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Socioeconomic and Aquaculture Research Unit

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1. General

1.1. Strategic perspective

Traditionally, research at the Finnish Game and Fisheries Research Institute (FGFRI) has been biologically oriented. In 1994 the institute was reorganized and the Socioeconomic and Aquaculture Research Unit (SEA) was established to sharpen the focus on the social and economic problems of the sector. Most of the research carried out in the Unit has, therefore, been initiated or completely restructured during the last 4 years. A thorough strategic analysis of customers, available resources and the demand for research preceded the restructuring. Today, a major part of the research can be classified as being applied and strategic in nature.

1.2. Goals and customers

SEA provides the scientific research and expertise needed by the national and EU administrations, planning bodies, the fisheries and aquaculture industry, recreational fishermen, interest groups, the media, and the scientific community and the public. The mid- and long- term problems for the fisheries industry and recreation receive high priority in the research. Due to the importance of restocking in fisheries management in Finland, the impact of aquaculture on genotypes is also within the scope of the research.

1.3. Activities

The SEA has 3 main fields of activity (Fig. 1). It compiles official fishery, aquaculture and hunting statistics and is responsible for research on both socioeconomic subjects and the aquaculture sector. Furthermore, the SEA provides expertise in the fisheries sector to national and international customers.

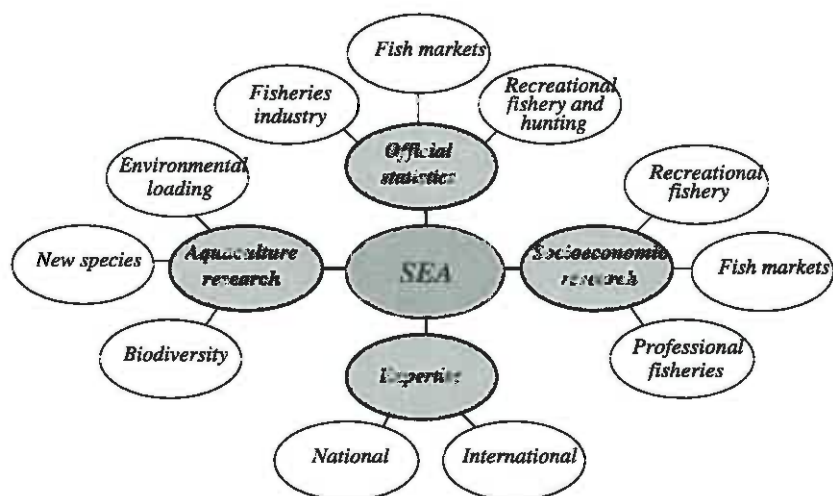


FIGURE 1. The key activities of the Socioeconomic and Aquaculture Research (SEA).

1.4. Personnel and costs

The staff of the SEA consists of 46 employees, 7 of whom are situated in the Statistics sub-unit. Of the permanent staff, 70% have academic degrees: 9 persons have doctorates, 1 licentiate, 19 master's and 3 bachelor's degrees. 15 researchers in the SEA can be classified as senior scientists having wide responsibility for project management and scientific performance. The areas of specialisation of the academic personnel include the following: zoology and biology (12), hydrobiology (6), fisheries science (4), limnology (1), economics (3), sociology (1), engineering (2), geography (2) and microbiology (1). The staff is located at 8 stations, most at the Helsinki Headquarters (23) and the Laukaa Research and Aquaculture Station (9).

By 1997, about 44 person work-years had been completed in the Unit at a total cost of FIM 17.3 million. A total of 81% of the costs were covered by the state budget for the institute, while 5% were financed from private funds and 14% from external public sources.

The distribution of various costs was as follows:

• Salaries	54%
• Other costs	18%
• Overhead	28%
• Total	100%

The percentages of costs for different types of activity were as follows:

• Research projects	72%
• Statistics	19%
• Consulting activity	9%
• Total	100%

1.5. National and international co-operation

Important partners of the SEA in Finland include the fisheries and aquaculture industry (fishermen, fish farmers, fish processors, fish wholesalers and the feed industry), interest organisations, fisheries and environmental administrators, universities and research institutes. International co-operation is vital especially with universities in Scandinavia, the Baltic countries, the United Kingdom and Canada. Researchers also take part actively in the work of many European networks (e.g. Cost, EssFin) and organisations (e.g. EAFE, IIFET, OECD, ICES).

1.6. Publications

Research results have been published in journals, posters and popular articles and at meetings and conferences as follows:

	1994	1995	1996	1997	1998*
Articles in scientific and social scientific-journals	3	2	10	10	12
Other scientific review articles	2	14	4	6	13
Statistical publications	8	8	8	9	9
Articles in series of the FGFRI	20	31	26	34	12
Other publications	49	67	39	24	46
Total	82	122	87	83	92

Situation as of November 1, 1998

2. Research Activities

In recent years about 300 million kg of fish and fish products have been available annually in Finland (Fig. 2). The peak was attained in the mid-1980s, when the annual fish supply exceeded 500 million kg. The combined producer and import value of the total fish supply in the 1990s has been about FIM 1.5 billion.

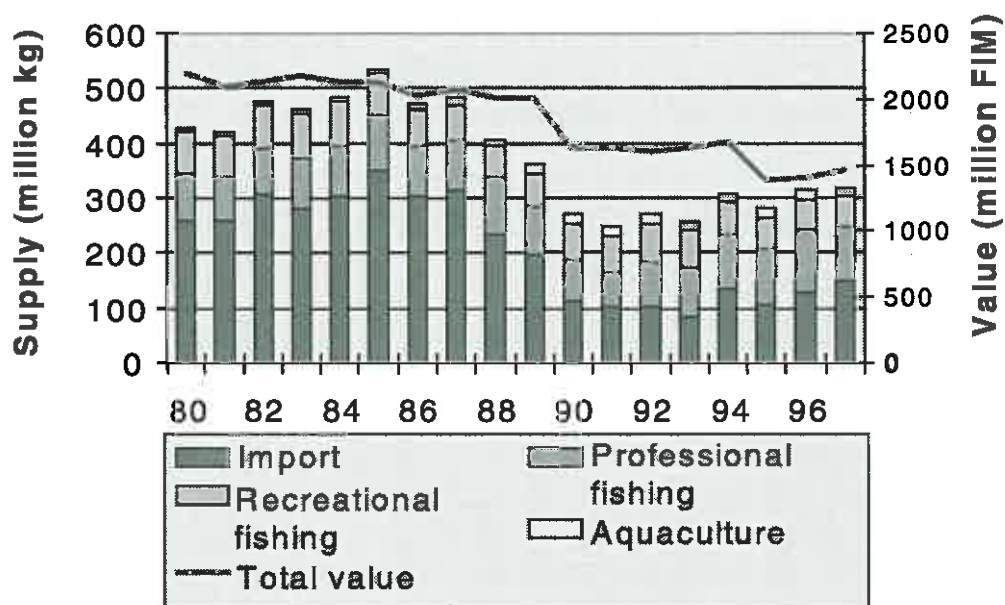


FIGURE 2. Availability of fish in Finland 1980-1997.

