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FINNISH GAME AND FISHERIES RESEARCH INSTITUTE

Aquaculture Unit

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1. GENERAL

The economically most important component of Finland's fish stocks - river spawning species - has been disturbed by anthropogenic activities starting over a century ago, and has suffered in particular from water engineering and water level regulation activities. The accelerating disappearance of migratory fish caused by power plant construction since the 1940s has led both to extensive obligatory and other stocking of juveniles and to the need for breeding programmes to preserve endangered fish. Finland has seen the latter as a task for the State because of the implications of such work for society and extensive character of the efforts involved. International commitments, including the Rio Convention and various EC directives, have further emphasised Finland`s obligation to preserve its original fish stocks and genetic diversity.

Due in large part to those obligations, Finland has in recent years begun paying greater attention to the origins of the juveniles used for stocking so as to reduce the degree to which populations differentiated to suit particular local habitats become mixed with each other. The view taken within the Finnish fisheries system is that aquaculture practised by the State is best placed to safeguard the continuing availability of the genetic material - eggs and fry originating from known differentiated local populations - needed to cultivate fish for stocking purposes.

The Finnish Game and Fisheries Research Institute (FGFRI) and its aquaculture activities have had and retain a central role in the preservation of original fish stocks. The organisation of State aquaculture, the development of personnel skills, the geographical location of aquaculture stations and the maintenance of high standard to ensure the success of cultivation are all geared primarily towards this principal goal. The depletion of wild populations has accentuated the importance of building up brood stocks to ensure supplies of eggs and fry. As the rate of natural reproduction of migratory species diminishes and fishing pressure on them increases, extensive stocking has become an essential requirement for the preservation of many species and stocks. Since this is nowadays mainly based on eggs produced at the FGFRI's stations, State aquaculture also plays an important role in reviving stocks of migratory species and ensuring that they remain at levels permitting them to be fished.

2. DEVELOPMENT OF STATE AQUACULTURE ACTIVITIES

The State has engaged in aquaculture in Finland since the mid-19th century. To start with, hatcheries were built to produce salmonidae fry for stocking, because it was believed that populations of these species were in decline. As early as 1892, however, a facility for aquaculture research and experimental cultivation was opened as an extension of the Evo fishery research station. It is one of Europe's oldest facilities of its kind.

Growing concern for the future of fish stocks, especially as many migratory populations had been destroyed by water engineering schemes, led to the launch of the central fish breeding station programme in the mid-1960s. The idea was to build four large stations, one each in northern, eastern, western and southern Finland, with the aim of building up brood stocks to produce eggs, especially those of endangered species and stocks (e.g. Siltamaa & Westman 1992). The first three were completed in the 1970s and 1980s, but the one in southern Finland was never built, egg production being decentralised to other State-run stations for fear of the risk of fish diseases. The central fish breeding station programme was abandoned in the late 1980s and the State's aquaculture activities were reorganised on a new basis.

Until 1971, State aquaculture came within the ambit of the fisheries authorities. In that year the Ministry of Agriculture and Forestry's fishing and hunting department transferred its six aquaculture stations and their budget allocations to the recently established FGFRI. This reorganisation was carried out because aquaculture was not seen as belonging to the Ministry's sphere of activity; instead, it was deemed more appropriate to entrust the Institute's Fisheries Research Department with responsibility for aquaculture-related research and development and for preserving stocks of valuable fish, work that required special expertise in relation to genetics. Another important reason was the need to provide the Institute with suitable research facilities.

To streamline cultivation and research and avoid overlap, all of the State's aquaculture-related functions were transferred to the Institute's Aquaculture Department, which was set up in 1988. Aquaculture research remained the responsibility of the Fisheries Research Department. The administration of the Institute was reorganised in 1993 to bring it into line with the requirements of management by results, and since 1 January 1994 the State's aquaculture functions have been handled by the Aquaculture profit centre (hereafter referred to as Aquaculture Unit), with the exception of cultivation research, which is assigned to the Socioeconomic and Aquaculture Research profit centre.

3. GOALS AND OPERATIONAL PHILOSOPHY

3.1. Tasks

The present tasks and goals of the Aquaculture Unit have largely taken shape on the basis of the work of several committees and working groups (e.g. Ohtaoja-committee 1971, Fisheries Target Committee 1979, State Aquaculture Target Working Group 1988) appointed by the Ministry of Agriculture and Forestry and the Council of State in the 1970s and 1980s to examine the State`s role and involment in aquaculture. The private sector's fear of competition was one of the main factors that caused a need for a division of labour between private- and State aquaculture and obligatory stocking operations. The demarcation lines between these three categories are set forth in the reports of the above and in other bodies such as the Kemijoki and Iijoki Rivers Salmon Stocking Working Group (1984) and State Aquaculture Planning Group, which functioned in the 1980s. In the 1990s several studies and reports have again focused on the State's involvement in aquaculture; examples include the 1991 report of the Aquaculture 2020 Committee, the 1992 report of a working group that examined the development of the administration of fisheries and a 1992 report by the FGFRI on a scheme to rationalise the central administration. In addition to this, tasks and activities in the field of State aquaculture have been dealt with in the annual action plans, strategic plans and annual reports prepared by the Institute and the Aquaculture Unit and in numerous other studies and reports including more than 350 papers presented at 22 symposiums on State aquaculture (references in Kalatutkimuksia 110, 1996).

The objectives of the Aquaculture Unit have been defined as follows:

"To maintain indigenous fish stocks and their biodiversity by means of aquaculture and expertice, to enhance opportunities for fisheries and to promote commercial aquaculture ".

To attain these objectives, the Aquaculture Unit:

- Maintains endangered and indigenous fish stocks and their genetic diversity through aquaculture, stocking and milt banks;
- Produces high-quality and disease-free eggs and juveniles of fish and crayfish of known background to meet the requirements of conservation, research, State stocking obligations and other governmental and private demand;
- Produces by means of selective breeding high-quality material for use in private food fish culture;
- Takes care of the State's contract cultivation to ensure future fishing prospects in Finland and guarantee the preservation of endangered stocks; and
- Develops aquaculture products and technology and related quality management systems.

The demarcation lines between the spheres in which the State and the private sector operate are nowadays quite clear and undisputed. The preservation of endangered

species and stocks and of their biodiversity as well as the production of their and other farmed fish eggs is seen as a State task. In Finland the work has a social dimension, international obligations are involved, special expertise is required, genetic purity is an important consideration, programmes are long-term and interdisciplinary, and rewards are rarely immediate; therefore such activities lend themselves poorly to with commercial operations and private aquaculture. Other tasks felt to be best looked after by the State are international cooperation, selective breeding programmes requiring special premises and expensive equipment, and experimental and development activities.

It has been a deliberate policy of State aquaculture to engage only in activities that generally promote fisheries and aquaculture but are not commercially profitable and therefore would not interest the private sector. They are nevertheless vitally important for ensuring that both aquaculture and fisheries can continue to develop. A good example is provided by M74, a syndrome that causes high mortality in yolk-sac fry of salmon hatched from eggs gathered from the wild. Any stocking programmes based solely on these eggs would have collapsed. Eggs were, however, also available from the FGFRI's brood stocks, and stocking could be maintained at the level considered desirable. Thus salmon fishing has been able to continue in several rivers including the Torniojoki, Simojoki and Iijoki and these stocks have been preserved.

The present operational model, elaborated by the various State committees and working groups referred to above and in consultation with the private sector, in which the FGFRI concentrates on producing eggs and fry and the private sector on juvenile cultivation and food fish production, has worked well. The private sector has expressed satisfaction and emphasised that it is not interested in the aquaculture activities performed by the State, because these are not profitable in private commercial terms.

The scope and volume of the Institute's work are guided by the funding made available to it in the budget submitted to and approved by Parliament each year and in the programme of goals appended to the appropriation request. This programme contains specific sub-goals for aquaculture and details the amount of funding requested for this purpose. In addition to this, the Ministry of Agriculture and Forestry specifies a set of targets for the Institute each year, including some specifically for aquaculture. The Aquaculture Unit additionally helps to draft the submissions requested from the Institute each year and makes experts available for cooperation with other bodies both in Finland and abroad.

3.2. Vision

Aquaculture Unit has the following vision.

"Aquaculture has ensured the preservation of specialised fish stocks and of their biodiversity and safeguarded the availability of high-quality seed material. Its aquaculture products and services are acknowledged".

4. PRODUCTS, SERVICES, INTEREST GROUPS, CUSTOMERS

4.1. Products and services

Aquaculture Unit provides both society in general and private customers with goods and services. These include preserving fish species and stocks, providing juveniles of endangered species for stocking purposes or the revival of local populations, maintaining milt banks, supplying juveniles required for obligatory stocking, providing Research Units with fish for study purposes and giving expert advice, such as in drafting submissions to various authorities. The bulk of activities are connected with performing tasks for society, as is reflected in their high share (about 65%) of the total costs of aquaculture.

Products sold on a commercial basis include eggs, juveniles from both fish farms and natural food ponds, the eggs and fry of selectively-bred rainbow trout, and advanced farming methods, technology and equipment. Other sales involve tagging services, transportation and property-management services. The production of goods and products for sale accounts for about 35% of total costs.

Eggs are currently produced by brood fish representing 18 species and 66 separate stocks, in addition to two crayfish species. When needed, the eggs of several species/populations can also be obtained from wild fish. Eggs and fry are supplied in various stages of development according to clients' preferences. Separate lists of products are maintained for each aquaculture station. Information files presenting the fish and crayfish species most in demand and their egg and juvenile products for sale have been produced. Since the FGFRI is expected to cover a constantly increasing share of its financing requirement out of the revenues it receives for goods and services, it has increased its for-profit activities and the range and volume of aquaculture products for sale in recent years. Advances in cost-accounting methods have made it possible to determine the economics of individual products and focus on the most profitable ones.

Cooperation with Research Units has substantially improved the quality of seed material and dependability of delivery. Largely for this reason, private aquaculture interests are increasingly abandoning egg production and buying a growing proportion of their requirements from the FGFRI. As a result of production agreements, certain activities, e.g. salmon egg production, have now been entirely entrusted to the FGFRI. The Institute likewise handles a large proportion of the production of eggs of trout, whitefish and other farmed fish. Progress made in the selective breeding of rainbow trout has led to an increase in the volume of products sold in this category.

