ISSN 1392-1657

ICHTHYOLOGICAL EVALUATION OF FISH PASSES CONSTRUCTED IN LITHUANIA

Valdemaras ŽILIUKAS, Vida ŽILIUKIENĖ

Institute of Ecology, Akademijos 2, 2600 Vilnius, Lithuania

Abstract. The current paper is a survey of fish passes built in Lithuania and a generalisation of the data on their efficiency collected during the period 1998–1999. At the present time, there are 11 fish passes in Lithuania, two of which are fish locks, three pool and orifice fish passes, three pool and weir fish passes, one Denil fish pass and two bay-pass channels. Two fish passes are at a standstill because of some technical faults. Three fish passes operate inefficiently. According to the data collected in 1998–1999, before the reconstruction, Tauragė fish lock provided a passageway for about 9% of vimba and 15% of sea trout, which had gathered at the dam during their spawning migration in autumn. In 1998 about 460 vimba and 220 sea trout ascended upstream through this fish pass, whereas in 1999 their number was 430 and 150 respectively. Through the fish pass of Anykščiai, only local spring spawners can get into their spawning grounds, since migratory fish species (vimba, sea trout, salmon, river lamprey) ascending upstream to spawn are stopped by the Kavarskas dam situated downstream of Anykščiai.
Key words: fish pass, efficiency, migration, species composition, relative abundance, sea trout, vimba

Introduction

Fish passes are one of the necessary conditions allowing migratory fish to use wide natural spawning areas. The first fish passes were designed in Europe almost 300 years ago (Clay 1995). France is the leading European country in the design of fish passes (at least 400 fish passes of different types have been built there during the last 15 years; Turnpenny 1996).

Since many important issues of fish passage around dams have remained unsolved in Lithuania yet, there are only 11 fish passes built on different rivers of the country.

More than 40 years ago, a hydropower dam was built on the Nemunas River, the largest river of Lithuania, near Kaunas. The Kaunas Hydropower Dam caused severe damage to the stocks of valuable migratory fish species, such as salmon, sea trout, vimba and river lamprey. About 50% of natural spawning grounds for salmon and 70% for vimba were lost (Maniukas 1962; Volskis 1969). The Wildlife Support Fund which was established in 1999 initiated the construction of a fish pass at the Kaunas Hydropower Dam, the highest dam in the country measuring 20.5 m.

While carrying out the 1997–2010 restoration and protection program of salmon stocks in Lithuanian waters (Bogdevičius *et al*. 2000), the investigation of the efficiency of fish passes and ichthyological analysis of the equipment under construction were started. In addition, two fish passes were constructed at the dams on the Vilnia River: a Denil fish pass near Rokantiškės and a bay-pass channel near Belmontas. Another reason for the construction and design of new fish passes is an increased number of small hydropower stations built at the already operating dams.

It has been established that the efficiency of fish passes depends upon their type, migrating fish species, environmental conditions and other factors (Katopodis & Rajaratnam 1983). Up till now, the data on the efficiency of fish passes presented in scientific publications have been very scarce (Web 1990; Travade & Larinier 1992; Linokken 1993; Aprahamian *et al*. 1996). The aim of this paper is to overview the fish passes constructed at the dams on Lithuanian rivers and to estimate their efficiency on the basis of research carried out in the period 1998–1999.

Brief characterisation of Lithuanian fish passes

According to their types, the following fish passes are distinguished (Clay 1995; Beach 1984):

- pool and weir fish passes;
- pool and orifice fish passes;
- vertical slots;
- Denil fish passes;

- bay-pass channels;
- fish locks;
- fish elevators.

At the present time, there are 11 fish passes in Lithuania (Table 1). In addition, there are projects to construct fish passes for migrating fish at more than 20 already operating dams.

Fish lock. This system operates on the principles of a lock chamber: the fish is collected in an enclosed area. The surface level of the water is then raised to the top of the dam by adding water. In Lithuania, there are two fish passes of this type: one at the Tauragė dam, the other is situated at the Anykščiai dam.

The fish lock at the Tauragė dam was built in 1980 on the right side of the dam on the Jūra River. The fish lock measures 26 m long and 3 m wide. The height of the lock (at the lower gate) is 6 m. The water yield in the lock chamber depends on how high the gate is raised. It can be regulated within the limits of 1.0–5.8 m^3/s. Inside the lock chamber, there is a movable fish trap. The lift of fish over the dam is regulated manually. Since the year 2000, the fish pass at the Tauragė dam has been under reconstruction.

The fish pass at the Anykščiai dam was built at the right side of the dam on the Šventoji River in 1987. The distance between the lower and upper pools is 33 m. The width of the lock is 8 m. The yield of the water passing through the lock in spring is 7.2–14.4 m^3/s; the water overflows the gate of the upper pool at the height of 0.6–1.0 m. The passage of fish is regulated manually.

Pool and weir fish passes are staircase-like devices made of a series of pools sloping downward from the upper pool to the lower one at a particular angle. The fish ascends upstream jumping over the cross walls from one pool to the next. In Lithuania, there are three fish passes of this type constructed at the dams on the Peteša and Juodė trout streams.

The fish pass on the Peteša stream was built in 1989. It consists of four pools and measures 12 m long and 2 m wide. The slope of the fish pass is 10%.

The fish pass near Kelmytė is also built on the Peteša stream, but several kilometres downstream from the first one. It consists of two elongate pools and a gate. This fish pass measures 6 m long and 0.6 m wide.

The fish pass in Naudžiai consists of eight small pools. It is 7 m long and 0.8 m wide; its slope is 30%.

In *Pool and orifice* fish passes, migrating fish ascends upwards from one pool to another passing through special orifices and notches in the cross walls of the fish pass. The fish passes of this type are built in Agluonėnai, Kertuojai and Strėva.

The fish pass of Agluonėnai built at the dam on the Agluona stream is the longest fish pass of this type in Lithuania. It measures 85 m long and 3.5 m wide. This fish pass consists of 35 pools separated from each other with ferroconcrete cross walls containing orifices measuring 1.0 × 0.4 m.

The fish pass of Kertuoja was constructed at the dam on the rivulet flowing from Kertuojai Lake in 1984 in front of the lock chamber. It measures 26 m long and 3.5 m wide. Inside the fish pass, there are seven ferroconcrete cross walls with orifices.

