Chapter 25
Rehabilitation of the fisheries of Lake Inari, northern Finland

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Hydropower development associated with Lake Inari, northern Finland, has altered its natural state, causing erosion of shorelines and considerable damage to the fisheries between the 1950s and 1970s. The catches declined from 250 t to less than 100 t. In 1975 the Finnish court ordered compensation for damages to the fisheries to be implemented through restoration works, payments to fishermen and by large annual stockings. In the 1980s, the catches of salmonids returned to their state before regulation as a result of stocking of brown trout (*Salmo trutta lacustris*) and Arctic charr (*Salvelinus alpinus*) and the introduction of two new species, land-locked salmon (*Salmo salar sebago*) and lake trout (*Salvelinus namaycush*). The catch of whitefishes (*Coregonus* sp.) has also approached its earlier level because of new fishing methods. A new species, vendace (*Coregonus albula*), was accidentally introduced to Lake Inari in the 1950s/1960s and it revolutionized the commercial fishery in the late 1980s. Trawling, winter seine and trapnet fishing were quickly accepted and the catch of vendace increased rapidly to over 300 t yr^{-1}. The total catch of Lake Inari was over double that before regulation (560 t in 1989). New people have been recruited to the commercial fishery and considerable sums have been invested in gear. However, commercial catches vary considerably, reflecting large fluctuations in year class strength.

25.1 Introduction

Lake Inari, which lies approximately 300 km north of the Arctic Circle (69°N, 28°E), has a surface area of 1102 km^2 and is one of the northernmost large lakes in the world (Fig. 25.1). Regulation of the water level in the lake since the 1940s for the purposes of hydroelectric power generation in the former Soviet Union and Norway has caused considerable damage to fish stocks. Fishing has declined and catches have dropped to one-third of their former level (Toivonen, 1966; Mutenia, 1985). In 1975, the Finnish government was obliged, as a result of a court order, to perform extensive restoration work on the lake and its surroundings, including clearing of the shorelines and fishing grounds in the littoral zone, to pay compensation to fishermen, to construct fish hatcheries and to initiate obligatory fish stocking to compensate for the problems caused by regulation (Kaatra & Simola,

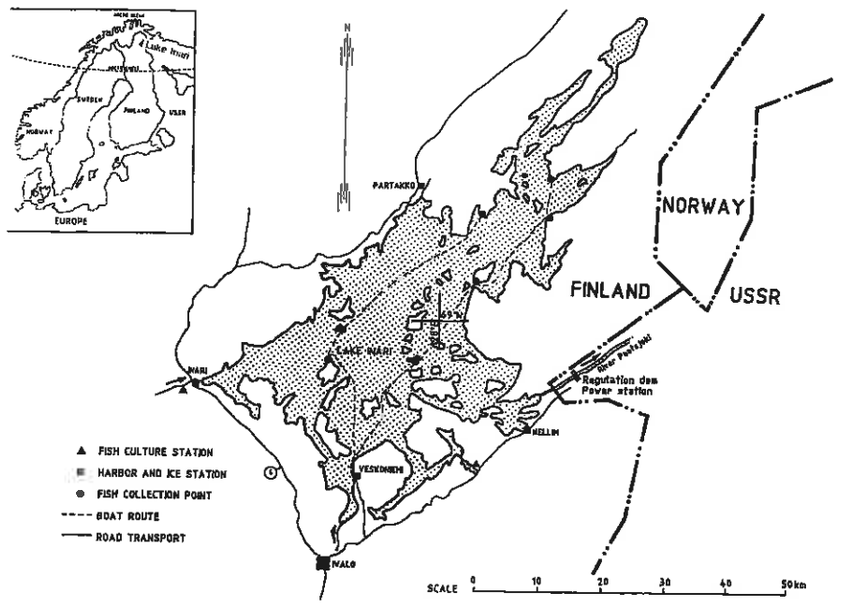

Fig. 25.1 Location of Lake Inari, regulation dam and power station, fishing harbours and fish collection route system.