4.2. Interest groups and customers

The most important interest group, and also the biggest customer, is the fisheries authority. Others include the forestry administration, private interests in the aquaculture and fisheries sector, recreational fishers, researchers, companies and other bodies with stocking obligations, riparian owners, lobbies, advisor organisations, the environmental authorities, fish consumers and the public at large.

4.3. Cooperation in research

Aquaculture was organisationally separated from research within the Institute's framework in 1988. It was considered important that aquaculture and research should continue to be handled by the same Institute for several reasons, primarily because there is a direct link between the two and therefore the latest research data are quickly and directly available to the Aquaculture Unit, where they can be tried and exploited. Correspondingly, the Research Units quickly become aware of problems encountered in aquaculture and can study them immediately. Combining the two activities under within the same institute has further enabled the facilities of aquaculture stations to be used for both cultivation and research purposes. Because of the fluctuating need for personnel and equipment at different times, it is a considerable advantage that they can be used flexibly for both production and research functions.

The State aquaculture stations were designed and built with both production and research in mind, and their suitability for the two functions has been continuously improved. Many, for example, have separate, adjustable sections to permit fish and crayfish to be studied under experimental conditions. Some have closed areas where research relating to disease prevention and control can be conducted and for this reason the Institute has been able to engage in cooperation with veterinary researchers in such fields as the development of vaccines.

Of the many tasks involved in State aquaculture, that of preserving endangered species and their biodiversity is one that requires particularly close and constant contact between research into the status and genetic make-up of fish populations, on the one hand, and practical aquaculture, on the other. The State's obligations with respect to stocking also require close liaison between research and aquaculture. Thanks to the stocking-related research data at its disposal, the Aquaculture Unit can direct its egg and fry usage to ensure that the stocking material is either originally from the water body in question or, failing that, consists of otherwise suitable species and stocks.

In practice, cooperation with research has been arranged in the following way: the Aquaculture Unit informs the Research Units what topics need to be studied, and the latter decide how to implement the necessary programmes and say what fish material these will need.

The Aquaculture Unit and its stations collaborate not only with the Institute's own research units, but also with universities and other research institutes. In recent years, collaboration with universities (Helsinki, Kuopio, Turku, Jyväskylä, Joensuu and Oulu) and research institutes in such fields as veterinary medicine and feedstuffs has increased considerably. The areas of research in which collaboration has been practised relate to development needs that arise both in the Institute's own operations and in aquaculture more generally.

4.4. Goals with respect to use of products

There are three main goals in relation to the use of aquaculture products, services and expertise (Fig. 1):

1. To preserve fish stocks and their biodiversity

- preservation of endangered and differentiated stocks under aquaculture conditions
- revival of natural populations through stocking
- preservation of genetic material in milt banks

2. To promote commercial aquaculture

- production of eggs and fry for purposes of fish farming and research
- selective breeding for aquaculture
- development of aquaculture products and technology

3. To improve prospects for fishing

- management of valuable fish stocks in the Baltic
- fulfilment of the State's stocking obligations
- development of stocking management

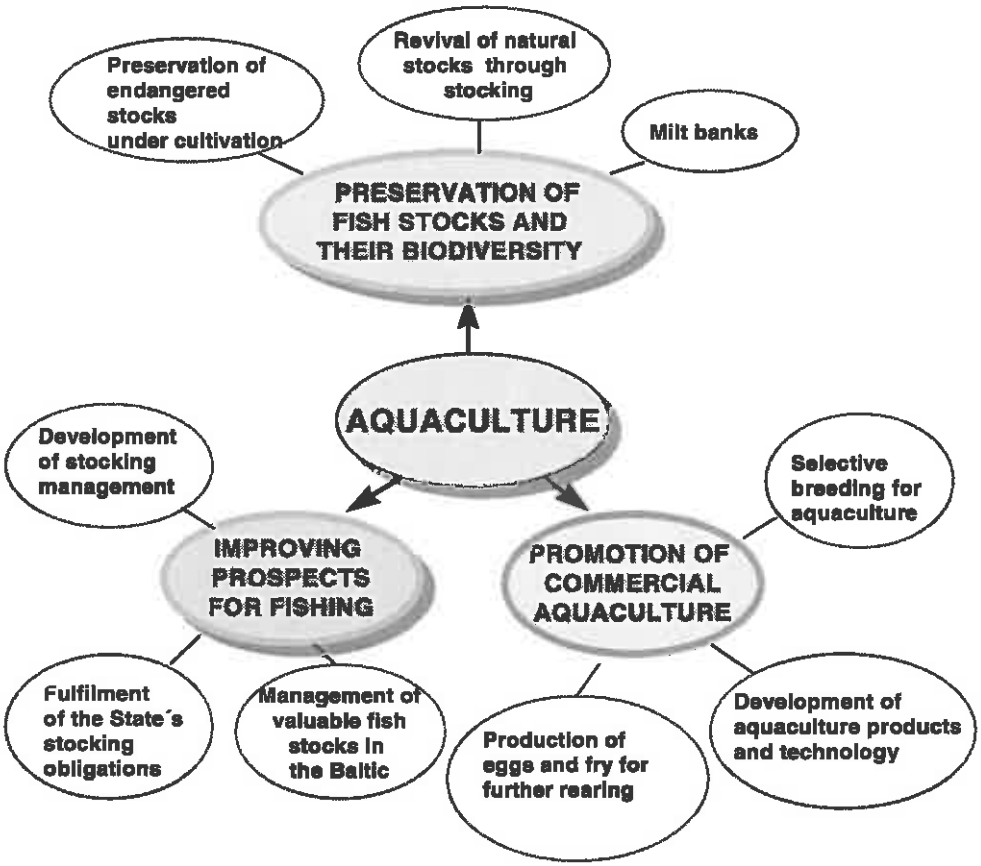

Fig. 1. Tasks of the Aquaculture Unit and intended uses of products

Fish and crayfish eggs and juveniles are sold to private fish farms as seed material. One third of the juveniles produced are sold and 50% are used to preserve and revive endangered stocks. In accordance with the result targets stipulated by the Ministry, the most important objects are salmon and sea trout stocks in the Gulf of Bothnia and the stocking programmes that the State is required to implement in the Lake Inari area. The remaining juveniles are used for renewing breeding stocks, for stocking in compensation for eggs taken from natural populations and for studying the management of fisheries.

The following section presents the tasks and activities of the Aquaculture Unit and the goals set for the use of its products.

5. PRESERVATION OF FISH STOCKS AND THEIR BIODIVERSITY

The primary goal of fish stock protection is to ensure that Finland`s indigenous fish species and their various genetic variants can continue to naturally reproduce in their natural environments. In the long term, the genetic representativeness of a species and its internal variation can be retained only in a natural habitat, where the diversity of the environment maintains the genetic variation. Unfortunately, Finnish fish stocks and their biodiversity have long suffered either directly or indirectly from the effects of habitat change (e.g. water engineering, pollution, acidification), excessive and/or selective fishing and unplanned stocking (new, competing species or alien populations of the same species). These factors combined with diseases and the M74 syndrome in salmon still pose the greatest current threat to existing fish stocks.

Habitat changes have been particularly harmful to the economically most valued species, that is, river-spawning fish. As a result many differentiated stocks of Atlantic and landlocked salmon, sea and brown trout, anadromous whitefish and lampreys have been lost. Many of the remaining populations have declined and are now threatened, their natural reproduction having been jeopardised due to their dwindling numbers or made impossible by regulation and/or damming of waterways. Without management measures, many populations would not be able so survive.

The accelerating destruction of stocks of anadromous fish after the 1940s, especially as a result of power plant construction, created a growing need to preserve fish with the aid of aquaculture. Indeed, the central goal of State aquaculture since the late 1960s has been to preserve stocks of economically-valuable species, and to revive and restore them. These tasks are also very much in line with the goals enshrined in articles 9 a, b, c and d of the Rio Convention, which Finland ratified in 1994. Likewise in alignment with the Rio Convention are most of the key points in the "Finnish National Programme of Action to Preserve Biological Diversity in the Period 1997-2005". This provides for protection to be arranged for endangered fish species and stocks by means of ex situ measures i.e. in fish farms and the use of these for restorative stocking (task no 60). It must additionally be ensured that adequate selections of fish are available to ensure, through aquaculture, the preservation of populations that have declined and the availability of high-quality, disease-free eggs (task no 29). Where these tasks are concerned, implementation has been entrusted to the FGFRI both in the national action programme mentioned above, in the report of the "Fish Protection Group" of the Ministry of Agriculture and Forestry and the Ministry of Environment (1996) and in the "Natural Resources Strategy" of the Ministry of Agriculture and Forestry (1997).

Of all the tasks entrusted to the Aquaculture Unit, the most important, most comprehensive and most obligating both nationally and internationally is that of ensuring that the still remaining indigenous species and stocks that have become endangered in Finland are kept, with the aid of aquaculture, as genetically diverse as possible. To this end, stocks are preserved at stations (living gene banks), stocking measures are implemented to revive declined populations in their original and new habitats, genetic material is preserved in milt banks, and high-quality eggs of original species and stocks are produced for the use of private as well as State fish farms. The FGFRI`s aquaculture stations were largely designed and built specifically to serve

these purposes. The Institute is, in fact, the only organisation in Finland that takes international obligations and agreements into consideration in preserving fishstocks through aquaculture.

5.1. Preservation of endangered and differentiated stocks by means of aquaculture

All of Finland's economically most important indigenous fish stocks are preserved at the Institute's aquaculture stations. These include all of the remaining salmon (*Salmo salar*) stocks (Torniojoki, Simojoki, Iijoki and Tenojoki), the Saimaa landlocked salmon (*S. salar* m. *sebago*) and arctic charr (*Salvelinus alpinus*), 23 sea trout (*S. trutta* m. *trutta*) and brown trout (*S. trutta* m. *lacustris* and *S. trutta* m. *fario*) stocks, 15 whitefish stocks (e.g. *Coregonus lavaretus*, *C. muksun*, *C. pidschian*), 10 grayling stocks (*Thymallus thymallus*), the asp (*Aspius aspius*) and several other stocks. All in all, 58 different stocks representing 13 original fish species and variants in addition to the crayfish are preserved (Table 1, Fig. 2). In addition to these, the Montta salmon stock was recently added to the aquaculture programme. In addition to indigenous species, several introduced ones are likewise cultivated. Among them are the lake trout (*Salvelinus namaycush*), carp (*Cyprinus carpio*), rainbow trout (*Oncorhynchus mykiss*) , peled whitefish (*C. peled*), brook trout (*S.fontinalis*), Hornava charr and signal crayfish (*Pacifastacus leniusculus*), 11 stocks in all, one of which, the River Neva salmon, is disappearing from its original habitat.

