Ministry of Agriculture and Forestry

International Evaluation of the Finnish Game and Fisheries Research Institute

Report of the Evaluation Group

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Preface

The Science and Technology Policy Council of Finland issued in 1994 a recommendation urging the ministries to carry out international evaluations of all State research bodies within their respective branch of administration. Evaluations would serve to further improve the operational capacities of the institutes.

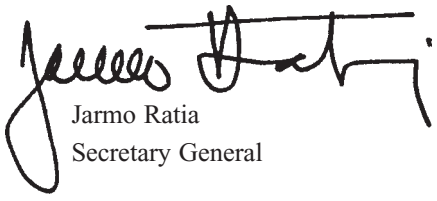
The Ministry invited Professor Henry A. Regier from Canada, PHD Stellan F. Hamrin from Sweden, Professor Jon Swenson from Norway and Professor Ossi V. Lindqvist from Finland to carry out the evaluation. The Ministry also appointed a national support group, consisting of representatives from the principal client and reference groups of the Finnish Game and Fisheries Research Institute to assist the evaluation panel in its work.

This report is the result of the evaluation panel's assignment.

The Ministry wishes to express its gratitude to the evaluators for their work, which provides an excellent basis for the further development of the FGFRI, and which lays out a range of options for the future of the Institute. The possibilities of implementing the panel's recommendations will be further examined.

The Ministry also wishes to thank the members of the national support group and others who have helped the evalution process. Finally the Ministry wishes to extend its appreciation to the management and staff of the Finnish Game and Fisheries Research Institute for their efforts throughout the course of the evaluation.

August 11,1999



Jarmo Ratia
Secretary General

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Chapter 1
Overview and general recommendations

Organization of the Evaluation Process

The team that evaluated FGFRI consisted of PHD Stellan Hamrin of Sweden, Professor Ossi Lindqvist of Finland, Professor Henry Regier (chair) of Canada and Professor Jon Swenson of Norway. Each evaluator had previously interacted with some researchers in FGFRI within international scientific networks and Prof. Lindqvist has had many interactions within Finland. M.Sc. Roni Selén of Helsinki served ably as the team's assistant.

A formal Steering Group for this evaluation included: Director General Seppo Havu, Senior Officer Christian Krogell and Senior Fishery Officer Pentti Munne, all of the Ministry of Agriculture and Forestry; Ministerial Advisor Hannele Nyroos of the Ministry of the Environment; Senior Research Officer Jaana Roos (until February 28, 1999) of the Academy of Finland; Senior Research Officer Annamaija Lehvo of the Academy of Finland (since March 1, 1999), Professor Jouko Sarvala of the University of Turku, Senior Officer Elina Selinheimo of Ministry of Finance, Docent Markku Viljanen of the University of Joensuu and Managing Director Markku Juola of Voimalohi Oy.

The evaluation team visited six FGFRI facilities from the south to the north of Finland and participated in seminars, consultations and informal discussions during two visits, each of one week duration, in February and March of 1999. There was opportunity to meet with numerous university cooperators of FGFRI researchers and some customers of the scientific results of the Institute. The agendas for those two visits may be found in Appendix D. Members of the evaluation team were exhilarated by the commitment, knowledge, excitement, openness and sophistication of colleagues in FGFRI and its network of collaborators.

A series of documents prepared for the evaluation process by FGFRI researchers helped to focus the team's work; see Appendix B. Evaluation reports on related research activities by other Finnish Institutes, the Academy of Finland and some universities were provided to the evaluators. Numerous published reports, of first-rate scientific work done within FGFRI and with some reported as doctoral theses of Institute researchers, were made available. Finally a short questionnaire was sent to a selected cross-section of customers of the Institute's scientific and technical services.

The Team's Approach to Evaluation

The evaluators were asked to evaluate, assess, or review the research, entrepreneurship and management being conducted by FGFRI, in the context of Finland's needs for scientific and technical information on its fish, game and reindeer and for efficient business practices in its aquaculture program and services unit.

Finland's needs follow, in turn, from its public policies related to these natural resources. But these policies appear to be strongly in flux now, and the team was not given a set of clearly specified policies according to which FGFRI's current activities could be evaluated with respect to relevance, efficiency and sufficiency, say. The team tried not to stray into a more inclusive policy or programme

audit. But we may have done something like that on occasion, and beg the reader's tolerance where this has occurred. Such text may be read as an implicit call for clarification of policy, with the help of FGFRI researchers.

Each of the four evaluators has taken the lead role with some particular parts of the report and has used an approach thought to be appropriate for a particular part. Hence there are differences in format and style, as in the specificity of recommendations, for example. Also, similar advice may have been given in different contexts. Evaluators interacted with each other until a working consensus on all recommendations was reached. They did not try to edit out all redundancy.

The team did not attempt to be fully comprehensive in the evaluation, but rather it tried to focus incisively on a number of issues that it thought were important to FGFRI's future.

In reading recent evaluations of some five other Finnish Institutes with responsibilities that relate in part to the habitats of fish, game and reindeer and to the environment for aquaculture, team members noted that some of the recommendations of those evaluation teams had strong implications for FGFRI. The recommendations that follow here could contribute to a synthesis of common elements of advice from the whole set of evaluations of these Institutes which in turn could provide guidance for stronger collaboration among these Institutes.

In working on this review the evaluation team was impressed by the positive findings of previous reviews of other Institutes. Also the team realized that FGFRI had already been transforming deliberately under Finland's open and critical policy toward scientific information services and management opportunities related to the use of market incentives. Hence the team's recommendations are more in the nature of "thinking along with FGFRI innovators" rather than a set of practically definitive actions that could perhaps be imposed on FGFRI by senior administrators.

The Evaluation Report

The evaluation report starts with four chapters that are quite general. In these chapters the team has attempted to communicate with a larger set of readers than just the experts of FGFRI and sister Finnish Institutes. In particular, the text of these chapters may relate also to the interests of governmental administrators, politicians as well as leaders of private organizations and corporations with which FGFRI collaborates. In Chapters 5 to 9 the text presupposes more scientific and technical familiarity with what FGFRI experts are now doing. Chapters 10 and 11 and the Appendices may again be meaningful to a larger set of readers.

The recommendations in Chapter 1 are the most general. The chapters that follow (except Chapters 2 and 4 which include no recommendations) contain somewhat more detailed recommendations each of which is specified in the context of some supporting text.

The team hopes that its recommendations will all be intelligible to the researchers and managers of FGFRI and sister Institutes. Presumably these experts would welcome an opportunity to cooperate with politicians, administrators and partners in the practical implementation of those that would then be deemed particularly useful and timely.

The team found that most of the processes and products of current FGFRI progammes are first-rate, as far as they go. Mostly what is now being done in FGFRI is excellent conventional science and efficient conventional management. The team urges a complementary emphasis on "strategic science and management" that can build on interesting innovations already underway in FGFRI and in

other Institutes. In the further evolution of FGFRI the leaders may seek a balance between: conserving necessary elements in what is currently deemed to be conventional; and initiating new elements in what is proposed as strategic innovation.

Within the Institute as a whole, the leader of each of the five units could commit to one or more strategic initiatives, while modifying the unit's conventional responsibilities. Other strategic initiatives could be a jointly conducted by the whole Institute, under the Director General's guidance. Still others would be organized at a higher level of governance, with collaboration of other Institutes, etc.

Our general recommendations that follow here in this Chapter 1 relate to this strategic science and management theme.

General Recommendations for a Strategic Theme

1. FGFRI has responsibilities that have an inter-national component and an intra-national component. Both of these components have been evolving within FGFRI, and should evolve further, in phase with recent and future developments in Finland's external and internal policies.

2. With respect to fish, game, reindeer and aquaculture, Finland is becoming more integrated into the Baltic Basin and into Europe, and is becoming more collaborative with Russia. Thus the program of FGFRI and of each of its Units should develop additional strong international elements which may be undertaken cooperatively with colleagues in other countries.

3. Concerning difficulties and opportunities with these resource systems internally within Finland, FGFRI should conduct more collaborative research with other Finnish Institutes and other agencies of government, in addition to universities. Such cooperation can be encouraged by sharing the use of new facilities and advanced equipment, for example. But more than that is needed.

4. Regional or basin-wide problems and opportunities that are important politically are now coming to be studied from a watershed or ecosystem perspective. This requires integration of disciplinary basic science, interdisciplinary applied science and transdisciplinary mission-oriented science. FGFRI's recent and good beginnings toward such a balanced scientific approach should be accelerated.

5. Increasingly with issues related to fish, game, reindeer and aquaculture, the responsibilities of governance are shared between a national government, other layers of government and non-governmental organizations such as associations of users of these resources. Each stakeholder in such a co-management arrangement needs information relevant to its interests and each bears some responsibility for collecting appropriate information to be shared with other stakeholders. With respect to co-management in a watershed context, say, FGFRI should reconsider its own responsibilities for, and revise its contributions to, the shared scientific information services.

6. More of FGFRI's responsibilities for scientific information services may come to be "outsourced" or contracted with universities and private scientific consultants. (The evaluation team

simply notes this as a likelihood and is not urging that this should occur.) If more out-sourcing can be expected, then FGFRI should help to formulate explicit procedural guidelines for such contracting arrangements, to ensure that relevant and reliable information be delivered in a cost-effective way.

7. Some of the current activities of FGFRI may need to be trimmed back to free-up resources for new initiatives like those above. Some older facilities that now have little use should be closed. Some of the fish-stocking could be reduced. With appropriate computerized expert systems, some data collection and analysis may be reduced. But long-term data series that are highly valuable, say with respect to global change, should be continued and perhaps improved.

8. FGFRI should create strong inducements for its researchers, staff and cooperators to innovate with respect to Finland's emerging policies, often by participating energetically in interdisciplinary, international, trade and co-management networks.

9. FGFRI and its sister Institutes in Finland could help to organize a Baltic Basin network of interdisciplinary ecosystemic science which could lead to more effective strategic efforts to resolve, cooperatively and cost-effectively, a series of complex issues with game and fish that may occur throughout the Basin.

Chapter 2.
Introduction

Purpose of the Evaluation Report

This report provides an evaluation of the Finnish Game and Fisheries Research Institute, FGFRI, with a nation-wide complex of stations, headquartered in Pukinmäki, Helsinki. Four internationally known scientists were commissioned by the Ministry of Agriculture and Forestry, MAF; to provide this evaluation; a biographical sketch for each is included in Appendix C

The terms of reference for the evaluation group were provided in January 1999, see Appendix A. The questions were designed to elicit overall conclusions regarding the breath and depth of the FGFRI's programme from scientific and resource-utilization perspectives.

The evaluation group was provided summaries of divisional programs, staff information and publications, as described further below. Two on-site visits with seminars and tours of some of FGFRI's research stations were arranged in February and March, 1999; see Appendix D for the agendas for these visits.

Aspects of FGFRI that are relevant to the evaluation are summarized below.

The Institute's Mission

FGFRI strives to uphold high standards of excellence in its capacity as an internationally significant research centre possessing specialized expertise in northern European game and fisheries. The information and aquacultural services provided by FGFRI promote the sustainable use of fish and game resources consistent with the demands of biological diversity and the advancement of commercial opportunities in the fish and game sector.

Since 1996, the FGFRI's operating philosophy has comprised the following objectives or aims:

- to generate information and provide expert services;
- to promote the sustainable use of naturally occurring game and fish resources in Finland;
- to advance commercial operations and recreation in the sector;
- to foster awareness of the impact of environmental changes on game and fish stocks, and to pr mote the management of habitats in such a manner as to support their viability;
- to produce reliable, up-to-date estimates, statistics and forecasts on game and fish stock abundance and catches;
- to preserve endangered fish stocks and the diversity of fish species by means of cultivation; and
- to promote national and international cooperation in its field of expertise

This operating philosophy was formulated late in 1998 as part of FGFRI's strategic planning. The present status of this work is described in further detail in the section dealing with the FGFRI's strategy, below.

Current programs

The Institute's research is organized in three units which are: Fisheries Biology and Management Research Unit, Socioeconomic and Aquaculture Research Unit, Game and Reindeer Research Unit. The Aquaculture Unit's primary role is not research but is to produce high-quality young fish for stocking, to help to preserve threatened stocks, etc. Each of these units has its own programme which was described for evaluators in briefing materials and in oral presentations at the site visits.

Organization of the FGFRI

The highest decision-making body in the FGFRI is the Board, which is in charge of strategic management of the Institute's operations. In 1998, the Board consisted of Managing Director Jouni Filppa, Director Per-Edvin Persson, Managing Director Kaisa Rossi, Professor Jorma Tahvanainen, M.Sc. Fisheries Biologist Oili Vuorimies and the Director General of the FGFRI as the Chairman of the Board.

The FGFRI consists of five profit centers or units with the Management Group as their joint coordinator. The Management Group consists of the Director General and the heads of the five units. The Director General of the FGFRI is M.Sc.Econ. Kare Turtiainen. The Fisheries Biology and Management Unit is headed by Dr. Petri Suuronen, the Socioeconomic and Aquaculture Research Unit by Dr. Juhani Kettunen, the Game and Reindeer Research Unit Dr. Eero Helle, the Aquaculture Unit by Lic.Phil. Kai Westman and the Services Unit by M.Sc. Lena Söderholm-Tana. The current organizational model was introduced in 1994.

Each Unit is responsible for one or two of the following areas:

- Fisheries biology and management research, i.e., production of research data on the status of fish stocks, the effects of habitat modification on fish stocks and fisheries management;
- Socioeconomic and aquaculture research, i.e., production of research data necessary for commercial and recreational fishing, aquaculture and other business in the fisheries industry;
- Statistics, i.e., compilation of statistics on fisheries, game management and reindeer husbandry;
- Game research, i.e., production of research data on game populations, hunting and the condition and management of game habitats, and coordination of the game monitoring;
- Reindeer research, i.e., production of research data on the biology of the reindeer, reindeer pastures and reindeer herding;
- Aquaculture, i.e., maintenance of gene banks of fish stocks, cultivation of fish and crayfish for revival of endangered stocks, obligatory stocking, research and other purposes, including cultivation contracts; and
- Services, i.e., production of support services required by the FGFRI and its customers, for which centralization of services is the most practicable approach.

FGFRI has 25 research and aquaculture stations across Finland.

FGFRI's operations are based on the annual State budget and on the operating and financial plan which is ratified early for four years. The "result targets" for the FGFRI are set by the Ministry of Agriculture and Forestry and specified in the operating plans for each Unit. The State appropriations allocated to each Unit are ratified separately. FGFRI's annual report and report on operations is made up of the Units' separate reports on their operations. Attainment of the result targets is also described in interim reports submitted to the Ministry each September.

Domestic cooperation

- The FGFRI's most important domestic partners - and occasionally its competitors - are other rese arch institutes, such as the National Veterinary and Food Research Institute, the Agricultural Research Centre, the Finnish Marine Research Institute, the Finnish Forest Research Institute, the Finnish Environment Institute, the regional environment centres, and universities, notably those of Helsinki, Joensuu, Jyväskylä, Kuopio, Lappi, Oulu, Turku and Åbo Akademi. The FGFRI also cooperates with the authorities, organizations and businesses related to fisheries and game management. Statistics are compiled in collaboration with Statistics Finland, the Ministry of Agriculture and Forestry, and employment and economic centres.
- FGFRI has agreements on cooperation with universities, other research institutes, private enterprises, environment centres, the Finnish Forest and Park Service and Statistics Finland, among others
- Fish farms are the most important customers for products related to aquaculture, but they are also FGFRI's competitors. FGFRI invites competitive tenders from private fish farms for cultivation contracts, under which FGFRI sells fish eggs to private fish farms and agrees to buy the juveniles back at a specific age, within limits set by the State budget. State-owned and private fish farms cooperate closely in aquacultural product development, breeding, experimental cultivation of new species, and development of cultivation technology.
- Universities have an important role in creating knowledge, providing education and recognizing academic qualifications for the FGFRI's employees. Some of these researchers teach at universities, twelve of them as docents. By combining fisheries expertise with social sciences, technology and economics, cross-disciplinary joint projects enable new approaches to be employed in fisheries research. This cooperation covers environmental studies, fish biology studies, methodology, studies in population ecology and genetics, pathological studies, aquacultural development projects, teaching and statistics.
- Governmental authorities, private organizations, fishing areas and fishing collectives have the role of initiators, customers and users of this research, more or less reflecting the needs of citizens at large. Finnish fisheries and the related authorities and information services form a decentralized nationwide network.
- Game and reindeer research is coordinated by the FGFRI, which also carries out most of the research, while the actual game management is done by game management associations and hunting clubs.
- Although the FGFRI competes for funding with other providers of consultancy services in the fisheries and game management sector, the FGFRI's strength lies in large-scale projects and projects requiring in-depth expertise, where long-term extensive reference material collected over a long period can be very useful.

International Cooperation

- FGFRI has concluded a number of international cooperation agreements with its neighbouring countries and the EU. These agreements concern fishing, water-level regulation, statistical monitoring and environmental protection in the Baltic Sea and the North Atlantic.
- There has been a considerable increase in the international activities carried out by the FGFRI, particularly those related to the European Union (EU). Decision making in EU requires more and

more detailed background information on fish stocks and their exploitation, and also on game and reindeer populations and their habitats. In fishery research, this necessitates cooperation with international organizations and participation in the assessment of resources.

- In the FGFRI's history, the oldest forum of international cooperation is the International Council for the Exploration of the Sea, ICES. Research on the salmon in the rivers Tenojoki and Näätämäjoki is discussed annually at the North Atlantic Salmon Conservation Organization, NASCO. The FGFRI has also been a member of the Working Group on Fisheries Research, NAF, of the Nordic Council of Ministers since the working group was established in 1989. NAF's primary task is to provide expert opinions on research project applications submitted to the Nordic Council of Ministers. In 1997, the FGFRI participated in five new or ongoing joint Nordic research projects.
- Cooperation with Russia focuses on waters between Finnish and Russian territory and assessment of game populations.
- FGFRI has a representative in the EU's Scientific, Technical and Economic Committee for Fisheries, STECF, which reviews the ICES's advice to the EU where intra-Community waters are concerned. Representatives of the FGFRI also provide expert scientific comments on research project applications and on the scientific programme committees. FGFRI has also actively taken part in Meetings of the Directors of Fishery Research Organizations of the European Union.
- FGFRI is involved in several fishery research projects organized by the EU. In 1997, EU projects were carried out on technical regulation of Baltic fisheries, fluctuations in the Baltic cod stocks, fish catch sampling in the Baltic Sea, tagging methods, and echo-sounding assessment of the salmon stock ascending the Tornionjoki river. The core of the research cooperation within the EU consists of projects funded by DG XIV. In some of the projects co-financed by the EU, which generally last for 1-3 years, FGFRI's role is that of coordinator. The total sum of funding for these programmes is 2.7 million ecus. Direct EU funding for game and fishery research amounts to about 250,000 ecus in 1997 and 1998 and will increase in the coming years.
- Eurostat meetings on fisheries statistics are the most important cooperation forum for statistical work. Other cooperation partners include the Nordic Council of Ministers and the ICES and the national statistical offices of individual countries.
- Representatives of the FGFRI have worked as experts at the International Baltic Sea Fisheries Commission, IBSFC, and the North Atlantic Salmon Conservation Organization, NASCO, every year since these were established. In 1997, FGFRI also took part in drafting the fisheries section of the Baltic Agenda 21 and the implementation of the Salmon Action Plan, SAP, based on a Commission decision.
- FGFRI participates in the FAO's European Inland Fisheries Advisory Commission, EIFAC, by submitting reports requested by the Commission or its working parties and taking part in the activities of the working parties.
- The FGFRI has representatives in the Nordic Council for Wildlife Research, the International Union of Game Biologists, the Bonn Convention Scientific Council, the European Bird Census Committee, the Nordic Council for Reindeer Research, the Circumpolar Seabird Working Group and the international Bird Strike Committee. The editor-in-chief and one of the sub-editors of the international journal Wildlife Biology are also FGFRI employees.
- The FGFRI is involved in joint research projects with foreign universities and research institutes and international scientific societies and organizations.

