FINNISH GAME AND FISHERIES RESEARCH INSTITUTE

Fisheries Biology and Management Research Unit

Helsinki 1999

RIISTAN- JA KALANTUTKIMUS

FINNISH GAME AND FISHERIES RESEARCH INSTITUTE
Fisheries Biology and Management Research Unit

January 1999

Contents

1. General

Objective

The Fisheries Biology and Management Research Unit promotes the sustainable use of fish and crayfish stocks. By studying the state of stocks and methods for managing them, the Unit provides high-quality research data and scientific advice for governmental agencies, the EU, national and international organizations, fishing industry, the scientific community and the public.

Main tasks

The basic tasks of the Unit can be divided into three major sectors:

(1) Fish stock assessment
(2) Research projects
(3) General expertise (see the figure below).

Assessment of major fish resources is a permanent task and involves the giving of management advice. Research projects are at present focused on six priority areas (programmes) which have been outlined in collaboration with the major users of information. In addition to these priority areas there are case studies dealing with acute topics, e.g. influence of the M74 syndrome on wild Baltic salmon stocks. The Unit also provides general expertise in its field.
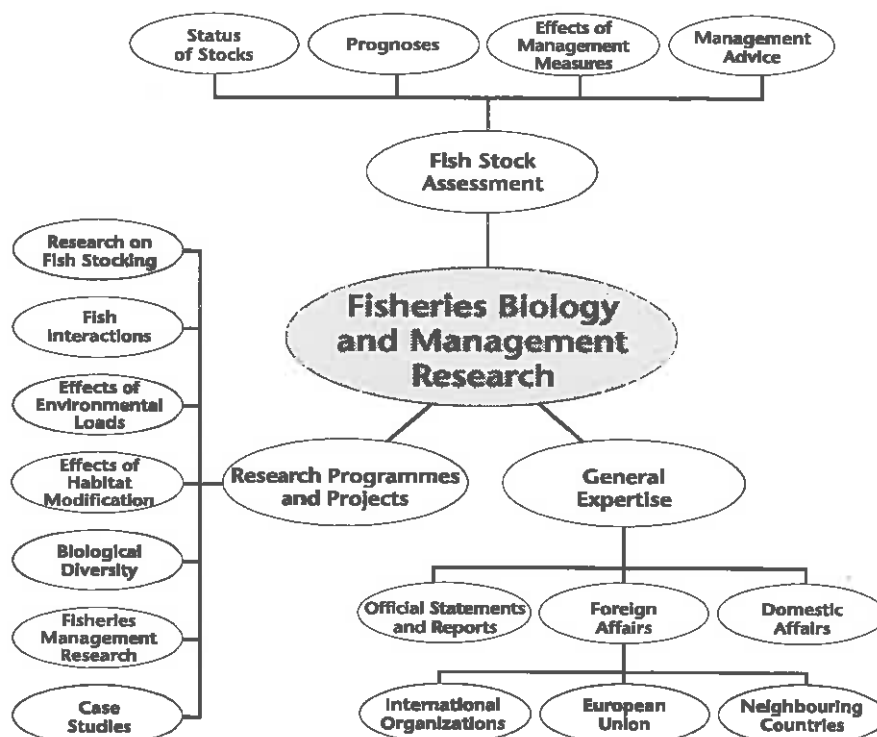
Main tasks of the Fisheries Biology and Management Research Unit

All research activities are carried out in scheduled projects. Most of these projects belong to the present priority areas (programmes) of the Unit. Each programme has a senior scientist as a chief coordinator. The coordinators are reporting directly to the Research Director (head of the Unit) of the status and progress of the work. The majority of research activities of the Unit can be categorized as applied research that aims at solving short and long-term problems in the sector. Basic research tasks, when necessary, are usually conducted in cooperation with universities and other suitable partners. The scope of research is influenced by obligations imposed by national legislation, international agreements and EU membership. The Ministry of Agriculture and Forestry annually expresses its most important research requirements by the Results Agreement.

Personnel

The permanent staff of the Unit consists of 76 researchers, assistants and technicians of whom 49 have university education, including 10 researchers with Ph.D. and 11 with licentiate degrees. Within the next two years about 10 additional researchers will finish their Ph.D. degrees. The main subjects in the academic education of the personnel include the following (number of persons): zoology and ecology 32, fisheries science 6, hydrobiology 5, limnology 3, genetics 2 and physics 1. In addition to the permanent employees, the Unit has had a number of researchers, assistants, graduate students and technicians on a fixed-term basis; their numbers are dependent mainly on the magnitude of external funding (averaging about 15 man-years annually).

Of the permanent staff, about 40% are located in the Helsinki main office. The rest of the staff are located in the 14 research and field stations around the country. The majority of the biological research data is collected in the stations.

Funding and costs

The budgetary funding of the Unit has been fairly stable in recent years. Off-budget funding (1000 FIM) has increased substantially:

Source on income	1994	1995	1996	1997	1998*
Income from sales	780	1 176	1 774	1 609	1 500
Other income	26	1	19	30	300
EU funding	0	0	72	1 460	2 000
Cooperative funding	5 023	3 967	4 514	4 053	4 500
Total	5 829	5 144	6 379	7 152	8 300

*preliminary

When including all overheads, the total yearly operating costs of the Unit are about FIM 40 million. In 1997, about 10% of the total costs were covered by incomes from cooperation partners in the public sector, and about 7% from customers and the EU. Major customers include power companies, fishing industry and municipalities. Growing attention has been paid to raise more funds from external sources and indeed, the Unit has recently succeeded to increase the research funding in particular from the EU (see Appendix 1).

When sharing the costs according to the main types of activity, the approximate distribution is:

Permanent stock assessment	21 %
Research programmes and projects	73 %
General expertise	6 %
Total	100 %

National and international cooperation

National authorities are important promoters and customers of research. Intensive cooperation also occurs with hydroelectric power companies, regional municipalities, fish hatcheries and fishing gear manufacturers. The Unit enjoys active cooperation with Finnish universities and research institutes. In particular, the cooperation with the Finnish Environment Institute, regional environment centres and the Finnish Institute of Marine Research is essential. Fishermen play an important role in research work by assisting in the collection of catch samples and reporting their catches.

An important international cooperation forum is the ICES (International Council for the Exploration of the Sea) with its working groups and scientific committees. Scientists of the Fisheries Biology and Management Research Unit also play a significant role in the working groups and as experts in the work of the IBSFC (International Baltic Sea Fishery Commission), NASCO (North Atlantic Salmon Conservation Organization) and EIFAC (European Inland Fisheries Advisory Commission). The IBSFC Salmon Action Plan initiated in 1997 calls for Baltic cooperation in research and monitoring of its impacts.

Close connections and cooperation exist with several foreign laboratories, institutes and universities, especially in neighbouring countries, but also in many other countries in Europe and North America. In the EU, scientists of the Unit participate as members of committees and working groups and as independent experts (e.g. Scientific, Technical and Economic Committee for Fisheries). The EU also promotes and finances several international research projects in which scientists of the Unit participate as a coordinator or partner (see Appendix 1). The Unit also plays an important role in EU-funded cooperation projects with Russian Federation (Barents Interreg and TACIS Cross-border programmes). The Unit's recent success in obtaining EU finance for its research projects is an indication of successful and active international collaboration.

Publishing activity

Results and issues concerning research activities are discussed in professional papers, posters, meetings, seminars and the public media. The most important scientific results are submitted to peer-reviewed international journals for publication. In recent years scientists have strongly been encouraged to publish in international journals. As a consequence, the number of refereed scientific articles has increased, and will further increase in the coming years. In recent years, growing attention has also been paid in producing books and guides for the general public. For instance, since 1997, the status and exploitation level of the most important fish stocks are annually reviewed in a 'Yearbook' that also demonstrates how stock assessments are performed. The target groups of these publications and guidebooks include fisheries authorities, organizations, fishermen and the media.

Publishing activity in the Unit since 1994 has been as follows:

	1994	1995	1996	1997	1998*
SCI and SSCI articles	6	14	21	16	17
Other peer-reviewed scientific articles	16	25	10	13	31
Articles in FGFRI's journals and books	19	61	37	47	34
Other articles (in periodicals, newspapers)	46	71	65	79	70
Total	87	171	133	155	152

*situation as of November 1, 1998

Developmental activities in the Unit

To further improve the efficiency of the activities and the overall quality of the products, the main developmental activities in the coming years in the Fisheries Biology and Management Research Unit will be focused on the following subjects:

- Communication and collaboration with authorities, customers, universities, research institutes and other interest groups will be increased.

- Scientific information produced by the Unit will be disseminated effectively and by wide use of different publication channels to increase its influence.

- A research policy strategy that ensures that the products are sound, credible and provide an objective basis for management decision, will be implemented.

- Scientists will be encouraged to publish high-quality scientific papers in particular on the priority areas of the Unit.

- Personnel will be supported to continuously develop their education and skills, job rotation will continue, and personal career and development plans will be established.

- Short and long-term visits to prominent research institutes and universities will likewise be encouraged and supported.

- Experts having strong theoretical background and special skills in research methodology and project management will be preferred in recruitment policy.

- Opportunities for prominent international scientists to work temporarily at the Unit will be arranged.

- Research personnel will be further concentrated in the largest and most important research stations by closing the smallest and/or strategically least important stations (critical mass).

- Senior scientists will be educated to have better capacity in designing and managing large-scale multidisciplinary research projects.

- Regular internal and external review and evaluation of the results and achievements of major research programmes and projects will be organized (quality and relevance of scientific advice).

