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MAIN CHANGES IN THE ICHTHYOCOENOSIS OF LAKE PEIPSI SINCE THE 1950s

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Abstract. During the postwar period four drastic and commercially important changes have occurred in the ichthyocoenosis of L. Peipsi, related to dwarf smelt, vendace, and pikeperch. In August 1959 and 1972 mass summer kills of dwarf smelt were registered in the lake, caused by severe night-time water anoxia. The stock of smelt was restored in 2–3 years. In 1990 the abundance of vendace dropped sharply in L. Peipsi in connection with a serious deterioration of its spawning conditions (high mortality of eggs) in successive mild winters. In 1991–94 vendace was not caught but later its stock started to restore gradually. As a result of intensive use of trawls and fine-meshed Danish seines, the stock of pikeperch was strongly suppressed in L. Peipsi in 1957–83. After trawls were prohibited and the number of Danish seines was considerably restricted, the stock and catches of pikeperch began to grow rapidly. Since 1989 pikeperch has become the principal export fish in the lake.

Key words: Lake Peipsi, dwarf smelt, vendace, pikeperch.

INTRODUCTION

Since the 1950s four drastic and commercially essential changes have occurred in the ichthyocoenosis of L. Peipsi. Three of them, connected with a sudden sharp decrease in the abundance of dwarf smelt and vendace, were temporary, being caused mainly by hydrometeorological conditions. The fourth change, brought about by a rapid increase and flourishing of the stocks of pikeperch, was mostly a result of intentional rearrangement of fishery in the lake. We hope that the results of this change will be permanent.

LAKE PEIPSI AND ITS FISHES

Lake Peipsi (Peipus) is lying partly on the territory of Estonia and partly on the territory of Russia. With respect to its surface area (3555 km^2) the lake

occupies the fifth place in Europe. Lake Peipsi consists of three parts: the largest and deepest northern part, L. Peipsi *s.s.* (2611 km^2, average and maximum depths 8.3 and 12.9 m, respectively), the middle narrow strait-like part, L. Lämmijärv (Warm Lake; 236 km^2, 2.5 and 15.3 m), and the southern part, L. Pihkva (L. Pskov; 708 km^2, 3.8 and 5.3 m). About 1570 km^2 of the whole aquatory of L. Peipsi belongs to Estonia (of this 1442 km^2 of L. Peipsi *s.s.*, 118 km^2 or a half of L. Lämmijärv, and 10 km^2 of L. Pihkva). The main inflows of L. Peipsi are the Velikaya River in the south and the Emajõgi R. in the west. The outflow, the Narva R., connects the lake with the Gulf of Finland. Water turnover time is 2–2.5 years.

Lake Peipsi *s.s.* belongs to unstratified eutrophic lakes with mesotrophic features, while L. Lämmijärv has some dyseutrophic features, and L. Pihkva is strongly eutrophic. The biological productivity of L. Peipsi is rather high, the biomass of zooplankton being mostly 2–3 g m^{-3} in the vegetation period and the mean biomass of macrozoobenthos (without big molluscs) 12.3 g m^{-2} (Nõges et al., 1996).

According to current data 33 fish species and one lamprey species inhabit permanently L. Peipsi together with the lower reaches of its tributaries (Pihu, 1996). As to the amount of catches (not considering their cost) the main commercial fishes (in the systematic order) are lake or dwarf smelt *Osmerus eperlanus eperlanus* morpha *spirinchus* Pallas (since the 1930s its annual catch in L. Peipsi has usually been 1500–3000 t, with a maximum catch of 9160 t in 1935), vendace *Coregonus albula* (L.) (300–1500 t, 3271 t in 1987; by now its abundance has declined sharply), pike *Esox lucius* L. (200–400 t, 610 t in 1931), roach *Rutilus rutilus* (L.) (400–600 t, 1560 t in 1939), bream *Abramis brama* (L.) (300–600 t, 1492 t in 1953), perch *Perca fluviatilis* L. (1000–1700 t, 3910 t in 1973), pikeperch *Stizostedion lucioperca* (L.) (20–200 t, 1360 t in 1998), and ruffe *Gymnocephalus strenuus* (L.) (500–1500 t, about 2500 t in 1972).

