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AN ESTIMATION OF THE EEL FISHERY IN LAKE VÕRTSJÄRV

Lake Võrtsjärv has become the most important eel production centre in the Soviet Union. The area of this largest Estonian inland waterbody is 270 km^2, the mean depth 2.8 m, the maximum depth 6 m. According to the fishery typology (Schäperclaus, 1964) this eutrophic lake is a typical pike-perch and bream lake. It represents 35 fish species with pike-perch, pike, eel and bream being of greatest economic importance. During 1980—1984 the share of the mentioned fish species made up 54—65% of the catch mass (80—92% of the monetary value). The economic role of burbot, perch, ide, tench and asp is quite modest. As to the fish composition, L. Võrtsjärv is regarded as the best natural waterbody in the Soviet Union.

Eel can be considered an aboriginal species in L. Võrtsjärv. In the period of 1933—1939 on the average about 1.8 tons of eel were annually caught from this lake. Consequently, the natural productivity of eel in the lake was 0.07 kg/ha. The construction of the Narva hydropower station in the early 1950s blocked almost totally the natural route of eel from the Baltic Sea to the waterbodies of the Peipsi—Pihkva basin, including L. Võrtsjärv. As a result, eel soon disappeared from the fish composition of the lake.

In 1956 the first portion of glass eels was imported into the Soviet Union. That same year 165,000 glass eels were introducted also into L. Võrtsjärv (Table 1). In the following years glass eels have been introduced into several inland waterbodies of the north-western part of the Soviet Union, the Ukraine, Byelorussia and even Georgia. Up to the present time over 25 million glass eels have been introduced into L. Võrtsjärv. Soon eels were caught again in the fishermen's gear and after 1965 they reappeared in the statistical data of the L. Võrtsjärv fishery. Since that time up to 1977 eel catches have increased steadily, reaching the average annual level of 48.5 tons in 1976—1978 (Table 1). The eel catch made up 22—29% of the total fish catch in those years. Due to its relatively high market prices the share of eel in the monetary value of the catch is still greater. It was up to 66—75% in 1976—1979 (Table 1). The eel production of the lake at that time was 1.8 kg/ha which is not high in comparison with West-European eel waterbodies. For example, in the pike-perch and bream lakes of the FRG the productivity of eel is 1.8—4.5 kg/ha. In the lakes of the GDR where glass eels have regularly been introduced, the eel production has been even 3.5—13,2 kg/ha (Tesch, 1973).

At the end of the 1970s eel catches of L. Võrtsjärv decreased unexpectedly due to sharp changes in meteorological conditions. In connection with the appearance of new and abundant eel generations in the fishery in the early 1980s the catches gradually increased. In 1980—1984 eel occupied the fourth place in the total catch after bream, pike-perch and pike, while its average share was 9.5% of the catch. On the basis of monetary calculations the share of eel in those years was 41.3% (Table 1).

Table 1

Share of eel in the fish management of Lake Võrtsjärv

Year	Elver stocking, millions	Catch of eels, tons	Share of eel (%)		F_a
			in catch	in production value *	
1933—39		1.8	0.3	16	
1965	0.7	0.3	0.1	0.9	not determined
1966	—	1.9	0.8	9.1	"
1967	—	2.7	0.7	9.3	"
1968	1.4	2.9	0.8	10.4	"
1969	—	5.0	2.5	22.2	"
1970	1.0	6.5	3.5	28.3	"
1971	—	6.5	3.4	26.9	"
1972	0.1	16.4	8.3	47.5	"
1973	—	21.3	11.3	59.8	"
1974	1.8	18.7	14.3	51.1	"
1975	—	36.9	21.8	66.9	8.4
1976	2.6	49.6	27.9	74.6	8.6
1977	2.1	50.0	29.1	72.7	8.7
1978	2.7	44.8	22.0	66.2	5.1
1979	—	19.0	10.3	43.5	3.8
1980	1.3	17.8	8.5	40.2	2.8
1981	2.7	16.5	5.8	32.7	3.1
1982	3.0	10.8	4.6	25.9	1.9
1983	2.5	24.5	8.5	40.9	3.2
1984	1.8	66.6	19.9	66.6	6.6
1985	2.4	71.9	15.9	60.6	6.5
1986	—	55.6	11.5	52.7	5.0
1987	2.5	61.2	15.4	62.4	6.1

* — According to present retail prices.

