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Assessment of ecological consequences caused by economic use of natural resources of Lake Inari (Finland)

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Abstract

On the basis of scientific research and fish industry inspections of Finnish Game and Fisheries Institute as well as work materials of Northern Fisheries Research Institute on the inshore waterbodies of the Russian North the condition of the water ecosystem of Lake Inari (Northern Finland) was analyzed. Integral assessment of damage caused to the fish reserves of this waterbody by multi-factor economic impact was presented. The conclusion was made about introducing corrections into the fishing program of Lake Inari.

Introduction

This work was completed within the framework agreement of Russian-Finnish Commission on Joint Use of Transboundary Water Systems.

The long-term ambiguity in relations between Russia and Finland on the issue of compensating for damage caused to the fish resources of Lake Inari by hydropower use of the Paatsjoki River (Paatsjoen, Paz, Patsojoki), despite the compromise agreement of October 1997, deems it necessary to study in more detail the situation in ecological aspect to assess the share of damage caused by economic activity of Russia.

At present there are contradictions and different interpretations of the term "ecological damage" and there is no universal unit for its measurement. The latter is of ecological, economic and social significance simultaneously and, therefore, there are many methodical and legal approaches used.

The environmental legislation of Russia specifies only the procedure for compensation of damage caused to wildlife and environment. The amount of damage itself is assumed rather voluntarily: according to taxes and methods, actual costs, losses, court decision or even on agreement of the parties. A similar situation exists in Finland where they recognize the rights of fishers and land owners for compensation for damage and reimbursement provided that the damage was established in court or by protocol.

Thus, the existing situation leaves room for compromise, especially on the international level.

Considering the long-term (since 1981) work experience on ecological expert examination and taking into account the opinion of the leading specialists concerning the priorities of fisheries in the sphere under examination, the specialists of NFRI adhere to the following provisions:

- changes in fish productivity must be accepted as the basis for assessing damage to fish resources: - natural productivity (capacity of water body to reproduce a certain amount of fish biomass per time unit), but not industrial; only in cases of direct annihilation of hydrobionts shall assessment be made according to the biomass;
- analysis of factors affecting fish resources of a certain water body must cover the whole catchment area of the water system comprising the reservoir under consideration, as well as all transboundary air pollution and other migrations;
- changes in the composition of fish population (the proportion of certain species) are not necessarily caused by technical factors (with the exception of fishing trade and artificial stocking). Quite common are natural fluctuations of population caused by global climate and production cycles as well as inter-reservoir correlations;
- today's scientific standards require recognising as acceptable such technogenic (ecological) load that results in biotic parameters' deviation (survival ability, productivity, population, etc.) or changes of its environment (water or bottom scurf quality, discharge volume, extreme characteristics of drain, level, etc.) not exceeding 20 - 25% of the normal (average perennial) or experimental control value (Bolotnov, 1990; Moskalev, 1976; Stroganov, 1975; Fashevsky, 1991);
- it is necessary to differentiate between unrecoverable (irreversible and long term) part of the damage and recoverable part (short term and self-healing within 5 - 7 years for water organisms), the former being subject to unconditional compensation;
- extreme difficulty of recording all factors affecting water ecosystem (a set of interrelated technogenic and natural factors) and of absolute damage assessment (including temporarily hidden genetic, biochemical, and other pathological consequences) accounts for the approximate character of compensation amount;
- ecologically legitimate and reasonably sufficient value of economic damage equivalent may be considered as the sum of nonrecurring investments in construction or land improvement that would result in annual recovery of biological resources in the volume of annual damage. Current expenses for the exploitation of compensatory objects are accepted in agreed volumes; while the compensation for lost profit is arguable as its volume wholly depends on the market situation and the activity of entrepreneurs (essentially it is of secondary character and may be received on the basis of products compensated for).

There is damage done to biosphere (water biological resources) and damage done to economic sectors in the process of operation, construction, and work involving natural resources. The damage to biosphere is primary and all other forms are derivative. In this context we consider assessing the volume of natural damage to fish resources as the basis for all further assessments and decisions on compensation.

1. GENERAL INFORMATION

1.1. Lake Inari characteristics

Lake Inari (Table 1, Picture 1) is the central water reservoir of the large lake-river system Paatsjoki (other names of the river are Pasvik, Paz, Patsojoki) with the catchment area of 18.4 thousand square km and transboundary location (78.9% on Finnish territory, 15.1% on Russian territory, and 6% on Norwegian territory). A large part of the basin constitutes the catchment area of Lake Inari itself which lies within Finnish borders and covers 14,512 square km (Ekholm, 1993).

Table 1. Basic hydrological characteristics of Lake Inari *(according to: Puro ja Maunuvaara, 1997)*

Name	Indicator
Catchment area	14 512 km^2
Surface of the lake at height +118.57 m, including lake Ukonjarvi (14 km^2)	1 043 km^2*
Water volume	15,9 km^3
Theoretical water turnover (volume : influx)	3,3 (years)
Coastline length (height 118.57 m)	3 270 km
Number of islands and rocks	3 318
Maximum depth	92 m
Average depth	14,3 m
Approximate dates:	
- freezing (1960-1989)	October 31
- clearing (1961-1990)	June 02

* Some sources report the area of Lake Inari 1041 and 1102 km^2 without an indication of the water level. Judging by table 1 (volume 15.9 km^3, average depth 14.3 m), the surface area is 1112 km^2. Apparently, the value of 1102 km^2 is closest to the reality. OK

The lake has a very complex trough with quite steep slopes. The shores are mostly rocky (Table 2), wholly or partly covered (Table 3).

Table 2. Shore characteristics of Lake Inari (M.Marttunen ym., 1997)

Type of shore	Share in total length, %	Declivity, %
Open, rocky	60	11,4
Open, sandy	24	9,9
Protected, sandy (covered)	16	4,1

Table 3. Characteristics of the surroundings of Lake Inari (M.Marttunen ym., 1997, Table.15)

Indicator	Areas				Total
	south-eastern	Ukonselka	north-western	central, northern	
Water area, км^2	285	124	184	448	1041
Total shore length, km	1221	480	413	1157	3271
- covered shore, %	36	21	17	28	28
- half-open shore, %	44	70	69	46	52
- open shore, %	20	9	14	26	20

Peat grounds also approach the water line over a large part of the shore (up to 40%). Pure moraine and open rock, that is difficult-to-erode rocks, are typical for 54% of the shoreline. The remaining part is evidently subject to erosion caused by various factors, including technogenic ones.

There are several schemes of dividing Lake Inari into areas, depending on the criteria chosen. The scheme presented in Table 3 is acceptable in morphometric aspect and as a basis for further ecological analysis.