Fishes of minor commercial importance in L. Peipsi are whitefish *Coregonus lavaretus maraenoides* Poljakow (60–90 t, 131 t in 1933), burbot *Lota lota* (L.) (100–200 t, 270 t in 1982), and white bream *Blicca bjoerkna* (L.). Eel *Anguilla anguilla* (L), rudd *Scardinius erythrophthalmus* (L.), dace *Leuciscus leuciscus* (L.), ide *Leuciscus idus* (L.), chub *Leuciscus cephalus* (L.), tench *Tinca tinca* (L.), bleak *Alburnus alburnus* (L.), vimba bream *Vimba vimba* (L.), and crucian carp *Carassius carassius* (L.) are occasionally found in fish catches. The catch of grayling *Thymallus thymallus* (L.), asp *Aspius aspius* (L.), and wels *Silurus glanis* L. is prohibited all the year round. The remaining 12 fish and lamprey species are of no economic importance.

Preferring oxygen-rich and cool water, vendace and whitefish are abundant only in L. Peipsi *s.s.*, while their number is insignificant in warmer and more eutrophicated L. Lämmijärv and L. Pihkva. Dwarf smelt is relatively more numerous in L. Pihkva where its feeding conditions are better than in L. Peipsi *s.s.*

Until the mid-1980s L. Peipsi was regarded as a smelt–bream lake, later it has acquired also some qualities of a pikeperch lake.

Considering fish catches (since the 1930s usually 9000–11 000 t or 25–31 kg ha^{-1} yr^{-1}) L. Peipsi surpasses all the other large lakes of North Europe. The total annual catch has, however, been fluctuating on a large scale, from 6300 to 15 100 t during the last 60 years, depending mostly on the abundance of dwarf smelt in the lake.

SUMMER KILLS OF DWARF SMELT

Regarding the amount of catches mainly dwarf or lake smelt has been the most important commercial fish in L. Peipsi. From the mid-19th century to the 1920s, when the hydrobiological condition of L. Peipsi was much better than nowadays, total annual fish catches exceeded at times 25 000 t (perhaps even 30 000 t), of which smelt alone constituted up to 20 000 t (Tyurin, 1974). In the 1930s smelt catches exceeded repeatedly 8000–9000 t a year. More recent large smelt catches in the lake were recorded in 1952–54 (4140–5650 t), 1967–69 (5774–6134 t), and 1980 (5567 t). In 1998 the catch of smelt amounted to 2966 t. In general, the numbers and catches of dwarf smelt are very variable (Fig. 1), depending first and foremost on hydrometeorological conditions in the spawning period combined with its short life span, usually 1–2 years. Stable water level, calm warm weather in spring, sufficiently large number of spawners, and favourable feeding conditions ensure formation of a vigorous new generation of dwarf smelt (Efimova, 1963; Pihu, 1966; Dorozhkina, 1985).

