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FISH CULTURE AND ENVIRONMENTAL IMPACTS IN FINLAND

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1.1.1. Production Capacity of Farmed Fish

Production in fish farming has progressed fast during last the decade in Finland. The total number of farms has almost tripled over 10 year period. During the last years the increase of the number of net-cage farms has been most rapid (figure 1). The majority of these net-cage farms is located in the brackish water area along the

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coast-line.

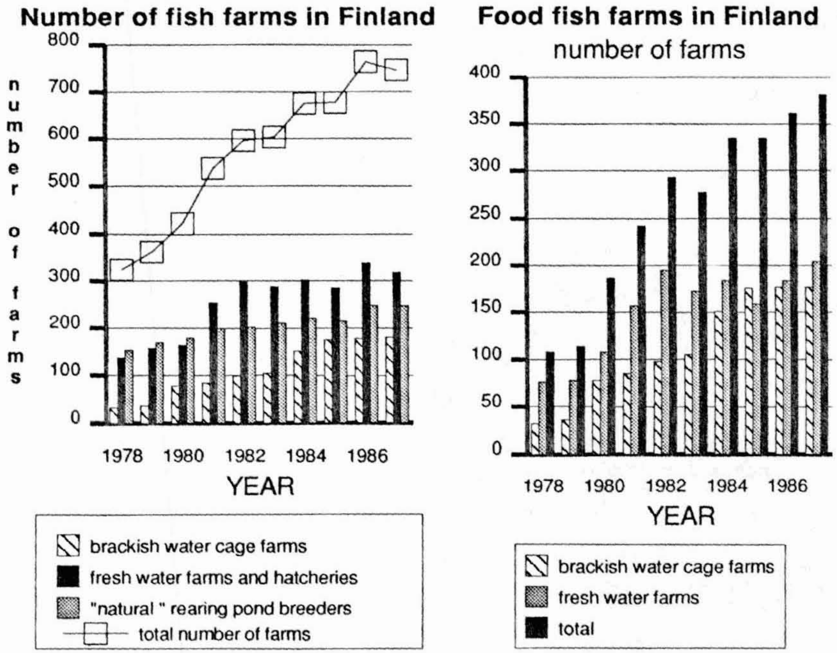

Figure 1. The Number of Fish Farms in Finland

Conventional pond farmers ("natural" ponds) are all located in the inland lake areas. An increase of fresh water farms during recent years has mostly been with the growing numbers of hatcheries. Consequently the increase of rearing capacity has resulted in a growing (Figure 2). In the glass cylinders are incubated mainly whitefishes and on trays salmonids respectively. The remarkable high increase in tray incubation capacity is partly a response to the norwegian demand with the aim to produce smolts for the norwegian market. Today Norway is more or less independent from smolt imports and this has caused overproduction problems in Finland during last three years.

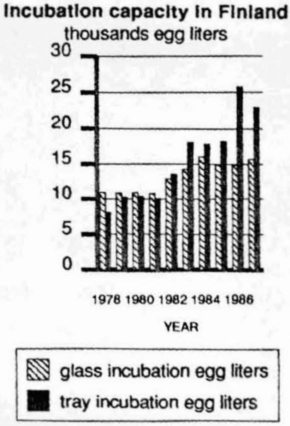

Figure 2. Incubation Capacity in Finland

The increase of rearing capacity for fingerlings is clearly seen also in the sector of the industry employing land-based systems plastic and concrete tanks): this area of aquaculture has doubled during the last five years. In part this increase occurred as a consequence of tank culture gained ground to fill the gap the reconstruction of earthen pondsystems, having less area availableof these has decreased (figure 3).

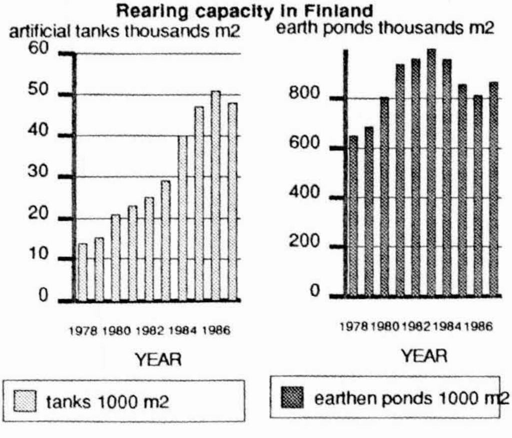

Figure 3. Rearing capacity in Finland, the area of tanks and ponds

The area for net-cage farms in brackish water has increased very rapidly, enclosures employed in inland waters remained under 5 hectares (Figure 4). The decrease in area in 1987 is due to the restrictive licencing policy of the authorities.

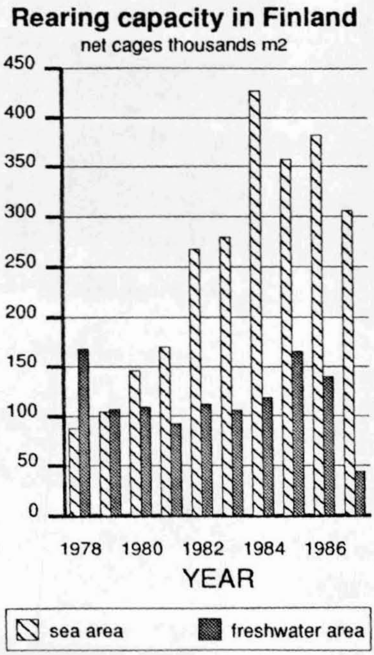

Figure 4. The area of net-cages in brackish water and inland areas

The number of net-cage farms has not increased in inland area (Figure 5).