The fish pass of Strėva is situated in the artificial mouths of the Strėva River near the reversionary channel of the Kruonis Hydroaccumulation Power Station. It consists of seven pools and measures 14 m long.

The *Denil* fish pass is made of a rectangular ferroconcrete gutter with baffles arranged quite close to each other. The current of water in this gutter is very turbulent, so the fish cannot take rest in it. For the fish to rest, there are special pools situated at intervals of 10–12 m for salmon and at intervals of 6–8 m for sea trout and other smaller fish (trout). In Lithuania, a *Denil* fish pass is built only on the Vilnia River near Rokantiškės.

Table 1. List of fish passes constructed in Lithuania.

Locality of the fish pass	Fish pass type	River (length, km)	The distance of the dam from the mouth of the river, km	District
Tauragė dam	Fish lock	Jūra (172)	43.0	Tauragė
Anykščiai dam	Fish lock	Šventoji (246)	86.0	Anykščiai
Agluonėnai dam	Pool and orifice	Agluona (20.4)	11.0	Klaipėda
Kertuojai dam	Pool and orifice	Kertuoja (1.3)	1.3	Molėtai
Strėva dam	Pool and orifice	Strėva (80.5)	0.0	Kaišiadorys
Peteša dam	Pool and weir	Peteša (12.1)	8.0	Vilnius
Kelmytė dam	Pool and weir	Peteša (12.1)	3.2	Vilnius
Naudžiai dam	Pool and weir	Juodė (15.5)	4.5	Vilnius
Rokantiškės dam	Denil	Vilnia (80)	13.0	Vilnius
Belmontas dam	Bay-pass channel	Vilnia (80)	11.8	Vilnius
Valtūnai dam	Bay-pass channel	Siesartis (75.6)	9.2	Ukmergė

Its exploitation was started in 1998. The fish pass measures 30 m long, 1 m wide and 1.5 m high, with the slope of 20%. There is 31 baffle installed in the fish pass; in the middle of the fish pass, there is a pool measuring 3 m long and allowing resting opportunities for the migrating fish. The velocity of flow in the fish pass depends on the water level and varies within the range of 1.18–1.29 m/s; the average depth of the gutter is about 0.7 m.

The *Bay-pass channel* fish pass is composed of the artificial stone spillways divided into separate pools installed in the bay-pass channel. The slope of a fish pass of this type varies from 4% to 10%. Fish passes of this type are popular in Denmark. In Lithuania, there are only two bay-pass channels built in Belmontas and near Valtūnai (the latter is under construction).

The Belmontas fish pass is located on the Vilnia River, at the lateral watercourse on the right side of the dam. It is made of nine spillways, situated at the intervals of 4 m. This fish pass measures 41 m long; its width at the level of normally affluent water is 3 m. The minimum water level in the gutter is 0.6 m; the average speed of the water current is 0.35 m/s. The ecological water yield is 1.91 m^3/s; the maximum water yield of the fish pass is 3.48 m^3/s.

The Valtūnai fish pass is at the final stage of construction. It is situated neat the right bank of the Siesartis River near a small hydropower station. It measures about 40 m long and 4 m wide.

Fish elevators operate on the principles of an elevator. The downstream fish are attracted by the water flow to a cage-trap containing a small pool. Then the cage-trap is raised to the top of the dam and the fish are released into the upper reservoir. Such fish elevators are usually built at high dams. In Lithuania, a fish elevator would be constructed at the Kaunas Hydropower Dam.

Material and methods

We investigated the efficiency of the Lithuanian fish passes in the period 1998–1999. The fish passes were estimated on the basis of the following criteria: their technical state, exploitation, rate of the water flow, water level, water temperature, limpidity, data of experimental fishing and the intensity of fish jumping.

We focused on the fish pass at the Tauragė dam on the Jūra River in order to compare its efficiency before and after its reconstruction. The investigation was carried out during the seasonal spawning migration of fish.

In the Jūra River, the fish were caught experimentally with bottom gill nets, the meshes of which measured 25, 45 and 70 mm in mesh size and with the beach seine in the lower pool of the Tauragė dam, the fish were caught with a bottom gill net, the meshes of which measured 45 and 70 mm in mesh size, and with a cage-trap in the fish pass itself. In the Agluona River fish were caught with electrofishing gear.

In order to establish the number of migrating fish in the lower pool of the Tauragė dam, we applied the area method widely used in ichthyology. The estimations were done on the basis of the data obtained during the experimental fishing and applying the following formula (Lapitsky 1967):

$$N_S = \frac{S \times n}{s \times K_f}, \text{ where}$$

N_S is the total number of fish in the lower pool of the dam;
S is the area of the lower pool of the dam;
n is the number of caught fish;
s is the fishing area;
K_f is the coefficient of the fishing efficiency.

In addition, on the basis of the data on the jumping intensity of sea trout and vimba, the number of migrating fish in the lower pool of the Tauragė dam was established according to the following formula:

$$N_S = \frac{n_j}{K_j}, \text{ where}$$

N_S is the total number of fish in the lower pool of the dam;
n_j is the number of jumping fish counted in the period of 10 min;
K_j is the coefficient of the fish jumping intensity.

To establish the number of fish transferred over the dam per day, the following formula was applied:

$$N_d = P \times (N_S \times K_e), \text{ where}$$

N_d is the number of fish transferred over the dam per day;
P is the number of tranfers per day;
N_S is the total number of fish in the lower pool of the dam;
K_e is the efficiency coefficient of fish entrance into the fish pass.

Results and discussion

Fish locks

Tauragė. The fish lock at the Tauragė dam provides an upstream passageway for the migratory fish (salmon, sea trout, vimba and river lamprey) to the upper pool of the dam.