Since we have no information concerning the bathymetrics of Lake Inari, we assume that 10% of its area is littoral (≈105 km^2 or 10.5 thousand hectares). 38.000 ha (34.5%) 0–10 m deep areas

Since 1951 the outlet of the lake, the Paatsjoki River, has been artificially regulated to meet the needs of water-power engineering. Since 1959 the lake has become virtually a reservoir of long-term regulation. The closest power station is "Kaitakoski", 10 km down the stream from the head of the Paatsjoki River. All in all, from 1951 till 1970-s, a chain of seven power stations was built on the river; five of them belong to Russia, and two to Norway.

The water level was raised by 55 m on the average, with the planned normal affluent marks of 119.50 m, and dead volume marks of 117.14 m in Baltic measure system. The local measure system is 1.47 m lower.

55 cm!

Salonen, E. 1992. Inarijärven kalataloudellinen käyttö- ja hoitosuunnitelma. Nykytila. RKTL, Kalatutkimuksia 50. 1992.

With the natural capacity of the lake trough (average depth / maximum depth) being 0.16 and water inflow (river discharge plus precipitation) about 5.1 km^3 a year, useful capacity of the reservoir equals 1.56 km^3 or 9.8% of total volume.

According to the classification of P.V. Ivanov (1948), Lake Inari with its relative depth index of 1.41 (average depth / $\sqrt[3]{\text{surface area}}$) belongs to the group of shallow reservoirs, in spite of some considerably deep parts (reaching 92 m). The largest influxes of Lake Inari are the Jutuanjoki River (average consumption is 58 m^3/s), and the Ivalojoki River (39 m^3/s). The outlet of the Paatsjoki River is characterised by average consumption in "Kaitakoski" of 153 m^3/s or 4.82 km^3 per year. Average outlet module is 12 l/s• km^2.

Specific catchment of the lake (Δ F) as an indicator of the catchment area influence upon the water reservoir, as well the stability of its level mode, equals 13.2. Lake and waterlogged characteristics of the basin constitute 13 and 17% respectively. Thus, the lake belongs to the type of lakes with middle stability of level modes, with average natural amplitude 50 - 125 cm, one flood maximum in spring and absence of summer-autumn mean water (according to the classification of K.D. Litinskaya). Water quality in Lake Inari at present meets high standards (Table 4).

Table 4. Average values (1975 - 1995) of the hydrochemical regime (water quality) of Lake Inari (*changes possible*)

Indicator	Summer		Winter	
	0 - 5 m	1 m above bottom	0 - 5 m	1 m above bottom
Content of dissolved oxygen, %	98-95	70-95	91-95	39-69
pH	7,2-7,3	6,5-7,1	6,9-7,1	6,4-6,6
Alkalinity, mmol/l	0,15-0,19	0,13-0,17	0,17-0,24	0,17-0,24
Oxygenation (COD Mn), mgO$_2$/l	2,8-5,1	2,9-6,3	2,9-3,6	2,5-3,9
Colouration (Pt), mg/l	11-32	10-45	13-19	11-39
Ferrum, mkg/l	21-160	25-332	23-96	36-672
Phosphorus general, mkg/l	3,6-6,8	3,4-11,0	4,0-5,0	4,9-12,3
Nitrogen general, mkg/l	168-185	193-258	151-204	222-376
Nitrogen NH$_4$, mkg/l	6,7-8,8	-	-	-
Conductivity (γ_{25}) m S/m	2,9-3,2	2,6-3,1	3,3-3,9	3,2-4,4
Transparency, m	4,0-7,4	-	-	-
Chlorophyll, mkg/l (horizon 0-2 m)	1,1-2,2	-	-	-

Note. The table is compiled according to the materials of stationary observations at 4 stations in the estuaries of the river Jutanjoki (depth 18 m), Nuoraselka (31 m), Nellimo (42 m), and Vassikkaselka (92 m), published by A. Puro ja Maunuvaara, (1997).

Juutuan-
vuono

Juutuanjoki ie. Juutuanvuono

The lake may still be considered oligotrophic, where 90% of substances get naturally and technogenic load is not substantial. It is concentrated primarily in the southern part of the lake, the area where the biggest part of the population lives and rests (approximately 9 thousand people). The total volume of sewage discharge is estimated to be 0.45 million m^3 a year. It is less than 0.01% of the income part of the lake's water balance. At the same time, the influence of natural inflow is quite visible, as the indices of colour, acidity, oxygenation, as well as ferrum, phosphorus, and nitrogen content decrease in the water northward. Some of these waters enriched by organics and biogenes flow into the Paatsjoki River, while northern and central areas of the lake are characterised by high water quality and oligotrophism.

1.2. Ecological characteristics of Paatsjoki system's water catchment

Large part of the Paatsjoki River basin, especially in Lake Inari catchment area, represents a country substantially covered by forests (approx. 77%), partly boggy, with hill ridges. Sandy and loam-sandy soils with boulders and gravel prevail in the southern part of the basin, - crystal rocks with excessive content of calcium, magnum, and ferrum, which creates a high buffer capacity of the reservoirs of this territory (Moiseenko et al, 1996).

The basin has a developed lake-and-river network with a high module of 11.6 - 13.4 l/s•km^2 (Leppajarvi, 1993) and natural regulation of the outflow conditioned by the lake (13.4%) and boggy (13.3%) character of the catchment. It's more characteristic of the northern part of the catchment, but the southern part with small lake content (3%) constitutes a major share of the inflow into Lake Inari through the rivers of Ivalojoki and Juutuanjoki. Major urbanised areas are situated here as well.

Inari community numbers 7.85 thousand people with the population density 0.52 people per square km. The total number of people living in the lake catchment area is 9.1 thousand people. Recreational water activities are well developed (up to 4 thousand sport fishermen in late 80-s). Industry is represented by small wood processing and food enterprises. On the whole, the area of the basin does not suffer from technogenic influence that could cause irreversible changes in the environment.

1.3. Lake Inari productivity

Lake Inari is located on the border of forest-tundra and northern taiga subzones, 300 km to the north from the Arctic Circle. Typical for this region are water reservoirs of oligotrophic type with low and very low class of productivity (Table 5).