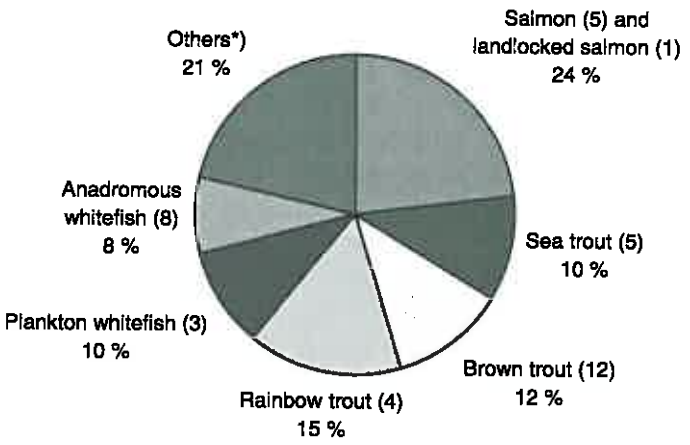

Fig. 2. Percentages of total biomass (111,000 kg) at the Institute´s aquaculture stations represented by fish over 3 years old in autumn 1996 (with the numbers of different stocks shown in parentheses). Others *): non-migratory brown trout (5), lake trout (2), arctic charr (3), brook trout (1), grayling (9), vendace (1), peled whitefish (1), sparcely raked whitefish (2), asp (1), carp (1), pikeperch (2).

Indicative of the comprehensiveness of this programme is the fact that all of the species and variants listed as "very endangered" by both the "Follow-up Committee for Endangered Animals and Plants" (1991) and the "Fish Protection Group" (1996) - the landlocked salmon, sea and brown trout, plankton whitefish and asp as well as the Baltic salmon designated by the former and the Saimaa charr designated by the latter- are now maintained at State aquaculture stations. At the moment, there is no awareness of a need to include new economically significant fish species or stocks in aquaculture programmes. With respect to certain trout populations, preservation needs are currently being studied.

No fish species of economic insignificance are being cultivated, but should ongoing studies indicate a need for this, the FGFRI has the capacity to expand the scope of its activities. The general expectation is that a growing emphasis on environmental values, fish diseases, the Rio Convention and EC regulations will step up demands for the preservation of fish and their biodiversity as well as for supportive stocking.

Maintaining fish by means of aquaculture is not an end in itself. If the level of protection called for in the EC´s Habitats Directive, i.e. the species has an independent capacity to remain viable over the long term, can be achieved, culture of this species could be discontinued. However, despite increased management measures such as regulation of fishing and habitat rehabilitation, the EC protection level has not been achieved for any of the species or stocks in the Institute`s aquaculture programmes.

The brood fish at the Institute's stations totalled about 116,000 at the beginning of 1998 and had a biomass of approximately 116 tonnes (Table 1). In the case of several stocks, the number of brood fish is a good deal higher than the preservation of biodiversity would actually require, because it has been determined on the basis of the amount of eggs and juveniles that need to be produced for purposes of sale or stocking. Using brood fish as a source of eggs ensures among the many other benefits greater dependability of supply than taking eggs from wild fish (e.g. Westman 1993).

The brood fish stocks at the stations are renewed using eggs extracted from wild fish. In the cases of some stocks in harnessed rivers and of other rare natural populations, however, this is not always possible or is very difficult (the River Iijoki salmon, the Saimaa charr and some trout populations are examples of this). As needs and opportunities dictate, juveniles caught in the wild and transferred to stations are also used to rear new brood fish. This is done in an effort to preserve biodiversity and prevent selection in culture. As a guide to this activity, the backgrounds of the fish have been explored (e.g. Kallio 1989) and their genetic diversity has been studied using for example enzyme electrophoretic methods (e.g. Koljonen 1991). Continuous monitoring of the state of the species and stocks maintained at the stations and genetic comparison with wild fish have begun in collaboration with researchers using the latest methods e.g. the microsatellite technique. The aim is to achieve breeding stocks in which all species and strains have genetic make-ups as close as possible to those found in fish remaining in the wild (e.g. Piironen 1996). The methods to renew brood stocks so as to maintain biodiversity in populations are currently being reviewed in collaboration with the Research Units.

TABLE 1. Brood fish stocks in spring 1998 (fish: 66 stocks, of which 60 in egg production, crayfish: 2 species) as well as production of eggs and newly-hatched fry in 1995-97 and an estimation for 1998.

			Brood fish at the beginning of 1998		Eyed eggs/newly-hatched fry 1,000s			
Species	Stock	Yearclass	No.	kg	1995	1996	1997	1998
Salmon, Atlantic	Tenojoki	1995	3 523	237	0	0	0	0
Salmon, Baltic	Iijoki	1985-94	2 700	2 589	2 239	1 014	1 804	1 050
Salmon, Baltic	Simojoki	1986-95	1 341	2 554	792	778	730	1 200
Salmon, Baltic	Neva	1988-94	2 138	4 913	1 637	2 079	1 560	2 100
Salmon, Baltic	Tornionjoki	1985-95	6 692	10 808	3 915	3 240	3 340	4 000
Landlocked salmon	Vuoksi watercource	1987-95	7 681	6 829	2 041	1 135	1 132	1 740
Sea trout	Ingarskila	—94	315	290	30	63	60	420
Sea trout	Tornionjoki	1985-93	808	1 934	1 864	1 596	1 150	1 360
Sea trout	Iijoki	1987-93	1 167	2 049	935	1 046	866	1 050
Sea trout	Isojoki	1987-93	671	971	406	346	559	500
Sea trout	Lestijoki	1991-94	816	925	972	1 006	544	290
Brown trout (*Salmo t.* m *lacustris*)	12 stocks a)	1985-95	14 920	16 113	5 816	4 488	5 280	7 200
Brown trout (*Salmo t.* m. *fario*)	5 stocks b)	1984-95	1 633	2 000	975	946	791	830
Lake trout	L. Superior	1977-89	1 068	3 827	614	404	1 150	1 200
Lake trout	L. Opeongo	1987-94	1 353	1 157	68	56	100	0
Charr	Inari	1990-93	1 142	1 433	472	742	770	470
Charr	Hornava	1993	213	441	0	0	0	20
Charr	Tornionjoki watercource	1987-88	106	76	0	49	20	10
Charr	Kuolimo	1985-94	6 043	6 516	32	163	409	390
Brook trout	U.S.A.	1990-93	174	314	146	27	200	230
Rainbow trout	U.S.A.	1994	517	569	161	239	200	150
Rainbow trout	breeding	1993-97	20 917	17 597	1 635	1 692	1 653	1 700
Grayling	10 stocks c)	1983-96	14 928	7 316	8 795	13 415	11 610	11 900
Vendace	diff. stocks	1991-95	1 000	100	319	250	300	1 500
Whitefish (*C. peled*)	Lake Endyr	1985-92	442	317	1 040	877	700	2 100
Whitefish (*C. muksun*)	3 stocks d)	1985-94	10 021	10 700	41 797	44 953	33 845	44 700
Whitefish (*C.pidschian*)	2 stocks e)	1986-92	3 426	4 906	6 837	6 936	9 585	10 500
Whitefish (*C. lavaretus*)	Kuusinkijoki	1990	280	700	4 925	2 365	3 000	6 600
Whitefish (*C. lavaretus*	sea, 6 stocks f)	1986-95	8 954	6 950	23 155	16 891	24 503	24 500
Asp	Kokemäenjoki	—90	22	21	0	472	400	400
Pikeperch	2 stocks g)	1987-94	1 275	395	3 104	2 552	4 000	2 500
Carp	Aneboda		123	411	1	170	520	100
Total			116 409	115 958	114 723	109 990	110 781	130 710
Crayfish	domestic		1 458	58	35	30	31	20
Signal crayfish	U.S.A.		2 051	67	31	92	100	90

a) Juutuanjoki, Kiellajoki, Siuttajoki, Ivalojoki, Kirintö-Lohijoki, Kuusinkijoki, Kitkajoki (Jyrävän alap.), Rautalammin reitti, Kitkajärvi (Jyrävän yläp.), Vuoksen vesistö, Oulujoen vesistö, Montta

b) Kemijoki, Ohtaoja, Ounasjoki, Vaarainjoki, Luutajoki

c) Juutuanjoki, Kitkajärvi, Rautalamm.reitti, Iijoki, Kemijoki, Kitkajoki, Puruvesi, Lieksanjoki, Pielinen, Kajaaninjoki

d) Rautalammin reitti, Vuoksen vesistö, Sotkamon reitti

e) Ivalojoki, Kallunkijärvi

f) Kokemäenjoki, Kymijoki, Iijoki, Kemijoki, Tornionjoki, Kalajoki

g) Vanajavesi, Sonkajanrannanjärvi

The operating model of the FGFRI shows that fears of fish preserved at stations quickly becoming "degenerated" or "domesticated", i.e. that differentiation would take place between the genetic characteristics needed to survive in captivity and those essential for coping in the wild, were, fortunately, exaggerated. Research has demonstrated that, for example, the Iijoki salmon, which has had to be kept at Taivalkoski aquaculture station since the river was dammed in the late 1960s and is therefore the stock that has depended entirely on aquaculture for the longest period (Pasanen 1993, 1996), boasts the same heterozygotic degree as found in other natural salmon populations (Koljonen 1995). A further indication of the usefulness of systematic cultivation in the preservation of endangered fish is the fact that the salmon stocks maintained at the Institute`s stations are more heterozygotic than those originating from harnessed rivers in Sweden and maintained solely using eggs taken from wild fish (Koljonen 1995). Pasanen (1993, 1996) has attributed this as probably being due to the strong selection to which fishing subjects wild salmon, and which those in breeding stations are spared.

To increase the role played by natural selection in the cases of stocks that have already disappeared from the wild, stocking programmes have been initiated to relocate, for example, the Iijoki salmon in the nearby, unharnessed River Kiiminkijoki and the Saimaa landlocked salmon in the River Ivalojoki. The aim is to subject also the juvenile stage to natural selection and thereby ensure that the stock remains viable, but also to make it possible to obtain eggs from fish returning to the river. The best way to ensure the greatest possible degree of biodiversity in stocks is to use the eggs and juveniles of fish at breeding stations and in the wild as well as captured wild juveniles to breed new generations of fish and eventually to use also frozen milt taken from a large number of males.