2. Research activity in the Unit

2.1. Fish stock assessment

Background

The annual fish catch in Finland during the past 10 years has varied between 120 and 180 thousand tonnes. The proportion of professional fishing out of the total catch averages 60%. According to the value of the catch, the most important species in the Baltic Sea fisheries are herring, whitefish, salmon, pikeperch, sprat and cod; in inland waters, the vendace is commercially the most important species. Pike, perch, whitefish, pikeperch, trout and vendace are the most common species in the recreational fishery; about 80% of the recreational catch is taken from inland waters. Several species are fished so intensively that the capacity of stocks to reproduce is weakened and their productivity lowered. This applies in particular to cod and pikeperch and to migratory fish that spawn in rivers, i.e. salmon, sea trout and anadromous whitefish. The natural stocks of most migratory fish are weak.
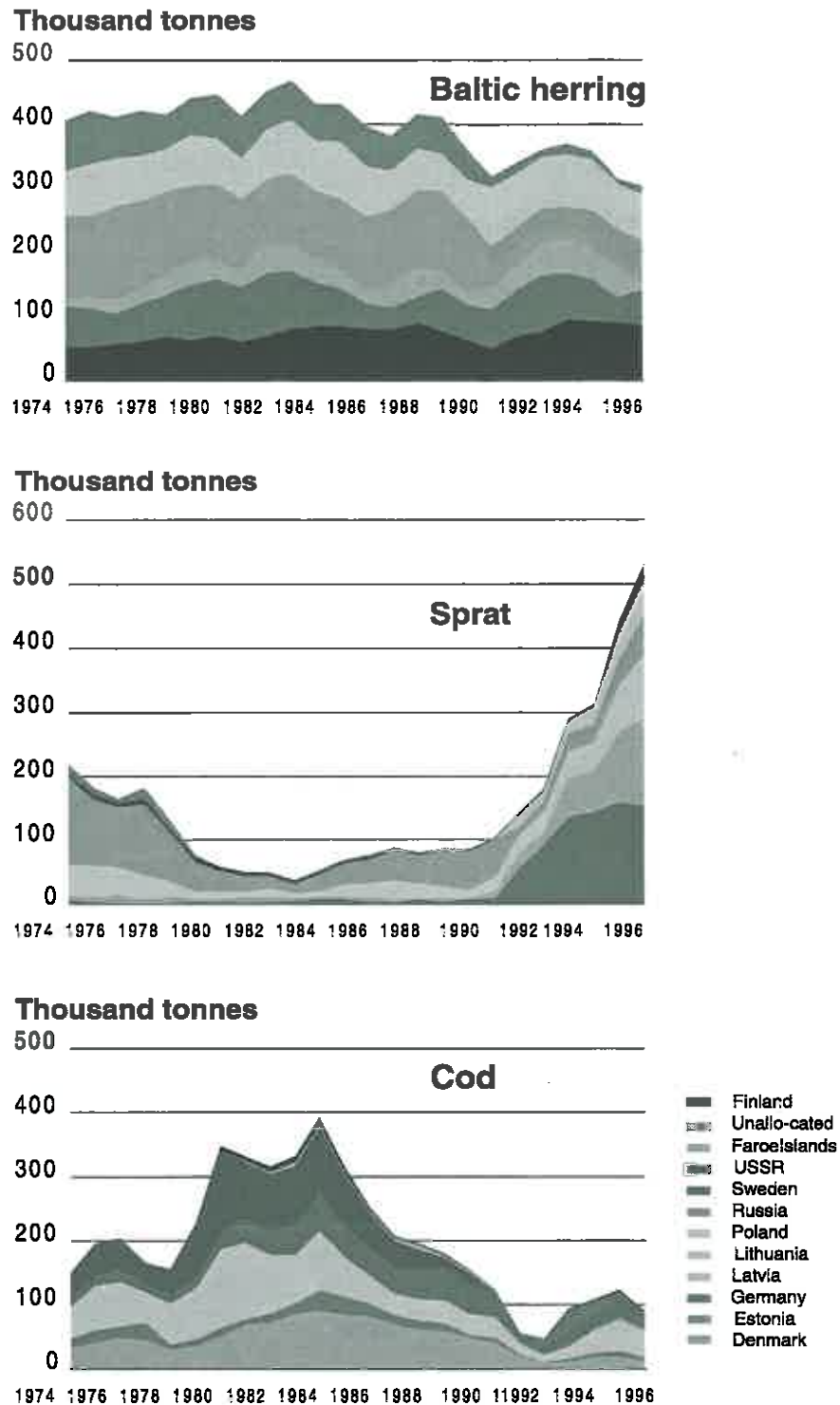
The Finnish Game and Fisheries Research Institute (FGFRI) is responsible for providing information on the status and exploitation level of several fish stocks. The obligations are due to international agreements concerning management of the Baltic Sea and boundary watercourses, as well as to the needs of national fisheries authorities and organizations. Stock assessment results are requested for planning and decision-making concerning fisheries management.

The IBSFC manages the salmon, herring, sprat and cod fisheries in the Baltic Sea. This management is mainly based on the use of total allowable catches (TAC). In the case of Baltic salmon, the present international objective before the year 2010 is to reach 50% of the natural production capacity in rivers capable of holding wild salmon stocks (IBSFC Salmon Action Plan). The major measures to be used in attaining this objective will be fishery regulations and stocking of young salmon in the rivers. Atlantic salmon stocks in the northern rivers Teno and Näätämö are managed by the NASCO and national authorities. The River Teno is a major border river between Finland and Norway, and supports one of the largest wild Atlantic salmon population in the world.

Both IBSFC and NASCO request scientific advice concerning the status and exploitation of these stocks from the ICES. The data collected by the national research institutes constitute the basis for calculations and modelling conducted by the assessment working groups of ICES. The working groups consist of scientists from national institutes. The ICES Advisory Committee on Fishery Management (ACFM) formulates the advice in accordance with requests by the fishery commissions.

Other economically valuable species such as pikeperch and whitefish occur in the coastal and inland waters and their fishery is managed by national (regional) fisheries authorities and regional organizations of water owners. The fishery of these species is

usually managed by technical regulations, e.g. number of nets, minimum landing size and mesh size, closed areas and seasons.

Thousand tonnes

Baltic herring

1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996

Thousand tonnes

Sprat

1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996

Thousand tonnes

Cod

1974 1976 1978 1980 1982 1984 1986 1988 1990 11992 1994 1996

- Finland
- Unallo-cated
- Faroeislands
- USSR
- Sweden
- Russia
- Poland
- Lithuania
- Latvia
- Germany
- Estonia
- Denmark

Catches of Baltic herring, sprat and cod in 1974-1997 by countries. Herring, sprat and cod are the major fish species in the Baltic sea. Changes in their catches reflect the status of the stocks, and their interactions.

Objectives

Stock assessment produces information on the current status of economically important fish stocks and estimates future trends in productivity. An essential part of the work is to develop measures for sustainable use of fish resources. Assessment also provides catch predictions and evaluates the consequences of fishery and management actions on productivity and yield of fish resources. Monitoring of the effects on enhancement of endangered stocks is also within the scope of fish stock assessment. The type of information requested is highly variable and dependent on the species and its environment, the means and measures used in management, the characteristics of the fishery and the status of the stock. From the scientific point of view, stock assessment results in information on species biology, population dynamics and research methods.
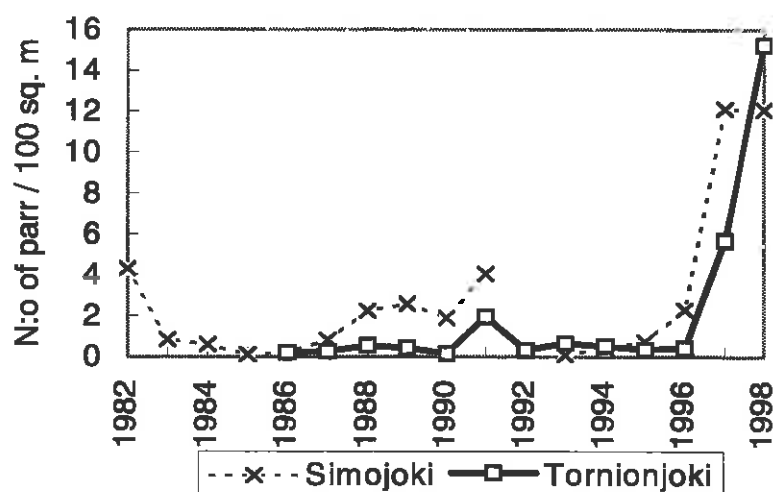
Densities of one-summer-old salmon parrs in the rivers Simojoki and Tornionjoki. Recent densities indicate successful management of these stocks. Results are based on annual electrofishing surveys carried out by the FGFRI.

Developmental activities in assessment task

The priorities of the assessment activities were reassessed and revised in early 1997. More attention will be directed towards the practical applicability and wider publication of the information produced. Access to assessment data will be improved, and the utilization of data and time-series in scientific publications will be increased. Methodological problems, data inaccuracies and uncertainty behind the assessments will be considered and analysed in more detail. Better sampling strategies will be developed; the volume of catch-sampling and fish-ageing activities will be reassessed on the basis of the new improved sampling procedures and strategies. Alternative methods and models, and advanced analytical techniques for stock assessment and long-term prognosis will be applied. The revision of the assessment projects is still partly underway and will be finished in 1999.

Projects and their scheduling

The table below presents the current permanent assessment projects, their starting years and monitoring areas. In addition to continuous assessment projects, there are various types of temporary projects such as the International Baltic Sea Sampling Project and the Baltic International Trawl Survey Database (see Appendix 1). The annual schedule in salmon, Baltic herring, sprat and cod monitoring is largely regulated by the international assessment and management system.

Species	Project started	Monitoring areas
Baltic herring and sprat	1973	Baltic Sea
Cod	1974	Baltic Sea (in Finnish waters only when cod is present in larger amounts)
Flatfish	1974	Baltic Proper, Gulf of Finland and Archipelago Sea
Baltic salmon	1972	Baltic Sea and rivers having natural production
Atlantic salmon	1975	Rivers Teno and Näätämö
Sea trout	1972	Rivers having natural smolt production
Whitefish	1975	Coastal areas and the spawning rivers of migratory whitefish
Perch, pike and pikeperch	1975	Southern and southwestern coastal areas
Vendace	1975	Selected lakes and Bothnian Bay

Methods

Annual information on the age composition of catches, as well as individual growth and recruitment, is essential when assessing status and dynamics of fish stocks; data on catch and catch-per-unit-effort (CPUE) is also needed. Data on the number, size and releasing sites of stocked fish are important especially in Baltic salmon and whitefish assessments, because the number of recruits is highly dependent on stocking.

Catch data used in assessment studies are in many cases obtained from catch statistics of the fishery. In some cases additional questionnaires are also used. The present vendace monitoring is mainly based on the use of questionnaires; a more extensive monitoring programme based on yearly surveys of selected lakes is at the planning phase. Stocking statistics are collected from regional fisheries authorities.

Catch samples are usually collected from commercial catches, in some cases also from our own exploratory fishing, or from catches of recreational fishermen. The sampling procedures for the most important marine and freshwater species (except salmon) in the Baltic Sea will be standardized internationally during an EU study (Sampling Programme) inititated in 1997.

Tagging is used for assessing fish migration, mortality, growth and stocking success (see the next chapter 'Fish tagging and marking'). Electrofishing is used to assess the densities of juvenile salmon, level of natural reproduction and success of parr stockings in rivers. The stocked salmon parr are recognized according to fin-clippings. Smolt production is measured by using smolt traps and the mark-recapture method. The numbers of ascending spawners are estimated using trap nets and submerged video camera systems. A Finnish-Swedish EU project was initiated in 1997 to establish a hydroacoustic monitoring system for spawning stock of salmon in the River Tornionjoki (see 'case studies'). A pilot study to assess salmon spawning run in

the River Teno by hydroacoustic was initiated on 1998 in collaboration with Norway. Hydroacoustic surveys are also used for abundance estimation of pelagic fish in the Baltic Sea and some lakes.