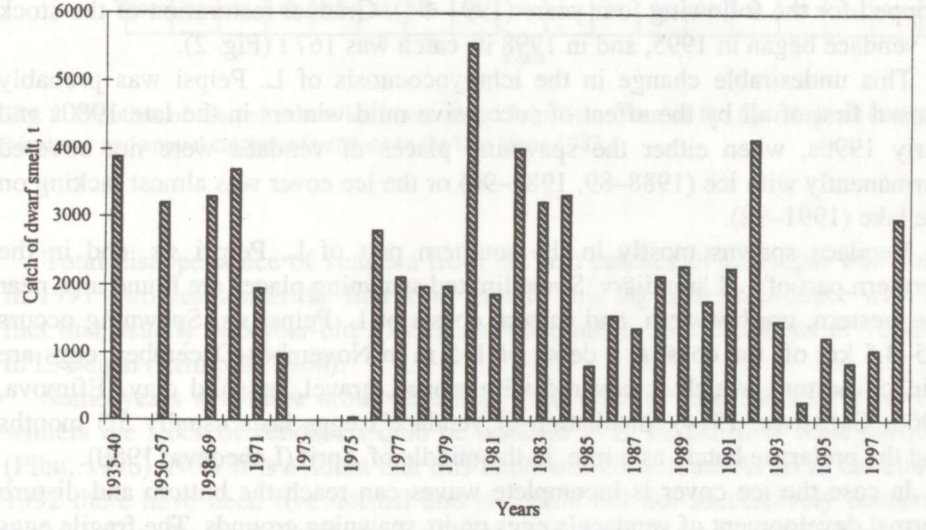

Fig. 1. Annual catches of dwarf smelt in L. Peipsi.

The stock of dwarf smelt in L. Peipsi suffered seriously for summer anoxia in August 1959 (Efimova, 1963) and 1972 (Dorozhkina, 1975; Kuderskij & Fedorova, 1977), caused by the coincidence of several unfavourable circumstances: low water level, prolonged calm and hot weather (water temperature up to 28 °C), and strong water bloom, which together led to a severe night-time oxygen deficiency in water as well as to mass smelt kill. It should be mentioned that dwarf smelt is much more sensitive to such adverse conditions than the other fishes (among them even oxyphilous whitefish and vendace).

In 1959, dwarf smelt perished in masses only in L. Pihkva (but not in L. Peipsi *s.s.*), but its stock was restored there already in two years (1961). In 1972, however, the summer kill of smelt was far more severe involving the whole L. Peipsi as well as the other smelt lakes in the neighbourhood, for example lakes Ilmen, Beloe, Seliger, Vodlozero, Rybinsk water reservoir, a.o. (Kuderskij & Fedorova, 1977). The sharp decline in the stock of smelt in L. Peipsi was conduced also by cold spring, heavy infection with *Tetracotyle* sp., and the high abundance of perch and other fishes predating on smelt (Dorozhkina, 1975). That time dwarf smelt lost its commercial importance in the lake for three years (1972–74) but became again abundant already in 1976 when its annual catch amounted to 2787 t.

DECLINE OF THE STOCK OF VENDACE

Vendace was one of the main commercial fishes in L. Peipsi until 1989. Its stock attained the highest level in 1986–89, annual catches being 1957–3271 t. In 1990 the abundance of vendace dropped sharply, and fishing for it in the lake stopped for the following four years (1991–94). Gradual restoration of the stock of vendace began in 1995, and in 1998 its catch was 167 t (Fig. 2).

This undesirable change in the ichthyocoenosis of L. Peipsi was probably caused first of all by the effect of successive mild winters in the late 1980s and early 1990s, when either the spawning places of vendace were not covered permanently with ice (1988–89, 1989–90) or the ice cover was almost lacking on the lake (1991–92).

Vendace spawns mostly in the southern part of L. Peipsi *s.s.* and in the northern part of L. Lämmijärv. Some limited spawning places are found also near the western, northwestern, and eastern coasts of L. Peipsi *s.s.* Spawning occurs 0.5–4.5 km off the coast at a depth of 1–5 m in November–December; eggs are laid on bottom, which is covered with stones, gravel, or solid clay (Efimova, 1966; Gal'tsova, 1974). Incubation of vendace's eggs lasts usually 5.5 months and the prelarvae hatch, as a rule, in the middle of April (Lebedeva, 1980).

In case the ice cover is incomplete waves can reach the bottom and disturb normal development of vendace's eggs on its spawning grounds. The fragile eggs can be injured mechanically or even buried under bottom sediments, which causes their mass perishing (Sterligova et al., 1988).