The fish stocks maintained at the Institute's stations represent a unique living gene bank even in a European context. Finland is undeniably in the forefront of nations that use aquaculture to preserve fish.

The principles, objectives and methods of brood fish cultivation and fish preservations have been dealt with by a number of authors (e.g. Kallio 1986, Koljonen 1986, 1993, Eskelinen 1991, Westman 1993, Pasanen & Juntunen 1994, Piironen 1995, 1996, Vaajala 1995). The subjects has also been discussed at nine State aquaculture symposia; in 1993 it was the main topic (Westman 1996). In addition, a number of reports have been published on the preservation of individual species and stocks with the aid of cultivation (e.g. Piironen 1990, Pasanen 1993, 1996).

5.2. Reviving natural populations by means of stocking

To revive fish populations that have declined and help restore them to their natural habitats, the FGFRI has long been releasing salmon, sea trout, landlocked salmon, Saimaa charr and anadromous and plankton whitefish juveniles of various ages into natural water bodies, including vacated spawning areas. The most extensive stocking operations have been carried out to revive depleted populations of salmon in the Tornionjoki and Simojoki, the only unharnessed rivers that are home to these stocks (Table 2). These operations are carried out on the basis of the annual targets set by the Ministry of Agriculture and Forestry. The juveniles used are bred both at the Institute's own stations and at private ones under contract.

TABLE 2. Stocking by the Institute in 1994-1998 to revive declined fish strains (in thousands of juveniles).

j = juvenile; s= smolt

SPECIES	1994		1995		1996		1997		1998	
Stock	j	s	j	s	j	s	j	s	j	s
SALMON										
Tornionjoki	853	33	734	62	541	51	708	126	680	171
Simojoki	137	26	253	69	195	139	217	145	220	96
Iijoki	110	4	240	22	74	33	104	21	97	29
LANDLOCKED SALMON										
Vuoksi watercource	50	58	48	75	62	119	0	73	1	81
SEA TROUT										
Tornionjoki	150	4	352	9	148	141	127	15	276	4
Iijoki	83	2	45	55	51	21	50	17	50	5
Lestijoki	7	61	46	67	28	47	5	22	30	19
Isojoki	1	6	0	11	0	3	0	10	0	13
Ingarskila	3	2	3	17	0	13	0	0	0	11
ARCTIC CHARR	1-y.	2-and >2-y.	1-y.	2-and >2y.	1-y.	2-and 2-y.	1-y.	2-and>2y.	1-y.	2- ja >2-y.
Kuolimo	42	24	2	21	0	21	21	2	41	20
ANADROMOUS WHITEFISH	1-summer-old		1- summer-old		1- summer-old		1-summer-old		1-summer-old	
Tornionjoki	336		158		120		150		112	

In 1997, in accordance with the Salmon Action Plan (SAP) adopted by the International Baltic Fisheries Commission in 1996, the FGFRI began an extensive resettlement programme by releasing 106,000 smolts and 99,000 juveniles of the Tornionjoki salmon stocks into the Pyhäjoki. The intention is to establish salmon in a number of former salmon rivers flowing into the Bay of Bothnia (Table 3) in order to help salmon populations to revive with the aid of natural reproduction. This work follows a stocking and resettlement plan for salmon, sea trout and migratory whitefish recently completed by the Institute.

TABLE 3. The Institute has made preparation to stock the following numbers of salmon juveniles and smolts to meet its obligations under the Salmon Action Plan (SAP) in 1999-2002 (1,000s).

A. Rivers with natural stocks B. Rivers with stocks to be revived

River	Tornionjoki		Simojoki			Kuivajoki		Kiiminkijoki		Pyhäjoki	
Stock	*Tornionjoki*		*Simojoki*			*Simojoki*		*Iijoki*		*Tornionjoki*	
Year	juv.	smolt	juv.	smolt		juv.	smolt	juv.	smolt	juv.	smolt
1999	600	60	160	70		35	30	120	30	80	73
2000	600	60	140	50		35	40	120	70	80	50
2001	600	60	120	50		35	40	120	60	80	50
2002	600	60	120	50		35	40	120	60	80	50

In the cases of many populations, stocking with cultivated juveniles will be a permanent task, because harnessing and other use of the water bodies in question have extensively destroyed natural opportunities for reproduction, especially for anadromous fish. Moreover, hydroelectric dams prevent anadromous fish from reaching any spawning beds that may remain intact upstream. Overfishing likewise poses a threat to many of populations, in addition to which it detracts from the effectiveness of stocking programmes. Without cultivation and stocking, many of Finland`s indigenous fish stocks, such as the Saimaa landlocked salmon and charr, the Iijoki and Simojoki salmon and the Tornionjoki and Lestijoki sea trout would have already disappeared and many other populations would be on the brink of extinction.

5.3. Preserving populations in milt banks

Fish genetic material can also be preserved in deep-frozen form in milt banks (e.g. Piironen 1991). The FGFRI has preserved the milt of the Tenojoki and Näätämöjoki salmon, the Saimaa landlocked salmon and charr, three populations of brown trout, two populations of plankton whitefish and seven populations of anadromous whitefish in liquefied nitrogen. Freezing techniques suiting different species are under development and the intention is to have stores of milt of all endangered species and stocks in banks within a few years. In collaboration with the Norwegians, the Tenojoki milt bank is being expanded. The use of frozen milt will also enable the genetic diversity of brood fish at the Institute's stations to be broadened.

6. PROMOTING COMMERCIAL AQUACULTURE

The aim is to support commercial aquaculture by producing high-quality, disease-free eggs and fry from fish with known backgrounds, by collaborating with the Research units to breed an economically more profitable variety of rainbow trout and by developing new products, aquaculture methods and technology.

6.1. Production of eggs and juveniles for rearing and research

The aim is to ensure that eggs and juveniles of fish and crayfish are available in the quantities required to meet both the requirements of the community and private demand. Egg requirements have been estimated with the aid of surveys in the various fishery districts and on the basis of stocking statistics. The five sub-units of the Aquaculture Unit continuously monitor the development of needs in their spheres by maintaining contact with authorities, fishery districts and associations and other customers and interest groups.

Eggs are obtained both from brood fish at stations and from the wild. In 1997, fish in the former category (18 species/varieties and 64 different stocks) produced around 111 million eggs and about 131,000 newly-hatched noble and signal crayfish juveniles (Table 1). About 51 million eggs were obtained from wild fish (6 species/subspecies and 18 stocks) the same year (Table 4).

Some 60% (92 million) of the 161 million eggs produced in 1997 were sold. The biggest categories comprised eggs and newly-hatched fry of whitefish (72 million or 78%) and spring-spawning species (grayling, pikeperch and asp totalling 12 million or 13%). The remaining eggs were used to produce juveniles, for selective breeding and to renew brood fish.

The work of the FGFRI to produce the eggs needed to rear juveniles for stocking from original species and stocks of known genetic background reduces the risk of unknown and "alien" species and populations being spread through stocking and meets one of the requirements of the Rio Convention.

The research fish produced by the Institute are used for a variety of purposes that include examining the success of stocking, developing stocking methods, studying the results obtained with using juveniles of various ages for stocking, studying the degree to which migratory behaviour is hereditary, comparing populations and for a variety of aquaculture-related studies.

TABLE 4. Eggs obtained from the wild and hatched (1,000s) in springs 1994-97.

Species	Stock (1997)	1994	1995	1996	1997
Salmon	Tenojoki a)	223	343	149	540
Landlocked salmon	Vuoksi watercourse	0	38	80	135
Lake trout	3 stocks b)	90	42	65	95
Charr	Inarijärvi	0	0	12	11
Grayling	Etelä-Saimaa c)	591	470	104	10
Vendace	Inarijärvi	153	75	1 080	1 550
Whitefish	Kuusamo/Koitajoki d)	1 656	1 404	1 027	2 400
Whitefish	(Kallunkijärvi, Ivalojoki)	110	55	4 553	0
Whitefish	4 stocks (inland) e)	3 346	3 345	5 090	4 300
Whitefish	4 stocks (sea) f)	11 776	29 923	29 873	36 400
Asp	(Kokemäenjoki)	173	537	0	200
Pikeperch	g)	13 084	9 210	6 890	5 900
Total (1,000s)		31 029	44 905	48 913	51 541

a) Iijoki (1994—96), Tornionjoki (1994), Tenojoki (1995—96), Oulujoki (1996), Kemijokisuu (1996)
b) Kuusinkijoki (1993), Oulankajoki (1994—96), Kitkajoki Jyrävän alap. (1996), Juutuanjoki (1993—94), Vuoksi watercourse (1994—1996)
c) Inari area (1994—96), Lieksanjoki (1994—96), Puruvesi (1994—96)
d) Vuoksi watercourse (1994)
e) Kuusinkijoki, Oulankajoki, Muojärvi, Kitkajärvi
f) Iijoki, Kemijoki, Kiiminkijoki, Simojoki
g) Vanajavesi, Averia (1994—96) ym.

6.2. Selective breeding for aquaculture

With the aim of improving the efficiency and economy of food fish production, the FGFRI is continuing to breed rainbow trout with the best possible genetic properties. The immediate goal of selective breeding is to accelerate the growth of fish so that the commercial stage can be reached in two seasons without having to bring forward the start. To this end, breeding programmes are being improved and measurement methods and computerised data-collection systems developed. The criteria against which the success of the selective breeding programme is assessed are the marketability of the fish and the efficiency of the breeding methods.

6.3. Development of aquaculture products and technology and the related expertise

The aim is to make high-quality products available to the private aquaculture sector, flexibly taking the needs of customers into consideration. Efforts are made to promote the operating conditions of this sector by working together with the Research Units, to develop methods and technologies that are both more economical and environment-friendly.

The Aquaculture Unit is constantly seeking to develop its own operations with a view to improving the cultivation methods for various species, devising more efficient work, production and measurement methods and reducing environmental impacts. Ever since the 1970s there has been a strong focus on R&D with the aim of furthering the latter goal. New methods for treating effluent waters are used not only at the

Institute's own stations, but also at private fish farms. In the 1980`s, in collaboration with the Research Units, considerable resources were channelled into developing and inaugurating a computerised fish-feeding program and associated automatic feeding equipment. More effective control of feeding and better feed compounds have greatly reduced the pollution load per kg of fish produced. The 1990s have seen the development of robot feeding, which is expected to be widely adopted over the next few years. The product range continues to be developed and diversified along the lines of a 1994 report dealing with commercialisation of the results of aquaculture research (Pursiainen et al. 1994).

