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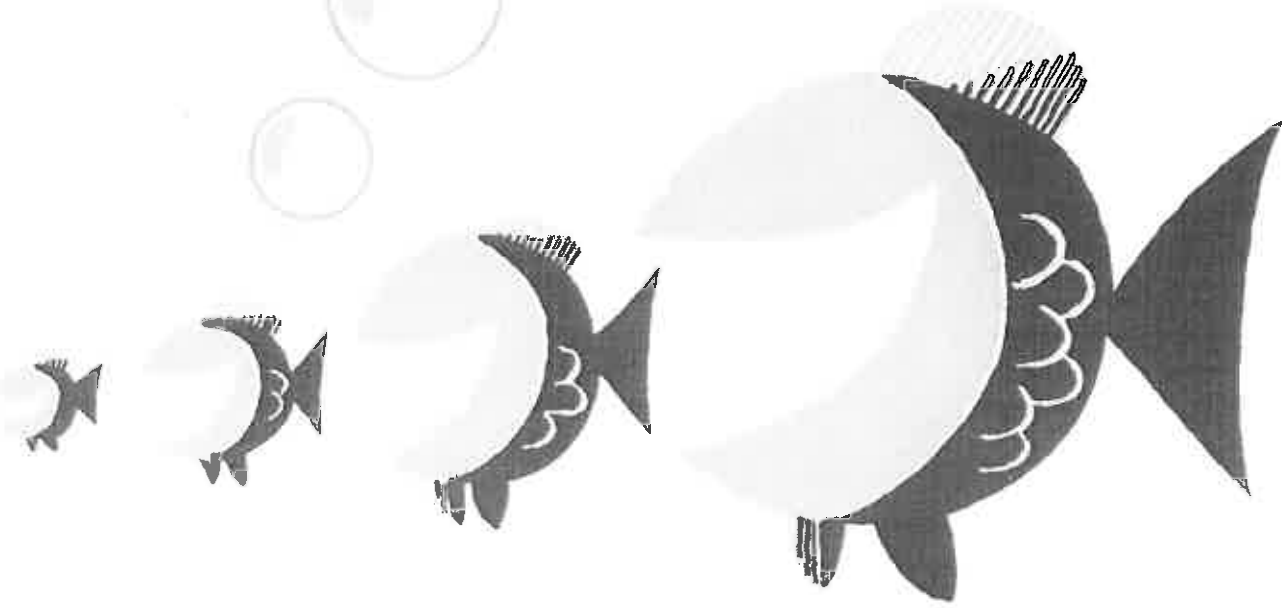

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KALATUTKIMUKSIA-
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Outi Heikinheimo-Schmid, Riitta Rahkonen, Kai Westman ja Pekka Tuunainen

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COUNTRY REPORT OF FINLAND FOR THE INTERSESSIONAL PERIOD OF THE EUROPEAN INLAND FISHERIES ADVISORY COMMISSION (EIFAC) 1990 - 1991

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Introduction

Finland's inland waters cover 33 522 km², which is about 10% of the country's total area. There are about 188 000 lakes and ponds with an area over 0.05 ha. Of these, 2 609 have an area over 1.0 km². The total area of Finnish lakes is 32 500 km². The lakes are shallow, the average depth being 7 m. About 0.6 hectare of lake area are available per capita of the population (5 million). The total length of the rivers exceeds 20 000 km.

Government responsibility for both inland and marine fisheries and their management in Finland is vested in the Ministry of Agriculture and Forestry. The fisheries administration comprises twelve districts, each headed by a fisheries biologist. Each district is divided into uniform fishery areas in order to facilitate planning of the fisheries and their management. Regional plans for fisheries are under preparation in the fishery areas.

In 1988 some 1.3 million people were engaged in fishing in inland waters. About 2 200 of them were professional or semiprofessional fishermen, and the rest fished for recreation and their own use.

The total catch from inland waters was estimated at about 36 000 tonnes in 1989. This was roughly 27% of the total catch for the country. The commercial catch from inland waters was some 4 300 tonnes in 1989. The main species in the commercial catch were vendace (Coregonus albula) and whitefish (Coregonus spp.) (Appendix 1).

Damming of rivers and water level regulation of lakes and reservoirs, mainly for hydro-electric power generation, have created serious problems in fisheries management. Owing to extensive water protection measures, pollution of waters has clearly diminished. About 80% of the lake area in Finland is classified as good or excellent. In 18% of the lake area the water quality is satisfactory, but 2/3 of this area contains brown, humic waters, which are not considered polluted. In about 2% of the lake area the water quality is passable or heavily polluted by industry or sewage.

Acidification creates problems mainly in small and medium-sized lakes. Attention has been paid to the occurrence of radioactive compounds in fish, due to the Chernobyl accident.

