Proc. Estonian Acad. Sci. Biol. Ecol., 2002, **51**, 1, 45–61

The stock and yield of the European eel, *Anguilla anguilla* (L.), in large lakes of Estonia

Andu Kangur, Peeter Kangur, and Külli Kangur

Võrtsjärv Limnological Station, Institute of Zoology and Botany, Estonian Agricultural University, 61101 Rannu, Tartumaa, Estonia; akangur@zbi.ee

Received 5 November 2001, in revised form 11 January 2002

Abstract. As a result of stocking since 1956, eel has become the most important commercial fish in L. Võrtsjärv (270 km^2) today. Downstream migration of eel from L. Võrtsjärv supports eel fishery in L. Peipsi (3555 km^2). The aim of this study was to assess the effectiveness of eel stocking in L. Võrtsjärv. The annual mean catch of eel and stocking rate and frequency were analysed by five-year periods. The stocking of eel in L. Võrtsjärv (annual average 35 ind. ha^{-1} in 1956–2001, maximum 84 ind. ha^{-1} in 1980–84) is below optimum rate, which explains the relatively low catches (annual average 1.2 kg ha^{-1} in 1965–2001, maximum 3.7 kg ha^{-1} in 1988, according to official statistics). The average number of glass eels required to produce 1 kg of eel catch (efectiveness of stocking) was about 32 in 1965–2001. A significant positive relationship ($r = 0.41$, $p = 0.03$, $n = 28$) was found between the stocking rate and the catches of eel in the sixth year after stocking. Eels caught from L. Võrtsjärv are larger (usually 60–80 cm) than those caught from other water bodies in Europe. Food competition between eel and the indigenous benthophagous fishes bream and ruffe is an important factor influencing the success of eel fishery in the lake.

Key words: European eel, stocking rate, stocking frequency, effectiveness of stocking, composition of catches.

INTRODUCTION

Stocking of fish is the main fish management action in fresh waters today (Vøllestad & Hesthagen, 2001). The term stocking is often used to imply the repeated release of fish into an ecosystem from an external location (Welcomme, 1998). Stocking is commonly used to mitigate the loss or reduction of stocks and to create new fisheries (Cowx, 1998). The most common reason for such a stocking practice is hydropower development (Vøllestad & Hesthagen, 2001).

European eel, *Anguilla anguilla* (L.), is a valuable commercial fish, which has a single known breeding place far outside the water bodies in which it is exploited (Moriarty, 1996). Because of their extremely complex life cycle, eels have not been bred in hatcheries. Therefore, stocking with wild caught glass eels is an important aspect of fishery management in many European countries. Virtually the whole eel production in eastern European countries is based on this measure (Moriarty et al., 1990).

Eel is a native fish in Estonian inland water bodies. Upstream migration of young eel from the Atlantic Ocean into the basin of L. Peipsi is complicated. It proceeds along the North Sea, the Gulf of Finland of the Baltic Sea, and the Narva River (Fig. 1). Therefore, natural eel stocks have never been very dense in Estonian large lakes. The annual catch of eel in 1939 was only 3.8 tonnes from L. Võrtsjärv and 9.2 tonnes from L. Peipsi (Kint, 1940). This means that the natural annual eel yield in L. Võrtsjärv was 0.014 kg ha^{-1} and in L. Peipsi 0.026 kg ha^{-1} at that time. However, the construction of the Narva hydropower station in 1955–56 (Mishcuk & Jaani, 2000) blocked almost totally the natural route of eel from the Baltic Sea to the water bodies of the L. Peipsi basin, including L. Võrtsjärv. With the purpose to restore the eel population and to use better the production capacity of L. Võrtsjärv, stocking measures were started in 1956. Unfortunately, no stocking programme of eel in transboundary L. Peipsi has yet been adopted.

The first attempts to stock glass eels in Estonian lakes were made before World War II (Suuressaar, 1972). A total of 20 000 glass eels were introduced in 1937, 80 000 in 1938, and 4300 in 1939. Unfortunately, the results of these stocking efforts are not known. Today, the stock of eel in L. Võrtsjärv depends entirely on the number of introduced young eels.

In order to predict the effects of fish stocking it is necessary to understand how different species interact in a system. The most important relations in an

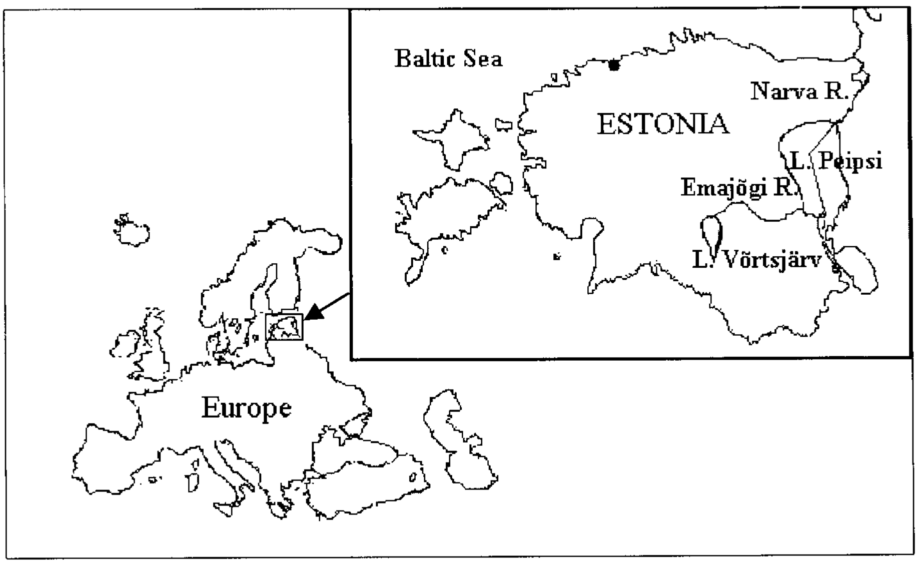

Fig. 1. Location of Lake Peipsi and Lake Võrtsjärv.