The Aquaculture Unit distributes information on the latest production technologies and biological findings through the professional literature and by means of national and international seminars and informal contacts. Personnel participate in the work of numerous development and planning bodies.

7. IMPROVING PROSPECTS FOR FISHERIES

7.1. Management of valuable fish stocks in the Baltic

As it is required to do by the Ministry, the Aquaculture Unit participates in maintaining stocks of Baltic salmon, sea trout and anadromous whitefish in the Baltic by releasing juveniles into rivers discharging into the Gulf of Finland and the Gulf of Bothnia and the estuaries of these rivers. The goal is both to revive populations that have declined and to improve prospects for the development of fisheries, especially salmon.

The FGFRI both produces the necessary juveniles at its own stations and buys them from private contract suppliers. In 1998, it released a total of 2,259,000 1- and 2-year-old Baltic salmon and sea trout juveniles and 112,000 one-summer anadromous whitefish fingerlings (Tables 2 and 5). Of the salmon and trout juveniles, 39% were the Institute's own production and 61% were from contract suppliers (Table 5). The largest numbers of salmon juveniles were released into the rivers Tornionjoki, Simojoki, Pyhäjoki, Kymijoki and Kokemäenjoki, the largest numbers of sea trout juveniles into the Tornionjoki-Muoniojoki system.

TABLE 5. Juveniles produced by private contract suppliers and released into the Baltic and inland waters in 1994-98 and stocking plans for 1999-2001.

Species	Stock	Age (yr)	1,000 juveniles released 1994	1995	1996	1997	1998	1999	2000	2001
Salmon	Neva	1	235	238	199	110	96	60	60	80
	Neva	2	217	430	417	226	244	340	340	340
	Simojoki	1	26	115	-	-	-	-	-	-
	Simojoki	2	11	64	116	109	59	54	54	60
	Tornionjoki	2	-	38	18	56	111	73	73	80
	Iijoki	1	50	50	-	-	-	-	-	-
	Iijoki	2	-	-	13	-	-	9	9	10
Sea trout	Tornionjoki	1	5	150	-	-	-	-	-	-
	Tornionjoki	2	-	-	91	-	-	10	10	10
	Iijoki	2	-	51	-	-	-	-	-	-
	Lestijoki	1	-	22	20	23	5	20	20	20
	Lestijoki	2	54	59	42	45	19	32	-	-
	Isojoki	1	-	-	-	-	-	20	20	20
	Isojoki	2	1	8	1	22	13	19	-	-
	Ingarskila	2	1	17	10	-	11	10	10	10
Landlocked salmon	Pielisjoki	1	37	23	-	-	-	-	-	-
	Pielisjoki	2	49	45	100	73	77	65	65	65
Arctic charr	Saimaa	1	40	2	-	20	31	20	20	20
	Saimaa	2	24	21	23	-	19	20	20	20
Total (1,000s)		1	393	600	219	153	132	120	120	140
		2	357	733	831	531	553	632	581	595

The practice of purchasing salmon juveniles from contract suppliers was begun on a trial basis in the mid-1970s and became established in the following decade. The idea was to reduce the need to build new State stations. The FGFRI produces the necessary eggs and sells them to private producers and, on the strength of funds allocated for this purpose in State budgets, contracts to purchase specified numbers of juveniles, which must meet the quality requirements set.

Since 1982, most of the juveniles produced under contract have been River Neva salmon intended for release into the Gulf of Finland, the Archipelago Sea and the Bothnian Sea. The endangered Saimaa landlocked salmon and charr were added in 1985 and the sea trout in 1987. Releases of juveniles in recent years are shown in Table 5. A total of 39 private fish farms have been under contract as suppliers in the period 1974-98; the current number is 16.

In contrast to previous practice, contracts to be concluded in spring 1999 for releases in 2000 and 2001 will be open to competition.

7.2. Fulfilment of the State's stocking obligations

The Ministry of Agriculture and Forestry and other authorities have each year entrusted the FGFRI with the fulfilment of certain of the State's stocking obligations. The most important of these relate to compensation for the detrimental effects of water level regulation in Lake Inari.

Compensatory releases of juveniles into Lake Inari began in 1976. As required by court decisions, the State has built cultivation stations and natural-food ponds in the area around the lake. Since 1987 it has not been possible to transfer living fish from other waterways into the Inari area for fear of spreading diseases, the Gyrodactylus salaris salmon louse in particular. In accordance with a plan approved by the Ministry, the stocking obligation is now being handled by an adaptive approach. This means that the state of fish populations is taken more carefully into consideration in determining the scale of stocking.

The juveniles to be released into Lake Inari and its tributaries in the period 1996-2000 represent eight stocks as follows: brown trout 1-year 37,000 and 3-year 58,000; arctic charr 1-summer 25,000 and 1-year 100,000; lake trout 3-year 27,000 and whitefish 1-summer 860,000.

7.3. Development of stocking management

In collaboration with the Research Units, the Aquaculture Unit has in recent years conducted numerous studies focusing on the results of stocking Baltic and lanlocked salmon, sea and brown trout and Saimaa charr and on the development of stocking operations, examined the significance of juvenile size, age, physiological quality, transport, timing and location of stocking, especially in the case of salmon and trout, compared the results of stocking natural and cultivated juveniles and investigated the results of attempts to revive salmonid populations in rehabilitated rivers and rapids.

8. MAIN EMPHASES IN AND SCOPE OF ACTIVITIES

8.1. Present situation

The scope and main focus of the works of the Aquaculture Unit are determined mainly by the targets set by the Ministry of Agriculture and Forestry, the extent to which original fish populations are in need of preservation or revival, the supply of and demand for eggs and juveniles, and the amounts of eggs that must be supplied to contract producers.

The breakdown of expenditure by main sector of operation is a good reflection of the division of operations between the various sub-fields of the Aquaculture Unit. In 1996 this expenditure (excluding contract juvenile-rearing) totalled FIM 36.4 million (roughly USD 7.2 million). Of this, FIM 7 million (19%) was spent on preserving the biodiversity of fish stocks, 11 million (30%) on improving prospects for fisheries and FIM 18.4 million (51%) on promoting commercial aquaculture. A more detailed breakdown of expenditure is shown in Fig. 4.

The scope of activities can also be examined in the light of production. The number of species and stocks cultured and the scale of egg and juvenile production are based on the preservation and revival tasks outlined in the foregoing as well as on the needs arising from the State's stocking obligations and the needs of contract farmers, the Research Units and the private sector. The number of brood fish kept is determined by the number of eggs that need to be produced for each species and stocks, bearing in mind the volumes that can be obtained from the wild. Brood fish are dealt with in section 4.1 and Table 1.

The objective of egg production is to ensure that high-quality eggs and juveniles of fish and crayfish of known origin are available in volumes commensurate with management needs and demand. Egg requirements can be reliably assessed with respect to those species and stocks that are being revived by the FGFRI, that fall within the scope of contract rearing, that are used to meet stocking obligations or with respect to which long-term supply agreements have been made with egg or juvenile purchasers. These include Baltic salmon, landlocked salmon, arctic charr, sea trout and some brown trout and whitefish species. In the cases of other species and stocks (especially pikeperch, some whitefish, grayling and crayfish), egg requirements can fluctuate considerably from year to year, depending on the pattern of supply and demand. To ensure dependability of supply, most eggs are produced from brood fish at aquaculture stations. Egg production is dealt with in section 5.1 and Tables 1 and 3.

A total of 1,840,000 1-year, 360,000 2-year and 200,000 older juveniles were produced at FGFRI stations in 1997 (Table 6); this is the equivalent of 1,900,000 50 g units. Half of the juveniles were released to help revive stocks that had declined and to meet obligations in the Lake Inari area, and 33% were sold.

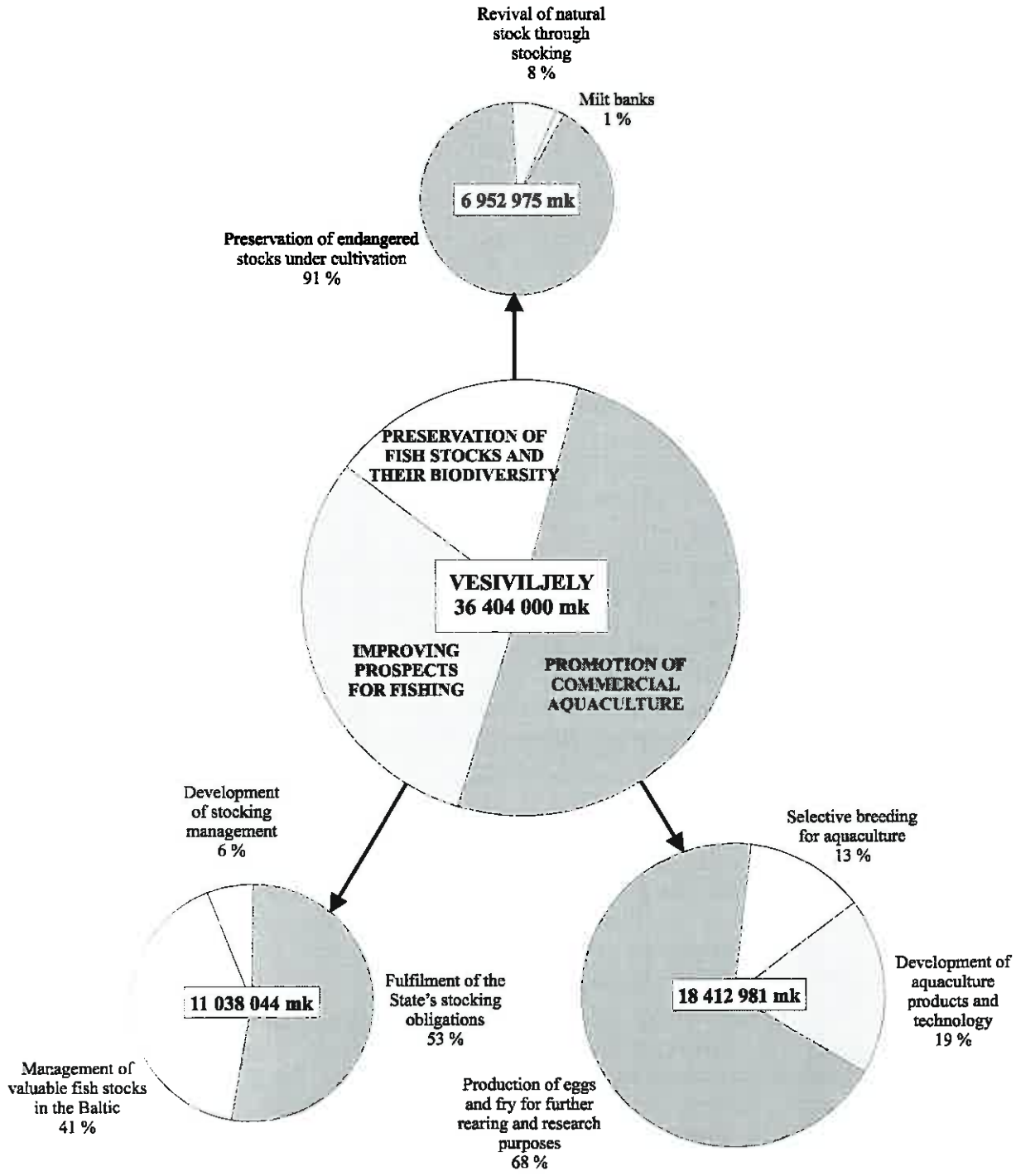

Fig. 4. Breakdown of Aquaculture Units` total expenditure by main task and product