The main part of the management of the economically important fish stocks consists of extensive fish stocking programmes. The total number of fish released in 1990 was about 40 million (output of newly hatched larvae excluded). Almost 63% of these were whitefish (Coregonus spp.) (Appendix 2).

Aquaculture of fish for human consumption increased rapidly in the 1980s and reached 18.5 million kg (98% rainbow trout Oncorhynchus mykiss) in 1990, which was about the same as in 1989. Some 70% of the fish is reared in brackish water in net cages (Appendix 3).

The EIFAC National Committee, chaired by the EIFAC correspondent for Finland, is responsible for liaison between EIFAC and Finland and works on subjects of current interest to EIFAC.

I FISHERIES BIOLOGY AND MANAGEMENT

1. Economic aspects of commercial and recreational fisheries

Commercial fishing in inland waters is mainly a part-time occupation. In 1989, only 16% of the 2 150 professional fishermen obtained more than half of their income from fishing. The annual profitability of commercial fisheries in inland waters is studied by means of daily records kept by households or enterprises.

Vendace is the most important fish species in the catch of commercial fisheries in inland waters. In recent years the vendace stocks have been poor in several lakes, and the vendace catch has been decreasing. It was 4100 tonnes in 1989. In Lake Inari, northern Finland, a strong vendace stock has developed as a result of introduction. The vendace catch from Lake Inari, most of which is taken with trawls, rose from 18 tonnes to 300 tonnes between 1986 and 1989.

The total catch of commercial fisheries from inland waters in 1989 was 4 300 tonnes, which is nearly 400 tonnes less than in 1988 (Appendix 1).

The annual human consumption of fish in 1989 was about 20 kg gutted fish per capita, and 60-70% of this was covered by the domestic supply (131).

Subsistence and recreational fishing is of great economic and social significance in Finland. The total number of people fishing in 1988 was 1.7 million, and nearly 80% of these fished mostly in lakes and rivers. The total catch from inland waters was 32 000 tonnes, 45% of this was taken with gill nets and 21% with wire traps, traps or trap nets. The mean annual catch per fishing household was 47 kg. The proportion of the catch used as food was 70% (61). Perch (Perca fluviatilis) and pike (Esox lucius) are the most important species in the catch. A personal fishing licence and permission given by the water owner are generally required for every kind of fishing, but district licences allow angling with natural bait and ice fishing with rods without eater owner's permission. Gill nets and different kinds of rods are the gear most commonly used.

In 1988 the annual catch of the native crayfish (Astacus astacus) was about 3.5 million individuals. The value of the catch was 42.5 million FIM (9.6 million USD) i.e. equal to the value of the vendace catch. Finland seems to be Europe's largest producer of the noble crayfish.

The numbers in brackets ( ) refer to the numbers in the bibliography.

There are no statistics on the lamprey (Lampetra fluviatilis) catch in 1984-1991. In 1983 it was 2.3-2.4 million individuals, which is about 100 tonnes. The value of the catch was estimated at 4.3 million FIM (977 000 USD).

2. Survey and appraisal of inland waters

Studies on the population dynamics and causes of year-class fluctuations for vendace have continued. The research on vendace is coordinated by a national working group (3, 108, 109, 132, 133). According to the information collected by this group, the vendace stocks were on an average level or better than average in northern Finland in 1989-1990, but mostly weak in the southern and central parts of the country. The reasons for this prolonged weakness of the vendace stocks in vast areas are still not known. It does not seem to be connected with fishing pressure or e.g. acidification. Even favourable climatic circumstances have not led to any recovery of the vendace stocks. The situation has caused severe problems to professional fishery in inland waters. The vendace stock was very strong in only 5% of the lakes studied in 1990.

The intensive trawl fishing on vendace has commonly been discussed in public in recent years. Research on the effects of trawling on the vendace stocks and other fish species taken as bycatch continues. The main topics are the survival of escaped 0-year-old vendace and the mortality of young brown trout that are released from the trawl (118).

A co-operative research program on Lake Saimaa, eastern Finland, has been going on since 1989. Three subprojects have begun so far, attention being mainly directed to the biology of vendace, assessment of the pelagic fish stocks and the success of stocking with brown trout. In the near future attention will be paid to interactions between vendace, whitefish and smelt (Osmerus eperlanus). The program will be carried out jointly by units subordinate to three different ministries, the Ministry of Education, the Ministry of Agriculture and Forestry and the Ministry of the Environment.

A biomanipulative approach has been adopted in the management of eutrophicated Lake Vesijärvi, southern Finland, in order to improve the water quality and the structure of the fish community. Selective harvesting has been carried out using pelagic trawling in summer. The catches in 1989-1991 were 172, 180 and 270 tonnes (66-103 kg/ha), respectively. The preliminary results have been encouraging: the water quality of the effectively fished basin has improved and the pikeperch stock has recovered due to effective stocking.

A biomanipulative programme has recently started in two other lakes, Lake Loppijärvi and Lake Köyliönjärvi, southern Finland. In these lakes, roach and other cyprinids were removed with fyke nets or winter seine.