Thus, eel is one of the main sources of fishery profits for the Võrtsjärv fishery.

One condition for the rational eel management is to catch all possible standard-sized eels. In L. Võrtsjärv eels reach the standard size (60 cm) at the age of 5—7 years in fresh water and remain in the fishery up to 17—19 years or even longer.

As a criterion of the effectiveness of eel management or, more exactly, the effectiveness of the use of introduced elvers, we propose the so-called fisheries-efficiency index (F_a):

$$F_a = \sum_{i=6}^{18} F_i = \frac{G_a \cdot 100}{\Sigma n_i g_i} \sum \frac{n_i}{P_{a-i}}, \text{ where}$$

F_i is the commercial return rate of the ith age group (%); G_a — the eel catch (kg) in the year a; n_i — the abundance of the ith age group in the examined sample; $n_i g_i$ — the sample mass (kg) measured for the study of the age structure of eels caught in the year a; P_{a-i} — the initial abundance of the eel generation forming the ith age group.

F_a shows which part (%) of all the eels reaching the standard age (length) was caught in the given year. F_a enables us to compare various catch years differing both meteorologically and by the intensity of fishery.

It can be seen from Table 1 that the value of F_a has been diminishing since 1978, reaching its minimum in 1982. This phenomenon was evidently due to the exceptionally rainy summer of 1978 which caused an unexpected rise of the water level in the lake. As a result, the fishing capacities of the fishing tackle decreased and a number of eels moved from the lake into the Suur-Emajõgi River (the only outflowing river). These eels would have contributed to the catches even now. The appearance of new numerous eel generations in the fishery has brought about a rise in eel catches, while F_a is reaching the level which corresponds to the hydrometeorological conditions of the lake and the character of fishing.

To estimate the efficiency of eel management in various waterbodies the rate (F) of commercial return can be used. F shows which part (%) of the fish belonging to one generation will be caught during the time this generation is in the fishery, i. e. in at least 14 years. In order to shorten the time of study, it is necessary to observe simultaneously several generations participating in the fishery at the same time. By summing up the mean return rates of the same age groups of various generations one obtains the return rate characterizing not a real but a theoretical generation.

$F_a < F$ because in calculating F_a only the age groups participating really in the catch are taken into account. In calculating F also those age groups are considered which would be subjected to the fishery in case the inlet of young eels had taken place every year. For example, in 1985 eels of the age groups 6+, 10+, 12+, 14+, 16+ and 18+ were lacking in the lake.

Both, F_a and F, characterize the survival of eels in the waterbody and the intensity of the fishery. In some isolated Central-European lakes which are well accessible to fishery the return of eels forms 20—30% (Schäperclaus, 1964). During the years 1975—1978 15 adult eels per 100 introduced elvers were caught from L. Võrtsjärv, during the period 1981—1984 only 7. Table 2 presents data of the commercial return of eels in various waterbodies.

Table 2

Rate of eel return in various waterbodies

Waterbody	Commercial return, %	Source
Evo lakes (Finland)	20	M. Pursiainen, personal communication
Polish lakes	6—8	Ciepielewski, 1975
Byelorussian lakes	3—8	Костюченко, Прищепов, 1971
Lake Seliger (USSR)	4	Никанорова, 1981

F and F_a depend on the natural mortality of eels (here belong conventionally also transport losses) as well as on the organization of the fishery and the correctness of catch statistics. The natural mortality of eels depends on the condition of elvers immediately before the inlet, on the perishing of young eels due to enemies, diseases and unfavourable environmental conditions. One of the main reasons for the death of fishes is the damage brought about during their transportation. The second important reason in the case of L. Võrtsjärv is the introduction of glass eels under the ice. The elvers suffering from the temperature shock are not able to scatter sufficiently and a lot of them fall a prey to local predatory fish (ruff, perch, burbot, pike-perch, pike, etc.).