Approximately half of the fish have been used for human consumption and the rest as fodder for the fur industry (70-90% of the Baltic herring and more than 90% of the sprat). Roughly 30-50% of the total supply has been imported. One third of the supply consists of the catch of professional fisheries and one third of production from aquaculture and the catch of recreational fisheries. The value of exports has been about FIM 100 million per year.

Per capita consumption of fish in Finland has been 14-15 kg in fillet weight in recent years, corresponding to just over 30 kg of live-weight fish. The main fish species on the dinner table are rainbow trout and Baltic herring. More than half of the fish for human consumption are processed.

There have been considerable changes in fish consumption. Whereas during the early 1980s more than 60% of fish were caught by professional fishermen, the supply from this source today is considerably less. On the other hand, the amount of farmed fish quadrupled during the 1980s. Imports of fish products and conserves also doubled during the years 1980-1993.

The characteristics of the Finnish fisheries and aquaculture sector today include the following:

- The size of a typical enterprise is small. Most of the activities including fishing, fish farming and processing are carried out by small, often family-owned firms. An exception to this is the fish feed industry which is run by large national and multinational companies. During recent years, however, large international companies have also been investing in the fish- processing industry in Finland.
- In contrast to most countries, sea coasts, lakes and rivers in Finland are privately owned, which makes fisheries management in Finland unique.
- Extensive and rapid changes have occurred in Finnish fish markets during recent years due to EU membership and the overall internationalization of the trade.
- The recreational fishery is one of the most popular leisure-time activities in Finland. More than 2 million inhabitants, over 40% of the population, fish every year. The catch of recreational fisheries plays a considerable role (55 million kg) in Finnish fish supply and fish consumption.
- The processing industry uses mainly domestic fish, the supply of which is seasonal and unsteady. Occasionally the processing industry suffers from a lack of raw material (Fig. 3).
- Of the fish farmed for food 99% are rainbow trout, which makes the industry vulnerable to market disturbances.
- Finnish environmental policy challenges the growth of the aquaculture industry.
- Restocking of fish is an important part of Finnish fisheries management.

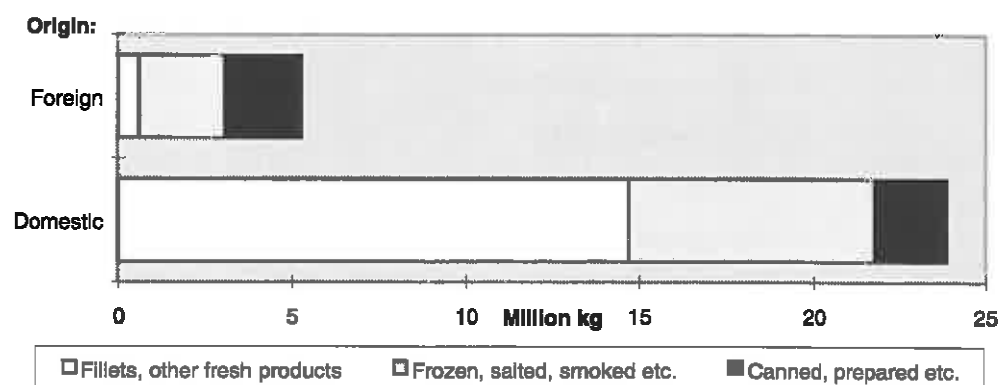


FIGURE 3. Processed fish, by origin and commodity, in 1995.

2.1. Fisheries and hunting statistics

2.1.1. Goals and regulations

The FGFRI is responsible for compiling official fishery and hunting statistics according to national and EU regulations and international agreements. The goal of fishery and hunting statistics, as part of the official statistics as a whole, is to reflect

general societal conditions in the country in relation to the needs of citizens in general and groups of citizens in particular. Fish and game statistics are required for the sustainable use of natural resources and to indicate the state of the environment. To meet the commitments of society and the demand of customers, the basic premise for statistics production at the FGFRI is that the statistics fulfil the following requirements:

- they represent key phenomena of the sector,
- they are compiled by relevant methods,
- they are real-time,
- they are cost-effective and,
- they are useful for customers.

Statistics production at the FGFRI is organized within a Statistics sub-unit that compiles information about the use of fish and game resources and the industry and recreation involved. Monitoring of game and fish resources is the task of other Units at the FGFRI. Statistical information is published in Finland and reported to EUROSTAT and other international organisations, e.g. to FAO, OECD and ICES.

2.1.2. Statistics production

The statistics that are in continuous production can be divided into 3 main groups:

I. Fisheries industry statistics

1. Catch, landings and effort of the professional marine fishery
2. Commercial freshwater fishery
3. Aquaculture and restocking
4. Fish-processing industry

II. Fish market statistics

5. Fish prices
6. Foreign trade
7. Utilization and consumption of fish

III. Recreational fishery and hunting

8. Recreational fishery
9. Hunting

2.1.3. Methods of statistics production

Fisheries and hunting statistics are based on registers and surveys. Registers are maintained by both the FGFRI and authorities. A large proportion of the data acquisitions are total surveys. There are 3 reasons for this: 1) acts controlling the compilation of statistics often require target groups to register their activities, 2) the target groups are small in size and 3) there is a need to compile estimates about subsets of populations.

The statistics on recreational fisheries and hunting are based purely on sample surveys. The framework and methods for compiling statistics on different themes are briefly described below:

1. Professional marine fisheries: These statistics are based on the registers of fishermen and fishing vessels maintained by the Ministry of Agriculture and Forestry (MAF). All 3000 fishing units are required to report on their fishery to the authorities responsible for fisheries control using either EU log-books or monthly coastal reports. The FGFRI obtains the data at the end of the year. At that point the data are checked and analysed, then supplemented, and crosschecked with landing statistics and the data collected from the first hand buyers of fish. Annual statistics are published within 6 months after the end of the statistical year. Both the data acquisition and compilation of statistics are controlled by EU regulations (e.g. EC 3880/91).

2. Commercial freshwater fishery: These statistics are based on the fishermen's register maintained by the FGFRI. There are about 1000 fishermen in the register, which is updated in co-operation with the administration, interest organisations and research projects. About half of the catch and the fishing data are obtained from local surveys by other units of the FGFRI. The rest of the data are collected by an annual postal survey. The statistics are compiled every second year. The report is published within 12 months after the end of the statistical year.

3. Aquaculture and restocking: The framework for the aquaculture statistics is the register maintained by the MAF in which all fish farmers are required to register. The number of fish-farming units in 1997 was about 700. Annually the FGFRI collects data on food fish and fingerling production. Organisations restocking fish in watercourses are required to inform about the restockings to the fisheries administration. From these reports the FGFRI collects the annual statistics on fish and crayfish restockings that are published within one year after the reporting period. Crosschecks on aquaculture and restocking statistics are a tool for verifying the quality of statistics production. Aquaculture statistics are controlled by EU regulation EC 788/96.