3. Management of inland waters

3.1. Stocking

According to the nationwide fish stocking register, the number of salmonids (Salmo and Salvelinus sp.) released to the wild at the age of one summer or more was about 7 million in 1990. The corresponding number for whitefish species was 25 million, for other fish 8.6 million (grayling (Thymallus thymallus), pike, pike-perch and cyprinidae), for lamprey 859 000 and for crayfish 82 000 (including 20 000 signal crayfish, Pacifastacus leniusculus). The value of the input was about 70-80 million FIM (16-18 million USD) (Appendix 2).

In addition, transfers were performed with some fish species (mostly vendace, 32 000) and with crayfish (95 000) and lamprey (135 000).

3.2. Marking and tagging

To evaluate the results of stocking, and for research purposes, 74 000 salmon, 57 000 sea trout, 45 000 brown trout, 3 000 whitefish and 2 000 other fish were tagged with Carlin tags in 1990-1991 (122). In addition, brown trout and whitefish were marked with microtags ("nosetags").

The visible implant tag (VI-tag) is being tested on different species at a fish farm. The VI-tag was also used experimentally on brown trout released in a natural lake, and the results will be compared with a control group tagged with Carlin-tags.

A hot branding method has been developed for marking fish juveniles. The method has been used successfully for e.g. brown trout and sea trout, salmon, pikeperch and whitefish, when the length of the fish has been 6 cm or more. The advantages of the method are its low cost and rapidity.

3.3. Introductions

During 1990 and 1991 the animal health authorities permitted the import of eels (60 000 and 118 000, respectively) from Swedish quarantine for stocking purposes in some small lakes in southern Finland. Eggs of rainbow trout were imported from Sweden in 1990 for breeding purposes. Fry of cod were imported from Sweden in 1991 for stocking purposes in the sea. Signal crayfish were also imported from Sweden in 1990, to be reared in closed ponds, but during 1991 the animal health authorities permitted only imports of eggs of signal crayfish.

For the purpose of reviving crayfish production and catching in the numerous crayfish plague waters, stocking of the plague-resistant signal crayfish has been continued. Due to a faster growth rate and greater capacity for reproduction, the productivity of the signal crayfish has

been found to be markedly higher than that of the noble crayfish in the same lakes. The signal crayfish also seem to tolerate fishing pressure very well.

So far, about 155 000 signal crayfish have been stocked in about 100 different water bodies in Finland. The stocking waters are former crayfish waters devastated by the plague. To reduce the risks of spreading crayfish plague, it has been proposed that only plague-free signal crayfish should be stocked. These can be reared even if the mother is carrying the plague fungus by using egg stripping and incubation techniques developed at the Finnish Game and Fisheries Research Institute.

4. Research programmes shared with other countries

Cooperation has continued between Finland and its neighbouring countries. In the Tenojoki (Tana) River on the Finnish-Norwegian border, the yearly studies on the Atlantic salmon (Salmo salar) stock include preparation of catch statistics, catch sampling, and assessments of parr densities, smolt production and smolt migration. Joint studies on salmon are also carried out in the Näätämönjoki (Neiden) River.

The Finnish-Russian Border Water Commission has continued its work in Lake Pyhäjärvi (Karelia), Lake Paanajärvi and in the Paatsjoki river system (Lake Inari). In the Tuloma River, research on the brown trout stock started in 1988. The possibility of recolonizing the upper reaches of the watercourse with salmon is also being studied. Finnish-Russian cooperation was continued in investigations on salmonid smolt production in the rivers of Finland and the Karelian Autonomic Republic and the Kola Peninsula.

Russian specialists from the Institute of Biology of Inland Waters, Borok (Academy of Sciences of the Russian Federation), in cooperation with the Finnish Game and Fisheries Research Institute, carried out biotelemetrical studies in three Finnish rivers. In the Tengeliönjoki River, northern Finland, the efficiency of an electric fish screen was examined. According to the experiments made with rainbow trout and other salmonids, the fish screen prevents adult rainbow trout from getting downstream into the channel of the hydroelectric power plant but has no effect on the migration of brown trout smolts. In the estuaries of the Vantaanjoki and Kymijoki Rivers, southern Finland, the behaviour of upstream migrating salmon and sea trout was studied by biotelemetry.

Joint Russian-Finnish research continued on the migration, genetics and physiology of different salmon and sea trout stocks in the Gulf of Finland.

Within the programmme of joint investigations of arctic coregonids and chars between the Russian Federation, Canada, Finland and Poland, collection of material for taxonomy, genetics and biochemistry has continued.

Research on the fish stocks and fisheries in the Tornionjoki River continued in cooperation with the Finnish-Swedish Border River Commission and the Swedish fisheries authorities.

Liaison was maintained with inland fisheries researchers in Poland, Hungary, Czechoslovakia and Germany, focusing on fish culture and research on whitefish, vendace and sea trout.