Just under 2.7 million 1-summer juveniles were produced in natural food ponds in 1997 (Table 7); this is equivalent to 2,458,000 5 g units. Most of this production consisted of whitefish and pikeperch. Of the total, 47% was used to discharge tasks assigned by the Ministry (including stocing obligations in the Inari area and reviving populations), 25% for research purposes and as compensation for egg-collection rights, and 28% was sold.

TABLE 6. Cultivated juveniles supplied for stocking purposes and to private fish farms in 1994-97 and production targets for 1998-2001 (1,000s).

		1994	1995	1996	1997	1998	1999	2000	2001
feeding-1-summer	Baltic and landlocked salmon	932	667	358	448	750	650	550	500
	Sea and brown trout	577	1 546	633	640	425	435	425	420
	Arctic charr	0	34	0	125	145	145	145	145
	Whitefish	16	221	40	18	18	18	18	15
	Grayling	22	15	70	70	140	140	140	140
	Other	3	23	43	263	293	293	293	290
	Total <1-year	1 550	2 516	1 143	1 564	1 771	1 681	1 571	1 510
1-years	Baltic and landlocked salmon	666	862	847	876	879	876	878	875
	Sea and brown trout	433	778	826	699	704	704	707	700
	Arctic charr	18	7	109	80	82	82	82	82
	Whitefish	6	5	6	10	10	10	10	10
	Grayling	10	7	2	0	0	0	0	1
	Other	37	29	19	172	174	174	174	170
	Total 1-year	1 170	1688	1809	1 837	1 849	1 846	1 851	1 838
2-years	Baltic and landlocked salmon	98	100	110	133	123	138	125	125
	Sea and brown trout	123	80	154	146	134	140	133	130
	Arctic charr	6	52	66	46	46	46	46	45
	Whitefish	1	0	1	0	0	0	0	2
	Other	4	19	16	32	32	32	32	30
	Total 2-year	233	252	348	357	335	356	336	332
3-years and older	Baltic and landlocked salmon	7	0	27	12	23	13	23	15
	Sea and brown trout	204	213	202	165	173	167	169	170
	Arctic charr	48	66	43	25	25	28	25	25
	Whitefish	2	1	3	1	1	1	1	1
	Other	1	5	12	0	0	0	1	1
	Total 3- and >3-years	262	288	287	203	222	209	219	212

TABLE 7. Natural food pond area at the Institute's disposal and production in 1994-97.

Natural food ponds available			1994	1995	1996	1997
hectares and number		ha	1 430	1 275	1 183	953
		pcs	59	47	50	42
Species		Age	1,000 juveniles produced			
Grayling		1-summer	118	108	60	211
Grayling		2-summer	2	0	0	35
Brown trout		2-summer	1	0	0	0
Pikeperch		1-summer	784	769	512	719
Pikeperch		2-summer	0	0	2	0
Burbot		1-summer	1	3	0	0
Vendace		1-summer	234	33	13	8
Plankton whitefish		1-summer	928	707	440	404
Plankton whitefish		2-summer	5	0	0	0
Sparsely raked whitefish		1-summer	1 004	992	1 023	798
Sparsely raked whitefish		2-summer	3	0	0	0
Asp		1-summer	15	0	5	0
Anadromous whitefish		1-summer	581	363	270	493
Totals	1,000s	1-summer	3 665	2 975	2 323	2 668
		2 summer	11	0	2	35

8.2. Need to change pattern of activities and production

In line with the strategic plan of the Aquaculture Unit, the main emphasis in activities will continue to be on preserving the biodiversity of fish stocks, producing eggs and fry for private farmers and research, fulfilling the stocking obligations and contract production assigned to the FGFRI , selective breeding of rainbow trout and the development of aquaculture products. The Ministry of Agriculture and Forestry, which sets the targets for the Institute, has not proposed any significant change in the pattern of tasks nor in areas of emphasis.

The volume of egg and juvenile production of the FGFRI, both overall and with respect to various species, depends mainly on the level of stocking and on associated changes in supply and demand. Calculated in terms of the market price of juveniles, the annual value of stocking is in the region of FIM 100 million (USD 20 million) in Finland. Of this, around 60% covers the discharge of long-term obligations and the State's own activities (contract rearing, management of salmon stocks, fulfilment of State obligations), and about 40% is "freely financed" and thus can be used as appropriate with respect to species, populations, size of juveniles used for stocking, etc.

Where the discharge of obligations and production required by the State are concerned, demand for eggs and juveniles is not likely to change significantly in the near future, because these functions are long-term in character. The biggest change on the production side will result from an increase in demand for juveniles under the Salmon Action Plan launched in 1997. The planned stocking volumes are presented in Table 3.

Changes in demand on the "freely financed" side are more difficult to predict. The most significant event in the external environment in which the Aquaculture Unit has been operating in the 1990s has been the price crisis that was triggered by surplus supply on the world food fish market. Continuation on of this crisis could affect the FGFRI's operations in several ways: a slump in production of food fish and a

consequent fall in demand for eggs, a weakening of companies' liquidity and an intensification of competition in juvenile production. Restructuring of the fishing licence system at the beginning of 1997 has already caused a substantial reduction in voluntary stocking. It is expected, however, that this disturbance will right itself within a few years.

Research results indicating the effectiveness of stocking play a key role in relation to changes in demand. Good stocking results are responded to rapidly and eagerness to stock the species or stock in question is soon reflected in demand for eggs. On the other hand, ingrained thinking means that it takes longer for poor results to alter demand.

Increasing the efficiency of aquaculture production has contributed to a change in demand. In juvenile production, the development of methods, feeds and feeding and of physical facilities has significantly lowered mortality. Parallel to this, the development of cultivation of brood fish has considerably improved egg quality. One indication of this is that in dimensioning the numbers of brood fish and the volumes of hatcheries 4 - 7 eyed eggs were required for each 2-year-old salmon smolt in the 1970s, but the figure has now fallen to about 1.3.

Greater efficiency in production has enabled estimates of egg requirements to be revised considerably downwards. Whereas the " The State Aquaculture Target Working Group" estimated in 1988 that a total of around 45 million salmon, trout and charr eggs would be needed in Finland in the 1990s, the current estimate of the FGFRI is about 17.5 million. Likewise, the estimate of the number of whitefish eggs that will be required has fallen from 261 million to 60 million, and the figure for pikeperch, grayling and Cyprinidae genus species from 68.5 million to 17.5 million.

9. SALES OF PRODUCTS AND SERVICES

The FGFRI is required to cover a steadily growing proportion of its expenditure through revenues from sales of products and services. The target for income of the Aquaculture Unit is written into the State budget (FIM 6.1 million in 1996. FIM 6.4 million in 1997 and FIM 7.7 million in 1998). Nearly half of revenues derive from the sale of eggs (Table 8). The commercial market for fish eggs is a narrow one and the share of the Institute is already large, 30-80% depending on the species. Thus there is little scope for increasing sales revenues by capturing a larger market share. Were prices to be raised , a likely consequence would be increased private production of eggs, which would often be of unverified origin and narrow in their genetic spectrum. Such a development could jeopardise achievement of the public goals set for the Institute's operations (origin, genetic quality, health, availability).

TABLE 8. Sales receipts from aquaculture products in 1995-97 and target for 1998.

Year	1995	1996	1997	1998
Eggs	3 120 000	2 945 000	2 714 000	2 694 000
Farm fish *)	1 064 000	3 308 000	3 050 000	3 074 000
Natural food pond juveniles	639 000	610 000	706 000	593 000
Fish and crayfish, FIM	4 823 000	6 863 000	6 470 000	6 361 000
Other (transport, packing, etc.)	**)	156 000	322 000	398 000
Other income (sales of equipment, rents, licence fees)			130 000	390 000
Total acuaculture income, FIM	4 823 000	7 019 000	6 922 000	7 149 000

*) includes rainbow trout produced at the Tervo station and rod-size fish; the 1995 figures do not include sea trout for the "Torneälvsproject" (River Tornionjoki Project) nor the participation of Sweden's Fiskeriverket in salmon production in the Tornionjoki; their contribution in 1996 was FIM 680,000 and in 1997 FIM 160,000.

**) included in the prices of services provided by the FGFRI, not indicated separately.

Sales agreements concluded by the property service brought in an additional FIM 673,000 in 1996 and FIM 570,000 in 1997 and estimation for 1998 is FIM 551,000.

Thus the Aquaculture Unit has to cover a considerable share of its income target through sales of juveniles. The market for live fish comprises three main product categories: salmonid fish for stocking, species that are produced in natural food ponds (whitefish, pikeperch, grayling, pike) and rod-size fish (rainbow and brown trout). An estimate of the Institute`s market shares by product category is shown in Table 9.

TABLE 9. Estimate of the FGFRI´s share of fish-juvenile sales, by product category.