Table 5. Main trophic characteristics of oligotrophic lakes (according to Kitayev, 1986)

Productivity class	Chlorophyll biomass "a", mg/m^3	Primary product, g S/m^2 • year	Biomass of zooplankton /benthos/fish, g/ m^2	Subtype of the reservoir

The lowest	< 0,75	< 6,25	< 0,625	ultraoligotrophic
Very low	0,75-1,5	6,25-12,5	0,625-1,25	α - oligotrophic
low	1,5-3,0	12,5-25	1,25-2,5	β - oligotrophic

Average (1975 - 1995) biomass indexes of chlorophyll (1.1 - 2.2 mg/m^3), zooplankton and zoobenthos (1.3 + 1.3 g/m^2), and primary products (fitoplankton 3.5 - 3.7 g S/m^2 per year) borrowed from the research materials on Lake Inari (Marttunen ym., 1997), definitely suggest that the lake is of oligotrophic type. This conclusion is also proved by the data acquired by the long-term monitoring of the hydrochemical characteristics of Lake Inari: they mostly match the parameters of oligotrophy (Table 4).

According to limnological and hydrobiological characteristics of Lake Inari (average depth, water transparency and colour, oxygen content, zooplankton and benthos biomass, ichthyofauna contents), the ichthyomass of Lake Inari, calculated by S.P. Kitayev's method (1994), was estimated to be 23 kg/ha, or approximately 2390 - 2400 t total, the fishing stock being 1600 t. This value matches the classification referred to (table 5) and is close to the values found for the reservoirs in adjacent Murmansk region, where the average index of ichthyomass reaches 19 kg/ha. Meanwhile, one must take into account the considerably higher level of technogenic impact on Murmansk region water systems compared with northern Finland.

Fishing industry in Lake Inari has existed for a long time. In the period preceding the regulation of the reservoir and later in the 80-s there were about 100 professional fishermen and the yields were respectively 250 and 460 - 560 t a year (fig. 2). Fishing for household needs was the occupation of 800 - 900 families (consumer fishery), and the number of amateur fishers reached 4 thousand (1989). Nowadays the number of fishermen — professional has reduced substantially; there are about 20 ~~fewer than 50~~ professionals ~~and about 100 amateurs~~ left.

!!

The ichthyofauna of Lake Inari includes 10 local species of fish and 5 colonisers. It is characterised by the absence of the carp family (with the exception of one single species, the minnow) and the prevalence of salmonids. The latter have ecological and morphometric varieties including six varieties of local whitefish, two kinds of char, and five populations of (Land-locked ~~bulltrout.~~ Brown trout. TAIMEN

Among the naturalised colonisers there is shallow-water vendace, which managed to form a proliferating fishery population providing in late 80-s yields of 300 t. ~~Lake~~ salmon, ~~brook char~~ Lake trout, and other introduced fish require constant replenishment by plant grown reproduction.

During the period of 1985 - 1993, there was a sharp increase in the number of practically all species of fish in the lake, both local and colonisers. Apparently it was determined by the coincidence of several favourable factors:

- increased content of biogenic elements in the water (nitrogen, phosphorus, silicon) as a result of additional arrival and decomposition of organic and mineral substances caused by the submergence and erosion of the shore;
- massive artificial stocking of the lake and its tributaries by young ~~salmon~~ Predatory salmonids and whitefish;
- arrival and naturalisation of vendace from adjacent reservoirs via tributaries as it found in Lake Inari all necessary conditions for feeding and reproduction in the period under consideration;
- general regional increase in the productivity of the ecosystems of inland reservoirs as a result of large-scale climate-and-production cycles, the peak of one of which was in the middle and late 80-s and was apparent in lakes Onega and Ladoga, as well as other reservoirs of Karelia, Arkhangelsk region, and Finland.

huom!

The phenomenon of a population boost with yields 2.5 - 3 times higher than the initial level (before the regulation of the outflow) is typical for most impoundments. In the area of European north it happens approximately 5 - 8 years after the beginning of the impoundment formation and new biocenosis forming, and lasts about 7 - 10 years. After the boost, the number of all fish groups invariably reduces to a relatively stable level, as a rule 20 - 30% lower than the initial level before the regulation. Thus, the productivity of most impoundments turns out to be lower than planned. Besides, it is characterised by considerable fluctuations of absolute amounts and structure, as impoundments belong to reservoirs with anomalous mode. Consequently, the level of productivity and fish yield at the peak of biocenosis formation, the population boost in the impoundment, can not and must not be the criterion in assessing the damage done to fish resources.

The period after 1990 when the annual fish yield in Lake Inari reached 163 t may be considered the phase of the ecosystem's relative stabilisation. The size of calculated allowable fish yield proves that too. With total industrial stock of 1600 t and ecological norm of catch 9 - 10% of it, the annual yield must be within 145 - 160 t.

It is known that the productivity of natural ecosystems is primarily and mostly determined by the supply of solar energy and by water mineralization. Other numerous factors (morphometry, water exchange, gas regime, biogenic load, bottom soil contents, flora and fauna structure) are less important. Relative amount of fish product in water reservoirs of all natural zones from tundra to tropics is approximately the same and equals 0.15 - 0.23% of the initial product with different absolute values (Bessonov, Privezentsev, 1987; Vinberg, 1975; Kitayev, 1986, 1984, 1994, etc). Consistent rise of productivity is possible only in case of constant supply of additional energy into the ecosystem, otherwise what happens is just redistribution of it among consumers, i.e. modification of the biocenosis with small changes in the integral production. Apparently, additional fish colonisation must be equivalent to the feeding capabilities of the reservoir and justified only in case of loss of spawning-and-breeding areas in order not to cause the reduction of productivity.

In relation of Lake Inari there is sufficient reason to consider the high bioproductivity of the period 1985-1993 the result of mostly natural rather than technogenic processes. This period of time is characterized by the mutual for the North and Northwest Europe increase of the arctic fresh-water fish population against the background of increasing air and water temperatures.

Voluntary settlement and naturalization of vendace in Lake Inari is probably one of the manifestations of this process. Initially, not having any enemies in the new conditions (predators or parasites), vendace formed a fishery population that provided for 190 - 300 t annual yield, or 46% of total yield, which also grew by 5,5 times (Tables 6 and 7, fig. 2). The populations of other species of fish grew as well.

high yield;
only 3 years, 1988 - 1990

Table 6. Dynamics of fish catches (t) in Lake Inari. Average figures for 1935-2003.