ecosystem are intra- and interspecific trophic relations. In large lakes Peipsi and Võrtsjärv the main indigenous benthophagous fishes are bream, *Abramis brama* (L.), and ruffe, *Gymnocephalus cernuus* (L.), whose diet overlaps considerably with that of eel (Kangur et al., 1999, 2000a). Therefore, the food relations and competition between benthophagous fishes are among the most important aspects in eel fishery in both lakes.

This paper summarizes the existing data on eel fishery in the large lakes of Estonia. An analysis is given of the long-term dynamics of elver stocking and yield of eel in L. Võrtsjärv. The aim of this study was to assess the effectiveness of eel stocking and the state of this fish in L. Võrtsjärv. Food relations and species interactions between the main benthophagous fishes inhabiting the lake are discussed as well.

STUDY AREA

Lake Peipsi and Lake Võrtsjärv (Fig. 1) are the largest lakes in the Baltic Sea basin. Both lakes support significant fishery. At present, the total freshwater catch of fish in Estonia is divided as follows: L. Peipsi (Estonian part), 85–88%; L. Võrtsjärv, 10–13%; and other water bodies, 1–2% (Vetemaa et al., 1999). Both L. Peipsi and L. Võrtsjärv are shallow lowland lakes, but they display slight differences in their trophic state as well as in the structure of the fish community and in fishery production.

Lake Peipsi (L. Peipsi–Pihkva) is situated on the border of Estonia and Russia. It is the fourth largest lake in Europe (Jaani & Raukas, 1999). The total area of the lake is 3555 km^2, its mean depth is 7.1 m, and maximum depth is 15.3 m (Table 1). About 1570 km^2 of the whole surface area belongs to Estonia. In 1921–98, the average water level of L. Peipsi was 30.0 m above sea level, but it fluctuates with an amplitude of up to 3.04 m (Jaani & Raukas, 1999). The average annual range of water level fluctuations is 1.15 m. The lake is generally well aerated by waves and currents throughout the water column (Jaani, 1996). The ice cover lasts from December to April.

The concentration of total phosphorus and nitrogen in the surface water over two northern lake parts (L. Peipsi *s.s.* and L. Lämmijärv) varied between 18 and 105 mg P m^{-3} and 250 and 1798 mg N m^{-3} (95% tolerance range), with the overall means of 43 mg P m^{-3} and 670 mg N m^{-3}, respectively, in 1992–2000 (K. Kangur et al., in press). During the growth seasons of 1992–99, water transparency by Secchi disc was mostly 0.6–3.4 m, with an overall mean of 1.7 m (Kangur et al., 2000b).

Lake Võrtsjärv (area 270 km^2) is a very shallow turbid water body with a mean depth of 2.8 m and maximum depth of 6 m (Jaani, 1990). The lake is strongly eutrophic. The mean total nitrogen concentration (± standard error) was 1600 ± 100 mg m^{-3}, total phosphorus concentration 54 ± 4 mg m^{-3}, and mean Secchi depth 1.1 ± 0.1 m in 1983–96 (Haberman et al., 1998). During the ice-free period, Secchi depth does not usually exceed 1 m. The ice cover lasts from November

Table 1. Characterization of L. Peipsi and L. Võrtsjärv

	L. Peipsi	L. Võrtsjärv
Area, km^2	3555	270
Mean depth, maximum depth, m	7.1, 15.3	2.8, 6.0
Trophic status	Eutrophic	Strongly eutrophic
Fisheries status	Smelt–bream–pikeperch	Pikeperch–bream
Average (± standard error) annual macrozoobenthos biomass, g m^{-2}	12.7 ± 0.7 (June 1964–2000)	6.7 ± 1.0 (1973–2000)
Average annual fish catch, kg ha^{-1}, in 1995–2000	18	10
Good commercial fishes	Perch, pikeperch, smelt, bream, pike	Eel, pikeperch, pike, large bream
Non-valuable fishes	Roach, ruffe	Small bream, roach, ruffe
Fish protection measures	Closed spring season, legal size for commercial fishes, limitation of the number of fishing gear, and minimum mesh size	
Main fishing gear	Bottom seine, gill nets, fence traps	Large fence traps, gill nets
Use of active fishing gear	Restricted	Not allowed

to April. In winter, oxygen deficit can occur under the ice. The lake is polymictic with some short (1–2 weeks) stratification periods during summer and weak inverse thermal stratification in winter (Nõges & Nõges, 1998). The mean annual range of water level fluctuations is 1.4 m (Huttula & Nõges, 1998).