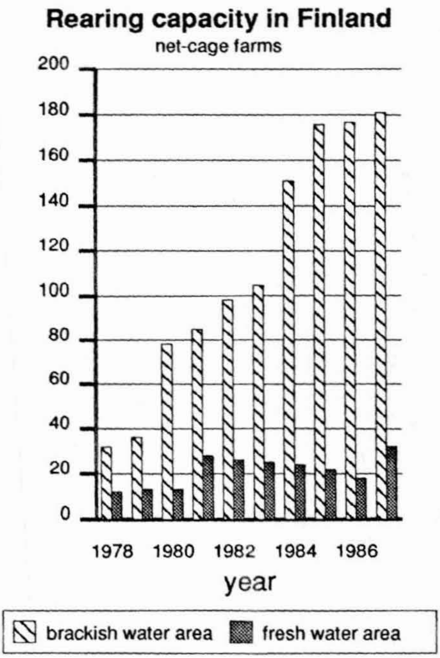

Figure 5. Number of net-cage farms in coastal and freshwater areas in Finland

Compared to the large number of Lakes in Finland (over 180 thousands) 30 net-cage farms with 5 hectares surface area is must be cinsidered as a surprisingly low involvement of this type of aquaculture in freshwater lakes. In practice it is nowadays almost prohibited to establish a net-cage farm in the lake area. The biggest net-cage farms in inland waters are located in rivers with large run-off volumes.

Brackish water net-cage farms are mainly operated by those food fish producers which rear larger rainbow trout.

The use of so called natural rearing ponds is an extensive culture method suitable for Finland with potential for expansion. There exist huge numbers of small stagnant ponds which are drained once a year. The main product in these ponds is whitefish. The natural rearing capacity has grown evenly over the last years(Figure 6).

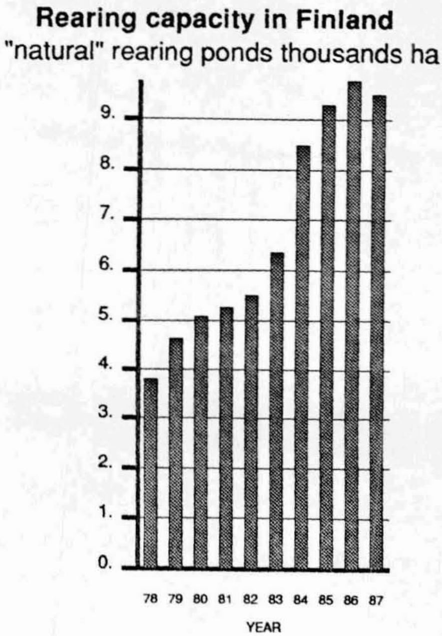

Figure 6. The area of natural rearing ponds in Finland

1.1.2 Production

1.1.2.1. Foodfish Production

The total food fish production in Finland in 1987 was over twelve million kilograms (Figure 7) with large rainbow trout (99 %) as the main product. Only some hundred tons of salmon were produced.

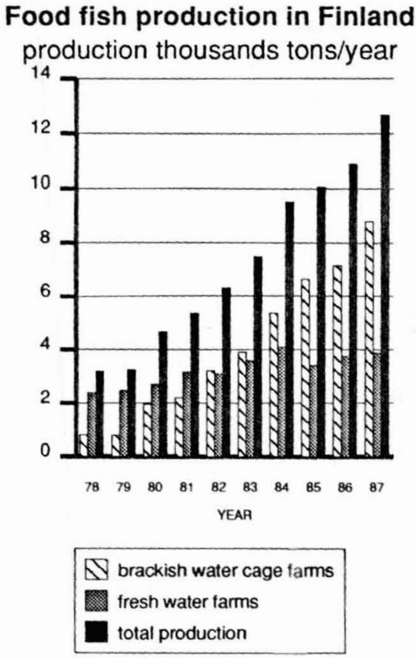

Figure 7. Food fish production in Finland

In 1982 the share of production between brackish water and fresh water areas was still even, however in 1987 only one third of all fish was produced in fresh water. The share of production capacity of freshwater net-cage farms is nowadays under fifteen per cent of the total area of net-cages.

1.1.2.2. Production of fish for Stocking

The production of fish for stocking purposes can be devided into two kinds of production: The first type produces newly hatched fry for stocking only. This production strategy is maybe not considered as economically viable or biologically very effective, but it is largely applied in Finland.

Regarding the stocking of salmonids the trend to release newly hatched larvae is probably more a sign of occasional overproduction than a well planned activity. Trouts are stocked at the highest rate, excluding rainbow trout which is used outside the food fish production only occasionally(Figure 8).

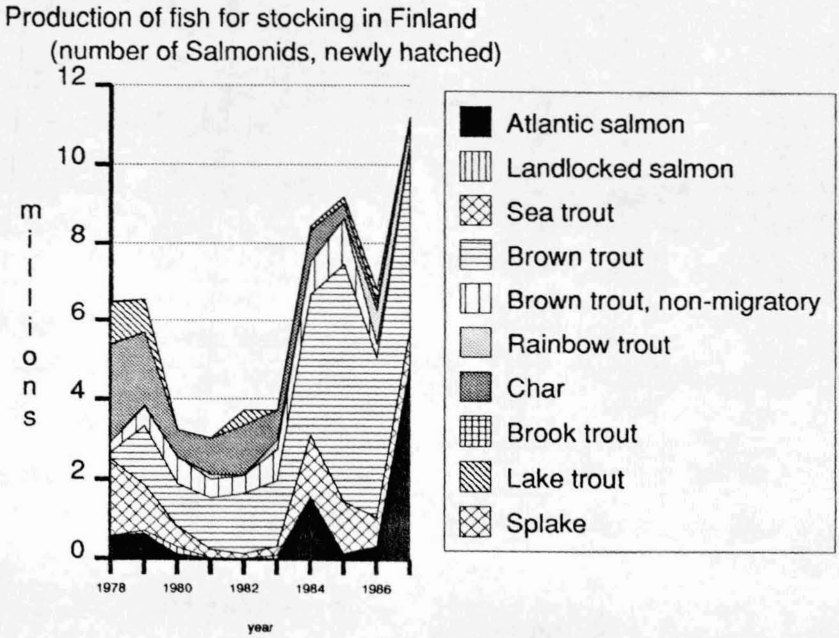

Figure 8. Stockings of newly hatched salmonids in Finland

Especially high is the number of coregonids stocked as newly hatched fry (Figure 9) into many water bodies. Coregonus lavaretus and C. peled are most numerous and vendace and grayling are only marginal species in this connection.