Fish species and groups	Average annual catch (%) by period										Average for 1935 - 2003
	1935-1940	1950-1955	1960-1964	1966-1970	1977-1981	1982-1986	1987-1991	1992-1996	1997-2001	2002-2003	
Reeska whitefish	3,8	7,9	3,2	5,7	3,6	3,2	29,8	5,7	9,4	4,4	7,7
~~Cisco~~ Vendace	0	0	0	0	0	3,8	177,9	15,4	7,2	6,1	21,0
Total: plantktophages	3,8	7,9	3,2	5,7	3,6	7,0	207,7	21,1	16,6	10,5	28,7
Brown trout	27,0	19,0	3,5	3,8	8,3	14,7	27,9	14,1	30,2	44,1	19,36
Char	20,5	15,3	4,4	3,3	4,1	6,2	11,4	4,7	6,3	8,8	8,5
Total: local salmonids	47,5	34,3	7,9	7,1	12,4	20,9	39,3	18,8	36,5	52,9	27,8
Landlocked salmon	0	0	0	0	1,0	1,7	2,7	0,9	2,0	2,8	1,1
~~Brook~~ trout Lake trout	0	0	0	0	9,4	17,9	13,7	5,9	8,9	9,5	6,5
Total: salmon colonizers	0	0	0	0	10,4	19,6	16,4	6,8	10,9	12,3	7,6
Grayling	13,2	8,7	4,7	3,2	4,9	6,5	7,0	6,5	7,9	9,3	7,2
Burbot	15,0	13,5	11,5	11,2	5,6	5,9	5,0	3,2	4,1	4,1	7,9
Pike	17,8	12,5	3,2	3,6	4,9	6,9	8,6	5,7	9,1	12,1	8,4
Total: Burbot + Pike	32,8	26,0	14,7	14,8	10,5	12,8	13,6	8,9	13,2	16,2	16,3
Whitefish location here?	145,2	103,9	77,5	42,9	57,1	40,0	100,9	86,6	72,2	61,6	78,8
Perch or close to Reeska?	5,7	4,4	3,1	4,6	5,0	6,3	0,3	3,9	5,3	6,0	4,5
TOTAL	248,2	185,2	111,1	78,3	103,9	113,1	385,2	152,6	162,6	168,8	170,9

Table 7. Dynamics of fish catches (%%) in Lake Inari. Average figures for 1935-2003..

Fish species and groups	Average annual catch (%) by period										Average for 1935 - 2003
	1935-1940	1950-1955	1960-1964	1966-1970	1977-1981	1982-1986	1987-1991	1992-1996	1997-2001	2002-2003	
Reeska whitefish	1,5	4,3	2,9	7,3	3,5	2,8	7,7	3,7	5,8	2,6	4,5
~~Cisco~~ → Vendace	0	0	0	0	0	3,4	46,2	10,1	4,4	3,6	12,3
Total: plantktophages	1,5	4,3	2,9	7,3	3,5	6,2	53,9	13,8	10,2	6,2	16,8
Brown trout	10,9	10,3	3,2	4,8	8,0	13,0	7,2	9,2	18,6	26,1	11,3
Char	8,3	8,3	4,0	4,2	3,9	5,5	3,0	3,1	3,9	5,2	5,0
Total: local salmonids	12,9	18,6	7,2	9,0	11,9	18,5	10,2	12,3	22,5	31,3	16,3
Landlocked salmon	0	0	0	0	1,0	1,5	0,7	0,6	1,2	1,7	0,6
~~Brook trout~~ Lake trout	0	0	0	0	9,0	15,8	3,6	3,9	5,5	5,6	3,8
Total: salmon colonizers	0	0	0	0	10,0	17,3	4,3	4,5	6,7	7,3	4,4
Grayling	5,3	4,7	4,2	4,1	4,7	5,7	1,8	4,3	4,9	5,5	4,2
Burbot	6,0	7,3	10,3	14,3	5,4	5,2	1,3	2,1	2,5	2,4	4,6
Pike	7,2	6,7	2,9	4,6	4,7	6,1	2,2	3,7	5,6	7,2	4,9
Total: local predators	13,2	14,0	13,2	18,9	10,1	11,3	3,5	5,8	8,1	9,6	9,5
Whitefish location!	58,5	56,1	69,7	54,8	55,0	35,4	26,2	56,8	44,4	36,5	46,2
Perch	2,3	2,3	2,8	5,9	4,8	5,6	0,1	2,5	3,2	3,6	2,6
TOTAL											100,0

Later on, intensive fishing and predator fish feeding on vendace decreased its population to the level of 3-6% of the yield, i.e. equal to the local dwarf whitefish - reeska.
At present the ichthyofauna of Lake Inari shows a tendency of stabilization with manifested restoration of the role of aborigines species and decrease of the introduced ones. In general, one can note the growing share of planktophagous fish and local salmonids, i.e. certain euthrofication of the ecosystem.

Figure 2. Dynamics of total catches (t) and catch composition (%) in Lake Inari for the period 1935-2003. Symbolic notation: 1 - Reeska, 2 – Nieriä, 3 - Harmaanieriä, 4 – Muikku, 5 – Järvilohi + Taimen, 6 – Siika (Pohjasiika), 7 – Made + hauki, 8 – Muut lajit. Total catch volume (t).

2. TECHNOGENIC TRANSFORMATION OF WATER ECOSYSTEM

2.1. Main waterpower engineering factors affecting fish resources

Practice and extensive research have shown that waterpower facilities have a strong impact on the ecological state of water systems. Often, negative consequences of this impact lead to irreversible damage compensation of which requires special measures.
In northern conditions the construction of waterpower facilities is accompanied by the following negative factors:
upsetting the integrity of the water basin's macroecosystem where different parts perform different specific functions, i.e. they are areas for spawning and spawn incubation, breeding, and wintering, migration routs;
abnormal proceeding of level, outflow, and temperature regime, which don't match the natural conditions of biological cycles of water organisms' reproduction;
deep and accelerated water wear off, draining parts of the bottom, and the winter ones, especially dangerous for fish spawning in autumn (salmon and white fish), as well as for benthos organisms;
deterioration of water vegetation in littoral areas subject to repeated drainage and erosion;
direct destruction of hydrobionts in the process of draining parts of the impoundment as well as in the process of water utilisation in turbines and discharging it through the water engineering system;
unfavourable for hydrobionts (except for pathogenous micro-organisms) conditions at the dam adjacent part of the lower pool.