According to present data, one lamprey and 33 fish species inhabit permanently L. Peipsi and its tributaries (Pihu & Kangur, 2001), and one lamprey and 31 fish species inhabit L. Võrtsjärv and the lower reaches of its tributaries (Pihu, 1998). About ten of these species are of commercial and recreational importance (Fig. 2). Conventionally, fishes caught from the lakes can be classified into commercially important (good) fishes and non-valuable (inferior or trash) fishes (Table 1). Commonly, good fishes (eel, pikeperch *Sander lucioperca* (L.), bream, pike *Esox lucius* L., ide *Leuciscus idus* (L.), tench *Tinca tinca* (L.), burbot *Lota lota* (L.), perch *Perca fluviatilis* L.) are used as human food. Inferior fishes (roach *Rutilus rutilus* (L.), small perch (SL < 12 cm) and ruffe, as well as small bream (about SL < 25 cm) are mainly used as food for domestic animals.

In L. Peipsi, smelt *Osmerus eperlanus* (L.) and whitefish *Coregonus lavaretus* L. are common fishes. Until the early 1990s, vendace *Coregonus albula* (L.) was common as well. These fish species are typically found in oligotrophic waters. In L. Võrtsjärv they have lost commercial importance owing to the eutrophication of the lake. As a result of stocking, eel has become the most valuable and important commercial fish in L. Võrtsjärv (Kangur, 1998).

At present, the basic fishing gear used in both lakes consists of local modifications of fence traps for eel, perch, vendace, and spawning smelt and gill nets for pikeperch, pike, and bream (Table 1). Bottom seining is used in L. Peipsi for perch and pikeperch, while towed fishing gear is forbidden in L. Võrtsjärv.

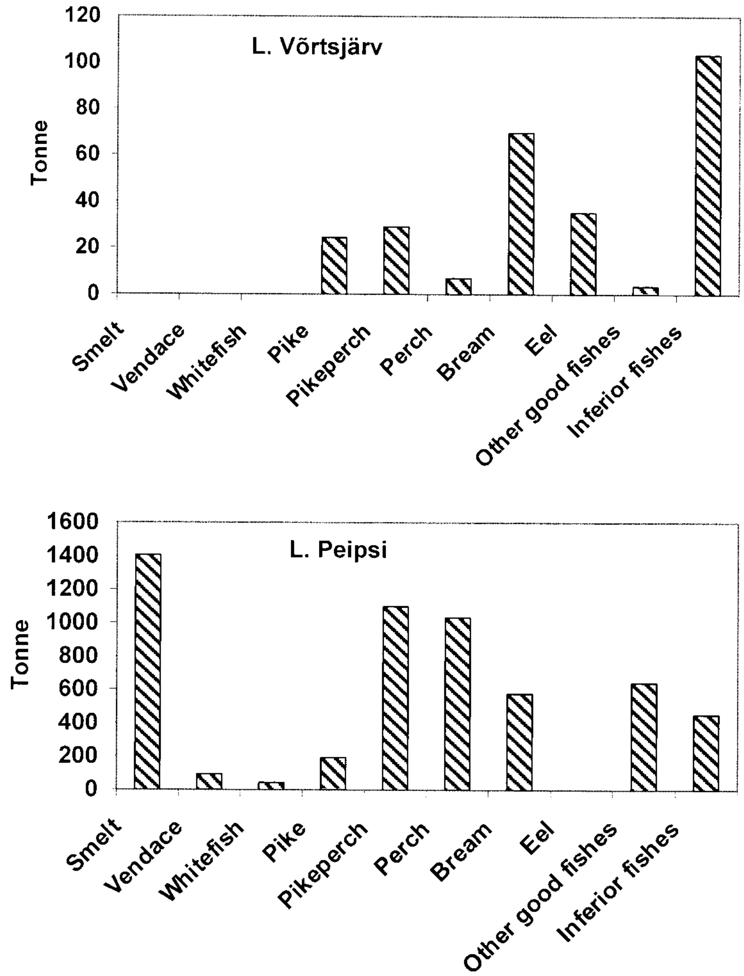

Fig. 2. Commercial catch of fishes in L. Võrtsjärv and L. Peipsi in 1994–2000.

MATERIAL AND METHODS

Measurements of eels have been carried out in L. Võrtsjärv since 1973. A total of 9000 specimens have been analysed, of these 3054 since 1994. Fish were caught with fence traps (mesh size 18–22 mm from knot to knot in the cod end) and an experimental trawl (mesh size 12–14 mm) in the southern and central parts of L. Võrtsjärv. The standard length (Sl) of fish was measured with accuracy up to 1 cm and the total weight up to 10 g. The condition factor (according to Fulton) and length–weight relationship of eel were calculated (Bagenal & Tesch, 1978). Also materials characterizing the condition of eel in L. Võrtsjärv in 1966–72 (collected by M. Kangur) were used.

The fisheries statistics of the Fisheries Department of the Estonian Ministry of the Environment and the Võrtsjärv Fishery Farm (existed up to 1991) on fish catches and the data on the stocking of young eels were used. The following variables were analysed by five-year intervals:

1. Annual mean eel catch, kg ha^{-1}
2. Stocking rate: young eels, ind. ha^{-1}
3. Effectiveness of stocking: the number of glass eels (or elvers) required to produce 1 kg of eel catch, derived from 1 and 2
4. Frequency of stocking: the ratio of the number of years when glass eels were stocked to all years in the period

The Pearson correlation analysis was used to measure the relationship between stocking rate and the catch of eel with a lag of 4–9 years in 1956–2001.