5. Other subjects

The International Seminar on Mass Removal of (Unwanted) Fish In Large Inland Waters was held organized in Lahti, Finland in June 1991. The seminar was attended by 102 participants from 12 EIFAC member countries and from Canada, China and the USA (EIFAC Occasional paper no. 26). The proceedings of the seminar will be published in 1992.

It was decided at the 16th Session of EIFAC, Prague, 1990, that a workshop on crayfish management and stocking should be arranged as a follow-up of the "EIFAC Workshop on Crayfish Culture" held in Trondheim, Norway, in 1987. Consequently, the EIFAC Working Party on Crayfish, in co-operation with the Finnish Game and Fisheries Research Institute and the University of Kuopio, organized a Workshop on Crayfish Management and Stocking in Kuopio, Finland, on 22-23 August 1991. Some 30 astacologists representing seven nationalities and three continents participated, and some twenty papers and review articles were presented and discussed. The proceedings of the workshop will be published in the Finnish Fisheries Research.

II FISH CULTURE AND DISEASES

1. Fish culture

In 1991, a special Commission, Fish Culture 2020, appointed by the Ministry of Agriculture and Forestry, presented its report "Objectives For Fish Culture". This report investigates fish culture today, and its development up to the present, both in Finland and other important production areas. The Commission evaluated prospects for development in the operating environment of fish culture up to the year 2020. Based on this evaluation, the Commission then drew up general development objectives and made recommendations for further action.

1.1. Fish farms and the production

In 1989 the total number of fish farms in Finland was nearly 600; in addition, natural rearing ponds were used with a total area of c. 9 000 hectares. The rainbow trout is practically the only fish species farmed for food in Finland, although a few attempts have been made to develop the farming of Baltic salmon, whitefish, arctic char and pike-perch in net cages in brackish and fresh water. In 1990, 350 farms (about one half of them in inland water) produced 18 500 tonnes of fish for human consumption (98% rainbow trout), of which only 5 400 tonnes was

reared in fresh water. The value of the food fish production in 1990, calculated at the producer price, was 357 million FIM (81 million USD) (Appendix 3, see also section I, 3.1.).

Noble and signal crayfish cultivation has increased since the late 1970s and at present there are some 40 crayfish farms producing mainly one-summer-old juveniles for stocking. The total production in 1990 was about 155 000 individuals.

Fish for stocking are produced either intensively in land-based fish farms (mostly salmonids) or extensively in large ponds with a natural food supply (mostly whitefish, grayling, pike and pike-perch and some cyprinid species). Many farms producing rainbow trout also rear other salmonids for stocking. In 1990, the number of salmonids produced for stocking purposes, excluding newly hatched larvae, was about 7 million. The natural freshwater rearing ponds produced about 34 million mostly one-summer-old juveniles (Appendix 2, see also section I, 3.1.). In 1990, the value of juvenile production for stocking was about 80 million FIM (18 million USD).

1.2. State fish culture

The Finnish Game and Fisheries Institute and its Aquaculture Division takes care of the State fish culture. The State has 13 fish culture stations already in operation and plans for further stations also exist. The fish culture stations produce high-quality eggs and fry to conserve and increase the stocks of valuable fish species. The stations also produce fish for research and for stocking carried out by the State. Research on fish culture and the conservation of threatened fish species and stocks are also important.

Twenty fish species, 80 different fish stocks and two crayfish species are cultivated in the State fish farms. The stations annually produce c. 100 million eggs and fry of whitefish, ca. 24 million eggs and fry of salmon, trout and char and c. 30 million eggs of pike-perch, grayling and other fish for stocking. Since it has become more and more difficult to obtain eggs from natural waters, due to weakening of the fish stocks, the State fish culture has attempted to ensure the supply of eggs and fry by cultivating brood fish at the stations. The use of the eggs can then be controlled so that only the most suitable fish species and stocks are released in each river or lake.

In 1991 a great project to improve rainbow trout breeds was started on a fish farm rented from a private company by the Finnish Game and Fisheries Research Institute.

1.3. Research on fish physiology

Research has continued on improving techniques for rearing high-quality smolts. In examining the fish in the stocking groups, not only the general smolt characteristics - minimum size, body silvering and condition factor - have been studied but also several physiological properties,

including the oxygen carrying and osmoregulatory capacities, and energy stores. Attention has also been paid to the hormonal control of smoltification (18). By connecting the physiological studies with tagging experiments, a clear correlation between the physiological smolt status and the tag return of adults was shown. A project to reduce the amount of grilse has been started on some fish farms producing smolts for stocking purposes.

The research on brood stocks and egg quality has continued. It includes experimental work on the effects of the annual light rhythm on the hormonal control of reproduction. Promising progress in regulating the spawning time has been made on salmon and trout brood stocks, in addition to rainbow trout (76, 77).

