government and providing essential information for management and in providing research-based information for policy formulation. They also co-operate with the Universities in postgraduate education. We formed the view that co-operation among the Institutes and Universities in Finland has been exemplary.

3.2 Secondly there are funding bodies. Government provides core funds, which appear to support about half the research system (Chapter 2) whilst the remainder is provided competitively from the Academy of Finland, The Finnish Funding Agency for Technology and Innovation (Tekes), Ministries, Private Foundations and external bodies such as the European Community Research Framework Programmes.

3.3 And thirdly, there is the body of people that carry out the research. This exists as a career hierarchy. At its apex are permanent professors and holders of senior posts in the institutes, sometimes with titular professorships, and senior scientists (institutes) and lecturers (universities), also with permanent posts. Following them are post-doctoral posts, and PhD students, all supported by temporary contracts. There is also a group of supporting staff, including administrators and technicians, amounting to between a fifth and a quarter of the number of research active staff and accounting for about one quarter of the total budget (Chapter 2).

3.4 Lastly there are those who benefit from the research carried out, but not included in the above groups. This includes the general public, business and other organisations within Finland and the scientific community in other countries, particularly those that surround the Baltic Sea, but ultimately world-wide. This Chapter and Chapters 4, on the research environment, 5 on the doctoral training system and 6 on the communication of research findings outside the research community are interlinked and overlap; we have attempted to minimise repetition, but some is inevitable.

Organisations

3.5 Universities are peculiar bodies. Their role in science is differently perceived by different people outside them and is continually changing. Fundamentally they see themselves as institutions where new knowledge is freely generated, by unfettered research, and communicated to students, who then take that knowledge into society at large. Others may see them primarily as bodies for the training of people in roles that society outside requires at the time, and that the research carried out should also be so directed. Most people would agree that their independence is paramount. Their loyalty is to the gaining of understanding, independent of any political or economic

sectional interest. Such loyalty is not even to humanity specifically but to the totality of understanding. In water research in Finland we found ample evidence of such academic freedom and are satisfied that the fundamental role of the Universities has not been compromised despite increasing pressure for 'applied' research and investment in it. We noted also a healthy integration of the results of fundamental research into applied questions, often in co-operation among the Universities and research institutes. We heard that Universities in Finland have state controls, for example in their ability to raise funds for new buildings, that are more restrictive than elsewhere and that at least some University rectors would like greater freedom and are likely to gain it. We heard also, from University staff, fears that this would result in compromise of their activities and decreased intellectual independence. On a world scale, there are many different compromises within these poles, whilst at the same time a great deal of truly independent information is generated. The strength of a University is in the minds of its most gifted members and we are confident that, as they have for nearly a thousand years, these will prevail to maintain independence of thought.

3.6 Government research institutes are less mysterious. They have a clearly defined role to support government, and in states where government is regularly elected, as in Finland, they are almost always honest brokers of relevant information. We saw excellent examples of work highly relevant to the needs of society in the Finnish Institutes, ranging from studies on the nutrients leaching from drained forests to the risks posed by the eating of fish contaminated by persistent organic pollutants; and from the prediction of patterns of rainfall events using sophisticated radar to the population dynamics of threatened species. We were particularly impressed by the cooperation between all the Institutes and Universities. This ranged from provision of expensive facilities such as sophisticated aquaria and open tank systems for fisheries experiments, and a research vessel, to supervision of research students. There was some hint indeed that supervision within the Institutes might be closer and more caring than in some Universities simply because of proximity of active researchers. The Institute staff have much less independence than those of the Universities, however, and one trade-off is in a greater proportion of permanent posts than in the Universities. However, Institutes are vulnerable to changes in government policy and currently have been instructed to reduce their staff progressively in an attempt to divert more young people from the public to the private sector in a Finnish population that is becoming richer in older people than in younger. This is understandable as long as some limit is set that prevents the Institutes from dwindling to such size that they are unable to function with flexibility and that they are able to continue to attract young scientists. This policy has forced more co-operation among Institutes and Universities, however, with very positive benefits, in one case with a rise in publication rate inversely correlated with a decline in funding.

Funding bodies

3.7 There is a range of funding bodies, mostly ultimately governmental. Funds can be divided into those provided by core budgets for Institutes and Universities and those provided through competition. The central funding body for research beyond core government funding in the area of water research is the Academy of Finland. The

Academy accounts for about one quarter of total internal non-core funding with Tekes administering a half and government ministries a quarter. There is some additional funding from private foundations (6.4 million Euro between 2002-2006), a small sum compared with government sources, but very valuable and carefully directed. Tekes has a minor role in funding fundamental research in aquatic sciences. Nontheless, Tekes funds applied research for innovations in environmental field e.g. projects concerning development of detectors and telemetry for environmental purposes. Private business contributed little to the contracts and research grants received by the Units for environmental research, though ultimately its activities are major contributors to environmental damage. There may be scope for governmental pressure for this to be remedied.

3.8 The Academy of Finland is the country's funding body for fundamental and strategic research. It responds to proposals generated by the scientific community, has occasional directed calls and programmes (in water research, BIREME, for research on the Baltic was funded from 2001-2005), designates Centres of Excellence and supports Academy Professors and Research Fellows and postdoctoral work. The Ministries fund research that relates directly to their activities and policies. Fundamental research is ultimately the driver for all else. Without new ideas there can be no new applications. The balance between the Academy (which is responsible for all areas of research, not just scientific and technical) and Tekes might thus be seen to be skewed in the wrong direction, particularly in view of the existing high investment in its own developmental research by private business and its minimal contribution to research in the wider interests of society.

3.9 We heard little criticism of the Academy's practices. One issue was that its single date of application for post-doctoral research fellowships in January, and the subsequent delay in funds being provided for successful applicants, can mean a two-year interruption in the careers of young scientists who have the misfortune to have their final degree examination early in the calendar year. Otherwise the Academy was perceived as a fair-minded, transparent institution. Its appointments to Academy professors (tenure 5 years, extendable to 10) and Academy Research Fellows (5 years) in the Universities are appreciated but might be construed as undesirably influencing, by the Academy's choices, the academic freedom of the Universities. However, this is unlikely because of the freedom given to those appointed and the scarcity of them. There are 40 Academy professors (in all subjects) from a total of 2100 professorships in Universities and 260 Research Fellows compared with perhaps 3000 posts funded in other ways. Academy Fellows are mostly recruited from among the latter posts, which generally have high teaching loads and limited opportunities for research. The Academy funds PhD studentships through project grants instigated by senior researchers but does not offer them independently to individual students. This practice differs from that of some other countries where postgraduate studentships not linked to larger projects are channelled through the research councils or equivalent funding agencies.

3.10 We were repeatedly told that obtaining funds was difficult, and that standards were high, and we do not disagree. Peer-reviewing practices are strict and epitomised by the completely non-national composition of the present panel. We do not believe however that obtaining funds is more difficult, at least than in other

European countries. We do think that a greater investment should be made in this area of research and we think that competition will nonetheless remain high, for increased funding will primarily give greater career security and encourage more young people to continue in scientific careers. We also, as working scientists, acknowledge that competition is not always a productive strategy and that much effort and time is wasted where only a small proportion of otherwise valuable research proposals is funded for lack of sufficient investment.

People

3.11 The research system in Finland clearly produces large amounts of very high quality, internationally competitive research in the area reviewed. It is also commendable to have policies in the Institutes that a very high proportion of research staff is trained at least to PhD level. The hidden aspect, however, is that this is at some human cost that might be avoidable. The issue is one of career security. We deal with parallel aspects of PhD training and funding in Chapter 5. Here we are concerned with the long years between submission of a successful PhD thesis and the acquisition of a permanent post. The relative research productivity of the Institutes is not markedly different from that of the Universities (Chapter 2) and we cannot distinguish any great difference in quality (Figs 3.1, 3.2) yet we heard that government policy is to have lower than 12.5% of temporary contract posts in the Institutes, whereas practice in the Universities appears to be diametrically opposite. A scientist may have reached the age of 40-50 before acquiring a permanent post and is forced to support his- or herself on three year or shorter contracts for two decades or more.

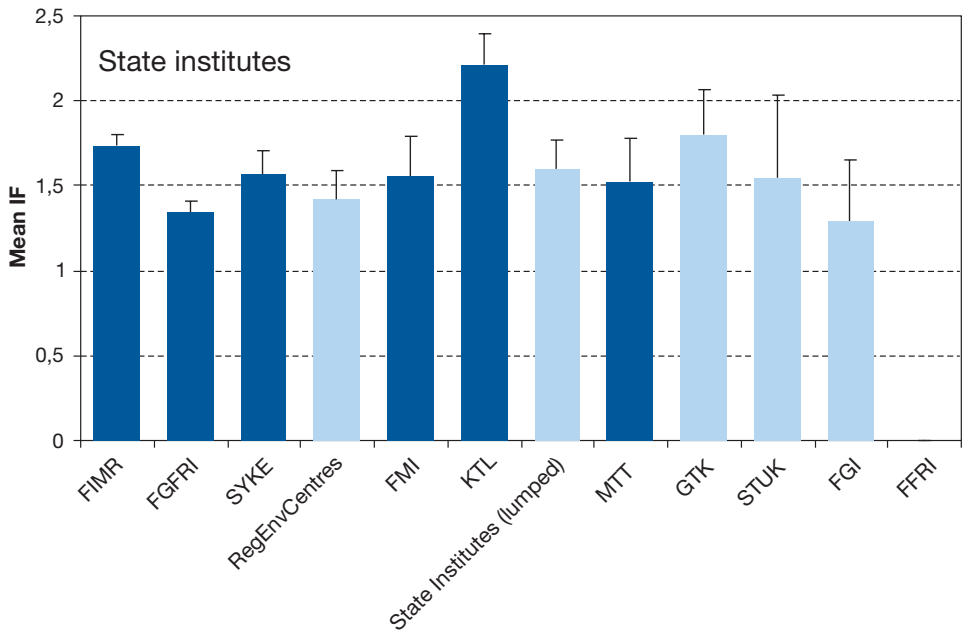

Fig. 3.1. Impact factors (IF) for papers published on the Baltic Sea by Finnish Research Institutes (based on an independent survey carried out by Dr P. Snoeijs for the BONUS Project). Dark colour indicates Units reviewed here. GTK= Geological Survey of Finland, STUK = Radiation and Nuclear Safety Authority, FGI= Finnish Geodetic Institute

3.12 There are no statistics on the rate of loss of people to other careers, but there are about 8200 PhD students, and 3100 postdoctoral workers (over the system as a whole). Assuming similar rates of turnover, there might be more than 50% attrition. This is probably not unusual in other European countries as PhDs join government departments, work for non-governmental charity organisations, become senior teachers, or enter other employment as professionals with independence and investigative and organisational skills. These calculations, however, give only a bare picture; what is not figured into them is the stress of insecurity and the time wasted in continually seeking funds for continuation of employment for those that do survive in the research system. We think there is a need for urgent reform of this system with the Universities being brought into line with the research institutes. We note and concur with the recommendation of the 1986 review of Hydrobiology '*that vigorous and innovative measures be taken to increase the number of existing positions by providing a moderate but continuous increase in permanent mid-career scientific positions, which are now quite inadequate'.* The Academy, in consultation with other sources, particularly the Ministry of Education and Foundations, which appear (Chapter 5) to be crucial in support of PhD students, might like to consider mechanisms to reduce the number of PhD places in favour of strengthening post-doctoral security. We were told (by the students themselves) that at least a proportion of PhD students is not highly motivated and although research group leaders might regret a decreased provision of labour, the system as a whole should benefit from such a reform.

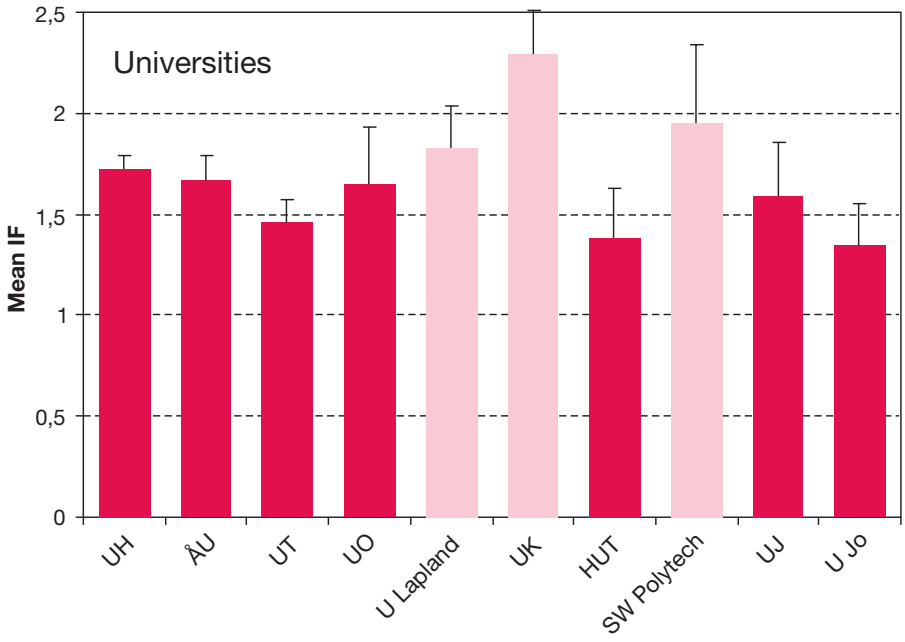

Fig. 3.2. Impact factors for papers published on the Baltic Sea by Finnish Universities (based on an independent survey carried out by Dr P. Snoeijs for the BONUS Project). Dark colour indicates Units reviewed here.

3.13 We noted a tendency for research to be focussed in Finland, and for there to be comparatively little interchange between Finnish scientists and those outside the Baltic states. Co-operation with other Baltic States, however, was judged to be very high on the basis of a quite detailed analysis by one of the Panel of the statistics of such co-operation. It is difficult to quantify, but the greater the international interchange, the more rapidly do new ideas and approaches fertilise a nation's research. We saw data on visits made to Finnish institutions by scientists from overseas, and of reciprocal visits, but we were struck by no great overall richness in either, nor by a plethora of invitations to Finnish scientists to address international conferences. Finland is an attractive country; perhaps the incentives to travel are too low; and perhaps an appealing natural diffidence gets in the way of promoting scientific achievements overseas other than through formal papers. We think positive incentives will help and suggest that postdoctoral fellowships offered by the Academy should encourage the spending of one or two out of four years in an overseas laboratory, and preferably not one around the Baltic. As Finland will wish to retain the services of these people, incentives to return to Finland must also be high and a more secure career structure would be one good way to ensure this. It may also be part of the solution to the problem of an ageing research community in the Institutes, though this is a problem largely consequent on government policy on Institute funding, which can be readily changed.

3.14 A final aspect of the personnel component of the research system is equality of opportunity. This is an issue greatly discussed in Finland. Taking the entire University system and data for 2006 (*www.research.fi*), the proportion of women (57%) undertaking first degrees is higher than that of men (43%). The gap widens slightly in favour of women at Masters level (60%, 40%) then reverses (women 47%, men 53%) at PhD level. What is most striking is the low retention rate of women in academic jobs relative to the proportion receiving PhDs. Only 37% of senior assistants are women and there are even fewer (23%) women professors. The water science community appears to be even less favourable towards women (Table 3.1.). Incentives to retain women in the academic workforce are needed; the Academy should undertake an evaluation of what would be needed to retain more women scientists through to the professoriate.

Table 3.1. Academy posts and other research posts in water research in 2002–2006.

Post	Males	Females	Total	Female %
Academy professors	2	1	3	33
Academy senior researchers	8	1	9	11
Academy research fellows	8	0	8	0
Professors (Academy posts included)	65	9	74	12
Senior researchers (Academy posts included)	121	56	177	32
Post doc researchers	60	56	116	48
PhD-students	138	196	334	59
Total	**402**	**319**	**721**	**44**

Infrastructure

3.15 In terms of infrastructure for research, we noted that most laboratories were very well equipped and that staff were proud of this. Research equipment currently is becoming more versatile, more powerful and more expensive, with needs for replacement more rapidly than perhaps formerly. Two Units maintained ships of substantial size but did not seem to think there were severe problems with refitting when necessary. A great deal of Ministry money appears to meet these needs. Laboratory equipment is a different matter for it can only be replaced as part of a specific grant. Such equipment may only be used for limited periods by an individual institution but much greater use of it can be obtained from specialist shared facilities. Finnish institutions have already realised this and equipment and services, for example at the National Public Health Institute and the various experimental facilities of the Finnish Game and Fisheries Research Institute are widely used. Nonetheless we feel that a specific fund to replace large instruments that are shared between institutions would help.