Acknowledgment: M.Sc. Roni Selén has composed this chapter.

Chapter 3
The evalution team's general impressions of FGFRI

Altogether FGFRI is productive and its people now share good morale. The recent research processes, the scientific products, the organizational structures and the administrative practices all show evidence of flexibility and ongoing renewal that we find desirable. The evaluation team did not focus much attention on the Institute's structures and processes in the context of the larger Ministry, because it sensed no serious problems in that respect. The Institute has a variety of connections with the "real world," both within government and with the public; some of these connections may need to be animated further.

The evaluation team has no strongly adverse criticism to make of FGFRI and would instead urge that further evolution occur quickly. Perhaps such evolution is also inevitable. Finland's major sets of policies related to fish, reindeer and game, as well as to other "natural phenomena" to which these biota relate, seem quietly to be undergoing major transformation currently.

Researchers in FGFRI use advanced biological concepts and methods, e.g. in the genetics of biodiversity and biotechnology, physiology of nutrition, epizootology of disease, population dynamics of exotic species, and behaviour of birds and mammals. Much of this work has been done in collaboration with highly competent university professors who have been supervising Institute researchers in completing impressive theses for doctoral degrees. Innovative research should continue to be undertaken collaboratively with universities. FGFRI deserves commendation for facilitating further education of the scientific staff, through help for them to obtain PhD's while working, and offering leaves-of-absence for professional development.

More women researchers should be recruited, perhaps particularly with respect to mission-oriented research. A number of "research professors" could be hired jointly by the Institute and a university, perhaps as term appointments. With an emphasis on use of new equipment and techniques, the technical staff will need educational upgrading through short courses, say. **RECOMMENDATION: The Institute should actively pursue the upgrading, diversification, and energizing of its personnel**.

The great majority of FGFRI's researchers were educated within some narrow version of biology. Most of these researchers will continue to work for years to come and it seems unlikely that FGFRI will recruit many young researchers soon. It is generally recognized (see below) that some interdisciplinary and transdisciplinary research is also needed urgently, especially to explore options concerning difficult policy issues. In the short term, the main way in which interdisciplinarity and transdisciplinarity will be achieved with respect to FGFRI's responsibilities will likely be through partnerships with other research organizations that are dominated by other disciplines. Presumably such partnerships will need to be mutually advantageous with respect to innovative research. **RECOMMENDATION: FGFRI should encourage and fund some of its innovative researchers to participate as partners in interdisciplinary work on policy challenges and opportunities related to fish and game**.

FGFRI researchers have been incorporating sophisticated new equipment of various kinds into their work. A strong emphasis is apparent with respect to various capabilities associated with computer-based electronic information services. Satellite-related locational, photographic and remote sensing

are increasingly used. Radio marking is employed to keep track of individual organisms. **RECOMMENDATION: Sharing of advanced equipment should be organized for cost sharing but also to foster the urgently-needed collaborative interdisciplinary work among Finnish governmental Institutes related to Fish and Game, Environment, Marine Research, Forestry and Geodesics**.

During the 1990s the Institute has been adapting rapidly to major societal and environmental changes in Finland and in the Baltic Region generally. More and bigger changes may be coming, some of which may be unpleasant surprises. **RECOMMENDATION: FGFRI should use its vibrant current status to evolve further and do so more rapidly during the coming decade than has been necessary even in the 1990s**.

To the extent that personnel of the Institute will participate actively in policy debates - in Finland, Scandinavia, the European Union and beyond - by providing relevant scientific information and by helping to frame crucial issues, it will likely have a strong future. Willingly to undergo rapid further evolution while continuing to supply necessary information and services of many kinds is difficult, to put it mildly. So advice to redouble innovative efforts is more a compliment than a criticism; FGFRI can rise to that challenge.

During the 1990s, fish and game research in Finland was transformed partially to align the Institute with emerging regional policies and a recasting of scientific endeavours generally within Finland. Three examples of regional policies are: (a) commitments under Agenda 21 from the 1992 Rio UN Conference on Environment and Development; (b) inter-jurisdictional initiatives following Finland's inclusion in the European Union; and (c) implications of the international Code of Conduct for Responsible Fisheries produced under FAO auspices to complement the UN Convention on the Law of the Sea. **RECOMMENDATION: In exploring needs for new research, FGFRI leaders should explicitly take into consideration the emerging policies of the Baltic Region and the Biosphere, to which Finnish policies are being aligned, at least in part**.

A growing concern in Scandinavia as elsewhere is the entry of exotic species into new ecosystems and the escape of bioengineered creatures from their artificial habitats." **RECOMMENDATION: Concerning exotics, socioeconomic researchers might focus on the question why the introduction of exotics has not been stopped in Finland (or anywhere else) and to advise on how the extant international agreement to do so can be implemented effectively. Concerning genetically-engineered stocks, entreprizes that intend to exploit such creatures should bear a heavy onus to demonstrate a priori that any accidental release would have consequences that were deemed to be acceptable under stringent, formal guidelines that FGFRI researchers will have helped to formalize**.

The coming decade of that continuing evolutionary process may involve more systematic research on regional issues; also strong research connections with global policies on ballast water, climate change and ozone depletion will likely emerge. **RECOMMENDATION: Key implications for fish and game of the further codification of international law (e.g. concerning sustainable sharing of catches of stocks that straddle national boundaries, protection of indigenous biodiversity, elimination of chemical toxins and contaminants, reduction of greenhouse gases) should help guide FGFRI's research priorities**.

A major part of FGFRI's scientific approach during the 1990s has been to make extant scientific approaches and conventions work more efficiently with the help of new techniques in order to meet the current demands for scientific information. Various conceptual and technological advances have been mentioned above. Major further innovations with such scientific information systems, especially involving collaborative research and information links with other Institutes, would be consistent with

Finland's stated interest to be an international leader in the "technology of information systems." **RECOMMENDATION: FGFRI should seek opportunities to be early participants in new computer-based and other electronic devices and techniques**.

During the coming decade, efficient collection, management and interpretation of some conventional kinds of data will continue to be necessary, but that will not be sufficient. Conceptual initiatives are needed concerning new kinds of research to be done and new kinds of information to be collected. For example, an interdisciplinary approach that is variously termed ecosystemic, watershed basin, coastal zone, landscape or bioregional has been developing in many parts of the world. Terrestrial ecologists in FGFRI are participating more strongly in this than are the aquatic ecologists. **RECOMMENDATION: FGFRI should assume a leadership role and commit to collaborate strongly with other Finnish Institutes and international organizations to apply the watershed basin or ecosystem approach to policy issues such as habitat rehabilitation, species preservation and adaptive management concerning new global processes**.

One likely difference between the past and the coming decades concerns the question of who has responsibility for providing necessary scientific information. In the recent convention the onus has been mostly on government agencies to conduct applied research and monitoring and to supply and manage the relevant scientific information. In the emerging convention that onus is coming to rest on formal partnerships between governmental and "private" organizations, or even largely on "private" organizations but with strong formal guidance by governmental organizations. The "private" organizations here include universities and technical schools, consulting firms, resource users and public interest groups. **RECOMMENDATION: Based on its experience with "partnering" and "co-management," FGFRI should formulate a general Institute policy guideline on how the onus or responsibility for the various elements of its information system are to be shared among the partners**.

Expert systems are being developed opportunistically and rapid further development would be helpful especially in partnership contexts. An effective combination of concepts and techniques, for implementation of a major practical or policy issue, can be formulated as an "expert system," subsequently to be applied routinely by "technicians." Development of expert systems could be expedited through greater and stronger cooperation between FGFRI and several other institutes of the Government of Finland, who are also devising expert systems. This is a difficult challenge and cannot be simply delegated to research assistants. There are many initiatives of this sort in other Western countries hence FGFRI might well find some software that has been created elsewhere and that can be adapted to the Institute's responsibilities in Finland. **RECOMMENDATION: FGFRI should commit to a phased process of adopting, adapting or developing expert systems; successful initiatives should be published formally and then be recognized as of equivalent importance to the publication of a major peer-reviewed research paper**.

"Comprehensive rational planning," a kind of generalized version of a monistic scientific method, may still have been attempted with complex political issues a decade ago. A planning approach more like that of participatory governance in a pluralistic democracy may now dominate. Implicitly, FGFRI innovators are involving themselves in pluralistic planning and decision making, as with the Baltic Sea fisheries, the Baltic salmon recovery plan, the countless small fisheries in inland waters, and the reindeer of the North. **RECOMMENDATION: FGFRI's scientific leaders should negotiate with other institutional stakeholders appropriate policy guidelines on the kinds of scientific services to be expected from FGFRI, under "participatory democratic research and planning"**

Discussion of scientific undertakings relevant to current and new policies may be facilitated with some explicit analysis of the broad concept of "science" per se. In Chapter 5 below we have sketched a heuristic classification of the "science" currently done by FGFRI into that:

(a) motivated by curiosity, i.e. basic research;

(b) focused on the implementation of a formal program, e.g. applied research to formulate an expert system within an established coherent policy; and

(c) mobilized in a participatory way toward replacement of an obsolete policy or resolution of a policy conflict, i.e. mission-oriented research. Increasingly, each is done interactively with partners: e.g. with university researchers in basic research; with legitimated resource users in applied research; and with major stakeholders or interest groups in mission-oriented research. The classification of science in Chapter 5 is intended for heuristic purposes with respect to FGFRI responsibilities, and not as a way of characterizing all of science.

FGFRI has been considering the issues of necessity and efficiency with respect to its many field facilities. Tactical considerations may include: collaborative sharing of a facility with other Institutes and organizations; balanced contribution to research, education and outreach to the public; local collaboration by a group of experts to mutual advantage; and opportunities for partnering with local stakeholders. Strategic considerations include: relevance of work in a particular facility to local, regional and global issues of concern; and length of an extant time series of data that are meaningful in the next decade's emerging context, with preference for extending a long-term data series indefinitely into the future. **RECOMMENDATION: As a case of mission-oriented science, FGFRI should formulate tentative guidelines for extending, sharing or terminating its use of particular field facilities, in order to negotiate uses of facilities with other possible stakeholders who may also control facilities of interest to FGFRI**.

All of the above implies that some of FGFRI's personnel have strong entrepreneurial capabilities, where the term "entrepreneurial" has broad self-organizational connotations. Also the organization of the Institute should be flexible to encourage new initiatives. **RECOMMENDATION: Clear inducements and rewards should be offered by the Institute to researchers who have a record of strongly innovative initiatives and to researchers who show promise of such innovation, all with respect to newly emerging policies**.

Recent reviews of the research being done in the various Finnish Institutes have emphasized the need for more of what we here term mission-oriented research. **RECOMMENDATION: More mission-oriented science should be facilitated, organized and funded jointly through formal but flexible collaborative arrangements established by senior administrators of the various governmental Institutes**.

In Finland there are issues that only a specific research institute like FGFRI can carry out. It is important that FGFRI recognize these so that the "niche is not left empty."

Internationally it is coming to be standard practice that plans for long-term and/or large projects are submitted to peer review within an appropriate international network of experts. At intervals during the course of study, or when completed, expert audits are also performed.

RECOMMENDATION: FGFRI should participate actively in international networks to review plans of major research and to conduct audits of such research while underway or when completed, all in an open and transparent way.

List of Recommendations

1. The Institute should actively pursue the upgrading, diversification, and energizing of its personnel.

2. FGFRI should encourage and fund some of its innovative researchers to participate as partners in interdisciplinary work on policy challenges and opportunities related to fish and game.

3. Sharing of advanced equipment should be organized for cost sharing but also to foster the urgently-needed collaborative interdisciplinary work among Finnish governmental Institutes related to Fish and Game, Environment, Marine Research, Forestry and Geodesics.

4. FGFRI should use its vibrant current status to evolve further and do so more rapidly during the coming decade than has been necessary even in the 1990s.

5. In exploring needs for new research, FGFRI leaders should explicitly take into consideration the emerging policies of the Baltic Region and the Biosphere, to which Finnish policies are being aligned, at least in part.

6. Concerning exotics, socioeconomic researchers might focus on the question why the introduction of exotics has not been stopped in Finland (or anywhere else) and to advise on how the extant international agreement to do so can be implemented effectively. Concerning genetically-engineered stocks, entreprizes that intend to exploit such creatures should bear a heavy onus to demonstrate a priori that any accidental release would have consequences that were deemed to be acceptable under stringent, formal guidelines that FGFRI researchers will have helped to formalize.

7. Key implications for fish and game of the further codification of international law (e.g. concerning sustainable sharing of catches of stocks that straddle national boundaries, protection of indigenous biodiversity, elimination of chemical toxins and contaminants, reduction of greenhouse gases) should help guide FGFRI's research priorities.

8. FGFRI should seek opportunities to be early participants in new computer-based and other electronic devices and techniques.

9. FGFRI should assume a leadership role and commit to collaborate strongly with other Finnish Institutes and international organizations to apply the watershed basin or ecosystem approach to policy issues such as habitat rehabilitation, species preservation and adaptive management concerning new global processes.

10. Based on its experience with "partnering" and "co-management," FGFRI should formulate a general Institute policy guideline on how the onus or responsibility for the various elements of its information system are to be shared among the partners.

11. FGFRI should commit to a phased process of adopting, adapting or developing expert systems; successful initiatives should be published formally and then be recognized as of equivalent importance to the publication of a major peer-reviewed research paper.

12. FGFRI's scientific leaders should negotiate with other institutional stakeholders appropriate policy guidelines on the kinds of scientific services to be expected from FGFRI, under "participatory democratic research and planning"

13. As a case of mission-oriented science, FGFRI should formulate tentative guidelines for extending, sharing or terminating its use of particular field facilities, in order to negotiate uses of facilities with other possible stakeholders who may also control facilities of interest to FGFRI.

14. Clear inducements and rewards should be offered by the Institute to researchers who have a record of strongly innovative initiatives and to researchers who show promise of such innovation, all with respect to newly emerging policies.

15. More mission-oriented science should be facilitated, organized and funded jointly through formal but flexible collaborative arrangements established by senior administrators of the various governmental Institutes.

16. FGFRI should participate actively in international networks to review plans of major research and to conduct audits of such research while underway or when completed, all in an open and transparent way.

Chapter 4
The Policy environment

For the evaluation of the activities of the FGFRI, some understanding of the policy environment in which the Institute is working is necessary. The information in this chapter complements what is included in Chapter 2 above.

A primary aim of the Institute is research towards the fisheries and game resources, which functions are also defined in the special Decree (1131/1987). Besides these research functions, the Institute is given other tasks such as caretaking and overseeing of state fish aquaculture, development of both national and international cooperation and utilization of the results of such research, providing services and supporting information production in its sector, and also compiling fisheries and game statistics as well as maintaining respective registers to the extent not covered by Statistics Finland.

The Institute is administratively under the Ministry of Agriculture and Forestry, and the Ministry has the power to give it special tasks to be performed. These tasks, together with annual plans and longer term strategies of the Institute, are usually discussed and defined in mutual negotiations between the Institute and the Ministry, once a year.

Finland has a large area (1100 km in north-south direction), in comparison to its population (5.1 mill.); thus the land and water area per capita is generally large, especially compared to most other European countries. The climatic and biological conditions can vary greatly in different parts of the country. The Baltic coastline is long (second only to that in Sweden), and thus Finland shares with other states bordering the Baltic strong interests in the fishing and fish stocks in most of the Baltic Sea.

Hunting and Fishing Rights as Related to Land Ownership

Hunting rights are tied tightly to ownership of land, but they can be rented or sold to outsiders. The number of citizens practising hunting is some 300,000. Nearly 40 % or some 2 million Finns are estimated to be engaged in fishing, one way or another. The fishing rights are traditionally also connected to land ownership ("whose land, his waters"); as in Sweden this practice goes back to the Medieval Ages. Thus the role of water owners, with their national Federation of Finnish Fisheries Associations and respective regional organizations, is relatively strong in overall fisheries management administration. The state has its own regional administrative system for fisheries (Regional Fisheries Authority), working through the Employment and Economic Centres, of which there exist 15 in the whole country. In Finland the citizens' access to waters and forests together with the traditional, so-called everyman's rights in land use, are unique and liberal in comparison with other European countries except for Sweden and Norway.

The ownership of waters in relation to fishing implies that one cannot own the fish but only the fishing rights; a fish is the property of the owner only after it has been caught. (The same applies to crayfish and some other aquatic crops.) The basic administrative unit in fisheries is the statutory fishery association (of which there are over 11,000); its membership is based on property ownership. A fisheries region covers a larger water area that includes several associations; such a region is the instrument for regional cooperation in management. Thus the basic nature of fisheries management at

the local level may be called "co-management," with its many special and unique social and economic features.

The degree of economic rationalization of the fishery resources at the local level is often not strong. This is in contrast with the management of hunting; apparently the relative scarcity of hunting rights (compared to fishing) makes the hunting licensing system follow more closely the patterns of economic demand. Generally the policies affecting the FGFRI are more straightforward for game than fisheries, and the game part is administered under fewer laws.

The Fisheries Act has been modified several times this century, and one general trend has been the gradual expansion of the fishing rights of the 'landless' people. This also follows from the political pressures that derive from the many long-term changes that have taken place in the society at large, not the least of which is the urbanization of the population especially after World War II. Quite often one hears complaints from the recreational fisheries sector that this sector is still under-represented in defining the fishing rights and access to fishing at large. The riverine fisheries, often targeted at the salmonid fish in relatively confined river stretches, appear to respond more to the demands of the market than the lake fisheries at large.