In 1998–1999, in the Jūra River below the Tauragė dam, 18 fish species belonging to six families were found:

I. Petromyzontidae
1. *Lampetra fluviatilis* (L.) River lamprey

II. Salmonidae
2. *Salmo trutta trutta* L. Sea trout

III. Esocidae
3. *Esox lucius* L. Pike

IV. Cyprinidae
4. *Rutilus rutilus* (L.) European roach
5. *Leuciscus cephalus* (L.) Chub
6. *Leuciscus leuciscus* (L.) Dace
7. *Leuciscus idus* (L.) Ide
8. *Aspius aspius* (L.) Asp
9. *Gobio gobio* (L.) Gudgeon
10. *Alburnus alburnus* (L.) Bleak
11. *Blicca bjoerkna* (L.) Silver bream
12. *Abramis brama* (L.) Bream
13. *Vimba vimba* (L.) Vimba
14. *Pelecus cultratus* (L.) Chekhon
15. *Rhodeus sericeus amarus* (Bloch.) European bitterling

V. Percidae
16. *Stizostedion lucioperca* (L.) Pike-perch
17. *Gymnocephalus cernuus* (L.) Ruff

VI. Gasterosteidae
18. *Gasterosteus aculeatus* L. Three-spined stickleback

During the experimental fishing with bottom gill nets in the lower pool of the Tauragė dam in August–October of 1998–1999, six fish species (among them vimba and sea trout) were caught (Fig. 1). In the middle of September 1998, the biggest catches were those of vimba and sea trout (58% and 21% according to their abundance and 32% and 51% according to their biomass respectively). In the catches of the end of August 1999, roach prevailed. They made 43% of the total number of all the caught fish. At the end of September and in the middle of October, the most numerous fish in the catches were vimba (75% and 94% according to the abundace and 76% and 94% according to the biomass respectively). The relative abundance of sea trout in the catches did not exceed 29%.

To estimate the intensity of migration of migratory fish, additional ichthyological research was conducted in the Jūra River at its confluence with the Nemunas River in 1999. The species diversity of fish caught with bottom gill nets was much greater in spring than in autumn (Fig. 2). At the end of May, 11 fish species were registered in the catches. According to abundance, bream, silver bream and roach (they made 69% of the total number of the caught fish) prevailed, whereas according to the biomass, bream, pike-perch and pike were prevalent (about 72% of the total biomass of the caught fish). At the beginning of September, only five fish species were caught. According to abundance and biomass, roach and bream were prevalent species in the catches (they made 86% and 89% respectively). According to abundance, vimba did not exceed 2% in the catches of fish in the Jūra River at its confluence with the Nemunas River at the end of May and at the beginning of September 1999, whereas according to the biomass it made 3%.

Biological characteristics of fish caught in the Jūra River downstream of the Tauragė dam in 1998–1999 are presented in Table 2.

In autumn, in addition to experimental fishing, we also observed the jumping intensity of migrating fish near

Table 2. Biological characteristics of some fish caught in the Jūra River downstream of the Tauragė dam.

Fish species	Length (L), cm		Weight, g		n
	range	average	range	average	
Vimba	28.0–39.0	32.1	206.0–615.0	339.9	72
European roach	23.5–36.0	29.6	220.0–768.0	401.6	50
Bream	27.0–50.0	39.3	250.0–1512.0	740.1	39
Silver bream	25.0–32.5	28.1	193.0–450.0	287.2	14
River lamprey	28.0–35.0	30.9	39.0–81.0	60.9	10
Chub	23.0–39.5	33.0	274.0–748.0	559.1	9
Perch	29.5–35.5	32.0	337.0–600.0	447.3	9
Sea trout	49.0–81.0	60.9	1190.0–6120.0	2844.0	8
Pike-perch	53.0–64.0	60.2	1333.0–2601.0	2164.8	5
Ide	30.0–37.0	32.7	440.0–719.0	521.0	4
Pike	40.0–84.0	52.5	325.0–4393.0	1506.5	4
Asp		43.0		590.0	1
Chekhon		42.0		544.0	1