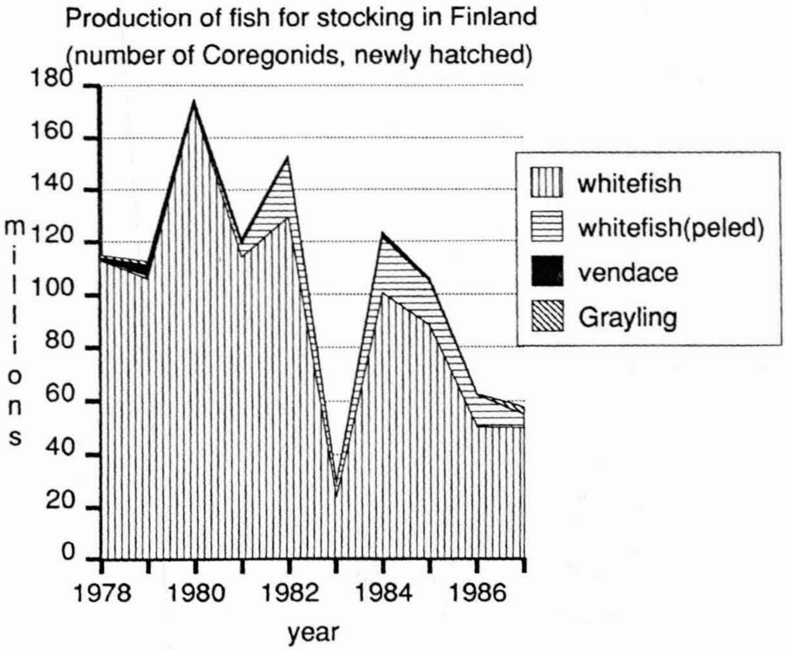

Figure 9. Stockings of newly hatched coregonids in Finland

Pike and pike-perch are incubated, reared and stocked newly hatched very often by fishermen and their organisations (Figure 10). Regarding pike, the natural reproduction is in general not endangered in Finland.

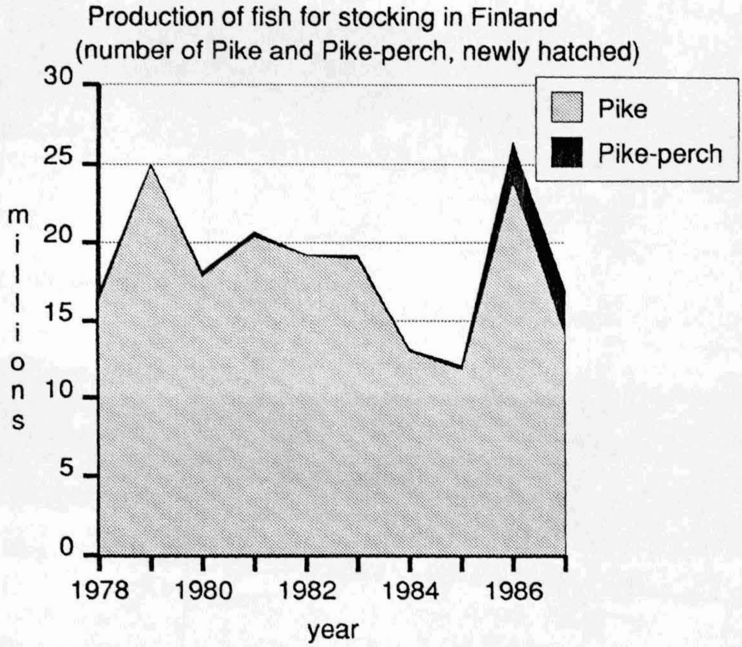

Figure 10. Stockings of newly hatched pike and pike-perch in Finland

Occasionally some other species have been stocked as newly hatched fry too and these activities are summarized in Figure 11.

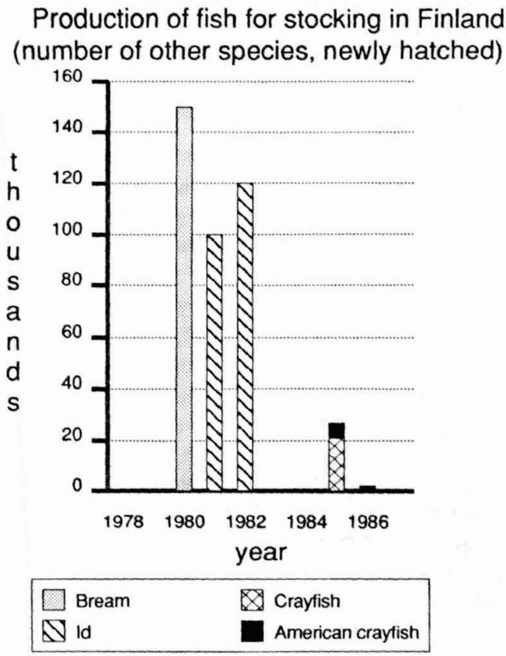

Figure 11. Stocking activity of reared species other than salmonids as newly hatched larvae

Stocking of salmon smolts has more than doubled during the last five years (Figure 12). The main reason for this development has been the international contract concerning Baltic Sea fishery which is obliging Finland to stock a certain number of smolts annually. Nowadays Finland is overcompensating with its stocking programme the level of its own salmon fishery.