4 The Finnish Research Environment

4.1 The concepts of top-down and bottom-up control of ecosystem function have a hazy origin but they have received a great deal of refinement through research on aquatic systems and have a well-defined meaning. Attractive terms are, however, often adopted in other contexts and lose that precision. In organisational terms these terms are now widely borrowed and appear to refer now to any pair of contrasted viewpoints, especially where there is a sense of mutual control and response. Chapter 3 was about the top-down pole, the provision of funds, with hints of the bottom-up response. Chapter 4 looks at the same topic with a reverse emphasis.

4.2 The organisation of Universities and Institutes, their location and custom are, to a large extent, matters of history. They are bodies that change relatively slowly, often over cycles that are about the length of a human career. Sometimes reformers are able to impose large changes more rapidly, but these are inevitably muted by internal resistance if they do not receive the accord of the vast majority of the people concerned. Worldwide, in the past three decades there have been significant changes as governments have imposed a more managerial approach on educational and research institutions, using terms like ‘value for money’, ‘critical mass’, and ‘accountability’ that have developed in commercial business. It is extremely difficult to determine whether this approach has succeeded in producing more new ideas or better understanding in the research world but it has had a considerable effect on how time is spent by working scientists. Many of the analyses, written by Units that we reviewed, talked of increasing amounts of time spent in responding to these measures. Senior scientists often now spend almost all of their time raising funds to maintain their teams and laboratories, and in Finland even the PhD students (Chapter 5) have

been frequently trapped into this system. We gained the impression of a research community passionate about its science and the role it could play in improving the Finnish, indeed global environment, but fearful of threatened changes that would further erode core budgets, and anxious about its ability to maintain its current strengths. We do not prescribe an immediate solution for this but merely observe that it is a situation that needs questioning based on rigorous evidence for its alleged effectiveness.

4.3 There has been much internal reorganisation in recent years, with a trend towards creation of larger Units by mergers of smaller departments into larger faculties. Sometimes these have not seemed the most logical on intellectual grounds, but there are many considerations that result in such changes. For the future, our advice is that one of the key problems in water research is a traditional separation of subject areas that goes back to early education. Modern understanding requires engineers to be well-trained in ecology, marine biologists to be thoroughly conversant with chemistry and physics and all to appreciate the interplay of the social sciences with their work. The subject areas created in the Universities that were appropriate in the nineteenth century may need revision. Of course there must be specialisation; there is no point in training 'jacks of all trades but masters of none', but truly interdisciplinary training and organisation may pay considerable rewards. There has been, in some countries, a trend towards creation of Schools (or Departments) of Environmental Science, blending together disciplines from environmental philosophy and law at one extreme to geophysics and meteorology at the other with a middle ground of ecology, soil science and economics. Sometimes this has been too ambitious a grouping, but Schools of Water Science with the same scope would seem a desirable development. We have heard several requests for a graduate school in water science and we found the graduate schools to be a very positive force. We did not feel, however, that a single graduate school in aquatic science would be appropriate but rather that the area needed several more specialist schools, in hydrology and freshwater ecology, and predictive ecosystem modelling for example. Such specialisation might seem to argue against the concept of a much bigger interdisciplinary department, but does not. The aim is to produce specialists with a wide view obtained from the contacts within a broadly based department, rather than specialists raised in conventional subject areas, with introverted approaches.

4.4 Counter to this we have found a strong sense of collaboration within Finnish aquatic science, with inevitable competition for funds but also excellent co-operation, especially between Institutes and Universities. The placing of satellite laboratories of the Institutes on University campuses, even in the same buildings, seems to have fostered this and bucks a trend of increasing centralisation that has caused discord in other European countries. The free availability of Institute facilities to University scientists, the willingness to place PhD students in Institutes and the appointment of shared professorships are also positive signs. We applaud the open policies for use of the various University field stations and think that the number and quality of such stations is excellent.

4.5 The existence of Academy Professors and Fellows and Centres of Excellence seems to be accepted. There will always be people deserving of these that are not awarded them where funds are limited and there is a danger that morale in the community is endangered if there are too few. The trend should thus be for a small expansion in this system. There are two current Centres of Excellence in the area we reviewed but we could see other potential candidates. We accept that Finland has a very positive policy to equal opportunities for women scientists and suggest that the Academy might wish in the future to increase the proportion of female academy professors to above the present level of fewer than 13%. We are concerned, however, that there is also too much dependency, in most University departments, on a very few individuals for their fund-raising and external prestige. Retirement, or, more likely, career moves of such individuals can be very disruptive to a department. The solution, we believe, is a more broad-based system of permanent posts that would have natural successors available in departments to smooth these disruptions.

4.6 We found the scope of activities in Finnish aquatic science to be broad and well-founded. There will be gaps in particular expertise, inevitably in a small country, but attitudes to collaboration outside Finland, especially in connection with research on the Baltic Sea were very positive. There was a very good balance of research, monitoring and expert services in most of the research institutes and a strong commitment to making the results of research available to a wide audience. Web sites were well-designed and attractive; placing of reports on the web has made them more available, and free, compared with previous, expensive paper publication. Many institutes have policies and plans to make original data freely available. Often we were told these had not quite come to fruition for technical reasons but we expect that these problems will be solved in the near future. Availability of data sets seems to be more jealously guarded, on the whole, in Universities, but these data are obtained at the expense of public funds and should either be published or made freely available for others to analyse. A number of Long-term ecological research (LTER) sites have been designated in Finland and this is both laudable and essential as our environment changes more and more. But there seems to have been no system created to maintain or instigate rigorously standardised data collection at these sites. It is not reasonable to expect individual Universities to have to raise funds for such work. Institutes might be expected to include LTER monitoring in their programmes, for long-term data sets are probably better safeguarded in institutions than by individuals, as they normally are in universities. There needs to be adequate and indefinite provision for such work.

5 The training of doctoral students and the career structure for water scientists in Finland

5.1 We independently talked to a wide range of graduate students from most Units. The groups were self-selected and had been asked to consider what issues they wished to raise about the PhD system in general. Many prepared written handouts to leave with us that showed a mature understanding, and the discussions were lively and articulate. We were very impressed by the quality of the people who came to talk to us.

5.2 Most of the students had already met their supervisors at the time of starting their PhD work, because of past associations as teachers or project supervisors. This helped smooth functioning of their research work. The students, in general, were highly motivated, very clear about the objectives of doing a PhD and determined to face funding and organisational difficulties while doing the research. They obtain enough facilities and have good interaction with scientists outside their institutions, whenever required. Generally, however, there is a sense of insecurity in guaranteeing continuous funding for their PhD programme and jobs or post doctoral positions after their graduation.

5.3 Most students said they were willing to take posts outside Finland, but were reluctant, because they generally feel that their research papers/performances are not competent enough and they think that they are too old at the time they complete their programme. The Panel generally found that papers written by postgraduate students were in high-ranking journals and did not agree with the students' assessment of their own quality. Students also felt they had little guidance on the availability of opportunities outside Finland. Some students felt there was overproduction of PhDs, which denies them suitable posts within and outside Finland.

5.4 The system for funding PhD programmes is a somewhat miscellaneous one. First there are completely funded positions with social benefits provided by a selection of graduate schools designated by the Ministry of Education in areas that the Ministry is convinced of a need for production of PhDs. Secondly there are posts with similar security, provided through research grants awarded by the Academy. We do not know the total number of such positions but were given the impression that it is small compared with the total number of PhD students. Most students seem to fund their studies on an *ad hoc* basis, usually with much help given by their supervisors, but seemingly often more or less independently. Raising of funds may include laboratory costs as well as living expenses. We were unable to quantify these issues but the messages we received were very consistent. Almost all the PhD students told us of insecurity in getting funding for their research programmes. Sometimes they had to change their fields of research interest because of the discontinuity of the funding.

5.5 On the other hand there appears to be pressure to create more PhD positions than the Academy, through grants, and the Ministry, through graduate schools, is able

or prepared to fund. Universities are given targets and receive sums proportionate to the number of PhDs they graduate. The burden of meeting the gap then falls on individual supervisors and the students themselves. We did not feel that the ratio of doctoral students to supervisors was excessive (Table 5.1). It could be increased in the Institutes especially, since there will be overlap in supervision with the universities for their students. In the Universities, the average is 3.2 students per supervisor and this equates to one graduation every 1-2 years. An ideal situation for supervision might be to take on one new student each year (to ensure continuity of techniques and long-term programmes) with a three to four year completion time and the current situation is not far from that.

Table 5.1. Ratio of number of doctoral students to supervising staff in the Units reviewed

Organisation	Faculty/department	2002	2003	2004	2005	2006	Mean
UH	FAF	3,5	3,5	1,7	1,6	1,3	2,0
UH	FB	2,4	2,8	2,5	2,4	2,2	2,5
UH	FS	7,6	8,1	6,8	6,2	6,2	7,0
UJo	FB	3,5	3,3	2,9	2,5	2,7	2,9
UJ	DBE	3,9	3,8	4,4	3,9	1,9	3,4
UO	DB	1,2	1,5	2,6	2,8	2,3	2,1
UO	WREEL	2,3	2,3	2,9	4,0	5,7	3,4
UT	FMNS	2,4	3,2	3,6	4,5	4,6	3,6
ÅU	FMNS	2,3	2,3	2,2	3,1	3,2	2,6
HUT	LWRE	2,9	3,1	2,2	2,4	2,0	2,4
MTT		0,6	0,5	0,5	0,9	0,7	0,7
SYKE		0,8	0,9	0,8	0,7	0,6	0,7
FFRI		0,3	0,0	0,3	0,3	0,1	0,2
FGFRI		0,6	0,6	0,4	0,2	0,2	0,4
FIMR		0,6	0,5	0,6	0,7	0,5	0,6
FMI		0,9	0,7	0,7	0,6	1,3	0,9
KTL		5,0	5,0	5,0	5,0	2,5	4,5
Mean		**2,4**	**2,5**	**2,4**	**2,4**	**2,2**	**2,4**

5.6 Combinations of mostly securely funded students, and a minority who pursue an independent line, occur in all countries but the Finnish system appears to reverse the balance. In 2006, Finnish Universities awarded 1890 licentiates and PhD degrees, and had 21900 registered graduate students. This implies a completion time of 11.6 years. Some of these registrations may ultimately be discontinued and in contrast we talked to one employee of a Foundation who had completed her PhD in just over two years. The overall situation, however, is that many students take a much longer time (perhaps five to seven years, though one University claimed four) to complete their PhD degree than for example in Denmark, the UK or India. Time taken in the USA may be as long for several reasons but these do not include funding insecurity. Finnish students may need to take interim alternative employment and have acquired family commitments by the time they graduate. This limits their career options subsequently by, for example, reducing their mobility. We understand that Finland is a party to the Bologna Agreement which proposes a combination of 3+2+3 years for

completion of the sequence of Bachelors + Masters+Doctoral work but has not yet been able to reform its system in accord with the agreement. We note that reviews of other areas, e.g. the Geosciences review have also alluded to this problem.

5.7 There are various possible solutions. The main solution the students suggested to us was the founding of a Graduate School in Water Sciences. Apart from providing funding, this would: provide specialized course work; promote effective interaction among doctoral students; attract international students; and provide environmental education to promote integration between physical, chemical, biological and socioeconomic approaches. We agree with the intentions but do not think this an adequate solution. Graduate schools in Finland are small and have few funded positions. Though there are currently 116 of them, they are under the control of a single Ministry whose perceptions inevitably may not be able to keep pace with scientific developments.

5.8 Solutions in other countries are to provide teaching fellowships to fund living costs coupled with extensive support through research grants (USA), provision of research studentships not linked directly to research grants but awarded competitively either to Departments to allocate (UK) or awarded individually to students on the basis of a nationally set examination (India), and guaranteed full funding for a three-year period, irrespective of the source of the funding, in Denmark and Germany. In the British system studentships are allocated to Departments based on a formula that includes the extent of existing research council funding to the Department, its rating in the periodic research quality exercise and its record in bringing students to completion within four years. In India there is a National Eligibility Test (NET) to select students. NET-cleared students are awarded automatic funding for 5 years (Junior Research Fellowships, JRF, for 3 years and Senior Research Fellowships,SRF, for a further 3 years) and they are also eligible to join a PhD programme at any university/institute in India. SRF are also available to provide funding on a stand-alone basis to those who are pursuing a PhD after two years of PhD registration and to those who have completed their PhD by independent funding. The award is based on assessment of previous performance.

5.9 It would be inappropriate of us to prescribe a detailed solution for Finland but we believe that urgent reform of the system is needed so that all students admitted on the basis of merit to do PhD studies should have surety of both personal and laboratory funding for at least three and desirably four years. We note the generous system in Finland of not charging tuition fees for students, even from overseas, and hope that this may continue.

5.10 Students felt that supervision of the PhD work by the professors is satisfactory but very much limited, because the supervisors devote most of their time to teaching, administration, preparation of new project proposals, foreign visits for collaboration, conferences and other activities. They did not complain about this but merely accepted it as a fact. Indeed survival in the world of research depends on development of independence of thought and action and to some extent the quality we saw in the students might be fostered by benevolent negligence. We did think, however, that it was yet another symptom of a system where increasingly managerial attitudes might be misusing the time of talented individuals. We have discussed solutions to this in Chapter 3 in terms of an increase in permanent mid-career posts in the Universities that could provide more supervision.

5.11 There was also discussion with both students and staff about the nature of the work that should be submitted as a PhD thesis. There is some controversy about the relative merits of an integrated monograph, a series (indefinite in number) of published papers, or a combination of published papers and submitted manuscripts (if manuscript is still the correct word in an age of electronic submission). We do not have a unanimous view on this. All systems appear to work though ultimately paper publication is the main currency for obtaining a future research post. Perhaps a compromise might be that monograph-type theses should include evidence of at least one completed publication. Over-ambitious publication expectations in some Universities may lead to further delay in achieving the degree and compound the problems brought about by insecure funding. Some Faculties expect two published papers and two submitted for publication. At least one demanded four or five published papers. We recommend that some attention be given to a degree of standardisation throughout the system.

5.12 Other issues that were raised, and which have merit, were that there may be a need for informal meetings for PhD students from different institutions to be able to discuss and present their work in a more relaxed atmosphere than a formal conference; that it should be easy for students to be allowed to attend specialist courses in other Universities (we were told of major barriers such as special fees in some cases); and that there might be funding for a competitive system for obtaining travel and subsistence funds for particularly expensive but important international conferences.

6 Communication of research findings outside the research community: an appraisal

6.1 In 2005, the Finnish Parliament, in a new University law, formally required the research community to make increased efforts to publicise the results of its work to a wider audience than the professional international science community. Traditionally, it has been believed, scientists have tended to give this endeavour less importance and effort than to writing papers for learned journals. Whether or not this was ever true, it is clearly desirable to make considerable efforts to inform a public that not only pays for the research but in whose interests it is to be as well informed as possible about an environment that affects its lives in every way. The range of ways of doing this is larger than that where a professional audience is involved. The latter read peer-reviewed papers, attend presentations at meetings and conferences and have an informal network of communication. The public can be reached through popular publications (books, articles in magazines and newspapers), radio and television interviews, talks to local groups and electronic media (web sites, DVDs) as well as through informal conversations. Much of this communication should be in Finnish and Swedish to reach a wide audience.

6.2 There are no accepted criteria for how much 'outreach' there should be but we felt that it was not unreasonable for there to be at least one, and preferably more, popular items for every peer-reviewed paper published from a project. Some projects attract enormous interest, others are more arcane though nonetheless equally important, so an average for a University Department or Institute might be more appropriate than a requirement for every individual project. Data were collected from Units on this aspect and we asked the Academy to count the numbers of publications and interviews. The results are shown in Table 6.1. They suggest an under-performance by most Universities (mean ratio, 0.39, range 0.07-2.4) and a higher mean (1.37, with range 0.1-5.47) for the Institutes. This is skewed, however, by the sterling performance of the Finnish Forest Research Institute. For the other Institutes the mean is somewhat higher (0.68, range, 0.1-1.32) than that for the Universities. We conclude that by our admittedly arbitrary standard, there is room for much greater outreach by almost all of the Units we examined. We cannot quantify the effectiveness of web sites but the Panel noted that most were attractive, useful and easy to use and merited the expense that is necessary to keep web sites updated.