4. Fish-processing industry: These statistics are based on the register of fish-processing enterprises. The register is maintained by the FGFRI and updated using the registers of Statistics Finland and the fisheries administration. Today there are about 300 firms in the register. In alternate years the FGFRI performs a postal survey measuring the production and activities of the firms. The survey is accomplished by telephone interview, and the results are published within 12 months after the end of the statistical year.

5. Fish prices: These statistics are based on 2 sources of information. The data on quoted fish species (Baltic herring, sprat, cod, salmon) are obtained from reports given to the supervising authorities by first hand buyers of the fish. The compilation of statistics on price and quantity of fish is controlled by EU regulations (EEC 1382/91 & EEC 2104/93). The results are submitted to EUROSTAT monthly. Data on nonquoted species are obtained from a questionnaire book-keepings of the 20 largest fishbuyers. These statistics appear twice annually and are published 3-4 months after the reporting period. Price data on aquaculture species are collected from fish farmers and their organisations.

6. Foreign trade: Statistics on foreign trade are based on data of the National Board of Customs, which collects information on foreign trade inside and outside the EU markets. The data are defined with information obtained by interviewing companies. This aids in interpretation of the customs data. The foreign trade statistics are published annually, within 6 months after the end of the statistical year.

7. *Utilization and consumption of fish:* Data on fish consumption and utilization are compiled from industry, trade and processing statistics using balance sheet calculations. Information about studies on fish consumption are used to estimate some components of the balance. The statistics are published annually in special publications of the statistics Unit and in fisheries magazines.

8. *Recreational fishery:* The framework of recreational fishery statistics is the population register. A postal survey measuring catches and fishing activities of recreational fishermen is carried out by sending a questionnaire to households sampled from the register. During recent years the size of the sample has been 4000 households. The total number of fishermen has been calibrated by independent telephone interviews in co-operation with Statistics Finland. The data have been collected in alternate years and the statistics published not later than 12 months after the end of the statistical year in question.

9. *Hunting:* The the hunting statistics are compiled from the register (approx. 300 000 hunters) of the Hunters' Central Organisation in Finland in which all hunters are required to register. The FGFRI collects data on small game bags by postal survey; the sample size of the survey is 5000. Data on large carnivores and ungulates are obtained from the catch quota system. The statistics are published annually, within 12 months after the end of the statistical year.

2.1.4. Statistical publications and other products

Since 1993 the FGFRI has published statistics on the series "Official Statistics of Finland/Environment" (SVT). The publications have appeared both in Finnish and in Swedish. Today all statistics are supplemented with quality reports.

In addition to regular, annual statistical publications the FGFRI has published statistical yearbooks. A special review has focused on Finnish fisheries from different perspectives including time-series, spatial statistics, comparison with European fisheries and fish flows. In 1998, a pocket fisheries book was also published.

In addition to the primary publications, the Statistics sub-unit offers sample survey research on special topics, surveys and reviews based on existing statistical databases. An inherent and essential part of the work is the processing of statistical information for research use and further analysis, especially for fish stock assessment and for fisheries economics studies.

2.1.5. Development projects

Statistics production is developed with the goal of improving overall quality. Special attention is given to continuity in statistics production. To this end the know-how of the personnel is extended through continuing education and rotation of tasks among personnel. The quality reports also undergo continuous development. The electronic publishing of statistics is being developed in co-operation with other statistical offices.

In the near future, statistics production will be supplemented with barometric measurement. They will measure both industry's and consumers' attitudes and expectations towards fish products and production environment. The barometric measurements will be in the test phase in 1999 and will be in production in the year 2000.

2.1.6. Resources

The Statistics sub-unit consists of 7 employees. Total costs in 1997 for the sub-unit were about FIM 3.4 million, of which the cost of statistics compilations was FIM 2.5 million. Financing from outside the state budget has been about FIM 0.1 million.

2.2. Socioeconomic research

Socioeconomic research consists of 4 groups of projects: research on professional fisheries, fish markets, recreational fisheries and the economic problems of aquaculture. The first 3 types of research have been organized as independent projects (Fig. 4.), as described below, while the research on the economic problems of aquaculture will be discussed in Chapter 2.3.

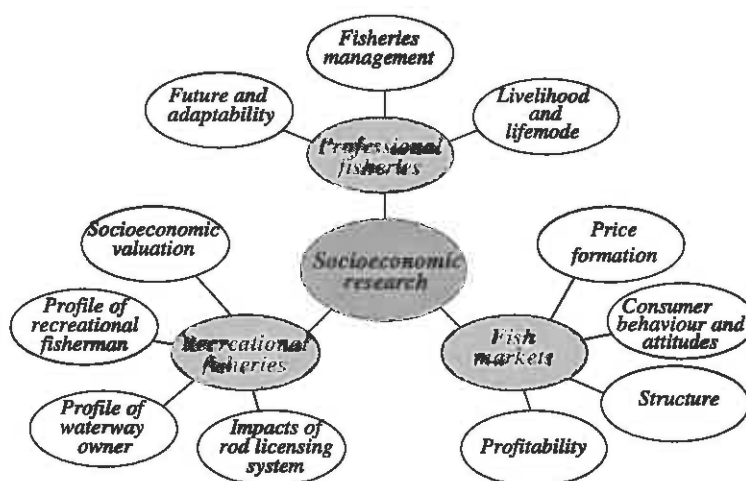


FIGURE 4. Socioeconomic research projects and subprojects.

The socioeconomic research projects occur in different phases. Data collection and analysis for the project on *Professional Fisheries* was performed during 1994-1997. At present the project is completing its final results to be published in international journals. The project on *Fish Markets* will be completed during 1999, when it will be reported internationally. The project on *Recreational Fisheries* was initiated in early 1998 and will be extended into 1999 by 3 new subprojects.

2.2.1. Professional fisheries in Finland 1994-1997

Background

It is widely accepted that the efficiency of fisheries management is dependent not only on the content of the schemes but also on the adherence of fishermen to them. Management policies or regulations have little chance of success without the support of various interest groups. A profound knowledge of the commercial fishery and the perspectives of fishermen offers a better tool for developing fishing as a livelihood. An extensive study on commercial fishery, fisheries management and the perspectives of fishermen in Finland has been completed and the final results of the project are being reported in international journals.

Objectives

The aim of the project was to analyse the structure of Finnish commercial fisheries as well as the perspectives and attitudes of fishermen. More detailed goals of the project included the following:

- To analyse the impact of fisheries management on fishermen and opportunities for fishermen to influence decision-making.
- To describe the structure and state of Finnish fisheries before EU-membership.
- To establish a firm basis for fisheries segmentation.
- To analyse the strategies of commercial fishermen for maintaining and developing the fisheries in a changing environment.
- To analyse the potential for fishermen to improve profitability of their fisheries by investing in fish quality, hygiene and marketing.
- To study the attitudes and expectations of fishermen about the future.
- To develop better research methods.