1985). The former Soviet Union paid a flat sum to the Finnish government in 1959 in compensation for the damage caused by the regulation, and has again been contributing to the compensation measures since 1984. The restoration work, obligatory stocking, establishment of a population of the vendace (*Coregonus albula* L.), a new species in the lake, the introduction of new fishing techniques and the organization of fish collection and marketing have restored Lake Inari to economic viability in the 1980s (Mutenia & Ahonen, 1990; Mutenia & Salonen, in press). Fishing by the local people and recreational fishing by tourists have markedly increased in the last few years, further adding to the significance of the lake in this respect.

25.2 Regulation of Lake Inari and its effects

The regulation of water level in Lake Inari began in the 1940s to meet the demands of Soviet power stations situated on the River Paatsjoki, which flows into the Arctic Ocean. The maximum permissible fluctuation in water level is 2.36 m. As the water level was raised by about 0.5 m above its norm, the water inundated the surrounding forests, which consequently died, causing considerable damage to fishing gear and hampering fishing in general. Production among the bottom fauna in the littoral zone declined, which in turn reduced the availability of food for the fish and reduced their rate of growth (Toivonen, 1966). Prior to regulation, the annual catch in the lake was approximately 250 t. This declined to

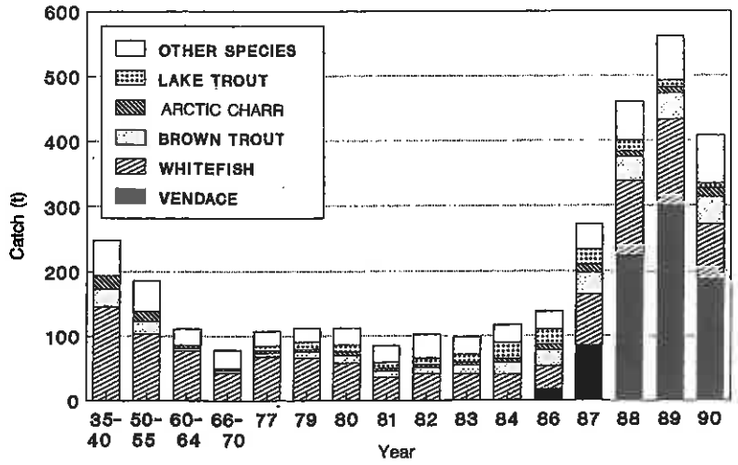

Fig. 25.2 Total catches (tonnes) from Lake Inari between 1935 and 1990. Note variable class intervals and missing years; no data were collected by questionnaire in 1985.

a low of 78 t in 1970 (Fig. 25.2). About 80% of the decline in catches has been attributed to regulation and 20% to other factors (Toivonen, 1972).

A contract regarding the regulation of Lake Inari was made between Finland, Norway and the former Soviet Union in 1959, by which the former Soviet Union paid a flat sum of approximately $US 1.7 million (at the 1991 monetary level, as used through the chapter) in compensation, the responsibility for subsequent compensation being thereby transferred to the Finnish government. A further agreement was negotiated between Finland and the former Soviet Union in 1983 under which the latter would participate in fish-rearing measures to sustain fish stocks in the lake. The former Soviet Union also undertook to provide a total of 150 million kWh of cost-free electricity to Finland between 1984 and 1993, amounting to a total value of $US 7.5 million. The annual energy produced by the seven power stations on the River Paatsjoki is currently 1340 GWh, valued at around $US 50 million. Three-quarters of the power generated is used by the former Soviet Union and the remainder by Norway, which has yet to participate in any compensatory measures.

25.3 Measures to compensate for regulation damage

As a result of complaints by local fishermen and further studies (Toivonen, 1966, 1972), in 1975 the Finnish law courts decided on compensatory measures to be taken with respect to Lake Inari. This was extended to other parts of the water system in 1982. The shores of the lake were cleared of logs and brushwood which had been, or were about to be, loosened by the regulation, were drifting on the lake or had already sunk. A total of 1994 km (72%) of shoreline was cleared to

prevent damage to fishing and boat traffic. In addition, 343 significant seine fishing grounds were checked and cleared and 4.8 km of shoreline protected against erosion. A total of over $US 3 million was invested in the clearance work, carried out between 1976 and 1979.