Table 6.1. Number of talks and popular articles given or written per person year by each unit and the ratio of these to number of peer-reviewed publications during the period reviewed.

Organisation, Faculty/department	Peer rev. publica-tions	TV-radio, popular science	Other output	Popular Total	Ratio
UH					
Faculty of Agriculture and Forestry	0,85	0,26	1,29	1,55	1,82
Faculty of Biosciences	0,97	0,23	0,10	0,33	0,34
Faculty of Science	1,20	0,20	0,18	0,38	0,32
UJo Faculty of Biosciences	0,89	0,24	0,05	0,29	0,33
UJ Department of Biosciences	1,42	0,15	0,17	0,31	0,22
UO					
Department of Biosciences	1,10	0,07	0,00	0,07	0,07
Water Resources and Environmental Engineering Laboratory	1,04	0,00	0,22	0,22	0,21
UT Faculty of Mathematics and Natural Sciences	1,34	0,12	0,00	0,12	0,09
ÅU Faculty of Mathematics and Natural Sciences	1,31	n.a.	n.a.	n.a.	n.a.
HUT Labratory of Water Resources Engineering	0,77	0,03	0,03	0,06	0,07
MTT	0,58	0,00	0,06	0,06	0,10
SYKE	0,99	1,15	0,15	1,30	1,32
FFRI	0,79	0,00	4,35	4,35	5,47
FGFRI	2,45	0,24	0,78	1,02	0,42
FIMR	1,22	0,55	0,14	0,69	0,56
FMI	0,88	0,43	0,32	0,75	0,85
KTL	4,42	3,90	0,00	3,90	0,88
Mean	**1,16**	**0,35**	**0,24**	**0,59**	**0,51**

6.3 The effectiveness of outreach depends very greatly on the abilities of individuals to write or talk. As the most effective communications are likely to be in Finnish, it is hard for us to assess the quality of these. However, we received presentations from all the Units and were impressed by the quality of these overall and take this to be at least indicative at least of a keenness to communicate through talks and interviews. Representatives of all Units were very forthcoming and we greatly enjoyed the presentations.

6.4 As recommendations we might suggest that, if it is not already done, PhD students should receive some training in popular writing and presentation and that at meetings organised within Finland, there might be more prizes for excellence in these areas. The Academy already has two annual awards, one for a young scientist who has made outstanding scientific achievements and the other for a young scientist who has made an important contribution for public understanding of science. There needs however, also to be a less exclusive system that involves many more students to encourage public outreach. We might also suggest that Units work towards an initial target of one item of outreach per item of peer-reviewed paper and that it become routine for these to be reported as part of the final reports that the Academy requires of research grantees.

7 Specific comments on Units of assessment

7.1 This review was mostly concerned with the system as a whole for Water Research in Finland, but the basis for this was a set of data compiled by individual Units that gave some indication of individual merit and we were asked to comment specifically. Our perceptions based on the documentary material sometimes changed, usually positively, when we talked to representatives of the Units and we were impressed by the uniformly positive attitudes of the people we met to a Panel that would undoubtedly seem to them to be something of an imposition. We felt that this was a sign of general good health in the system and give the comments below in the spirit of gentle encouragement. We are well aware that we might give more attention to Units and people whose work we knew previously but have tried to overcome this. We are also aware that there are qualities in institutions that can only be appreciated by a visit of some length and of course this was not possible. Comparative statistics on size of Unit, funding, publication rate in absolute terms and normalised on a per person basis are included in Chapter 2 and are not repeated here.

Finnish Agrifood Research Institute

7.2 The Environmental Programme of MTT Agrifood Research is a small component of a larger Institute; it has the second smallest active research staff of all the water research Units that our panel reviewed. There has been a recent refocusing of agriculturally related research at MTT away from maximizing fertilizer use efficiency

and agricultural production towards environmental impact. Although it is well established that agriculture leads to major runoff of nutrients compared with natural systems, the runoff is not uniform but is influenced by many local features that make monitoring and management difficult on a farm-by-farm basis. The water research programmes of the Institute primarily focus on nutrient leaching to surface water from crop and animal production, including methods for minimizing nutrient leaching.

7.3 Evidence of changes in emphasis came from a new SOILWEATHER programme that will include real-time monitoring of weather, soil conditions, and nutrient loading to the water system in the relatively large (2000 km^2) Karjaanjoki River watershed and this contributes to one of the suggestions made in Para. 2.22. There are good collaborations with other government institutes and with universities and the research is responsive to new societal needs for environmental information, including strong linkages with private companies in the agri-environmental sector and with farmers. The environmental economics group at MTT is very prominent and is being integrated into the water research programmes. We would encourage this development strongly.

7.4 We felt that the international visibility of this Unit, which also has sophisticated lysimeter fields for research on water and nutrient balances in different parts of Finland, which might be more extensively used, was lower than it deserved and that opportunities for international networking through scientific conferences and exchange visits should be increased.

Finnish Environment Institute

7.5 The Finnish Environment Institute (SYKE) is a large organisation with a main laboratory and some outposts, largely based on University campuses. It has three main aquatic foci: on protection of the Baltic Sea; on hazardous substances and risks; and on freshwater research. It is the central research institute in Finland concerned with the environment and it has strong links with policy makers and government. Its role is as much advisory as research and in consequence much of the research is of a monitoring nature, albeit using sophisticated methodology and carefully accredited techniques. Its approach is largely in monitoring and modelling as opposed to experimentation and hypothesis testing and this is in line with its mission. Nonetheless SYKE has had substantial international experimental projects including those on eutrophication and Baltic Sea. It straddles the line between gaining new information, particularly that needed for policy formulation, and acting as a government monitoring agency, much like the Environment Protection Agency in the USA or the Environment Agency in the UK, though with a much more research involved and without the regulatory function, which is taken in Finland by the regional environment authorities. Much of its work concerns risk assessment of environmental damage and it is moving more effort into the sociological components of this.

7.6 Not all institutions need have the same approach and philosophy and SYKE does well in the role that has been externally defined for it by government. It is outward looking and its connections with the Universities are excellent. Its intentions for making its data freely available on the web are admirable and we thought its

employment policy of creating a very large proportion of permanent posts led to good employee relations and a settled atmosphere. It has a proactive view towards newly arising environmental issues and excellent outreach within Finland and towards developing countries and Eastern Europe. Its publication record is good with papers that are of wide interest in reputable journals.

7.7 It carries out substantial and important research on hydrology and water resources. The operationally used, country-wide Watershed Simulation and Forecasting System is currently being updated and refined. Processes and threats related to surface water quality are subject to considerable research efforts with particular focus on the ecological effects of nutrient loading and on the impact of climate change. Restoration of rivers and lakes is considered an area of great importance. Integrated approaches that combine ecohydrology with socio-economic stresses are an area of growing importance, where the development of decision support systems for operational use is a major challenge.

7.8 Funding streams are diverse with about a third coming from a central core grant, another third from Ministries and the remainder from other sources, dominated by the EU. The Academy of Finland contributes less than 10%. Government funding is declining, which is one reason why more time is being spent on administrative and fund-raising tasks and in advice to external bodies. Future proposals for more detailed external management of government research institutes are feared and an increasingly dirigiste approach would be likely to decrease the innovativeness of any institute and to turn its thinking and approach inward.

7.9 SYKE notes that increasing amounts of time are spent on administrative tasks, including fund-raising, but sees its varied sources of income as opportunities. It is well-equipped, with the caveat that future funds will be needed for replacement of expensive equipment and it feels a need to 'enhance existing research infrastructure', particularly the expensive equipment now considered essential for marine research. It trains doctoral students through the Universities but these are a small part of its activities and it sees value in a graduate school. It has had major participation in EU Framework programmes (15% of its income). SYKE has a wide remit with many projects and foci. It seems to have excellent channels for communication of its findings outwards, though largely to a Finnish and pan-Baltic audience. There are major international figures on its staff or collaborating with it. Future opportunities lie in extending its modelling approaches towards a socio-economic component, though the satisfactoriness of such extension may be disappointing to those more familiar with physico-chemical and even ecological models. There may be future problems as its advisory functions to government increase with more and more complex European legislation, whilst government policy towards the public service is to decrease investment. Inevitably this will squeeze the ability of the Institute to carry out research, and as a response to this a further expansion of links with Universities should be encouraged. Overall SYKE appears to be negotiating very successfully the tightrope between a fundamental / wide-scale applied research institute and a government agency and is well aware of the perils of a fall. Its main threat is that of a deliberate push from advisory requests that will upset the structure evolved to cope with its present balance between research and advisory tasks.

Finnish Forest Research Institute

7.10 Water research is a small component (2.1%) of the overall activities of Finnish Forest Research Institute (FFRI), which is a relatively large research institute, with major focus in forests and forestry. Water research areas are primarily on the quantity and quality of runoff from forested areas, and on the environmental effects of forest management practices, such as cuttings, soil preparation, and drainage. In hydrological and water quality studies in headwater catchments, there has been a particular focus on the extensive peatland forests, including the effects of ditching and fertilization on runoff. The water research by this Unit has benefited from the 90,000 hectare research forest under the control of the FFRI.

7.11 Forestry in peatlands is almost confined to Finland, so the research that has been conducted has provided important new information relevant to the current as well as future management of these regions when they are harvested. The availability of the large area of research forest has permitted replicated field manipulations to help understand factors controlling the quantity and quality (dissolved and particulate) of runoff both from the peatland forests and mineral soil sites. We felt that these problems had essentially been solved and that this aspect of research was reaching the point of diminishing returns. The Ministry of Agriculture and Forestry apparently does not share this view and is requiring more detailed work. The call for more detailed water research arises from the current plans to intensify forest cuttings and to produce biofuels both in peatland and mineral soil forests. However our feeling is that a change of direction would now be beneficial through integration of the results into a wider perspective of forest ecosystem function.

Finnish Game and Fisheries Research Institute

7.12 The research programme of the Fisheries Research unit at Finnish Game and Fisheries Research Institute (FGFRI) consists of five main themes. (1) Restoration of fishing waters with projects on eutrophicated lakes, habitats in rivers, reproduction and nursery habitats in coastal waters, ecotoxicology and fish-based methods for ecological classification of rivers and lakes. (2) Development of management and exploitation of fish stocks with projects on possibilities and benefits of multi-annual management of Baltic salmon stocks, critical interactions between different species in ecosystems, ecological and socio-economic effects of marine protected areas, and methods to evaluate alternative fisheries management systems. (3) Fish stocking with projects on evaluation of factors that influence fish stocking results, development of solutions and practices that enhance the ecological, economic and social sustainability of stocking programmes. (4) Biological diversity with projects on evaluation of potential changes and risks to lose diversity, occurrence and state of threatened stocks, fish stock register maintenance. (5) A crayfish programme with projects on biological and ecological knowledge of the distribution ranges and ecological limits of the two native crayfish species, methods for maintaining sustainable crayfish stocks and fisheries, and minimisation of the influence of stock fluctuations.

7.13 The Livelihoods and Socioeconomic research unit focuses its research on sustainable use of fish resources for both food supplies and recreation, needs of

consumers in the global market, high-quality and healthy food supplies, a diverse and sustainable industry, and development of feeds and farming technology. The Game and Reindeer research unit organises its research within the areas: effects of environment on the species' ecology, factors that influence population dynamics, and ecotoxicology in relation to seals.

7.14 The Institute has a very high and constant publication rate of journal papers. Outreach cooperation and external funding, both national and international, is well developed. Due to decreasing basic funding, the Institute has been forced strongly to focus its activities. This has implied that resources for basic research are becoming very short. Moreover, the present scope of activities may be threatened, if the demand for yearly staff reductions is maintained. The institute has a country-wide net of research stations, mostly associated with universities. The two main experimental stations are very well equipped.

7.15 The Institute has been very successful in recommending research-based restrictions for salmon catches. The regulation has been adopted by all countries around the Baltic Sea, and the salmon has in recent years made a remarkable recovery. Important results on growth of the Baltic herring have been obtained also, and fish tagging has been developed as an effective research tool. The impacts of coastal eutrophication on fish reproduction have been studied in detail, and in general there is a good symbiosis between monitoring programmes and related research activities.

7.16 Aquaculture has become a major business activity, and the Institute has contributed through development of feed programmes and new recirculation techniques. Whitefish and pikeperch have successfully been introduced as new species in aquaculture. The Game and Reindeer Research unit has both aquatic and terrestrial focus. Main activities concern populations, regulation, migration, reproduction and mortality. Generally the Institute puts strong emphasis on dissemination of research results to the public through a new website, and in particular the game unit has been successful in establishing an interactive contact with the public.

7.17 The Panel was impressed by the wisdom with which the FGFRI has managed its financial circumstances and would encourage even more interaction with Universities and other Institutes for it is clearly central to applied ecological research in Finland and very well equipped. It is clearly providing essential research and monitoring services in a country where all of hunting, fishing and appreciation of nature are important national interests. It is regrettable that it must statutorily confine its interests to exploitable species for these are only parts of ecosystems, yet have major interactions with other, the majority, of species. Staff would like to examine more fundamental aspects of ecosystem function, for example in the roles of waterfowl and ways should be found for this to happen. Ultimately it is in the interests of the game species. There are also opportunities for modelling fish stock assessments under the inevitability of increasing climate change and also for formalising, archiving and making available long-term data sets on fish that will be of great use to others. In this respect there may also be a need to harmonize and integrate monitoring programmes with other Units so that a wider range of information is included and repetition avoided.

Finnish Institute of Marine Research

7.18 The Finnish Institute of Marine Research (FIMR) is the major marine research institute in Finland and a major player in the Baltic Sea region. The range of fields studied is by necessity quite broad and balanced among physical, chemical and biological oceanography. This includes a strong combination of monitoring and process-orientated research. Some specific areas include: physical oceanography of the Baltic Sea, sea ice, food webs, eutrophication and nutrient dynamics, algal booms, including harmful ones, non-indigenous species, and pollutants.

7.19 The strength of FIMR's research programmes is indicated by their high success in competing for funding from external sources, including the Academy of Finland.

Interactions with other institutes and university departments both within and outside Finland are extensive. The recent move to a new joint building on the University of Helsinki campus with the Finnish Meteorological Institute has increased collaborations, sharing of facilities and technical personnel and some joint professorships with the University. There has been a strong record of publications in high quality journals. The overall research approach is strongly interdisciplinary, supports the Institute's governmental mission, and has an important foundation in basic research to support the applied research needs.

7.20 The recent restructuring of research into programmatic areas (State of the Baltic and Global Change; Processes of the Baltic Sea; and Dynamics of Sea) supports a modern interdisciplinary approach to marine research and applied problem solving and an excellent educational environment for PhD students. There is a good balance of Baltic Sea/Finland-relevant research and research relevant on global climatic change, such as in the Arctic and the Institute is very strong in sea ice research and marine physics in general. We were impressed by the very good laboratory and analytical facilities, which are critical to the continued strength of the research programmes, and by the R/V Aranda, which is a critical facility for FIMR research and important for joint field experiments and new collaborative research.

7.21 Opportunities for the Institute include an expansion of efforts towards modern data distribution systems and to make their historical and current monitoring data freely and easily available for downloading on the web. FIMR could also play a leading role in developing a Finnish focus for integrated, aquatic ecosystem modelling; such a modelling framework might include a watershed approach with a Baltic Sea perspective. The Institute was clearly very willing to make its research vessel available to other groups, provided some of its costs could be met. Allocation of sea time on the vessel appears to be managed on an opportunistic basis and although the printed publicity material we saw was excellent, perhaps some more extensive advertisement might help alleviate a financial burden that must be quite heavy.

7.22 During the last stages of completion of this report we learned that there are government proposals to disband the FIMR, to transfer its staff in the physical sciences to the FMI, and its biologists to SYKE, whilst also disposing of the RV Aranda. We do not know the real reasons for this and we can see that merging the marine work carried out in SYKE with that in the FIMR could be profitable. However, the separation of the physical aspects of marine science from the biological is, in our view, a retrograde step. Separation of these aspects has been a barrier to understanding in the past and current world trends are increasingly for bringing

together all the marine sciences to gain a proper understanding of the complexities of the seas and oceans. We have alluded to this several times. We would ask that the Ministries concerned review this decision urgently. It is in no way in the environmental interests of a country that depends so greatly on the ecosystem of the Baltic Sea.