Subprojects and main results

Data collection and the main part of the analysis were carried out during 1994-1997. The wide scope of the project was divided into 3 subprojects that operated as a mutual framework for the studies rather than as a rigid organisational structure.

Subproject 1: Fishing as a livelihood and way of life

This subproject dealt with the structure of fishing enterprises and problems in the profession. Fishing as a livelihood was determined to be dependent not only on external ecological and economic circumstances, but also on social factors. In particular, management actions, culture and traditions were considered to better understand the state of professional fisheries.

Subproject 2: Fishermen and fisheries management

This subproject analysed fisheries management from the point of view of the fishermen. Furthermore, the readiness of fishermen to develop their industry with the aid of institutional arrangements was studied. It was concluded that the development of fisheries management calls for wider involvement of the user groups in the decision-making process. Fishermen were willing to take responsibility for management of their fisheries, e.g. by preparing decisions for fisheries regulations that could develop fisheries management in a more participatory direction. The main obstacles preventing this were determined to be the low degree of unionisation of fishermen and the geographical scattering of fishermen.

Subproject 3: Adaptability of fishermen: future perspectives

Present and future adaptability and flexibility of the fishermen were studied using strategy analysis. The strategies analysed included use of technical equipment, economic structure, and general orientation to the profession, e.g. attitudes towards new fish-processing and marketing arrangements. Prospects for the industry in the future were studied by combining the information from strategy analysis with background data on the livelihood and its problems. It was concluded that construction of larger networks and investing in education would assist fishermen in finding new approaches and help them to strengthen traditional strategies.

Methods

A variety of subjects were analysed by combining quantitative and qualitative social scientific methods. To obtain valid and reliable data, the material was collected using both structured questionnaires and theme interviews. In the study, 207 fishermen in the Baltic coastal area and 60 fishermen in the lake area were interviewed, corresponding to 7% of Finnish professional fishermen.

The principal method for analysing the qualitative material was classification, in which fragments of the transcribed texts were first categorized according to content into 36 categories. This classification aided in organising the extensive material and was used as an index in the research work. The qualitative and quantitative data, combined or separate, were further analysed in several studies. In some of these, the discourse of the fishermen was studied using status-related classification, i.e. grouping of statements and of the reasons for the statements.

Resources

The total cost of the project in 1994-1997 was FIM 4.3 million, in which 15.4 person work-years were invested.

2.2.2. Recreational fisheries in Finland 1998-2001

Background

Recreational fishing is among the most popular of free-time activities in Finland. About 2 million Finns fish in their leisure time. Recreational fishermen are the most important user group for many fish species. The existence and accessibility to fishermen of nature and wilderness is experienced as being almost self-evident. The tradition of subsistence fishing in Finland is also quite established. Although the significance of catch has reduced the gillnet fishery still remains a popular catching method. Segmentation of the vast group of recreational fishers can be based on the type of gear used, the level of specialisation, by target catch or by the type of fishing water, for instance.

The fisheries management system is characterized by the fact that most inland and coastal waters are privately owned, with reference to land ownership. The owner is usually a collective that forms a statutory fishery association. Fishery regions were established in 1982 as new organisations for management of larger areas under the authority of the Ministry of Agriculture and Forestry. *Every man's right* has recently been extended to include angling and ice-fishing and possibilities for fishing with rod and reel in private waters have been enhanced through legislative action.

In relation to research on the extent of the pursuit, the resources allocated the recreational fishery have thus far been modest. Since 1975, however, statistics on the recreational fishery have been collected on the national level. The number of fishermen by county, type of gear used and the most important catch species, for instance, have been recorded every second year.

Objectives

The aim of the surveys and case studies is to collect information about recreational fishermen as a part of society and society as the environment for recreational fishing. The management systems are examined from the recreational fisherman's point of view. Both social and economic aspects will be considered.

Subprojects

Subproject 1: Socioeconomic valuation of the recreational fishery (1999-2001)

The value of outdoor recreation is often understood only when opportunities for engaging in the activities are about to be lost. In conflicting situations, however, it has not been possible to treat the recreational fishery in the same way as other waterway uses, because the total value of recreational fisheries in monetary terms has usually not been known. To be able to consider properly the role of recreational fishing, it must be possible to express the non-market value of the pursuit explicitly. The project aims at describing and analysing the economic value and cultural significance of the recreational fishery. The economic value will be defined separately for the different segments of recreational fishers. The survey will be executed simultaneously in all of the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) with standardised methods and definitions.

Subproject 2: Profile of the recreational fisherman (1999-2001)

The motives of recreational fishermen, their incentives and their expectations for the hobby will be mapped. Information will be gathered about the relations of recreational fishermen to other interest groups, such as owners of waterways, professional fishermen and fish farmers, and about their attitudes concerning other uses of water systems. Topics of interest in this context will be opinions about fishing licence policies, fish-stocking programmes, availability of fishing sites and demand for additional services.

The life course of the recreational fisherman will be analysed in more detail. The project will study the motives for involvement in recreational fishing. The impact of different life style situations and of Finnish summer-cottage culture on the hobby will also be analysed. As a topic of special interest, the opinions of Finns about catch-and-release and put-and-take fishing will be studied.

Subproject 3: Profile of the waterway owner (1999-2001)

The project analyses the structure, dynamics and objectives of waterway owners and management organisations. A large number of waterway owners are also recreational fishermen. Conflicts between different user groups will be considered. Fishing licence policies, fish-stocking programmes and decision-making at various levels of management are reviewed. The standpoint of the survey will be that of the recreational fisherman.

Subproject 4: The impact of new rod licensing system (1998-1999)

In 1996 the Finnish Parliament passed a new law on angling. The main aim of the project has been to monitor and analyse the impact of the law in practice.

The distribution of fishing with rod and line in all 223 fishery regions of Finland has been examined. The number of fishing days as well as the catch by types of fishing gear and fish species have been reported. Furthermore, special problems arising between different interest groups due to the new rod licensing system are under analysis. The Ministry of Agriculture and Forestry will use the fishing statistics to refund the licence income to the fishery regions. The information collected will also be used in a variety of reports on the regional and national status of the recreational fishery.

Methods

The basic method used in the sociological and economic research on the recreational fishery is postal surveys. Special attention has been and will be given to sampling and background information to guarantee the precision of these estimates.

The contingent valuation method is used for establishing the nonmarket value of an environmental sound recreational fishery. A hypothetical market is set up using economic scenarios and people are asked about their willingness to pay or to accept a bid as a compensation.

In addition to the postal surveys, interviews with selected key persons will supplement the profiles of recreational fishermen and waterway owners. The data from these structured interviews will be analysed using methods of qualitative discourse analysis.