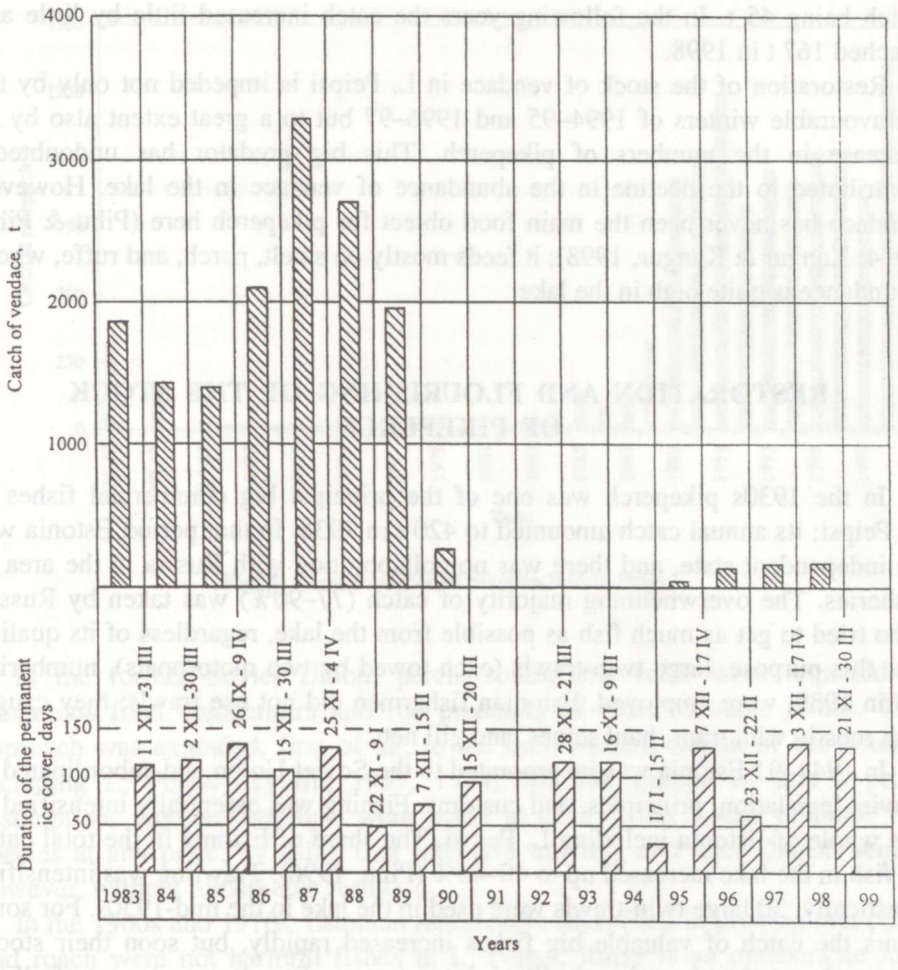

Fig. 2. Duration of the permanent ice cover on L. Peipsi *s.s.* (data of the hydrological station at Mustvee) and annual catches of vendace in the lake since 1983.

Total disappearance of vendace from the fish catches of L. Peipsi was noted in 1991, two years after the first mild winter. This lag is in accordance with the fact that usually two-year-old specimens predominate in the catches of vendace in L. Peipsi (Efimova, 1966).

Some years ago there arouse the hope that after several successive normal winters the stock of vendace would be restored in L. Peipsi, if at least partially (Pihu, 1996). Now it is evident that this hope will come true. As from the end of 1992 there have been five normal and two mild but not successively occurring winters (Fig. 2), the eggs of vendace have developed in more or less favourable conditions. In 1995 vendace reappeared in the fishery statistics of L. Peipsi, its

catch being 45 t. In the following years the catch increased little by little and reached 167 t in 1998.

Restoration of the stock of vendace in L. Peipsi is impeded not only by the unfavourable winters of 1994–95 and 1996–97 but to a great extent also by an increase in the numbers of pikeperch. This big predator has undoubtedly contributed to the decline in the abundance of vendace in the lake. However, vendace has never been the main food object for pikeperch here (Pihu & Pihu, 1974; Kangur & Kangur, 1998); it feeds mostly on smelt, perch, and ruffe, whose abundance is quite high in the lake.