According to the research conducted by Finnish specialists since 60-s, 80% of the negative processes at Lake Inari are determined by factors connected with the outflow regulation for waterpower purposes. The remaining 20% are attributed to local pollution and other factors.
After launching of the first power station "Janiskoski" (table 8) in 1951 with the maximum estimated fall of 21.5 m and daily regulation, the water level and water exchange regimes became unstable. The construction of the highest in the cascade power station "Kaitakoski" with long-term regulation contributed since 1961 to a more regular hydrologic situation in Lake Inari. Seasonal phases of levels became closer in time to the natural processes, though acquired differences in fluctuation amplitude and watermarks.
As a result of the outflow regulation in Lake Inari, the yearly power generation by Russia is 1005 GWh and 400 GWh by Norway, i.e. 40.8 and 29.2% respectively. Total generation in summer (810 GWH) is higher than in winter (595GWH).
The analysis of materials kindly provided by the Finnish side allowed for characterisation of the present regulation situation in Lake Inari as follows:

water level was raised 55 cm on the average with the watermarks of normal affluent level (NAL) 119.50 m and dead volume level (DVL) 117.14 m in the Baltic height system, the difference with the local system being +1.47 m (fig.3).
since 1960 the schedule of filling the impoundment has been strictly followed, there have been practically no cases of going beyond the NAL and DVL, except for forcing NAL by 5-7 cm in 1964 and 1989;
average long term amplitude of level fluctuations was 1.45 m with the absolute value of 2.48 m within the marks of 117.09 m (1961) and 119.57 m (1964 and 1989); maximum yearly amplitude 2.21 m was registered in 1961, that is in the very beginning of the regulation period;
yearly level changes are quite synchronous in their phases but differ in amplitudes in consecutive years.

Table 8. Main hydro-engineering characteristics of waterpower stations on the Paatsjoki

Station	Year of launching	Estimated fall, м	Rate, m^3/s		Generation, GWh a year	Kind of regulation and effective volume (km^3)
			average	estimated		
Kaitakoski	1959	7,5	152	200	68	long term - 2,45
Janiskoski	1951	20,5	152	180	214	daily - 0,006
Rajakoski	1955	21,0	152	240	227	daily - 0,011
Melkefoss	1970	18,5	169	320	225	daily - 0,006
Skogfoss	?	20,4	182	280	263	?
Bjornevatn	?	10,5	184	260	136	?
Borisoglebskaya	1963	19,3	195	340	270	weekly 0,027

Pre-freshet drop of the reservoir reaches the marks of 118.0 - 117.5 m, Baltic System, with rare exceptions (117.20 m in 1961 and 117.25 m in 1971).

Thus the new regime of the lake is characterised by the amplitude of level fluctuations on the average 20 cm larger than the initial natural one, a four months' period (June - October) of stable high water level and respectively shortened and more intensive period of winter level fall (fig. 4). The rates of outflow in the Paatsjoki River are considerably levelled within the range of 119 - 170 m^3/s as opposed to the natural inflow into the lake at the rate of 48 - 385 m^3/s. According to the Kolenergo data, the discharge of water from Lake Inari is allowed in the range from 45 m^3/s (in case of extremely low water level) to 500 m^3/s (in case of extremely high water level), but in normal conditions the daily rate is 120 - 240 m^3/s depending on the inflow, levels, repair works, etc. The discharge procedure is preliminary agreed upon by three parties and then adjusted according to weekly Finnish recommendations. As a rule, the latter are strictly followed.

/to over 500m^3/s in 1992.

2.2. Other forms of impact upon the ecosystem of Lake Inari.

Finnish specialists assume that besides power engineering about 20% of the damage to the Inari fish resources are attributed to various kinds of trade and recreation within the limits of private catchment, not connected with the Russian side. This paper does not consider them, but it's necessary to mention such active factors as fishing and artificial stocking of Lake Inari, the influence of which upon the structure of ichthyocenosis can not be ignored.

Besides, there is a danger for the lake ecosystem to be affected by a powerful source of pollution, "Pechenganickel" company in Murmansk region, Russia. In order to study this issue within the framework of Russian-Finnish research co-operation program and Russian-Norwegian committee on environment, in 1992 - 93 the study of bottom scurf was carried out in Lake Inari and some other reservoirs in the basin of the Paatsjoki river (Pasvik). At two stations in Lake Inari, an increased concentration of lead and cadmium was registered in the upper layer (0 - 1cm) of the bottom scurf (table 9). The concentrations of nickel and copper are a little higher, but all other metals present match the background concentration indexes. It suggests that the source of pollution is local, mainly automobile exhaust gases, while there is no evidence of atmospheric fallout from "Pechenganickel" (Dauvalter, 1998a, 1998b).

Table 9. Characteristics of the bottom scurf in Lake Inari (according to Dauvalter, 1998) in surface 0 -1 cm (numerator) and bottom layers (denominator).

Station	Humidity, %	Losses after annealing, %	Metal concentration (mkg/g of dry weight)					
			Ni	Cu	Co	Zn	Cd	Pb
1. Varttasaari (40m deep)	92 86	18 14	47 46	42 41	15 16	98 97	0,61 0,54	25 9
2. Vassikaselka (95m deep)	95 84	20 16	45 32	58 51	11 13	83 90	1,10 0,21	54 7

In the lower part of the Paatsjoki river the same studies registered considerable accumulation of Ni, Cu, Co, Zn, and Cd in the bottom scurf and numerous pathological disturbances of toxicogenous kind in the fish (Kashulin et al, 1998), which was not found in the fish of Lake Inari.

On the whole, the balance of transboundary interactions in pollutants between the north-west of Russia and the Scandinavian countries is characterised by the prevalence of aerogenous fallout on the Russian territory (table 10), not to mention the water transportation of pollutants wholly directed from Finland and Norway to Russia. This balance supports the conclusion on the absence of aerogenous damage to the water system of Lake Inari from the Russian side. Observed changes in the chemical contents of the lake water were registered mainly in its southern part.

Table 10. Total balance of transboundary interactions in aerogenous pollution (according to "Ecological problems of the North-West...", 1997).

Country	Substance	Fallout, kt		Difference in the volumes of two-sided fallout (kt), suffering side
		from Russia to the country	from the country to Russia	
Finland	SO_x	57,0	57,0	0.0
	NO_x	5,3	42,0	36.7 - Russia
	NH_3	8,5	13,3	4.8 - Russia
Norway	SO_x	21,0	0,0	21.0 - Norway
	NO_x	1,1	24,6	23.5 - Russia
	NH_3	0,6	1,6	1.0 - Russia
Sweden	SO_x	12,0	13,0	1.0 - Russia
	NO_x	2,1	29,7	27.6 - Russia
	NH_3	1,3	4,4	3.1 - Russia

Northern and central parts of Lake Inari, where the probability of transboundary pollution is higher, are in a more stable condition and retain their oligotrophic character.

2.3. Ecological consequences

As a result of turning Lake Inari into an impoundment, the most negative impact on its fish resources should be attributed to:

lowering of fish productivity in the shallow zone as a result of corrosion processes, reforming of the littoral, reduction of areas with water vegetation, death of feed organisms in the period of winter level drop;

loss of some spawning-breeding areas as a result of the changes in the littoral and in level states;

direct perishing of the spawn of autumn-spawning fish during winter drops of the impoundment (perishing of fish is also possible but only as an exception);

changes in the structure of ichthyocenosis as a response to the change in the living and reproduction environment of certain fish populations.