The mass death of eels due to illnesses or parasites has not been observed in L. Võrtsjärv. A great number of fish, including eels, died as a result of unfavourable abiotic environmental conditions in 1967, 1978, and 1987. The feeding eels (yellow eels) are quite well protected from enemies owing to their hidden, nocturnal way of life. Remains of eels have rarely been found in stomachs of predatory fish, but if found, then mainly in winter, spring and autumn when eel is relatively inactive.

In L. Võrtsjärv eels are caught only with basket traps (a local modification of 'bottengarn'). Electric barriers are being tested which would prevent entrance of eels starting their spawning route into the Suur-Emajõgi River. The departure of spawning eels is conventionally regarded as natural mortality.

The greatest obstacle to the development of eel management in L. Võrtsjärv is the shortage of glass eels. Considering the food resources of the lake and its other ecological characteristics, 100 ind./ha could be introduced into the lake, i. e. up to 2.7 million glass eels every year (Кангур, 1981, 1984).

The basic food for eel in L. Võrtsjärv are the larvae and pupae of *Chironomus plumosus*, after that the fingerlings of ruff, perch and other fishes. According to our calculations the eel population of L. Võrtsjärv consumed nearly 15% of the annual production of *Ch. plumosus* in 1984. In order to relieve the food competition between eel and other benthophagous fishes it is now permitted to diminish the abundance of bream as a low-value fish in L. Võrtsjärv. Since 1975 this species is caught without any restristions (while the fishing of pike-perch and pike is strongly restricted).

The development of the eel culture in L. Võrtsjärv is a rather profitable fishery activity; at present the income from the sale of adult eels exceeds mote than threefold the expenses made on purchasing glass eels and on fishermen's salaries.

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VÕRTSJÄRVE ANGERJAMAJANDUSE TÕHUSUSE HINDAMISEST

Angerjamajanduse tõhususe hindamiseks kasutatakse tavaliselt tööndusliku tagasipüügi suurust (F). F näitab, milline kogus antud põlvkonda kuuluvaist angerjaist püütakse välja nende aastate jooksul, mil see põlvkond allub tööndusele. Tingimustes, mil klaasangerjaid on asustatud vaheaegadega, saab F-i arvutada alles 3—4-aastase ajavahemiku kohta.

Nimetatud puudust ei ole püügi tõhususe indeksil (F_a). F_a näitab, milline kogus (%) tööndusliku vanuse saavutanud angerjaist püüti vaadeldaval aastal. F_a võimaldab võrrelda üksikuid aastaid, mis erinevad hüdrometeoroloogiliste tingimuste ja kalapüügi intensiivsuse poolest, samuti hinnata asustusmaterjali kasutamise ning kogu angerjamajanduse tõhusust.

Анду КАНГУР

ОЦЕНКА К ВЕДЕНИЮ УГРЕВОГО ХОЗЯЙСТВА В ОЗЕРЕ ВЫРТСЪЯРВ

Для оценки эффективности угревого хозяйства обычно применяется величина промыслового возврата (F). F показывает соотношение числа выловленных угрей к числу посаженных. Поскольку посадка мальков происходит не ежегодно, а с перерывами, минимальный период для вычисления F составляет 3—4 года. Более оперативным является индекс эффективности угреловства:

$$F_a = \sum_{i=6}^{18} F_i = \frac{G_a \cdot 100}{\Sigma n_i g_i} \sum \frac{n_i}{P_{a-i}},$$

где F_i — промысловый возврат отдельных возрастных групп угря, выловленных в году a, %; G_a — вылов угря в году a (кг); n_i — численность угрей отдельных возрастных групп выборки; g_i — средняя масса угрей отдельных возрастных групп (кг); P_{a-i} — исходная численность отдельных возрастных групп, F_a — доля угрей, достигших промыслового возраста, выловленных в году a, %.

F_a позволяет сравнивать отдельные годы угреловства, отличающиеся между собой метеорологическими условиями и интенсивностью вылова.