Also, the status of the professional fishermen, especially on inland waters, has been somewhat enigmatic as they do not always directly fit into the 'ownership' category. Their presence and activities are often confined, by purchasing of licensing, to publicly-owned waters that are extensive enough for professional fishing. (The main target fish species of inland professional fishermen are often fluctuating stocks that also represent economic risks for the fishermen.) The marine professional fisheries work in very complex situations, both politically and biologically, depending also on the kind of fish they are targeting.

Fisheries Management

The Fisheries Act (1982) gives the general principles for fisheries management; the aim is towards maximum sustainable production. This requirement apparently has been interpreted as the Maximum Sustainable Yield (MSY), which at first was understood in purely biological terms but it has recently acquired more economic and social dimensions. The 'content' of the MSY also has directed the kind of research required for fisheries management. However, the situation in most inland fisheries is that of "planned underfishing", and none of the common freshwater fish species can be said to be endangered. (This does not apply to the migratory salmonid fish or local salmonid populations, whose decline is often connected to direct environmental or physical reasons.) In inland situations, the most common management action is stocking of fish, which also is one of the main activities of many statutory fisheries associations. (The associations are not involved in fish trade or other such external activities.) The general trend visible now in management is towards less voluntary work and towards more professional expertise.

Thus one may ask how reasonable at all is the "determination" of the MSY for different fish species, especially when the numbers of target lakes can be counted in tens of thousands, and the main management action often is fish stocking anyway. In the "underfished" situations, the concept of co-management, with a strong social dimension in decision making, apparently can work well, though the "maximum production" may seldom be reached. (This may also partially be the result of the exclusion of, or limitations experienced by, the professional fishermen.) For the highly fluctuating pelagic fish

species (vendace, etc.) the concept of MSY may not apply at all in its strict sense. The same may be applicable to crayfish stocks, though for different reasons. In inland waters, the condition of the aquatic habitat itself may be a more important determinant for the fishery than the MSY.

Fisheries in a Broader Context

The fisheries management situation in the Finnish marine waters is much more complex, also management-wise. For some fish stocks, an apparent "overfishing" situation may already apply, and especially for the salmon, the fishing may target the "wrong" kind of fish. The numbers of rivers still harboring migratory salmon or trout or whitefish have declined strongly. In the sea, the historic, native river-run fish are mixed with the stocked fish, and both of them may be targets of the same fishery without discrimination, which can also cut down the numbers of parent fish entering the spawning runs. Apparently there is a strong need to have a new look at the genetic structure and the quality at large of the (stocked) fish.

Disputes between the interests of fishermen working in different marine areas (including coastal vs. offshore) are not too common, except concerning the migratory salmonids. A more recent problem facing the marine fishermen is the strengthening of the seal populations, which are seen as "unfair competitors."

The level of human consumption of fish is relatively high in Finland, amounting annually to 30 kg per capita of live-weight fish. One half of this is imported, one quarter comes from recreational fisheries and another quarter from fish farming and professional fisheries. Fish farming had expanded several-fold in the 1980's, but in recent years its production has leveled off. At the same time, volume of fish farming has increased in the Baltic coast, but with a relative decline in freshwaters. The rainbow trout and Baltic herring are the two main species on people's table. Still, however, most of the total catch of Baltic herring is used as feed in fur animal farms. Finland is both importing and exporting fish and fish products, including also crayfish.

Complementing the Fisheries Act (1982), the Water Act focuses on the aquatic environment and is used to protect the fishing grounds and water courses. The system is of highly dual nature, as it is the water courts that issue the permits to actions that affect the aquatic systems. The Nature Conservation Act as such has little direct bearing on fisheries and fish species. Administratively, the aquatic ecosystem is thus divided into fish and "other parts," and they are under different public authorities, namely the Ministry of Agriculture and Forestry (and thus also the FGFRI) and the Ministry of Environment, respectively.

The aquatic systems have undergone pronounced changes especially in the last 40 years. The old point sources of industrial pollution and community sewage have been closed or are being treated, with overall improvement in water quality. Yet the lakes and rivers are still showing the adverse impacts of dredging, swamp and forest draining, flood control, peat mining, etc., from the last few decades. Acidification of lakes is of smaller significance, but especially the western rivers appear to be affected by it, due partly to the newly exposed soil conditions. The overall trend in inland waters is their mild but gradual eutrophication.

Finland is participating in the fisheries and environmental management of the Baltic Sea through several organizations and international agreements. The membership in the European Union has affected overall fishing management only slightly. Management and hunting of wildlife and especially of the big game is being more strongly affected by EU rules and directives.

Chapter 5
Three type of science

Different Scientific Approaches

Fish and game researchers conduct science in a number of ways; three versions are sketched here for purposes of our review of FGFRI. For convenience only, the three kinds can be designated by code words:

alpha for disciplinary, curiosity-motivated, basic science;

beta for interdisciplinary, applied, programmatic science; and

gamma for transdisciplinary, mission-oriented, participatory science.

These three types may be more like points in a spectrum rather than discrete classes. This schema may help to understand the current scientific practices of FGFRI and similar organizations but not to classify all contemporary science.

From another but related perspective on science, innovative researchers in Finland and elsewhere are increasingly working within a "Bayesian" rather than the conventional "frequentist" mindset. A Bayesian approach may be used where "uncertainties" cannot readily be resolved in a conventional way. This topic is not addressed further in this report mostly because no member of the evaluation team has the expertise to do so.

Scientific Ethics

A scientist is expected to have a strong personal commitment to objectivity, honesty, transparency and rationality. Review of a scientist's work by peers - who are also expected to be objective, honest, transparent and rational - provides a check on a scientist's ethical commitments. In addition to assessing the process, peer reviewers also assess the products of a researcher's science with respect to such qualities as realism, accuracy, reproducibility, coherence, etc. People wishing to use scientific information for practical ends are also interested in its relevance and legitimacy.

A privilege to be known as a scientist comes with an obligation to be scientifically responsible and to demonstrate that responsibility, ultimately by convincing one's skeptical and honorable peers. To the extent that a strong commitment to scientific ethics is internalized within the broader process of science of any kind, scientists in general will continue to be trusted by non-scientists.

Obviously a scientist must possess substantive knowledge and technical competence in order to conduct worthwhile scientific studies. Beyond this, the professional ethics of researchers and peers are a continuing concern for funders and users of research results. The "transaction costs" of funding and holding scientific researchers accountable can be minimized when and where trust and respect are earned and shared within a network that itself is trusted and respected by experts in other networks.

The evaluation team has no particular concern about scientific ethics with respect to FGFRI personnel. The issue is raised here because it relates to our alpha-beta-gamma schema in that professional ethics are practiced in somewhat different but complementary ways in these three approaches.

A code of ethics may follow from a priori considerations of actions that are right and actions that are wrong, all internalized as part of an individual's deep sense of duty; such a code may be termed "deontological." Alternatively a code may be inferred from a posteriori consequences of different actions; such a code may be termed "utilitarian" or "consequentialist."

Traditionally the professional ethics of science rest strongly on deontological bases, even when a scientist is paid to serve some practical interest. But consequentialist considerations may be used to buttress the deontological, in that the transaction costs of scientific endeavours tend to be high where a commitment to appropriate deontological ethics is thought to be low. Hence minimization of transaction costs, which may be perceived to be a utilitarian good, can be served by thorough-going internalization of shared deontological commitments.

Ethical guidelines have been developed for fisheries in FAO's Code of Conduct for Responsible Fisheries with implications for fisheries researchers. The International Standards Organization has been developing such codes for international commerce in manufactured or cultured products as in the ISO 9000 and ISO 14000 series. (FGFRI's Aquaculture Unit already has accreditation for quality under ISO 9001.) Global implementation of Agenda 21 relies heavily on appropriate commitments to deontological as well as to utilitarian ethics by peoples, governments and individuals. **RECOMMENDATION: FGFRI scientists should help to develop a set of explicit guidelines for professional scientific ethics with respect to FGFRI's responsibilities for the different kinds of science. Such guidelines will be needed especially as research activities are contracted or "out-sourced" to for-profit consulting companies. These guidelines would then be part of FGFRI's code of conduct**.

Alpha Science or Basic Research

In the fields of fisheries and wildlife, alpha science is practiced mostly at a level of a scientist with an advanced university degree, or by a small group of such scientists who are working within a coherent paradigm that is currently found to be acceptable within an academically-legitimated discipline. "Basic" or "pure" science within the alpha tradition is ideally motivated by curiosity, though nowadays some possible practical application is usually foreseen.

An alpha researcher with weak professional ethics may be excluded from a network that has self-organized with respect to the particular paradigm/discipline. National academies of science historically acted as guardians of the ethics and champions of the practice of basic or "pure" science.

An approximation to an alpha approach, with curiosity constrained in part by FGFRI's formal commitments, is apparent in the several scientific elements within each of a number of recent doctoral theses completed by FGFRI personnel. An empirical, usually reductionistic, test of an universalistic hypothesis is performed to yield a valid inference. Optimistically, such an inference can then be applied to other theoretical or practical problems anywhere and anytime, hence it is taken to be universalistic.

But alpha science can also proceed with respect to a narrative hypothesis, as with a case study in a particular (not universal) space and time context. In the study of evolution and ecology, for example, alpha scientists usually iterate between universalistic analytic and contextual narrative perspectives, and integrate the two approaches. A combination of these complementary approaches may be found in some recent theses of FGFRI scientists.

Generally, the universalistic-analytic theme of alpha science with its professional ethics is alive and well in FGFRI, as it should be. The contextual-narrative theme is less in evidence, and appears not to be as "disciplined" as the former theme. As yet little critical attention seems to have been directed to using the two themes explicitly in an iterative way and then integrating a balanced understanding of a particular case study. **RECOMMENDATION: An FGFRI researcher with responsibility for basic or alpha research should try to integrate an universalistic analytic approach with a contextual narrative approach, as with organismal, population and ecosystem realities**.

Beta Science or Applied Research

Beta science involves, simplisticly, iteration between (i) a compatible set of analytic/narrative inferences from alpha science and (ii) some empirical attributes of a particular real system in its time-space context. Attributes are selected for their perceived relevance to some practical problem in that system. It is a kind of applied science, usually within a profession which has an appropriate code of ethics about the processes and products of such applied scientific research. Engineering and medicine are such professions, and have national bodies that play a role for beta science something like the early role of a national academy for alpha science, as sketched in the previous section. In some cases, as in the USA and Canada, the academy has expanded its activities into beta and even gamma science, with examinations by expert interdisciplinary or multidisciplinary committees of difficult practical issues.

With respect to a particular project, such contextual beta science may involve one or more groups of people with different interests in the problem being addressed. In the case of beta science, by informal convention, these stakeholders agree at an early stage in their joint study to accept or create a single consensus model of an applied science type with respect to which all the different interest groups will henceforth interact. If scientists themselves enter into this process, initially as protagonists for a particular set of scientific concepts and methods, then the whole interactive process leading to a working consensus on a shared model may be facilitated by an expert in such a consensus-building process. In effect, the stakeholders commit to sharing the risk that the single model that will be accepted may be "wrong" or "inaccurate."

Following incorporation of the necessary and sufficient data in the agreed model and after exercising the model in a rational way, the logical outcome will then be used in an attempt to resolve the problem being addressed. If a subsequent post-audit or test leads to an inference that the common model is seriously inadequate, then the process may start over with a major modification of the model or with creation of a new model which may be closer to the "truth," etc. Thus this approach accepts that not all ignorance can be resolved, in part because the relevant reality is continuing to evolve and thus is generating new ignorance. The beta approach fosters joint learning through cooperative empirical efforts to dispel some of that ignorance, whether old or new. In real life, decision-making does not wait until some a priori, abstract criterion of scientific closure is achieved.

One version of beta science, "adaptive environmental assessment and management," AEAM, has been evolving since about 1975 within an innovative network initiated by C.S. Holling. Both the creation and use of a testable conceptual model and the interactive collegial process among the stakeholders was emphasized about equally by Holling and colleagues in AEAM. The model is often a dynamic simulation, of key attributes of the system, acceptable to all stakeholders.

A successful North American example of AEAM that has now been evolving for about two decades concerns the interaction of the exotic sea lamprey and various salmonids in the Great Lakes, and what this interaction implies for "integrated management" of this pest.

The formal ICES working groups, to estimate sustainable yields of particular fish populations for the IBSFC, use beta models. Somewhat different but compatible versions of a particular model of population dynamics and sustainable yield are in play. A compatible fact-finding process (catch sampling, research surveys with various gears, habitat factor measurements, etc.) is designed collegially and then implemented to provide information to an international team of information synthesizers who employ a set of mathematical and statistical formulae that comprise an "expert system," in effect. The team then transmits its advice to the Commission's decision makers. The latter generally limit their options for decisions to those already assessed by the researchers, i.e. the researchers and decision-makers share the same conceptualization of the fishery. Standardized data collected each year provide a test, though perhaps not a sufficient test, of the consensus model. Projects may be undertaken to provide additional information for revising some calibration details. The whole process may be quite stereotyped from year to year, with incremental modifications annually.

As with AEAM simulations, the ICES models are case histories or "contextual narratives" that are generally acceptable to the different national and professional stakeholder groups participating in these fisheries. That the ICES traditions are themselves a form of science, i.e. beta science, may not be appreciated explicitly. Hence inadequate attention may be devoted to testing this combination of concept and process rigorously. **RECOMMENDATION: Professional ethics should require that the processes and products of beta or applied scientists be subjected to thorough-going tests and audits periodically, or the combination should not be recognized as being "science."**

International organizations like ICES and IBSFC have always had to contend with information that has been knowingly biased to serve a special interest of a particular stakeholder being served by a group of "scientists" employed by that stakeholder. With some countries in some time periods, the ethics of national self-interest have trumped those of disinterested professional science. Or some sector of the fishery received preferential scientific treatment by "scientists" within a particular country, e.g. offshore trawlers over inshore trap fishers. The mores of diplomacy or politics often oppose direct consideration of such biases, especially among countries who are not on good terms in other respects. With a global commitment to the new legal elements on straddling stocks in the UN Convention on the Law of the Sea and to FAO's complementary Code of Conduct of Responsible Fisheries, more direct consideration by FGFRI of professional ethics related to fisheries science would be timely. Again no indirect indictment of Finland or Finnish scientists is implied here.

An expert system may be created to formalize a particular alpha/beta set of capabilities with respect to practical aspects of some firm policy. Researchers in the FGFRI units could now develop additional expert systems for their more routine information-related responsibilities. Routinely using such an expert system would be more a technical than a scientific function. Periodic audits of its performance and relevance, and possible revision or replacement of it would require strong involvement by scientists.

A comparative assessment of a number of well-developed cases of beta or applied science could be undertaken. **RECOMMENDATION: Based on a comparative study, consensus should be sought on appropriate incentives and guidelines for devising expert systems, technical handbooks and other products of beta science for well-founded programmes concerning game, reindeer, aquaculture and fish, separately and jointly**.

Gamma Science or Mission-Oriented Research

Mission-oriented research may ideally involve an orderly process of interactions of different interests or stakeholder groups each of which may have its own preferred combined alpha/beta convention relevant to its sectoral interest. Such a stakeholder group may not be prepared to set its perspective aside in order to find a common model as in the case of beta science. Hence gamma science is pluralistic, while alpha and beta science may each be monistic in its own way.

Mikael Hilden of Finland has referred to the concepts of "discourse ethics" and "communicative action" by Juergen Habermas as relevant to scientific efforts of a gamma type to rehabilitate the Kyronjoki River, in which he has participated.

Because a democracy is necessarily pluralistic and because some methods of mission-oriented research may resemble those of a well-functioning democracy, the gamma approach may be termed democratic science. Related terms include participatory research, action research and conflict resolution.

When something has gone seriously wrong with an issue in fishery or game management that employs a beta approach, say, then an official enquiry may be instituted to seek the causes and recommend corrective measures. In effect, such an enquiry performs an audit of the shared, conventional model and the processes and products of the researchers and managers. In some ways such an enquiry might parallel a corporate audit under ISO 14000, say. A timely audit might help to head off some cases of serious failures of information services and the resulting political crises. **RECOMMENDATION: Using the concepts and methods of gamma science, FGFRI or the Ministry should consider creating a standing audit function, to be activated on occasion, for beta science capabilities**. Such a capability might be marketable to other countries.

The gamma approach is invoked to help resolve real-life conflict in complex settings among stakeholders or sectors of society or among nations. Different interest groups may come to accept the outcome, provided that "due process" is assured throughout. The researchers for a particular interest group supply information (data, methods, concepts, models, findings) that is purportedly germane to the issue under conflict and researchers serving other interest groups are expected to relate that information as a test of their own preferred view of relevant matters. Though effective resolution of the conflict will involve rational interactions, logical consensus overall may not emerge on all the separate concepts and methods of the gamma science involved.

Since nothing can be accepted as "scientific" unless it satisfactorily undergoes peer review, the people who mobilize gamma science in effect call for a wider circle of peers than is commonly the case with beta or particularly with alpha science.

One of the key features of the methodology of gamma science is the emphasis on "due process." Due process does not preclude a prior common commitment by all stakeholders to a policy guideline that ranks the various values sought by different interest groups, which policy then constrains the process of gamma science. In fact, some specification of key deontological and utilitarian principles to constrain a particular application of gamma science may be necessary to make the latter tractable.

Another constraint may appear as an a priori convention concerning which of the adversaries bears the greater burden of proof. For example, a proponent for a particular "utilitarian package" of sustainable yield may have an onus to demonstrate that this involves virtually no threat to an a priori deontological commitment to the preservation of biodiversity.

Reciprocal trust and respect may be necessary preconditions with gamma science as with the other types. It can be earned through transparent commitment to the relevant professional ethics appropri-

ate for gamma science. Trust and respect may be in short supply at the outset of an attempt to resolve conflict; experts in conflict resolution have ways to help them to emerge.

Forensic science is designed for an explicitly "adversarial" version of the gamma approach as applied to particularly contentious issues in litigious jurisdictions, as with the "tobacco issue" in courts of the USA. The one true narrative that encompasses true facts and true causes is sought under guidance by a judge who is expert in conducting a trial process. The high transaction costs and unequal abilities by the parties in the litigation to cover such costs may often bias the process. Less formal and less costly methods of conflict resolution under guidance by legal judges may, in effect, use a less formal gamma approach to achieve concurrence by the parties to distribute blame in proportion to the wrongs committed.

A quasi-judicial fact-finding tribunal or commission may be given responsibility by senior governments to undertake an enquiry using such a gamma scientific approach. This approach may also be abused as when governments commission what is ostensibly a serious study but which in reality may be little more than a ruse to postpone a decision for some years. With proper use, a practical version of formal due process may guide the processes and deliberations of such an enquiry. Recent pacification of the Baltic Basin may permit more international initiatives of this kind.