Finnish Meteorological Institute

7.23 The Finnish Meteorological Institute (FMI) has five departments (Weather Service, Research and Development, Customer Services, Technical Services, Administration) that report to the Director General. The Research and Development department has programmes relevant to aquatic research concerned with earth observation, climate, meteorology, air quality and the Arctic. The focus is in atmospheric sciences with only about 10% of the work related to water research. This includes: weather radar and determination of patterns of precipitation for hydrological applications; climate change and effects on the hydrological cycle, including future scenarios for Finland for energy needs and forest production; numerical simulation of the atmospheric water budget; atmospheric aerosols and chemical composition of cloud droplets and rain water with respect to nutrients, acidification, heavy metals and PAH and air-sea exchange of aerosols; modelling of chemical composition of rain water; atmospheric load to the Baltic Sea and terrestrial waters; ship emissions and their dispersion and deposition to ecosystems; and snow and ice cover including remote sensing.

7.24 There can be little doubt as to the degree of sophistication of the equipment and approaches of the Institute. It claims to be one of the ten best weather services in the world and it has wide collaborations in northern Europe and the Baltic area. We heard much of the purely physical aspects of its work, but its interests in rain chemistry are extensive and in the Panel's opinion well justified. There is extensive cooperation with FIMR and SYKE and perhaps less with Universities. However, graduating PhD students seem always to find employment in high-level, subject-related posts.

7.25 The Institute is proud of its record and sees as a threat the directed reduction in staff, as do most other institutes. It is forward looking and sees a limitation in its inability alone to complete the chain of models from atmosphere to hydrosphere to biosphere that might link weather and climate ultimately to fish production and algal growth. The Panel thinks collaboration to achieve this would pay dividends. The Institute also sees an opportunity for further collaboration with sister institutes in doing this and is also thinking of embarking on earth-system models where it will certainly need collaborative expertise from biogeochemists and environmental microbiologists, an area unfortunately underrepresented at present in Finland. There may also be opportunities for linking meteorological work with urban hydrology and environmental engineering in University departments, especially as extreme weather events may become increasingly frequent and pose major risks of flooding.

Finnish National Public Health Institute

7.26 The main aquatic role of the Public Health Institute (KTL) is in the measurement of persistent organic pollutants, particularly in food fish and the human population

that consumes them. This work is centred in the Department of Environmental Health Laboratory of Chemistry on the University of Kuopio campus. Its data have shown a much more widespread incidence of POPs across Finland than had previously been believed, outside the well-known problems of the Baltic Sea. Of particular concern are polychlorinated biphenols, dibenzofurans, sawmill fungicides and tin compounds. The Institute has refined methodology and state of the art instruments and carries out thousands of analyses per year. Recent studies have investigated the concentrations of dioxins in fishers and the fish they eat and have revealed high concentrations in the people, yet a lower incidence of heart disease and cancer than other populations, which is attributed to a healthy, outdoor lifestyle.

7.27 The Institute has close collaborations with the University of Kuopio, FIMR and SYKE and also other Scandinavian countries, and connections with Spain, UK and USA but not an otherwise deep international penetration. We gained the impression that it saw itself almost as a service mostly within Finland, though its research results are of wide interest. It has given a fairly large number of radio interviews as a manifestation of this. It has few senior staff and feels that its work in the water area is vulnerable both to future cuts in funding and the risk of loss of the few senior staff. There are several technicians and PhD students, employed more or less continuously making analyses, and we were surprised to find that its instrumentation is largely manual, though producing very precise results. Newer instruments use robots to eliminate a great deal of labour and we felt that investment in these may be one way for it to deal with staff reduction. New instruments are very expensive, however and it is not immediately clear how the present instruments will be replaced.

7.28 We found its research impressive and of high social importance and felt that it should be more widely publicised with creation of more opportunities for its staff to travel abroad for conferences. The laboratory was clearly working at full capacity and we wondered whether some expansion or establishment of a partner laboratory in another Institute might not be needed as demand for sophisticated analyses increases with the production of more and more potentially harmful chemicals. We also felt that there were opportunities for collaboration in basic research with the Universities.

Åbo Akademi University, Faculty of Mathematics and Natural Sciences

7.29 Water research in this Unit includes groups in two departments: Environmental and Marine Biology and Biochemistry and Pharmacy. The Unit focuses mainly and equally on biosciences & ecology and marine research, and also, to a lesser extent, on water resource management, limnology and ecotoxicology. The research is mainly in shallow coastal and archipelago waters. Strong areas of research include zoobenthic ecology, aquatic vegetation dynamics, fish populations in shallow areas, pelagic ecosystems, coastal plant and bird assemblages, and cyanotoxins, including development of advanced analytical methods, field studies of toxin production in lake and Baltic Sea environments, biophysical studies at the cellular level, and prevention of human exposure to cyanotoxins. The Unit has very good laboratory facilities and field stations, which recently have been substantially improved. The Unit has access to an ultra-modern Turku BioCity complex, which provides additional resources for

molecular techniques as well as additional opportunities for collaborations with other biosciences in Turku. The Aquatic Pathobiology laboratory is very well equipped for cellular and molecular level analyses of environmentally induced problems in fish populations.

7.30 This is a very productive, relatively small Unit conducting high quality research with a strong record of publication in high quality peer–reviewed international journals. These papers have included both project-specific papers, as well as a number of broader syntheses. There is good collaboration within the Unit with the two groups working well together. The research is well integrated into the international scientific community; research active staff at all levels, from PhD students to senior staff, participate in international scientific conferences and are involved in international collaborations. Multidisciplinary projects in the Unit actively link science, decision support systems, and society, including the school system.

7.31 Many of the detailed ecological process studies in the coastal marine ecosystems have helped marine resource managers. The Unit is developing a strategy for continued excellence, with plans to increase its profile in evolutionary and behavioural ecology, and plans for continued inter- and multidisciplinary research and education. The generally high level of scientific quality of the research is indicated by the many visits abroad (senior staff as well as most post-docs and PhD students) for collaborative research, invited keynote and other talks at international fora, and training. The high regard for their scientific work is also indicated by their invited presentations to governments within Finland and at EU-level. There are many visitors to the Unit.

7.32 There may be additional opportunities for collaboration with the University of Turku. It emerged that there is collaboration already though there was little reference to it by either University in the written documentation. The Panel felt that there may also be scope for combining marine experimental work with modelling done by other groups and the Unit has done well to attract funding for a new collaboration with Sydväst University of Applied Sciences to develop a research team on "Integrated Coastal Zone Management". This programme will provide 5-6 externally funded research positions (post-docs) in the next 5 years.

Helsinki University of Technology, Laboratory of Water Resources Engineering

7. 33 The research efforts of the Laboratory of Water Resources Engineering of the Department of Civil and Environmental Engineering are organized within three main categories: (1) Human impacts on the hydrological cycle and transport of nutrients with projects aiming at measuring and modelling hydrological variables and leaching of nutrients from typical land use types in Finland including urban areas; (2) Environmentally friendly hydraulic engineering with projects, e.g., on the influence of flood plain and channel vegetation and evaluation of current design methods; and (3) Water and development primarily in developing countries, focusing on the concept of integrated water resources management and the UN millennium development goals, but also on improving understanding in Finland.

7. 34 The Laboratory functions well. The research efforts are well coordinated, and the external funding is maintained at an appropriate level. The campus facilities, including modern laboratories, are very good. The research strategy puts emphasis on

practical research with strong focus on the use of mathematical modelling. Traditional and ecological engineering approaches are combined in a fruitful manner, and cooperation with other universities and research institutions is adequate. The international outreach to developing countries as well as to development agencies and UN institutions etc. is very impressive. The Panel was impressed by the efforts being made in the soft engineering of urban watersides. There is still a long way to go before ecological aspirations are satisfied by conventional civil engineering but we felt that this Unit was making more effort than most civil engineering departments to bridge this gulf.

7. 35 The Panel believes that both national and international (outside of the existing strong activity in water resource development) cooperation could be further enhanced. A stronger focus on climate change impact studies appears a straightforward avenue for future research efforts. Application for external funding is time-consuming but absolutely necessary as basic funding for the management of the laboratory is felt to be far from being sufficient by the senior staff. All senior scientists should be eligible as main supervisors for PhD students, not just full professors. This is apparently not the practice in this Unit though it is common elsewhere.

University of Helsinki, Faculty of Agriculture & Forestry

7.36 The three aquatic groups of the Division of Applied Chemistry and Microbiology of this Faculty seem to do everything expected of them remarkably well. Their documentation revealed a Unit of very strong researchers, one an Academy Professor running a Centre of Excellence, another an Academy fellow and the third well-known also internationally. The Unit depends very much on external funds and is skilled and successful in obtaining them. Its publications are important, its international penetration is considerable, its doctoral training produces people who gain prestigious awards, and it pays strong attention to outreach.

7.37 It is helped by the high profile of cyanobacterial blooms and the toxins they produce and has pioneered methodology for determining their molecular structures and genetic basis. It has also opened up new fields in non-extreme Archaebacteria, a group of Prokaryotes rather different from conventional bacteria that may be of considerable functional importance, and is now moving also into the interactions of microbes with metals and organic compounds. Its approach is strongly molecular but it appreciates that molecular methods are tools not ends and attempts to make ecological connections where it can. It revealed a strong self-criticality in its documentation.

7.38 Such a small Unit, no matter how distinguished, is vulnerable. The Academy Professor will move to a permanent Professorship in the Faculty of Biosciences in 2010 which will to some extent safeguard part of the Unit but will weaken the remainder. The Panel sees this Unit as strong enough for more permanent positions to be created or the University of Helsinki may lose its talents elsewhere.

University of Helsinki, Faculty of Biosciences

7. 39 Water research is distributed among three Units at the University of Helsinki: the Faculties of Bioscience, Natural Science, and Agriculture and Forestry, as a result of the complex history of the development of the University and some historic

aspects of the delineation of subject areas. The Faculty of Biosciences is the largest and includes four groups orientated towards behavioural and evolutionary aspects of fish ecology, two originating in the former Department of Limnology, which also have strong fish and fisheries components, and a prominent palaeolimnological group, all located in the Department of Biological and Environmental Sciences on the Viikki campus in Helsinki. The Department of Ecological and Environmental Sciences is at Lahti, and combines strong applied limnology and sophisticated studies of carbon exchange within lakes and wetlands. The department embodies its fundamental research in a culture of working with local authorities and bodies in the management of the lake resources of its area. There are also three well-known field stations within the Faculty, each with permanent administrative staff, though in greater numbers at Lammi and Tvärminne than at Kilpisjärvi. The research at the stations is conducted by people funded by temporary contracts and at Lammi and at Tvärminne by two research professors having temporary positions. The sea-ice ecology group, a combination of university researchers from Helsinki, Oulu and Kuopio and the Finnish Institute of Marine Research, collaborates with Sweden, Denmark, UK and Germany on the role of sea-ice biogeochemistry in the overall nutrient and carbon cycling in the Baltic Sea. There has been participation in various graduate schools, one of which, now discontinued, was regarded as an exemplary model.

7.40 This Unit is a very strong research unit with much funding from the Academy and high aspirations for the number of doctoral students trained. It has a wide diversity, ranging from cutting-edge approaches to fishery management, climate change, sea-ice and lake restoration through ecological engineering, as well as nutrient management, to the evolutionary ecology and conservation of fish and amphibians. It is tempting to wonder why the physico-chemical limnology carried out in the Faculty of Science and the aquatic microbiology of the Faculty of Agriculture and Forestry have not been linked with the aquatic science of the Faculty of Biosciences in what would be a world-leading Faculty of Aquatic Sciences, but continued reorganisation, especially following a recent reshuffle can be very disruptive. There is a hint that the aquatic sciences in the various Faculties are seeking some common strategy, though little detail yet of what it is hoped to achieve.

7.41 The faculty appears well-equipped, has some very prominent scientific leaders and the field stations are important resources that the University has had the wisdom to maintain over many years. They attract overseas researchers as well as providing excellent facilities for Finnish scientists from Helsinki as well as other Finnish Universities. Its publication list is healthy and at the field stations, especially at Lammi, and also at Lahti and Kotka, where the fisheries work is centred, links with the community are positive and strong. In terms of international recognition, as reflected in invitations to speak at international conferences, the impact appears limited to a smaller group of people than anticipated, but we suspect that the faculty's systems for recording such information may not have been comprehensive enough to have given a full view.

7.42 The Panel has the impression of a powerful Unit, but possibly one, from the lack of introspection in the analysis of its own activities in the documentation provided, that distances itself a little from self-criticism. The impression is given of individually strong but separate research groups like a set of mediaeval city-states, perhaps competing with each other when there may be advantages also to greater co-

operation. Nonetheless there are advantages to the city-state model, as evidenced in the high proportion of internationally well-known people in the Unit. There are opportunities for greater collaboration in limnology and palaeolimnology with the Faculty of Science, in using long-term data sets for lake modelling, in collaboration with FIMR in ice studies and, with notable exceptions in lake restoration, catchment research and palaeoclimatology, in extending the Faculty's communication of its research to the community in general.

University of Helsinki, Faculty of Science

7.43 Water research is carried out in three departments: (1) Department of Physical Sciences, Division of Geophysics with research on geophysics of the earth's hydrosphere with special focus on natural ice. Main research topics are sea ice, seasonal snow cover, hydrodynamics of lakes, lake ice, lake optics, optics of coastal waters, ice-ocean modelling, and oil spill drift and dispersion; (2) Department of Geology with research on glacial modelling, hydrogeology and past geoenvironments using aquatic proxies like diatoms, chironomids, foraminifera and isotopic composition of organic matter and carbonates; (3) Department of Geography with research concentrated on effects of urbanisation on water systems, shoreline displacement and development of water systems, and water quality and land use effects on water systems, in particular urban hydrology.

7.44 There is a strong tradition for lake research, including ice cover and lake optics. The snow and ice research, particularly the sea-ice modelling, is well recognised, and the faculty has a high production of PhD students and prominent publications.

The water-related research in the three departments, however, appears disparate. An effort to bring the research programmes together more, might lead to an overall gain in competitiveness. The Panel sees advantages in a better coordination with the research carried out in the Faculty of Biosciences in both sea-ice research and in palaeolimnology. Urban hydrology needs coordination with the research in this field at the Helsinki University of Technology. The joint location at the Kumpula campus with other geosciences institutions brings new opportunities, but this will, apart from a better coordination, require a broadening of the presently rather narrow research profiles, especially in Geography. Detailed studies should be extended to address broader problem areas. The staffing is limited and seems to be decreasing, which makes future water research vulnerable. Sincere efforts to increase the permanent staff are needed.

University of Joensuu, Faculty of Biosciences

7.45 The University of Joensuu divides its interests in aquatic sciences largely between two groups, the Laboratory of Aquatic Ecology and Ecotoxicology and the Ecological Research Institute, which was, until 2006, a part of the Karelian Institute, with a special mission to enhance intellectual and material development of Eastern Finland, Karelia, and Northwestern Russia. The Institute is small in academic staff numbers, has around 20 people involved and a smaller budget per person as compared with the Laboratory which has fewer people, but more academic staff and a comparable total budget. The Ecotoxicological Laboratory presents itself as a highly

specialist, technological unit concerned not with standard testing but with the environmental context of toxicology, particularly in a severe boreal environment, whilst the Ecological Research Institute has a wider remit of general limnological work on large-lakes. There has been a particular emphasis on Lakes Saimaa in Finland (a research ship is maintained) and Ladoga, in Russia, palaeolimnology and work on a local, rare seal species.

7.46 The university has occupied an important strategic position close to the Russian border and much of the funding for the Ecological Research Institute has come from Government departments and core University funding with a comparatively small sum from the Academy. Its mission has been not so much front-line fundamental research but the finding of common scientific ground with Russia. It nonetheless has a respectable publications record and a notable position internationally in involvement with large lakes and a wide expertise in limnology, with publications in good journals. Its ratio of staff to students is high. The Ecotoxicological Laboratory funded to a much greater extent by the Academy, is, like the Ecological Institute, well equipped but has a much higher doctoral student to faculty ratio and clearly feels pressured in this respect. Its publications are in specialist journals and depend a great deal on instrumental expertise. It anticipates difficulties in guaranteeing the future of highly trained technical staff and in finding time to train new doctoral students.

7.47 Neither component complains about time taken up with administrative tasks and this may be because both have a reasonable proportion of administrative staff and seem to be able, with regard to their very different missions, to have obtained sufficient funds. The changed mission of the Institute to more fundamental research may jeopardise some ministry funds and it will have to gain more Academy funds. Its very general scope may make this more difficult than for a University specialising its interests. The impression given is of a more inward-looking, technically directed approach in the Laboratory. It sees its role in terms of impact on the scientific community. The Institute has had a more outgoing role and clearly demonstrates its outreach activities. Both units have good international collaborations, perhaps more intercontinental in the case of the Ecotoxicological Laboratory, though both are probably undervalued by the international community. A characteristic Finnish reticence perhaps precludes a great many invitations to speak abroad.