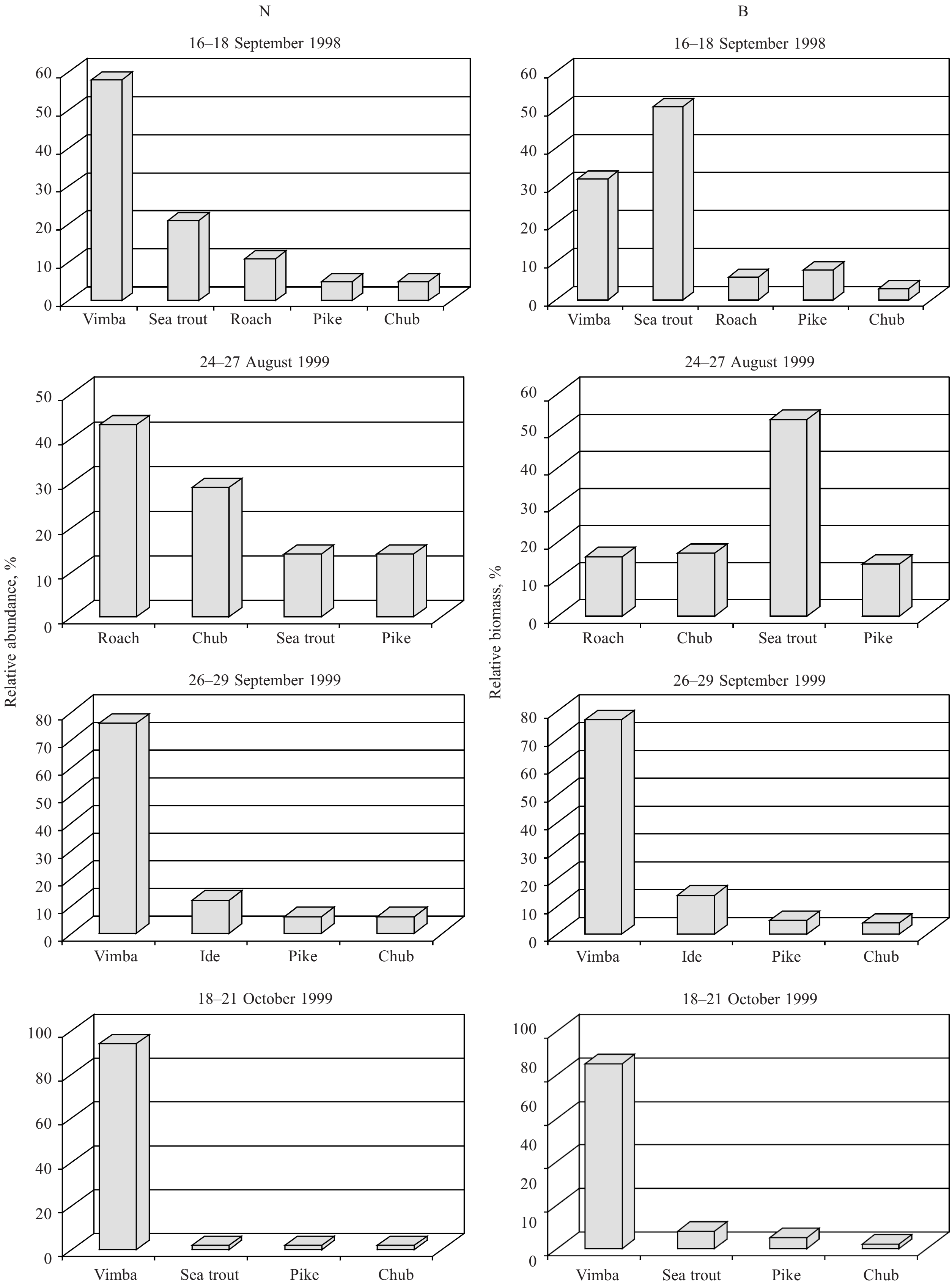

Figure 1. Relative abundance (N, %) and biomass (B, %) of different fish species in the lower pool of the Tauragė dam on the Jūra River in 1998–1999 (the fish were caught with bottom gill nets).

the Tauragė dam. Our research data revealed that the jumping intensity of migrating fish is directly connected to the number of fish gathered at the dam. It has been established that the number of sea trout jumping from the water in the period of 10 min makes about 46% of their total number at the dam, whereas the number of jumping vimba makes 22%. Thus, the coefficient of the fish jumping intensity (K_j) for sea trout is equal to 0.46 and for vimba to 0.22. The values of these coefficients are only orientational and are applied only during spawning migration of fish in autumn. In future, after having acquired more data, the values of these coefficients should be revised.

It should be noted that most of the sea trout and vimba try to ascend over the dam upstream by day. The jumping dynamics of these fish on 29 September is shown in Fig. 3. This figure shows that sea trout and vimba jump from the water most actively at 13 or 15 p.m. The data we received on other days were analogous.

In September 1998, in the lower pool of the Tauragė dam, the temperature of water varied from 11°C to 14°C; the limpidity of water was from 30 cm to 140 cm; and the level of water near the fish pass varied from 150 cm to 260 cm. The highest concentration of migrating fish near the dam was observed in the third ten-day period of September (72 jumping sea trout and up to 270 jumping vimba) when the temperature of water was 12.5–13.2°C, the level of water near the fish pass was 1.6–2 m; the limpidity was about 30 cm.

In October 1998, the temperature of water dropped to 7.5–9.5°C. The water level during the first ten-day period of that month was rather low, only 130–150 cm. However, during the second ten-day period of October, it rose to 220–300 cm. The limpidity of water varied

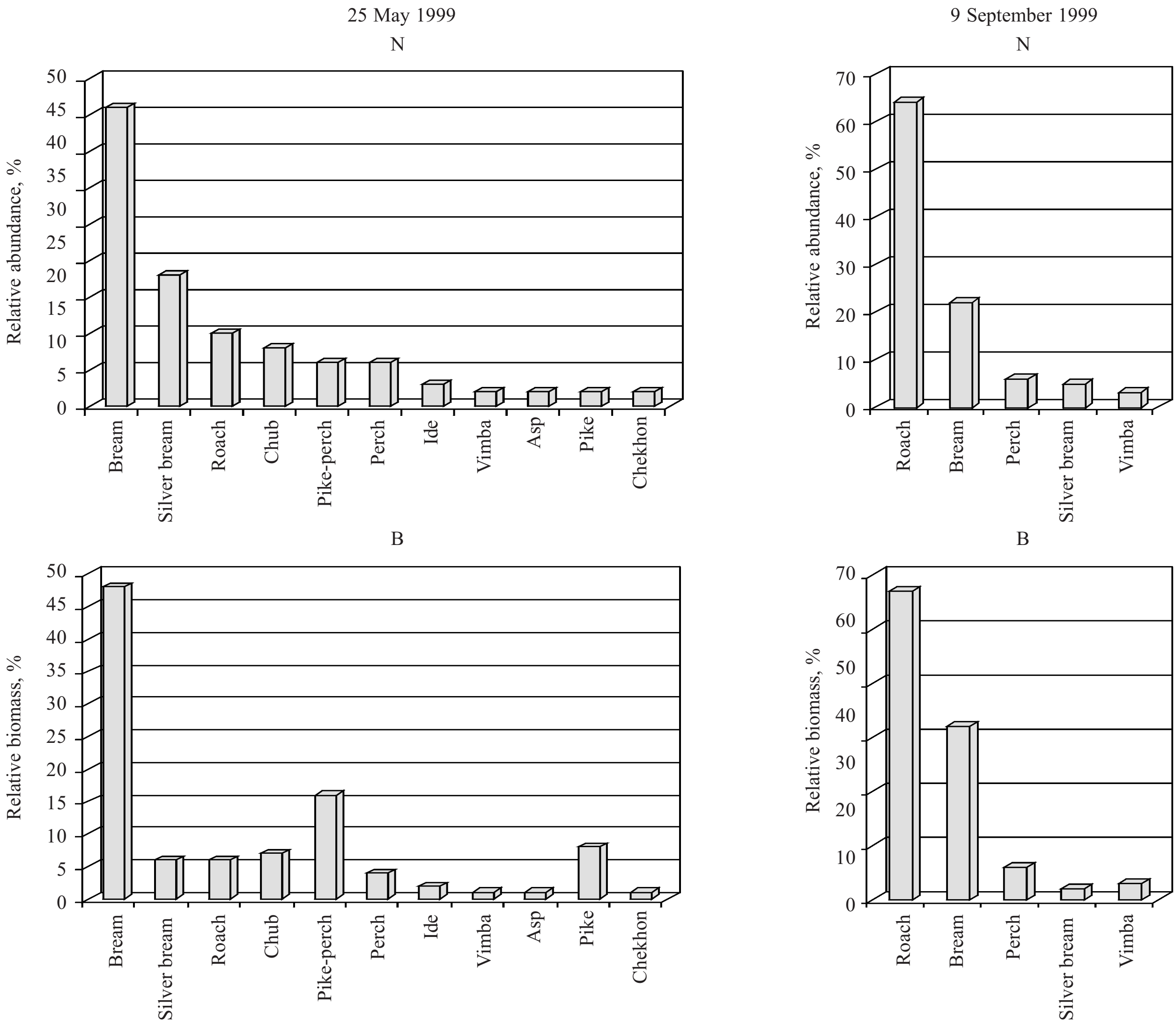

Figure 2. Relative abundance (N, %) and biomass (B, %) of different fish species in the Jūra River at its confluence with the Nemunas River (the fish were caught with bottom gill nets).