1.4. Research on fish nutrition

Farmed fish in Finland mainly receive dry feed. Low-value fish (mainly smelt) and Baltic herring are used to some extent mainly as raw material for semimoist feeds. Recently, utilization of Baltic herring as raw material has received increasing attention as an alternative protein source for imported fish meal originating outside the Baltic. The idea is to recirculate nutrients in the Baltic and thus decrease nutrient loading from net cage farms.

Nutrition research in Finland can be classified according to the main goals of the on-going work. These are: reduction of the environmental impact of aquaculture, reduction of the production costs, increasing the use of domestic raw material for fish feeds, increasing the quality of aquaculture products and widening the range of farmed fish species from salmonid fish to non-salmonid fish and invertebrates (104). In order to achieve these goals recent studies have dealt with subjects such as salmonid broodstock nutrition, larval nutrition (especially whitefish and pike-perch), growth and nutrition at very low temperatures (< 5 °C), protein-to-energy ratios in feed, use of semimoist and moist feed, and feeding, feed intake and growth relationships in the rainbow trout (52, 103).

1.5. Development of aquaculture technology

Most modern fish farms have adopted microprocessor-controlled systems to optimize automatic feeding, and to control water flow, illumination and temperature.

A new aquaculture technology development unit came into use at one State fish culture station in central Finland in 1989. In this unit it is possible to test various basins and feeds in both natural and extreme temperatures and other cultivation conditions.

In intensive aquaculture systems new species need new technical developments. For example, production of live feeds for crayfish and pike-perch has received attention.

The development of aquaculture technology includes examination of the physiology of fish for stocking, reared under different conditions. A considerable and increasing part of the stocking material in Finland is produced using heated effluents to stimulate growth, which requires a whole series of new technological steps.

A new outflow water treatment technology came into operation on a productive scale at one State fish culture station in northern Finland in 1989. Testing of the procedure is still incomplete, but it appears that the phosphorus loading from fish farms can be reduced to the lowest level generally attainable in flow-through systems.

2. Fish and crayfish diseases

2.1. Fish

The official Fish Health Control System conducted by the National Veterinary Institute will be replaced by a new programme during 1992.

At the beginning of the 1980s vibriosis was the most serious fish disease in Finland. Vaccination against vibriosis has been fairly effective, and thus other bacterial diseases have now become more prominent.

Furunculosis occurs not only in coastal regions but also in some freshwater hatcheries. Furunculosis was diagnosed on 48 and 85 different farms during 1990 and 1991, respectively. Most of the farms are situated in the archipelago and the coastal area of the Baltic Sea, where most of the rainbow trout production takes place. Fourteen cases have been detected at freshwater farms (land-based and net cages). Effective vaccines against furunculosis are not yet available and thus therapeutic antibiotics are commonly used, which results in residues and bacterial resistance.

Bacterial kidney disease (BKD) was diagnosed on one farm per year during 1989-1991; all of in the Åland islands. The mainland is still free of BKD. Transport of eggs and live fish from Åland to the continent is prohibited.

IPN virus was isolated only once during 1991, in comparison to seven isolations from different farms in 1990. The main serotype has been Ab. There have been no clinical signs of IPN.

Research on fish diseases increased considerably in Finland in the late 1980s. Besides the official Health Control System, for example, the distribution of viral and bacterial diseases and the monogenean Gyrodactylus salaris have been studied in some research projects (48). A research project on the influence of water quality on fish diseases in the coastal area adjoining the Gulfs of Finland and Bothnia has been completed and the results will be published (145,

146). A research project on the influence of water quality on fish diseases, including parasites, in four lakes differing in water quality in Central Finland is near to completion (9, 54, 55, 124). A new drug for bacterial diseases in fish in Finland, oxolinic acid, has been tested (4, 5, 6). The immunological response has been investigated in both farmed and wild fish. A study with the aim of improving disinfection methods for the eggs of the main fish species cultivated in Finland will be finished in 1992. A guidebook for fish farmers, on fish diseases and their prevention, was completed in the Aquaculture Division of the Finnish Game and Fisheries Research Institute.

2.2. Crayfish

Some new cases of crayfish plague appeared in 1990-1991. A comprehensive survey on the occurrence of crayfish plague and crayfish deaths has been made by the Finnish Game and Fisheries Research Institute. Methods and possibilities to control the plague were presented in a recent report of the crayfish disease study group appointed by the Ministry of Agriculture and Forestry.

Haemolymph studies on Aphanomyces -infected crayfish and signal crayfish have continued.

The number of finds of the parasite Psorospermium haeckeli has risen to 70 (25 in 1989) in southern Finland. The haemolymph values of infected crayfish are under study. In certain conditions P. haeckeli can cause death in both natural crayfish populations and aquaculture stocks.

It is interesting that, among signal crayfish, Psorospermium has been discovered in only one animal on a crayfish farm.