On-site interviews have and will be used to complement the postal surveys, especially in the profile studies. The data from interviews will be analysed using qualitative discourse analysis.

Data collected on the impact of rod licensing system give regional figures as fishery statistics for the first time and permit analysis and presentations using the geographic information system (GIS) as an analysis tool.

Resources

During the 4 year period the 4 subprojects will use FIM 4.5 million and 22 person work-years.

2.2.3. Fish Markets in Finland 1996-1999

Background

Extensive and rapid changes have occurred in Finnish fish markets during recent years due to EU membership and the overall internationalization of the trade. Changes in the economic context, for example in fish markets, may affect the fisheries industry more than changes in fish stocks and the environment. National studies on the consumption of fish were initiated in the FGFRI during the late 1980s. Other phenomena related to fish markets have been studied in single projects. In 1996, a larger project focusing on fish markets was begun (1996-1999).

Objectives

The objective of this research project is to provide information on fish markets for the authorities and other decision makers in Finland and the EU, as well as for professional fishermen, the aquaculture sector, retail, distribution and catering sectors and consumers. More detailed objectives are:

- to analyse fish price formation in Finland
- to study consumer behaviour and attitudes
- to study the structure of Finnish fish markets
- to analyse the profitability of the fish industry

New approaches and methods will also be developed and analysed.

Subprojects

The project was begun in 1996 and will be completed in spring 1999. The study was organised into 4 subprojects:

Subproject 1: Fish price formation (1996-1997)

The effect of the importation of Norwegian salmon on the price of domestic wild salmon and farmed rainbow trout was studied during 1996-1997. The prices of domestic wild salmon, rainbow trout and Norwegian salmon were dependent on each other in the long term. Before Finland joined the EU, such co-integration could not be shown statistically.

Subproject 2: Consumer behaviour and attitudes (1996-1998)

Consumption patterns for Finnish households and the catering sector were studied in 1996-1998. Almost all Finns eat fish and attitudes towards fish were mostly very positive, however, the attitude of the younger generation towards unprocessed, fresh fish, was more reserved compared to that of older generations. The most important purchasing locations for fresh fish for households were supermarkets and local shops. The varying conceptions of fish quality in the markets have also been investigated in 1996-1998. The attitudes of wholesalers, retailers and the catering sector towards the components of the quality of rainbow trout fillets were somewhat different. All considered freshness to be very important, but wholesalers stressed the quality actions taken in primary production whereas retailers focused on sensory characteristics and the catering sector on factors such as safety and nutritional aspects.

Subproject 3: Structure of the fish markets (1997-1999)

In the third subproject the structure of the Finnish fish markets was studied in 1997-1998. The percentage of professional fisheries in the total fish supply has decreased markedly during the past 2 decades. On the other hand, aquaculture production has almost quadrupled during the same period. Imports and exports of fish have increased. Fish prices have decreased and competition in the national market has increased due to internationalisation. In 1997-1998, a literature survey was compiled concerning importance of the producer associations in common fishery policy.

Subproject 4: Analysis of profitability (1996-1998)

Most of the fishery and fish processing enterprises are small and their economic know-how limited. In the fourth subproject, a computer-aided tool to assist in profitability analyses of professional fishing and fish processing (1996-1998) has been developed. The object was to improve the economic skills of entrepreneurs with the aid of a practical and easy-to-use tool. The fishery consultative sector has been trained to use the tool to enable them to teach entrepreneurs. Moreover, the profitability of quality investments for trawlers has been analysed in a case study in 1997-1998. The investments were particularly profitable when the market situation in the food sector was good.

Principal approaches and methods

The problems in this study are approached from different methodological perspectives:

Decision theory: Fish quality was analysed using the analytic hierarchy process (AHP).

Econometrics: The effect of Norwegian salmon imports on the domestic wild salmon and rainbow trout markets was analysed using time series analysis.

Social sciences methods : Both mail and phone surveys and qualitative methods such as theme interviews have been conducted while studying consumption behaviour.

Economics: The profitability studies have been analysed using cost-benefit analysis with respective sensitivity analysis.

Resources

The permanent staff in the fish markets project will work approximately 1.5 person work-years annually, and the total annual cost of the project is about FIM 0.7 million.

2.3. Aquaculture research

In the working programmes of the fourth and fifth EU research frame programmes, the central challenges for aquaculture research center on the following 3 themes: diversification of species in production, environmental issues and genetics. The SEA has evaluated these as key problems in the Finnish aquaculture industry as well. Aquaculture research has been organised into 4 projects as illustrated in Figure 5.

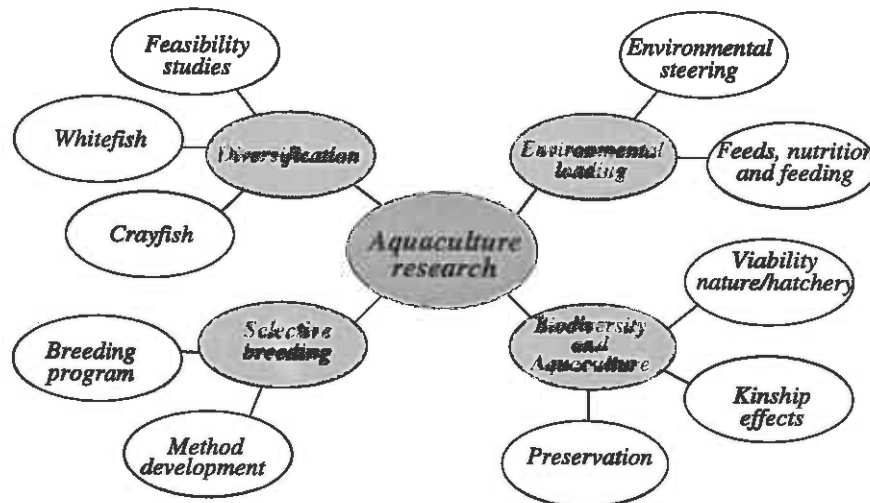


FIGURE 5. Projects in aquaculture research.

The current projects were mainly initiated in 1997 and later, but research activities related to these subjects were already being carried out in the 1980s. An intensive experimental phase is taking place in the projects on *Reduction of environmental loading in aquaculture*, *Diversification of aquaculture production*, and *Effects of aquaculture on biodiversity*. The *selective breeding of rainbow trout* project is finishing its first phase and the first results are about to be measured.

2.3.1. Reduction of environmental loading in aquaculture 1997-2000

Background

Farming requires licences that normally regulate the amount of fish production, amount of feed used and/or nutrient loading. Environmental monitoring is supervised by environmental authorities.

In 1998, the Finnish government agreed on a target programme for water protection for 1996-2005. According to the programme, the aquaculture sector should reduce its nutrient loading by 30% within a decade.