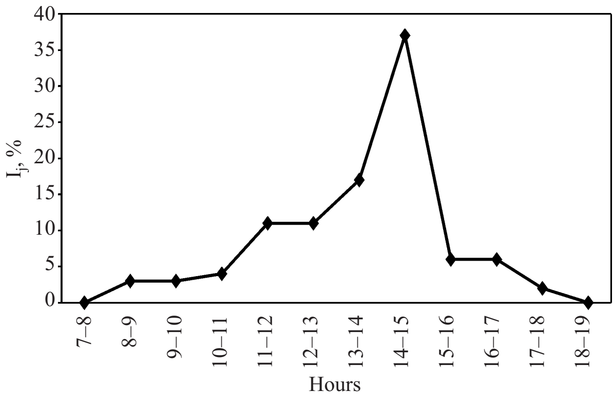

Figure 3. The intensity of jumping dynamics (I_j, %) of sea trout and vimba by day near the Tauragė dam on 29 September 1999.

from 80 to 135 cm. The intensity of fish jumping was much lower than in September (for sea trout, it was 24 ind/h, for vimba, 60 ind/h). The dynamics of water temperature, water level and the intensity of fish jumping during different months are shown in Figs 4 and 5.

Figure 4 shows that in September 1999 the temperature of water was by 3.8°C higher and the level of water was by 0.6 m lower than in 1998. Due to the above-mentioned factors, abundant aquatic vegetation has thriven in the Jūra River. Such unfavourable conditions slowed down the migration of migratory fish species in 1999. Judging by the jumping intensity of vimba and sea trout (Fig. 5), their concentration at the Tauragė dam was much lower in 1999 than in 1998.

In October 1999, the number of migrating fish increased

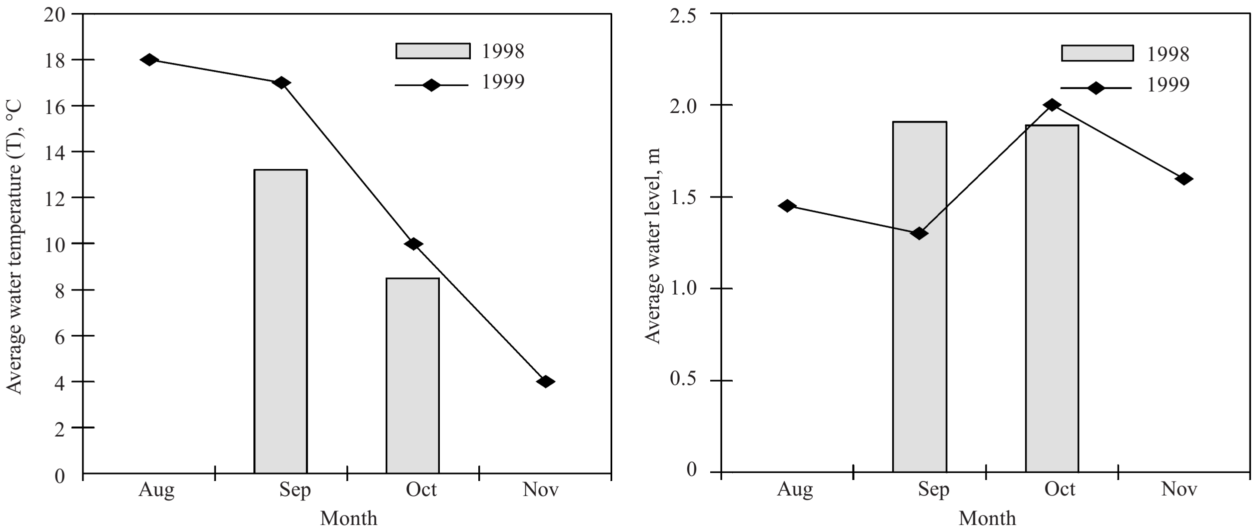

Figure 4. Average water temperature and water level near the fish pass of the Jūra River during the spawning migration of fish in 1998–1999.

