Arch. Pol. Fish. (2011) 19: 3-11
DOI 10.2478/v10086-011-0001-z

RESEARCH ARTICLE

A radio telemetry study of sea trout *Salmo trutta* L. spawning migration in the Łeba River (northern Poland)

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Received – 15 February 2011/Accepted – 24 March 2011. Published online: 30 March 2011; ©Inland Fisheries Institute in Olsztyn, Poland

Abstract. Large areas of the Łeba River catchment are inaccessible for fish because of barriers, and this reduces significantly their spawning possibilities. The sea trout *Salmo trutta* L. population in the Łeba River is sustained through compensatory stocking with smolts. In the autumn of 2007 and 2008, seventy two sea trout were caught in a lake, through which the river flows, several kilometers upstream from its mouth. These individuals were tagged with radio transmitters that were recorded by two automatic stations in the river. They were also monitored with active telemetry. Only 26 of these fish moved upstream (41% in 2007 and 33% in 2008), and five reached the spawning grounds. Neither the release location in the lake nor the size of the fish influenced the timing of the fish entering the river or the extent of their migration. Among the fish originated from smolt stocked in the river segment below the lake, 24% continued to migrate and entered the river after approximately 5.7 days, as compared to 45% of the wild fish entering the river after approximately 2.3 days. Most of the stocked fish remained in the lower reaches of the river, upstream from the lake.

Keywords: hatchery-reared, radiotelemetry, *Salmo trutta,* spawning migration

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Introduction

Several small rivers flow from the moraine hills of northern Poland into the southern Baltic Sea. The character, gradient, and thermal regime of these rivers are advantageous for salmonid fish spawning so they all had populations of sea trout *Salmo trutta* L., and some even had populations of salmon *Salmo salar* L. (Bartel 1988, 2001). Beginning in the early twentieth century, hydroelectric plants were constructed on nearly all of these rivers, which limited access to the upper river catchment area and most of the spawning grounds. Salmon populations became extinct because of barriers, increasing water pollution, and increased fishing pressure in the Baltic Sea (Bartel 2001).

The negative effect of barriers, even those equipped with fish passes, is well reported (Webb 1990, Aarestrup and Jepsen 1998, Linnik et al. 1998, Hansen et al. 2000, Karppinen et al. 2002). The impossibility of free migration forces sea trout to look for alternative often accidental spawning grounds (Dunkley and Shearer 1982, Gerlier and Roche 1998). Occasionally, fish miss their natal tributaries and try to reach the upper parts of rivers. This phenomenon of wandering, called as "over-shooting" (Hara 1993), was observed during a few radio telemetry studies (Aarestrup and Jepsen 1998, Svendsen at al. 2004). In many cases it happens because sea trout or salmon failed to pass the weirs in tributaries.

Sea trout, however, managed to survive in some rivers until the compensatory smolt stocking program was initiated in the 1970s. Coastal rivers were stocked in the 1970s and 1980s with approximately 150,000 individuals annually (Dębowski and Bartel 1996). This figure increased in the 1990s and early 2000s to over 400,000 individuals (ICES 2010). These smolts were released primarily into the lower reaches of the rivers, and often into their mouths.

At least some spawning sites are known in each catchment, and high densities of sea trout parrs are often confirmed in them (ICES 2010); however, the role of natural recruitment in sustaining these populations is unknown. It is also unknown to what degree fish originating from stocking participate in spawning. It is assumed that they would have difficulties locating spawning grounds. Long-term smolt tagging has indicated that they become disoriented during return migration and many are caught in other rivers (Dębowski and Bartel 1995).

The aim of the current studies conducted on one coastal river, the Łeba, was to answer the following questions. The main aim was to determine the impact of barriers equipped with fish passes in the lower river course on migration. The second aim was to assess the probability of differences in migration rates between fish released as smolts and wild fish. Finally, the course of sea trout migration and the number of fish reaching the spawning grounds were examined.

Materials and methods

Study area

The Łeba is one of a few small rivers that flows directly into the Baltic Sea along its southern coast (geographic co-ordinates of the river mouth: 17.5507 E and 54.7680 N) (Fig. 1). The length of the river is 127 km. Its catchment covers an area of 1768 km^2. The mean flow rate at the mouth is 18.8 m^3 s^{-1}, and the mean gradient is 1.26 m km^{-1}. In its lower reaches, the river flows through Lake Łebsko (surface area of 71.4 km^2), which is the third largest lake in Poland. This highly eutrophic basin has a maximum depth of 6.3 m and a mean depth of 1.6 m. When wind strength and direction are favourable, sea water flows into the lake through a 3.1-km-long, channelized segment that connects the river to the sea. This periodically increases the salinity of the lake waters to 3‰. The lower run of the river and the lake are within the boundaries of the Słowiński National Park.