The latter process to a great extent depends on the factors of fishing and artificial stocking. This circumstance and the parameters of the regulating regime *do not allow considering the waterpower impact on Lake Inari as extreme.* Scientifically calculated conditions of maintaining the sustainability of populations in water ecosystems allow for technogenic impact that results in the change of abiotic elements of the environment not more than 20 - 25% of the average long-term values (Bolotnov, 1990, Stroganov, 1975, Fashevsky, 1991).

Lake Inari has been regulated with raising the average level by 55 cm, i.e. within the limits of natural fluctuation amplitude of 50 - 125 cm, the maximum possible being 170 cm (Litinskaya, 1976). The new level mode has average long-term amplitude value of 145 cm, which is higher than the average natural amplitude 125 cm by 16%, or within acceptable limits. In spring-summer period, the time of spawning of ordinary fish (not numerous in Lake Inari) and the time of growing up of all species of fish, there is no drop in the water level. Consequently, the most damaging for the ecosystem is winter outflow regulation.

? Mitä tarkoitetaan ?

The process of shore abrasion and the littoral reforming in the lake proceeded according to the scheme of gradual increase of the lower shallow area, the sublittoral, approximately by 70% at the cost of the reduction of upper areas, the eulittoral and supralittoral, by -30 and -75% respectively. As a result, the littoral currently has the area of about 100 - 105 km^2 as opposed to the initial value of 80 km^2. Apparently, there must not be any loss of spawning-breeding areas. Reforming of the shore in large impoundments is most active in the first three years, but lasts indefinitely long, more than 50 - 60 years, without clear attenuation (Impoundments..., 1986). It implies further growth of the littoral area, but there is also a restriction for the development of water vegetation the area of which is going to decrease. Consequently, the conditions for phytophil fish and all young fish become worse, and general littoral productivity, which is calculated as the average for the reservoir, decreases. In natural conditions, littoral productivity is 3 - 5 times higher than the average in the reservoir.

littoral - area, see page 9!
Definition of littoral area ?

Thus, the second major factor that accounts for the damage to Lake Inari is the complex of negative processes in the shore area. Meanwhile, the bulk of the lake water (more than 80%) maintains its natural condition as the ecosystems of large reservoirs quite actively resist external influences by reforming the structure and redistributing the flows of energy and matter aimed at stabilisation.

As concerns the hydrochemical situation, there have been no big changes. In the first 20 years of the impoundment formation, there was registered a trend of growing percentage of phosphorus and other organic elements in the water, but later it went down. Local pollution was absorbed by the bottom scurf, while the present inflow of purified sewage (up to 0.45 million m^3 a year) and the atmospheric fallout of sulphur, nitrogen compounds (Table 11) do not have any considerable impact on Lake Inari.

Table 11. Sulphur and nitrogen fallout at "Janiskoski" station of Russian hydrometeocenter, m kg/ m^2 a year

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
H^+	8185	7658	4956	7603	6480	6723	4720	7545	5328	4670
SO_4 - S	256	286	250	247	249	248	203	208	140	135
NO_3+NH_4-N	51	45	46	69	99	81	62	92	79	54
MM	507	480	333	467	616	448	407	539	381	366

There are no characteristics of integral deterioration of water quality (growth of mineralisation and biogens with the increase of sulphates' share, emerging toxic elements, eutrophication, etc.).

According to the research findings and fish yield contents, the greatest technogenic damage in Lake Inari was done to the stock of burbot, pike, char, ~~bulltrout~~, "~~riika~~" whitefish, and nine-~~pin~~ stickleback. If we assume that the basic level of fishing is 248 t (1935 - 1940-s), present losses reach 125 t in local fish, which is partly compensated by the yields in coloniser fish (Table 12). Thus the total damage to fishing in Lake Inari may be estimated as 100 t of fish products a year.

brown trout
riika
-spined

Table 12. Expert assessment of damage to fishing in Lake Inari caused by technogenic factors

Fish species	Yields in 1935-1940-s		Yields in 90-s		Difference (damage)	
	t	%	t	%	t	share of the initial

Whitefish	145,0	58,5	69,2	42,1	-75,8	0,48
Brown trout	27,0	10,9	34,2	20,8	+7,2	1,27
Arctic Char	20,5	8,3	7,0	4,3	-13,5	0,34
Grayling	13,2	5,3	8,3	5,1	-4,9	0,63
Pike	17,8	7,2	10,0	6,1	-7,8	0,56
Burbot	15,0	6,0	4,1	2,5	-10,9	0,27
Perch	5,7	2,3	5,5	3,3	-0,2	0,96
Other	3,8	1,5	8,0	4,9	+4,2	2,11
Other local	248*	100	146,3	89,0	-101,7	0,59
Vendace ~~Cisco~~	0	0	6,9	4,2	+6,9	0
Landlocked salmon	0	0	2,2	1,3	+2,2	0
Lake ~~Brook~~ trout	0	0	9,1	5,5	+9,1	0
Total colonizers	0	0	18,2	11,0	+18,2	0
Total:	248	100	164,5	100	- 83,5	0,66

*Note
We believe that the average yearly yield of 248 t is ecologically excessive and thus part of the damage is caused by overfishing. However, it is virtually impossible to single out the share of fishing in the complex chain of technogenic impact.
By the decisions of the Water Court of northern Finland and the Higher Administrative Court made in 1974 and 1975 concerning lake Inari, and in 1982 and 1984 concerning its adjacent water systems, plans of compensation stocking were adopted (Table 13).

Table 13. Adopted plans of artificial stocking of Lake Inari water system (*to be changed or deleted*)

Planting material	Stocking volume, thousand entries per year		
	Lake Inari	side system	total
! 1. Young ~~bulltrout~~ brown trout ~~of lake~~ or (land-locked) salmon, downstream migrant stage	100,0	15,0	115,0
2. Young arctic char, ~~1 year old~~ 1-summer old	250,0	-	250,0
3. Whitefish, fingerling 1-summer old	1000,0	108,0	1108,0

? Fish Farm!