Flat sums were paid to 292 fishermen in compensation for losses in catches caused by the regulation of Lake Inari and its adjacent basins, and the damage caused to fishing tackle was recompensed 1.5-fold. The owners of individual lengths of shore received compensation for landslides on the banks and for the measures required for their prevention. The above compensation payments amounted to a total of $US 4.5 million (Table 25.1).

A new fish hatchery had to be constructed to implement the compensatory stocking measures, an existing hatchery had to be expanded, and natural feeding ponds had to be established. The total construction and investment costs involved in fish stocking were about $US 10 million up to 1991, and the annual operating costs have been around $US 1 million in the last few years (Heinimaa, pers. comm.).

25.4 Stocking and the arrival of the vendace in Lake Inari

Before the regulation took place the whitefishes (*Coregonus* sp.), brown trout (*Salmo trutta m. lacustris*) and Arctic charr (*Salvelinus alpinus*) were the most important species to the fishery (Fig. 25.2). As part of the compensation for regulation, the Finnish government was obliged to introduce 1 million one-summer-old whitefish (*Coregonus pidschian* and *C. muksun*), 100 000 brown trout or land-locked salmon (*Salmo salar m. sebago*) of migratory size and 250 000 one-summer-old fry of the Arctic charr or lake trout (*Salvelinus namaycush*) annually into Lake Inari. Of these, the land-locked salmon and lake trout were species new to the lake. The government was also expected to introduce a total of 108 000 one-summer-old whitefish and 15 000 three-year-old brown trout annually into adjacent watercourses of Lake Inari, and to monitor the results of these stocking measures.

As the stocking could not be achieved in the first instance, the numbers of both whitefish and predatory salmonids stocked in many years were double those required. The total numbers of all salmonids introduced into the lake between 1983 and 1991 have been maintained at a high level and varied between 2 and 4 per hectare (Fig. 25.3).

The vendace is not native to Lake Inari, and entered it by accident when some fry intended to be introduced into small lakes in the Paatsjoki watercourse escaped from the hatchery in 1956 (Sergejeff, 1985). Vendace fry were also introduced into a small lake connected to Lake Inari by the River Ivalojoki (distance approx. 30 km) in 1964–66. These had been brought from lakes 150–250 km further south to study whether they could eliminate the local dwarf whitefish from the small lakes of the Paatsjoki river system. Vendace populations subsequently became established in Lake Inari, were first observed in 1973 and

Table 25.1 Compensation payments made to fishermen and landowners in respect of damages caused by regulation. Compensation payments applying to Lake Inari itself were made in 1977 and those for other parts of the water system in 1983. The costs have been adjusted to 1991 monetary levels

Reason for compensation	Lake Inari			Upper water system		
	Persons receiving compensation	Total payments ($US million)	Average compensation ($US per fisherman)	Persons receiving compensation	Total payments ($US million)	Average compensation ($US per fisherman)
Decline of fish yield	203	3.4	16850	89	0.5	5140
Damage to gear	173	0.1	870	4	0.004	1090
Collapse of banks and their protection	138	0.5	240	—	—	—
Total	514	4.0		93	0.5	