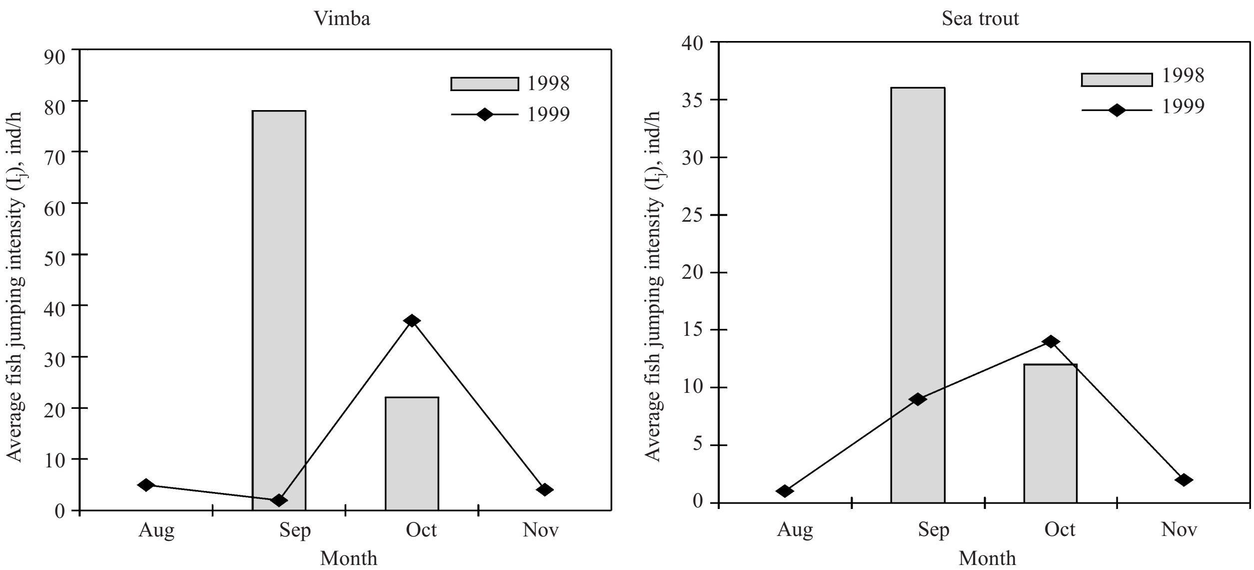

Figure 5. Dynamics of the jumping intensity of vimba and sea trout (I_j) near the Tauragė dam.

in the Jūra River due to the drop in water temperature and to the rise of the water level. The jumping of sea trout and vimba intensified during that month, but it was less intensive than in 1998 (Fig. 5). The biggest experimental catches of vimba and sea trout in the lower pool of the Tauragė dam also occurred in October.

On the basis of the data obtained during the fishing with bottom gill nets in the lower pool of the Tauragė dam (before its reconstruction) and with the cage inside the fish pass, it was established that the percentage of sea trout and vimba, which got into the fish pass when the cycle of attraction lasted for 1 h, made 18% and 11% respectively of their total number at the dam, i.e. the efficiency coefficient of their entrance (K_e) into the fish pass made 0.18 and 0.11 respectively.

Thus, the data on the intensity of fish jumping and the experimental catches show that the highest concentrations of migrating vimba and sea trout near the Tauragė dam occurred in the third ten-day period of September 1998 and in the second ten-day period of October 1999.

On the basis of calculations carried out applying the above-presented formulas, it was established that about 7,000 vimba and 2,000 sea trout gathered at the Tauragė dam during their spawning migration in the autumn of 1998. From the middle of September till the middle of October, about 460 vimba and 220 sea trout were transferred through the Tauragė fish lock over the dam to their upstream spawning areas (Fig. 6).

Due to the unfavourable conditions for migration, which had formed in the Jūra River in the autumn of 1999, according to our calculation, only 3,900 vimba and about 800 sea trout arrived to the Tauragė dam. From the end of September till the beginning of November 1999, about 430 vimba and 150 sea trout were provided a passageway over the dam to their upstream spawning areas (Fig. 6).

In 1998–1999, depending on the intensity of fish jumping, about 11 transfers of fish over the dam upstream were carried out a day. When vimba and sea trout stopped jumping, their transfer over the dam upstream was stopped. Until the reconstruction, the Tauragė fish pass provided a passageway for about 9% of vimba and 15% of sea trout, which had gathered at the dam, to their upstream spawning areas.

Anykščiai fish pass. According to ichthyological research carried out in previous years (Žiliukas & Žiliukienė 1996), there are 22 species of fish dwelling in the Šventoji River near Anykščiai. Before the river had been dammed up, the prevalent fish species in its littoral-zone were three-spined stickleback, gudgeon and chub. After the dam had been built on the Šventoji River above Anykščiai, such fish species as riffle minnow and asp disappeared in the 2-km long water stretch. The decline in number of such fish as gudgeon and minnow was also observed. According to the research data collected in 1993–1995, the main ichthyomass in the Anykščiai reservoir consists of roach, bream, pike, ide and perch (both according to the biomass and abundance). In the juvenile fish community of the littoral zone of the reservoir, the three-spined stickleback, chub and dace are prevalent.

The way of migrating fish (sea trout, vimba, salmon and river lamprey) to their spawning grounds up the Šventoji River is obstructed by the dam built downstream of Anykščiai near Kavarskas in 1963. Thus, the

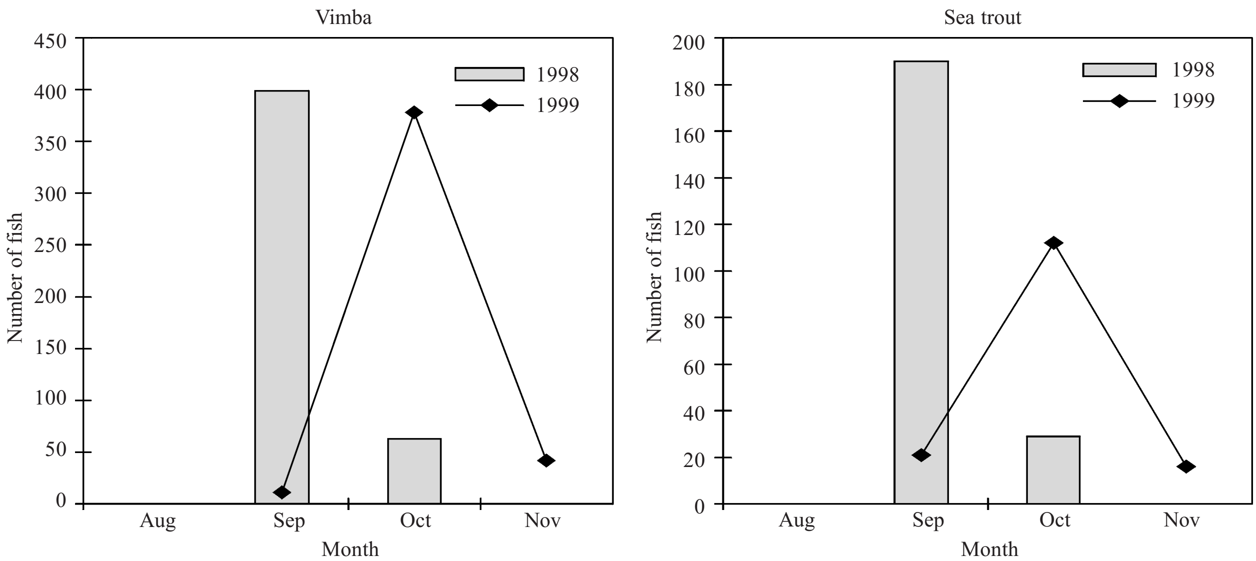

Figure 6. Number of vimba and sea trout transferred through the Tauragė fish pass during the spawning migration of 1998–1999.

fish pass of Anykščiai is mostly used by the local fish species, such as roach, dace, chub, perch and pike, which spawn in spring. It is also used by eel, the only catadromic migrant. During the spawning migration, from four to six transfers of fish are carried out.