! ! In order to accomplish these tasks, fishery enterprise "Inari" was expanded, another one, "Sarmijarvi", was built, and 17 breeding impoundments were created (344 ha) with natural feeding. Stocking of Lake Inari was started in 1976, and the side ~~reservoirs~~ waters and rivers - in 1985. Fishing practice and research findings showed unexpected dramatic changes in the structure and size of ichthyofauna of the lake in 1986 - 1992, including the temporary "burst" of shallow-water vendace ? when it reached Lake Inari in 50-s and 60-s through the river systems of the Juutuanjoki and the Ivalojoki. It resulted in the introduction of "adjusting" stocking principle, considering the specific situation of the feed/predatory fish ratio in the lake. As a result, the volumes of predatory fish Salmonids ~~and whitefish planting~~ stocking were reduced after 1996. ! in some periods.

3. DAMAGE TO FISHERY

3.1. Losses in fish resources

The damage to fish resources of Lake Inari and its basin is caused by the lowering productivity of the littoral, deterioration of some spawning-breeding areas, and impact of fishing and artificial overstocking ~~on fish reproduction.~~
It is virtually impossible to distinguish the components contributing to the decrease of the littoral productivity due to the complex impact of factors of biotope reformation and their variety within the lake. Assuming the initial level of the littoral fish productivity to be on the average 25 kg/ha, and 6 kg/ha for the lake, by analogy with the Kumskoje impoundment, where the productivity of open and shore areas became practically equal, general losses of fish product in Lake Inari on account of the littoral will be approximately:
(25-6) kg/ha • 10.5 thousand ha = approx. 200 t/year
littoral area definition, see pages 2, 10!

Apparently we may also include here the losses of productivity on account of perishing feed organisms of the benthos during winter level drops at approximately 30% of the littoral area. They are estimated to be 9 - 10 t of fish product.
In a balanced water ecosystem, bioproduction potential is realised due to the spawning-breeding areas covering 10 - 15% of the total surface area (Poddubny, 1990). Assuming the normal spawning-breeding area in Lake Inari is 12% or 12.5 thousand ha located primarily within the range of depths 1.5 - 5m (fish spawning in autumn), we see that 15% of

these areas (1.9 thousand ha) is subject to the annual impact of ice and drainage during winter level drops. The value of 1 ha of spawning-breeding area in terms of reproduction calculated by the final icthyomass, is about 230 kg. Thus, the damage caused by the reproduction losses in Lake Inari is estimated to be 435 t of ichthyomass, or 110 t of fish product.

Thus, neglecting the changes in ichthyocenosis structure, we can say that the fish-production potential of Lake Inari suffers the damage of about 110 t a year, or 3.0 kg/ha, due to the impact of outflow regulation. It is equivalent to the decrease of trade stock by 830 t on the average, or the loss of 80 t of yield a year. Taking into account the consequences of other factors contributing to approximately 20% of damage (according to Finnish researchers), the total volume of damage to the trade is estimated to be approximately 100 t of yield shortage, which matches the actual figures of yield decrease (Table 10). not damaged, but e.g. oscillated

Besides, we believe that fish resources are ~~damaged~~ by massive stocking of Lake Inari. Fish ~~planting~~ stocking should take into account the feeding capacity of the oligotrophic reservoir (6 - 7kg/ha), losses of trade return (100 t) and optimal percentage of predatory fish (up to 23%, preferably less). Massive stocking accompanied by natural spreading of ~~shallow-water~~ vendace in 1980-s ~~(as an attempt to compensate the insufficient settlement of commitment in the preceding years)~~, together with other favourable circumstances (see Clause 1.3), resulted in the average increase of fishing by 260 t, the initial level being 248 t. It allows us to assume that stocking was conducted in volumes 2.5 times larger than necessary. By ecological standards, this surplus is estimated as 3 times as natural feed-producing capacity of the lake in a balanced state allow fishing volume of 160 t, not 460 - 560 t. We should separate stockin

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case

In late 80-s, the yields of predatory fish reached over 80 t, among them 74% were colonisers. Apparently, the ichthyomass of predators was about 800 t, and their annual growth about 200 t. The latter requires 900 - 1000 t of feed fish a year, i.e. 9 kg/ha, which exceeds natural productivity by 1.5 times. As a result, the populations of ~~shallow-water~~ vendace, stickleback, and other fish-~~victims~~ prey were eaten out. The situation with their stock was aggravated by unfavourable reproduction environment.

Very uncertain better to remove!

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of vendac

The effect of massive stocking ~~destroyed~~ the balance of the already disturbed ecosystem of Lake Inari, which immediately resulted in dramatic decrease of total ichthyomass and changes in its structure. Relatively proliferating were only benthophagous fish, primarily whitefish.

not destroyd but e.g. oscillated!

On the basis of expert evaluation of waterpower facilities in Karelia, the value of specific damage to fish resources in relatively regulated outflow equals 12.14 t/km^3. Applying this value to Lake Inari, the damage may be estimated to be 58.5 t, i.e. a little lower than the value calculated above.

3.2. Economic damage

As shown above (introduction), legal ambiguity in the procedure and size of compensation for the damage to natural resources accounts for the compromising way of evaluating it. It is necessary to remember that compensating measures allow for maintaining the existing volume of production but with changed contents and quality. As a rule, it is impossible to reconstruct the previous conditions of reproduction

In 1990s, annual work of stocking Lake Inari cost 4.05 million Finnish marks (FM), which included: ~~planting~~ Stocking material production (2.10 million), spawn (1.25), transportation of the young (0.50), administrative expenses (0.2 million FM). Besides, control work costs about 1.4 million FM (Report on damage ..., 1997) and from time to time it is necessary to pay for work not connected directly with fish resources (Table 14).

Table 14. Compensation of damage connected with the regulation of Lake Inari (prices of 1991)

Basis for compensation	Lake Inari (since 1977)		side systems (since 1983)	
	number of recipients	total sum, m.$	number or recipients	Total sum, m.$
1. Losses of fish product	203	3,40	89	0,50
2. Losses to fishing gear	173	0,10	4	0,004
3. Losses of banks and others	138	0,50	-	-
Total	514	4,00	93	0,504

To cover the expenses of advisable and necessary fish farming work, the Finnish side demanded Russia to pay the sum of 1.75 mln. FM a year (0,32 million USD).

Obviously, there is no need to consider capital investments in establishing a fish farm in the basin of Lake Inari, because Finland received non-recurring compensations from the USSR and Norway according to mutual agreements. Yet, the parties' obligations concerning participation in work aimed at maintaining the fish resources of Lake Inari in sustainable form are unconditional.