Researchers who network under the auspices of the International Association for the Study of Common Property, IASCP, have been clarifying gamma processes in which "traditional ecological knowledge" or TEK of an Aboriginal people or local community, say, may be inter-related with some findings from a conventional beta version of Western science. Here, as elsewhere, the "transaction costs" can reach excessive levels in the absence of some shared trust and respect among the stakeholders.

A relaxed gamma version may appear in the current scientific debate about the M74 Syndrome with salmonids in the Baltic Region. Different groups of scientists as stakeholders are contending over the causes of this syndrome. Currently, different proposed causes imply different practical consequences to interests generating ecosystemic stresses that may be implicated in the M74 Syndrome.

Gamma-related adversarial processes may also relate to the different alpha/beta paradigms involved in the low-key struggle for primacy between proponents of population dynamics and watershed/ecosystem approaches in fisheries. The latter approach may involve designation of fish refuges instead of, or in addition to, simply controlling total fish catches consistent with estimates of sustainable yield. In Finland both kinds of approaches can be found.

Sometimes invoked as a crisis approach when an emerging issue has not been corrected in a timely way, an appropriately conducted gamma process may lead to a "solution" to an immediate problem but may also trigger revisions of policy guidelines generally, and thus help to forestall future policy-related crises. This may permit some such problems to be resolved with new beta scientific means in more routine ways.

Gamma science appears not yet to have been used as much in the Baltic Basin as in the North American Laurentian Basin, say. Several generic versions of such mission-oriented science have been evolving interactively in the Laurentian Basin, e.g. concerning air quality, water quality, water quantity, fisheries and ecosystem quality. Even in the Great Lakes, critical study of gamma science as such has been neglected.

Closing Comments

There are other aspects of this simplistic three-part characterization that may be mentioned. Thus alpha science is generally unidisciplinary, beta science is often interdisciplinary and gamma science may be transdisciplinary though not undisciplined. These terms concerning "disciplinarity" are used here in the way that they were characterized some 30 years ago by Erich Jantsch and others who were then at Organization for Economic Cooperation and Development in Paris.

With respect to the systemic scale or complexity of FGFRI's responsibilities consider the following example. Alpha science may relate to the genetic characterization of a species population; beta science to rehabilitation of a migratory population using an appropriate expert system based on policy consensus among stakeholders; and gamma science to resolution of serious conflicts with respect to incompatible uses (one of which may be natural reproduction by salmon) of a watershed basin with its tributaries on land and its distributaries in the sea.

Although all the three versions of science sketched above are being employed by personnel of FGFRI, only the relevant methodology with the universalistic-analytic approach to alpha science appears to be common knowledge. Most of the Unit's personnel are involved implicitly with narrative alpha science and with beta science. Unit leaders and senior scientists appear to be active informally in gamma science, as in providing advice in decision-making processes. FGFRI is presumably expected to show leadership in all three in its role as the senior advisory capability for the Finnish Government.

RECOMMENDATION: More focused consideration of emerging conventions of all three heuristic types of science identified here would now be timely. Senior administrators of a number of Finnish Institutes with over-lapping research domains might agree to motivate and expedite such efforts, in part by motivating researchers from selected Institutes to study collaboratively and reflectively a series of complex issues now confronting decision makers. FGFRI's list of candidate issues is long, e.g.:

- **large predators / moose / reindeer;**
- **fish-fisheries / aquaculture / ospreys / cormorants;**
- **fish / fisheries / seals;**
- **fishing rights / tourism / regional economy / co-management;**
- **river habitat restoration / salmon stock preservation / genetics / hatcheries;**
- **lake eutrophication / fish / fisheries / ducks / restorative oligotrophication;**
- **vendace / fishing rights / genetic selection by gillnets / stocking;**
- **crayfish / native and exotic species / introductions / disease;**
- **Baltic cod and herring / catch targets / catch allocation / accountability; and**
- **aquaculture / diversification / genetics / feeds / wastes / bioengineered stock.**

RECOMMENDATION: FGFRI innovators should lead in efforts within Finland to implement various regional and global international commitments concerning "natural resources" which presuppose the availability of scientific information services that incorporate all three kinds but especially gamma or mission-oriented science.

Acknowledgment: In this chapter we have used insights from the work of: Mikael Hilden and Sakari Kuikka of Finland; Michael Jones of Michigan; USA; and Stephen Bocking of Ontario, Canada.

List of Recommendations

1. FGFRI scientists should help to develop a set of explicit guidelines for professional scientific ethics with respect to FGFRI's responsibilities for different kinds of science.

2. An FGFRI researcher with responsibility for basic or alpha research should try to integrate an universalistic analytic approach with a contextual narrative approach, as with organismal, population and ecosystem realities.

3. Professional ethics should require that the processes and products of beta or applied scientists be subjected to thorough-going tests and audits periodically, or the combination should not be recognized as being "science."

4. Based on a comparative study, consensus should be sought on appropriate incentives and guidelines for devising expert systems, technical handbooks and other products of beta science for well-founded programmes concerning game, reindeer, aquaculture and fish, separately and jointly.

5. Using the concepts and methods of gamma science, FGFRI or the Ministry should consider creating a standing audit function, to be activated on occasion, for beta science capabilities.

6. More focused consideration of emerging conventions of all three heuristic types of science identified here would now be timely. Senior administrators of FGFRI and a number of Finnish Institutes with over-lapping research domains might agree to motivate and expedite such efforts, in part by inducing researchers from selected Institutes to address collaboratively and reflectively a series of complex issues now confronting decision makers. FGFRI's list of candidate issues is long, e.g.:
   - large predators / moose / reindeer;
   - fish-fisheries / aquaculture / ospreys / cormorants;
   - fish / fisheries / seals;
   - fishing rights / tourism / regional economy / co-management;
   - river habitat restoration / salmon stock preservation / genetics / hatcheries;
   - lake eutrophication / fish / fisheries / ducks / restorative oligotrophication;
   - vendace / fishing rights / genetic selection by gillnets / stocking;
   - crayfish / native and exotic species / introductions / disease;
   - Baltic cod and herring / catch targets / catch allocation / accountability; and
   - aquaculture / diversification / genetics / feeds / wastes / bioengineered stock.

7. FGFRI innovators should lead in efforts within Finland to implement various regional and global international commitments concerning "natural resources" which presuppose the availability of scientific information of all three kinds but especially of gamma or mission-oriented science.

Chapter 6
Fisheries biology and management research unit

Description

Through research, broadly defined, this Unit promotes and guides the sustainable harvesting of fish and crayfish stocks. Consistent with the mandate of the entire Institute, equitable "sustainable use" involves some shared responsibility with other parts of the Institute and with other Institutes for the habitats and organismal health of these stocks. Population extirpation and species extinction would demonstrate an extreme form of unsustainability. For this practical reason, and because such extirpations and extinctions are deemed unethical for other reasons, the Unit shares in a responsibility to safeguard and rehabilitate the natural biodiversity of the fish and crayfish taxa and interacting elements of aquatic ecosystems, the coastal zone and watersheds.

The large permanent staff of the Unit includes 76 personnel. By the year 2001 about one-quarter of the Unit's staff are expected to have PhDs, with most of the recent additions having advanced academically within the Unit. About 80% of the total complement of 49 university graduates were educated in some version of biology.

The budget of the Unit started from a low base when it was founded in 1994, after the recession of the early 1990s. The annual budget of the Unit is now about 40 million FIM, 80% of which comes from the governmental budget and 20% from external sources including sales of research contracts, cooperative funding, competitive EU funding and others.

This Unit appears to be organized administratively in a lateral interactive way with numerous groups rather than, say, in a centralized hierarchic structure. For heuristic purposes, the Unit describes itself as having three sectors each of which has a series of sub-sectors. The sectors are:

1. "research programmes and projects" that relate to ecological aspects, sampling and physiological details of important difficulties and opportunities with fish and crayfish management;
2. "fish stock assessment" in which data from surveys and monitoring are assembled, processed and transmitted to management for action; and
3. "general expertise" with respect to larger regulatory and policy issues in Finland and internationally.

In Chapter 5 three kinds of scientific expertise were labeled as alpha or basic, beta or applied, and gamma or mission-oriented. There appears to be an approximate correspondence between the Unit's heuristic sectors and those three versions of science.

The Unit's scientists were almost all educated in basic science and mostly in some version of biology. Recent doctoral theses, which are generally excellent, bridge findings in a bottom-up way from appropriate basic studies into a case of applied science focused on some practical issue that is important in the Unit's mandate. The Unit's scientists use information from their basic and applied research, some of which is assembled in the form of theses and conference proceedings, to provide mission-oriented "general expertise" as sketched above. Clear statements of policy-related needs for information could then lead to top-down guidance of research priorities, but this is not now emphasized, apparently.

The Unit has identified many "developmental activities" some of which appear to relate to an ongoing transformation in Finland of broad management policies relevant to the Unit and to FGFRI generally. Some "developmental activities" appear to involve the piecemeal transformation of scientific information services to be more effective and efficient with respect to the emerging policies.

A broader "developmental activity" is presented as "Senior scientists will be educated to have better capacity in designing and managing large-scale multidisciplinary research projects." That sentence may be interpreted to be a commitment to participate actively with Institutes dominated by other academic disciplines in the ongoing broad transformation of management practices and relevant scientific information. Some of the large-scale projects presumably will relate to major policy issues with international connections, and will fall within mission-oriented or gamma research as described in Chapter 5.

Critique

As indicated above, the Unit's experts have described the evolving complex of "scientific research" that is now being conducted by the unit as related to three sectors: research projects, assessments and general expertise. As such, these sectors refer explicitly to no major policy complexes. Within the larger policy transformation with which FGFRI is involved, "paradigm shifts" with respect to a number of policy-related complexes may be underway, as already indicated in Chapter 5 and as discussed further below. If so, then the Unit may increasingly do such "large-scale multidisciplinary research" in an orderly way with orderly iteration between the three types of science.

Under auspices of the International Baltic Sea Fisheries Commission, IBSFC, a Salmon Action Plan, SAP, was negotiated recently; a Finnish national plan to help to implement it is currently in preparation. Presumably some of the research on salmon is intended to contribute directly to SAP. Examples may include the recent separation of all the stocks of Baltic Salmon into two super-complexes each of which originated from a different glacial refugium. The international study of the M74 syndrome is another example. Further, one of the objectives of some interdisciplinary or transdisciplinary watershed studies in the Baltic Basin is to help restore or augment natural reproduction of salmon. The Unit is presumably considering what kinds of research would contribute most to the success of SAP.

In general, the approach of ICES and IBSFC to the large fisheries of the Southern Baltic Sea appears to be consistent with a conceptual convention concerning "sustainable use of fish and shellfish" with beginnings a century ago and that became dominant world-wide in the 1960s. Some particular version of a general kind of fishery commission was institutionalized for almost all oceanic and freshwaters that were not wholly within some nation state. The standard approach owed much to the mindset of an international network of fisheries experts centred at Lowestoft, England as extended globally through FAO. In some regions this approach has been modified in part with such innovations as:

(i) development of expert systems;
(ii) expansion of the basic biological model into a bioeconomic model;
(iii) construction of systemic simulations involving several ecological, technical and socioeconomic factors;
(iv) use of a Bayesian approach to deal with uncertainties;
(v) clarification of packages of certain rights as with access to fishing and individual quotas;
(vi) use of economic instruments to allocate resource harvests;

(vii) reduction of state subsidies of fishing enterprises;
(viii) participatory adaptive co-management at a community level;
(ix) internalization by fishers of an ethical code of conduct with respect to all aspects of fishing;
(x) imposition of an onus on fishers to demonstrate that they are practicing stewardship through the provision of accurate data on their fishing efforts and catches; and
(xi) commitment by all the scientists involved to a shared professional code of ethics.

In the case of the Baltic Region, an early version of a population dynamics approach still seems to dominate. If an updated or even an alternative approach were to be considered, it would presumably need some different kinds of scientific services than are currently being offered by FGFRI.

The countless small fisheries and crayfisheries in freshwaters as currently administered appear to be making impossible demands on FGFRI for relevant local information. Some customers are not confident that some of the information being provided by the Unit is reliable (see Chapters 10 and 11). Old ownership and harvest traditions are valued deeply as being part of the Finnish culture. Meanwhile, urban anglers from anywhere in Europe are willing to pay for privileges to fish in such waters, presumably on the condition that some exciting fishing experiences can be expected. To satisfy the latter condition it may be necessary to relax some old traditions and to make appropriate changes in the scientific information services and fish stocking services. Unit experts appear to be considering this whole complex problem and increasingly in a transdisciplinary scientific way, but appear not to be taking a lead role to resolve it.

Eutrophication is continuing in many inland and coastal waters, and especially in the Gulf of Finland. With excessive eutrophication, toxic blooms of algae are appearing episodically in these waters. Eutrophic waters do offer fishing opportunities, but usually for species of lower value than those that thrive in oligotrophic waters. Even with a strong international agreement to reverse eutrophication, some remediation can occur through biomanipulation and some use can be made of tolerant fish species in moderately "degraded" waters before oligotrophication has been successful some years in the future. For a combined policy of long-term rehabilitation and short-term adaptation some inter-Institute "multidisciplinary large-scale research" may be timely.

Economic development of rivers, acid peat bogs, river corridors and the coastal zone is continuing to degrade fish habitat in some locales. Elsewhere strong efforts are underway to correct environmental abuses of this type, with leadership by researchers of the Finnish Environmental Institute. FGFRI researchers, and especially those of the Fisheries Biology and Management Unit, should be more involved directly in this work; their physiological, genetic and ecological knowledge of fish and crayfish would be valued.

The many vendace populations pose as a species-related complex problem. One aspect relates to the possible genetic selectivity of small-meshed gillnets, to which vendace may adapt by shifting from K-selected to r-selected life history features. With assistance from the Academy of Finland a cooperative, comparative ecological study of vendace was undertaken some years ago by Finnish researchers of universities and the Institute. These researchers are strong participants in a network of coregonid researchers of the Northern Hemisphere which meets periodically in an international scientific conference to share new information. With this networking as a base, the vendace experts of Scandinavia and particularly of Finland should organize team research to address this complex issue in an orderly and phased way.

The six examples above are offered here as difficult challenges for the Institute's experts that deserve attention with respect to combinations of all three types of science sketched in Chapter 5. The

evaluation team's role is not to advise on these as policy issues per se. Are experts from the Fisheries Biology and Management Research Unit currently leading in efforts to perceive and explore salient features of new "paradigms" and conventions that may already be emerging with respect to such complex issues? Or is leadership apparent in one or more of the other units, e.g. in the Socioeconomic and Aquaculture Research Unit, or in other Finnish Institutes, or in other countries?

It is not now possible to satisfy all the current demands on the Fisheries Biology and Management Unit for relevant insight and information concerning "sustainable use of fish and shellfish" and stewardship of aquatic biodiversity. With respect to the old approach in Finland, a strong onus appears to rest with the formal government agency to be responsible for the scientific information services that are necessary for the several nested levels of "management." A new regime may be implicit in what is variously termed an ecosystem or watershed or landscape or bioregional approach combined with co-management partnerships. To the extent that game researchers have, at least implicitly, always preferred a broader ecological approach than the population dynamics approach to sustainable use, the fisheries researchers have something to learn from them.

An emerging governance regime, in which public and private partnerships may play strong roles, may already be discernible to the perceptive observer competent in what is described, in Chapter 5, under mission-oriented or gamma science. If so, then the Unit's leaders could help to identify key features of the emerging regime and explore implications for a partial re-organization of the Unit's scientific information services to be effective and efficient in the new approach.

Evaluation and Recommendations

Some researchers of the Fisheries Biology and Management Unit are proficient in advanced concepts and techniques related to basic science in the biology of fish and crayfish. They have good working relationships with experts in various universities and elsewhere in the Unit. Competence like this by the Unit's own researchers greatly facilitates incorporation of new basic science into applications relevant to the Institute's mandate, and permits effective partnerships with basic researchers in universities, especially if funds, equipment and facilities can be shared. **RECOMMENDATION: Expertise in advanced concepts and techniques of basic biology, including ecology, should continue to thrive in this Unit, but the contributions of some experts in basic economics and sociology are also needed**.

More and more, applied research is becoming organized as interdisciplinary team research that is planned and conducted in a phased way. In a case where no serious policy conflict exists and scientific understanding suffices, such applied scientific services can be organized as a computerized expert system related to a particular conceptual model, at least in part. Within the obligations of the Fisheries Biology and Management Research Unit, such applied team research is coming to be conducted through partnerships with other stakeholders. More may be contracted with fisheries interests and with private consulting firms, all with close involvement and under formal guidance by senior experts in the Unit and FGFRI generally. **RECOMMENDATION: Scientific information services in non-conflictual policy contexts should increasingly be organized as expert systems which include appropriate computer software and handbooks of relevant ecological, economic and policy parameters**.

Transdisciplinary mission-oriented or gamma research may be episodic, with each such event organized to resolve conflict concerning a major practical policy issue. Sometimes it may be conducted under the auspices of some standing organization operating at arm's length to the governmental ad-

ministration and to the contesting sectors of interest of the day. Nowadays such mission-oriented work is also being conducted in international settings. The Unit is apparently committed to expand its work in this field of scientific information services. **RECOMMENDATION: On contentious, complex issues the Institute's administration should offer incentives to Unit leaders to help organize and conduct mission-oriented research episodes together with leaders from other disciplines and sectors of interest. Other experts of the Unit or from elsewhere should then be recruited on a temporary basis to conduct real-time investigations to serve the immediate process of such "action research" or "communicative action."**

Altogether, personnel of this Unit have supplied diverse scientific information services heretofore, and its experts seem poised to become more creative in all three versions of science identified above. One of the problems to be faced and resolved concerns appropriate incentives and rewards for the necessary leadership with the newer capabilities. If the Unit and Institute were to get bogged down, then the government and other clients for such services might contract with private firms for those services. **RECOMMENDATION: The Unit should assert a robust leadership role in balanced scientific services including the basic, applied and mission-oriented, and provide formal guidance for any out-sourcing or contracting of such services with other organizations in order to ensure that such services meet quality, relevance and efficiency criteria**.

The Unit, as with the Institute generally, has recently emphasized publication in the peer-reviewed literature that has international recognition. Respectable publication outlets now exist for all three versions of science. Old distinctions, such as "soft" and "hard," have lost much of their relevance, but criteria of what can be considered "good science" are needed with each version. **RECOMMENDATION: The Unit's leadership and innovators should foster excellent publications, that are accessible to users of this information in Finland and elsewhere, in all three types of science identified here**.