Virtual population analysis (VPA) and other related methods are used to estimate the size of fish stocks and spawning stocks, level of fishing mortality and future development of stocks and catches. Yield-per-recruit models are used to determine the long-term effects of fishing. Run-reconstruction models are used for the assessment of Baltic salmon stocks showing different fishing mortalities in various migration areas.
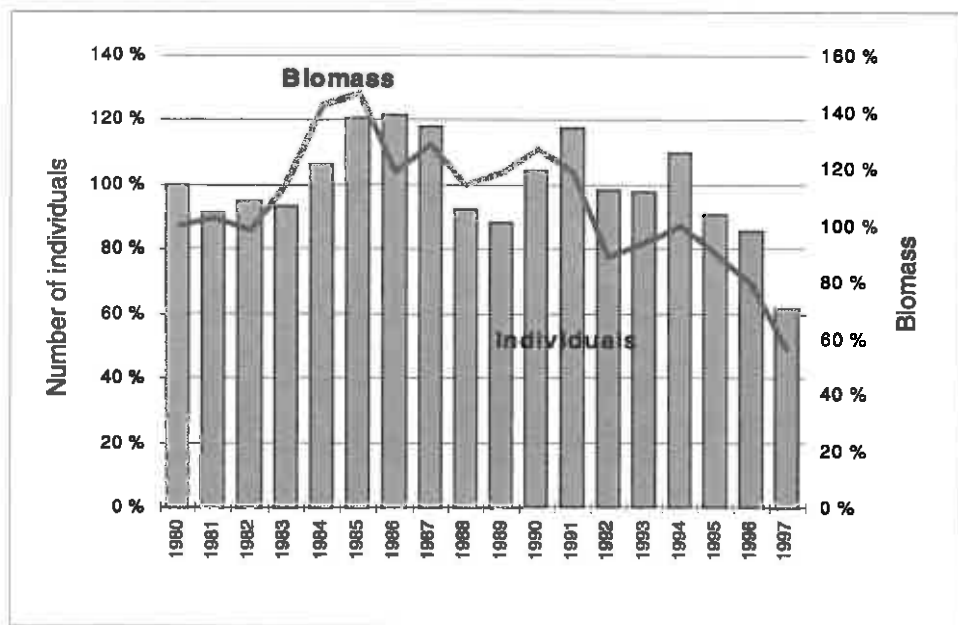
An example of the results of stock assessment. The relative biomass and number of individuals in Baltic herring spawning stock in the Bothnian Sea during 1980-1997. The stock sizes in biomass and numbers are relative to the year 1980, which is expressed as 100%.

Resources and costs

The costs of the assessment projects are largely covered by the budget-funds of the FGFRI. In 1994-1996, the total annual costs of the assessment projects were FIM 10-12 million including labour costs of FIM 5-6 million (about 21 man-years), overheads of FIM 4-5 million, and other expenditure totalling about FIM 1 million. Due to the various revisions made in early 1997 in the assessment activities, the total annual costs of the assessment projects in 1997 were FIM 8.6 million (excluding the International Baltic Sea Sampling Project). Data collection, ageing and recording have accounted for about 70% of personnel costs. More than half the total costs have been due to the salmon and Baltic herring studies.

2.2. Fish tagging and marking

The Fisheries Biology and Management Unit is responsible of fish tagging and marking activities of the FGFRI. Tagging and marking provide information on the spatial distribution, migration patterns, growth and mortality rates and stocking success of various species and stocks. The information is used, for instance, in stock assessments and fisheries management. Tagging is a routine monitoring method used in stocking obligations set by the water courts.

The main objectives of the tagging office are:

● to develop methodology and tagging techniques,

● to offer tagging services,

● to offer and develop information services,

● to promote the application of tagging methods and results in fisheries research,

● to maintain a tagging register.

The tagging office is responsible for the registration of all Carlin taggings made in Finland. At present, the number of fish annually marked with individual tags is about 75 000. The annual number of recaptures is about 10 000. Tagging data are used by scientists, fisheries authorities, various organizations and hydroelectric power companies. At the moment the tagging database consist of about 300 000 observations. Due to the precise position information, the database is an excellent source of data for various GIS-applications (Geographic Information Systems). Mass marking techniques have recently been developed and applied especially with regard to the need for stocking studies.
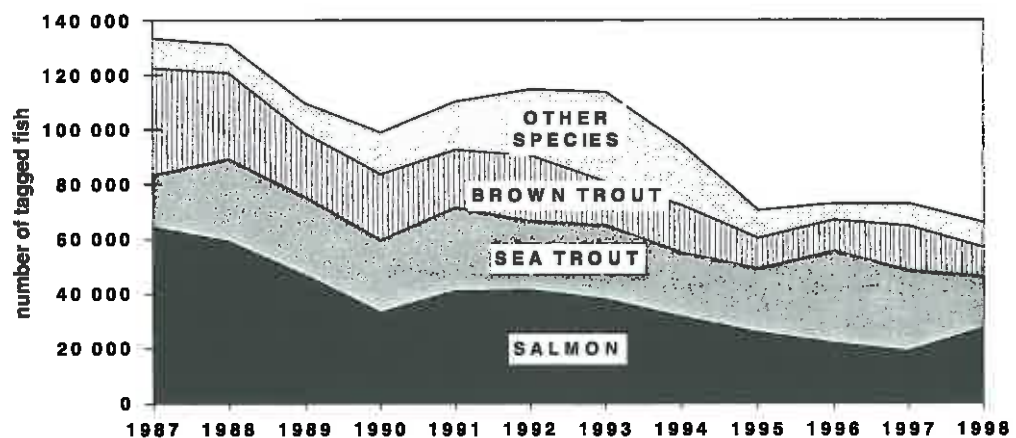
Tagging of fish with individual tags (Carlin) in Finland in 1987-1998.

Carlin tags have traditionally been used for fish biological studies in Finland. In general, the recapture rate in Carlin taggings is high (probably due to the rewards payed to fishermen). Radio transmitters attached to salmon have been used when ascending salmon have been followed in rivers during spawning runs. Data storage tags recording depth and temperature have been utilized in connection with sea-surface temperature (via satellite) to determine spawning migration routes of salmon at sea. Hydroacoustic tags have been used to follow salmon postsmolt migration at sea and migration routes of salmon in rivers.

Adipose fin clipping by itself or connected with coded wire tagging is nowadays the most commonly used mass-marking method in Finland. Hot-branding is cheap and

suitable for crayfish and smaller fish, and has been successfully used e.g. for salmonid juveniles in rivers. The fluorescent pigment spraying method offers a fast and cost-effective means for mass-marking of small fish; this method is currently used in estimating the results of anadromous whitefish stockings and also for distinguishing natural from stocked salmon smolts. Preliminary studies have been performed on marking of otoliths with Alitzarin Red S. Labelling newly hatched yolk-sac fry with radioactive strontium have been successfully used for research purposes.

The total annual costs of the tagging office are about FIM 1.2 million, including labour costs of FIM 0.4 million (approximately 3 man-years), overheads of FIM 0.3 million, and other expenditure of FIM 0.4 million. Mass-marking methods have mostly been applied in separate projects; thus, their costs are not included here. The total sales are about FIM 0.5 million annually.
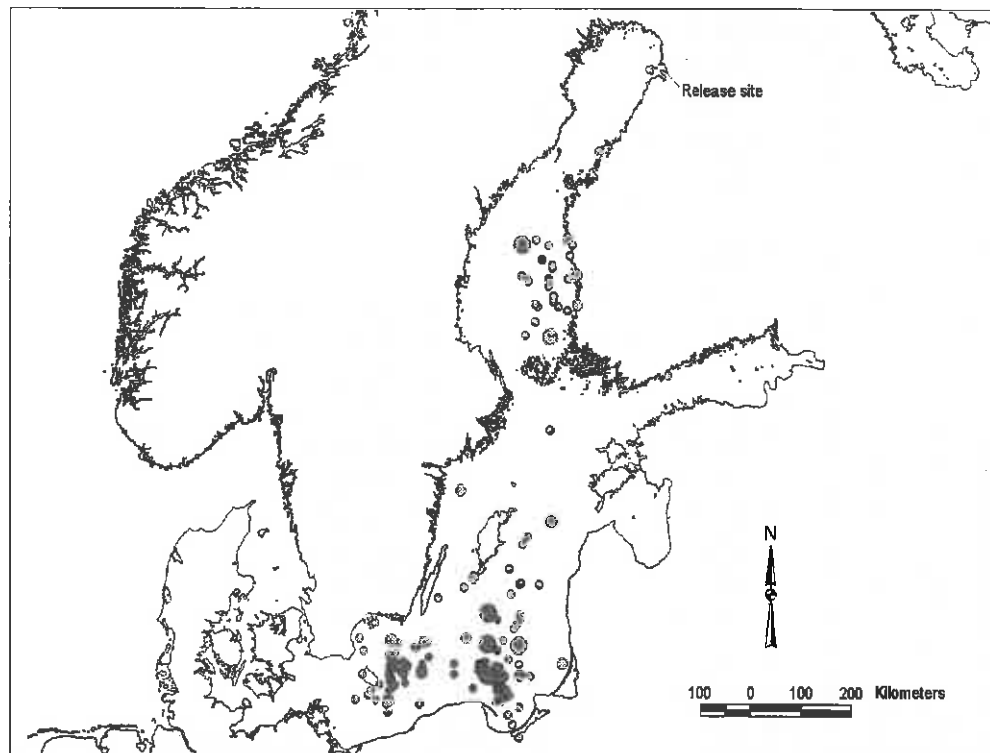
Tagging data contain information e.g. of recapture sites. From the institute's database various types of printout can be provided routinely, e.g. map presentations. In the figure above, the distribution of River Oulujoki salmon recaptures are shown on the second winter after release during the 1990s.

2.3. Fish stocking research

Background

Baltic Sea and rivers with anadromous fish species

The damming of Finnish rivers for power production began in the 1920s, restricting or hindering river access of several Baltic salmon, migratory brown trout and migratory whitefish stocks. The situation was further aggravated by large-scale degradation[1] of the remaining spawning habitats. Since the early 1950s, several rearing programmes have been initiated by both the power companies and the FGFRI to preserve and enhance those stocks that had lost their spawning grounds and to maintain coastal and offshore fisheries exploiting these stocks. Recently, growing attention has been paid to the enhancement of recreational river fisheries through the restoration of deteriorated river habitats, followed by intensive restocking. At present, reared fish account for 80-90% of Finnish salmon and migratory brown trout catches and 65% of the migratory whitefish catch in the Baltic Sea. Coastal releases of pike and pikeperch are locally important.

Inland waters

Efforts to extend the natural occurrence of valuable fish species, and that of noble crayfish, began during the late 1800s in Finnish inland waters. The subsequent development of mass rearing of young fish and crayfish for stocking purposes was promoted by the collapse of several fish stocks and fisheries, caused by habitat deterioration[1] (landlocked salmon, brown trout, whitefish, crayfish, asp), disease (crayfish plague) and overfishing (pikeperch, Arctic char). At present, relatively low-priced stocking material is available for several fish, and for two crayfish species (native noble and introduced signal crayfish), and stocking is commonly considered as a useful tool for manipulating fish and crayfish communities and catches. The main species stocked are whitefish, brown trout, pikeperch, pike and noble crayfish.

Stocking studies of the FGFRI have improved the preconditions for sustainable management of rearing, ranching and enhancement programmes in both freshwater and marine environments, and have also contributed to scientific knowledge of the life histories and biology of several fish species. Among the recent achievements are:

- Summary of the results of 20 years of studies on factors affecting the yield from whitefish stocking in inland waters in northern Finland,

- An extensive 10-lake study to assess the yield and profitability of pikeperch fingerling stocking,

- Improved knowledge to develop methods for the restoration of fish stocks and fisheries in deteriorated river habitats,

- Information on the postsmolt stage (migration, growth and survival) of ranched Baltic salmon,

- Information on the migrations and yield of stocked brown trout in northern lakes.