RESULTS

Stocking and catches of eel

In 1956, stocking of wild caught glass eels into L. Võrtsjärv was restarted. The eels were imported to Estonia from England and France as glass eels. About 44 million young eels were introduced into the lake during 1956–2001. However, stocking has been irregular (Fig. 3). Mainly glass eels with a standard length of about 7–8 cm and a wet weight of 0.3 g were stocked (Tabel 2). In the years

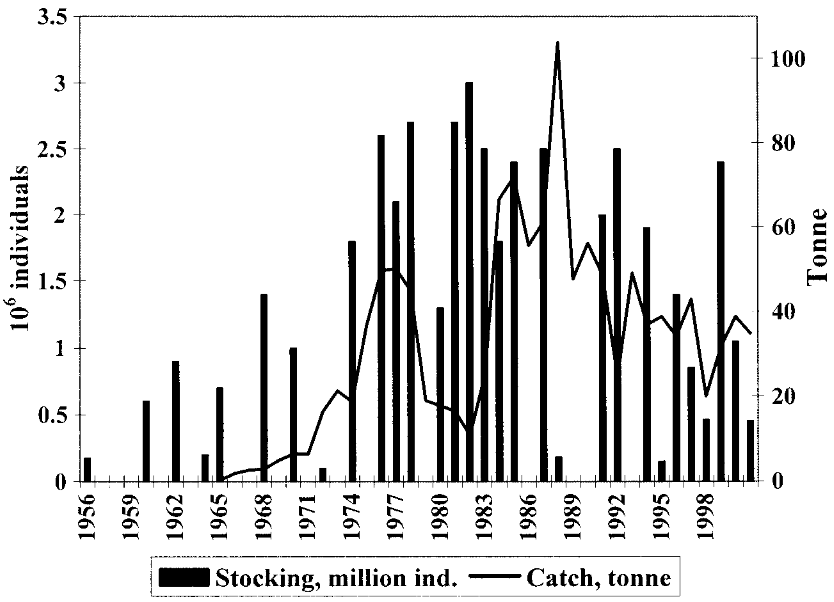

Fig. 3. Stocking and catch of eel in L. Võrtsjärv.

Table 2. Measurements of young eels stocked into L. Võrtsjärv

Time of stocking	Development stage	No. of fish	Tw, g		Author
			Avg	Range	
1995, Oct.	Fingerlings, Sl = 12–25 cm	115	10.22	3.0–13.0	A. Kangur
1997, May	Glass eels	260	0.27	0.13–0.34	A. Kangur
1998, Apr.	Glass eels	181	0.32	0.28–0.34	A. Kangur
1999, May	Glass eels	–	0.26	–	A. Järvalt, pers. comm.
2000, Apr.	Glass eels	241	0.35	0.31–0.55	A. Kangur
2001, March	Fingerlings	–	~ 80	–	A. Järvalt, pers. comm.
2001, Sep.	Fingerlings	–	3.7	–	A. Järvalt, pers. comm.

– No data available.

1988, 1995, and 2001, young eels reared previously in a fish farm (fingerlings) were stocked. In 2001, the stocking rate of these fingerlings was 16.7 ind. ha^{-1}. The fingerlings were reared in indoor recirculating tank systems for different time before stocking into the lake. Therefore their weight was variable (Table 2). The frequency and rate of stocking were changed in recent decades (Table 3). Since 1994 young eels have been stocked every year. However, the stocking rate has been relatively low: annual average in 1956–2001 was about 35 ind. ha^{-1} with a maximum of 84 ind. ha^{-1} in 1980–84.

The peak of stocking with glass eels occurred in the early 1980s (Fig. 3). As a result, during the following five years the catches of eel were the highest,

Table 3. The stocking of glass eels* and yield of eel in L. Võrtsjärv

Years	Frequency of stocking	Stocking rate, ind. ha^{-1} y^{-1}	Catch, kg ha^{-1} y^{-1}	Effectiveness of stocking
1956–59	0.25	1.6	0	–
1960–64	0.60	12.6	0	–
1965–69	0.40	15.6	0.09	132.8
1970–74	0.60	21.5	0.51	30.3
1975–79	0.60	54.8	1.48	14.5
1980–84	1.00	83.7	1.01	54.3
1985–89	0.60	37.6	2.52	33.2
1990–94	0.60	47.4	1.59	23.6
1995–99	1.00	39.0	1.24	38.2
2000–01	1.00	27.7	1.36	28.6
Average	0.64 (in 1956–2001)	35.3 (in 1956–2001)	1.22 (in 1965–2001)	31.8

* In 1988, 1995, and 2001 young eels reared previously in a fish farm were introduced.

Table 4. Relationship between stocking rate and catches of eel registered with a 4–9-year lag

	Lag, years					
	4	5	6	7	8	9
Correlation coefficient, *r*	0.16	0.29	0.41	0.25	0.28	0.18
Significance level, *p*	0.42	0.15	0.03	0.20	0.15	0.38

constituting 2.5 kg ha^{-1} y^{-1} (Table 3). The maximum catch of this fish was recorded in 1988 (104 t or 3.7 kg ha^{-1}). The average annual catch of eel in L. Võrtsjärv constituted 32.8 tonnes (1.2 kg ha^{-1} y^{-1}) in 1965–2001. In 1995–2001, the declared annual catch of eel was on average about 34 tonnes.

A positive relationship was found between the stocking rate and the catches of eel registered in L. Võrtsjärv with a 4–9-year lag. The most significant correlation ($r = 0.41$, $p = 0.03$, $n = 28$) was found between the stocking rate and the annual yield of eel six years later (Table 4).