Particularly with respect to mission-oriented research concerning the kinds of problems being addressed by this Unit's experts, there is currently much transdisciplinary scientific work being conducted in international networks, and especially in academic networks. Perhaps such gamma capabilities have been evolving more rapidly elsewhere than in Finland. For example, in North America many universities have transdisciplinary environment and resource institutes that engage in research, teaching and extension with respect to gamma research, though fisheries is only infrequently a primary focus of their work. **RECOMMENDATION: The Unit's leaders, who have already committed themselves to policy-relevant work under the heading of "developmental activities," should now commit strong efforts to do so within international networks**.

List of Recommendations

1. Expertise in advanced concepts and techniques of basic biology, including ecology, should continue to thrive in this Unit; but the contributions of some experts in basic economics and sociology are also needed.

2. Scientific information services in non-contentious policy contexts should increasingly be organized as expert systems which include appropriate computer software and handbooks of relevant ecological, economic and policy parameters.

3. On contentious, complex issues the Institute's administration should offer incentives to Unit leaders to help organize and conduct mission-oriented research episodes together with leaders from other disciplines and sectors of interest. Other experts of the Unit or elsewhere should then be recruited on a temporary basis to conduct real-time investigations to serve the immediate process of such "action research" or "communicative action."

4. The Unit should assert a robust leadership role in balanced scientific services including the basic, applied and mission-oriented, and provide formal guidance for any out-sourcing or contracting of such services with other organizations in order to ensure that such services meet quality, relevance and efficiency criteria.

5. The Unit's leadership and innovators should foster excellent publications, that are accessible to users of this information in Finland and elsewhere, in all three types of science identified here.

6. The Unit's leaders, who have already committed themselves to policy-relevant work under the heading of "developmental activities," should now commit strong efforts to do so within international networks.

Chapter 7
Socioeconomic and aquaculture research unit

Description

The establishment of the Socioeconomic and Aquaculture Research Unit (SEA) within the FGFRI, in 1994, is rather recent. The main focus here is on the more general social and economic problems in the policy field of the Institute. This kind of research relates to the profound changes that have happened in society at large and still continue to exert their influences. These changes include the decline in the numbers of professional fishermen (but subsequent intensification of fishing methods), more intensive pressure by recreational fisheries, and keener international competition in fisheries and aquaculture-related industries.

The Unit has several fields of activity, namely:

1. production of statistics for fishery, aquaculture and hunting;
2. socioeconomic research in these fields; and
3. aquaculture research.

The partners and clients of this Unit are widely spread nationally and also internationally. Nationally they include: the entire fisheries and aquaculture industries; several appropriate organizations and administrative branches; as well as the research sector, including several universities and other research institutes. The collection of statistics, for example, is motivated in part by many international obligations.

The Unit has a work force of 46 employees, with 70% of them having an academic degree (including 9 with a Ph.D.). The statistical sub-unit employs seven persons. The total annual budget for this Unit is of the order of 17 mill. FIM, with the various research projects covering more than two thirds of the total, and the statistics sector ca. 20%. The Unit is also involved in many kinds of consulting activities.

The total numbers of publications produced by this Unit have been variable but without showing any clear trend in the last few years. However, an increasing trend of publications in refereed scientific journals is apparent; though the benchmark level of 3 papers in 1994 is rather low, it had risen to 12 in 1998. The numbers of statistical publications have remained rather stable in recent years, which is natural, but now their contents also cover new aspects compared to earlier years, including the implications of the new regional administrative system (“TE-keskukset”).

a) Statistics sub-unit

The role and need of fish and game statistics are defined by the FGFRI to be those “required for the sustainable use of natural resources and to indicate the state of the environment”. The ‘market’ for statistics is both national and international, including the process to implement various EU and other international agreements. The international agreements concern especially production of statistical data on aquaculture production, marine professional catch, fish prices and import/export of fish.

The statistics compiled by the sub-unit cover three main areas, namely:

1. the fisheries industry with professional and commercial fisheries, aquaculture and restocking as well as fish processing;
2. the fish market, which covers e.g. fish prices as well as fish trade and utilization and consumption of fish; and

3. recreational fishing and hunting.

The statistics that the FGFRI is publishing appear (annually) in the series "Official Statistics of Finland/Environment" (SVT), which is printed in both Finnish and Swedish. The statistics are also reported to many international organizations, such as FAO, ICES, etc.

The methods used in the collection of statistics vary, but in general terms they can be described as being based on existing registers (e.g. registers of professional marine and inland fishermen) and surveys. Data on recreational fisheries and hunting are based solely on sample surveys. Data covering foreign trade are obtained from the Board of Customs.

The Statistics sub-unit employs seven persons, with a total cost of 3.4 million FIM (in 1997). Virtually all of this cost is covered by the state budget.

Apparently new information technologies set both new demands as well as new opportunities for the overall management of fish and wildlife statistics. However, the evaluation team inferred that FGFRI is conducting relatively little critical research on the methods used and their development, though apparently attention is being paid to ensure that the long-term trends show some consistency and are thus 'real.'

b) Socioeconomic research sub-unit

This sub-unit of four groups relates to professional fisheries, recreational fisheries, fish markets and the economics of aquaculture. Such information is seen as vital for the fisheries management in general, especially noting that the fish markets are now relatively open internationally.

With respect to general aspects of fisheries management, there is now also a trend towards more local co-management, which emphasizes both better professional management skills by the administration and also stronger commitment by the fishermen themselves. This is a particularly demanding field because of the linkage also between fishing rights and land ownership; with greater orientation to the market these old conventions are becoming less constraining. Thus there is a clear need for more and better socioeconomic research in fisheries as in any kind of use of natural resources.

For both types of fisheries, professional and recreational, socioeconomic research projects are planned to span several years. The research relies on the methods of social sciences and economics. Postal surveys play a prominent part but are complemented with interviews of selected persons.

The fish market studies cover such topics as price formation and structure of fish market, consumer behaviour, profitability analyses, etc. Similar statistics are also important to the success of the commercial aquaculture sector.

The cost of this kind of research to FGFRI has been 4.3 mill. FIM for professional fisheries (for the period 1994-97); the current and projected future cost for this recreational fisheries research is 4.5 mill. FIM (for about a 4-year period). The fish market and related research has been done with only 1.5 work-years annually, and thus with a rather small budget investment of 0.7 mill. FIM.

c) Aquaculture research sub-unit

This sub-unit is directing its activities towards four main issues:

1. reduction of environmental impacts of aquaculture;
2. diversification of commercial aquaculture production to cover new species;
3. research towards maintenance of (genetic) biodiversity for farmed and stocked fish; and
4. selective breeding of farmed rainbow trout.

The first program is based on the fact that environmental loading can be reduced not only by treating the water itself but also by providing overall biological conditions for fish that lessen the release of phosphorus and nitrogen from aquaculture facilities. Thus fish physiology is also a target of research.

Better and more efficient feed and feeding systems have come to be perceived to be important, and in many cases they are the main means of tackling this problem. Better feeds are also a matter of competitiveness for fish farming at large. The technology itself for water treatment is difficult considering the small concentrations of nitrogen and phosphorus compounds in water; the technical solutions that have been incorporated in the FGFRI fish rearing and aquaculture stations have been rather expensive, though necessary, but they are often not applicable for smaller private fish farms because of their sheer cost.

The diversification program is directed at developing culture methods for several native species including perch, whitefish, pike-perch and Arctic charr. Culture methods for two species of crayfish, one native, one alien, are also being developed.

It is questionable, from the standpoint of biodiversity maintenance, whether it is advisable to stock an alien species that carries a disease that is lethal when transmitted to the native crayfish. The Ministry has justified rearing and stocking signal crayfish for some southern waters in which the native crayfish had been extirpated, because of the plague or other reasons, and numerous attempts to re-introduce native crayfish had failed. The Ministry has acknowledged that more attention has to be paid to the protection of native crayfish.

Finland has a common "signal crayfish strategy" created by the Employment and Economic Development Centres; this strategy was being renewed in mid-1999. The aim of the strategy is to ascertain the sustainable production of natural crayfish waters, to stop illegal spreading of the signal crayfish, and to protect the native crayfish and to ensure its economic importance.

The biodiversity program aims at establishing and maintaining good genetic structure of the brood stock as well as the possible hatchery effects on viability and genetic structure of fish juveniles. The criteria for selective breeding of rainbow trout include growth rate and age at maturation; the improvement obtained so far in growth rate seems to be at least satisfactory.

The total costs to FGFRI for all these activities is of the order of 6.5 mill. FIM annually. The program for the selective breeding of rainbow trout involves also other outside funds.

Critique, Strengths and Weaknesses, Evaluation and Recommendations

Considering the aquaculture part of the activities of the SEA Unit, the important fact is that generally the physical facilities of the FGFRI in different parts of the country for aquaculture research are excellent. In the present form the 13 fish rearing and research stations have been mostly built after the 1970's, though the oldest one (Evo) was established over a hundred years ago. The Inari and Taivalkoski stations have been rebuilt only a few years ago. At the price level of 1993, the construction costs (depreciable value) of all 13 stations comes close to 400 mill. FIM.

The academic staff contains now several Ph.D.'s and more new theses, in cooperation with several universities, are progressing toward completion. The FGFRI seems to be moving more towards modern methods and technics especially in genetical studies, though one may also ask whether this move is fast enough, in the light of the very rapid development (also in terms of methods development) in molecular biology and biotechnology. In this Unit the FGFRI has strong groups of competent scientists, though several of them are hired on a temporary basis only, which may not help with morale

The research by the FGFRI aimed at supporting and developing the commercial fish farming, including getting new fish species for commercial cultivation, is generally well thought of and takes

place also in cooperation with the appropriate industries. (With new species entering the aquaculture, proper attention should also be paid to the disease problems that may suddenly arise.) Lessening the environmental impacts and improving fish feed are certainly the very key issues for the future of Finnish fish farming. Similarly, market studies give good support to the fish farming industry.

The FGFRI may also be considering the issues related to technology transfer and policies related to immaterial rights, etc. Generally such issues are important with research, and especially with applied research in the context of Finland's science policy.

The need for more strategic studies in genetics and molecular biology of fish has been emphasized also in the analysis of the Aquaculture Unit (Chapter 8). This is of course closely related to the total management scheme of aquatic resources.

The role of socioeconomic studies in fisheries and aquaculture has recently become even more important. General developments in the society, changing values, urbanisation, etc. all create new administrative and political pressures to which the management has to respond, hopefully in a pro-active way. This requires a certain vision in directing the future research, and such strategic 'brainstorming' should be part of the planning of any future action in the FGFRI. Strategy is not only for the inner relevance of the Institute itself, but it should also reflect the societal and environmental changes at large, again in a pro-active way. Changes in society can be facilitated by developing a proper knowledge base for such changes

The FGFRI is collecting and publishing a wide variety of statistics, from fish catches and stockings to fish trade and market structure. We recognise that the statistics related to fisheries and hunting as well as fish stockings are of key importance for management and nature conservation. Understandably fisheries statistics are also a sensitive issue, because they have influence on so many things in the whole management system that also involves large numbers of people with differing interests. (In recreational fisheries alone the numbers of people in Finland who are fishing at some time exceeds 2 million, that is some 40 % of the population.) The decision on what kinds of statistics are produced is and should also be a strategic decision. (Of course there are also international agreements, etc. that closely dictate what are the targets of statistics collected.)

Besides the strengths, the fisheries statistics collection system practiced by the FGFRI also has some weaknesses. The latter are partly related to the strategic issues of the management of the natural resources at large, and partly they appear to result from the methods used. The main methods employed are based on different registers and surveys. In such situations the statistician has to emphasize either precision or realism, because quite often these two criteria seem to be mutually exclusive.

First, consider the reported average fish catch in inland waters of 15 kg/ha. This estimate was obtained by dividing the calculated total fish catch by the water surface area. The number, 15, appears high, and may reflect the uncertainties in the methods used in estimating the catches of various fish species. In fact, and if true, in many cases it may represent an overfishing situation or close to it, when otherwise there is an agreement that inland waters are generally underfished. It is also debatable whether a single national catch 'average' is of any use because Finland extends over 1000 km in north-south direction and the natural fish production may vary from ca. 1 kg/ha (in the north) to 30-40 kg/ha in some waters in the south. There have been few if any attempts and experiments at really measuring the true fishing capacity of lakes. **RECOMMENDATION: Better estimates of total catch by policy-relevant classes of waters should be obtained soon**.

Second, a brief inspection of some of the statistics books indicates that some of the estimates may not be 'real', but be product of the models used. Biases may appear simply from the often relatively

small samples sizes, which may also change the same catch figures greatly even in subsequent years. Also, the relationships between stocked fish and fish caught later do not always look realistic (in cases where there is little or no natural reproduction). Matching of long-term trends in fisheries statistics is always problematic, but the FGFRI reportedly has paid special attention to it. There already exist a number of local surveys, whose degree of realism may be much higher. This also seems to apply to crayfish catch statistics. It may happen that the mandatory fisheries management plans produced for the fisheries areas are often made without much reference to the official statistics. Thus it is advisable that the FGFRI also should build closer cooperative ties with the regional fisheries management bodies. **RECOMMENDATION: Estimates of annual catches of selected species and of total catch should incorporate estimates based on local studies**.

Third, there seems to be little research conducted by the staff of the FGFRI on the methods used in their statistics collection and their relevance and reliability for the Finnish conditions. In many cases the information is not just a matter of compiling answers from registers as such, but requires a more complicated approach with a multitude of methods used in social sciences, etc. The reliability is best estimated by obtaining comparable information from different but independent sources, which may dictate that fewer statistics be collected but their degree of realism be higher. (But, admittedly, time is also a resource, and publications of many of the statistics cannot be delayed too much.) The FGFRI apparently has already made efforts towards cooperation in these problems with scientists in universities, and this cooperation should be strengthened further, also by partially 'outsourcing' it to other research bodies. These same methodological questions are not only 'domestic,' but fisheries statistics struggle with the same problems also internationally. Also the problems of 'gray' fishing (i.e. what remains outside of all statistics) and 'illegal' fishing should receive further attention. **RECOMMENDATION: In collaboration with experts of other countries the heterogeneity of fisheries and game statistics should be addressed by researchers to find ways to assess and improve the internal coherence of the total mix with respect to policy needs**.

Fourth, part of the statistics problem is also biological. Considering the sometimes extensive fish stocking programs, proper and transparent cost/benefit analyses of their success, feasibility and relevance become transparently understandable. This is not a matter of statistics collection alone, but it requires specific biological studies of the real success of stocked fish. It is apparent that extensive stockings have seldom if ever produced permanent improvements in local fish production, which also gives the impression that lakes are used as 'holding places' for fish. The one conclusion here is that fisheries management often works in altered environments and habitats that simply are not suitable for productive fish populations, but require permanent stocking efforts in order to look 'sustainable.' **RECOMMENDATION: Under certain circumstances it may be advisable and instructive to separate stocked fish from natural stocks in the catch statistics**.

It is apparent that continuous fish stockings for decades may produce certain (even population genetic) drawbacks and problems, although the FGFRI is already involved in this kind of studies to avoid those long-term effects. There is already discussion in Finland about the feasibility of stockings vs. the long-term benefits of habitat restoration and ecosystem management. That is, a move towards more natural type of management and nature conservation seems apparent (see Chapter 6).

Fifth, because of the growing importance of the ecosystem management approach, more knowledge and statistics about the state of the environment for the benefit of fish populations and their management should be available. This could be best achieved in cooperation with other organisations, e.g. those within the Finnish Environmental Institute and the Institute of Marine Research. The published

water quality criteria may not always apply well to fish, since fish do not live from water alone but are also dependent on proper functions of the entire ecosystem, including the watershed. **RECOMMENDATION: An ecosystem approach, in collaboration with other Finnish Institutes, requires a new strategic set of scientific concepts and statistical information, including socioeconomic data, for such mission-oriented research**.

Sixth, the statistics sub-unit and related research would thus benefit from transparent strategic planning, whereby the statistics collection and the methods used are tightly bound and dictated by the very purpose for which the data and statistics are used. That is, for some purposes nationwide data might be sufficient, but for some special purposes some quite new methods may be required. Some statistics are used for fisheries management indirectly, e.g. in cases where the Ministry allocates the money from the various fisheries fees collected from the public to each fisheries district on the basis of their fishing 'pressure'. **RECOMMENDATION: Revisions of fisheries or game policies may demand statistics of a new type or collected in a different way; this issue needs consideration currently**.

In various parts of our review, the evaluation team has recommended strengthening of "socioeconomic research" especially in an ecosystemic or larger systemic context. This should include rapid innovation with mission-oriented or gamma research, as recommended in Chapters 5 and 6 above. Increased research on "statistics" is also recommended, above in this Chapter 7. For example, logical and empirical understanding based on previous applied and mission-oriented work can be distilled into a form of statistical filter or expert system to identify non-conforming or outlier data and estimates; some of these "errors" should then be examined further by researchers. In some cases this will result in better understanding, an up-dated filter and changes in the sampling/estimation routines, etc. **RECOMMENDATION: The responsibilities of this Unit should include a stronger emphasis on statistical research as well as innovative mission-oriented or gamma research to help inform the FGFRI Board, the Finnish Government, and others**.

List of Recommendations

1. Better estimates of total catch by policy-relevant classes of waters should be obtained soon.

2. Estimates of annual catches of selected species and of total catch should incorporate estimates based on local studies.

3. In collaboration with experts of other countries the heterogeneity of fisheries and game statistics should be addressed by researchers to find ways to assess and improve the internal coherence of the total mix with respect to policy needs.

4. Under certain circumstances it may be advisable and instructive to separate stocked fish from natural stocks in the catch statistics.

5. An ecosystem approach, in collaboration with other Finnish Institutes, requires a new strategic set of scientific approaches and statistical information, including socioeconomic data, for such mission-oriented research.

6. Revisions of fisheries or game policies may demand statistics of a new type or collected in a different way; this issue needs consideration currently.

7. The responsibilities of this Unit should include a stronger emphasis on statistical research as well as innovative mission-oriented or gamma research to help inform the FGFRI Board, the Finnish Government, and others.

Chapter 8
Aquaculture unit

Description

The Aquaculture Unit has three main programmes, viz.:
1. preservation of endangered and indigenous fish stocks and their biodiversity;
2. support and promotion of commercial aquaculture; and
3. enhancement of opportunities and prospects for fishing.

Aquaculture research in the FGFRI is performed mostly within the Socioeconomic and Aquaculture Research Unit (SEA). This separation of aquaculture activities within the Institute is clear. The Aquaculture Unit is concentrating on the direct production activities, while the SEA is engaged in the respective research. There is expectation at the Institute level for cooperative research on aquaculture presumably led by one of the two aquatic "research units."