Twenty-one species of fish occur in the Łeba catchment, among which the dominants are brown trout *Salmo trutta* L., three-spined stickleback *Gasterosteus aculeatus* L., and nine-spined stickleback *Pungitius pungitius* (L.)(Dębowski et al. 2002). The numerous barriers mean that only a small area of the catchment is available to migrating fish, namely 60 km in the Łeba River and a few small tributaries in the lower reaches. The available segment of the Łeba has only a slight gradient and is channelized. The main potential and historical spawning grounds are located upstream from the barrier. The area of the current spawning grounds is small, and it is concentrated mainly in the Łeba downstream from the mill that halts migration and in the small tributary Okalica (Fig. 1). Additionally, there is a dam at 47 km that fish negotiate by leaping over or using the fish pass. The density of sea trout parr near the spawning grounds has reached 300 ind. 100 m^{-2} in recent years (ICES 2008).

Since the 1960s, the river has been stocked systematically with sea trout smolts and fry. These are the progeny of fish migrating to spawning grounds that are caught each year in trap nets in Lake Łebsko. Smolts aged 1+ and 2+ are released to the river segment that connects the lake with the sea, several tens of meters from the river mouth, in quantities ranging from 10,000 to 50,000 individuals annually. Fry is released mainly into tributaries in quantities that have recently reached 400,000 individuals annually.

In the past five years, commercial fisheries have caught from 311 to 772 kg of sea trout, mainly for breeding. Intense angling that targets mainly kelts is practiced in the river; the size of these catches is unknown.

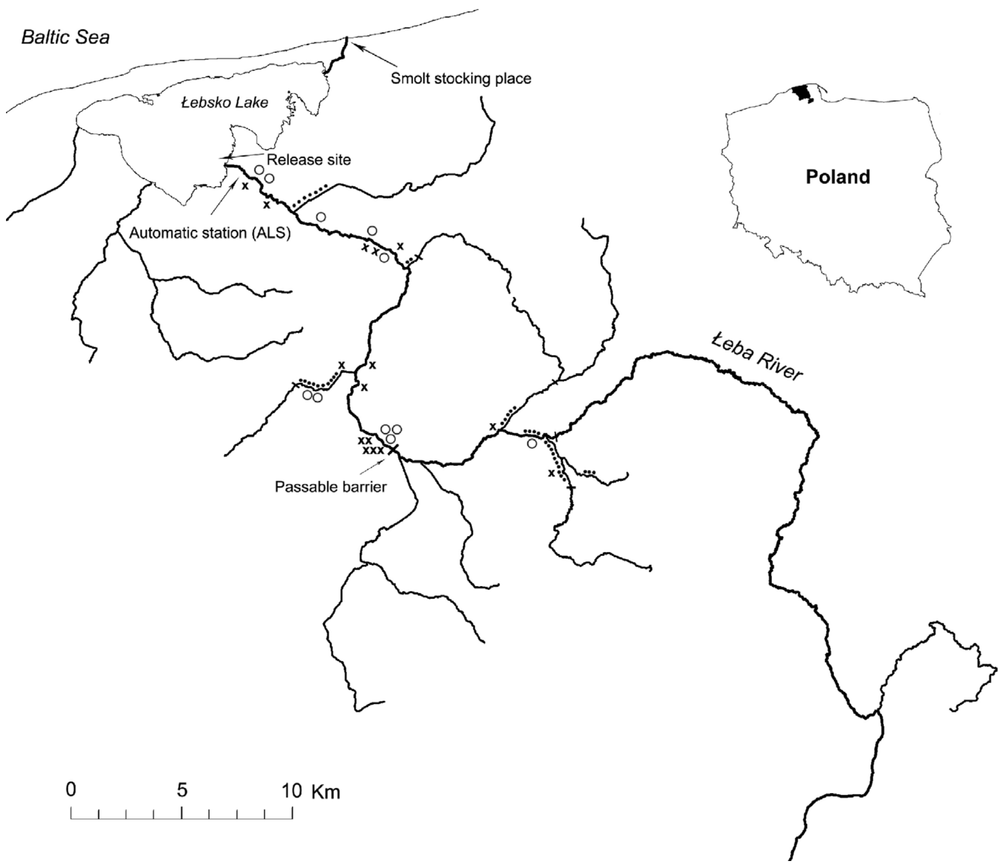

Figure. 1. Łeba River catchment with main barriers and spawning grounds marked (segments with dots). Migration reaches of individual fish ("o" – in 2007 and "x" – in 2008).