It should be noted that in Anykščiai reservoir and in the Jara River, which falls into the Šventoji River 37 km upstream of it, vimba were found. Thus, before the dam near Kavarskas was built, vimba ascended the Šventoji River to their spawning areas located upstream from Anykščiai town. The remaining vimba have formed a small local population.

According to its hydrotechnical-hydrological characteristics, the Anykščiai fish pass meets the main requirements applied to fish locks. In addition, it is 2.7 times broader than the Tauragė fish pass. However, for the Anykščiai fish pass to operate efficiently, one more fish pass should be built near the Kavarskas dam situated downstream of it.

One of the disadvantages of fish locks is the discontinuity of their work cycle. The migrating fish cannot get into the fish pass when the lock is being filled with water and during the phase when the fish leave the lock. In addition, as the automatic control is absent, the number of transferred fish depends not only on the objective, but also on the subjective factors.

Pool and orifice fish passes

Agluonėnai fish pass. This fish pass provides a passageway for migrating Salmonidae fish to their spawning grounds in the upper reaches of the Agluona River. In 1996, the density of Salmonidae juveniles in the Agluona River upstream of the fish pass was 1,500 ind/ha. Sea trout made about 60% of these fish (Kontautas *et al*. 1998). According to the published data, after the fish pass had been built on the Agluona River, the density of sea trout juveniles increased from 737 to 1,493 ind/ha (Kesminas *et al*. 2000).

At the end of October 1999, no Salmonidae fish were found in the Agluona River downstream of the fish pass and in the fish pass itself during the experimental catching. We assume that when the water level is high, the fish ascend the fish pass upstream at once.

The efficiency of the Agluona fish pass greatly depends on the water yield. When the water level in the fish pass is low (lower than 36 cm), large fish cannot use this passageway (Račiūnas 1995). In order to increase the efficiency of the fish pass, it is necessary to install a valve for the regulation of water yield in the water release shaft.

Kertuojai fish pass. This fish pass was built to facilitate spring migration of local lake-dwelling fish species (roach, perch, bream and pike). In the lock, there is no shield and mechanisms of its control installed. Thus, due to the rapid flow, fish are unable to pass through this fish pass. We are of the opinion that it was unnecessary to build a fish pass on this stream connecting two lakes and measuring 1.3 km.

Strėva fish pass. There was no migration of fish observed from the Kaunas reservoir through the fish pass built on the Strėva River. These observations were confirmed by the local fishermen as well. Thus, we may conclude that this fish pass is inefficient. Such inefficiency results from the perpendicular position of the fish pass with respect to the reversible canal.

Pool and weir fish passes

Peteša, Kelmytė and Naudžiai fish passes. These fish passes were built for the salmon-trout migrating to their natural spawning areas in the Peteša and Juodė Streams. The Peteša and Kelmytė fish passes are inoperative now due to some technical faults. Since the difference in height among the pools is too great and the slope of the fish pass itself is too high, many fish species cannot ascend the Naudžiai fish pass upstream. In order to make the Naudžiai fish pass more efficient, it is necessary to elongate this fish pass and to install pools providing resting opportunities for salmon-trout in it.

Pool fish passes are widely used in many countries of the world. They are considered to be among the most efficient fish passage systems and can be applied for many migratory fish species. The designers of pool fish passes should take into consideration the fact that fish passes must efficiently allow to get through all migratory fish. For instance, for the Cyprinidae fish to ascend upstream, the difference in height among pools should not exceed 30 cm (Larinier 1992). The efficiency of these fish passes for salmons may reach 80% (Webb 1990).

Denil fish pass

Rokantiškės fish pass. The characteristic feature of this fish pass is relatively high selectivity, i.e. it is suitable for those Salmonidae fish which are rapid swimmers and are able to stay in a very rapid current of water for a long time. This is a characteristic feature of all Denil fish passes. They are applied when the fluctuation of the water level of the upper pool is very insignificant. In the Rokantiškės fish pass, this condition is preserved, as it is possible to regulate the water level in the pool with the help of shields.

Bay-pass channel fish passes

Belmontas and Valtūnai fish passes. These fish passes correspond ecological conditions which are necessary for the migration of Salmonidae fish and vimba. In addition, bay-pass channels efficiently allow other rheophilous fish species to migrate.

Conclusions

At present, there are 11 fish passes built in Lithuania (two fish locks, three pool and weir fish passes, three pool and orifice fish passes, one Denil fish pass, and two bay-pass channels). The Peteša and Kelmytė fish passes do not operate due to some technical faults. The Kertuojai, Strėva and Naudžiai fish passes are inefficient and should be reconstructed, except the Kertuojai fish pass.

The Anykščiai fish pass is suitable only for local fish species (roach, dace, chub, perch, pike) spawning in spring since the Kavarskas dam downstream obstructs the way of migratory fish (vimba, sea trout, salmon and river lamprey) ascending upstream the Šventoji River to their spawning areas. Thus, to facilitate the ascending of migratory fish upstream to their spawning areas, one more fish pass near Kavarskas should be built.

Studies carried out near Tauragė dam during the spawning migration of migratory fish in autumn revealed that in 1998 the highest concentration of vimba and sea trout was registered in the third ten-day period of September, whereas in 1999, their highest concentration was observed in the second ten-day period of October. In 1998, the number of vimba near the Tauragė dam was about 7,000, whereas the number of sea trout was about 2,000. Due to the unfavourable weather conditions of the autumn of 1999, the number of migratory fish near the dam was much lower: only about 3,900 vimba and 800 sea trout.

Most of the vimba and sea trout try to pass the Tauragė dam by day from 13 p.m. till 15 p.m. It was established that the number of sea trout jumping from the water in the period of 10 min made about 46% of their total number present near the dam, whereas vimba made only 22%. These values are only orientational and are applied only during the spawning migration of fish in autumn. In future, after having acquired more data, they could be made more precise.