	Market volume in FIM	Institute`s share, %
Reared juveniles	35	c. 2
Natural food pond juveniles	40	c. 4
Rod-sized fish	15	c. 3

The State budget requires the FGFRI to avoid competing with the private sector. Regulations and costs limit the Institute`s scope for competing in price or terms of payment in ordinary juvenile production, nor is this the aim. The objective is to shift the focus of sales efforts primarily to the development of new products to promote the management of fish and crayfish populations. An important area of strength that has been rather little used to date involves the development of new operational concepts for research and aquaculture products. Examples include combinations of juvenile production and stocking and research services with the aid of which the management of fish stocks and the prospects for aquaculture could be improved and diversified.

To promote marketing efforts, the Aquaculture Unit will continue to produce supportive material such as folders describing the products and services offered for sale and packages of material for use at fairs and exhibitions. The result of a questionnaire-based customer survey conducted in 1996 is utilised in marketing, in addition to which regional market studies are carried out and personnel are trained in marketing techniques. With the removal of export barriers, presumably within the next couple of years, efforts will be made to seek foreign markets for products. Preparations are already being made by drafting brochures in several languages to present products that it is thought of interest.

10. ETHICAL QUESTIONS RELATED TO PRODUCTION

Since the main goal of the Aquaculture Unit is to preserve endangered fish stocksand produce high-quality eggs, fish farms have been located and planned to guarantee first and foremost that the fish thrive, are healthy and grow well. Structural factors with a bearing on contentment are good water quality and dependable water flow, spaciousness, easily-cleaned basins, good feed stores and effective shielding against outside disturbances. The roofing of cultivation facilities in recent years has sought to improve the tending and monitoring of fish.

The wellbeing of fish in aquaculture stations is ensured by means of regular, mainly automated, feeding, systematic health checks and good pond hygiene. Every effort has been made to keep handling of fish to a minimum, but when this has to be done, e.g. in conjunction with transfers, transport, stripping of eggs and release during stocking, every effort is made to use methods that disturb the fish as little as possible. Fish stress and means of reducing such stress have been studied in collaboration with the Research Units. During marking and egg-stripping operations, the fish are anaesthesised. Each station has its own veterinarian in charge. The personnel at all stations are experienced and highly skilled.

The equipment used in transporting fish is of a high standard and all permits required under the Protection of Animals Act are in order. In the event that water should have to be changed, the Aquaculture Unit has identified places where high-quality transport water can be obtained without the danger of spreading fish diseases. Transport equipment used by more than one fish farm is always disinfected when transferred from one station to another.

11. PERSONNEL

On 1.9.1988, 95 persons were transferred from the Research Department to the Aquaculture Department. The personnel strength of the latter was at its greatest in 1992, when it reached 106. When the present profit centre type of organisation was initiated in 1994, 77 persons were assigned to the Aquaculture Unit.

At the end of 1997 there were 68 permanent employees (3 in Helsinki and 65 at the stations) and their labour input in performing aquaculture tasks corresponded to 65 person work-years. Part of the labour requirement is satisfied by means of fixed-term contracts (equivalent to about 6 years in 1997) and by buying in labour at the Tervo station (4 years). Thus the total labour input in aquaculture was about 75 person work-years in 1997. In addition to that, persons taken on under employment programmes contributed about 24 person work-years in 1997. There will probably be a further decline in the labour requirement in the next few years as functions are centralised, automation increases and the number of natural food ponds is cut down.

In line with the resources strategy adopted, the input of regular personnel has been shifted as much as possible from production to development and to assistance with aquaculture research. Further, labour is sold to the State Real Property Authority responsible for property management at the aquaculture stations.

Most of the personnel have received 1 - 4 years of intermediate-level vocational training in the fisheries field and the other operative employees have been given training on the job (Fig. 5). The emphasis in training has, naturally, been on fish biology, for which reason technical and commercial services and additional training have to be bought from outside sources.

Most of the aquaculture personnel are aged over 40. Ageing causes a gradual decline in work performance and special attention will be paid to preventative measures. In engaging new employees, the main preference will be for young persons.

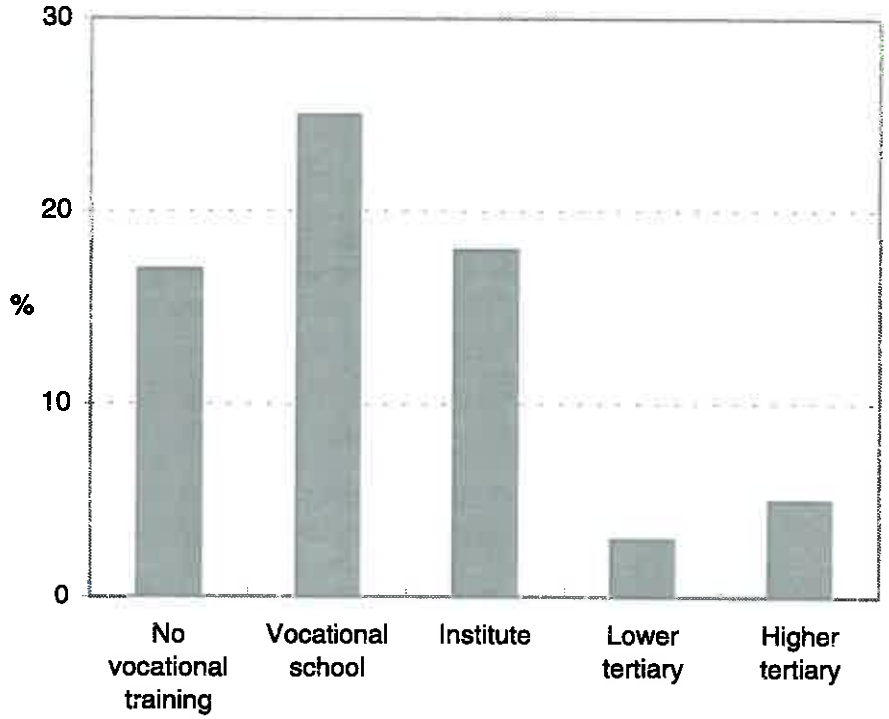

Fig. 5. Educational background of personnel (68) of the Aquaculture Unit

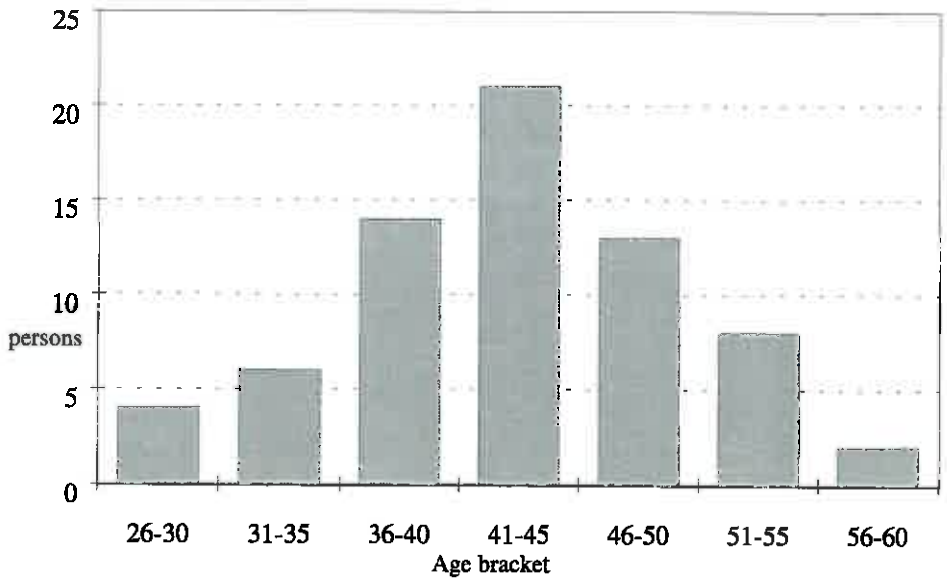

Fig. 6. Age structure of personnel of the Aquaculture Unit 1997

12. PRODUCTION FACILITIES

12.1. Aquaculture stations

The Aquaculture Unit is operating in 13 stations. Due to the rationalisation of production and the concentration of activities in the past couple of years, the Porla aquaculture station near Lohja has been disposed of, and plans to expand the Simo station and build an aquaculture station at Porraskoski and facilities to catch and preserve wild brood fish at Merikarvia and Kokemäenjoki have been abandoned. As of January 1999 the activities of the Aquaculture Unit will cease at the Evo station and will be integrated with those of the Laukaa station.

To prevent diseases, ensure that aquaculture can continue all year round and increase efficiency, rearing facilities have been roofed in recent years. The greatest need for repairs in the near future will be in the outdoor pond area at the Laukaa station. In 1995 ownership of the stations now in use was transferred to the State Real Property Authority , which then leases them to the FGFRI. Maintenance of the stations and essential repairs are carried out in cooperation with the property-holding company.

TABLE 10. Aquaculture capacity by station.

INDOOR							OUTDOOR					
	Basin area m²					Total	Basin area m²			272-	500-	Total
Station	0,5-1	2-4	7-8	13-16	28-64	m²	4-7	24-63	75-250	850	2 300	m²
Evo	10	30	0	0	0	108	10	0	25	1	0	4 500
Tervo	387	0	0	0	11	640	0	0	0	12	20	38 400
Laukaa	30	48	0	6	20	1 237	0	4	45	10	0	9 045
Saimaa	0	120	0	10	31	1 810	0	31	38	3	0	7 321
Kainuu	0	72	0	15	0	458	0	64	24	6	0	7 400
Taivalkoski	2	77	4	34	61	3 826	0	21	8	0	0	1 291
Kuusamo	15	24	22	0	12	1 033	0	0	0	0	0	0
Simo	0	14	0	0	0	49	6	0	0	0	0	103
Lautiosaari	0	0	0	6	0	84	10	7	0	0	0	202
Muonio	0	40	0	19	16	1 201	0	0	0	0	0	0
Tornionjoki	0	96	23	11	10	1 115	0	0	0	0	0	0
Inari	10	24	36	0	24	1 594	0	0	1	0	0	250
Sarmijärvi	0	33	23	0	0	316	0	0	30	0	0	6 000
Total basins	454	578	108	101	185		26	127	171	32	20	
Total m²	261	1 944	818	1 401	9 047	13 471	179	6 087	21 516	16 730	30 000	74 512

12.2. Natural food ponds

An amendment to the Fishing Act in 1983 transferred responsibility for the management of fish stocks to water owners, and stocking on a public-utility basis was no longer regarded as a task for the State (e.g. 1988 report of the State Aquaculture Working Group). As a result, the construction of new natural food ponds was discontinued and existing ones that were no longer required for production purposes or which were expensive or difficult to maintain were disposed of or are being disposed of as their leases expire or opportunities to hand them over to local interests arise. Pond capacity was at its greatest in 1987, when there were 88 covering a total of 2,200 hectares. At the end of 1997 there were 63 ponds covering 1,423 hectares; of these, 42 (953 hectares) were being used by the Institute for juvenile production. The other 21 (470 hectares) had been leased to outside interests, some were unmaintained and others had been left fallow to improve their production potential or because of over-production in the area. A large proportion (80 hectares) of the ponds left fallow are in the Lake Inari area, where the volume of whitefish juveniles required to meet stocking obligations has declined since the 1980s.