---

[1] Dredging of rapids, water level regulation, silt deposition, agricultural loading, industrial wastes

Objectives

The management of stocking programmes requires (a) a rearing strategy, (b) a release strategy and (c) a harvesting strategy to ensure maximal survival and optimal harvest of released fish and minimal genetic and ecological problems (e.g. straying, overfishing, diseases, predation). The corresponding research objectives are:

- to determine optimal rearing and release techniques and quality (size, condition, disease control) of fingerling, parr and smolt,

- to determine optimal choice of stocks, release times and sites, and numbers of fish released,

- to determine how the fish should be harvested to ensure economical feasibility and minimal harmful effects on other fish stocks and fisheries.
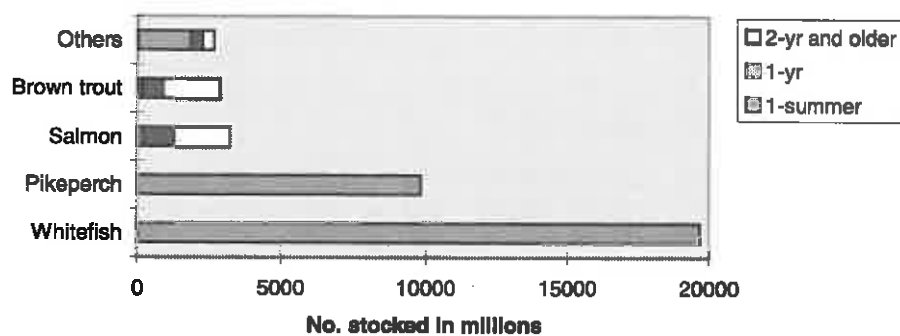
Number of fish stocked in Finland in 1997 (total value about FIM 85 million). The FGFRI is the main producer of fish larvae and fry for continual rearing.

Ongoing projects and their schedules

Baltic Sea and rivers with anadromous fish species:

- *Evaluation of salmon parr releases as an enhancement method in the River Kymijoki (1992-1999)*

- *Choice of stock for the reintroduction of migratory brown trout in southern coastal rivers (1994-2000)*

- *Yield of migratory whitefish releases in the Gulf of Bothnia and Gulf of Finland (1995-2005).*

- *Assessment of the revival of salmon, trout and migratory whitefish in the River Vantaanjoki after habitat restoration (1992-2000)*

- *Monitoring of the results of salmon and trout releases in the rivers Tornionjoki, Simojoki and Kiiminkijoki (1997-2001).*

- *General release strategies for salmon, migratory brown trout and migratory whitefish (1998-1999)*

Inland waters:

- *Influence of stocking on the recruitment of pikeperch populations; impact of age and size on the survival of pikeperch fingerlings (1994-2002)*

- *Factors affecting the survival of stocked noble crayfish and signal crayfish (1997-2005)*

- *Assessment of the ecological and economic impacts and developmental potential of fish stockings in Lake Inari: management implications (1994-2003)*

Methods

- *Tagging (Carlin) and marking (fin clipping, hot branding, microtagging, fluorescent pigments):* identification of stocked fish in catches (paired releases of different treatment groups),

- *Data-storage tags, hydroacoustic tags:* studies on fish migration,

- *Electrofishing:* estimation of the survival and distribution of stocked fish in riverine habitats,

- *Fishing questionnaires:* assessment of annual gear-specific fishing efforts and total catches of different fish species in stocking areas,

- *Smolt trapping:* estimation of the effect of parr stocking on smolt production,

- *Electrophoresis:* salmon stock identification in catch samples,

- *Scale analysis:* discrimination of wild and hatchery-reared salmon in catch samples,

- *Catch samples and catch-per-unit-effort (CPUE) data:* growth and stock assessment, effect of stocking on recruitment.

Resources and costs

The execution of the ongoing projects requires annually 12-14 man-years. The total annual costs of ongoing projects are about FIM 3.5 million, of which about 75% is funded by the FGFRI and about 25% by other public organizations and customers.

2.4 The role of fish interactions in inland fisheries management

Background

Fisheries management in Finnish lakes mainly includes fish stocking and technical fisheries regulations, e.g. minimum mesh size limits and closed seasons. Stockings and selective fishing affect interactions within fish communities and throughout the ecosystem. These interactions are not known in detail, and the results of human activities cannot always be foreseen. Due to the limited knowledge of these interactions the outcome of management actions are unpredictable, and often economically poor and even harmful to the fish community.

Gill-net fishing is exceptionally popular among recreational fishers in Finland. Fishermen using gill nets take over 50% of recreational freshwater fish catches. Until recently, little effort has been devoted to limiting the mesh sizes or number of nets allowed. This has resulted in over-fishing of predatory fishes such as brown trout and pikeperch. Mesh size regulations are now, however, beginning to enjoy support among fishermen and authorities. The changes in fishing practice will be reflected in the fish community, e.g. predation pressure on prey fish populations will increase. Problems in the management of gill-net fishing are also due to the mixed-species nature of the fishery, e.g. stunted whitefish and fast-growing brown trout are often fished for in the same areas. In many areas both species are stocked simultaneously, or one species is stocked and the other reproduces naturally. Gill-net fishing is also the major cause of problems in re-establishing populations of the endangered Arctic char and in collecting genetically sustainable amounts of land-locked salmon spawners in the Lake Saimaa system.

Favourable conditions are present for studying management and fish interactions in various geographically diverse Finnish lakes. The commercial vendace fishery enables collection of catch and population data at relatively low cost. Long time series are characteristics of several vendace populations. Fish stockings are presently well documented. A great variety of lakes and ponds is available for manipulation experiments, and institute's fish hatcheries can produce a variety of fish species and sizes for experiments. Of the various factors affecting fish communities, this research programme focuses on those that can be regulated by human actions, i.e. stocking and fishing. Results can be used for supplying management options for fisheries managers as tools for fulfilling user-group needs and preferences.

Objectives

The primary aim of this programme is:

- to produce information on interactions and dynamics within fish communities,
- to develop tools for managing fisheries in different environments,
- to document and forecast consequences of management actions.

Ongoing projects and their schedules

- *Impacts of trawling and winter-seining on vendace populations (1997-2001).* In a 1997 pilot study, the possible use of echo sounding with exploratory trawling to follow changes in abundance and migrations of small pelagic fish (including young-of-the-year) was tested. A remote-controlled echo sounder moving under the ice was developed to allow studies to be conducted also during winter. The eventual project is now in the planning phase, and will be launched in early 1999.

- *Effects of gillnet mesh-size regulation on fish catches and the fish community (1998-2006).* An earlier phase of this study resulted in technical and biological background information for management of (mixed species) gill-net fishery, e.g. factors affecting gill-net selectivity and catchability (mesh size, twine thickness, fishing depth) of several freshwater fish species. The next phase of this study will include monitoring and comparison of effects of two mesh-size regulation options on catch, age- and length distribution, growth and reproductive output of the target species.

- *Effects of fishing in a virgin fish community (1998-2005).* Effects of fishing (gill-netting, seine-netting) in a virgin fish community will be monitored on the Russian side of Lake Pyhäjärvi, where fishing has been prohibited for 50 years but will begin soon again.

- *Fishery regulations and the maximum sustainable yield of noble crayfish and signal crayfish stocks (1997-2005).* The effects of heavy exploitation, size and seasonal restrictions and total closure on the population dynamics of noble crayfish and signal crayfish stocks are being investigated, and an optimal harvesting strategy that also considers the crayfish plague is being designed.

- *Impact of stocking age, feeding conditions and predation on the survival and growth of Arctic char and the effects of char predation on the fish community (1997-2000).* Plans for reintroduction and establishment of new fishable and self-reproducing stocks demand better knowledge on the efficiency of various stocking practices (age, size etc.) and the effects of char on native populations, e.g. vendace.

- *Options for utilization of vendace stocks (1997-2000).* Simulation models for fisheries management that account for biological and economical aspects are being developed. The first step was to model the daily mortality of 0+ vendace due to trawl-induced injury and fish predation to give advice on trawling and stocking practice.

- *Adjusting stocking densities of predatory fish with prey fish stocks (1998-2001).* The approach is based on the results of bioenergetic calculations of the influence of predatory fishes on valuable commercially harvested fish stocks.

Methods

Basic methods include:

- Collection of population samples (size, weight, age) and CPUE data,
- Exploratory fishing with gill nets, trawls, seines and crayfish traps,
- Hydroacoustics and depletion methods for assessing fish density,
- Stomach content analysis together with bioenergetic models,
- Various tagging methods,

- Simulation models for estimation of the effects of management options in the fish community and on fish catch and their economic consequences.

Resources and costs

The annual costs of this research programme are about FIM 1.5 million consisting of 4-6 man-years. About FIM 0.2 million are annually covered from external sources.
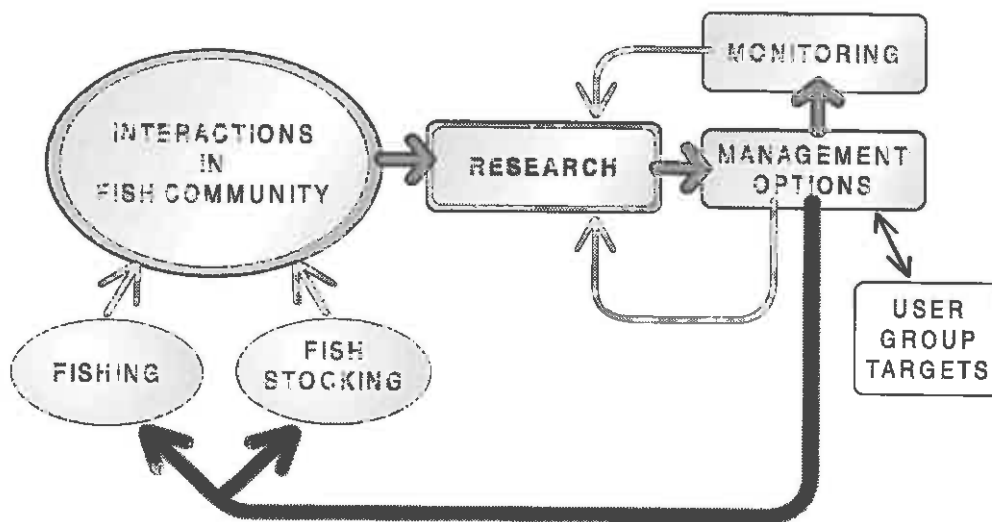
Main areas of interest for fish interaction research.

2.5. Effects of environmental load on fish and fisheries: distribution and mitigation of damages

Background

Aquatic ecosystems are affected by load of many types of pollutants, such as nutrients, air pollutants, heavy metals and toxic substances. Eutrophication is the major environmental problem in Finnish lakes: it has been assessed that 10% of the 30 000 Finnish lakes larger than 4 ha are suffering from eutrophication. Nutrient load from point sources has been decreasing for several years, but diffuse load from agriculture and forestry has increased. On the Baltic coasts, nutrient load is 3-10 times higher today than in the early 1900s, and loading from Russia on the Gulf of Finland is considered a major problem. The main effects of eutrophication are the responses in fish populations and communities, especially the increasing numbers and dominance of less valuable cyprinid fishes. Disturbances in the odour and taste of fish are also recorded, and increased periphyton growth makes the use of gill and fyke nets more difficult and less effective. On the other hand, at early stages of eutrophication, catches of some valuable species such as pikeperch are increasing. Acid precipitation affects not only the small oligotrophic lakes in southern Finland but also those in northeastern Lapland. Soil-induced acidification is a problem in rivers and estuaries in certain areas of the west coast.