RESTORATION AND FLOURISHING OF THE STOCK OF PIKEPERCH

In the 1930s pikeperch was one of the principal big commercial fishes in L. Peipsi; its annual catch amounted to 420 t in 1938. In that period Estonia was an independent state, and there was no collaboration with Russia in the area of fisheries. The overwhelming majority of catch (77–90%) was taken by Russia, who tried to get as much fish as possible from the lake, regardless of its quality. For this purpose, large twin-trawls (each towed by two motorboats), numbering 18 in 1939, were employed. Estonian fishermen did not use trawls; they caught fish mostly with traps, haul seines, and gill nets.

In 1944–91 Estonia was incorporated to the Soviet Union and subordinated to Soviet legislation, principles, and customs. Fishing was essentially intensified in the whole of Estonia including L. Peipsi. The share of Estonia in the total catch of fish in the lake increased up to 40–45% (Pihu, 1996). Trawling was intensified drastically: 30 large twin-trawls were used in the lake in the mid-1950s. For some years the catch of valuable big fishes increased rapidly, but soon their stocks were exhausted and catches declined. Intensive trawling damaged most of all the stock of pikeperch, which is particularly sensitive to this type of fishing gear. Unlike the majority of other big fishes, pikeperch (both young and adult) prefers open lake parts, which are also much more suitable for trawling than the inshore zone.

At the end of the 1950s, application of twin-trawls in L. Peipsi was prohibited but they were replaced with another active fishing-gear, Danish seines. These seines were quite harmful, killing young specimens of valuable fishes, primarily pikeperch, in large numbers. As a result, the stock of pikeperch fell to a very low level for a long time. During 1957–83, the mean annual catch of this valuable fish in the lake was merely 18 t, falling occasionally to 8 t (Fig. 3). At first Russian ichthyologists tried to explain this regrettable situation by shortage of suitable spawning sites in the lake (Efimova, 1963; Shirkova, 1966). Later they had to admit the strong negative impact of unreasonable fisheries policy (Negonovskaya, 1974; Dorozhkina, 1975; Il'inskij, 1995).

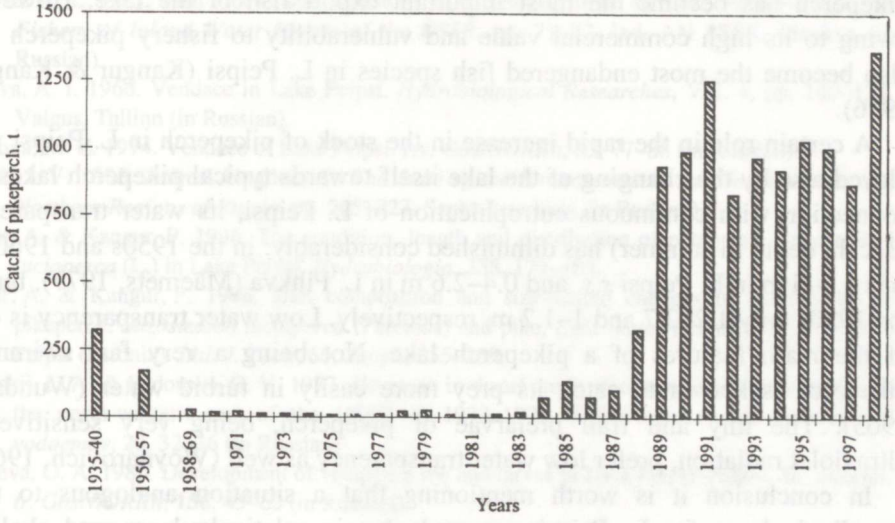

Fig. 3. Annual catches of pikeperch in L. Peipsi.

In the former Soviet Union, perch, roach, and ruffe were regarded as dangerous food competitors and roe predators of more valuable fishes. This approach was extended, first of all, to the northwestern region of the country including L. Peipsi (Tyurin, 1957, 1974). On the ground of this a priori assumption, vigorous attempts were made to destroy the stocks of these fish species at any price, by using first intensive trawling and later Danish seines; however, without remarkable results.

In the 1960s and 1970s, Estonian researchers succeeded in proving that perch and roach were not harmful fishes in L. Peipsi. Ruffe is an undesirable food competitor and roe eater, indeed, but reducing its abundance by means of intensive fishing is useless (Pihu & Pihu, 1971, 1975).