According to the data collected in 1998–1999, at least 11% of vimba and 18% of sea trout were transferred through the Tauragė fish lock above the dam at one time during their spawning migration in autumn. From the middle of September till the middle of October of 1998, about 460 vimba and 220 sea trout ascended upstream through this fish pass, whereas from the end of September till the beginning of November of 1999, their number was 430 and 150 respectively.

Acknowledgements

We thank the Lithuanian Ministry of Environment for providing us the possibility to investigate the efficiency of fish passes built in Lithuania. We also thank the head of the Tauragė district agency at the Klaipėda region department of the Ministry of Environment, R. Jurgelionis and inspector J. Krakis for their help while carrying out scientific experiments in the Jūra River at the Tauragė dam.

References

Aprahamian, M.W., Wyatt, R.J. and Gough, P.J. 1996. Monitoring the performance of a fish pass. *Fish pass technology training course*. Dorset.

Beach, M.H. 1984. Fish pass design – criteria for the design and approval of fish passes and other structures to facilitate the passage of migratory fish in rivers. *Fisheries research technical report* 78: 46.

Bogdevičius, R., Greičiūnas, V. and Kesminas, V. 2000. Restoration and protection of salmon stocks in Lithuania. *The salmon of the Baltic Sea in Lithuania*. Vilnius: Aldorija (in Lithuanian).

Clay, C.H. 1995. *Design of fish passes and other facilities*. London: Lewis Publishers.

Cowx, I.G. and Welcomme, R.L. (eds) 1998. *Rehabilitation of rivers for fish*. Oxford: Fishing News Books.

Katopodis, C. and Rajaratnam, N. 1983. A review and laboratory study of hydraulics of Denil fish passes. *Canadian technical report of fishery and aquatic science* 1145: 181.

Kontautas, A., Sodeikis, S., Matiukas, K. and Jankauskienė, R. 1998. Density of salmon and sea trout juveniles in Lithuanian rivers in 1996. *Fishery in Lithuania* III (2): 61–68 (in Lithuanian).

Kesminas, V., Kontautas, A., Virbickas, T., and Stakėnas, S. 2000. Monitoring of Salmonidae juveniles. *The Baltic salmon in Lithuania*. Vilnius: Petro ofsetas (in Lithuanian).

Lapitsky, I. 1967. Method of the fish counting in the Tsimlyansk reservoir. *Works of State Research Institute of fishery in lakes and rivers of Volgograd depart-*

ment III: 117–130. [Лапицкий, И.И. 1967. Метод учета численности рыб в Цимлянском водохранилище]. *Труды Волгоградского отделения ГосНИОРХ* III: 117–130.

Larinier, M. 1992. Pool and weir fish passes and artificial channels. *French journal of fishing and fish breeding* 326–327: 45–72 (in French).

Linokken, A. 1993. Efficiency of fish passs and impact of dams on the migration of grayling and brown trout in the Glomma river system southeastern Norway. *Regulated Rivers*: *Research and Management* 8: 145–153.

Maniukas, J. 1962. Materials on the investigation of ichthyofauna in the Nemunas River. *Hydrobiological investigation* III: 206–213 (in Russian).

Porcher, J.P. and Travade, F. 1992. Fish passage facilities: biological basis, limits and legal considerations. *French journal of fishing and fish breeding* 326–327: 1–11 (in French).

Račiūnas, L. 1995. Record of fish passing through the fish passes. *Scientific report*. Vilnius (in Lithuanian).

Travade, F. and Larinier, M. 1992. Inspection techniques for fish passes. *French journal of fishing and fish breeding* 326–327: 142–154 (in French).

Turnpenny, A.W. 1996. Report on the Vienna 1996 conference on fish migrations and fish bay-pass channels. *Fish pass technology training course* 37–40.

Volskis, R. 1969. *Vimba*. Vilnius: Mintis (in Lithuanian).

Webb, J. 1990. The behaviour of adult Atlantic salmon ascending the Rivers Tay and Tummel to Pitlochry dam. *Scottish fisheries research report* 48: 27.

Žiliukas, V. and Žiliukienė, V. 1996. Ichthyofauna formation in Anykščiai water reservoir. *Fishery in Lithuania* II: 259–268 (in Lithuanian).

Lietuvoje pastatytų žuvų pralaidų įvertinimas ichtiologiniu aspektu

V. Žiliukas, V. Žiliukienė

Santrauka

Darbe pateikiama Lietuvoje pastatytų žuvų pralaidų apžvalga, bei apibendrinami 1998–1999 m. tyrimų duomenys, leidžiantys įvertinti kai kurių jų efektyvumą. Dabartiniu metu Lietuvoje yra pastatyta 11 žuvų pralaidų, iš kurių: 2 šliuzo, 3 baseinėlių su vientisomis pertvarėlėmis, 3 baseinėlių su išpjovomis pertvarėlėse, 1 Denil, 2 apėjimo kanalo tipo. Petešos ir Kelmytės žuvų pralaidos dėl techninių kliūčių nefunkcionuoja, o Kertuojų, Strėvos ir Naudžių – veikia neefektyviai. Ateityje minėtas žuvų pralaidas, išskyrus Kertuojų, reikėtų rekonstruoti. Anykščių žuvų pralaida perkeliamos tik vietinės pavasarį neršiančios rūšys, kadangi Šventąja aukštyn į nerštavietes migruojančioms žuvims (žiobriui, šlakiui, lašišai, upinei nėgei) kelią pastoja žemiau esanti Kavarsko užtvanka. 1998–1999 m. tyrimų duomenimis Tauragės šliuzo tipo žuvų pralaida iki rekonstrukcijos rudeninės migracijos metu per vieną kartą buvo perkeliama 11% žiobrių ir 18% šlakių, atplaukusių prie užtvankos. 1998 m. nuo rugsėjo iki spalio vidurio iš viso perkelta apie 460 žiobrių ir 220 šlakių; 1999 m. nuo rugsėjo pabaigos iki lapkričio pradžios – apie 430 žiobrių ir 150 šlakių.

Received: 15 October, 2001
Accepted: 01 March, 2002