In the present research programme, the major focus will be on the distribution and mitigation of harmful effects on fish and fisheries due to eutrophication. Acidification which has been the focus of environmental research in the FGFRI since the 1980s, is considered to a smaller extent.

Major environmental changes can often be considered as large-scale, although unwanted, experiments. Increasing their understanding can result in new findings in population and community ecology. New findings on the recovery of fish populations in acidified lakes after reduced acid precipitation are expected along with changes in intra- and interspecific relations. The effects of both increased and decreased nutrient concentrations on fish communities in coastal waters will be demonstrated. Tools for assessing the need for and results of mass removal of unwanted fish during restoration of eutrophic lakes will be developed. Research on soil-induced acidification affecting reproduction areas of several coastal fish stocks is connected to water court processes.

Objectives

The main objective of this research programme is to produce information that effectively supports the assessment, impairment and reduction of damages to fisheries caused by environmental loading.

Ongoing projects and their schedules

- *Fish Status Survey of Nordic Lakes - species composition, distribution and effects of environmental changes (1996-1998).* In this joint project of Finland, Sweden and Norway, a general figure is produced on the extent of the effects of the two major environmental changes, acidification and eutrophication, on the fish status of lakes in Fennoscandia. Data from three countries were collected from about

5000 lakes by using a mailed questionnaire directed to organizations and people aware of the fish status of the lakes.

- *Effects of mass removal of unwanted fish in eutrophied lakes (1997-2001).* An extensive study is conducted as a joint project with water and fisheries authorities, local interest groups and the University of Helsinki to produce general information on the suitability of mass removal of cyprinids for restoration of eutrophic lakes.

- *Eutrophication-induced changes of fish community structure in coastal waters of the Gulf of Finland (1997-1999).* The effects of nutrient loading on fish community structure will be studied along the east-west eutrophication gradient in cooperation with Russian scientists. Recent fish community structure of two locations will be compared with data obtained from the 1970s.

- *Effects of acidification on fish and crayfish populations (1997-2002).* The fish and crayfish populations of 10-15 acidified lakes in southern Finland will be surveyed and the effects of pollution from Russian smelters in the Kola region on fish status of brooks and lakes in northeastern Lapland will be studied.

- *Effects of acidity due to sulphide soils on fish and fisheries in the estuaries of western coastal rivers of Finland (1990-1998).* Of special interest are the very variable effects of acidification on reproduction and nursery areas and recruitment of the coastal fish stocks.

- *Composition of fish communities in Baltic coastal reference areas (1989-) .* This continuous monitoring project has established an international network of monitoring areas in the Baltic Sea to trace large-scale changes in coastal fish assemblages. The monitoring is conducted annually by means of a multimesh gill-net survey directed towards relatively large species (e.g. perch) living close to the bottom.

Several projects belonging to this priority area, such as assessment of the effects of eutrophication on reproduction and nursery areas of certain fish species, e.g. Baltic herring, and evaluation of the effects of nutrient loading from aquaculture on natural fish communities and fisheries, are in the planning stage and will be started later.
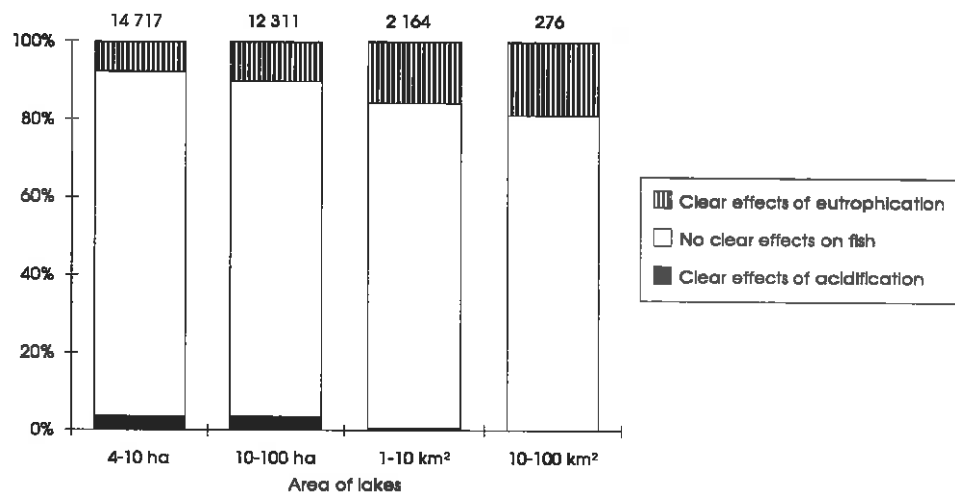
Occurrence of eutrophication-induced and acidification-induced changes in fish communities of Finnish lakes of different size categories. The total numbers of lakes are given above the columns. Data from the project 'Fish Status Survey of Nordic Lakes'.

Methods

In many projects, the basic method of collecting data is stratified random sampling with multimesh survey gill nets and the primary variable is CPUE. Other methods such as trapping, electrofishing, seining and echocounting are also applied, and variables such as fish species composition, age and size structure of fish populations, growth and diet of fish are included. In sampling of 0+ fish and juveniles, high-speed samplers and small beach seines are used. Recruitment is assessed by using relative year-class strengths and the size of the year-classes by VPA. In the event of detailed questions on the mechanisms of certain impacts, laboratory experiments can be applied.

Resources and costs

The total annual costs of this research programme are FIM 1.5-2.5 million. The amount of labour allocated for this programme annually varies between 5 and 10 man-years. The FGFRI covers about 50% of the costs; the rest are funded from external sources (mainly cooperative funding).

2.6. Habitat modifications in freshwaters: mitigation of effects by rehabilitation and fisheries management

Background

About 250 regulated lakes or reservoirs are used for power production in Finland. With regard to lake regulation, the main outflowing river channels of the watersheds have often been modified by power plants to a chain of river reservoirs. On the other hand, to facilitate log drive practices most of the small and medium-sized streams were channelized during the 1950s and 1960s. Large-scale forest drainage later lowered the water retention time in the basins, altering the annual flow patterns and increasing the sediment load. The artificial and hydrological changes outlined above have affected many freshwater ecosystems in a negative way. The most obvious symptom of this is the reduction, and even local extinction, of fish species, but the impacts may, however, apply equally well to less noticeable species such as benthic macroinvertebrates and aquatic vegetation.

Much of the past research on man-modified water systems conducted by the FGFRI has concentrated on the efficiency of supplemental stockings of one fish species at a time. Recently, a multispecies approach has been put forward on an ecosystem- or basinwide scale. The need to protect and manage aquatic populations, especially with respect to water resource usage, has led during the last decade to the development of habitat and fisheries management models that examine the habitat requirements and population dynamics of aquatic species and their life stages. The ability of these models to predict habitat capacity and aquatic populations adequately is the focus of ongoing debate and research. The applicability of such models to the ecologically and climatologically diverse regions within Finland, and to the full range of management issues that may exist, has not yet been evaluated. As a result, there is a requirement for an integrated, applied research programme that will allow the evaluation of existing fisheries management and aquatic modelling techniques as well as facilitating the development and application of new methods and innovations to the full ranges of issues concerning human-modified aquatic environments.

Objectives

The primary objectives of this research programme are to

- provide scientifically valid information on the prevailing processes in human-modified aquatic systems,

- assist resource (fisheries) management authorities and agencies to re-establish and maintain ecologically sound management of human-modified aquatic systems.

To achieve the main objectives, a multidisciplinary research programme has been developed. This is essential because the programme focuses on issues requiring knowledge of hydrology, geomorphology, lake and river ecosystems dynamics, aquatic ecology, and social and economic aspects of human behaviour. To ensure the successful conclusion of the study, the research programme has been divided into four 'action areas', each of which is further divided into subprojects of variable time periods.

Projects and their schedules

Visions. This area of research will focus on the public opinions of fisheries management issues to clarify the target setting of management, and to test the willingness of people to engage in management programmes. The research is carried out as substudies of those projects included in the other action areas.

Modelling. This topic area will examine the validation and improvement of existing modelling procedures and provide techniques for application to issues not yet addressed.

● *Multidimensional approaches to management of Lake Oulujärvi fisheries (1996-1998)*

● *Development of habitat-modelling framework for the quantitative analysis of running water ecosystems (1998-2000)*

● *Reconciling fish stockings and fisheries management: innovations arising from multispecies fisheries management models, decision analysis and gaming procedures (2000-2004)*

Biological potential. Research will focus on the biological potential of human-modified lakes and rivers. In lotic environments the main issues will be identification of critical fish species and life stages and habitat requirements. The work will also provide numerical data detailing these requirements to facilitate robust habitat modelling. Water level regulation and the assessment of its consequences in lake ecosystems and their fish assemblages forms another study section.

● *Evaluation of habitat enhancements in northern rivers used for log drives: habitat modelling approach (1995-1998)*

● *Habitat preference criteria for lotic fishes with emphasis on spatial relations between fishes, benthic macroinvertebrates and the stream habitat in seasonally varying lotic environments (1998-2002)*

● *Habitat mapping derived objectives as a precondition for efficient fisheries management in large river reservoirs (1999-2004)*

● *Classification of Finnish regulated lakes and reservoirs by environmental, fish assemblage and yield parameters (1998-1999)*

● *Pike and burbot in regulated lakes and reservoirs: impact assessment of water level regulation and mitigation possibilities (2000-2003)*

● *Impacts of water level regulation on early life of vendace (2000)*

● *Restoration of Atlantic salmon stock in the upper part of the River Tuuloma in Northern Finland and Russia* (EU Barents Interreg II and TACIS Cross-border programmes) *(1998-2001)*

Fisheries management. Research in this area will examine the consequences of different management schemes in various human-modified environments.

● *Stocking and fisheries management developments in large northern reservoirs (1997-1999)*

● *Re-establisment of lotic fish stocks and fisheries in rehabilitated northern rivers (1998-2004)*

Habitat modelling
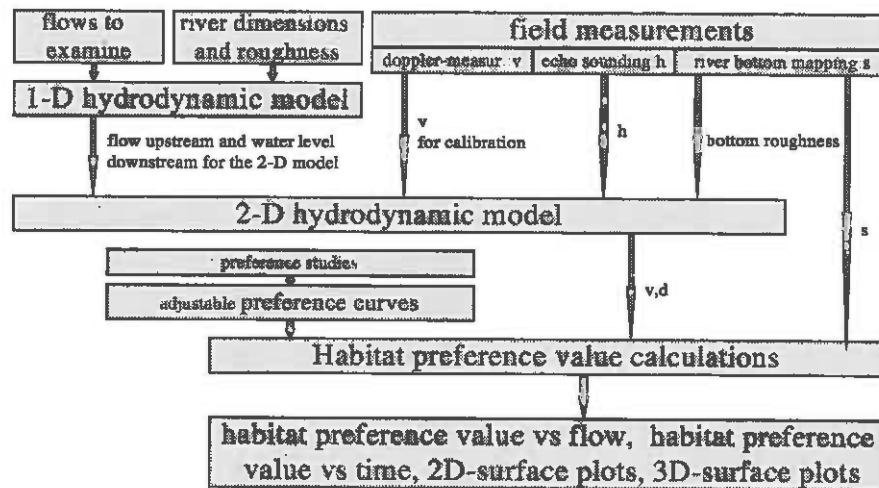
A schematic view of the habitat modelling framework being developed for the quantitative analysis of running water ecosystems. Legends for small letters: v = water velocity, h = river bottom topography, s = river bottom substrate size, d = water depth.