The FGFRI carried out a decision analysis concerning environmental actions in aquaculture. The participating stakeholders were fish farmers, nature protectors, fishermen and the authorities. All stakeholders defined their objectives for environmental protection, and then experts analysed which measures would best suit the interests of various stakeholders. Analysis revealed that the most effective actions to take to achieve the different objectives are related to fish feeds and feeding practices; e.g. reduction of phosphorus in the feed, enhancement of the feed conversion ratio and digestibility of the feed.

Objectives

The aims of this project are:

- to produce research information for the development of an environmental steering system and
- to produce research information related to feeds, nutrition and feeding practices, that will aid in reducing nutrient loading.

It is estimated that the targets of the National Environmental Protection Programme for Aquaculture will be reached within 5 years after the project's end in 2003-2005.

Subprojects

Subprojects for development of an environmental steering system for fish farming

Subproject 1: Sustainable development of aquaculture - survey of the initial situation (1997-1999)

Survey of the initial situation concerning nutrient loading has been carried out and a report on it published in 1998. According to the results, the amount of nutrient loading represented in the statistics is much lower than the true values. This finding calls for development of environmental steering in fish farming.

The current phase of this subproject studies the attitudes of fish farmers towards the alternatives for developing steering system. Theme interviews are being used for this purpose. In addition, the potential of voluntary environmental systems (e.g. organic farming) and the development of a control system are being reviewed. The next phase aims to create an environmental strategy for aquaculture to fulfil the requirements for water protection.

Subproject 2: Life Cycle Assessment (1998-2000)

The previous life cycle assessments for fish and for other food industries will be reviewed in a preliminary study. On the basis of this preliminary study, the products and production methods to be compared with the usual Finnish farming methods will be chosen, and an inventory table of the environmental effects of fish farming will be compiled. In the third phase, the environmental effects of fish farming will be compared and evaluated.

Subprojects on developing feeds, nutrition and feeding practices

Subproject 3: Regulation of appetite and digestion in fish (1997-1999)

The development of more efficient feeding practices in aquaculture requires better understanding of the regulation of appetite. Current knowledge on appetite regulation in vertebrates is based on research carried out on mammals, which does not directly apply to fish. Thus far, new research methods have been developed to study the appetite and digestion of fish, and to determine the applicability of new models in estimation of appetite. In 1998, joint experiments with the University of Gothenburg have been initiated concerning neural and hormonal regulation of appetite.

Subproject 4. Environmentally sustainable feed for fish farming (1998-2000)

This project aims to produce new public information for the feed industry and environmental authorities. The main objective is to increase the use of plant protein in feeds and thus reduce environmental loading and also save fish stock resources. In addition, the effect of plant protein-based feed on fish quality and production costs will be studied.

The specified objectives are as follows:

1. to determine the lowest possible nutritional load that can be achieved by replacing fish meal with soya concentrate, without causing an increase in production costs and adverse effects in fish quality (1998). This study is based on experiments conducted at the Rymättylä Fisheries Research Station.
2. to determine the protein level that a mature rainbow trout needs in its diet when using mostly soya concentrate. The experimental design is based on the results from the 1998 experiment. In addition, the FGFRI will take part in experiments in which feeds with low phosphorus concentration are tested on a commercial farming scale to study their effects on nutrient loading and production costs.

Subproject 5. Nutritional factors influencing the absorption and excretion of phosphorus in rainbow trout (1997-1998)

The digestibility of phosphorus in feed components should be improved to be able to bring the feeds with low phosphorus content into use on a commercial scale. On the basis of the experiments done, the digestibility of phosphorus is better if the fish meal is ground properly and feeds containing plant protein are treated with phytase enzyme. Results from this subproject are utilised in Subproject 4.

Subproject 6. The effect of environmental factors (1998-2000)

The aims of the project are to determine:

- whether changes in environmental factors cause stress in fish and whether it is possible to use this stress response for defining the effects of environmental factors on production factors: growth rate, growth efficiency and appetite as well as phosphorus load;
- how wide environmental changes cause stress in fish and
- how strongly or frequently fish need to be stressed to impair growth performance.

In addition to stress, variation in environmental factors, such as rapid changes in water temperature, affect fish farming due to the acclimatisation of fish. Central variables in this acclimatisation process are not known well enough to be able to give advice on how to raise fish under acclimatisation. Acclimatisation is a consequence of inaccuracy in physiological processes caused by short-term environmental changes.

Other aims of the project are to assess the duration and scale of acclimatisation under changing environmental conditions, to determine:

- how extensive environmental changes require acclimatisation in fish, and
- what types of effect acclimatisation has on production parameters

Subproject 7. Tailor-made studies on development of feeds and feeding (1996-)

Tailor-made studies usually lasting one growth season are being conducted for the feed industry. The subjects of the contracts are related to the composition of feeds and to feeding techniques, using the results and experience from Subprojects 3, 4 and 5.

Methods

Owing to a broad scope of the field of research, a wide variety of research methods are being used. Subprojects for development of an environmental steering system for fish farming are mainly based on questionnaires, theme interviews and methods of decision analysis while the research for developing feeds, nutrition and feeding practices is more biologically oriented. In biological research, internationally approved methods for fish physiology, nutrition and feeding studies are being applied. Special emphasis has been placed on validity of the statistical design of the experiments to reduce the risk of uncertainty for end-users and decision-makers. New research techniques have been developed, especially in Subproject 3, that have led to active international collaboration.

Resources

Estimated labour costs are 4-5 person work-years and FIM 2 million annually, for a total of about 23 person work-years and FIM 10 million by the end of 2001.

2.3.2. Diversification of aquaculture production 1996-2001

Background

Cultivation of fish for human consumption in Finland has focused on one species, rainbow trout, during its 20-year-old history as a farmed fish species in the country. Marked changes occurred in the fish market during the 1990s which revealed that it is too risky to base the aquaculture industry on one species. The greatest change was that the market value of rainbow trout decreased about 50% in 10 years (Fig. 6). Another important alteration was the opening up of the fish market which led to increased imports of fish. The most serious competitor is Norwegian salmon imports of which increased rapidly to 4 million kg, its market value being about one third that of Finnish rainbow trout. Having alternative species for commercial fish cultivation is considered necessary for positive development of the aquaculture industry.