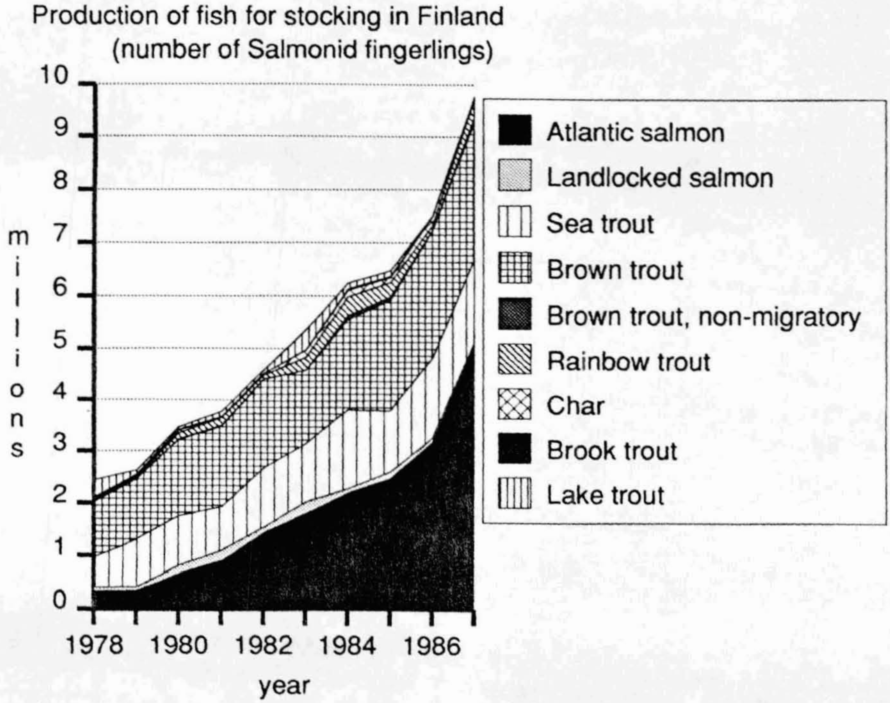

Figure 12. Stockings of salmonid species in Finland

Other important salmonid species in aquaculture are trouts, others than rainbow trout. Brown trout is separated in three groups: sea migrating (so called Sea trout), lake migrating (so called Lake trout) and non-migratory trout (dwarf-form); the latter one has also a special name in finnish.

Whitefish, Peled and grayling are produced only in natural rearing ponds. Stocking of fingerlings are mainly Coregonus lavaretus and production has increased evenly over the past years (Figure 13) as has also the area of natural rearing ponds (figure 6).

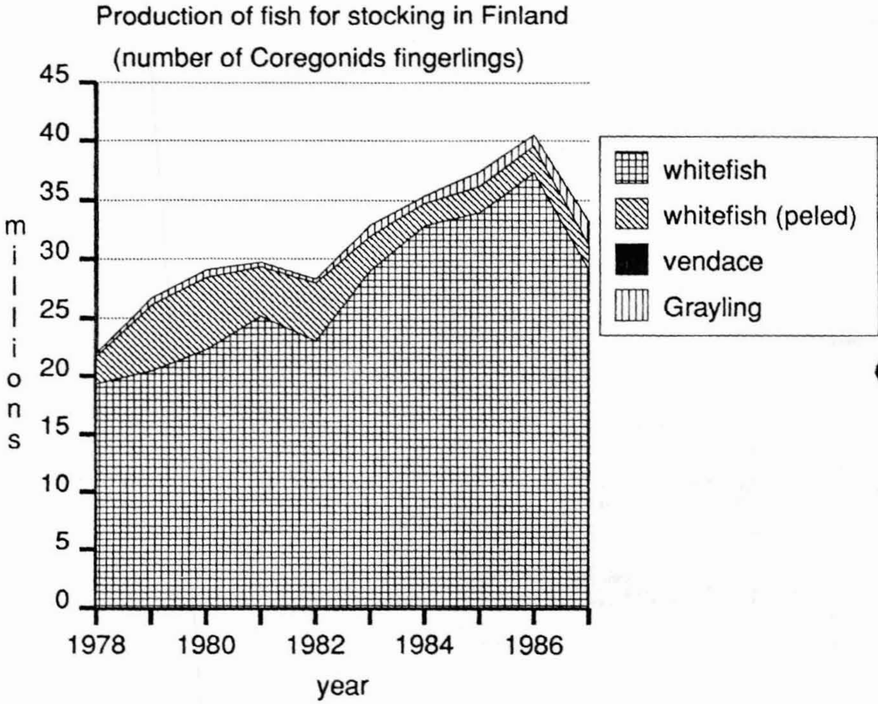

Figure 13. Stockings of Coregonid fingerlings in Finland

Demand for pike perch has been increasing (Figure 14). Pike and pike-perch are also cultured in natural rearing ponds. Pike is stocked already after some weeks of rearing usually in the end of June.

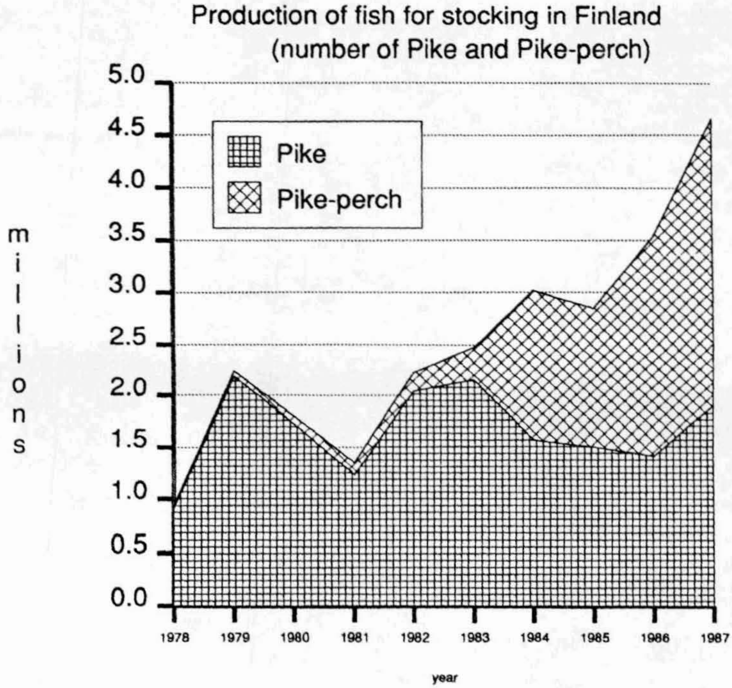

Figure 14. Stockings of pike and pike-perch in Finland

Stocking activities with other fish species have been rather occasional (Figure 15). Crayfish culture and stocking of crayfish is in its phase and shall in the future be fast growing branch in Finland.