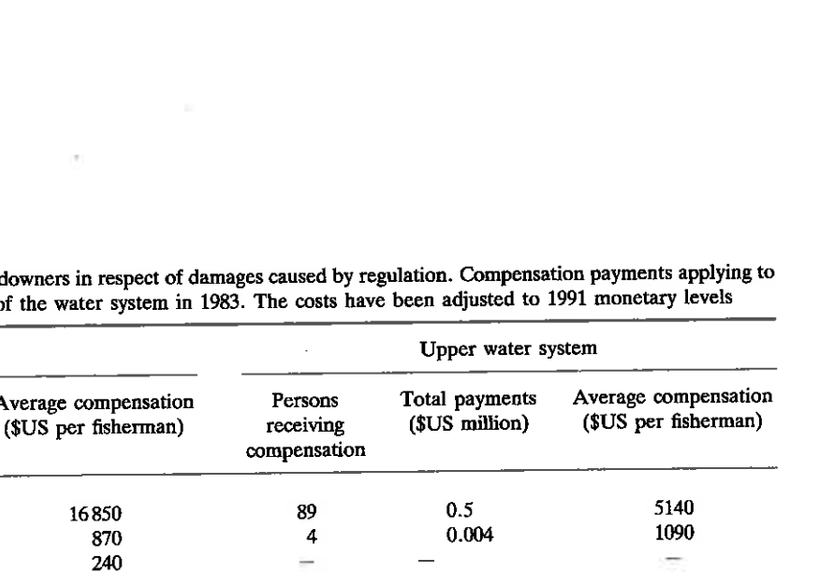

Fig. 25.3 Total stocking of salmonid smolts in Lake Inari between 1976 and 1991.

have regularly contributed to the catches since 1978 (Sergejeff, 1985). Experimental fishing in 1983–84 showed that the species had spread throughout the lake (Mutenia & Salonen, in press).

25.5 Effect of compensatory stocking and the vendace on fishing and catches

The intensive stocking regime has increased the brown trout catch to a level higher than that under natural conditions, and the total catch of all predatory salmonids has been much higher than before regulation. Whitefish catches approached pre-regulation levels in 1989, thanks mainly to the start of a fishery with trapnets. Since 1989 catches have begun to decline owing to a fall in population size of whitefish (Salojärvi & Mutenia, Chapter 28) (Fig. 25.2).

Professional fishing began to revive in the latter half of the 1980s, first as a result of the stocking of salmonids and the introduction of new fishing techniques for vendace and whitefish towards the end of the decade, i.e. trawling, winter seine and trapnet fishing. The number of trawlers rose from 3 to 16 pairs between 1987 and 1989, while the total catch increased very rapidly in the late 1980s as the professional fishing of vendace increased (Fig. 25.4). When the vendace appeared in the catch statistics for the first time, in 1983, the total catch was 380 kg, but by 1989 it had increased to 302 tonnes (Mutenia & Salonen, in press). The highest total catch of all species, 560 t, obtained in 1989 (5.1 kg ha^{-1}), was more than twice the amount caught when the lake was in its natural state (Fig. 25.2). Vendace account for about 50% of the total catch, whitefish just under 25% and salmonids 15%. (Whitefish was the most important species before regulation, constituting almost 60% of the entire catch.)

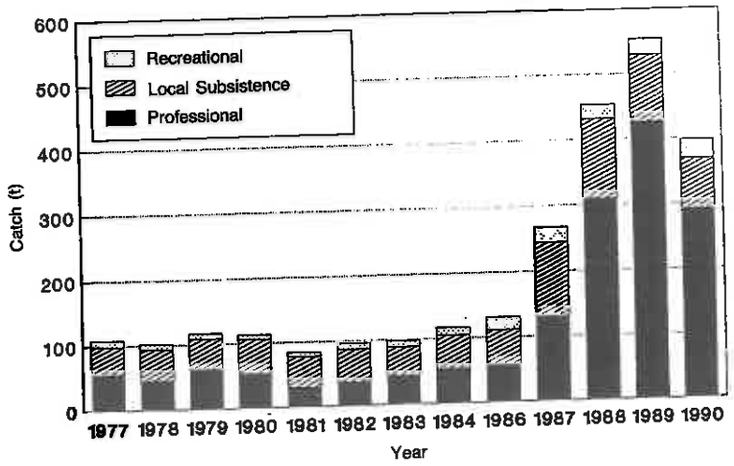

Fig. 25.4 Distribution of catches by professional, subsistence and tourist recreational fishermen in Lake Inari between 1977 and 1990. No data were collected by questionnaire in 1985.