The number of glass eels (or elvers) required to produce 1 kg of eel catch in L. Võrtsjärv varied with a minimum of 14.5 stocked eels (Table 3). To find out the effect of stocking on catch during the whole period of eel fishery in the lake, young eels introduced into the lake during the last five years (1997–2001) were excluded from analysis because most of them have probably not yet reached legal size. In the stocking practice used for L. Võrtsjärv the average number of glass eels required to produce 1 kg of eel catch (in 1965–2001) was about 32 (Table 3).

Lake Peipsi was stocked with eels only in 1981–82. Then 430 000 specimens were introduced into the lake. As a result, the catches of eel in this lake should be negligible. Most eels caught in L. Peipsi are probably runaways from L. Võrtsjärv. The declared annual catch of eel in L. Peipsi was 218 kg in 2000. According to the information provided by fishermen, the actual catches of eel in this lake are significantly higher.

Growth of eel and composition of eel catches

The growth of eel in L. Võrtsjärv is close to isometric ($b = 3.046$, Fig. 4). Fulton’s condition factor of eel for August–October 1966–2001 varied from 0.128 to 0.283 in the 10–103 cm size range of eel (Fig. 5). The increasing tendency of the condition factor with eel growth is statistically not significant.

The commercial stock of eel in L. Võrtsjärv comprised mainly the length groups of 50–95 cm and the freshwater age groups between 6 and 16 years. According to our measurements, the average weight of eel in commercial catches was 0.903 kg in 1996. It decreased considerably in the following years, being 0.655 kg in 2001 (Table 5).

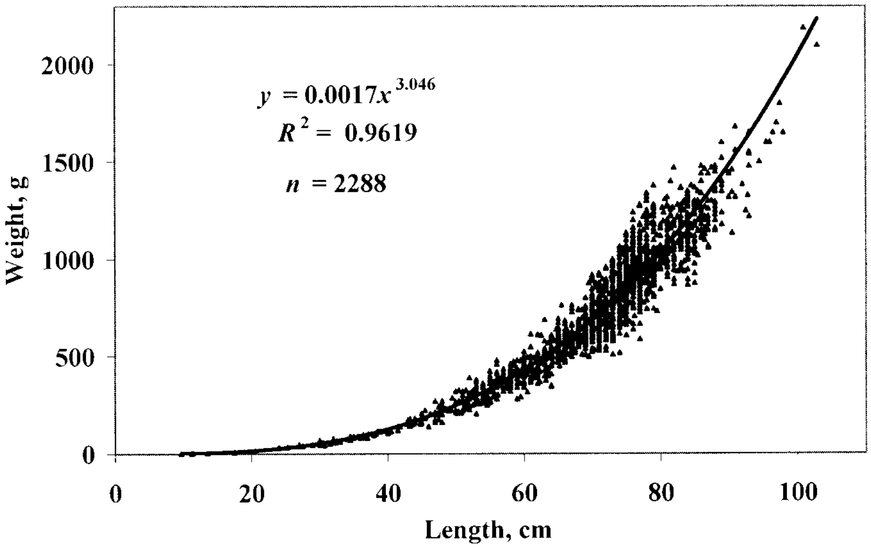

Fig. 4. Length–weight relationship of eel in L. Võrtsjärv in August–October 1966–2001.

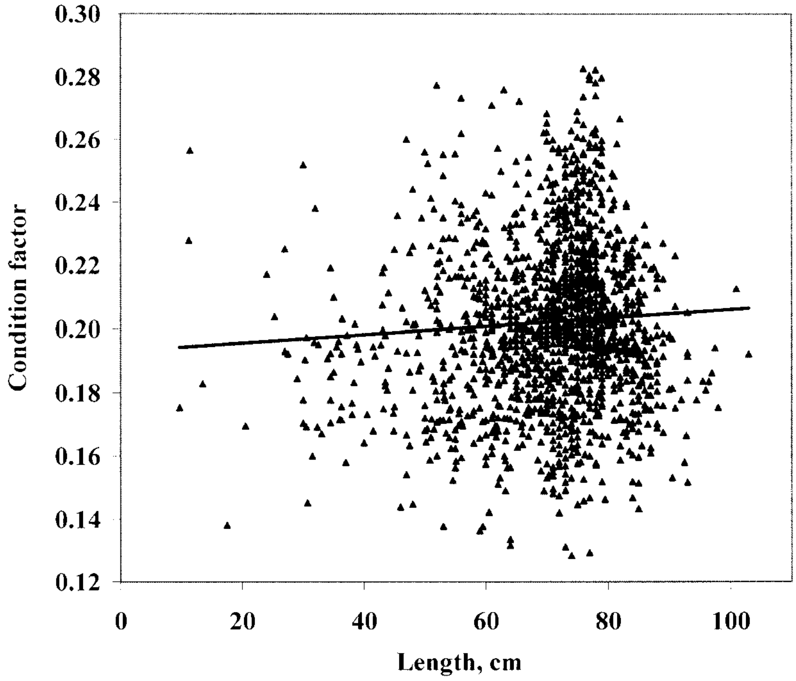

Fig. 5. Relationship between the length and condition factor of eel in L. Võrtsjärv in August–October 1996–2001.

Table 5. Mean weight (± standard error) of eel in commercial catches in L. Võrtsjärv

Year	No. of measured specimens	Mean weight, g
1994	294	638 ± 11
1995	344	806 ± 12
1996	215	903 ± 7
1997	370	792 ± 14
1998	567	708 ± 15
1999	318	610 ± 15
2000	534	599 ± 4
2001	403	655 ± 10

In 1994–98, the median length of captured eels was almost the same, 70–75 cm (Fig. 6). The legal size of eel in large Estonian lakes (L. Võrtsjärv and L. Peipsi) is 55 cm today, while before 1998 it was 60 cm in L. Võrtsjärv. As a response to the reduction of legal size, a decrease in the mean length and median length of eel has been observed in commercial catches. In 1999, the decrease in the median length of eel in commercial catches was especially sharp – 10 cm (Fig. 6).