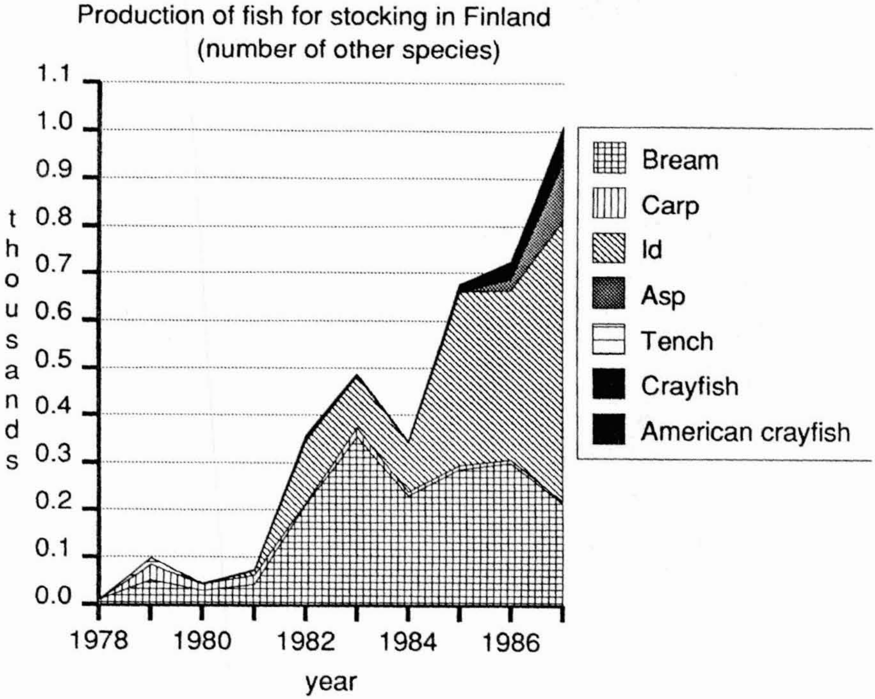

Figure 15. Stockings of other species in Finland

2. General Legislation and Monitoring Practice

According to water regulations practically all fish farms in Finland must have a licence issued by the Water Court. This licence specifies the maximum allowable capacity as well as the amount of feed to be used, the maximum allowable growth rate and the biomass of the fish.

The farmer is obliged to keep a diary for inspection by the authorities; all data concerning the use of water, feed, medication and other parameters specified in the licence must be recorded. Farmers are also obliged to pay for control studies on their effluent quality and investigations of the environmental impacts on the recipients of the effluents.

For land-based farms the sampling to document effluent water quality is done by collecting samples at least over 48 hours and this must be done 3-12 times annually depending on the size of the farm.

The environmental impact in the recipient may be studied 3-6 times per season by measuring total phosphorus and chlorophyll content in trophogenic layer of the recipient-lake. Temperature, secchi-disc depth and (in the sea area) also the conductivity is determined.

The costs of the effluent and recipient monitoring studies have been on average at the level of 0.04 - 0.11 US Dollar per kilogram fish produced. In the marine area where only recipient monitoring is done the costs have been about 0.02 - 0.07 US Dollar per kilogram fish produced (Häkkilä 1988).

The Finnish National Board of Waters and Environment is represents common interests in the Water Courts. It is also the authority accepting the monitoring programs for fish farms. The attitude of the National Board of Waters and Environment is thus very decisive regarding the extent of fish farming.

For monitoring of net-cage farms the same programmes, used for freshwater land based farms have been applied. The data for nutrient and chlorophyll concentrations have nevertheless only occasionally shown any detectable change in the marine environments. The biggest farms are therefore, obliged to include in the studies fishery-, benthos-, and sediment surveys as well.

The transfer, by the authorities, of the basic concepts from the freshwater areas to the brackish water has been misconception, since there is a lack of scientific understanding of the holding capacity of the coastal areas (e.g. such as the Vollenweider model for limnic areas).

The net cage farms have been seen as one case where industrial activities and the water protection measures demanded by the authorities has been the same. Because the net cage farms do not have any effluent pipes to which effluent treatment facilities could be attached some of the farmers are obliged to pay 'water protection charges' in the same way as other industrial operations, if they do not have any capacities to purify their effluents.

Instead of viewing them as industrial operations and thus a point source of effluents it would be better to consider marine fish farms as (aqua)culture installations and oblige them to take care of their own environment through appropriate site selection and monitoring programmes. The monitoring programmes should be designed specifically for marine areas and not simply as application of fresh water monitoring protocols.

3. Future Trends of Production and Development

The Finnish Foundation for Development Areas forecasted the development in fish farming in Finland and provided the following evaluation (Hakanen et al.1987):

The food fish production is expected to double in the early 1990's. Rainbow trout will again be the major species farmed, but also farming of other fish species will gain importance. The main market will be the domestic one. Production of young fish is not expected to limit the food fish production in the future. On the contrary, there may be occasional overproduction of smolts.

In the same study the authors could not anticipate any great increase in the production for stocking natural waters, but changes may occur in the relative numbers of fish species stocked in Finland.

The Finnish fish farming industry employs about two thousand persons directly (Partanen et al. 1988). Indirect employment effects are estimated to be several times the above figures contributing to the economic growth of the society. Fish farming is seen as an area which still has some room for expansion and which may employ more people in the remote areas, especially in those developing in Finland.