7.48 The university is involved with several graduate schools and coordinates that in Environmental Science and Technology through the Ecotoxicological Laboratory. As often there are concerns about staffing, the vulnerability of dependence on short-term contracts and the future of posts that will be vacated by retirement. The Panel notes a strong polarity in the two components, with the Ecotoxicological Laboratory seeing itself as rather separate, but maintaining strengths of specialist expertise in an area that will remain crucial as human activities continue to produce a huge range of potentially very dangerous chemicals of complex behaviour in the environment. On the other hand the Institute had to be broad under its former remit, is highly dependent on funds from three ministries that might not be so forthcoming as political tensions have eased and on an infrastructure, including a ship, that must be highly expensive (the ship is financed by three ministries and used by several universities and research institutes). The Panel sees virtue in moving towards specialisation of the Institute perhaps on its greatest strengths as natural retirement

vacates posts and on merging the two components so that one of the specialisations remains the ecotoxicological work, which might then be able to acquire a greater number of senior scientists than at present and be able to incorporate genomic and genetic mechanism research, which it presently lacks. There may also be advantages in extending links with other Units. The Panel gained the impression of a somewhat isolated Unit.

University of Jyväskylä, Department of Biological and Environmental Science

7.49 The University of Jyväskylä presented itself extremely impressively. It aspires to being the major centre for limnology in Finland and has a credibility that augurs well for the future. The Unit focuses equally on ecology (lake food webs & biogeochemistry, fish bioenergetics), limnology (physical and winter), and fisheries science (fish biology, parasitology and health of aquatic organisms and sustainable use of inland fish stocks) and aquatic ecotoxicology. Sectoral offices of FGFRI and SYKE complement the Unit.

7.50 The group working on lake food webs and biogeochemistry is internationally recognized as a leader in isotopic tracer studies on the role of terrestrial organic matter in lake food webs and carbon fluxes, as is the parasitology group, focusing on life history evolution in parasites and key factors affecting parasite–host co-evolution. This helps in design of sustainable prevention methods against pathogens and parasites in aquaculture. The impending retirement of the leader of this group will not lead to loss of impetus as she will remain as an emeritus Professor and has been replaced by a talented young new professor in complementary aspects of fish disease. Studies on bioaccumulation pathways of organic compounds and herring growth, and population models in the Baltic Sea food web, were initiated in Jyväskylä and have extended to laboratories throughout Finland and the Baltic states.

7.51 The Unit has excellent facilities for research. It is centred in an area of many lakes, is close to Lake Päijänne, which is a designated site for long-term monitoring and research and has aspirations to establishing an experimental lakes area close by. It maintains a well-equipped field research station at Konnevesi and an automated monitoring station on Lake Jyväsjärvi that transmits limnological and meteorological data. In addition the accredited Institute for Environmental Research (IER) of The University of Jyväskylä provides comprehensive state-of-the art analytical services. Developing areas in Arctic limnology will make use of molecular techniques to probe the function of the predominant benthic mat communities in such lakes and the University is clearly looking to the future in terms of acquiring new expertise and techniques. The Unit has extensive collaboration with world-leading parasite taxonomists (having described more than 50 parasite species new to Finland and 6 new to science),

7.52 This is a credible Unit with a solid, long-term reputation. It concentrates on areas where its expertise is particularly high. Its publication record is ample, in good journals with high citation indices, but its international penetration is probably not so internationally recognized as it might be, as reflected in rather few invitations to its staff to give talks abroad. It sees a need for the development of a pan-University Graduate School in freshwater ecology to provide a more secure and integrated

training for doctoral students. Our impression was of an exceptionally well-organised, self-critical Unit that presented a considered and balanced view of the state of Finnish research organisation. It has aspirations to become the leading centre of limnology in Finland and to achieve this perhaps needs to strengthen its experimental work and to regain expertise in stream systems.

University of Oulu, Department of Biology

7.53 At the University of Oulu, aquatic research is mainly conducted in two departments: the Department of Biology (Faculty of Science) and the Department of Process and Environmental Engineering (Faculty of Technology). All water research at the university is strongly linked to the Thule Institute, which exists to integrate many aspects of research in cold, northerly environments. The current professorships in aquatic sciences in the Oulu region, at the University, SYKE and FGFRI are all rather newly established (2004). The University researchers co-operate closely with researchers at SYKE and FGFRI in the Oulu area. In many cases it is practically impossible to tell apart the relative contributions of each Unit to the shared projects, e.g. by shared resources, shared professorships, shared teaching, and shared facilities.

7.54 Department of Biology at Oulu University together with the office of the FGFRI, is the only place in Finland where stream ecology is the main focus of aquatic research and education, and the University of Oulu is the only university in Finland where community and macro-ecological issues and conservation biology are the focus areas of freshwater-related research and education. Emphasis is on river restoration and management. Several of the research groups extend thematically beyond the limits of traditional aquatic research by focusing on links between the aquatic and terrestrial (riparian) ecosystem.

7.55 The aquatic group at the Department of Biology is a very small Unit and the focus of research varies strongly with the persons holding the key positions. In this respect, water research in the Department has changed its focus profoundly during the evaluation period. It has shifted from evolutionary ecology of aquatic organisms to broad-scale biodiversity issues. Currently the research in aquatic ecology falls into three major subjects: population biology; population genetics; and biodiversity research. In the near future, the main focus will remain in large-scale ecological issues of biodiversity and conservation biology.

7.56 The Unit is comparatively small but productive and with good international links. All aquatic-orientated research groups, including doctoral students, strongly depend on external funding by the Academy of Finland. Other major funding sources are private foundations and the Ministries of Environment and of Agriculture and Forestry. Much of the research is strongly field-orientated.

7.57 The Oulanka Research Station, close to the Arctic Circle and the Finnish-Russian border, is a key facility provided by the university to aquatic research and is a centre for many field courses given by the university (not only the Biology Department). Another field station owned by the University of Oulu is the Bothnian Bay Research Station located on the Island of Hailuoto, the largest island of the Bothnian Bay is much used in teaching. The Department of Biology also owns an experimental research facility ("Zoological Garden") located at the University Campus. The Unit provides indoor and outdoor aquariums, field laboratories and

other facilities for experimental work. A research facility not owned by the university but very important for the experimental work of the Department's research groups is available at the Kainuu Fisheries Research Station owned by FGFRI. The station is situated some 140 km southeast of Oulu. The experimental facilities provided by this station are outstanding by any comparison. It is expected that they will be a key component of all aquatic research to be conducted by the Biology Department research groups, in close collaboration with scientists of the FGFRI.

7.58 The freshwater research groups work in close co-operation with the end users of research information. In particular, the contacts to environmental administration are strong, and strongly facilitated through shared academic positions. For example, the work bears direct relevance to the implementation of the EU Water Framework Directive in Finland. The Department's research on stream restoration has shown that a majority of current restoration projects are ineffective in enhancing salmonid fisheries, stream biodiversity and ecosystem functioning. As a result, stream restorations in many parts of Finland are now designed so that mosses and other macrophytes are not destroyed during the restoration, enhancing their recovery, with potentially important implications for the recovery of wholesale stream biodiversity. It is a pity that the sister Laboratory of Water Resources and Environmental Engineering at Oulu, which is also interested in river restoration operates an essentially separate programme. The Panel thinks there is a great need to bring together engineering and ecological interests in an equal partnership between these Units.

7.59 At present, only two positions at the Biology Department are specified in aquatic ecology. This is perhaps insufficient and cannot provide a satisfactory solution in the long term. However, prospects are not optimal because of funding difficulties. This obviously places strong demands on research groups in terms of obtaining external funding. Such funding in Finland is heavily competed for, however, and although the department's aquatic groups have been successful in attracting external funding thus far, there is no guarantee that this will continue to be so, jeopardizing any long-term planning of research projects. This is true everywhere of course, but the particular significance of a University serving, almost alone, the scientific research needs of a huge Finnish stream and river system should be recognised and the Panel urges immediate attention to this.

University of Oulu, Water Resources and Environmental Engineering Laboratory

7.60 The research of the Water Resources and Environmental Engineering Laboratory of the Department of Process and Environmental Engineering is organized among three research groups: (1) Hydrology and water resources with projects on flow process studies using isotopes, contaminant transport, peatland hydrology, watershed restoration, interaction between groundwater and surface water, and drinking water abstraction from eskers; (2) Water chemistry and water treatment with projects on treatment and distribution of drinking water, water treatment including industrial and domestic effluents, and optimisation of water treatment process parameters; (3) Geoenvironmental engineering with projects on contaminant migration, aquifer remediation, groundwater protection, and landfills. Only the first fell within our remit.

7.61 The faculty puts emphasis on research issues related to the northern environment and has established a strong regional cooperation network. The chosen approach is a combination of data collection in field and laboratory and mathematical process-based modelling. The practical research is facilitated by three well-functioning laboratories (soil, hydraulics, and chemistry). Strong links have been established to regional offices of the research institutes in Oulu.

7.62 The publication strategy appears very efficient as evidenced by the fact that the productivity of the Unit in terms of journal papers and PhDs has increased considerably during the last few years. The research efforts are well focused on society-relevant subjects that nonetheless lead to international publications. Generally, the faculty seems well organised with a clear strategy for further development. The Unit, however, is quite vulnerable due to its dependence on one key person. For a positive long-term development more permanent positions and an attractive university career structure are desirable. The present classical engineering approach to river restoration would benefit from the specific ecological expertise now available in Oulu University, Department of Biology. The requirement that all papers in a PhD thesis must be published before the thesis can be approved should be reconsidered.

University of Turku, Faculty of Mathematics and Natural Sciences

7.63 The University of Turku in many ways epitomises the characteristics of a strong regional research-driven University. Its aquatic research is separated into four different departments: Biology, Geography, Geology, and the Turku University Environmental Research Centre, which is a marine centre but there appears to be little contact among them. There is a strong thread of aquatic work running through programmes that do not specifically describe themselves as such and the Faculty lists many of the problems that we saw in other Universities of relatively small size, shortage of funds, increased administration to obtain support, and dependence on a few particular individuals with permanent posts. There is nonetheless an all-round strong performance with considerable international recognition.

7.64 The Biology Department has two strong poles. One is a Centre of Excellence in Evolutionary Genetics and Physiology, with an emphasis on fish and how variations in oxygen concentration have affected the evolution of oxygen dependent transcriptional regulation of genes. To this has recently been added strength in conservation genetics of salmonids by recruitment of a professor from the University of Helsinki. The second pole is in limnology with work on the biological basis of fish production, fish population dynamics, restoration of eutrophicated lakes (including the effects of fish on water quality), submerged plants as ecosystem drivers, and use of stable isotopes in food web studies. This work will continue for several more years but is likely to be lost on the retirement of the current professor, which will mean loss of one of the five main centres for limnology and freshwater ecology in Finnish Universities. Academy funding is a major contributor to research in this Department.

7.65 The Department of Geology carries out work on sedimentology and some palaeoecology, now likely to expand with a new professor in palaeolimnology whilst that of Geography includes GIS studies of the Archipelago sea, flood prediction, glacial hydrology in Iceland and river dynamics in Amazonia. The Environmental

Research Centre possesses a small research vessel and has a record of sustained work on benthos, zooplankton and fish ecology in the Archipelago Sea. It also has used its data collections in modeling with respect to climate change and should forge collaborations with other Units to make wider use of these. The appointment of a new Professor in palaeolimnology should offer new opportunities.

7.66 The Panel thought that here was an opportunity to organize the water research into a more coherent Unit for the strengths are many and the benefits of sharing of ideas and expertise could be considerable. Turku might have the seed corn for the pilot School of Aquatic Sciences we have referred to earlier, with extension at least in informal ways to the considerable expertise in Åbo Akademi University. We do not underestimate the organizational inertia of any long-standing University, however. We were impressed by an all-round high competence, a good variety of research topics and locations, including several outside Finland, a self-criticality and understanding of the role of such a University.

8 Recommendations

8.1 We have a number of recommendations to make from our review. These should be taken as strong pointers to open discussions to enhance a system that we are unanimously convinced produces very high quality research, and which amply rewards the investment Finland makes in it. In this Chapter we confine ourselves to the system as a whole but in Chapter 7, we have made some more specific points directed at individual institutions.

8.2 We suggest that there is a need for some revision in the balance of allocation of funds to favour the area of aquatic research (and of environmental issues in general). Because safeguarding the global environment is now becoming the most important issue for human survival in any civilised way, it behoves the developed world to make increasing efforts to understand the changes that are happening, and how to mitigate and adapt to them. We suggest that funding of this research area is currently inadequate (Para 2.2, 2.6, 3.7, 3.8) and that commercial enterprises are failing to meet their legitimate costs of this burden. There is little point in maintaining a prosperous economy in the short term if it leads to environmental and social collapse in the slightly longer term. We note an undesirable policy of reduction in size of all the research institutes irrespective of the importance of the work they carry out (Chapter 7). And we feel that could be more encouragement to participate in European Union projects and thus to obtain EU funds in some areas.

8.3 We recommend that serious attention be given to creating a more secure career progression for post-doctoral scientists in the Universities (Para 3.11, 3.12, 4.5). We note that similar recommendations were made by the panel on Food Sciences and Related Research in Finland (2006) and Energy Research in Finland (2006). The situation is even less favourable for women scientists and consideration should be given to discovering the reasons for progressive reductions in proportion of women with advancement up the career ladder (Para 3.14). The Academy might contribute to

this overall goal by some increase in the number of Centres of Excellence and Academy Professors (Para 2.9, Para 4.5) and by creating a more user-friendly system for application and delivery of postdoctoral fellowships (Para 3.9).

8.4 We think that Finnish research is sometimes too inwardly directed (Para 2.31). We recommend establishment of a scheme to ensure continued input of new approaches by making a condition of Academy post-doctoral fellowships that the initial 1-2 years of a four-year fellowship be spent, wherever possible, in an overseas laboratory, with appropriate funding (3.13) and that postdoctoral fellowships should always involve migration to a different institution from that where the PhD was obtained. We feel that this is a more effective way of exploiting different approaches than short visits of Finns abroad or visitors to Finland, though these, nonetheless, have considerable value and should, of course, continue to be encouraged.

8.5 We recommend an urgent reform of the system for allocating funds for PhD work (Chapter 5). This may mean greater selectivity but the present system is wasteful and unnecessarily stressful for students (Para 5.9). We note that a similar recommendation was made by the panels on Finnish Geosciences (2003), and Energy Research in Finland (2006). There is also a dearth of graduate schools in the area of water research and creation of schools in hydrology and freshwater ecology (Para 2.11) and simulation modeling would be appropriate for widening the training and experience of students in these areas, but would not be a comprehensive solution to the funding problem. We also recommend that some attempt be made to standardize expectations for what is submitted as a PhD thesis (Para 5.11) and to improve opportunities for interchange of ideas and experience among students from different institutions (Para 5.12).

8.6 We recommend the founding of a School or Department of Aquatic Environmental Sciences to educate students who will be able successfully to integrate understanding in currently traditionally separate areas (Para 4.3). Its scope should include all of the current physical, chemical, biological and social sciences. The latter are important for we have little fundamental understanding of why human societies are have not been able to prevent severe environmental damage (Para 1.9). There is also now a huge range of research approaches from the molecular to the advanced statistical analysis of huge data sets and an understanding that complex systems, whether fresh or salt, have common characteristics as well as detailed differences (Para 2.24). Exploitation of these can be best facilitated by new organizations. At the same time, the current graduate school concept can be used to guarantee specialist expertise within a broader understanding.

8.7 We recommend that there be more integration among predictive modellers and experimental scientists so that models of physical processes, hydrological processes and biological processes can be linked together and gain greater environmental reality through more rigorous validation from real data on processes (Para 2.32-2.35). The obvious starting point would be models of the Baltic Sea areas and their catchments. This might be achieved by directed funding but the fundamental problem is in too narrow an earlier education (Para 4.3). We have suggested that consideration be given to creation of a School or Department of Aquatic Sciences in a University to facilitate an integrated and interdisciplinary approach (Para 8.6). We recommend that the current proposal to disband the FIMR

(Para 7.25) and distribute its physical science to FMI and biological science to SYKE be urgently reconsidered. Scientifically, such separation would be a retrograde step and out of line with current trends in international research. We also note a shortage of research on biogeochemical processes, data for which are needed for models linking the biological and physico-chemical aspects of complex systems.