According to our observations, the proportion of eels under legal size, caught with commercial fishing gear (large fence traps, mesh size 18–22 mm in the cod end), was the largest in 1997–98 – up to 9.3%. During last years the co-catch of

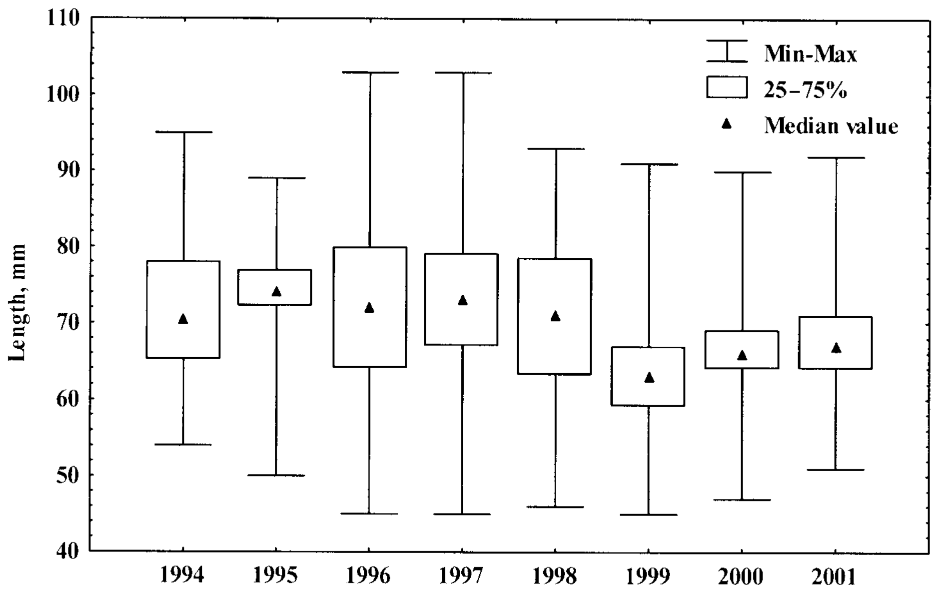

Fig. 6. Length distribution of eels sampled from L. Võrtsjärv using fence traps in August–October 1994–2001.

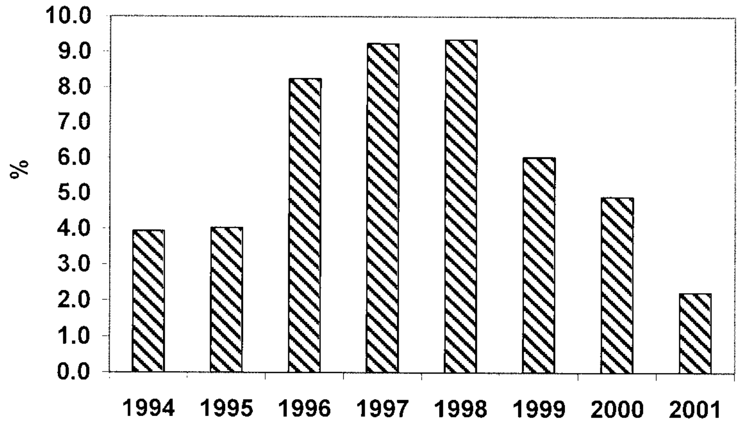

Fig. 7. Percentage of eels under legal size in commercial catches in L. Võrtsjärv in 1994–2001.

small eels has decreased up to 2–3% (Fig. 7). Catches peak at about 60–79 cm, decreasing to nearly zero around 90–95 cm. The proportion of larger specimens in the total catch is negligible.

DISCUSSION

Stocking is often performed to compensate for human disturbance to the environment, which has reduced fish production (Vøllestad & Hesthagen, 2001). Over Europe 25% of the running freshwaters and 4% of the lakes with historical eel populations are believed to be inaccessible due to artificial obstructions (Moriarty & Dekker, 1997). In connection with the damming of the Narva River the stock of eel in the large lakes of the L. Peipsi basin depends entirely on the number of introduced young eels. Hydropower dams obstruct not only the upstream migration of recruits but also the downstream migration of silver eels. Stocking with young eels has been an important aspect of fishery management in L. Võrtsjärv since 1956. As a result of more or less regular stocking, eel has become the most important commercial fish in the lake. Because of the existence of quite a large stock of introduced eels in L. Võrtsjärv, this water body resembles a large eel pond where pikeperch, bream, ruffe, and other fishes can be regarded as additional fishes.

Until the end of the 1980s, the stocking of eel in L. Võrtsjärv was financed by the government. However, after the collapse of the Soviet economic system, stocking has depended solely on fishermen. Stocking has been quite successful economically, since the share of eel accounts for 60–70% of the monetary value of the total catch of fish from this lake (Kangur & Kangur, 1999). The greatest obstacle to the development of eel fishery in the lake is the shortage of glass eels, because the supply of glass eels for stocking purposes has diminished and prices are rising constantly (Kangur, 1998). According to Wickström (2001), both recruitment and stock of the European eel have declined. In continental Europe a drastic decline in recruitment was observed in the early 1980s following large catches in the 1960s and 1970s (Moriarty, 1990).