III FISH AND POLLUTED WATER

1. Fish and fish farm effluents

The main factor limiting the growth of the fish farming industry in Finland is the problem of fish farm effluents. In fresh waters, the main nuisance is eutrophication caused by phosphorus; organic loading and direct oxygen uptake are of less importance. Net cage farming on the Baltic coast can cause changes in the primary production because of nitrogen loading.

Fish farming is mainly increasing in the sea. In fresh waters the production actually decreased in the late 1980s if measured by mass. The new low-phosphorus feeds, effective feeding techniques and new methods of removing suspended solids from the outlet waters decreased the total phosphorus load in inland fish farming by 37% in the last decade, though the total production in fresh waters increased by about 56% in the same period.

In Finland a new project aimed at promoting the use of herring as raw material for fish feed in Baltic aquaculture was started in 1990. This was done in order to reduce the nutrient loading entering the Baltic Sea from outside the region. The effect of the herring content in the feed on the growth of the fish, and the consequent nutrient load in fish farming, was studied.

2. Biological monitoring

Standard toxicological and physiological methods for evaluating the effects of effluents on fish at different stages of development have been used as supplementary methods in monitoring waste discharge areas and, for example, in compensatory stocking programmes and to complement national biological monitoring. A five-year research programme, "Fish diseases as water quality indicators", started in 1987, has revealed a great variety of diseases and parasites in fish from coastal waters receiving waste loads. A similar research project has been going on in inland waters since 1989. Water quality criteria have been prepared for fishing waters and will be evaluated over a period of some years. International cooperation within the Helsinki Commission, ICES and OECD will continue in this field.

3. Bioaccumulation of toxic and radioactive substances in fish

The results of a seven-year study on the Hg load and accumulation in fish show that, in addition to point-source pollution, there is a more general anthropogenic-derived increase in Hg levels in lakes. The results indicate that the anthropogenic mercury load through atmospheric deposition has increased especially during the second half of this century. It is estimated that the highest Hg level acceptable for edible fish in Finland (1.0 µg/g) is exceeded in three thousand of the 56 000 lakes. The value of these polluted small lakes as fisheries is, however, comparatively small. Even higher concentrations were observed in large predatory fish in newly impounded man-made reservoirs. Intensive fishing proved to be successful in lowering mercury concentrations in pike and burbot (97, 129, 130).

A national programme for monitoring the concentrations of chlorinated hydrocarbons and heavy metals in fish has been in progress since 1978. The extention of parameters has revealed that fish contain only minor amounts of chlorinated phenolics, chlordanes, dibenzodioxins and furans. Concentrations of chlorinated hydrocarbons including polychlorinated dibenzodioxins and dibenzofurans have been analysed in Baltic salmon that spawn in the Simojoki River, northern Finland. Hatching success and viability of fry and concentrations of these environmental toxicants will be evaluated. For comparative purposes, organochlorine concentrations have been analysed from landlocked salmon and from Atlantic salmon spawning in an arctic river.

Monitoring has been continued to determine the occurrence in fish of radionuclides released during the nuclear power plant accident in Chernobyl in 1986. The fallout was heaviest in central Finland. The highest Cs-137 concentrations have been found in fish from small

oligotrophic lakes. The radioactivity of fish in the fallout areas has been decreasing and in 1991 was about half of the highest values detected in 1987. In the areas of the highest fallout, the consumption of perch and other predator fishes from small lakes should still be restricted to two or three times a week. Other fish species and all fish from large lakes can be consumed safely throughout the country (119).

4. Acidification of inland waters

The Finnish Acidification Research Programme HAPRO was carried out during 1985-1989. In 1990, a project group was set up in the Finnish Game and Fisheries Research Institute to continue the research on the effects of acid precipitation on fish and crayfish. Responses of fish and crayfish populations to acidification and physiological research were included, as earlier. During the last few years, increasing attention has been paid to liming as a tool to mitigate acidification. In addition, regional fish status surveys in lakes and brooks of northern Finland were started in 1990. Assessment of the impacts of acidification on recreational fisheries was also started in 1990 (95, 99, 100, 126).

The fish status of eight limed lakes, which has been followed since 1986-1987, was examined again in 1991. In some lakes that had a sparse roach population left during the liming, the trend was from a percid dominated fish community to one dominated by cyprinids (roach). The size of perch populations in two highly acidified lakes was estimated by marking and recapturing in spring 1991. The structure of both populations was quite normal in the early 1980s. Today, a few dozens of perch were left in both lakes. This provides an example of the gradual decrease of fish populations due to acidification (91).

In acidified lakes, the reproduction of crayfish is severely disturbed if the pH of the water stays below 6 throughout the year. In these cases, the embryos usually die just before hatching.