Fish farming in Finland is now a common and well established trade. Out of the fish food production, about 98 % consists of large-sized, i.e. over 800 g rainbow trout. The sales value of the production was about 55 million US dollars in 1986 (figure 16).

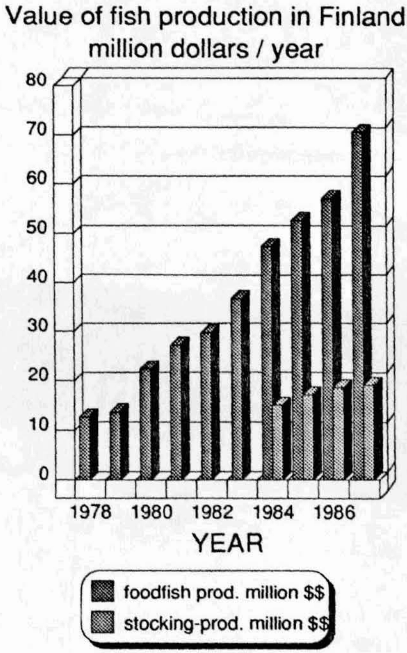

Figure 16. The value of farmed fish production in Finland

As a general trend in the Finnish fish farming there is now a relative increase of food fish production in marine areas, while the production of fingerlings is becoming relatively more prominent in freshwater farming.

4. Loading from Fish Farming

4.1. Nutrients

The production of fish to stocking size in Finland is now estimated to be about 600 tonnes annually. This means that an estimated amount of about 7 tons phosphorus and about 45 tonnes nitrogen loading is derived from this culture.

The nutrient loading from food fish farming is estimated to be about 140 tonnes of phosphorus and 950 tonnes of nitrogen annually. The contribution of fresh water and marine farming to this overall nutrient load is presented in Figure 17. (Mäkinen 1988b).

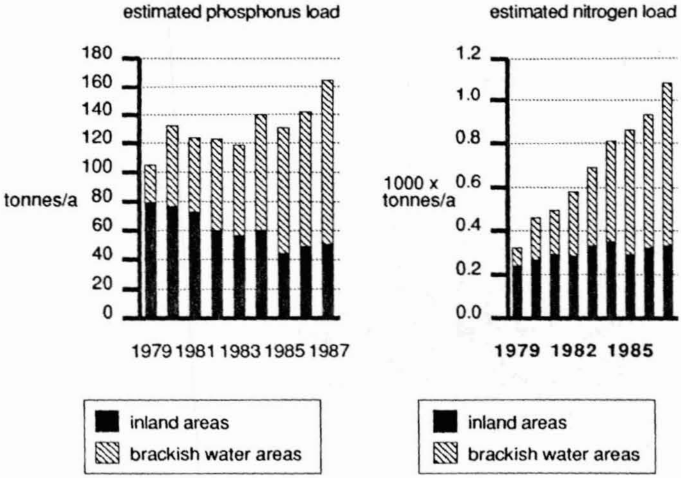

Figure 17. Estimated phosphorus and nitrogen load

The contribution of the nutrient load from the fish farms to the total nutrient load derived from human activities is rather marginal in Finnish waters : under four percent for phophorus and under two percent for nitrogen (KOMITEANMIETINTÖ 1986)

4.2. Environmental Loading through Other Substances: Chemicals and Antifouling Agents

Other harmful substances than suspended solids and nutrients enter the environment through fish farming. They are mainly comprised of (1) chemicals for desinfection of ponds, tanks and equipment and (2) chemicals used as therapeutic agents against diseases and (3) antifouling agents.

The following quantities of various substances were compiled from data collected by the National Veterinary Administration and by the National Board of Waters and

Environment in Finland. Overlap of data and missing data were corrected as far as possible. However, the data presented here contain still some inconsistencies and describe only the scale of the consumption of medication and other chemicals in finnish fish farming.

The therapeutics mostly used are bathing agents with the common marine salt as the major harmless substance. It is used mainly against Chilodonella parasite in production of fingerling in fresh water farms. The total amount of salt presently used is about hundred tons (Figure 18).

Formaldehyde is another agent for treatments and is mainly used against Ichtyobodo and monogens. The amount used is about 4.5 tons annually (Figure 18).

The third commonly used agent is malachite green mainly against Ichtyophtirius and often employed together with formaldehyde. The use of this chemicals amounts to about 300 kg annually (Figure 18). Small amounts of chloramine and benzalconchloride are also used in the country. The latter is used also for desinfection of equipment on farm sites.