The Aquaculture Unit's preservation programme includes cultivation and stocking of endangered species and the establishment of permanent milt banks. The aquaculture promotion consists of selective breeding, production of eggs and fry for further rearing elsewhere, and development of aquaculture products and technology. (Only 10 % of the Unit's expenditures are used for aquaculture development, mainly together with the SEA Research Unit.) Enhancement of stocks for fishers includes fulfilment of stocking obligations, management of valuable stocks in the Baltic, and development of stocking management. The Aquaculture Unit stresses its role towards fulfilment of governmental obligations.

The Aquaculture Unit's practical operations have been recognized as meeting the quality requirements for the ISO 9001. These quality requirements cover a whole range of operations from biology to the quality of the personnel, and as such it could be a pace-setting step for aquaculture at large in Finland.

The Aquaculture Unit is the second largest unit within the Institute both with respect to total costs and to the number of employees. Several years ago, the Unit was by far the largest of the units; in 1994 aquaculture research was transferred to other units, which apparently clarified the situation within the FGFRI. The number of permanent staff is 65 and the total labour input is about 76 work years, partly supported by employment subsidies.

Only 3 of the unit's staff are stationed in the headquarters at Helsinki. The rest of the staff are divided between 13 different stations grouped in five different regions; with expected reorganisations only 11 stations will remain. All the 11 stations have permanent staff present. Considering only the indoor areas, seven stations are larger than 1000 sq. m. and three are larger than 1500 sq. m.

Strengths and Weaknesses

In Finland, as also in Scandinavia, there is an old tradition of fish stocking and fish farming, which can be traced back at least a thousand years. This tradition has strongly shaped the fish communities of the Scandinavian countries, increasing the geographic distribution of several species (notably coregonids) which may have harmed some weaker competitors like trout and charr.

A particular feature for most of Scandinavia is its tradition that fishing rights are tied tightly to land-owning, and gill netting is still one of the most popular ways of fishing for non-commercial fishermen.

Finland has experienced extensive physical changes in its aquatic habitats, due to a number of reasons, especially during the last 50 years, but also earlier. This has resulted in a loss or weakening of a number of natural fish stocks and especially those of migratory species. Thus there is a widespread need for preservation of endangered indigenous fish stocks together with compensatory stockings. Many of the latter are done to comply with orders from water courts, in which the state itself may have legal obligations. These state obligations in particular are carried out by the FGFRI.

The fishing pressure in Finnish lakes is variable, but generally it is also affected by the 'natural' fluctuations of the pelagic stocks, especially that of vendace. The problem of 'coarse' fish is apparent especially in areas where eutrophication has advanced. The fish stocking rate (some 130 million fry per year) seems be a response to this fishing pressure, but also it reflects the extensive changes in the environment.

The fish catch in the Baltic by Finnish fishermen has increased through the 1990's, though the numbers of professional fishermen has declined during the same period.

The Aquaculture Unit seems to be a fairly efficient part of the Finnish cultivation programme, serving also the private sector. The stations are equally distributed in different isolated parts of the country, which reduces the risk for the spreading of diseases. Locating such facilities inappropriately would otherwise be disastrous both for the cultivation programmes and for the wild fish stocks.

The Unit is strongly engaged in the work with preservation of endangered species, and the evaluation team highly approves of that commitment. Large resources are devoted to this problem, - maybe larger than similar efforts in other Scandinavian countries. Perhaps also for historical reasons within the Finnish national policies and traditions, most of these efforts are directed more towards fish cultivation and not towards habitat restoration; the latter is certainly a 'cheaper' solution in the long run. This policy may partly be due to the fact that the main responsibility for the physical habitat belongs to another branch of the state administration, which again underlines the importance of inter-institute cooperation. Also, compensation stockings obligated by court orders are of course linked with the existing laws (as well as with many other kinds of interests) and can be changed only slowly with time.

Although we may say that as a management policy, stocking works towards preservation and maintenance of many fish stocks at least on a short-term basis, there are still many long-term risks involved. These not only concern Finland but are being discussed in many parts of the world in relation to sustainable development of fisheries. The researchers in FGFRI are well aware of the general risks with cultivation from a genetical point of view. They are doing what they can to reduce the negative effects of cultivation.

It is obvious that the formulated goals of 25 parents of each sex and a randomly or stratified sampling of the whole genetical spectrum of the stocks cannot always be fulfilled. Even if those goals could be achieved, such a large cultivation and stocking programme would in the long run have negative effects on the genetic structure of the wild stocks affected by the programme. Molecular tools for this kind of research are rapidly being improved and sharpened. Furthermore, extensive fish stockings may direct the attention too much to the "single-species management" of the whole fishery, to a partial detriment of an ecosystem approach, which is discussed elsewhere in this report.

The Unit's staff is dominated numerically by people with relatively low formal education. Only 10 % of them have an academic degree, but apparently the skills at the level of technician are adequate

for the work. The relative output of articles in peer-reviewed journals is the lowest within the Institute. This is a result of the separation within the Institute between aquaculture research at the SEA Research Unit, and the more routine aquaculture work within the Aquaculture Unit.

Evaluation

The work of the Aquaculture Unit of the FGFRI cannot be evaluated without consideration of the national and the Ministry's basic strategy of fish cultivation and stocking, in a programme demanded or expected by various stakeholders or "customers." It is acknowledged that the stocking programmes, while strengthening some local stocks, may be a potential threat towards the long-term preservation of species and wild stocks in terms of both their genetic structure and continued existence. This is a paradox and the current situation may ultimately conflict with the Rio Convention as in Agenda 21 and with EU directives on habitat, which are recognized by the Unit researchers. (But there are situations where a short-term cultivation programme is a necessity, because otherwise a particular stock may be lost forever.) There is need for studying and developing further options for preserving Finland's natural fish and crayfish stocks.

a) Fish Cultivation

For several reasons, fish cultivation produces fish genetically different from those derived from natural spawning:

- The breeding stock does not fully represent the total stock. In part this follows from purely theoretical reasons. Such an effect will be enlarged by practical obstacles to fulfill the proposed goals for minimising the theoretical effects.
- In a hatchery the eggs and fish are subject to different conditions than in nature. This will unavoidably create fish less adapted to life in lakes and streams both through selective mortality and through learning processes.
- Due to the usually lower mortality in hatcheries, the number of recruits from the breeding programme will be disproportionally large compared to the number of recruits from natural spawning. The resulting genetic pool will therefore change and the overall genetical diversity will be reduced.
- In natural spawning - and especially in salmonid species - the partner choice in spawning is perhaps the most important part of the play in which evolution works through natural selection, thereby optimising the survival with respect to environmental conditions. In long-term cultivation this process is lost, and it has been shown that this affects the competitiveness of the fry and the genetical composition of the stock.

Even if these problems can be somewhat reduced by using "wild" parent fish, it will in the long run change the natural stocks of those species which should be preserved. This is particularly the case with endangered species, where it is often very difficult to find the recommended numbers of parents.

b) Stocking

Stocking is performed for three main reasons:

to save endangered stocks;

to compensate for reduced natural recruitment; and

to enhance the size of natural populations for fishing purposes.

Nearly half of the cases of fish stocking in Finland, especially in the northern half of the country, are to comply with court orders. They serve both compensatory and enhancement purposes.

When habitat restoration is not possible it is sometimes necessary to cultivate and stock fish. When this is done it is very important that all efforts are made to reduce the negative effects on the genetical diversity. It is also important to stock fish in such a way that the cultured fish do not breed with natural stocks. When a wild stock is almost or totally lost in nature, then it is not possible to save it from a strictly genetical point of view, of course. It might, however, be possible to save some of the ecological characteristics of the stock by introducing it into a restored or a new but similar habitat. To use the latter strategy may result in the reduction of reliance on long-term cultivation.

Stocking fish for enhancing natural populations, which is often favoured by the public, can also be questioned for at least two biological reasons.

Firstly, in Scandinavia it can be assumed that in most cases the present fish community fully uses the existing ecological production. Introduction of fish will therefore negatively affect the same or other species within the community. Thus such species interactions may negatively affect the biological balance and intended results and may even upset the socioeconomic outcome.

Second, the cultivated stocks will interbreed with existing stocks of the same - or sometimes even worse - of related species. This is not in accordance even with international agreements and should be avoided.

c) Exotic species

Finland, like many other European countries, had in the past a relatively open attitude towards introductions of exotic species, and not only for aquatic environments. Several North American salmonid species have been introduced into Finland in the past, and some of them are also cultivated. On several grounds we strongly feel that future policies should be much more stringent. Already from a purely ethical base, introductions should be avoided in order to preserve and protect the native fauna. Especially with salmonids there is also a real threat of crossbreeding with native species. And we already know how difficult it is, particularly in fish introductions, to combat the spreading of new diseases.

Swedish colleagues of the FGFRI interpret an international agreement that both countries have signed as forbidding the introduction of exotic species.

Several regulations, both national and international, cover the gene-modified (GM) organisms, and generally forbid their release into the wild. The FGFRI is not involved in the production of GM stocks. (However, it is running a genetic breeding programme to improve the production qualities of the rainbow trout, but for fish farming only.)

An unfortunate example of an exotic is the release of the signal crayfish (Pacifastacus) as a substitute for the native crayfish, compounded by the susceptibility of the native crayfish (Astacus) to the crayfish plague fungus. Scientists have learned that the signal crayfish ecologically displace the native species wherever they co-occur, but also that the signal crayfish is relatively (but not totally) resistant to the plague. This means that most if not all signal crayfish stocks are or will be infected by the plague and at least with time they will easily acquire it. Policy-related aspects of this issue are addressed in Chapter 7; clearly some serious research is needed to help find a way out of this trap.

Recommendations

The evaluation team notes that the experts of the Aquaculture Unit do not have a primary responsibility to conduct research. But they do apparently have opportunity to collaborate in research relevant

to aquaculture that is undertaken by colleagues in the Socioeconomic and Aquaculture Unit, or relevant to biodiversity with colleagues in the Fisheries Biology and Management Research Unit. The recommendations below that relate to research would presumably involve personnel of the Aquaculture Unit in a collaborative way.

The evaluation team recognises that the present cultivation and stocking programmes for compensation and enhancement enjoy strong support, for various and often good reasons. But the scale at which this programme is operating could be economically unwise and could have negative effects on the biodiversity of Finnish aquatic ecosystems in the long run. **RECOMMENDATION: More research should be directed towards the aquaculture problem, urgently, to help the Ministry to reconsider its long-term direction. This research could proceed as a mission-oriented or gamma research initiative. The complex problem is not only a matter of genetics but also of the interacting effects of aquaculture on the whole fishery system including fishing pressure, type of gear used, etc**.

Part of the above mentioned stocking and most of the cultivation and stocking of endangered species and stocks are intended to compensate for physical alterations of habitats. In the long run it is difficult to save endangered species and stocks in this way and it may also be economically costly. **RECOMMENDATION: Research efforts for restoring altered or destroyed habitats should be intensified and further resources for these activities should be transferred towards habitat restoration activities. Researchers should quickly investigate whether cultivation of endangered stocks and species should be reduced because it seems to be based mostly on short-term and ad hoc arguments**.

When habitat restoration is not possible for creating a viable stock, a careful decision has to made in each single case, whether to rely further on aquaculture or how to modify the programme (if not stopping it altogether). **RECOMMENDATION: If aquaculture will be used where habitat restoration is not feasible, then researchers should help guide a careful breeding program to be established in a station with conditions representative for the actual stock. Such a strategy would likely lead to the use of several small, local aquaculture units rather than a few large ones**.

It is important for Finland to protect its natural fauna and flora with respect to the introduction of exotic species and, where appropriate, genetically-engineered stock. **RECOMMENDATION: Concerning exotics, socioeconomic and biological researchers might focus on the question concerning the influence of the exotics in Finland and to advise on how the extant agreement could be implemented.**

The signal crayfish seems to constitute a special case. The species is now so widely spread that it has to be recognised as part of the Finnish fauna. This established fact, however, makes the obligations to save the native crayfish species particularly strong. The situation for the native crayfish might be even worse than is generally realized because the species apparently is now being pushed north of its old range, where the conditions for the species are suboptimal. **RECOMMENDATION: Researchers should help the Ministry and other fisheries partners to devise a special programme, which may parallel a new programme in Sweden, to identify and protect areas where the signal crayfish do not now occur and where it seems possible to stop or prevent further 'legal' or illegal introductions. Information to the public of the value of preserving the native species is important as well as information about the long-term negative effects (through spreading the plague, etc.) of the signal crayfish**.

Under all circumstances genetical studies of the Finnish fish stocks will be necessary on a rather large scale in the future. **RECOMMENDATION: FGFRI should establish liaison with an ad-**

vanced genetics laboratory, with competence in fish and aquaculture at large as well as in game and reindeer, in collaboration with genetics experts in universities, nationally and internationally.

Apparently consideration is now being given to a physical reduction of the Institute's aquaculture activities. **RECOMMENDATION: The sites and numbers of the fish rearing stations should be studied thoroughly in view of the changing requirements related to maintenance of genetic stocks of fish.** The partially contradicting goals of a few, efficient units for large-scale compensatory stocking and small, local units for preservation purposes must be considered as well as FGFRI's total need for regional field stations with optimal size of collaborating research groups.

RECOMMENDATION: FGFRI should continue to strengthen its research on habitat restoration, in collaboration with other appropriate branches of the Government and particularly the Environmental branch. Special attention should be given to total watershed management, which is a good way to obtain desirable long-term results.

RECOMMENDATION: In a complementary way, FGFRI should improve the scientific quality and quantity of the research - biological, ecological, socioeconomic - related to aquaculture and stock management and to improve the efficiency, both short-term and long-term, of the aquaculture research. International collaboration and even international hiring of the staff would likely bring good results to the Institute's work at large.

List of References

1. More research should be directed towards the aquaculture problem, urgently, to help the Ministry to reconsider its long-term direction.

2. Research efforts for restoring altered or destroyed habitats should be intensified and further resources for these activities should be transferred towards habitat restoration activities. Researchers should quickly investigate whether cultivation of endangered stocks and species should be reduced because it seems to be based mostly on short-term and ad hoc arguments.

3. If aquaculture will be used where habitat restoration is not feasible, then researchers should help guide a careful breeding program to be established in a station with conditions representative for the actual stock. Such a strategy would likely lead to the use of several small, local aquaculture units rather than a few large ones.

4. Concerning exotics, socioeconomic and biological researchers might focus on the question of the influence of exotics in Finland and to advise on how the extant agreement could be implemented.

5. Researchers should help the Ministry and other fisheries partners to devise a special programme, which may parallel a new programme in Sweden, to identify and protect areas where the signal crayfish do not now occur and where it seems possible to stop or prevent further 'legal' or illegal introductions.

6. FGFRI should establish liaison with an advanced genetics laboratory, with competence in fish and aquaculture at large as well as in game and reindeer, in collaboration with genetics experts in universities, nationally and internationally.

7. The sites and numbers of the fish rearing stations should be studied thoroughly in view of the changing requirements related to maintenance of genetic stocks of fish.

8. FGFRI should continue and strengthen its research on habitat restoration, in collaboration with other appropriate branches of the Government and particularly the Environmental branch. Special attention should be given to total watershed management, which is a good way to obtain desirable long-term results.

9. In a complementary way, FGFRI should improve the scientific quality and quantity of the research - biological, ecological, socioeconomic - related to aquaculture and stock management and to improve the efficiency, both short-term and long-term, of the aquaculture research. International collaboration and even international hiring of the staff would likely bring good results to the Institute's work at large.

Chapter 9
Game and reindeer research unit

Description

The Game and Reindeer Research Unit, GRRU, focuses mostly on warm-blooded animals in terrestrial habitats while the Units that relate to fish, crayfish and aquaculture focus mostly on cold-blooded animals in aquatic habitats. Warm-blooded animals such as seals and cormorants are of interest to both groups.

GRRU is divided into to two subunits (though also termed "Units"), the Game Research Unit (GRU) and the Reindeer Research Unit (RRU). These subunits are very different, although they both are strongly dominated by research in the domain of basic and applied science concerning terrestrial warm-blooded animals.

Game Research Unit

The basic task of the GRU is to increase knowledge about the biology and state of game populations and ecologically-associated animal populations, their use of environments, and effects on the surrounding community, including human activities. ("Game" here includes mammals and birds that are of interest to hunters and to other people.) This information consists of research results and expertise; it is used by other expert colleagues to promote the sustainable use and well-being of game populations.

GRU's primary responsibilities (which roughly parallel the alpha, beta and gamma types of science sketched in Chapter 5) are to:

1. conduct research on game species, particularly on environment and habitat, factors affecting abundance, and basic species biology;
2. monitor the populations of the most important game species; and
3. provide expert services.

The total costs of the GRU are distributed among these responsibilities as 23% to monitoring, 62% to research, and 15% to expert services (1996-97). The total funding has been increasing during the past three years, due to increases from the state budget and external funding. The total budget for this Unit in 1997 was FIM 11.8 million.

The GRU consisted, in late 1997, of 21 permanent employees in Helsinki and several research stations, and 1 additional visiting scientist. Nine of these 22 employees carry out scientific research; 7 of these have a PhD and 1 has a MSc. Their formal education is in ecological zoology, biology and genetics. During 1994-97, the rate of publication was 2.0 scientific articles/scientist/year and 4.7 total publications/staff person/year.

The main customers of the GRU are a diverse, but relatively easily definable group. They consist of the Ministries of Agriculture and Forestry (game management) and of the Environment (endangered species), the Hunters' Central Organization, organizations and citizens dealing with the management of land and water, the scientific community, and the public.

Reindeer Research Unit

The basic task of the RRU is to increase understanding of the biology and state of reindeer stock, the state of reindeer pastures and other factors that affect the reindeer population. RRU's primary responsibilities are to:

1. conduct research on reindeer, reindeer husbandry, and reindeer pastures;
2. monitor the quality and quantity of reindeer pastures; and
3. provide expert services.

The total costs expended by the RRU in 1996-97 were distributed among these tasks as 27% to monitoring, 63% to research and 10% to expert services. The funding has been fluctuating during the past years, although generally increasing. The total budget in 1997 was FIM 3.4 million.

The RRU had only 4 permanent employees in 1997, all stationed at the Reindeer Research Station at Inari. Two of these are scientists, one with a PhD and one with a Licentiate degree; their formal education is in physiological zoology and ecological zoology. In addition to the permanent staff, additional workers are hired with funding from the Ministry of Agriculture and Forestry, Ministry of Labour, and other funding sources. During 1994-97, the rate of publication was 1.8 scientific articles/scientist/year and 6.0 total publications/staff person/year.

The main customers are the Ministry of Agriculture and Forestry, other national and local agencies, the Reindeer Herders' Association, reindeer owners, the scientific community, and the public.