New fish status surveys were started in 1990 in order to determine whether the emissions from the Kola area affect the fish in inland waters in northeastern Finland. Fifty lakes were test fished with experimental gill nets. A similar number of brooks were electrofished in order to map the densities of the brown trout young in areas close to the northeastern border of Finland, where the first symptoms of acidification due to Kola emissions should appear.

The comparisons of sensitivity of several fish species and stocks to acidity and aluminium were compared further. In addition to mortality, behavioral and sublethal physiological disturbances were studied. Newly hatched brown trout from an acidic and humic brook showed a better tolerance to low pH and to aluminium than brown trout fry from a lake population. Trout fry from the brook population tolerated a pH down to 4.5 at aluminium concentrations < 200 µg/l. Baltic salmon sac fry from the Iijoki stock tolerated a pH of 4.8 without aluminium, but if the Al concentration was 100 µg/l, a pH of 5.3 was harmful. Aluminium was shown to affect the

growth and total-body ion concentrations of whitefish sac fry even at pH 6.0 in dilute artificial test solutions (136, 137).

A three-year study of present and future effects of acidification on recreational and subsistence fisheries was started in 1990. A nationwide postal questionnaire was used to gather information on the number of fishermen and the importance of fishing in waters sensitive to acidification. Furthermore, information on the public opinion concerning lake neutralization and emission control was gathered. Results should be ready for publication at the end of 1992.

A multidisciplinary lake liming project was started in 1990. A small acidified lake was divided in two with a plastic curtain. One half of the lake was limed and the other left as a control. The structure and function of the entire ecosystem of the lake will be studied from bacteria, protozoa and algae to zooplankton, zoobenthos and fish in order to see whether lime-induced changes in the ecosystem affect the living conditions of fish. Experimental work on the effects of liming on fish (perch, whitefish) and crayfish are included, and likewise as assessment of the effect of liming on the enrichment of Hg and Cs-137 in biota (96).

5. Effects of forest management on fish and fisheries

A new project on the effects of forest management on surface waters was started in several research institutes in 1990. The Finnish Game and Fisheries Research Institute is responsible for the fish and fisheries studies of the project. Attention will be paid to ecological changes in habitats, fish and crayfish populations and food chains. Both lakes and rivers are included. The physiological effects of forestry-induced changes in water quality on fish, such as the effects of iron and humic material on brown trout gills and physiology, will also be studied. The effects of forest management in the catchments of brooks and lakes on recreational and subsistence fisheries will be studied using the same nationwide postal questionnaire as was used to study the effects of acidification.

6. Physical habitat modification

Restoration measures have been carried out in rivers in order to improve the reproduction areas of salmonids, to increase crayfish production and to provide opportunities for recreational fishing. About 10 million FIM (2 million USD) was used for these measures in 1990-1991. Five fish ladders were built and about 250 rapids were restored.

A model describing the ecosystem of regulated lakes was developed by the National Board of Waters and the Environment in cooperation with the Finnish Game and Fisheries Research Institute and the Technical Research Centre of Finland. The goal of the project was to evaluate the effects of lake regulation on fish stocks more accurately than before. The model has been tested with data on whitefish stocks from Lake Oulujärvi and Lake Kiantajärvi, northern Finland. The model can be used for estimating the role of different factors in the calculated

effect of regulation, and for understanding the functioning of the system, although it cannot yet provide accurate estimates with percentages (67).

The migration of fish downstream from Lake Oulujärvi, regulated for hydro-electric power production, was studied hydroacoustically in 1990-1991. According to the results, 1-5% of the whitefish population (2 years or older) left the lake annually. This has no effect on the whitefish catch from the lake but can support fishing in the Oulujoki River. More remarkable is the downstream migration of the brown trout young, originating from stocking. Between 7 and 21% of the released brown trout migrated out of the lake, mostly during a short period in June and July.

A five-year research project on "Effects of climatic change on fishes, fish populations and aquaculture", financed by the Academy of Finland, started in 1991. The aim is to study the effects of changes induced by the assumed higher temperature and increasing winter rain on fish population dynamics and production and aquaculture.

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Taulukko 1. Kalansaalis vuonna 1989, 1 000 kg.

Table 1. Fish catches in 1989, 1 000 kg.

Tiedot perustuvat Riista- ja kalatalouden tutkimuslaitoksen tekemiin tiedusteluihin. Virkistyskalastuksen saalistiedot vuoden 1988 tiedustelun mukaan.
The data are based on inquiries made by the Finnish Game and Fisheries Research Institute. The data on recreational and subsistence fisheries are from the year 1988.