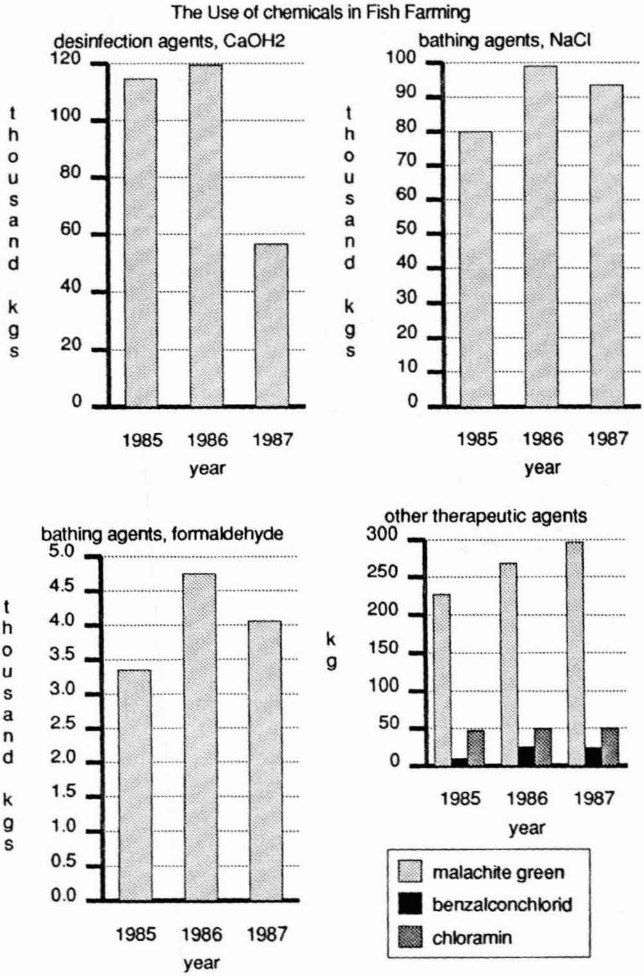

Figure 18. The use of chemicals in finnish fish farming, fresh water area

Among the desinfection agents chalk is the one used at the largest amount: about 120 tons annually (Figure 18). It is not only used for desinfection purposes in earthen ponds but also as a medium for pH adjustment in natural rearing ponds. Small amounts of other desinfectants are also used, such as iodophors for egg desinfection. With regard to anesthetics MS 222 the one used most commonly.

With regard to antibiotics in Finland, the use of oxytetracyclin in, has been growing when furunculosis was diagnosed more frequently in inland area. The total use in fresh water was about 600 kg in 1986 (Figure 19).

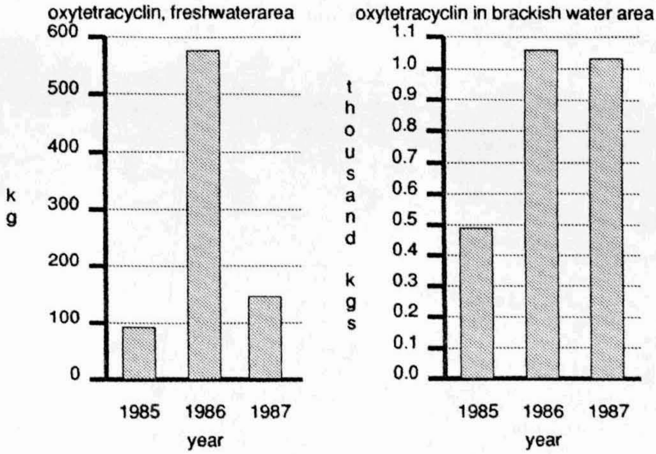

Figure 19. The use of antibiotics in fish farming in finland

In marine areas the use of other chemicals than antifouling agents and antibiotics is rather small. Oxytetracyclin is again the mainly used antibiotic in brackish water net-cage farms with a total amount of about 1050 kilograms annually (Figure 19).

The use of chemicals in food fish production has been rather marginal in Finland. The introduction of vibriosis vaccination reduced greatly the application of antibiotics in the early 80s. In 1988 the use of antibiotics was much higher due to the exceptional warm summer. Figure 20 depicts the relative amount of all chemicals and antibiotics used per kilogram fish produced (antibiotics comprising mainly oxytetracyclin with terramycin at marginal levels). The use of chemicals seems to be very much higher in fresh water fingerling production and has also been growing during last years. Also when the more harmless marine salt and chalk are not considered in fingerling production in 1987, this branch of the industry used about hundred times more chemicals than the food fish production sector (Figure 20). Not all of this amount was used for chemotherapy but also for desinfection of equipments and other purposes.

The use of antibiotics is more similar in fresh water and brackish water production. The summer 1987 was rather cold. Consequently the use of oxytetracyclin stayed at lower level.

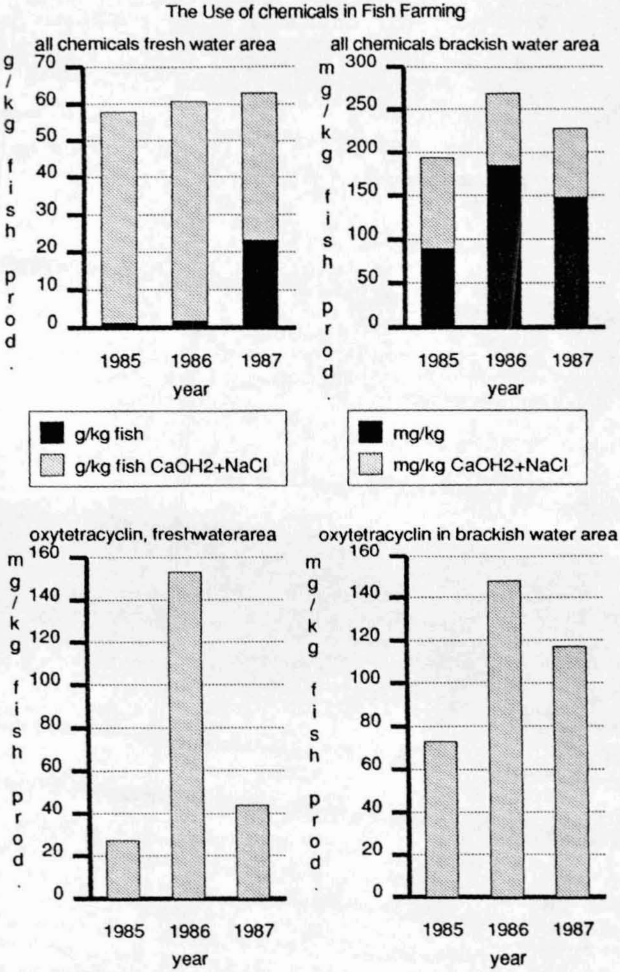

Figure 20. The Use of chemicals and antibiotics per kilogram of farmed fish in Finland

The antifouling paints are applied mainly for maintenance of brackish water net-cages. The amount used is still now unknown and, therefore, cannot be considered here. In fresh water farms, antifouling substances are used only occasionally, mainly on outdoor plastic and concrete tanks. Organic tin substances (TBT) are not among those paints used by fish farmers in Finland. The most effective compound used in paints is usually based on copper.