Critique

Game Research Unit

The GRU continues the long and successful Finnish tradition of monitoring populations and conducting research on the ecology of game species, particularly on small game. Building on this, and the generally strong Finnish competence in terrestrial ecology, has resulted in a creative unit producing long-term monitoring results that are perhaps unique in the world, and ecological research of high quality. The scientists in the unit have been actively and successfully cooperating with other research groups both in Finland and internationally, and this should continue, and even be increased.

The greatest strength of the unit is still in small game. Small-game monitoring has been standardized with the introduction of the "wildlife triangles." This method has been tested and calibrated with previously used methods. It has also been expanded to encompass the winter period and to provide comparisons with adjacent Russian Karelia, with a completely different history of forest management, but otherwise similar geology and forests.

One example of the relevant ecological questions being addressed with wildlife triangle data is the landscape ecology research looking at environmental factors influencing abundance of small game at many levels of scale, from the local point to entire Finland. This monitoring, and that of inland and coastal waterfowl and seals also received good critique from an international review (International evaluation of the monitoring schemes for game and wildlife in Finland, Kala- ja Riistaraportteja 86, 1997). Data from the monitoring programs are the backbone of Finnish game management, and are also important for research at the unit.

The research activity on moose and carnivores has been weak by comparison, at least when judged by scientific publications. In the international evaluation of monitoring, concerns were also raised about the monitoring of large carnivores and moose. These areas need to be strengthened. The evaluation team is pleased to note that there is new research activity starting in the area of large carnivores, and that some wolves and brown bears have been radiomarked to answer basic ecological questions. This research is being coordinated with other studies of large carnivores on the Nordic level.

Reindeer Research Unit

The RRU is small and relatively isolated, both by its mandate and by its geography. These should be causes for concern, but the personnel of the RRU work to overcome them with an impressive network of national and international cooperating scientists, including many who conduct research at the station.

The research station is the only one of its kind in Fennoscandia, and has a study herd plus a rather well equipped laboratory. It is used by several cooperating researchers both from Finland and abroad. We noticed that Norwegian researchers were much more active in this cooperative research than Swedish researchers. The research is of good quality, and is relevant to reindeer husbandry. Particularly the pasture monitoring provides relevant and useful information for the regulating agencies that decide the maximum number of reindeer to help reverse the present state of overgrazing. Of course, this information is also essential for reindeer husbandry at large. It is positive that the RRU and GRU cooperate in areas of common interest, such as predation on reindeer.

Evaluation and Recommendations

Game Research Unit

The GRU is among the foremost institutes of its kind in the world. The personnel are productive. The rate of scientific publication is about average for this kind of institute, but when combined with the popular literature, the rate of publication is quite high. Both the scientific and popular literature hold to a high standard, and the popular literature appears to be appreciated by the customers. **RECOMMENDATION: Cooperation with Finnish universities and internationally, though generally good, should be increased.**

As stated earlier, the research is dominated by both basic and applied science. **RECOMMENDATION: In the future, more research on the ecosystem or landscape level and more research on integrated wildlife management will become more important especially with respect to regional and global factors; the GRU should progress more rapidly with this approach**.

The backbone of the small game monitoring, and much of the research, is the wildlife triangle and other systematic monitoring systems that are dependent upon large numbers of volunteers that conduct the work once or several times per year. These volunteers are the critical link in a system that is unique in the world. **RECOMMENDATION: Emphatically, more research in cooperation with experts of other countries is needed on moose, especially in relation to predation by large predators and the evaluation of the moose monitoring system. RECOMMENDATION: Moose and**

large carnivore projects should be coordinated even more than is now the case with similar projects, especially in the Nordic region.

Is information from the monitoring and research adequately finding its way into the practical management? Although this is primarily the responsibility of the managing authorities, there is often a certain skepticism about research results within management agencies. RECOMMENDATION: The GRU could facilitate the flow of information by providing courses and training to key people doing the practical management work. **RECOMMENDATION: Research and monitoring conducted by the GRU should be linked more closely with that of other relevant research institutes and also more closely with other relevant units within the FGFRI (e.g. seals and Baltic fisheries).**

Reindeer Research Unit

The RRU is also among the foremost institutes of its kind in the world. The employees produce literature at a rate similar to the GRU, although it is somewhat lower for scientific literature and somewhat higher for popular literature.

There are hazards to being small and geographically distant. **RECOMMENDATION: The RRU should maintain and even expand its network of cooperators and continue to provide the facilities at the research station to cooperating researchers**.

The Unit's research is primarily basic and applied science, but there is a great potential to increase the work on the applied level of science and expand it to an ecosystem management at a mission-oriented level, especially in the overgrazing issue. Overgrazing on reindeer ranges is a major problem in Finland, Norway and Sweden. It is an economic problem for reindeer husbandry, and it is an ecological problem as well, e.g. by reducing biological diversity. The monitoring work of the RRU is of major importance to understand and avoid the biological aspects of this problem. But why do the reindeer owners overgraze their (or society's) ranges? **RECOMMENDATION: A cooperative ecosystemic research project should be undertaken to examine the ecological effects of the reindeer overgrazing and human dimensions of this human-caused problem**.

Both Units

RECOMMENDATION: Both the GRU and RRU would benefit from a written long-term research strategy. This "indicative strategy" could consist of two parts: research carried out by the GRU and RRU; and all applied research on game and reindeer funded by the Ministries of Agriculture and Forestry and of the Environment, i.e., not just FGFRI research. The first part should be formulated together with the Ministry of Agriculture and Forestry. The second part should be initiated cooperatively by the Ministries. Of course, unforeseen events cannot be planned for, hence the strategy must not be taken to be fully "purposive." Instead an amendable, indicative strategy should help to guide long-term research that is relevant to the management needs of the Ministry.

List of Recommendations

1. Cooperation with Finnish universities and internationally, though generally good, should be increased.

2. In the future, more research on the ecosystem or landscape level and more research on integrated wildlife management will become more important especially with respect to regional and global factors; the GRU should progress more rapidly with this approach.

3. To design appropriate feedback to help maintain the volunteers' enthusiasm, a sociological study should be conducted to infer what motivates them and what they really want from their efforts.

4a. Emphatically, more research in cooperation with experts of other countries is needed on moose, especially in relation to predation by large predators and the evaluation of the moose monitoring system.

4b. Moose and large carnivore projects should be coordinated even more than is now the case with similar projects, especially in the Nordic region.

5a. The GRU could facilitate the flow of information by providing courses and training to key people doing the practical management work.

5b. Research and monitoring conducted by the GRU should be linked more closely with that of other relevant research institutes and also more closely with other relevant units within the FGFRI (e.g. seals and Baltic fisheries).

6. The RRU should maintain and even expand its network of cooperators and continue to provide the facilities at the research station to cooperating researchers.

7. A cooperative ecosystemic research project should be undertaken to examine the ecological effects of reindeer overgrazing and human dimensions of this human-caused problem.

8. Both the GRU and RRU would benefit from a written long-term research strategy.

Chapter 10.
Services unit

General Observations

The Services Unit of the FGFRI covers the internal services, including financial and personnel administration, office services, property management, legal matters and the information technology or IT systems. For the services outside the Institute, this Unit is responsible for communications, library and other information services, as well as publications. The Services Unit is also responsible for implementing the administrative results targets agreed upon in the annual contract negotiations between the Ministry of Agriculture and Forestry and the Institute.

The Services Unit must obviously be responsive to the Institute's Board and its Management Group, both of which are led by the Institute's Director General. The Board, which consists of six persons, has the following functions: approve the budget proposal, annual accounts and strategic plans of the Institute; approve the working order of the Research Institute; and deal with matters within the Institute's purview that are strategically important and of far-reaching significance when the Board so decides following a proposal by the chairman.

The Management Group consists of the Director General of the Institute and the heads of the five profit centres or units. The Group's main role is to support the Director General in heading the Institute, and coordinate activities between the units. It is not a decision-making body but has an intense working routine with frequent meetings.

The Services Unit employs 37 full-time persons in the main office in Helsinki and in five offices elsewhere in the country. In addition, funds from the Ministry of Labour have been used to hire temporary staff, so that the combined work force in 1997 was some 85 work years. (The input of this extra labor fund will probably decline in the near future.)

The total budget of the Institute (in 1998) was ca. 116 mill. FIM, out of which the state budget covered 72 mill. FIM, and the rest came from various other sources, including sales. The staff expenses were 67 mill. FIM. The rent the Institute paid for its premises was ca. 16 mill. FIM in 1998. The total expenditure of the Services Unit is of the order of 24 mill. FIM (in 1998), which also includes the cost of the top management of the Institute.

Regardless of the Unit of the Institute that is providing them, the overall services provided by the FGFRI, both the in-house services and those provided to the outside, have each expanded and improved in recent years.

The FGFRI increasingly is relying more on information technology (IT) in its internal workings and outside relations; technical possibilities would allow for a realization of a number of expanded service tasks. The Institute's web site was updated in 1999.

The FGFRI's main library in Helsinki serves well at least the headquarters itself and is also a public library. The acquisitions of the library are at least satisfactory, and the library is connected to major information networks and electronic libraries in the Institute's fields of action. The various stations have smaller libraries for the use by the local staff.

To develop its information services at large, the FGFRI has made advances in recent years. A new type of Annual Report of the Institute's main activities and finances has been published since 1994.

Also, a list of publications and articles written by the staff of the FGFRI are printed annually. The Services Unit publishes weekly press reviews. Members of the staff of the Institute often appear in public, especially in newspaper interviews, etc., which in many cases is a necessity in these fields of natural resource management; this information always attracts a good amount of interest among the public. The Institute has recently started publishing a newsletter "Apaja," which is targeted at the Institute's customers; apparently it is well received. Furthermore, the FGFRI staff also participates in national seminars that are aimed at both the professionals and the general public and interested people.

FGFRI's publications, and especially scientific publications and articles, have increased in numbers in recent years, and their graphic appearance has improved with a new logo, etc. A new, recently-implemented policy deals with a series of publications of books and booklets for the interested public at large as well as professional people, covering both fisheries and game management. This publications policy is partly based on commercial sales of books and booklets and other information materials.

The Institute does not publish its own scientific journals. Instead it is participating, together with several other Finnish scientific organizations and institutes, in the publication of the series "Boreal Environmental Research".

The statistical yearbook, usually comprising several booklets on fisheries and wildlife, is published in cooperation with Statistics Finland, in a series called "Environment".

The international contacts and duties of the FGFRI have increased in recent years, and especially after Finland joined the European Union in 1995; the FGFRI is obliged to produce data and information about fisheries and wildlife in Finland for the various administrative and decision making bodies of the EU. The FGFRI represents Finland also for the EUROSTAT fisheries statistics, and again various statistical data are sent to OECD, ICES, FAO, EIFAC, and the Nordic Council of Ministers. The FGFRI represents Finland in a number of international organizations in the fields of fisheries and wildlife and game management. The FGFRI also participates as a partner in several research programs of the EU. The Baltic Sea is one of the major international interest areas where Finland and thus also the FGFRI participate actively.

Recommendations

The services provided by the FGFRI generally are supportive of the overall aims and strategies of the Institute. The evaluation team makes the following recommendations with an expectation that they may be consistent with what the Unit's innovators are already attempting.

RECOMMENDATION: The applications and possibilities of information technology should be developed further, and the FGFRI web site could and should be the central interactive core for fish and wildlife management in Finland. To make the system really workable, the FGFRI needs a good permanent webmaster and continuous efforts from all project leaders so that each project is represented on the web site, and that the leaders continuously update their projects. Now the web site appears to be fairly informative, but it is in Finnish language only. Thus certain sections or all should be published also in English; and partly even in some Scandinavian language or in Russian. An active web site would also be interactive in the sense that it can invite the clients and customers as well as the public at large to respond to it, and thus the FGFRI would be better aware of the problems out in the field.

RECOMMENDATION: The availability of data in electronic form, both statistical and research data, should be considered in the light of the need of cooperation with outside organizations. (But of course the rights of individual scientists should be protected.) What are the policies for accessing FGFRI data by outsiders? The current web site provides some general statistics freely already, but it is not sufficient. The current statistical booklets are necessary as such, but they must be supplemented with access to their electronic form.

The contents of the fisheries statistics has been discussed critically in Chapter 7 and elsewhere. If such data were available in electronic form, informed persons could do new calculations and observations, correlate FGFRI data with other data and statistics, and propose alternative inferences. **RECOMMENDATION: Data should be made available rapidly, under appropriate constraints, with an expectation that feedback from users of the data would lead to improvements in the data series**.

RECOMMENDATION: The pricing policy of the data and statistics should be reconsidered. The main purposes are: that the information be as widely available as possible because it is generally produced with public funds; and that it reaches especially those who really need such information. There are some customers who might be heavy users of the services of the FGFRI, but the pricing policy now prevents them from obtaining all the information they need. (The FGFRI may set special prices or give them free of charge to certain long-term and steady customers.)

The publications of the FGFRI are not sufficiently known to the potential users and customers, and so better marketing efforts are needed. It is not enough just to give out annual lists of publications and articles written by the FGFRI staff. Also, the availability of reprints of scientific articles published in international journals should be secured, unless that is already done in the electronic form. The main library of the FGFRI in Helsinki seems to be serving the headquarters' staff well, but problems seem to exist as to its service to its own staff in the numerous stations all over the country. The circulation system of books, etc., seems to be slow, and possibilities offered again by the internal electronic information system should be further pursued. **RECOMMENDATION: In this era of information explosion, the Services Unit should continue to innovate on how to serve those with special needs for information, and especially for the information included in Institute publications**.

RECOMMENDATION: The FGFRI should make the up-dating and preservation of long-term data and statistics, covering both fisheries and wildlife, as secure as possible. And, at the same time, the Institute should make sure that the access to the archives is easy enough. For example, fisheries or wildlife statistics spanning over several decades or even centuries could be of immense value for many kinds of nature and environmental research.

RECOMMENDATION: Information about the FGFRI's facilities (special laboratories, library acquisitions, instruments, fish aquaculture stations and their capacities, etc.) should also be available on a web site to encourage and foster cooperation and collaboration with outside scientists and organizations, both nationally and abroad.

RECOMMENDATION: As a form of service to its own scientists and customers as well, a clear policy concerning issues of technology transfer, patent policies, etc., should be developed. This also requires special actions when contracting for research work with and for outside organizations or for otherwise clear commercial purposes.

The financial bookkeeping of the major projects seems to be in good order, but for the smaller projects a project leader seems to have to run a separate system in order to follow a project.

RECOMMENDATION: A single service protocol for financial bookkeeping should be developed to cover all kinds of projects, big and small.

The numerous international contacts and representations of the FGFRI must be difficult for the staff, though the evaluators know of no clear problems in this context. (Finland has to take care of its share of international contacts and agreements, which is difficult in a small country with small organizations.) It is a challenge for the FGFRI administration and the supporting personnel to properly prepare and augment the work that goes into representing Finland in such contacts and meetings. **RECOMMENDATION: FGFRI should pay continuous critical attention to its international involvements**.

List of References

1. The applications and possibilities of information technology should be developed further, and the FGFRI web site could and should be the central interactive core for fish and wildlife management in Finland.

2. The availability of data in electronic form, both statistical and research data, should be considered in the light of the need of cooperation with outside organizations.

3. Data should be made available rapidly, under appropriate constraints, with an expectation that feedback from users of the data would lead to improvements in the data series.

4. The pricing policy of the data and statistics should be reconsidered.

5. In this era of information explosion, the Services Unit should continue to innovate on how to serve those with special needs for information, and especially for the information included in Institute publications.

6. The FGFRI should make the up-dating and preservation of long-term data and statistics, covering both fisheries and wildlife, as secure as possible.

7. Information about the FGFRI's facilities (special laboratories, library acquisitions, instruments, fish aquaculture stations and their capacities, etc.) should also be available on a web site to encourage and foster cooperation and collaboration with outside scientists and organizations, both nationally and abroad.

8. As a form of service to its own scientists and customers as well, a clear policy concerning issues of technology transfer, patent policies, etc., should be developed.

9. A single service protocol for financial bookkeeping should be developed to cover all kinds of projects, big and small.

10. FGFRI should pay continuous critical attention to its international involvements.

Chapter 11
Comments by the Institute's customers

In 1995, just after the FGFRI had emerged from a reorganization, the FGFRI conducted a customer survey using an outside consultant. The survey covered over 180 respondents, including universities, research institutes, administrators, private companies, and others. Generally, the response was very favourable to the image and role of the FGFRI in its field. The survey also helped to pave a way for better cooperation with outside organizations.

In 1996 FGFRI surveyed mostly the immediate customers of its aquaculture sector. Mostly these customers were very satisfied with the services and products provided by FGFRI. (The report has appeared in "Kala- ja Riistaraportteja" nro 52, 1996.)

In 1999, with the help of FGFRI personnel, the evaluation team sent out 19 questionnaires to relevant institutes, organizations, agencies, companies, etc., which the team felt constituted a cross section of the "customers" of the whole of FGFRI. Answers were received from 7 of these customers. Respondents included other governmental institutes, a fishery manager, a private company and an association with fishery interests. Some points were made repeatedly. Except occasionally, team members were not taken by surprise by the responses, from which the team infers that the facts and criticisms offered are currently widely known in Finland. The summary below presents the questions and a selective but unbiased summary of the answers, with some recommendations.

The Questions and Responses in 1999

1A.What are your organization's current needs for research and information that are appropriate for FGFRI to address?

Obviously, some of the answers to this question were very specific and are therefore not summarized. Some institute respondents emphasized the need for more involvement by FGFRI researchers in joint studies on issues relevant to both institutes.

1B. Is the FGFRI conducting research that relates to these needs?

Of the 7 answers, 6 replied "yes and no", and one did not answer the question. FGFRI obviously cannot do everything; the customers stated that the FGFRI was addressing at least some of their needs. One customer stated that the situation was improving, and the general impression appeared to be one of satisfaction but wanting more.

2A. In five years time, what do you foresee will be your organization's needs for research and information that are appropriate for FGFRI to address?

Again, these answers were quite customer-specific, but there were recurring elements. Most important was the emphasis on "big issues", especially at the ecosystem level. Several customers mentioned such large-scale issues as biodiversity, global change, rehabilitation of ecosystems, integrated approaches to resource management, environmental impacts, etc. **RECOMMENDATION: More research should be organized as collaborative inter-institute efforts on ecosystem-level issues and on integrated watershed and coastal zone management approaches**.

2B. Is the FGFRI conducting research that relates to these future needs?

The customers answered yes (2), yes and no (3), or unknown/unanswered (2). It appears that the customers view the FGFRI as responding to at least some of these future challenges.

3. How do you rate the quality of FGFRI's research in the area of interest for your organization?

Except for one customer responding "good", the others agreed that the quality was variable, from very good to quite poor. Although this is a small sample, it appears that FGFRI should be concerned about the perception of its customers. The research performed by the FGFRI should be accepted as being dependably of high quality.