8.8 We recommend that in the area of freshwater ecology and limnology, there is a need to expand work on flowing waters, (including sophisticated ecologically-based approaches to restoration (Para 2.23)) which is currently barely represented despite a considerable river length and a crucial importance of rivers in fisheries, waste disposal and amenity (Para 2.20, 2.21). We also suggest that experimental whole catchment and lake approaches should be encouraged and that more attention be given to integrating peatland and wetland research into the wider field of freshwater science (Para 2.21). We are concerned that there is a trend to contraction in the latter (Para 2.21). It is almost superfluous now to recommend that work on the implications and mitigation of climate change be expanded, not least in view of the dramatic increase in temperature of the Baltic Sea. It is important also, however, that the need for research is not used as an excuse to delay the fundamental changes necessary in western societies to avoid a catastrophic outcome to present climate trends.

8.9 Long-term data sets and continued environmental monitoring in a rigorous way, with assured funding, have become very important. We recommend that an inventory be made, with suitable funding, of current data sets, with an assessment of their reliability and security and potential usefulness in integrated models and that these data may be made freely available on the Internet. Initially this might be confined to the Baltic Sea. Results should be made widely available so that an assessment can be made of which sets to continue, with assured long-term funding. We suggest that assured funding is also required for designated Long term ecological research sites. Continuous data from these are too important to be left to casual funding (Para 4.6).

8.10 We recommend that attention be given for the setting up of a fund for replacement of expensive analytical instruments and super-computing facilities that are used on a shared basis among institutions (Para 2.33, 2.39, 3.15). Consideration should also be given to the future financial security of the several research vessels owned both by Institutes and Universities. We acknowledge the very important role of the many field stations in supporting water research in Finland and the general area of the Baltic and would wish to see continued strong support for them.

8.11 We agree that communication of research findings outside the research community is important and essential. We found some reticence in doing this overall and we recommend that there should be positive encouragement through a target of at least one item of popular communication per peer-reviewed research paper, courses for PhD students in popular communication and reporting requirements for research grants (Para 6.4).

A Terms of Reference for the Evaluation Panel

1 Background and purpose

The Research Council for Biosciences and Environment has decided on 26 September 2006 that Finnish water research will be evaluated with respect to the international level. The evaluation combines an external assessment by an international Evaluation Panel with an internal self-assessment exercise.

This document sets out the standard Terms of Reference applicable to the Panel. The content of this document is relevant to the Panel Members as well as to the Units being assessed. The document should be read in conjunction with the Instructions to Submission Form, which will be used by the Units being assessed when preparing their evaluation documents. The unit refers to the faculty, department, institute or research station involved in the evaluation.

2 Definition of the field to be evaluated

The evaluation focuses on natural science research pertaining to surface water. Research to be evaluated is carried out in the fields of aquatic biology and ecology (molecular biology and genetics, microbiology, physiology, taxonomy, systematics), limnology, ecotoxicology, marine/brackish water research (Baltic Sea), water resource management, hydrology and other environmental research related and relevant to the study of surface waters in Finland. The research under evaluation also comprehends physical and chemical water research. The evaluation does not involve follow-up (i.e. monitoring) or other routine application of methods for assessing the quality of water.

The evaluation covers research on water systems as a whole: research on rivers, lakes, springs as well as marine/oceanographic research. Further, research within various disciplines focusing on the movements, quality and biota of water is evaluated. Research within the scope of evaluation includes research into the effects on water bodies caused by leaching as well as discharges and loading (e.g. eutrophication). Risk assessment and research related to the impacts of climate change and adaptation are also included. The evaluation covers meteorological research that relates to the effects in catchment basins and surface waters.

Research on groundwater, water supply and sewage technologies is not evaluated, except in cases where the volume of groundwater research is small and forms an integrated part of surface water research in the Unit. Research related to water resource management, including aspects of water economy will be evaluated. Public health research and sociological and policy research do not come within the scope of this evaluation. Moreover, peat land and other soil water research are not evaluated. .

3 Organisation

The Research Council for Biosciences and Environment of the Academy of Finland approved the general agenda for the evaluation of the research field in autumn 2006. The Council also appointed a Steering Group to lead and support the execution of the evaluation.

The members of the Steering Group are:

Liselotte Sundström, Professor, Research Council for Biosciences and Environment, Chair of the SteeringGroup
Johanna Buchert, Professor, Research Council for Natural Sciences and Engineering
Marja-Liisa Hänninen, Professor, Research Council for Health
Minna Hanski, Senior Adviser Water Resource Management, Ministry of Agriculture and Forestry
Juha Kämäri, Professor, Research Council for Biosciences and Environment
Jaakko Pehkonen, Professor, Research Council for Culture and Society

4 International Evaluation Panel

An international group of independent high-level experts will carry out the evaluation. All faculties, departments, independent research institutes and research stations will be evaluated by the Evaluation Panel.

The Academy of Finland has invited seven renowned scientists as Evaluators:

Brian Moss, Professor, School of Biological Sciences, University of Liverpool, UK, Chairman of the Panel
Wolfgang Fennel, Professor, Deputy Director, Baltic Sea Research Institute, Waremunde, Germany
Chinnaiya Namasivayam, Professor, Baharathiar University, Coimbatore, India
Dan Rosbjerg, Professor, Institute of Environment & Resources, Technical University of Denmark
Sybil Seitzinger, Professor, Institute of Marine and Coastal Sciences, Rudgers University, USA
Pauline Snoeijs, Professor, Department of Plant Ecology, Uppsala University, Sweden
John Stegeman, Senior Scientist, Woods Hole Oceanographic Institution, USA

5 Objectives of the Evaluation

The purpose of this exercise is to evaluate Finnish water research and research education. The evaluation covers the period of 2002–2006, on which the recommendations to be provided for the future will be based.

The objectives of the evaluation are:

- To form a general picture of the focus, scientific quality and strategies of Finnish water research and research education
- To assess the organisation, strengths and weaknesses of the research field and research units

- To make suggestions and recommendations concerning the needs for development, focus and emphasis of the whole research field

The basic unit to be assessed by the Panel is a faculty, a department of a university or an independent research institute or relevant part of it. The units are mostly inter-disciplinary research environments. Each unit will be reviewed, but the emphasis of the evaluation is on the research field as a whole.

6 Evaluation criteria and recommendations

The Evaluation Panel is asked to give:
- written statement on the quality of the research, achieved results, scientific contribution as well as doctoral training, where applicable
- written statement on the quality and efficiency of the research environment and organisation
- written statement on the research system
- written feedback about the interaction between research and society, and its impact

The main emphasis is on the scientific evaluation. The Panel should ensure that the evaluation takes into account all relevant material available.

The Panel is also asked to give recommendations for the future of the field (Section 6.5).

6.1 Scientific quality of the research

The Panel's main role is to evaluate the quality of Finnish water research internationally. The quality statement is based on evaluation documents submitted by the Units. Panel members will have the opportunity to complete this information during presentations and interviews in Finland. All research, whether basic or applied, should be given equal weight.

The quality statement must reflect the work of all the research staff listed in a unit.

Important issues to be considered:

- What is the quality and productivity of Finnish water research and research education compared to international standards?
- Do the present water research focus upon innovative, fruitful and challenging research lines, themes and problems (strategy)?
- Strengths and weaknesses, needs for improvement?

6.2 Research environment and organisation in its immediate vicinity

The evaluation deals with the prevailing research practices, research environments and collaborative networks. Does the research environment and organisation promote the quality of research and research education?

Important issues to be considered:

- What is characteristic to the activity, leadership and administration in the field?
- How does the research and research education of the unit interrelate with the strategies of the accommodating organisation?

- Role of the national and international networks (universities, research centres, enterprises)?
- What is the role of interdisciplinarity in the units as well as within the whole field?
- Strengths and weaknesses, needs for improvement?

6.3 Research system

On the basis of the assessment of the units, the Panel may also evaluate how appropriate the prevailing research system is.

- Does the prevailing research system promote the quality of research in terms of strategic plans, staff, funding, infrastructure and mobility?
- Does the Panel see any synergy benefits in the Finnish water research system? What kind of action and cooperation could promote them? (e.g. common strategies, cooperation, new division of labour, better use of infrastructure, critical mass)
- Strengths, weaknesses, needs for improvement?

6.4 Interaction between research and society

The Evaluation Panel is asked to give feedback about the interaction between research and society and the impacts of research on society (e.g. environmental, technological, economical). The feedback is to be based on the evaluation documents as well as interviews and discussions. The Panel should especially consider other activities such as expert tasks, popularised works, patenting, technology transfer and cooperation with other sectors of society.

The Panel should pay special attention to the societal contribution of each unit as well as the relevance of the research on the national as well as international level. The questions to be asked are

- How actively and efficiently does the unit communicate its points and findings to various stakeholders and the rest of society?
- In what way has the research of the unit and its cooperation with other actors in society contributed to the success of these actors?

The Panel should consider this from the point of view of e.g. environmental protection, adaptation to climate change and hydrological extremes, restoration, fisheries, establishment of new regulations and norms, common understanding on aquatic issues etc. The Panel is asked to discuss the interaction between the unit's research and society from relevant aspects.

Important issues:

- Is the research of the field relevantly focused with respect to the future scenarios of the national as well as international developments?
- How fruitful is the cooperation between the unit and the communities ultimately applying the results of the research, and what kinds of results have been achieved?
- What is the academic and non-academic need for research doctorates in the field, and how well is it met with the current doctoral training?
- How to improve societal effectiveness of Finnish water research?

6.5 Panel's recommendations for the future

The Panel is asked to provide recommendations for the future development of the research field. The Panel will need to consider that the recommendations are mainly dealing with the field, not a unit, research group or individual researchers.

Key issues to be addressed are:

- What opportunities and challenges does the field have?
- How should the field meet these challenges and utilise the opportunities?
- What kinds of means could be recommended in order to improve and strengthen research performance at various levels?
- How should the quality and societal impacts of research be promoted?

The Evaluation Panel should provide recommendations on

- research representing single-, multi- and interdisciplinarity,
- development of the research structure: personnel, funding, environment, infrastructure and strategies
- strengthening the impact and effectiveness of the research on society
- other important issues

7 Tasks, responsibilities and working arrangements of the Panel

Panel members will set responsibilities within the group and together with the Evaluation Secretary. The Evaluation Office will provide all evaluation documents and background information dealing with the Finnish research system. The evaluation material consists of evaluation documents, the units' presentations, interviews and discussions.

For full description of the evaluation documents please see the Submission Form and related Instructions, which will be used by the units being assessed when preparing their evaluation documents together this Terms of Reference.

7.1 Desk research

Desk research will be carried out before the Panel's visit to Finland. The material includes

- facts of the research staff and funding
- list of publications
- lists of key publications of senior staff
- collection of the key publications
- list of doctoral theses
- lists of visits and collaborations
- self-assessment exercise of the unit

The Steering Group suggests that Panel members do preliminary assessment of each research unit before discussing with research staff. The Evaluation Panel may supplement their views during the visit to Finland.

7.2 Presentations and discussions

Each research unit has an opportunity to give a presentation dealing with the focal points of the unit's research.

A sample of researchers will be interviewed during the site visit, e.g. heads of units (research), senior staff, professors, post doctoral researchers, visiting foreign scholars. The Evaluation Panel will also discuss research education with graduate students.

The specific timetable and instructions will be provided by the Evaluation Office in due time.

7.3 Confidentiality

Panel members undertake not to make use of and not to divulge to third parties any non-public facts, information, knowledge, documents or other matters communicated to him/her or brought to his/her attention in the performance of the evaluation. The evaluation and the ratings are only for official use and confidential until the final summary evaluation report is published.

7.4 Evaluation report and publicity

The evaluation report including the main recommendations is based on the evaluation criteria defined by the Steering Group of the evaluation. The report will be written and edited by the Panel members with the assistance of the Evaluation Secretary/ Coordinator. The evaluation report is confidential and only for official use until publication.

Prior to final editing and publishing, the units of assessment get to review the report to correct any factual errors. The evaluation report will be published in the Academy of Finland Publications Series in both printed and electronic form (www.aka.fi).

7.5 Impartiality

Evaluation follows impartiality rules common to the field of evaluation. The Panel member will be disqualified if his/her impartiality is endangered or if he/she feels that he/she has a conflict of interest with a research group included in the evaluation.

Therefore, if you may be unable to evaluate a research group, please notify the Academy as well as the other Panel members of it as soon as possible. The clarification must preferably be done during the first Panel meeting.

8 Schedule

Dec 2006	Appointment of Steering Group
Dec 2006	Communication to the field
April 2007	Appointment of Evaluation Panel
Mar 22, 2007	The onset seminar
Apr–Aug 2007	Preparation and delivery of evaluation documents
Nov 5–9, 2007	Interviews and discussions with units of assessment
Nov–Dec 2007	Preparation of report
Mar 2008	Publishing and releasing the report
2008	Informing of and communicating results
2009–	Follow-up of implementation of provided recommendations

9 Coordination of Evaluation

The Evaluation Team working mainly at the Academy of Finland operationally coordinates the evaluation process. Director Johanna Ikävalko, Senior Adviser Timo Kolu and Project Secretary Hanna Kunnari form the Evaluation Team together with the Evaluation Secretary. The Evaluation Secretary will assist the Panel on site visits and in preparing and editing the evaluation report. The duties of the Project Secretary are to compile the evaluation documents, organise the practical details of the site visits and provide administrative support.

10 Funds

The evaluation is funded by the Academy of Finland and the other funding bodies involved in the Steering Group of the evaluation. The Academy of Finland will pay an expert fee to the Panel Members. All travel expenses related to the Panel's visits and accommodation in Finland will be covered or reimbursed by the Academy of Finland.

B Members of the Evaluation Panel in Brief

Brian Moss, Chairman of the Panel, Professor, School of Biological Sciences, University of Liverpool, UK, President, International Society for Limnology

Brian Moss is Holbrook Gaskell Professor of Botany at the University of Liverpool, UK, but will be unlikely to be able to tell you what the pink-flowered tree is in your garden because he has been a freshwater ecologist for many years and the botanical connection is with algae and aquatic plants. He has held posts in Malawi, the USA and UK and has taught or carried out research or both on six continents over a period of more than forty years. He is an experimentalist whose current research involves eutrophication, lake restoration and climate change and in addition to the conventional long list of papers in learned journals, he has published a well-known text book on the Ecology of Freshwaters, now still in its third addition as other matters have seriously delayed the writing of the fourth, a book on a major coastal wetland system in the UK, The Broads, the People's Wetland, and a manual for shallow lake restoration. He also has minority interests arising from the teaching, in East Africa, of courses for the Tropical Biology Association, including the processing of organic matter in rainforest streams by crabs, and the effects of birds on freshwaters, whilst also being much concerned with wider global environmental problems and how art and poetry might be used to get over messages about the environment to the wider public. He also plays the double bass, though perhaps with less competence than he does other things! His experience in research assessment has embraced the Peer Review College of the Natural Environment Research Council in the UK, the Scientific Advisory Board of the Dutch Institute of Ecology, the chairing of the research assessment of biological sciences, carried out a few years ago for the University of Helsinki, and numerous assessments for professorships in several countries. He also sits on the editorial boards of several journals, does much reviewing and has been editor of the Journal of Ecology. He has been President of the British hydrological Society, Vice-president of the British Ecological Society and recently was elected President of the International Association for Limnology. He was awarded the Association's Naumann-Thienemann Medal in 2007 for his research and leadership in creating new understanding of shallow lake function.

Sybil Seitzinger, Vice Chair, Professor, Institute of Marine and Coastal Sciences, Rutgers University, USA, Director, Rutgers/NOAA Cooperative Marine Education and Research Program, Elected President, American Society of Limnology and Oceanography

Sybil P. Seitzinger is Director of the Rutgers/NOAA Cooperative Marine Education and Research Program and Visiting Professor at Rutgers University's Institute of Marine and Coastal Sciences in New Brunswick, NJ, USA. She is currently President of the American Society of Limnology and Oceanography (ASLO) and a member of the Scientific Committee of IGBP. She has served on numerous advisory panels

including a panel to evaluate management and research options for the Baltic Sea in 1997 for the Royal Swedish Academy of Sciences and Swedish Environmental Protection Agency and more recently (2005–06) on the Expert Panel on Baltic Eutrophication, also for the Sweden Environmental Protection Agency. She is a member of the Scientific Advisory Committee for the International Nitrogen Initiative (INI) and Chair of an international taskforce (Global NEWS) that has developed watershed models of nutrient transport by world rivers.