	Merikalastus Marine fisheries				Sisävesikalastus Freshwater fisheries			
	Ammatti-kalastajat Professional fishermen	Osa-aika kalastajat Part time fishermen	Virkistys- ja kotitarve-kalastajat Recreational and sub-sistence fishermen	Yhteensä Total	Ammatti-kalastajat Professional fishermen	Virkistys- ja kotitarve-kalastajat Recreational and sub-sistence fishermen	Yhteensä Total	YHTEENSÄ TOTAL
Silakka - Baltic herring	74 780	6 343	1 220	82 343	-	-	-	82 343
Kilohaili - Sprat	210	13	..	223	-	-	-	223
Turska - Cod	1 570	344	276	2 190	-	-	-	2 190
Kampela - Flounder	41	29	374	444	-	-	-	444
Hauki - Pike	80	73	1 497	1 650	193	7 894	8 087	9 737
Muikku - Vendace	43	51	22	116	2 181	1 876	4 057	4 173
Siika - Whitefish	690	447	980	2 117	767	1 952	2 719	4 836
Lohi - Salmon	865	156	145	1 166	14	145	159	1 325
Taimen - Trout	190	61	389	640	26	429	455	1 095
Kirjolohi - Rainbow trout	25	17	112	154	..	279	279	433
Harjus - Grayling	-	-	4	4	..	174	174	178
Kuore - Smelt	102	141	137	380	269	57	326	706
Lahna - Bream	79	65	478	622	44	1 760	1 804	2 426
Säyne - Ide	6	4	150	160	2	247	249	409
Särki - Roach	45	26	844	915	356	4 107	4 463	5 378
Made - Burbot	92	43	225	360	64	1 391	1 455	1 815
Ahven - Perch	181	115	2 697	2 993	226	9 654	9 880	12 873
Kuha - Pike-perch	182	41	325	548	19	484	503	1 051
Muut - Pthers	420	52	91	563	139	1 185	1 324	1 887
Yhteensä - Total	79 601	8 021	9 966	97 588	4 300	31 634	35 934	133 522

FISH, CRAYFISH AND LAMPREY STOCKING IN FINLAND IN 1990

(Finnish fish stocking register)

Species	Estimated No. of each type of stocking product for each species in 1990 (000's fish)	
Whitefish	fry	60449
	fingerlings	23972
	fish before takeable size	195
Peled (introduced)	fingerlings	645
Vendace	fry	1100
	fingerlings	348
	fish of takeable size (transfers)	146
Baltic salmon	ova	479
	fry	2944
	parr	988
	smolts	1687
Landlocked salmon	ova	154
	smolts	107
Sea trout	ova	29
	fry	110
	parr	248
	smolts	969
	fish of takeable size	1
Brown trout (migratory)	ova	1722
	fry	2568
	parr	734
	smolts	1671
	fish of takeable size	18

Species	Estimated No. of each type of stocking product for each species in 1990 (000's fish)	
Brown trout (local)	ova	550
	fry	221
	fingerlings	72
	fish of takeable size	92
Rainbow trout (introduced)	fry	88
	fingerlings	112
	fish before and of takeable size	59
Char	ova	132
	fry	564
	fingerlings	73
	fish before takeable size	71
	fish of takeable size	2
Brook trout (introduced)	fish before takeable size	5
Lake trout (introduced)	fry	158
	fingerlings	4
	fish before takeable size	51
Grayling	fry	77
	fingerlings	1326
Pike	fry	2073
	fingerlings	944
Bream	fingerlings	214
	fish of takeable size (transfers)	7
Carp	fish before takeable size	2

Species	Estimated No. of each type of stocking product for each species in 1990 (000's fish)	
Ide	fingerlings	223
	fish of takeable size (transfers)	2
Asp	fingerlings	86
Pikeperch	fingerlings	5332
Burbot	fish before takeable size (transfers)	12
Eel	elvers	59
Crayfish	fingerlings	81
	crayfish of takeable size	74
American crayfish (introduced)	fingerlings	18
	crayfish before or of takeable size	7
Lamprey	fry	500
	fingerlings	896
	lamprey of takeable sizes (transfers)	135

KALANVILJELY SUOMESSA 1990 - FISH CULTURE IN FINLAND 1990

RUOKAKALATUOTANTO[1]
FOOD FISH PRODUCTION

	Meri Brackish water	Sisävesi Fresh water	Kaikkiaan Total	Arvo Value
Tuotanto - Production	1 000 kg	1 000 kg	1 000 kg	Mmk
Kirjolohi - Rainbow trout	13 024	5 297	18 303	348
Lohi - Salmon	157	61	218	7
Muut lajit - Other species[2]	0	72	72	2
Yhteensä - Total	13 181	5 430	18 593	357
Laitoksia - Farms Kpl - pc	164	187	351	

1) Tuotantomäärät perkaamatonta painoa - In ungutted fish

2) Taimen ja siika - Brown trout and whitefish

TUOTANTOTILAT
PRODUCTION CAPACITY

	Meri Brackish water	Sisävesi Fresh water	Kaikkiaan Total
Verkkoaltaat 1 000 m^3 Net cages	782	256	1 038
Kiintoaltaat 1 000 m^3 Ponds and tanks	46	1 471	1 517
Luonnonravintolammikot ha Natural food rearing ponds	1	9 061	9 062

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