According to actual expenses on stocking Lake Inari, the cost of producing 1 conventional unit of young fish (the total number is 2758 thousand units) is 1,41 FM. Calculated by the norms existing in Russia, the industrial return of stocking Lake Inari in volumes accepted primarily (Table 13) equals approximately 200 t. It is twice as high as the estimated damage to the trade, but on the other hand it caused the mentioned above negative effects of overstocking the lake. ? ~~Apparently, it is necessary to reduce planting predatory salmon fish, as local predators (burbot, pike, bulltrout, and~~ char) ~~are also~~ depressed. At the same time, the catch structure of recent years and results of artificial stocking of Lake Inari speak about restoration of populations of aborigines fish species and better effect of ~~planting~~ their young. Therefore, the volume of whitefish stocking should remain the same, as breeding its fingerlings is 1.5 times cheaper

stocking

than down-stream migrants of salmon, calculated by 1 t of industrial return. (Consequently, it is possible to reduce two times the stocking expenses, down to 2.0 mln. FM.) Difficult to say, better to remove!
Considering the existing volumes of power generation in the proportion 71 and 29% (Russia and Norway) and the damage to the industry by the regulation (80 t), we can estimate the shares of the countries participating in industrial use of the Paatsjoki basin as follows: Russia - 57%, Norway - 33%, and Finland - 20%. Thus, the shares of the parties in the compensation expenses calculated with the basis of 4.05 mln. FM, are the following:

Russia - 2.31 mln. FM
Norway - 0.93 mln. FM
Finland - 0.81 mln. FM

According to M. Hilden (1989), the major threat for the development of fish farming in Finland is the aggravation of environmental conditions. It's not only the financial losses caused by the damage to the fish stock that matter most, but very serious social consequences. In the country with the population of 5 million people, 1.5 million call fishing their hobby, their total annual yield reaches 34 thousand t. The indirect income of the municipality from sport fishing in Lake Inari in 1989 was 6 mln. FM 6 million FM, and in 1993 it became less than 3 mln. FM (Salonen, 1994).
Recognising the incontestability of damage compensation for using the water resources of the Paatsjoki basin for power engineering, and considering the advisability of reducing the volumes of fish stocking Lake Inari, we can say that the amount demanded by the Finnish side 1.75 mln. FM must be accepted by the Russian side.

Where it came from?

CONCLUSION

The basin of Lake Inari may be referred to as a territory suffering from technogenic influence that does not cause catastrophic changes in the fish resources of the lake. The reservoir has maintained its oligotrophic character but its ecosystem became unstable, which is typical for lakes with regulated outflow. However, not only waterpower engineering factors are to blame for the loss of balance in the ecosystem. Considerable influence s comes from fish ~~farming melioration~~ (stocking) and fishing itself, ~~both~~ all having financial and social efficiency. ies
Therefore, changes observed in Lake Inari ecosystem are explained not only by the impact of waterpower engineering but to a large extent by (fish industry use) and natural global climatic and bioproductional processes. At present the lake is an example of rather rational management of fish reserves with integrated use of its water resources.
Ecologically justified fishing yield for the oligotrophic Lake Inari is the figure of 160 t on the average, while the existing scale of artificial stocking causes negative effects in the structure of ichthyofauna and lake productivity. Apparent is the necessity of making the fish yield volumes match the production potential of Lake Inari.
The share of Russia in the damage to Finnish fisheries, judging by the yields in lake Inari, is estimated to be less than 60 t, consequently the compensation size (electricity generation) must be agreed upon keeping this value in mind.

accidental introduction of invasive vendace

not very good revelation!

All these 3 last sentences are very strange, and should be rewritten!

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Assessment of ecological consequences caused by economic use of natural resources of Lake Inari (Finland)

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JOHTOPÄÄTÖKSET

Inarijärveä voidaan pitää alueena, joka kärsii (ihmisen toiminnan) teknologisista vaikutuksista, jotka eivät kuitenkaan aiheuta katastrofaalisia muutoksia järven kalavaroille. Säännöstelty järvi on säilyttänyt oligotrofisen luonteensa mutta sen ekosysteemi on tullut epävakaaksi, mikä on tyypillistä järville, joiden laskujoki on (padottu). Kuitenkaan, vesivoimataloudelliset tekijät eivät ole ainoastaan syyllisiä Inarijärven ekosysteemin epävakauteen. Merkittäviä vaikutuksia on aiheutunut myös kalanistutuksista ja kalastuksesta itsestään, joilla kummallakin on ollut sekä taloudellisia että sosiaalisia (seuraamuksia). Täten, havaitut muutokset järven ekosysteemissä eivät selity pelkästään vesivoimataloudella vaan suuressa määrin myös kalataloudellisella käytöllä sekä luonnollisilla, globaaliin ilmastoon ja biologiseen tuotantoon liittyvillä prosesseilla. Nykyään Inari on esimerkkitapaus sekä kala- että vesivaroiltaan hyvinkin rationaalisen käytön ja hoidon kohteena olevasta järvestä. Ekologisesti (pitkällä tähtäimellä) arvioituna oligotrofisen Inarijärven kalantuotto on keskimäärin 160 tonnia (/vuosi), vaikka (laajamittaiset) kalanistutukset (jossain vaiheessa, ei nykyään) ovat aiheuttaneet negatiivisiakin vaikutuksia järven kalastolle ja järven tuottavuudelle. On ilmeistä, että perusedellytys on (kalatalouskäytön ja hoidon) (yhteensovittaminen) järven tuotantokyvyn kanssa. Venäjän osuus vahingoista Suomen kalataloudelle, järven kalantuotoista päätellen, on arvioitu olevan vähemmän kuin 60 tonnia, ja näin ollen kompensaation määrä (sähköntuotantona) on hyväksyttävä pitäen tämä arvo mielessä.

The basin of Lake Inari may be referred to as a territory suffering from technogenic influence that does not cause catastrophic changes in the fish resources of the lake. The reservoir has maintained its oligotrophic character but its ecosystem became unstable, which is typical for lakes with regulated outflow. However, not only waterpower engineering factors are to blame for the loss of balance in the ecosystem. Considerable influence comes from fish farming melioration (stocking) and fishing itself, both having financial and social efficiency. Therefore, changes observed in Lake Inari ecosystem are explained not only by the impact of waterpower engineering but to a large extent by fish industry use and natural global climatic and bioproductional processes. At present the lake is an example of rather rational management of fish reserves with integrated use of its water resources. Ecologically justified fishing yield for the oligotrophic Lake Inari is the figure of 160 t on the average, while the existing scale of artificial stocking causes negative effects in the structure of ichthyofauna and lake productivity. Apparent is the necessity of making the fish yield volumes match the production potential of Lake Inari. The share of Russia in the damage to Finnish fisheries, judging by the yields in lake Inari, is estimated to be less than 60 t, consequently the compensation size (electricity generation) must be agreed upon keeping this value in mind.