Her research addresses nutrient biogeochemistry in coastal marine ecosystems, including sources, effects and fates. The spatial scales of her work range from measurements at molecular scales to models at global scales, with the impact of human activities being a central component of many of her programmes. Her current research projects include: 1) global modelling of N, P and C transport by world rivers to coastal ecosystems; 2) denitrification in rivers, estuaries and continental shelves; 3) harmful algal blooms (HABs); and 4) dissolved organic matter – chemical characterisation, inputs and bioavailability in aquatic ecosystems. She has published more than 90 peer-reviewed publications, more than 50 of which have been published since 2000.

Wolfgang Fennel, Professor, Deputy Director Baltic Sea Research Institute (IOW), Warnemünde, Germany

Wolfgang Fennel is the head of the department of Physical Oceanography of the IOW and Professor at the University of Rostock. He leads the modelling group aiming at the integration of circulation models and biogeochemical models. As theoretical physicist by education, he moved to the field of physical oceanography and was involved in fieldwork, theory and numerical modelling with particular interest in interdisciplinary cooperation.

He has experience in international research panel work and was involved in evaluations of large projects and of research institutes. From 1998 to 2002 he was Vice President of SCOR (Scientific Committee on Oceanic Research) and from 1998 to 2007 he was member of the steering committee of GEOHAB (Global Ecology and Oceanography of Harmful Algal Blooms). He is also strongly involved in ICES science committees (Baltic Committee and Oceanography Committee). As editor in chief he is running the Journal of Marine Systems.

Chinnaiya Namasivayam, Professor, Bharathiar University, Coimbatore, India

C. Namasivayam received his Master's (1975) and doctoral degrees (1982) in Analytical Chemistry from the University of Madras, Chennai, India. He was a lecturer at the University of Madras (1978–85). After postdoctoral training (1982–84) at the University of Victoria, Canada, he worked as a scientist at Southern Petrochemical Industries Corporation, Tuticorin (1985–87) and as a reader at Bharathiar University, Coimbatore, India (1988–94). He became a full professor of Environmental Sciences at Bharathiar University in 1995. Dr Namasivayam's research focuses on colloid and interface science, modelling of fixed-bed reactors and absorbers (photocatalysis), surface chemistry and thermodynamics, modelling of wastewater and water treatment processes, and wasteland reclamation. He has

directed ten national and one international (DAAD, Germany) research project. His research has led to more than 100 peer-reviewed publications including journal articles, patents and book chapters. His research articles have been cited more than 2,000 times. He has supervised more than 50 MSc and PhD students. Dr Namasivayam is a member in various societies including IUPAC (Fellow) and Institution of Chemists, India (Fellow), carries numerous expert tasks as an international and national reviewer and evaluator for journals, universities, granting agencies and research institutes. He has received many honours and awards including NSERC visiting scientist (1985–92) at the University of Victoria, Canada, International Visitor on Environment (Indo-American Environment Leadership Program) by USIA, Washington, DC, USA (1996), Invitation Fellow by the Japan Society for Promotion of Science (JSPS) at the University of Tokyo, Japan (1999), DAAD, DFG Visiting Scientist at the Karlsruhe Research Centre, Germany (2001–02), Visiting Professor at four universities in Taiwan (2005) and NWO Visiting Scientist at Wageningen University, the Netherlands (2006–07).

Dan Rosbjerg, Professor, Institute of Environment and Resources, Technical University of Denmark, Vice-president, International Association of Hydrological Sciences (IAHS)

Dan Rosbjerg is Professor of Hydrology and Water Resources at the Department of Environmental Engineering, Technical University of Denmark (DTU). He obtained an MSc in Civil Engineering 1969, a PhD in Hydrology 1973, and was conferred the degree Dr. Tech. 1993. Has held positions at DTU as Head of the Institute of Hydrodynamics and Water Resources 1978–89 and Director of the Groundwater Research Centre (a centre of excellence) 1989–2001, and has since 2001 been a member of the Board of Directors for DTU. He was President of the Commission on Water Resources Systems of the International Association of Hydrological Sciences (IAHS) 2001–05, and has since 2007 been a Vice-president of IAHS. From 1996 he has been Danish delegate to UNESCO's International Hydrological Programme (IHP) and chaired the Ad Hoc Governance Committee of IHP 2002–04. He was member of the NATO Science advisory panel on Environmental and Earth Science and Technology 2000–04. Has since 1986 been Editor of the international scientific journal Nordic Hydrology, from 2008 renamed to Hydrology Research. Rosbjerg's current research interests include development of hydrological models at different scales, flood and droughts, model parameterisation and uncertainty, sustainability assessment, and optimisation of water resources. He has supervised 20 PhD students and published more than 100 refereed papers. His experience in evaluation comprises several PhD committees and professor appointment panels, membership of the Swedish Research Council's evaluation panel on Processes in Soil, Atmosphere and Water 2003–05, and membership of the Swedish National Agency for Higher Education's evaluation panel on Physics, Astronomy, Meteorology and Hydrology 2004–05.

Professor *Pauline Snoeijs*, Pelagic Systems Ecology, Stockholm University, Sweden, General Secretary Baltic Marine Biologists

Pauline Snoeijs is Professor of Pelagic Systems Ecology at Stockholm University, Sweden, as from 1 January 2008. She obtained an MSc in Biology from the University of Nijmegen in the Netherlands in 1982 and a PhD in Plant Ecology from Uppsala University in Sweden in 1989. She became Professor of Plant Ecology at Uppsala University in 2003. She has studied the ecology and ecophysiology of phytobenthos and phytoplankton in the Baltic Sea for more than 25 years. In recent years she has participated in Arctic expeditions for studying sea ice communities. She is also an enthusiastic nature photographer.

She is General Secretary of the Baltic Marine Biologists (BMB) and Chairperson of the Advisory Board of the EU ERA-NET BONUS. Her experience in evaluation comprises more than 40 PhD committees, appointment panels for more than 20 lecturers and professors, evaluation panels on ecology and marine sciences for the Academy of Finland and the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, expert panels for the development of the Action Plan of the Helsinki Commission (HELCOM), a panel to construct the BONUS-169 Baltic Sea Science Plan and Implementation Strategy and a panel to evaluate the Polar Research Centre for the Norwegian Research Council.

Her current research deals with the pelagic system of the brackish Baltic Sea and integrates ecology, ecophysiology and biochemistry. In a well-functioning aquatic food web, the flow of important nutritional compounds from algae to fish should be balanced. However, is this the case in the strongly eutrophied and contaminated Baltic Sea? For example, the Baltic salmon shows symptoms of oxidative stress and deficiency of vitamin B1. In this context she studies how the production of vitamins, fatty acids and antioxidants is regulated in phytoplankton and how these compounds are transferred to crustaceans and fish. She has published more than 60 peer-reviewed research papers, edited nine books and supervised 13 PhD students.

John Stegeman, Senior Scientist, Director of the NSF/NIEHS Woods Hole Center for Oceans and Human Health Woods Hole Oceanographic Institution, USA

John Stegeman is Senior Scientist at the Biology Department of the Woods Hole Oceanographic Institution (WHOI). He has a PhD in biochemistry from Northwestern University, and has been studying pollutant chemical metabolism and effects, primarily in aquatic species for more than 30 years. This work has centred principally on the cytochrome P450 (CYP) genes that are involved in the metabolism of xenobiotics and hormones. Dr Stegeman has authored or co-authored more than 250 publications, most dealing with the biochemistry and molecular biology of CYP enzymes and genes. His research has included studies of carcinogenesis and oncogene activation in fish in polluted environments, and the mechanisms by which CYP1A may contribute to the toxicity of chemicals, including uncoupling of CYP1A and the consequent contribution to oxidative stress, in adult and developmental stages of

vertebrates. The regulation of CYPs in the cardiovascular system and possible involvement in cardiovascular disease has been an active interest for 20 years. His current studies also consider the origin and evolution of CYP genes and their diversity in deuterostomes. The information and probes for CYP have been applied to the analysis of pollutant chemical effects in fish, birds, marine mammals and humans. Dr Stegeman has served as an ad hoc and a regular member on grant review panels (Study Sections) for the National Institutes of Health (US) and on Science Advisory Boards of several Environmental Health Sciences Centers and chaired the Science Advisory Board of the National Toxicology Program (NTP, US), and served on several committees for the US National Academy of Sciences. He served as chair of the Biology Department at WHOI 2000–06, and is currently Director of the NSF/NIEHS Woods Hole Center for Oceans and Human Health.

Evaluation panel and evaluation team. From left to right: T. Huttula, D. Rosbjerg, S. Seitzinger, W. Fennel, B. Moss, T. Kolu, P. Snoeijs, C. Namasivayam, J. Stegeman and A. Aitola.

C Execution of Evaluation

The members of the Steering Group were

Liselotte Sundström, Professor, Research Council for Biosciences and Environment, Chair of the Steering Group

Johanna Buchert, Professor, Research Council for Natural Sciences and Engineering

Marja-Liisa Hänninen, Professor, Research Council for Health

Minna Hanski, Senior Adviser Water Resource Management, Ministry of Agriculture and Forestry

Juha Kämäri, Professor, Research Council for Biosciences and Environment

Jaakko Pehkonen, Professor, Research Council for Culture and Society

Evaluation Team

Dr. *Timo Huttula*, Expert Secretary, Timo Huttula Env. Consulting

Mr. *Timo Kolu*, Senior Adviser, Academy of Finland, timo.kolu@aka.fi

Ms. *Anneli Aitola*, Project Secretary, Academy of Finland, anneli.aitola@aka.fi

Ms. *Mirka Gustafsson*, Science Adviser, Academy of Finland

Dr. *Johanna Ikävalko*, Director, Biosciences and Environment Research Unit, Academy of Finland (until May 31, 2007)

Evaluation Office

Academy of Finland
Biosciences and Environment Research Unit
P.O. Box 99 (Vilhonvuorenkatu 6)
FI-00501 Helsinki, Finland

D Submission Form

(Please read instructions carefully)

GENERAL INFORMATION

Organisation	
Faculty or equivalent	
Department or equivalent	
Address	
Phone	
Internet Website	
Head of Department	
Phone	
Email	
Contact person for Evaluation	
Phone	
Email	

Share of water research in (%)

Faculty	
Department	

Collaborators

1. Organisation	
1. Department or equivalent	
2. Organisation	
2. Department or equivalent	

Submission form shall be submitted by May 14, 2007 in four (4) paper copies as well as one copy in electronic format (PDF). Please send also all appendix files (excel) to following address:

Project Secretary Hanna Kunnari
Suomen Akatemia, PL 99
00501 Helsinki
Email: akva@aka.fi

More information:

Senior Adviser Timo Kolu
Email: Timo.Kolu@aka.fi
Tel. 09-774 88 341, mp. 0400-415 909

Director Johanna Ikävalko
Email: Johanna.Ikavalko@aka.fi
Tel. 09-774 88 336

1 Staff

1.1 Staff in 2002-2006 (**Appendix1**)

1.2 Research active staff in 2002-2006 (**Appendix1**)

2 Funding

2.1 Unit's core and external research funding in 2002-2006 (**Appendix2**)

2.2 The role of the Academy of Finland and other funding bodies in promoting the scientific and societal impact of research (max. 2 pages)

3 Unit's research profile and scientific publishing

3.1 Unit's research profile in the context of the evaluation
(in relation to staff or funding)

Research field	(%)
Biosciences and ecology [1]	
Ecotoxicology	
Limnology	
Marine research	
Water chemistry and physics	
Water resource management/hydrology	
Other (please specify):	
Total	100%

Comments:

[1] Ecology, taxonomy, systematics; molecular biology and genetics; microbiology; plant and animal physiology.

3.2 Description of the Unit's research profile (max. 3 pages). Describe the Unit's research orientation, strategy and main results during the period under evaluation (see instructions).

3.3 Number of scientific publications and other outputs in 2002-2006 (**Appendix3**)

3.4 List of publications and other output in 2002-2006 (**Appendix3.4**)

3.5 Lists of senior researchers' key publications (See 1.2) (**Appendix3.5)**

3.6 Copies of the Unit's key publications in 2002-2006 **(Appendix3.6)**
(append copies of publications, maximum *number of publications = number of senior researchers* but a minimum of *five* publications)

4 Doctoral training

4.1 Doctoral thesis supervision in 2002-2006 (**Appendix4**)

4.2 Completed doctoral degrees in 2002-2006 (in order of completion, per year, **Appendix4**)

4.3 Organisation of doctoral training. The role of graduate schools and other research training and supervising. Describe aims, practices and arrangements of the doctoral training in the Unit (1page).

4.4 Present employment of PhDs (**Appendix4**)

5 Unit's collaboration contacts

5.1. Visits abroad during 2002-2006 (minimum duration of visit: two weeks, **Appendix5**)

5.2. Visits to the Unit 2002-2006 (minimum duration of visit: two weeks, **Appendix5**)

5.3. Short but particularly important visits (**Appendix5**)

5.4. Most important national and international collaborators (max. 10, **Appendix5**)

5.5 Describe the most important outcomes of the visits and collaboration contacts (max. 1 page)

6 Other scientific and societal activities

6.1 Invited presentations in international scientific conferences in 2002-2006 (**Appendix6**)

6.2 Memberships on editorial boards of international scientific journals in 2002-2006 (**Appendix6**)

6.3 Prizes awarded to researchers, honours and scientific positions of trust in 2002-2006 (**Appendix6**)

6.4 Memberships on committees and in scientific advisory boards of business companies or other similar tasks of no primarily academic nature 2002-2006 (**Appendix6**)

7 Unit's self-assessment

7.1 The Unit's research strategy 2007–2009(2011) (relation to the parent organisation's strategy, priority areas in research, development measures; max 1 page)

7.2 Infrastructures (including research stations, max. 2 pages).

Describe a) the Unit's unique and most important own infrastructures b) other infrastructures important for the Unit's research. Need for new infrastructure?

7.3 SWOT – Evaluation of the Unit's existing scientific strengths and weaknesses, and future opportunities and threats (e.g. expertise, funding, facilities, organisation, strategy, science policy; max. 2 pages).

7.4 Benchmarking. Evaluate the Unit in relation to international competitors (compare resources and results, opportunities/restrictions to those two to three relevant research groups, max. 2 pages).

7.5 The Societal impact of the Unit's activities (max. 1 page)

7.5b Contact information of most important users/collaborators related to societal needs?

7.6 Assess the academic and societal need for doctoral training within the Unit's research fields and the Unit's role in doctoral training (max. 1 page).

Instructions for filling in the Submission form (Please read carefully)

The evaluation covers the period from 2002 through to 2006. All data and information deal with this period unless otherwise stated in the Submission form or these instructions.

GENERAL INFORMATION

Share of water research in Faculty and Department (or equivalents). The share of the water research is counted as a percentage of the research funding in 2006.

Collaborators are mentioned here only if collaborators' data and information is included in the submission form and appendices.

1 Staff

1.1 Number of staff

Indicate information on the staff in full time equivalents (FTE). *Full time equivalent* refers to annual full-time work including paid holidays and other statutory days off. Other holidays, leaves of absence etc. shall be deducted from the calculated working time.

One person-workday is 8 hours 15 minutes and one person workweek 41 hours 15 minutes effective working time (lunch hours included, 1 hour/day). If the person's working time is less than the norms of normal office hours, the amount of person-work is calculated using the working time norm as divider.

If the person has other duties than research, only the part that is used for research work is included.

Research active staff includes persons who plan, produce and publish new knowledge, theories and methods as well as products and processes based on them, and lead research projects.

Persons under the following titles shall always be listed under the **research active staff**:

- Academy Professor (in Finnish: akatemiaprofessori)
- Academy Research Fellow (akatemiatutkija)
- Assistant (assistentti);
- Chief Research Scientist (johtava tutkija)
- Clinical Teacher (kliininen opettaja, apulaisopettaja)
- Doctoral Assistant (tohtoriassistentti)
- Group Leader (ryhmänjohtaja)
- Head of Research (tutkimuspäällikkö)
- Laboratory Director (laboratorionjohtaja)
- Postdoctoral Research Fellow (tutkijatohtori)
- Professor (professori)
- Research Professor (tutkimusprofessori)
- Research Director (tutkimusjohtaja)
- Research Lecturer (tutkijalehtori)

- Senior Curators (yli-intendentti)
- Senior Researcher (vanhempi tutkija)
- Specialist Researcher (erikoistutkija)
- University Lecturer (yliopistonlehtori)

Staff categories

1 Professor

Professors in university or research professors in research institutes.