Methods

- *State-of-the-art habitat modelling techniques:* Evaluation of habitat enhancement and restoration by estimating habitat quality and potential

- *Electrofishing:* Estimation of fish densities and survival and distribution of fish in river habitats

- *Mailed fishing questionnaires:* Assessment of annual gear-specific fishing efforts, total catches of different fish species and public opinions on fisheries management questions

- *Catch samples and CPUE data:* Growth and stock abundance assessment

- *Multivariate analysis methods:* Classification and analysis of multivariate datasets on subjects in the question.

- *Experimental research designs:* Verification of different hypotheses under controlled conditions.

Resources and costs

The research programme calls for 5-8 full-time researchers and 1-3 research assistants. During the period 1997-2004 the yearly costs of the research programme will be about FIM 2 million (excluding Tuuloma-project). Two-thirds are personnel costs. A large share of the costs will be covered by sources other than the FGFRI, the most important being hydroelectric power plants.

2.7. Research on biological diversity

Background

Research on biological diversity includes projects in which the objective is to produce information for maintaining biological diversity either at the species or genetic levels. Human activities have in many ways changed the natural distribution and reproduction of several fish species and thus caused loss of populations and genetic changes to the remaining natural populations. Research is needed for evaluating potential changes and risk of losses of diversity when changes in natural populations occur due to habitat destruction and rearing or stocking programmes. Risks for genetic diversity are also caused by small population sizes and unnatural selection in both fish hatcheries and in nature. Genetic research is required for evaluating the magnitude of these risks in order to avoid them as far as possible. The purposes of the biological diversity programme of the FGFRI are:

- to describe and identify the potential genetic groups within effectively harvested and managed fish species (mainly salmonids),

- to describe the genetic differences in certain quantitative life history traits of fishes (i.e. migration behaviour, growth rate, age at maturity),

- to create strategies for rearing and releasing practices based on the genetic structure of the species in different watercourses,

- to create an updated database on the distribution, state and management of the various stocks of the commercially valuable and most threatened fish species in Finland, including those mentioned in Annex II of the EC Habitats Directive (92/43/EEC),

- to increase information on threatened fish stocks to promote conservation measures

- to develop effective and adequate (optimal) enhancement methods for restoration of habitats and supportive releases for different species and areas (mainly salmonids and asp in rivers),

- to develop methods for analysing stock compositions of salmon catches in mixed stock fisheries in the Baltic Sea.

Objectives

Research on biological diversity can be divided into (a) genetic studies and (b) studies for maintaining species-level diversity.

(a) The aim in the genetic study is to obtain better understanding of evolutionary differences between fish stocks and the importance of these differences for exploitation, management and conservation practices of commercially valuable fish species. The long-term objective is to meet the goal of sustainable use, a state in which genetic diversity is not decreased due to human exploitation (e.g. fishing, rearing, releasing). Moreover, genetic diversity can be applied in catch analysis for estimating proportions of different stocks in mixed stock fisheries.

(b) One tool for maintaining species-level diversity is inventing and monitoring the state of the most threatened species and stocks. This is the aim of the Fish Stock
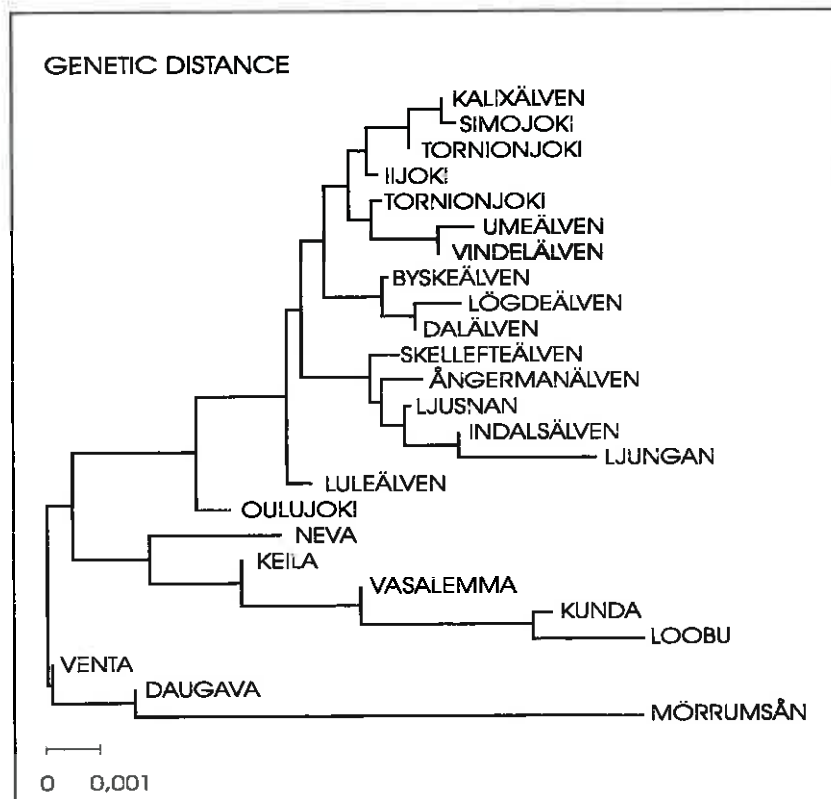
Register that is being kept by FGFRI of the commercially valuable and most threatened fish stocks in Finland. Practical enhancement projects with fish releases, fishing regulations and habitat restorations are often needed for maintaining or enhancing naturally reproductive stocks. In addition to the practical enhancement work FGFRI is performing in several watercourses, research on enhancement methods is undertaken to ensure the success of the projects and to widen the general understanding of enhancement conditions.

Ongoing projects and their schedules

- *Research on the maintenance of genetic diversity of salmonids (1981 -1999).* The goal is the identification of different genetic units within several salmonid species for management purposes. Since 1997, analysis of DNA microsatellite variation has been possible in addition to analysis of allozyme diversity.

- *Stock composition analysis of Atlantic salmon in the Baltic Sea (1991-2002).* Genetic stock composition analysis has been proved to be useful in estimating proportions of different salmon stock groups. The research will continue and DNA microsatellite variation is expected to enable improved accuracy and precision in estimates of individual stocks.

- *Research on the inheritance of life history characteristics (1986-1999).* The majority (ca 90%) of Atlantic salmon smolt production in the Baltic are reared and sea-ranched. Artificial smolt production differs largely from natural smolt production with respect to selective factors. The sea distributions of the hybrids differ from those of the pure parental stocks released at the same place and time.

- *Fish Stock Register (1985-).* The register records information on the most valuable and threatened fish stocks in Finland including fish species mentioned in the EC Habitats Directive. The recent register includes data from 12 species and will include all commercially valuable freshwater fishes in 2000. The final goal is to include all fish species occurring in Finland. The stock register classifies the stocks according to their originality, threat category, and reproduction type (see the figure below for an example). For handling of the extensive database, Geographic Information System (GIS) is used.

- *Research on enhancement of salmonids by releasing programmes (1970-).* Salmonid stocks are being reintroduced into some former salmon rivers (see the Salmon Action Plan). FGFRI is responsible for monitoring the state of the stocks, for developing methods for their enhancement and for preparing necessary stocking plans for hatchery-reared parr and smolt.

Methods

- Qualitative genetics: Enzyme electrophoresis, principal population genetic methods, stock composition analysis, microsatellite analysis.

- Quantitative genetics: Crossing, rearing, releasing and transplantation experiments, Carlin tagging.

- Stock registry: GIS, Access database, ArcView map program, classification of characters.

- Enhancement projects: Releasing programmes, stocking experiments, electrofishing.

GENETIC DISTANCE

KALIXÄLVEN
SIMOJOKI
TORNIONJOKI
IIJOKI
TORNIONJOKI
UMEÄLVEN
VINDELÄLVEN
BYSKEÄLVEN
LÖGDEÄLVEN
DALÄLVEN
SKELLEFTEÄLVEN
ÅNGERMANÄLVEN
LJUSNAN
INDALSÄLVEN
LJUNGAN
LULEÄLVEN
OULUJOKI
NEVA
KEILA
VASALEMMA
KUNDA
LOOBU
VENTA
DAUGAVA
MÖRRUMSÅN

0   0,001

Genetic distances between Atlantic salmon stocks in the Baltic Sea on the basis of allozyme analysis.

Resources and costs

The yearly costs of this research programme are about FIM 1.5 million. The projects calls for 4 full-time researchers and 1-3 research assistants. A substantial share of the costs are covered by sources other than the FGFRI; funding from the Academy of Finland is particularly important. The projects on qualitative genetics (maintenance of diversity and stock composition analysis) require close cooperation with universities.