The number of professional and semi-professional fishermen has risen to nearly 100, of whom 45 reported fishing as their primary occupation in 1990. Most fishermen use trawling as their primary method, at least half of the professional catch being obtained by this means. The total value of the professional catch to the fishermen themselves has varied between $US 500 000 and 1.1 million in the last few years (Salonen, in press). Considerable investment was made in professional fishing in the late 1980s, and fishermen have been assisted in the form of various government grants and loans for the purchase of equipment. A total of $US 1.5 million was invested in trawling up to 1989 (Mutenia & Salonen, in press).

Local subsistence fishing has traditionally occupied a prominent position in Lake Inari, and has been practised by one local family in three over the last few years. Until 1987, approximately 50% of the total catch was contributed by this fishery (Fig. 25.4). Subsistence fishermen have extensive fishing rights, including a free fishing permit allowing each to place up to 15 nets in the lake. The catch per household is around 100 kg yr^{-1}; an average of 38 kg of fish caught from Lake Inari is consumed annually by each person in such a household (Salonen, in press), a figure which exceeds the average level of fish consumption in Finland.

The number of non-local recreational fishermen increased markedly in the 1980s, but has remained at around 4000 in the last few years. Their permits allow trolling, fly fishing and spinning. A total of 50% of their catch was brown trout, which constituted one-third of the total brown trout catch in 1990. Recreational fishing has a significant indirect effect on the local economy by promoting tourism, the most important livelihood in the area.

25.6 Development in the management of fish stocks and the fisheries

In the light of the monitoring results, management and compensatory stocking was adjusted around 1990. Stocking of *C. muksun* was discontinued in 1989 as the results obtained were extremely poor. Modest results (average 20 kg per 1000 fingerlings) were achieved with stocking of *C. pidschian*. Tagging data showed that only one-quarter of the fish of this species that were caught had been stocked. This was attributed to the unexpectedly successful natural breeding of the *C. pidschian*. As a result, the number of whitefish stocked was temporarily reduced to 0.5 million per year (Salojärvi & Mutenia, Chapter 28).

Stocking results for salmonids have been varied, but are, in general, poor. Tagging data indicate returns of less than 100 kg per 1000 smolts, and suggest that brown trout should be stocked at the age of 3 yr or older, or at a minimum size of 22–24 cm. Land-locked salmon should be stocked later in the summer than brown trout (Mutenia & Salonen, 1991). Lake trout should be stocked when at least 24 cm, and Arctic charr 30 cm in length, when they become piscivorous (Ahonen & Jääskö, 1991). The legal size of all predatory salmonids is 40 cm.

These data undermine the need for high stocking densities of salmonids and the exercise should be critically appraised, especially if the size of stocked smolts increases. Natural reproduction of brown trout and Arctic charr, and variation in the stock size of vendace, the most important prey species of the salmonids, should be taken into account.

Considerable variation in year class strength of vendace has been observed: 1986 was an extremely strong year class, which had a major impact on the growth of the fishery and catches in 1988–89. By contrast, the 1987 and 1988 year classes were weak, as manifested in a marked decline in catches in 1990 and 1991 (Salonen, in press). Commercial fishing is essentially dependent on year class variations of the vendace, which are thought to be the result of extreme climatic conditions experienced towards the northern limit of the species' natural range in Finland (Mutenia & Salonen, in press).

The expansion of the fishery is primarily attributable to a government-supported experimental fish collection and distribution centre started in 1985–86. This provided facilities for icing the catch, which improved fish quality, and improved distribution to the larger markets in the south (Mutenia & Ahonen, 1990). Fish from Lake Inari have consequently gained a good reputation in Finland, and those transported south for sale have met with a steady demand. However, fish prices have generally declined as catches have increased. Further possibilities of processing the fish in the area are unlikely, although demand for fillets by the tourist industry is increasing.

Lake Inari is primarily owned by the government, and controlled by legislation established in 1951. This legislation is being restructured in the light of recent changes in the fishery.

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