2 Other *Senior researcher*

Senior researcher is a person who plans and leads research projects. Senior researcher in university is e.g. professor or adjunct professor (dosentti) who supervises doctoral dissertations. Below senior researcher means professor or other senior researcher.

3 *Postdoctoral researchers*

Postdoctoral researcher is a person who has earned his/her doctoral degree no more than five years ago and does not yet have competence for senior researcher.

4 *Doctoral students* (category: Doctoral students) belonging to either of the following groups:

- Persons with at least an MA or MSc (or equivalent) degree who have been employed by the university as full-time researchers or assistant researchers to do doctoral studies for a period of no less than six months.
- Persons with at least an MA or MSc (or equivalent) degree who, for a period of no less than six months, have fulfilled the following two criteria: they a) have been affiliated with the Unit as full-time researchers or assistant researchers to do doctoral studies and b) have been receiving research funding from some other source than another university or research institute.

These groups include, e.g. doctoral students employed by graduate schools.

Doctoral students who do not fulfil either of the above criteria, i.e. who have not been employed by the university and have not been receiving other funding, can also be included in the research active staff for the period they are not holding a post in another university or research institute. The Unit can decide case by case whether to include these doctoral students

5 *Visiting researchers and research students*

Visitor is a foreign person who is doing research or completing his/her doctoral studies in the unit.

6 *Other research active staff*

Researchers and research students who are not included in the categories above.

7 *Technical personnel*

Technical personnel refer to persons working under the supervision of research active staff to carry out projects but who are not involved in the theoretical planning, publishing or other related activities.

8 *Administrative personnel*

Administrative personnel refer to persons who take care of administrative tasks related to the research, such as financial and personnel administration or other office duties but who are not normally involved with the technical implementation of the projects.

1.2 List of research active staff in 2002-2006

List all research active staff and their tasks for the period of 2002-2006. Task refers to actual job or position that person has (e.g. head of unit, research professor). Task category refers to categories in Table 1.1. Please use abbreviations MA, MSc, PhD for academic degrees.

In case the person's duties have changed during the period under review (e.g. from doctoral student to post doctoral researcher), indicate the person's both tasks and period according to the format.

2 Funding

2.1 *Core funding* for scientific research applies to the Unit's budget funding and possible other funding for research awarded by the parent organisation. The funding covers both the salary costs with social charges of the staff and the operational costs which include consumption costs and investment costs for research activities.

Use of research funding received from *external sources*, indicated per year. Academy of Finland fellowships should also be included and counted. Salaries should be counted as 1.33 * gross salary.

2.2 Describe how the funding awarded by the Academy of Finland and other funding bodies has promoted the scientific research and contributed to the societal impact of the Unit's activities. Scientific impact refers to the contribution of the research carried out by the Unit to the development of the field. Societal impact refers to the ability of the research activities to promote values that are considered as important in society. Work for societal impacts may have additional funding besides research funding. This kind of additional funding is not included in Table 2.1.

3 Unit's research profile and scientific publishing

3.1 Estimate of the Unit's research orientation according to fields of science related to this evaluation.

3.2 This question surveys how the research carried out in the Unit has impacted research in its own field(s). Describe what have been the research strategy and orientation of scientific publishing, most important research results, the role of interdisciplinarity etc. In case the research carried out in the Unit is clearly specialised in the different fields of aquatic research, describe each field separately. If it is reasonable you may also describe the Unit's research strategy from the 1990's to the present. (see also Question 7).

3.3 In the summary table, calculate the number of each type of outcome in the list during the period under review.

3.4 List of publications and other outcomes in the order indicated in the summary table, by type of outcome. Regarding each outcome, indicate the name of the author/

authors, title/publication etc. and the type of outcome. This table can also be produced in rtf-format.

3.5 Each professor and senior researcher shall list five of his/her key publications during the entire research career indicated in the order of quality. Unlike other information, the list may also include manuscripts published in 2007 or manuscripts approved for publication but still unpublished. A copy of the manuscript approved for publication shall be submitted with the other information.

At the end of the publication data, give the citation index of their publications. Indicate this citation index as the last information by using the abbreviation CI = number of citations.

Example:

Von Wright A, Bruce A. Genetically modified micro-organisms and their potential effects on human health and nutrition. Trends in Food Science & Technology 14, 264-276 (2003). CI=2

References to books should give the names of all editors, place of publication and publisher, publication year.

3.6 For ensuring easy readability do not make the font size smaller when copying publications. The copies of publications shall be two-sided. Minimum number of publications is five. Maximum number of publications = number of senior researchers.

4 Doctoral training

4.1 If at least half of the doctoral dissertation has been supervised and done at a research institute, the research institute can also list the doctoral dissertation as its own outcome. In this case indicate also the university where the doctoral dissertation has been *presented for approval*. Please indicate the supervisors' *share* of the supervision if the dissertation has more than one supervisor.

4.2 Indicate only degree-awarding organisations.

4.3 In addition to the name of the organisation, indicate the type of organisation (university, business company, research institute, state, municipality or other).

5 Unit's collaboration contacts

5.1–5.2 List the visits per year. List the visits of each year by country in the alphabetical order. In Field 1, give other information in accordance with the title except the duration of the visit that is to be indicated in Field 2. The minimum duration of a visit to be indicated is two weeks. In item Topic of visit indicate clearly the objective of the visit, for example regarding a post doc period describe what were the content objectives related to the visit.

5.3 You may describe shorter visits (duration less than two weeks) that have been of a particular importance to the Unit or the field of water research.

In item 5.4 Collaborator refers to a person or a research team with whom the cooperation has either generated or is expected to generate within the next three (3) years one of the outcomes indicated in Item 3.4.

5.5 Describe here e.g. key joint publications, researcher training, adoption and use of new technologies or new approaches.

6 Other scientific or societal activities

6.1 Plenary or other invited presentations.

6.2 Indicate the task e.g. chief editor, editor, referee.

7 Unit's self-assessment

Self-assessment is an important part of the evaluation. *Please answer carefully*.

7.1 Units strategy and its relation to faculty/university-, research institute strategy. Describe the Unit's research programme for the next few years, the key research objectives and means to achieve these objectives. What is the role of basic and applied research? Do the strategies of the parent organisation and the Unit support each other?

7.2 Is there need for new knowledge, facilities, is the present level of funding sufficient for attaining the objectives? What is the role of research stations?

7.3 In addition to present strengths and weaknesses it is also important to assess future opportunities and threats in broader perspective. System level issues (e.g. university- and science policy options, future funding opportunities, facilities etc.) should be included in future prospects.

7.5 Describe here how the Unit's research activities and cooperation with other actors in society have promoted the activities of other societal actors. Describe e.g. how the activities have contributed to environmental protection and risk management, the activities of industry and SMEs, production and use of new services and products, drafting of new regulations and norms etc.

7.5b User/collaborator's name, address, email and telephone number.

E Funding for Finnish Water Research 2002–2006

Table 1. Total research funding 2002–2006 (thousands €)

Organisation	Faculty/ department	2002	2003	2004	2005	2006	Total
UH	FAF	763,1	808,6	839,7	823,5	1017,6	4252,5
UH	FB	3424,1	3885,0	4118,4	4349,4	4355,6	20132,6
UH	FS	710,6	471,6	604,6	732,8	587,7	3107,4
UJo	FB	1042,8	1102,3	1483,2	1352,9	1477,3	6458,4
UJ	DBE	1859,9	1830,7	1692,8	1665,7	1692,4	8741,4
UO	DB	354,0	476,4	903,2	828,4	728,6	3290,6
UO	WREEL	506,4	484,0	501,6	448,9	479,3	2420,2
UT	FMNS	927,0	1158,5	1289,5	1311,9	1511,8	6198,8
ÅU	FMNS	987,4	1211,0	1443,9	1287,8	1110,7	6040,8
HUT	LWRE	1004,4	1169,2	1259,0	1428,8	1425,6	6287,1
MTT		362,0	409,0	410,0	432,0	941,0	2554,0
SYKE		2477,9	2919,6	2515,9	2710,2	2826,9	13450,4
FFRI		253,2	383,8	377,0	443,3	645,5	2102,7
FGFRI		1478,0	1596,0	1605,0	1647,0	1572,0	7898,0
FIMR		3446,0	3537,0	3539,0	3014,0	2868,0	16404,0
FMI		110,0	160,0	323,7	364,5	429,8	1388,0
KTL		346,0	317,5	241,5	307,0	253,0	1465,0
Total		**20052,7**	**21920,2**	**23148,0**	**23148,2**	**23922,9**	**112192,0**

Table 2. Core research funding 2002–2006 (thousands €)

Organisation	Faculty/ department	2002	2003	2004	2005	2006	Total
UH	FAF	183	203	206	247	290	1129
UH	FB	1594	1617	1704	1874	1801	8590
UH	FS	243	212	340	352	319	1465
UJo	FB	562	548	522	566	601	2798
UJ	DBE	628	814	651	650	751	3494
UO	DB	151	166	294	288	345	1244
UO	WREEL	329	319	321	312	305	1586
UT	FMNS	316	351	392	466	650	2175
ÅU	FMNS	461	428	548	465	485	2386
HUT	LWRE	554	703	725	787	853	3623
MTT		269	298	310	329	462	1668
SYKE		948	1321	1098	1031	1217	5616
FFRI		244	336	350	400	511	1841
FGFRI		1066	1137	1144	1125	1177	5649
FIMR		2825	2685	2752	2124	2279	12665
FMI		90	120	220	220	220	870
KTL		20	20	20	20	20	100
Total		**10483**	**11277**	**11597**	**11257**	**12286**	**56899**

Table 3. External research funding 2002–2006 (thousands €)

Organisation	Faculty/ department	2002	2003	2004	2005	2006	Total
UH	FAF	580,0	605,8	633,3	576,5	727,9	3123,4
UH	FB	1830,1	2267,7	2414,6	2475,3	2554,8	11542,5
UH	FS	468,0	260,0	265,0	381,1	268,5	1642,7
UJo	FB	480,6	554,7	961,3	787,0	876,4	3660,1
UJ	DBE	1232,1	1016,7	1041,4	1015,4	941,8	5247,5
UO	DB	202,7	310,6	609,6	540,0	383,8	2046,8
UO	WREEL	177,6	165,0	180,6	136,7	174,4	834,3
UT	FMNS	611,5	807,6	897,4	845,5	861,5	4023,6
ÅU	FMNS	526,3	783,4	896,2	823,1	625,8	3654,8
HUT	LWRE	450,0	466,4	534,0	641,6	572,3	2664,3
MTT		93,0	111,0	100,0	103,0	479,0	886,0
SYKE		1529,9	1598,4	1417,4	1679,5	1609,4	7834,7
FFRI		8,9	47,9	27,1	42,8	134,6	261,2
FGFRI		412,0	459,0	461,0	522,0	395,0	2249,0
FIMR		621,0	852,0	787,0	890,0	589,0	3739,0
FMI		20,0	40,0	103,7	144,5	209,8	518,0
KTL		326,0	297,5	221,5	287,0	233,0	1365,0
Total		**9569,8**	**10643,7**	**11551,2**	**11891,2**	**11636,9**	**55292,9**

F Interview Schedules

Timo Huttula, 17.9.2007							
Finnish Water Research Evaluation 2007, Week schedule							
	Sun	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**
Day/Time	4.11.2007	5.11.2007	6.11.2007	7.11.2007	8.11.2007	9.11.2007	10.11.2007
08:30-09:00		Finnish Institute of Marine Research	UH: Faculty of Biosciences	Finnish Environment Institute	HUT: Laboratory of Water Resources Engineering	Finnish Game and Fisheries Research Institute	
09:00-09:30							Report drafting
09:30-10:00							
10:00-10:30							
10:30-11:00					UTU: Faculty of Mathematics and Natural Sciences	UJo: Faculty of Biosciences	
11:00-11:30							
11:30-12:00		UH: Faculty of Agriculture and Forestry	UH: Faculty of Science	National Public Health Institute			
12:00-12:30							
12:30-13:00				Lunch	Lunch	Lunch	
13:00-13:30		Lunch	Lunch				Lunch
13:30-14:00				UO: Department of Biosciences*	UJ: Department of Biological and Environmental Science	Report drafting	
14:00-14:30		Agrifood Research Finland*	UO: Water Res. and Env. Eng. Laboratory*				
14:30-15:00							
15:00-15:30		ÅU: Faculty of Mathematics and Natural Sciences		Excursion			
15:30-16:00			Finnish Meteorological Institute*		Finnish Forest Research Institute*		
16:00-16:30							
16:30-17:00							
17-18	Introductory meeting	Dinner	Dinner		Dinner		
18-19							
19-20	Dinner	Report drafting	Report drafting	Dinner	Report drafting		
20-21						Dinner with collaborators	
21-22							
Note: Each time slot contains internal discussion of the panel (15-20 min) after the unit interview. * = Ph.D. student interviews as parallel session							
HUT = Helsinki University of Technology, UH = University of Helsinki, UJ = University of Jyväskylä, UJo = University of Joensuu, UTU = University of Turku, ÅU = Åbo Academy University							

Timo Huttula, 24.10.2007					
Finnish Water Research Evaluation 2007, Student group discussions					
	Mon	**Tue**	**Wed**	**Thu**	**Fri**
Day/Time	5.11.2007	6.11.2007	7.11.2007	8.11.2007	9.11.2007
08:30-09:00					
09:00-09:30					
09:30-10:00					
10:00-10:30					
10:30-11:00					
11:00-11:30					
11:30-12:00	FIMR (4) + ÅU (4)		FEI (3) + UO_BIO (3)		
12:00-12:30					
12:30-13:00			Lunch	Lunch	Lunch
13:00-13:30	Lunch	Lunch			
13:30-14:00			HUT (3) + NPHI (2) + UTU (3)		
14:00-14:30	UH_SC (3) + FFRI (?)	FMI (2) + UH_AGROFOR (4)			
14:30-15:00					
15:00-15:30					
15:30-16:00		UO_WAT (3) + UH_BIO (4)		UJ (4) + UJo (2) + FGFRI (1)	
16:00-16:30					
16:30-17:00					
HUT = Helsinki University of Technology, UH = University of Helsinki, UJ = University of Jyväskylä, UJo = University of Joensuu, UTU = University of Turku, ÅU = Åbo Academy University					
FEI = Finnish Environment Institute, FFRI = Finnish Forest Research Institute, FGFRI = Finnish Game and Fisheries Research Institute, FIMR = Finnish Institute of Marine Research, FMI = Finnish Meteorological Institute, NPHI = National Public Health Institute					

G Water Research Units, their Abbreviations and Contact Persons

Organisation	Faculty/department	Abbreviation	Contact Persons
University of Helsinki	Faculty of Agriculture and Forestry	UH/FAF	Professor Christel Lamberg-Allardt
University of Helsinki	Faculty of Biosciences	UH/FB	Professor Jorma Kuparinen
University of Helsinki	Faculty of Science	UH/FS	Professor Matti Leppäranta
University of Joensuu	Faculty of Biosciences	UJo/FB	Professor Ismo Holopainen
University of Jyväskylä	Department of Biological and Environmental Science	UJ/DBE	Professor Juha Karjalainen
University of Oulu	Department of Biology	UO/DB	Professor Timo Muotka
University of Oulu	Water Resources and Environmental Engineering Laboratory	UO/WREEL	Professor Björn Klöve
University of Turku	Faculty of Mathematics and Natural Sciences	UT/FMNS	Professor Jouko Sarvala
Åbo Akademi University	Faculty of Mathematics and Natural Sciences	ÅU/FMNS	Professor Erik Bonsdorff
Helsinki University of Technology	Laboratory of Water Resources Engineering	HUT/LWRE	Professor Pertti Vakkilainen
Agrifood Research Finland		MTT	Dr. Mari Walls
Finnish Environment Institute		SYKE	Professor Saara Bäck
Finnish Forest Research Institute		FFRI	Dr. Pasi Puttonen
Finnish Game and Fisheries Research Institute		FGFRI	Dr. Raimo Parmanne
Finnish Institute of Marine Research		FIMR	Dr. Markku Viitasalo
Finnish Meteorological Institute		FMI	Dr. Timo Vihma
National Public Health Institute		KTL	Professor Terttu Vartiainen