GRAYLING
Thymallus thymallus

�▮	Original
▮	Mixed
▮	Introduced
—	Border of main water course

Rovaniemi

Kemi

Oulu

Kajaani

Vaasa

Kuopio

Joensuu

Tampere

Pori

Turku

Helsinki
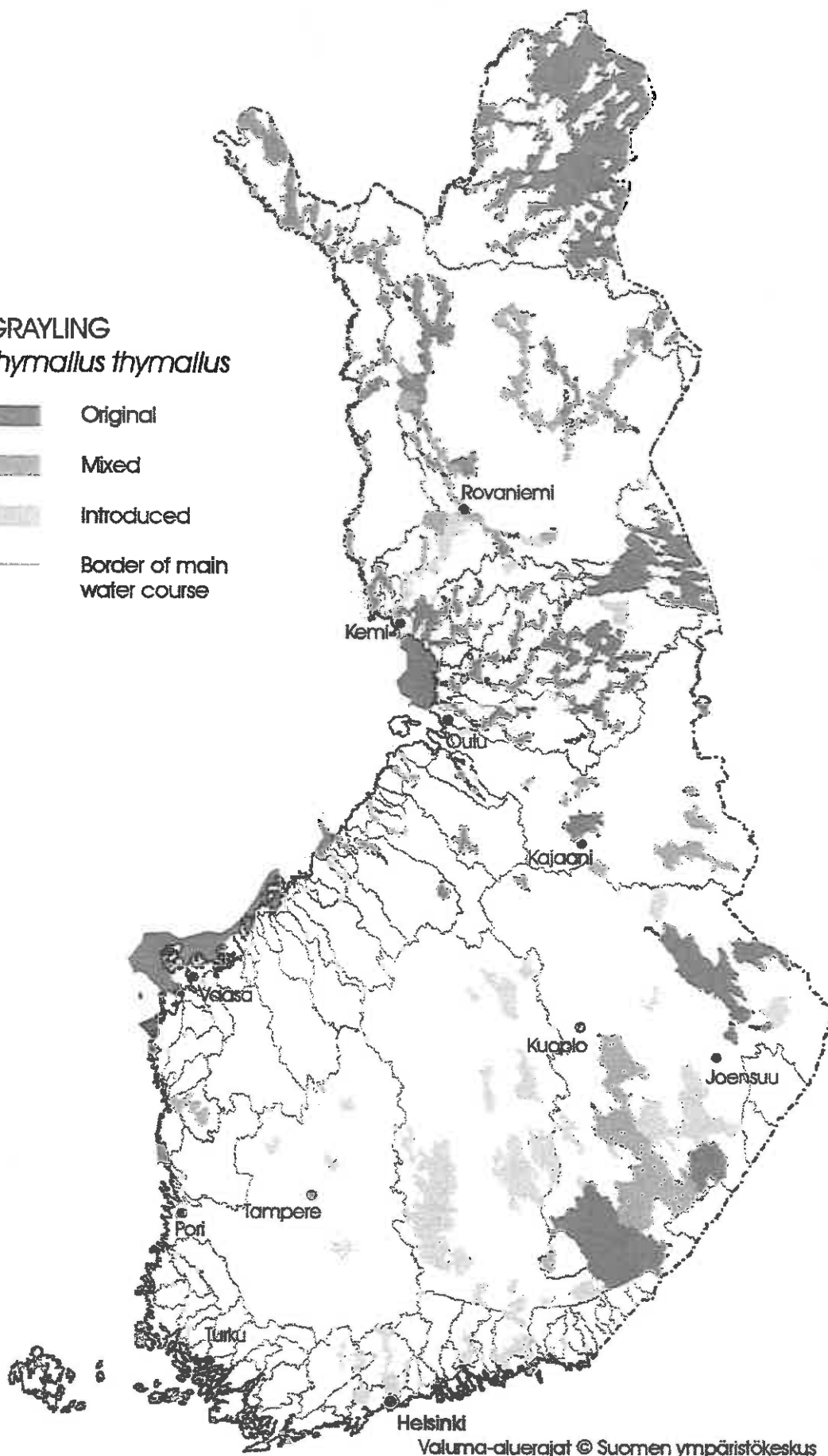
Valuma-aluerajat © Suomen ympäristökeskus

An example of the Fish Stock Register: Distribution of Grayling stocks in Finland. Original, Mixed and Introduced stocks marked differently.

2.8. Technical regulations in fisheries management

Background

The fishery of many Finnish marine, coastal and inland fish species are managed by technical fisheries regulations, i.e. by minimum permitted mesh size and fish landing size limits and by area and time restrictions. Technical management measures play an important role also in the fisheries policy of the EU. The objective of technical measures is to create conditions where capture of juvenile fish is minimized, and the risk of either growth or recruitment overfishing, or both, is decreasing. Although technical fisheries management measures are widely used to regulate the fishery, the scientific basis of many of these measures is poorly known, and the intended effects of these measures have often not been realized. The first steps taken, however, indicate that even small-scale studies can lead to significant changes in understanding related to the mechanisms and assumptions behind technical management measures.

In Finnish coastal and inland waters especially, the gill-net fisheries of perch, pikeperch, pike, whitefish and brown trout are complex systems to be managed *(see also the programme on the role of fish interactions in inland water fisheries management)*. These species, with largely overlapping habitats, are highly valued by both professional, subsistence and recreational fishermen. A multitude of different types of gear, with varying selective properties, are employed to catch these species. In most cases, catches are a mixture of at least two species. Another general problem, especially with gill-net fishing, is the use of mesh sizes that are too small.

The research programme on the applicability and effectiveness on technical regulations in fisheries management is still at the planning stage. In the FGFRI, present studies that are directly linked to the development of technical regulations can be divided into two sections:

● Gear-selectivity studies aiming to find and promote efficient but ecologically safe fishing methods and gear modifications,

● Theoretically oriented management and population studies aiming to assess the impacts of technical and other management measures on fish populations and fisheries. This research branch applies probabilistic decision theory to fisheries management decisions and is closely related to the sosioeconomic management studies conducted in the FGFRI.

Objectives

The major objective of this research programme will be to develop efficient and cost-effective approaches to practical fisheries management. This requires biological, technical, economic and sosiological information. The corresponding research objectives are:

● to assess and evaluate the general effectiveness and applicability of current technical measures in fisheries management,

● to develop management alternatives and fishing practices that support the general objectives of sustainable fisheries, and that are culturally acceptable and therefore easy to implement,

- to develop gear designs and fishing practices that protect or enhance survival of nontargeted fish and other animals, and minimize other undesired effects of fishing activities on the environment,

- to develop capture methods and gear designs that reduce conflicts between fishery and marine mammals,

- to improve the methodological basis for impact analysis of technical management measures, e.g. by applying decision analysis tools to fisheries management.
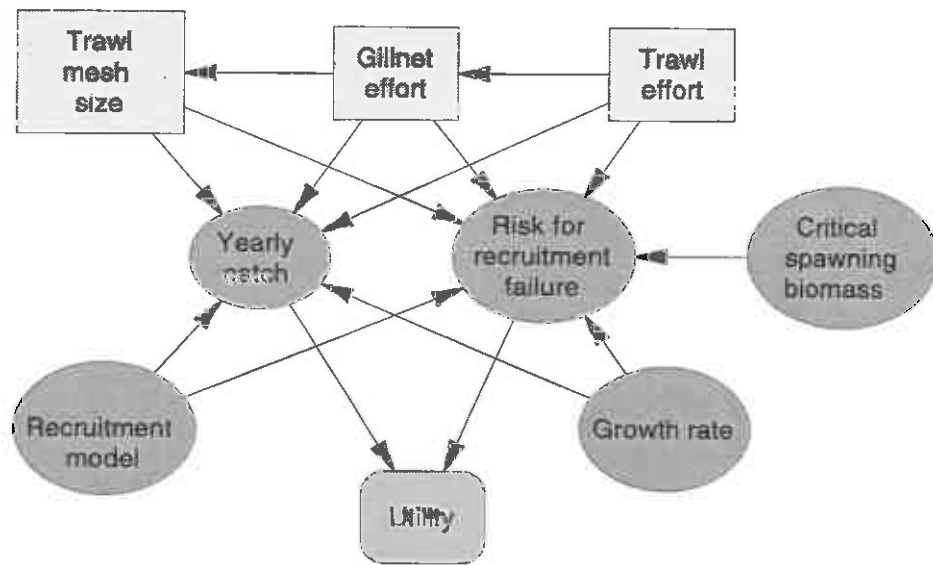
An example of an influence diagram model in which trawl selectivity (mesh size), and trawl and gill-net effort are used as decision variables. The most essential uncertainties are included in the probability distributions of the model. The model is applied in the ongoing BACOMA project.

Ongoing projects and their schedule

- *Applications of decision analysis to Baltic Sea fisheries management (1992-1998)*
- *Improving technical management in the Baltic cod fishery (BACOMA) (1997-1999)*
- *Assessment of selectivity and escape mortality of walleye pollock in the Alaskan pelagic trawl fishery (1997-1998)*
- *Development of alternative capture methods and gear designs in salmon and whitefish trap-net fishery suffering from attacks by grey seals (1998 -)*
- *Evaluation of the effectiveness and applicability of technical measures in fisheries management (TECMES) (1999-2000)*

Methods

- Growth and stockassessment: Catch samples and CPUE data,
- Gear selection and by-catch survival studies: Full-scale fishing experiments under commercial fishing conditions using cod-end covers, collection cages and various underwater observation techniques,
- Prevention of seal conflicts: Testing of various gear designs and scaring devices, behaviour studies,
- Decision and impact analysis: selection modelling using length-based population models, Bayesian belief nets, influence diagrams, Monte Carlo simulations, fish stock assessment models.

Resources and costs

In total, 3-5 man-years and about FIM 1.5-2 million will be annually used in the studies. Most projects currently underway are conducted in cooperation with foreign research institutes. A large share of the costs are funded by external sources, in particular by the EU. The pollock project has been funded by the Alaskan Fisheries Development Foundation and is conducted in cooperation with the University of Washington.

2.9. Examples of case studies

2.9.1. The M74 syndrome of Baltic salmon

The M74 syndrome is a reproductive disorder of Baltic salmon. A typical finding of the M74 has been that all or most of the offspring of a given female die as yolk-sac fry within a few days after typical symptoms have appeared. In addition, even mild M74 symptoms render yolk-sac fry susceptible to fish diseases and parasites. After the first observation in 1974, M74 mortality remained at a moderate level of about 20% until the late 1980s when the mortalities of yolk-sac fry increased. In Swedish and Finnish fish hatcheries, the mean mortalities of salmon yolk-sac fry hatched from eggs collected from the females ascending rivers after feeding migrations in the Baltic Sea have in recent years varied from 50% to over 90%. In 1997 females, however, the M74 frequency and mean yolk-sac fry mortality were clearly lower than in previous years.
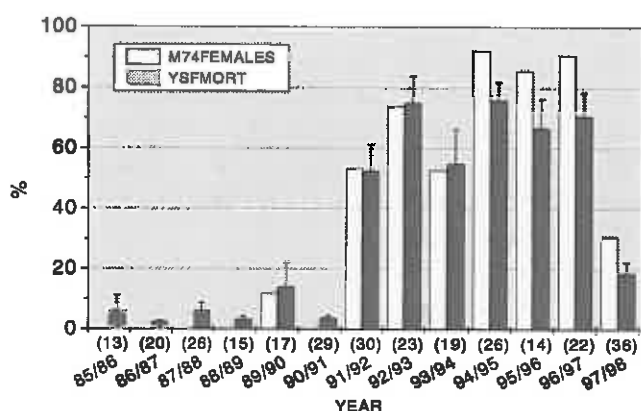
Mean percentages of salmon females producing M74 yolk-sac fry (M74FEMALES) and mean percentage total mortalities of yolk-sac fry (YSFMORT) from the River Simojoki hatchery.

A syndrome similar to M74, 'the early mortality syndrome' (EMS), has been detected in salmonids in the Great Lakes of North America. Both syndromes are considered as dietary in origin. Baltic herring and sprat are the main prey species of Baltic salmon, and comprise more than 95% of the weight or number of ingested prey specimens. A common finding for both M74 and EMS is that they are detected in waters heavily polluted by halogenated hydrocarbons, and thiamine deficiency occurs in both syndromes.

The goal of the project is to determine the causes and mechanisms of the M74 syndrome so as to produce a programme for protecting naturally reproducing salmon stocks. The study can be divided into the following subprojects:

• *Preservation and use of salmonid genetic resources.* Evaluates the breeding strategies of Baltic salmon and develops a programme for conserving its status (biodiversity).

• *Baltic salmon in the Baltic Sea ecosystem.* Investigates food composition of salmon in different feeding areas and assesses thiamine content of salmon during different migration phases.