4A. Is the relevant information from FGFRI easily available to your organization and members?

The responses here were mixed. Some stated that charging for the publications from FGFRI was a problem now with tighter budgets, that data were more difficult to obtain than results, and that work published in scientific journals was unknown to some of them.

4B. If not, how would you like to see it improved?

The team found the responses to this question a bit surprising, because the responses to the previous question were generally favorable. Most of the customers want more information, particularly in the form of annual lists of publications, from scientific publications to popular publications in Finnish, and of ongoing projects. Two respondents would like to have more joint projects as a way to improve the accessibility to relevant data.

RECOMMENDATION: FGFRI should publicize its projects and publications better, with annual lists sent to the direct customers, with such information put on the Institute's website and with other methods presented in Chapter 7.

5. How would you describe the communication between your organization and FGFRI?

Here, the respondents were again in general agreement. They state that there is some communication, but most stated that this was due to self-motivated individuals rather than to the Institute itself. One commented that it was difficult to communicate with the upper echelons of the Institute. **RECOMMENDATION: FGFRI should note and support successful communication on the part of those researchers who are communicating successfully; the Institute should open channels of communication to upper echelons and to the Institute as a whole**.

List of Recommendations

1. More research should be directed to collaborative inter-institute efforts on ecosystem-level issues and on integrated watershed and coastal zone management approaches.

2. FGFRI should publicize its projects and publications better, with annual lists sent to the direct customers, with such information put on the Institute's website and with other methods presented in Chapter 7.

3. FGFRI should note and support successful communication on the part of those researchers who are communicating successfully; the Institute should open channels of communication to upper echelons and to the Institute as a whole.

Appendix A

TERMS OF REFERENCE FOR THE EVALUATION OF FGFRI

The text material of this appendix is transcribed from the formal agreement between each evaluator and the Finnish Ministry of Agriculture and Forestry.

Preamble

The Finnish Game and Fisheries Research Institute (FGFRI) is an organization under the Ministry of Agriculture and Forestry (MAF). The FGFRI is a state research organization which carries out fisheries, game and reindeer husbandry research and takes care of the state's fish farming in Finland. It is also an instrument for providing expert service to public decision-makers and the FGFRI. The evaluation will be important in giving an objective view on the FGFRI as an organization in its field of research both in the Finnish and the international context. The MAF believes that an evaluation carried out by outside experts is the best way of getting impartial views as a basis to define the tasks of the FGFRI in research in Finland and to evaluate its ability to operate in the open research market.

Evaluators

Based on the above, the MAF has invited Prof. Henry Regier from Canada. Prof. Stellan Hamrin from Sweden, Prof. Ossi Lindqvist from Finland and Dr. Jon Swenson from Norway to carry out the evaluation according to this agreement.

Objectives of the evaluation are:

1. To evaluate if the mission and objectives of the FGFRI are in line with the developmental objectives of the society, fisheries and game and reindeer husbandry.
   - Are the management practices in line with the duties of the FGFRI?
   - Are the objectives of the duties clearly stated by the FGFRI?
   - Does the FGFRI have effective mechanisms for fostering cooperation with other research institutes?
   - Are the scope and breadth of the FGFRI's management practices functional?
2. To evaluate the quality, effectiveness and productivity of the FGFRI's activities.
   - How well has the FGFRI succeeded in its tasks?
   - What are the strengths and weaknesses of the FGFRI?
3. To ensure that the activity, organization and management of the FGFRI adequately corresponds to the needs of society, administration, fisheries and game and reindeer husbandry.
   - Are the organization, management and activities of the FGFRI flexible?
   - Is the FGFRI able to fulfill its growing number of international duties successfully?
4. To give recommendations for the developmental work of the FGFRI.
   - What and where are the greatest limitations of the FGFRI and how should the institute and its activities be developed to overcome these limitations?

Main tasks of the evaluators

The MAF will supply the evaluators with material concerning the history, status and strategy of the FGFRI.

The evaluators shall visit Finland two times during the evaluation process, e.g. to interview the FGFRI's management and personnel, the FGFRI's clients and representatives from the industry, economic life, administration, organizations and universities. The major research financers should also be interviewed.

After having studied the material and conducted the interviews the evaluators are expected to draw up their final report.

The evaluators shall visit Finland one time after the evaluating process to participate in a seminar, in which the final evaluating report will be presented to Finnish authorities. Also a discussion about views and recommendations of the evaluating group will be held with the support group and representatives from the FGFRI.

Appendix B:

REPORTS CREATED BY FGFRI FOR THE 1999 EVALUATION

Riista- ja kalatalouden tutkimuslaitos - raportti tutkimuslaitoksen toiminnasta kansainvalista evaluointia varten, Kala- ja riistaraportteja nro 134A

Finnish Game and Fisheries Research Institute - report on the FGFRI's operations submitted for international evaluation, Kala- ja riistaraportteja nro 134B

Riista- ja kalatalouden tutkimuslaitos - Vesiviljely, Kala- ja riistaraportteja nro 135A

Finnish Game and Fisheries Research Institute, Aquaculture, Kala- ja riistaraportteja nro 135B

Riista- ja kalatalouden tutkimuslaitos, - Elinkeinokalatalouden tutkimus,

Kala- ja riistaraportteja nro 136A

Finnish Game and Fisheries Research Institute - Socioeconomic and Aquaculture Research Unit, Kala- ja riistaraportteja nro 136B

Riista- ja kalatalouden tutkimuslaitos - Finnish Game and Fisheries Research Institute - Palvelut - Services, Kala- ja riistaraportteja nro 138

Finnish Game and Fisheries Research Institute - Game and Reindeer Research Unit, Kala- ja riistaraportteja nro 139B

Finnish Game and Fisheries Research Institute - Fisheries Biology and Management Research Unit, Kala- ja riistaraportteja nro 140B

Appendix C

BIOGRAPHICAL INFORMATION ABOUT THE EVALUATORS

Stellan F. Hamrin

Swede born in Sweden 1944. Earlier married to a political economist; two children.

Bachelor degree in chemistry, zoology, limnology and statistics at Lund University followed by a Master degree (Fil. Lic.) in Limnology (comparative lake limnology) and PhD degree in Limnology (Population oscillation in vendace, Coregonus albula) also at Lund University.

Researcher at Lund University (Inst. of Limnology) from 1971 to 1993. Institutional board member from 1975-1993 (Inst. of Limnology and Inst. of Ecology). Ecological adviser (within the framework of the University) for South Swedish Water Ltd, 1971-1993, and responsible e.g. for impact studies on Lake Bolmen.

Initiator and manager of long term lake ecological studies of: 1) chemistry, plankton and fish in relation to climate, water regulation, pumped storage hydro-electric plants and acidification/liming; 2) fish community production and intertrophic relations; and 3) large lake biomanipulation (lakes Vombsjön and Finjasjön).

Since 1993 Director of Inst. of Freshwater Research (National Board of Fisheries) at Drottningholm with responsibility for fish research in lakes and running water. Since 1999 member of the Board of Stockholm Water Ltd and coordinator of a European Research project (FAbOSA - Fish ageing by otolith shape analysis).

Author of about 30 articles in peer reviewed international journals and active participant in about 20 international congresses.

Ossi V. Lindqvist

Born in Finland in 1939, and a graduate of the University of Turku. Married to a biochemist, with four children.

Post-graduate studies at both the University of California and University of Colorado. Assistant Professor at the University of Dayton, Ohio in the early 1970's.

Associate Professor (since 1973) and full Professor of Applied Zoology (since 1984) at the University of Kuopio. Chairman of the Finnish National MAB Committee (UNESCO) in 1977-82. President of the International Association of Astacology in 1978-81.

Rector of the University of Kuopio in 1990-98. Chairman of the Council of Finnish University Rectors in 1993-97. Member of the National Council for Science and Technology in 1996-99. Invited foreign member of the Royal Swedish Academy of Agriculture and Forestry (1997-). Currently Professor in and Director of the Institute of Applied Biotechnology of the University of Kuopio.

Participant in several evaluation missions on science and science policies; also consultant in science and university management as well as on issues of technology transfer on several occasions in different European countries and several universities in the 1990's. Member of the Finnish delegation to the Unesco World Conference on Science in 1999.

Research interests involve fish and fisheries management and crayfish biology. Extensive experience with tropical fisheries, e.g. scientific coordinator of the Lake Tanganyika Research Project (FAO) since 1992. Work experience also on several other African lakes as well as waters in Sri Lanka.

Henry A. Regier

Canadian, born in Canada in 1930; has lived in the USA for seven years and in Italy for one year. Married to a psychotherapist; two daughters and four grandchildren.

University degrees in interdisciplinary ecological studies at Queen's in Canada (BA) and Cornell in USA (MS, PhD), and a post-doctoral fellowship at Cornell for one year.

Secondary school teacher in Canada for two years; fisheries researcher for the Ontario government in Canada for two years; faculty member at Cornell for two years; senior staff member at the Food and Agriculture Organization in Rome for one year; and faculty member at the University of Toronto for 29 years, in Zoology and in transdisciplinary Environmental Studies. Semi-retired since 1995.

Academic, applied and mission-oriented research, with graduate students and associates, mostly on the rehabilitation of degraded aquatic ecosystems of the Great Lakes Basin.

Participated, sometimes as convener, in international initiatives related to applied and mission-oriented eco-studies under auspices of FAO (ACMRR, UNCLOS), ICSU (IBP), UNESCO (MAB), UNEP (Indicators), IIASA (Sustainable development), INTECOL (Ecosystem science), IPCC (Climate change), etc.

Served as President of the American Fishery Society in 1978-9 and as Commissioner of the Great Lakes Fishery Commission in 1980-89.

Participated in UN conferences on hunger and food in The Hague in 1970, on the environment in Stockholm in 1972, on the human population in Bucharest in 1974 and Cairo in 1994.

Served on two scientific reviews by the US National Research Institute; co-chaired one relevant to the 1978 binational Great Lakes Water Quality Agreement. Also on a panel to review aquatic science in Finland for the Finnish Academy; and on two panels concerning aquatic science done by the US Environmental Protection Agency.

Jon Swenson

American, born in USA in 1951; has lived in USA, Canada, Sweden and now presently in Norway. Married with two children.

University degrees in Fish and Wildlife Management (BSc and MSc) from Montana State University, USA and in Zoology (PhD) from University of Alberta, Canada. Docent in Wildlife Ecology, Swedish University of Agricultural Sciences.

Experience includes positions as a wildlife management biologist for the Montana Department of Fish, Wildlife and Parks (USA) for 10 years, a research biologist at Uppsala University and Swedish University of Agricultural Sciences for 3 years, senior research biologist at the Norwegian Institute for Nature Research for 6 years, and presently as Professor of Ecology and Natural Resource Manage-

ment, Department of Biology and Nature Conservation, Agricultural University of Norway (from 1999). Was a visiting professor at the Institute of Wildlife Biology and Game Management, The Agricultural University, Vienna in 1997.

Primary research interests have been the influence of human activities (farming, forestry, hunting, tourism, etc.) on wildlife at the individual, population, and landscape scales. Study species have included grouse, large predators (primarily brown bears), ungulates, and birds of prey.

Professional activities have included: Chairman of the Swedish Scientific Committee for Wildlife Research, Council of the International Bear Association, Core Group of the Bear Specialist Group for IUCN and Species Survival Commission, Core Group of the Large Carnivore Initiative for Europe, Grouse Specialist Group, Technical Advisory Council of the Norwegian Hunters' and Anglers' Association, associate editor for Wildlife Biology, editorial board member for several journals and member of many professional committees.

Served on the following scientific reviews: Review of the status of the Yellowstone grizzly bear population for the Grizzly Bear Steering Committee, Review of the research projects on grizzly bears in the Northern Continental Divide Ecosystem for the Grizzly Bear Steering Committee, and Review of the brown bear research project in the Cantabrian Mountains for the Regional Government of Asturias, Spain.

Appendix D

THE AGENDAS FOR THE TWO VISITS OF THE EVALUATION TEAM TO FGFRI FACILITIES, IN FEBRUARY AND MARCH 1999

Details of the First Visit, 12.2. - 16.2.1999

Friday 12.2.1999
Meeting with the National Support Group for the evaluation
Guided tour at the headquarters of the FGFRI
Discussion of the visit program of the evaluation group

Saturday 13.2.1999
Presentation of the FGFRI, the operating environment, strategy, development and co- operation: Dr. Eero Helle
Presentation of the Fisheries Biology and Management Research Unit: Dr. Petri Suuronen
Presentation of the Socioeconomic and Aquaculture Research Unit: Dr. Juhani Kettunen
Presentation of the Game and Reindeer Research Unit: Dr. Eero Helle
Presentation of the Aquaculture Unit: Phil.Lic. Kai Westman
Presentation of the Services Unit: Ms. Lena Söderholm-Tana

Sunday 14.2.1999
Visit to Laukaa Research and Aquaculture Station
Presentations at the Station
Synergy of fishery research and aquaculture; Selective breeding in farmed rainbow trout: Mr. Unto Eskelinen
Aquaculture research: Ms. Päivi Eskelinen, Dr. Juha Koskela and Dr. Jouni Vielma
Vendace research: Mr. Pentti Valkeajärvi

Monday 15.2.1999
Visit to Evo Research and Aquaculture Station
Presentation of the station
Fish Stock Assessment: Dr. Petri Suuronen
Salmon monitoring and research
Guided tour at the station: Dr. Jaakko Erkinaro
Whitefish, pikeperch and sea trout in the coastal waters: Ms. Outi Heikinheimo
Effects of environmental load on fish and fisheries: Dr. Martti Rask
Crayfish research: Dr. Kari Ruohonen
Goals and strategies in game research: Dr. Harto Lindén

Tuesday 16.2.1999
Statistics and recreational fisheries research: Ms. Anna-Liisa Toivonen and Dr. Juhani Kettunen
Summary and the program for the next visit: Dr. Eero Helle

Details of the Second Visit, 28.3. - 31.3.1999

Monday 29.3.1999

Visit to Inari Fisheries Research and Aquaculture Station
Obligatory stocking in Lake Inari
Presentation of the station: Mr. Petri Heinimaa
Methodogical basis of fish stock assessment and the use of assessment data in fisheries management: Dr. Sakari Kuikka
Fisheries management research: Dr. Petri Suuronen
Habitat modifications, mitigation of effects: Dr. Ari Huusko
Fish stocking research: Dr. Petri Suuronen

Tuesday 30.3.1999

Visit to Reindeer Research Station
Presentation of the station and reindeer research: Dr. Mauri Nieminen
Large predator research in the FGFRI: Dr. Ilpo Kojola
Visit to experimental reindeer farm
Baltic seal research
Additional selected matters about the FGFRI plus general discussion: Dr. Eero Helle

Appendix E

FURTHER COMMENTS ABOUT THE AQUACULTURE UNIT

Following the submission of the other parts of this report some additional information has become available to the evaluation team. Reconsideration of our text in Chapter 8 about the Aquaculture Unit has led to the comments of this appendix. In general these comments augment rather than contradict the text and recommendations of Chapter 8.

Earlier information supplied to the evaluation team by FGFRI emphasized the role of research in that Institute, consistent with its title. Members of the team inferred that the non-research part of the Aquaculture Unit was a relatively minor thing within the Institute as a whole and that the members of the Aquaculture Unit should be part of a team with equivalent scientific knowledge. Recently the team has come to sense that this inference was wrong, or that practical reality has been evolving rapidly.

An entrepreneurial role has emerged within the Aquaculture Unit that is quite important to the Institute as a whole. (It may also be expanding in other units, as we note in passing in various Chapters.) There seems to be a commitment within the FGFRI to commercialize its aquaculture products more, and even to enter the international fish farming markets. Will it also attempt to commercialize all its services in the artificial preservation of reproductive stocks of endangered taxa?

With a strongly entrepreneurial Aquaculture Unit, it could be argued that an efficient approach administratively would be to organise the routine aquacultural services outside a research Institute and separate from it. From a policy perspective, this question clearly goes beyond the terms of reference of the current evaluation team.

If a strong and growing aquaculture initiative were to remain within FGFRI, the evaluation team suggests that certain actions be taken now to mitigate some current difficulties that may get worse with time.

The basic difference between the present Aquaculture Unit and the “research units” in the FGFRI is the much reduced importance of ecological scientific competence that a commercialized aquaculture unit may need. This difference is visible at present in the (low) number of scientific publications published by the Aquaculture Unit, which appears to be consistent with the Institute’s policy. In the long run this difference may become more pronounced and may lead to difficulties in the cooperation between the Aquaculture Unit and the other units. This difference in ”competence” will have to be bridged somehow, but the evaluation team now sees no obvious solution to that problem. Either some sort of training course system may have to proceed continuously or the personnel may have to divide their work between different Units. Neither of these solutions appear to be very efficient from an administrative point of view.

If a final decision has been taken that the Aquaculture Unit’s responsibilities include little research activity, then its responsibility for preserving endangered species should be transferred to another Unit, preferably the Fisheries Biology and Management Unit. Saving and preserving endangered stocks is basically an ecological, not an aquacultural problem. It is therefore not relevant to make a Socioeconomic Unit responsible for this particular problem.

The long-term success of preserving endangered stocks and species is based on the necessity to reestablish self-reproducing stocks in nature. In the long run, stocks cannot be saved through artificial

breeding alone even if that may be necessary for a certain initial period. It is therefore an important strategic decision on how much money and other resources are be put into commercial aquaculture and how much is directed towards long-term preservation/conservation activities. This decision should be taken soon at the appropriate administrative level.

In order to direct the stocking and preservation of fish and other aquatic animals it is very important to identify and continuously to check different cultured and wild stocks throughout the country. This work will need the services of a special genetical laboratory that continuously keeps up with new scientific and technological developments. The evaluation team suggests that the FGFRI enter into a close partnership with a university which has made a long-term commitment to fish genetics and ecology. FGFRI should contribute major funding to assist with the capital investment in the laboratory. Within FGFRI, the Fisheries Biology and Management Unit may provide the most direct connection with such a genetics laboratory.

Publication 7a/1999

Publications of the Ministry of Agriculture and Forestry in Finland 1999:

1/1999 Maa- ja metsätalousministeriön hallinnonalan paikkatietostrategia
ISBN 951-53-1915-3

2/1999 Kansallinen metsäohjelma 2010
ISBN 951-53-1932-3

2/1999 Finlands nationella skogprogram 2010
ISBN (väärä: 951-53-1932-3)

2/1999 Finland's national forest programme 2010
ISBN 951-53-1948-X

2/1999 Le Programme forestier national de Finlande 2010
ISBN 951-53-1950-1

2/1999 Finnlands Nationales Forstprogramm
ISBN 951-53-1965-X

3/1999 Elina Nikkola
Uusiutuvien luonnonvarojen kestävän käytön yleismittarit
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