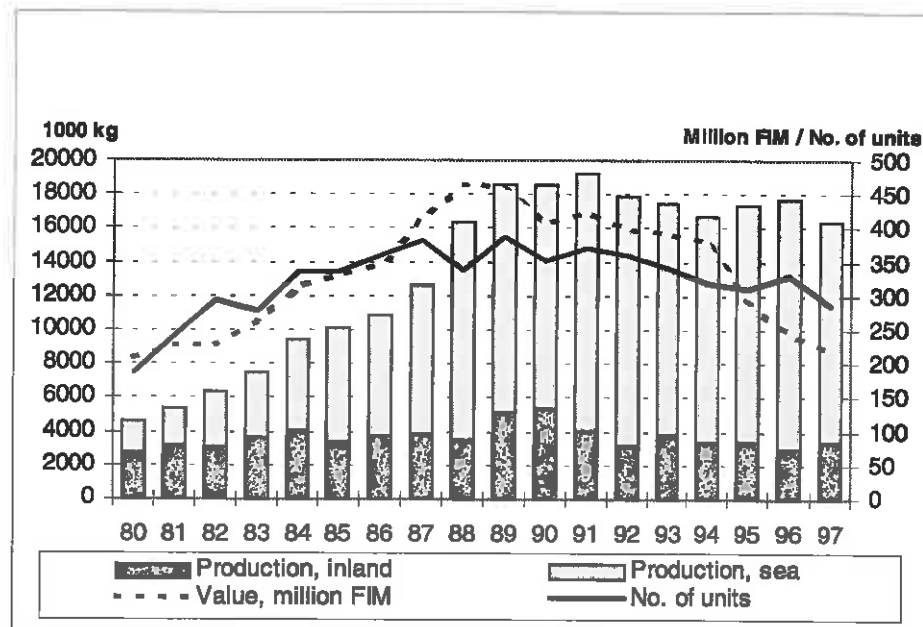


FIGURE 6. Food fish production in Finland, real market value and number of production units in 1980-1997.

Objectives

The main goal of this project is to produce new information that would make it possible for a new species to improve its position in Finnish aquaculture. To avoid the risk of choosing the wrong species or of problems concerning research objects, the project was divided into 3 phases. In the first phase, species with the best possibilities in the fish market were chosen. The second phase assessed the key problems in production using bioeconomic models. The third phase involves tackling the most important production problems by means of experimental studies.

Subprojects

Subproject 1: Feasibility studies 1996 - 1999

The potential of new species for commercial cultivation was analysed by studying market demand and farming prospects (availability of seed material, suitability to Finnish climatic conditions and farming know-how). According to these analyses, perch (*Perca fluviatilis*), pike-perch (*Stizostedion lucioperca*) and whitefish (*Coregonus lavaretus*) have the best market possibilities for commercial cultivation. On the other hand, whitefish and Arctic char (*Salvelinus alpinus*) have the best farming prospects.

The farming process for whitefish, perch and crayfish (*Pacifastacus leniusculus* and *Astacus astacus*) has been analysed using bioeconomic influence diagram analyses. The analysis for whitefish was based on a scenario of 3-season farming: the first inland, 2 others in brackish water net cages in the Finnish Archipelago. The analysis for perch was based on a scenario in which wild perch are caught in spring, kept in net cages and either fed or not. The analysis for crayfish was based on a scenario, in which table-crayfish farming began with one-summer-old fry (eggs incubated with heated water).

According to these analyses, the profitability of whitefish cultivation is mostly influenced by mortality, growth rate and feeding costs. The economics of wild perch cultivation are influenced strongly by the availability of proper-sized fish, their ability

to learn to eat in net cages and the development of end product prices during early summer. In the case of signal crayfish, the central variables that can be influenced through research are the production costs or price of fry, density of the crayfish during cultivation, crayfish mortality and crayfish growth rate. So far, whitefish and crayfish have passed on to the third phase where the most important production problems are studied by means of experimental studies.

Subproject 2: Whitefish research 1997 - 2001

At the moment, problems in the profitability of whitefish cultivation (slow growth rate, high feed costs and mortality) are mainly due to the fact that farming practices adopted from cultivation of the other salmonids are poorly suited to whitefish. Problems in the profitability of production have been identified by studying feeding behaviour, nutritional requirements and disease resistance. The effects of water temperature, growing density, amount of feed, length and frequency of feeding time, as well as the effects of feed quality on feed intake and growth of whitefish, have been clarified. Protein is the most expensive component of fish feed, and it is also the most important factor in nutritional loading. For this reason, studies on both protein requirements and different protein sources are included. The mortality of whitefish during the mariculture phase is reduced by means of investigating the causes of mortality (diseases and parasites) as well as by testing the effects of commercial bivalent vaccines against furunculosis and vibriosis.

According to the results, the feeding behaviour of whitefish can be optimised, thereby increasing their growth rate and the profitability of production. Feed intake can be improved by giving feed during day light hours at a suitable frequency. Restricting feeding during short periods leads to a reduced growth rate but does not cause aggressive behaviour.

Studies on improved disease resistance and nutritional requirements have been initiated in 1998. It appears that commercial vaccines give good protection to whitefish. According to the growth results we have managed to design a basal diet that can be used in further studies on the amino acid requirements.

Subproject 3: Crayfish research 1997 - 2001

The main goal of this subproject is to develop intensive and semi-intensive techniques for economically profitable production of crayfish through cultivation. The most important factor in economically profitable production proved to be the market price of the one-summer-old juveniles that are used as starting material for intensive and semi-intensive cultivation. In addition, profitability may increase by reducing mortality during cultivation, increasing rearing density and improving growth rate.

The main challenges are to develop simple and easily handled shelters to minimise the mortality caused by cannibalism, to determine the best rearing density and to analyse the effect of age and sex sorting on growth and survival rates. Research on intensive cultivation technique goals e.g. shortening the long natural cultivation cycle of crayfish in Finland, calls for new research information on crayfish biology and cultivation technology. Moreover, research is needed to determine the nutritional demands of crayfish to be able to develop nourishing and tasty feed for intensive and semi-intensive cultivation.

Methods

In feasibility studies both postal and phone surveys have been conducted. Farming processes for different species have been analysed using the bioeconomic influence diagram method. This method was chosen because it makes it possible to handle and describe factors and relationships between factors that contain a large amount of

uncertainty. Cultivation of new species involves much uncertainty due to lack of experience and research-based information.

Biological research is mainly carried out in the laboratory, where accurate manipulation of environmental conditions is possible and enables setting of experimental variables. Research will also be conducted under semi-intensive conditions (cultivation of crayfish in earthen ponds and fish in net cages) when appropriate. Internationally approved research methods are applied, such as individual monitoring of the growth rate of tagged fish, X-ray technique for appetite measurement and dose response method for studies on nutritional demands. Diseases are monitored by parasitological and bacteriological methods, and the effects of different vaccines are studied using challenge tests and antibody measurements (ELISA).

Resources

The total annual cost of the project is approximately FIM 2-2.5 million. The project requires about 4-5 person-workyears per year. The FGFR1 covers 60-70% of the total cost of the research programme and the rest of the funding is obtained from several sources.

2.3.3. Biodiversity and aquaculture 1997-2000

Background

Natural populations of salmonid fish have weakened dramatically in Finland, and many of these populations today are subject to large-scale aquacultural measures. Reproduction of several endangered fish species (such as landlocked salmon and arctic charr) is dependent almost totally on aquacultural measures. Catches of salmon in the Baltic are also based on cultured fish stocked as smolts in the sea. The prevalence of the yolk-sac fry mortality syndrome has weakened naturally reproductive salmon stocks in the Baltic, and underlines the importance of preservation of these fish stocks in hatcheries. Stocking of salmonids makes possible a substantial recreational fishery and provides a source of livelihood in rural areas.