- *Diseases, nutrition and etiology of M74.* In addition to diseases, examines the dynamics of thiamine in female salmon brood fish.

- *Environmental toxicants in reproduction disorder of Baltic salmon.* Investigates the connections and mechanisms of action of toxicants (in the M74 syndrome).

The project is characterized by extensive cooperation with two related Nordic projects and with American and Canadian scientists. In 1994-1997, the project has yearly required about FIM 1 million, including about 3 man-years of staff costs. Financial contributions from the Academy of Finland (FIM 1.3 million), Ministry of Agriculture and Forestry (FIM 1.2 million) and the Nordic Council of Ministers (FIM 0.5 million) has been essential for this project.

## 2.9.2. Hydroacoustic assessment of salmon in the River Tornionjoki

Almost every wild salmon population in the Baltic is endangered, due to overfishing. This has greatly emphasized the need for proper assessment of these stocks. According to the IBSFC management objective, the natural reproduction of Baltic salmon should be increased to the point that every river could produce at least 50% of its potential smolt production capacity by the year 2010. The prerequisites of this management objective are information on the productivity of Baltic rivers, the stock-recruitment dynamics and predictability of the effects of management actions on future spawning runs and reproduction. Despite this urgent need, almost no monitoring of spawning runs in Baltic rivers has been undertaken, and the information needed by managers is thus deficient.

Salmon in the River Tornionjoki constitute one of the most important Baltic stocks to be monitored for management purpose. The FGFRI has studied the stock since the 1970s. Studies have included compilation of catch statistics and catch samples, fish taggings and estimation of salmon parr and smolt production. The hydroacoustic assessment project began to replenish information on the salmon stock with regard to the following aspects:

- Size of the population yearly ascending the river,

- Timing of the upstream migration and the factors influencing it,

- Size and fecundity of the spawning population (hydroacoustic data complemented with river catch and fecundity data).

Hydroacoustic data are gathered with split-beam echo sounders at a suitable site on the lower reaches of the Tornionjoki (see the figure below). To evaluate the reliability of the hydroacoustic data, fish migration at the monitoring site is also assessed on the basis of catch statistics, catch samples and complementary test fishing. The migratory behaviour of salmon at the monitoring site is also documented by tracking salmon tagged with radio or ultrasonic transmitters.

The total costs of this 2-year project (1997-1999) are about FIM 3.8 million, including about 9 man-years of staff costs (personnel costs account for FIM 2.5 million). About 50% of the costs are funded by the European Commission. If the objectives of the project are to be realized, hydroacoustic assessment of the spawning run will be merged with the long-term monitoring of the River Tornionjoki salmon stock.
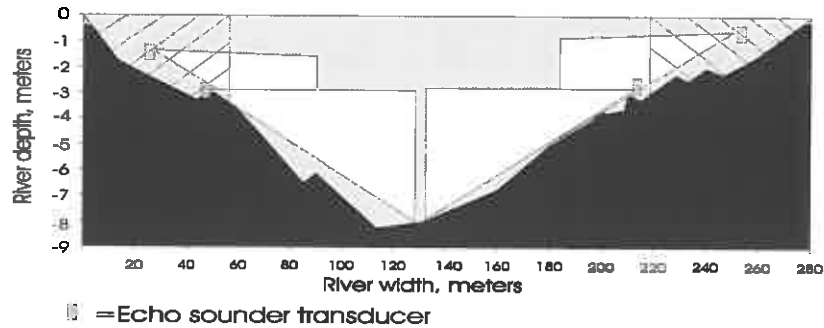
Transectional profile of the Tornionjoki near the river mouth, location and nominal coverage of the transducer beams (white triangles) and weirs (shaded areas near the river banks) directing fish passage.
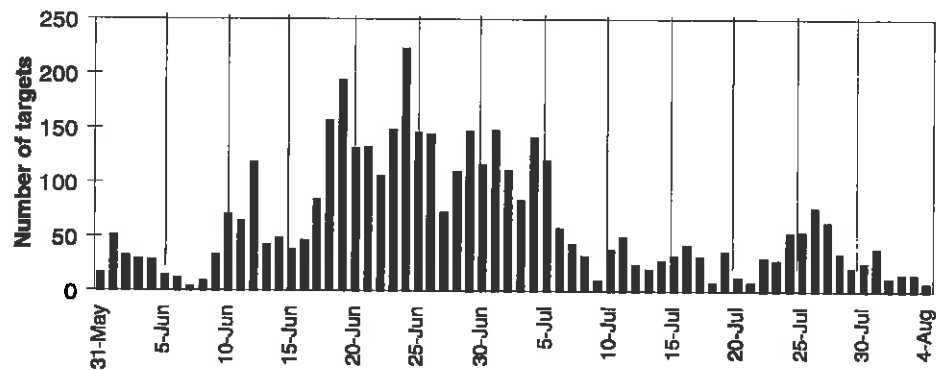
Preliminary data on daily numbers of large (mainly over 90-cm-long) salmon migrants detected with echo sounders in 1997.

2.9.3. CORE - STORE

Mechanisms influencing long-term trends in reproductive success and recruitment of Baltic cod: implications for fisheries management (CORE 1994-1998)
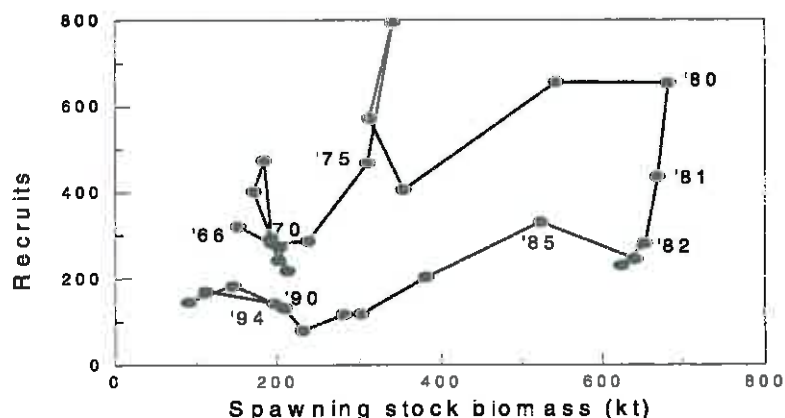
The main objectives of the CORE project were to identify and describe the dominant biotic and abiotic processes affecting the developmental success of early life stages and maturation of cod in the central Baltic and to incorporate these processes into recruitment models. This was done to enhance prediction of future stock fluctuations due to environmental perturbations, species interactions and fisheries management directives as a prerequisite for integrated fish stock assessment in the central Baltic. In total, 11 national laboratories in the Baltic Sea region participated in this research programme. The programme was separated into four major components:

1. Trend analysis containing time series of hydrographic conditions for successful egg development and of egg and larval abundances.

2. Process analysis containing analysis and estimation of fecundity and quality of spawning products, analysis of physical and chemical factors acting directly on the developmental rate, mortality and small-scale distribution of eggs and larvae, estimation of mesoscale distribution and drift of pelagic early life stages and densities of 0-group cod and analysis and estimation of predation on early life stages and influence of prey availability on growth, condition and survival of early life stages.

3. Modelling concentrating mainly on implementation of a multilayer flow model to investigate the effects of circulation patterns in the Bornholm Basin on the advection of cod early life stages.

4. Evaluation of stock enhancement programmes targetting recommendations for areas where cod ranching may be applicable.

Stock-recruitment relationship for central Baltic cod stock in 1966-1994.

3.2. Environmental and fisheries influences on fish stock recruitment in the Baltic Sea (STORE 1998-2001)

The main objectives of the STORE project are to determine the stock-recruitment relationships for Baltic cod and sprat in relation to key environmental factors influencing the production of viable spawn and the survival of early life history stages, improve short-term predictions of stock development by integrating recruitment estimates based on the present status of the stock and its biotic and abiotic environment, develop predictive recruitment models for medium to long-term forecasts of stock development under different environmental and fishery scenarios and estimate biological management reference points, critical stock limits and target-spawning stock sizes based on stock-recruitment relationships. In total, 16 national laboratories in the Baltic Sea region will participate in this research programme. The programme is separated into six major components:

1. Evaluate the accuracy of the spawning stock biomass as a measure of viable egg production.

2. Ascertain the direct impact of hydrographic factors on the fertilization and developmental success of cod and sprat eggs and early larvae by performing field and laboratory experiments.

3. Identify and describe the hydrographic, oceanographic and behavioural processes influencing growth, survival and distribution of 0-group cod and sprat.

4. Investigate the effects of stagnation periods, inflows of saline North Sea water and other hydrographic processes on cod and sprat early life history, using advanced eddy-resolving 3-dimensional baroclinic shelf circulation models.

5. Determine the impact of predation on early life history stages of cod and sprat caused by clupeids and scyphomedusae.

6. Integrate the findings of the previous five tasks into new recruitment models, and assess the usefulness of such models in management.

Appendix 1. Participation in the EU-funded projects and studies.

EU-funded research projects and studies that are currently under way or will begin in early 1999 at the Fisheries Biology and Management Research Unit. The column where the EU contribution is shown indicates funds directly received by the institute (FGFRI) from the EU. Most of the projects are based on a shared-cost principle, i.e. institute covers as large a share as the EU (1 ECU ≈ 6 FIM).

Name of the Project Years	Contract	Contribution from EU (ECU)	Coordinating Country
CORE - Mechanisms influencing long-term trends in reproductive success and recruitment of Baltic cod: Implications for fisheries management. 1994-1998	AIR2 CT 94-1226	41 660	Germany
Improving technical management in Baltic cod fishery (BACOMA). 1996-1999	FAIR CT 96-1994	277 000	**Finland**
Improvement of Tagging Methods for Stock Assessment and Research in Fisheries. 1996-1999	FAIR CT 96-1394	11 000	Iceland
International Baltic Sea Sampling Project for Commercial Fishing Fleets (IBSSP). 1997-1999	EU Study 96/002	354 698	Denmark
Hydroacoustic Assessment of Salmon in the River Tornionjoki. 1997-2000	EU Study 96/C75	239 000	**Finland**
European Fish Ageing Network (EFAN). 1997-1999	FAIR CT 96-1304	12 000	Norway
Establishing a Baltic International Trawl Survey (BITS) database. 1998-2001	EU Study 96/072	17 145	Sweden
SAP- Sustainable fisheries. How can the scientific basis for fish stock assessment and predictions be improved ? 1998-2001	FAIR PL97-3805	12 000	Norway
STORE - Environmental and fisheries influences on fish stock recruitment in the Baltic Sea. 1998-2001	FAIR PL 97-3959	60 726	Germany
Evaluation of the effectiveness and applicability of technical measures in fisheries management (TECMES). 1999-2000	EU Study 98/016	177 633	**Finland**
International Baltic Sea Sampling Programme II (IBSSP II). 1999-2001	EU Study 98/024	513 060	Denmark
Surveying the pelagic fish resources and establish an acoustic database in the Baltic Sea (BALTDAT). 1999-2000	EU Study 98/xxx	290 178	Sweden
Improvement of Stock Assessment and data collection by continuation, standardisation and design improvement of Baltic international bottom trawl surveys for fishery resource assessment (ISDBITS). 1999-2000	EU Study 98/099	30 092	Denmark