5. New Studies going on Concerning Environmental Impact of Fish Farming in Finland

5.1. Sludge Collection Methodology

Testing of a new innovative technique for sludge collection from earthen ponds is presently in progress in Finland (Karttunen et al. 1988). A prototype of a specially deviced unit, consisting of floating "whalebones" on the bottom for trapping and collecting of drifting sludge was tested. The aim is to develop an economic way to remove sludge from old fish farms employing very long earthen ponds. The particular intention is not to reconstruct the whole farm in accordance with modern criteria.

5.2. Feeding Practice and their Influence on Waste Load

The quality of feed is decisive for loading figures. The development of feed, especially the improvement of its nutritional value and feed conversion efficiency together with the lowering of excessive nutrient contents, gives far better results on reducing the environmental effects of aquaculture than any treatment method for effluents. The reduction of phosphorus and nitrogen contents in relation to the content of metabolizable energy and the increase of digestibility together with feeding optimization can quite easily help to reduce the nutrient load by about two third when compared to earlier feed formulations (Mäkinen 1988a, Ruohonen & Mäkinen 1987).

Regarding net-cages, especially in marine areas, and rearing of larger fish there is still a need for research on feeding optimization, relating bioenergetic studies and the use of markers for measuring ingestion,egestion and digestion rates. Also, indirect methods to measure feed losses on full-scale net-cage farms are urgently needed. A new project aiming to measure the feed losses in different ways has recently been implemented in Finland.

5.3. Mitigation of Environmental Impact by Other Measures

Besides internal measures to reduce the pollutional load from net-cage farms the selection of an appropriate site for placing of a farm is one of the most important ways to minimize harmful environmental effects.

In 1987 the Nordic Council of Ministries agreed to fund a three years project with the aim to develop an environmental impact assessment strategy for marine fish farms. This project will serve as a model to be utilized for planning purposes and for a better exploitation of coastal areas.

The preliminary report of this project on "Basic Concepts concerning assessments of environmental effects of marine fish farms" is already published (Håkansson et al. 1988).

The central part of this project was to develop a load diagram similar to the well known and widely applied Vollenweider diagram for limnic areas. The idea still is to develop an analogous diagram of the environmental risk assessments for the marine areas as the project progresses. The concept presupposes that the choice of the most suitable parameter is made for describing the environmental sensitivity of an area, as well as the observed biological effect.

The sensitivity term shall be a quantitative index which includes different morphometric parameters describing the size (shoreline length, maximum depth, water surface area, total area, section area, water volume), the form (mean coastal width, mean depth, mean slope) as well as the topographic openness and bottom dynamic conditions of a coastal area. The effect term shall be measured by some practical and simple parameters (i.e. secci-disc depth, chlorophyll-a content)

In the diagram these two variables will be combined with the knowledge of the "dose" (= BOD and/or nutrient loading or the size of the farms). The acceptable level of loading (size of the farm) will thus be defined.

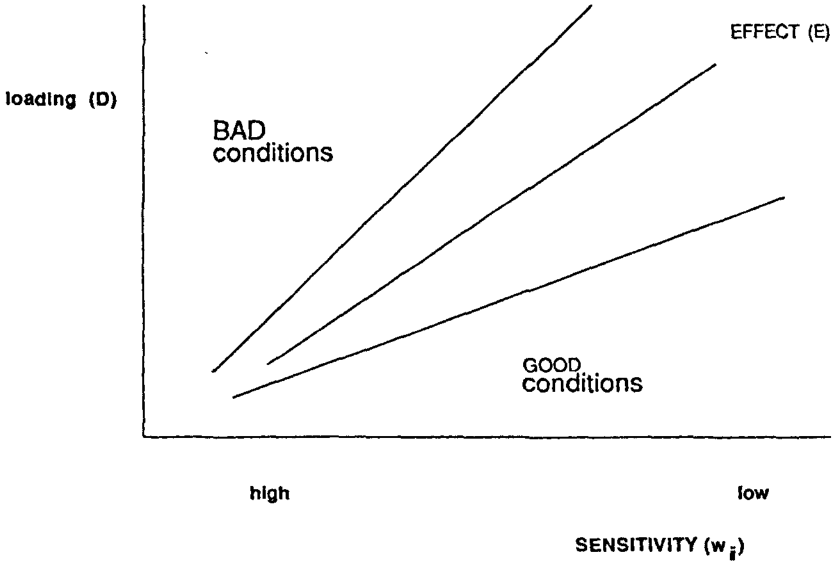

Figure 24. The load diagram (see the text)

With the assistance of this diagram which reflects an input-output-model, it should be possible to compare the sensitivity of different areas and use the results in regional planning and for appropriate site selection. It is hoped that the model will allow to to predict the impacts of a certain fish farm size in selected area.

5.4. Fish Farming Chemicals in the Environment

The clearance time for chemotherapeutants such as oxytetracycline is 30 days in Finland and this time limit applies for the summer time. During winter this time is longer and lasts up to the 60 days. The exact time is determined for each operation by the veterinarians.

The residues and the persistence of oxytetracycline was studied in wild fish and sediments in 1987 in the finnish archipelago (Björklund et al. 1989). In wild fish residues of oxytetracycline were detected up to 13 days after the medication. The half-life of oxytetracycline in fish farm sediments were 9 days on other and 419 days on other farm.

6. Summary

Production in fish farming in Finland has increased fast during the last decade. The total number of farms has almost tripled over a period 10 years. Number of net-cage farms increased most rapidly during the last years. The majority of these cage farms is located in the brackish water areas along the Finnish coast-line.

The nutrient load from food fish farming in 1987 was estimated to have contributed about 140 tons of phosphorus and 950 tonnes of nitrogen to the total input to the environment. The contribution of fresh water and marine farming to this overall nutrient load is presented. The relative contributions of this load to the total nutrient load derived from human activities is rather marginal in Finnish waters: inputs are under four percent for phosphorus and under two percent for nitrogen.

In marine areas, the use of other chemicals than antifouling agents and antibiotics has been small. Oxytetracycline is the antibiotic substance mostly used in brackish water net-cage farms. The total amount has been about 1,050 kilogrammes annually.

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