Investigations of the length distribution of eel captured in L. Võrtsjärv in different years indicated considerable variability, depending largely on the initial number of eel generations stocked in the lake and reflecting differences in legal size. Eel reaches legal size (55 cm today, 60 cm before 1998) usually 5–7 years after stocking in this lake. This is in accordance with our earlier investigations of the growth rate of eel using otoliths in L. Võrtsjärv (Kangur, 1998). Although the individual growth of eel in this lake is quite variable, its average annual growth rate (about 5.9 cm per year during a 16-year life span in the lake) appears to be rather fast in comparison with many other European habitats. From year 2, the mean annual back-calculated increments of length for eel from L. Võrtsjärv (7–8 cm annually) were rather constant until year 7, but decreased for the last years constituting 2–3 cm per year for over 10-year-old specimens (Kangur, 1998).

Ask et al. (1971, cited in Wickström, 1986) reported an annual growth of 5.5–6.1 cm during the first four years for eels from the west coast of Sweden and the Straits of Öresund. For freshwater eels they reported a growth rate of 4.5 cm $year^{-1}$ during the same period. Tesch (1983) stated that the length of female eels in natural waters rarely exceeds 37 cm by the end of their fourth year of life. This means an annual growth of about 7 cm at the most. A better growth of eel was estimated in Lake Neusiedler See (Austria and Hungary): 8 cm annually during the first four to five years after stocking (Hacker & Meisriemler, 1978).

However, age determination of the European eel is well known as problematic, due to widely differing methods for the preparation of the otolith, as well as differences in the interpretation of the otolith by the reader (Moriarty & Steinmetz, 1979). A major problem in the age determination of eels is the formation of supernumerary zones in some otoliths as a consequence of interrupted summer growth, which can lead to faulty age determination (Deelder, 1981).

A considerably high growth rate and good condition of eel in L. Võrtsjärv indicates that this water body is highly suitable for this species. According to Bisgaard & Pedersen (1991), in a Danish stream Fulton's condition factor equalled 0.11 in the size range of eel of 13–31 cm. Similarly to our data for eel from L. Võrtsjärv, Sinha & Jones (1975) observed an isometric growth of this fish from different localities in North Wales and found variations of calculated constant *b* from 2.99 to 3.10.

The length distribution of eel catches is strongly influenced by the age (length) composition of the eel stock in the lake as well as the measurements of the cod end of the fishing gear. The mesh size in the cod end of the commercial fence traps is 18–22 mm (36–44 mm stretched) today in L. Võrtsjärv. Such fishing gear minimizes the co-catch of eels under legal size, selecting fish larger than 50–55 cm.

Depending on the type and selectivity of the fishing gear used in L. Võrtsjärv, eels caught from this lake are larger (usually 60–80 cm) than those caught from some other water bodies in Europe. Besides, the legal size for eel in Estonian large lakes is considerably greater than customary in other European countries. For example, in Danish inland waters the legal size for this fish is 45 cm (Pedersen, 1996). In Lake IJsselmeer (The Netherlands) the minimum legal size of eel is only 28 cm whereas catches peak at about 30 cm and specimens larger than 40 cm are quite rare (Dekker, 1993). The normal length of eel at capture in Poland is 60 cm (Moriarty et al., 1990). In the Shannon River (Ireland) eels larger than 70 cm were also quite rare (McCarthy & Cullen, 2000).

To establish a stable stock of eel in L. Peipsi, regular introduction of glass eels, at least 10 million specimens per year, is indispensable (Pihu & Kangur, 2001). The experience gained on L. Võrtsjärv (Kangur, 1988, 1998) allows us to expect that such annual amount would ensure an eel catch of 370–600 tonnes year^{-1}. The high amount of macrozoobenthos biomass in L. Peipsi (Kangur, 1999) indicates that the rich macrozoobenthos resources of this lake are underconsumed, and there is enough food for eel. As L. Peipsi is a transboundary lake, close collaboration between the Republic of Estonia and the Russian Federation is inevitable to carry out such a costly undertaking as stocking.

It is recommended to stock L. Võrtsjärv with 3 million (more than 100 specimens per ha) of glass eels annually (Kangur, 1998). This is in accordance with the recommendation of Wickström (2001) that 100 elvers should be stocked annually per hectare in Swedish eutrophic lakes.

Actually, the stocking rate of young eels in L. Võrtsjärv has been significantly lower (average about 36 ind. ha^{-1} per year). In recent years young eels reared previously in a fish farm (fingerlings) have been used for stocking in L. Võrtsjärv (about 17 ind. ha^{-1} in 2001). The effect of these stockings can be assessed in some years. Wickström (2001) recommended stocking annually 20 medium-sized yellow eels (fingerlings, *satzaale* in German) per hectare in Swedish eutrophic lakes. According to official statistics, the average catch of eel in L. Võrtsjärv was 1.2 kg ha^{-1}, maximum catch reached 3.7 kg ha^{-1}. As a consequence of low stocking rates, large catches cannot be expected from L. Võrtsjärv.