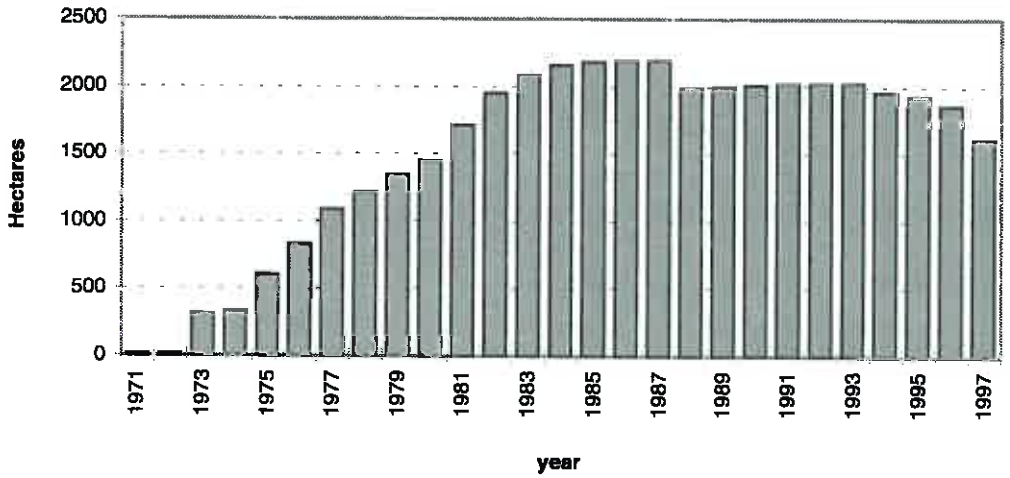

Fig. 7. Natural food pond area (hectares) at the disposal of the Institute in 1971-97.

13. ORGANISATION OF THE AQUACULTURE UNIT

The Aquaculture Unit comprises five operational and regional sub-units, each of which comprises an administrative centre and from one to five aquaculture stations and a number of natural food ponds. The demarcation lines between the spheres of operation of the various sub-units are determined mainly by watercourse boundaries and the need to combat fish diseases. To this end, it is prohibited, for instance, to bring live fish into the Upper Lapland region. The species and stocks cultivated in each sub-unit's area are adapted to local conditions and differentiated, and the preservation of their diversity is the responsibility of the sub-unit in question. The fact that management of all of the facilities within the area of a single sub-unit is the responsibility of the director of that sub-unit has facilitated greater synergy and enabled overlapping of production and functions to be eliminated. It has also led to more shared use of personnel and equipment and harmonised marketing efforts and customer service in different areas. Better co-ordination of disease-prevention measures is a further benefit.

The Aquaculture Unit assigns targets to each sub-unit which in turn determines targets and tasks for the individual stations under its control. Management of the Western Lapland sub-unit was combined with that of the Upper Lapland sub-unit in the beginning of 1999.

The Aquaculture Unit has the following regional sub-units:

Southern Finland

Administrative centre: Laukaa. The operational area covers the Kymijoki and Kokemäenjoki watercourses and the Gulf of Finland, Archipelago Sea, and Bothnian Sea marine areas as well as the smaller rivers discharging into them. Aquaculture facilities: Laukaa, Tervo and Evo research and aquaculture stations.

Eastern Finland

Administrative centre: Enonkoski. The operational area comprises the Vuoksi watercourse and the adjacent, small watercourses draining eastwards. Aquaculture facilities: Saimaa research and aquaculture station.

Northern Finland

Administrative centre: Taivalkoski. The operational area comprises the Kemijoki, Simojoki, Iijoki, Kiiminkijoki and Oulujoki watercourses and the other rivers in the province of Oulu flowing into the Bothnian Bay or eastwards into Russia. Aquaculture facilities: Taivalkoski game and fish research station, Kainuu fish research and aquaculture station, Kuusamo aquaculture station, Lautiosaari and Simo hatcheries. Aquaculture is not pursued at the Simo hatchery in winter, and in summer it is used mainly as a reception and storage facility for salmon juveniles to be released into the River Simojoki.

Western Lapland

Administrative centre: Inari. The operational area mainly comprises the unharnessed waters of the Tornionjoki and Ounasjoki. Aquaculture facilities: Muonio and Tornionjoki aquaculture stations.

Upper Lapland

Administrative centre: Inari. The operational area mainly comprises the river systems discharging into the Arctic Ocean. Aquaculture facilities: Inari fish research and aquaculture station and Sarmijärvi aquaculture station.

14. PLANNING, DEVELOPMENT OF OPERATIONS, COLLABORATION AND INFORMATION

In Finland as elsewhere, growing concern about the ever-accelerating diminution of our planet's biodiversity has highlighted a need to step up efforts to preserve what still exists. That is one of the goals enshrined in the new nature conservation legislation that entered into force at the beginning of 1997. The Rio Convention and accession to membership of the European Union have brought Finland new obligations to preserve the biodiversity of fish stocks and ensure that any exploitation is on a sustainable basis. National and EU legislation and international conventions (such as those of Rio and Gdansk and the UN Law of the Sea Convention) mean that Finland is responsible for indigenous fish stocks living within its territory, for preserving their biodiversity and for ensuring that any exploitation of these fish is on a sustainable basis irrespective of their economic value.

"The Fish Protection Working Group" appointed by the ministries of Agriculture and Forestry and of the Environment recommended in 1996 that

> " ... with the aid of (State) aquaculture, measures should be taken to maintain those fish species, varieties or stocks which cannot be protected in the wild and whose preservation or biodiversity is threatened in their natural habitat. This should be done following protection plans drawn up individually for each species and in a manner that guarantees the preservation of genetic diversity."

The 1997 Natural Resources Strategy of the Ministry of Agriculture and Forestry states that

> "The genetic diversity of economically important fish stocks shall be maintained by, among other means, aquaculture."

"The Fish Protection Working Group" also recommended that, in addition to the economically important fish that have to date been preserved with the aid of aquaculture, other species and stocksshould also be added to the programme as the situation demands. The FGFRI has already begun looking into needs to preserve species of little commercial importance. One such species is the vimba (Vimba vimba), in relation to which studies have been conducted in collaboration with the University of Helsinki.

A number of surveys (including that of the Aquaculture 2020 Committee) have identified the expectations of the commercial aquaculture sector. These include the development through selective breeding of rainbow trout varieties with better genetic properties than those now available, the introduction of new species for use in aquaculture and for stocking and of new aquaculture products enabling the product range to be broadened and productivity to be raised, the development of cultivation methods and technology causing less pollution of waters, and an assured supply of high-quality, disease-free eggs.

An extensive customer survey drawn up for the Aquaculture Unit by the North Savo Polytechnic in 1995 (Riista- ja kalaraportteja (Fish and Game Reports) No. 52) established the satisfaction and experiences of customers with the Institute`s aquaculture products, sales outlets operations, customer service, provision of

information and auxiliary services. Over 80% of respondents (158) reported receiving high-quality products and just under two-thirds considered the product range sufficiently broad. According to some 70% of customers, the sales outlets were appropriately located, purchasing was quick and straightforward, and customer services was well handled. The greatest need for improvement (about half of respondents) was in the provision of information and in communication.

The Aquaculture Unit naturally strives to take these expectations into account. The resources saved as the unit`s own production is scaled down will be redirected mainly into development and trial operations intended to achieve the above goals.

The Aquaculture Unit has begun development of a quality system embracing all of its operations. The aim in introducing the system is to ensure that operations continue to develop in a managed and purposeful manner that ensures added quality and profitability. In aquaculture, product quality is achieved through a process that mostly takes years to complete. Several key characteristics can be identified from the history of cultivation and depend on the quality of operations. Pressures to develop quality systems for aquaculture also come from customers and other interest groups. The Aquaculture Unit wants to be in the forefront of development and in a position to offer services in this area, too.

The practical groundwork for the development of a quality system began in autumn 1997 on the basis of the ISO 9001 standards. To facilitate description of the contents and functions of the quality system, four working groups have been drawn from the personnel. In the course of 1998 they drafted quality documentation of various sub-fields of operations. Training for the quality system and implementation of the system itself took place in 1998. Internal auditing, development of the system in the light of experience and a decision on certification will be made in 1999.

Management by results creates an increased need for knowledge concerning output, costs, the use of production inputs, obtaining revenues, finance, pricing and statistical data. Calculation models that will ensure more accurate reporting of production planning and results were introduced in 1998. Studies of capacity and performance data reflecting the scope of operations are continuing. A new fish-accounting programme is in trial use at FGFRI aquaculture stations.

Since cultivation facilities were roofed over, reproductive disturbances have appeared in brood fish in the northern FGFRI aquaculture stations. Professor J.E. Thorpe, a wellknown Scottish fish researcher, was therefore requested by the Aquaculture Unit to evaluate cultivation activities at the six northern stations and to propose solutions to the reproductive problems. Professor Thorpe carried out the evaluation in spring 1998 and made a number of recommendations. These have now been taken into account in attempts to improve the situation.

A package of information about measures taken by State aquaculture stations to protect the aquatic environment and the development of these measures will be completed in 1999. Plans relating to personnel training will be brought up to date during 1999. There is a particular need to concentrate on training in relation to marketing and cost calculation.

The State aquaculture stations continuously make places available for trainees. These are enrolled or candidate students of the Finnish Fishery Management and Environment Institute, persons studying fishery-related and biological subjects or persons intending to work in the field. Aquaculture personnel teach courses and participate in seminars and symposia. The operations carried on at aquaculture stations are presented to the public through reports and articles, seminars, symposia, exhibitions and comparable channels. External information is being developed by, for example, increasing the number of press releases issued. Brochures presenting

individual stations and functions are being revised to bring them into line with present needs. A multimedia programme describing Aquaculture Unit´s operations was completed in 1997 and an English-language version of it appeared in early 1998.