The preservation of genetic diversity in endangered fish stocks is related to the quality of rearing methods in hatcheries on the one hand and to fishing regulations and the condition of watercourses on the other. Several factors may affect genetic biodiversity in aquaculture (Fig. 7). Hatchery broodstocks are usually founded by catching mature fish from the sparse populations in the wild, and then mixing the eggs and milt of these fish. This is the crucial stage that directly affects the genetic structure of cultivated populations. The number of individuals used as founders and the mating procedure followed determine the limits of the possible genetic structure and variability of a broodstock. Incubation of the eggs and subsequent rearing may affect the survival of fertilized eggs to maturity, and by that way to the biodiversity which is achieved at the maturity of each broodstock. The effectiveness of aquacultural processes in maintaining biodiversity are expressed in the genetic structure of the next generation.

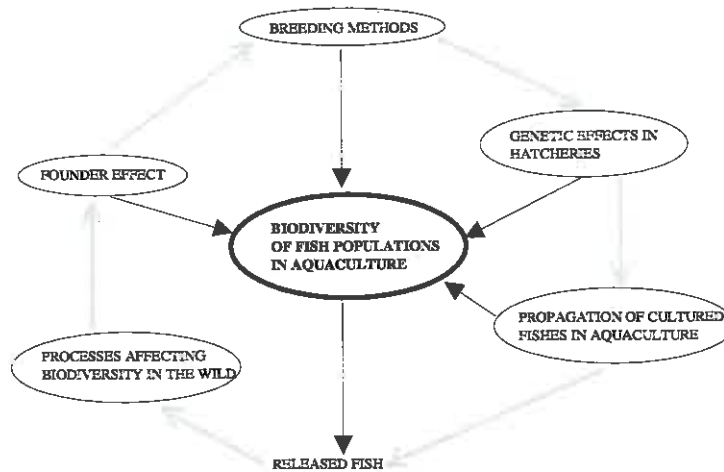


FIGURE 7. Factors affecting biodiversity in an aquacultural rearing cycle.

Objectives

The aims of the research are to examine the effects of breeding practices and rearing processes on the genetic diversity and phenotypical variation of fish stocks maintained in farms to gain information on the efficiency of aquacultural procedures for maintaining the diversity of fish stocks. The results will be applied in practical hatchery routines for creating feasible methods for maintaining biodiversity.

Subprojects

Subproject 1. Maintaining biodiversity in broodstock fish farming (1997-2000).

The genetic structure of broodfish is examined and a new broodstock founded by using family-based matings and taking equal amounts from progeny of all families. Parentage analysis of dead fry and juveniles of this new broodstock allow us to determine whether differing mortality occurs among families under aquacultural conditions. We also study the phenotypic variation in egg quality, fertilization and hatching success of separate families of Baltic salmon and the effects of aquacultural processes at different stages of the rearing cycle on maintaining the diversity observed in parents. The results to date show that at the early developmental stage viability is significantly dependent on female and male properties and also female-male crossing pairs.

Subproject 2. Kinship effects in reproductive success (1997-1998).

In this subproject the kinship effects on fertilization success and viability at early developmental stages and on juvenile growth were studied. Rainbow trout from the selective breeding programme are used as experimental fish. No effects of moderate inbreeding on the survival of eggs at the early developmental stage were found. The variation among females was marked. Inbreeding resulted in reduced specific growth rates in juveniles and this effect increased with increasing rates of inbreeding.

Subproject 3. Comparison of the effects of hatchery and natural environmental conditions on the viability and genetic structure of cultivated juveniles (1997-2000).

The aim of this subproject is to examine whether certain families (genotypes) are favoured under farming conditions and others in the wild. In landlocked salmon we study genetic variation between hatchery stocks and stocked fish after maturation in a lake. In hatchery groups, stocked eggs and broodfish the differences in genetic structure in the hatchery and the natural environment can be examined. The persistence of landlocked salmon in Lake Saimaa is entirely dependent on stocking activities. Microsatellite variation showed that hatchery supplementation of wild stock has not markedly changed the genetic composition of the population in the past 10 years.

Subproject 4. Alternative aquacultural measures for maintaining diversity of fish stocks

In the planning phase.

Methods

Individual-based fertilizations, family-based incubation and culture in the first summer, and individual tagging enables collection of individual survival and growth data. Rearing experiments will be carried out on both an individual and a family-basis under farming conditions to determine the various aquacultural effects on the fitness of broodfish. Egg and fry size are measured by image analysis. Genetic variation is measured by microsatellite variation in DNA.

Resources

The total cost of the project was FIM 0.7 million in 1997 and 1.5 person work-years.

2.3.4. Selective breeding in farmed rainbow trout 1992-2001

Background

The genetic diversity of rainbow trout is being put to use in a selective breeding programme. Aquaculture became an important fishery sector in the 1970s and its growth continued during the 1980s. It was already observed during early 1980s that genetic improvement of the production features is an important tool in the positive development of the sector. In 1980-1985 the FGFRI, the Agriculture Research Centre and the Academy of Finland carried out a joint project that examined existing rainbow trout stocks in Finland, assessed the economic profitability of the breeding programme, and instituted the first breeding scheme. In 1986-1992, a pedigree population was founded for the breeding programme by crossing the four best stocks from 2 generations. In 1991-1998, the breeding programme was tested and developed. A breeding station has been bought and equipped, methods have been developed and tested and a project organisation has been created.

Objectives

The goal of the aquaculture industry is to enhance those characteristics of rainbow trout that have real economic importance. At the moment, the selection criteria include growth rate and maturation age. A goal in the near future is to enhance the growth rate such that a 2-year production cycle is possible without earlier-than-normal spawning and starting with warmed water. In addition, the goal is to improve the

breeding programme for fish, including methods for measuring new traits, computer-based data collection, identification of fish individuals and breeding models.

The tasks of the project are to plan the breeding scheme, handle the different phases in the farming cycle at breeding and test stations, measure and evaluate breeding traits, and choose the parents of the next generation. The Aquaculture Unit is responsible for practical farming of the breeding population and marketing the products.

Methods

Pedigree registers are maintained, genetic parameters and breeding values are estimated using a relationship matrix and genetic enhancement estimated using multivariate analysis. Identification of families is based on a combination of cold-branding and fin-clipping methods, and individuals are identified using ID-tags. In addition to length and weight measurements many different dimensions are measured using image analysis.

Results

The most important measurement taken in the selective breeding programme is the genetic advancement of selected traits. In 2 generations the growth rate has improved according to predictions, i.e. about 10% per generation.

Resources

Resources needed for different areas of the selective breeding programme have been 5.5 person work-years and FIM 3.7 million per year in total and the SEA accounts for 1.2 person work-years and FIM 1.5 million.