Moriarty et al. (1990) showed, using multiple correlations, that the level and frequency of stocking are the principal factors determining the variability of eel catches in Polish lakes. Stocking at intervals longer than four years led to reduced catches. The minimum stocking frequency in every fourth year agreed well with the observation that the first effects of stocking frequently appear after five years. In L. Võrtsjärv, irregular stocking (e.g. in the years of the collapse of the Soviet economic system) resulted in smaller catches. In Polish lakes the stocking rate of glass eels was mostly over 100 ind. ha^{-1}, with a maximum of 388 ind. ha^{-1} per year (Moriarty et al., 1990). Eel yield amounted up to 7.5 kg ha^{-1} in these lakes. According to the calculations of Moriarty et al. (1990), the stocking rate of 275 glass eels ha^{-1} is expected to yield maximum catches (5.2 kg ha^{-1}). In 1993 and 1994, yields larger than 5 kg ha^{-1} were attained in a variety of habitats in European water bodies (Moriarty, 1996).

Migration of stocked eel between lakes usually does not allow the use of simple stock and yield calculations (Moriarty et al., 1990). Downstream migration of eel from L. Võrtsjärv via the Emajõgi River supports the fishery of this fish in L. Peipsi. Upstream migration of young eels supports the eel fishery in rivers and small lakes in the basin of L. Võrtsjärv. Probably, increased food competition between eel and indigenous benthophagous fishes, mainly bream and ruffe (Kangur et al., 1999), can encourage stocked eel to seek other waters. This may be one of the main reasons for the low effectiveness of eel stocking in L. Võrtsjärv. Moreover, the feeding areas of benthophagous fishes in L. Võrtsjärv are decreasing due to the expansion of macrophytes in shallow areas.

Under natural conditions, trophic relationships are the most important forcing factors (Biro, 2001). Competition is a significant regulatory mechanism within and between populations regulating their stock size, density, and dynamics. The results of our previous study (Kangur et al., 1999) showed that the diet of the main benthophagous fishes in L. Võrtsjärv overlaps considerably in respect of *Chironomus plumosus* (L.), which may lead to food competition between them. We observed a strong positive correlation ($r = 0.69–0.81$) at a high significance level ($p < 0.01$) between the condition factor of eel and the biomass of the whole group of Chironomidae, particularly *C. plumosus* (Kangur & Kangur, 1998). It can be concluded that the well-being of the eel population in the lake depends largely on the biomass of this chironomid. The mean annual biomass of macrozoobenthos in L. Võrtsjärv (6.7 ± 1.0 g m^{-2} in 1973–2000) is about two times as low as in L. Peipsi (12.7 ± 0.7 g m^{-2} in June 1964–2000, Table 1). The variation of total biomass in both lakes depends mainly on the dominant species of the profundal, *C. plumosus*. In L. Võrtsjärv the biomass of macrozoobenthos is strongly suppressed, especially in summer, by the large number of fishes feeding on benthos. As eel is far more valuable than the other benthophagous fishes occurring in L. Võrtsjärv, it is important to maintain the abundance of bream, and especially that of ruffe, at an acceptable level with the aim to preserve the food supply for eel. In order to relieve food competition it is allowed to reduce the abundance of bream in the lake, and since 1978 this species has been caught without any restrictions.

ACKNOWLEDGEMENTS

The authors are indebted to the Estonian Science Foundation for financial support (grant No. 4986) and to the Estonian Ministry of the Environment for the provision of fisheries statistics. Our sincere thanks are due to all persons who helped us both in field sampling and laboratory analysis. We also thank Mrs. Ester Jaigma for revising the English text and two anonymous reviewers for their valuable suggestions and comments, which improved the paper a great deal. This research was partly supported by Contract No. EVK1-CT-2000-000076 Mantra-East.

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Euroopa angerja (*Anguilla anguilla* (L.)) varu ja saagid Eesti suurjärvedes

Andu Kangur, Peeter Kangur ja Külli Kangur

Angerjas on praegu Võrtsjärves kõige olulisem püügikala tänu noorangerjate enam-vähem regulaarsele sisselaskmisele alates 1956. aastast. Peipsist püütavad angerjad on enamikus Võrtsjärvest sisse rännanud. Sellesse piiriveekogusse angerjate asustamise programmi pole veel aktsepteeritud, ehkki toitu oleks seal angerjale põhjaloomade rikkalike varude näol piisavalt. Töö põhieesmärk oli hinnata Võrtsjärve angerjate asustamise efektiivsust. Angerjate asustusmäära ja -sagedust ning saakide muutusi analüüsiti viieaastaste perioodide kaupa. Paljuaastane keskmine asustusmäär (35 is ha^{-1}, suurim 84 is ha^{-1} 1980.–1984. a) on

madalam optimaalsest, sellega seletuvad suhteliselt väikesed saagid (ametlikel andmetel keskmiselt ligi 1 kg ha^{-1}, suurim 3,7 kg ha^{-1} 1988. a). Ühe kilogrammi saagi saamiseks on Võrtsjärves siiani kulunud keskmiselt 32 klaasangerjat. Asustusmäär ja angerjasaagi suurus kuuendal aastal pärast asustamist olid statistiliselt oluliselt seotud (r = 0,41, p = 0,03, n = 28). Võrtsjärvest püütavad angerjad on suuremad (tavaliselt pikkusega 60–80 cm) kui paljude teiste Euroopa veekogude omad. Võrtsjärve angerjamajanduse edukus sõltub toidukonkurentsist angerja ja kohalike bentofaagide – latika ja kiisa vahel, kes kõik eelistavad toiduks *Chironomus plumosus*'e vastseid ja nukke. Kuna angerjas on hinnalisem püügikala kui latikas või kiisk, on oluline hoida viimaste arvukus madalal tasemel, et säästa toiduvarusid angerjale.