Both Estonian and Russian ichthyologists reached the conclusion that the use of Danish seines in L. Peipsi is harmful for valuable fishes (Pihu & Kangur, 1970; Dorozhkina, 1975). In accordance with their joint demands, the number of Danish seines was considerably restricted on the lake since 1974 (from 137 in 1966 to 40 at present), while the mesh size of the seine's cod-end measured between adjacent knots was increased from 8–12 to 20–22 mm.

As a result of remarkable attenuation of the detrimental impact of Danish seines, pikeperch could at last realize its reproductive capacity in L. Peipsi. Viable pikeperch generations were formed in the lake in 1980, 1985, 1986, 1989, 1991, 1992, and 1995. Subsequent high survival rate laid a firm foundation for a boom in the stock and catches of this valuable fish. Thus, in 1984 the catch of pikeperch in L. Peipsi was 73 t, in 1988 325 t, in the 1990s already 867–1360 t.

Pikeperch has become the most important export fish of the lake. However, owing to its high commercial value and vulnerability to fishery pikeperch has also become the most endangered fish species in L. Peipsi (Kangur & Kangur, 1996).

A certain role in the rapid increase in the stock of pikeperch in L. Peipsi was played also by the changing of the lake itself towards typical pikeperch lakes. In connection with continuous eutrophication of L. Peipsi, its water transparency (Secchi depth in summer) has diminished considerably: in the 1950s and 1960s it was 1.8–5 m in L. Peipsi *s.s.* and 0.4–2.6 m in L. Pihkva (Mäemets, 1977), but in the 1990s only 1.2–2.7 and 1–1.2 m, respectively. Low water transparency is one of the main features of a pikeperch lake. Not being a very fast swimmer, pikeperch is known to catch its prey more easily in turbid water (Wundsch, 1963). The tiny and frail prelarvae of pikeperch, being very sensitive to ultraviolet radiation, prefer low water transparency as well (Woynarovich, 1962).

In conclusion it is worth mentioning that a situation analogous to that described above for L. Peipsi occurred also in relatively large and shallow eutrophic Lake Võrtsjärv in Central Estonia (area 270 km^2, maximum depth 6 m) in the 1950s and 1960s (Pihu, 1998). According to its limnological and hydrobiological qualities, L. Võrtsjärv is a typical pikeperch lake, and this species was quite abundant there before World War II. In the 1950s intensive fine-meshed trawls were used in L. Võrtsjärv, which soon damaged severely the stock of pikeperch and turned the lake to a ruffe water body. Thanks to rearrangement of fishery in the early 1970s (trawling was stopped, protection of valuable fishes was improved essentially) the stock of pikeperch was restored quickly (in 3–4 years) and L. Võrtsjärv has become a good pikeperch lake again.

The experience gained in recovering the abundance of pikeperch by rearrangement of fishery in L. Võrtsjärv was successfully applied 15–20 years later on L. Peipsi.

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TÄHTSAMAD MUUTUSED PEIPSI IHTÜOTSÖNOOSIS ALATES 1950. AASTATEST

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1959. ja 1972. aasta augustis toimus Peipsis öise hapnikupuuduse tagajärjel tindi massiline suremine. Tindi varud taastusid 2–3 aasta pärast. 1990. aastal langes järves rängalt rääbise arvukus. Seda põhjustas kalade marja hukkumine koelmutel mitme järjestikuse pehme talve tõttu, kui rääbise koelmukohad polnud püsiva jääkatte all. Aastail 1991–1994 ei saadud rääbist üldse püüda, hiljem on varud hakanud pisitasa taastuma. Kohavarud olid Peipsis traalide ja peenesilmaliste mutnikute intensiivse kasutamise tõttu aastail 1957–1983 äärmises madalseisus. Pärast traalpüügi keelamist ja mutnikute arvu tunduvat vähendamist hakkasid kohavarud ja -saagid kiiresti kasvama. 1989. aastast alates on koha muutunud Peipsis kõige tähtsamaks eksportkalaks.