Telemetry

The studies were conducted in autumn 2007 and 2008. Adult sea trout were caught with trap nets in Lake Łebsko near the river outlet (in 2007 and 2008), or in the vicinity of the peninsula on the southeast shore of the lake (in 2007) (Fig. 1). The fish were anesthetized with a solution of Propiscin (2% etomidate). Transmitters were placed in the stomachs of the fish (Bridger and Booth 2003). The parameters of the device were as follows: model F1840B manufactured by Advanced Telemetry Systems, Isanti (ATS), MN, USA; weight – 22 g; transmitting on individual frequencies within the range of 154.000 to 154.999 MHz; signal frequency – 50 ppm; fitted with motion sensors generating additional signals and a "death" function (switching to a frequency of 100 ppm after 12 h of no transmitter movement). The fish were released in the vicinity of the site at which they had been caught; this was either near the river outlet, which was about 9 km from the inlet, or near the river inlet into the lake for the fish caught near the peninsula (Fig. 1).

In 2007, 27 fish (18 males and 9 females) from 45 to 73 cm of length (FL), were tagged November 6 or 15. Of these, 15 were released near the river inlet into the lake, while 12 were released near its outlet. In 2008, 45 fish measuring from 51 to 77 cm were tagged from October 9 to 30. Among these fish there were 21 males and 24 females, and 25 fish originated from smolt stocking (stocked fish) and 20 fish from natural recruitment or fry stocking (wild fish). Since 2005, the adipose fins of all smolts are clipped prior to release which allows determining the origin of the fish. On average, males were smaller than females – 57.0 vs 60.7 cm FL (U Mann-Whitney test, $P < 0.05$), and the fish released near the river outlet from the lake were smaller than those released near its inlet –

58.2 vs 62.5 cm FL ($P < 0.05$). The mean fish lengths did not differ significantly among years or based on the origin of the fish (wild or stocked).

Due to the high conductivity of the water, tracking the fish in the lake and the river segment connecting the lake with the sea was impossible. The fish were registered by an automated R4500 ATS device located 1.1 km from the inlet. A second station was located 45 km upstream in the spawning grounds (Fig. 1). Additionally, manual tracking was performed irregularly from boats, cars, and on foot at approximately weekly intervals in various segments of the study area. Due to the irregularity, recorded migratory reach must be concluded to be minimal.

The fish are capable of regurgitating the tags (McCleave et al. 1978). Smith et al. (1998) and Rivinoja et al. (2006) estimated regurgitation rates in migrating salmon to be about 15%, but it also possible that they can be significantly higher (Mellas and Haynes 1985). With few exceptions, it was impossible to ascertain if the motionless tags (which were indicated by greater impulse frequency) had been regurgitated or were inside dead fish. This is why the location of these tags cannot be designated as the definitive end of a particular individual's migration, and it designates the minimal range of the migratory fish. It was possible to determine the following: (a) if the fish entered the river, (b) time lag between release and entering the river, (c) the farthest confirmed migration point, (d) the fates of some of the fish.

Log-linear analysis and the Pearson χ^2 test were used to study the distribution of abundance. The comparison of variables among groups was done with the U Mann-Whitney test. The Spearman correlation was applied to study the dependencies among variables at a level of significance of $P = 0.05$. Statistical analysis was performed with the Statistica package (StatSoft Inc., Kraków, Poland).

Results

In 2007, 11 fish entered the river (41%) and in 2008 15 did so (33%) (Table 1). The difference between years was not statistically significant. The differences between the numbers of females and males that entered the river (14 or 33% and 12 or 40%, respectively) were also insignificant. More wild fish entered the river (9 or 45%) than did those from smolt stocking (6 or 24%); however, this difference was not statistically significant. Similarly, the site where the tagged fish were released did not influence the number of fish that entered the river: 19 (33%) at the outlet and 7 (47%) at the inlet. The mean length of fish entering and not entering the river were very similar at 58.7 and 59.3 cm (difference insignificant).

In 2007, the fish entered the river (passed the first automated monitoring station) after an average of 6.0 days, while in 2008, they did so after 4.0 days; males entered after 5.1 and females after 4.8 days (Table 1). The fish released at the outlet entered the river after 4.6 days (but in 2007 after 6.5 days), while at the inlet they did so after 5.7 days. None of these means differed significantly statistically. However, wild fish entered the river statistically significantly faster ($P < 0.05$) than did fish that had been stocked as smolts, at averages 2.3 and 5.7 days, respectively (Fig. 2). The time lag before the fish entered the river was not correlated with either their length or release date.

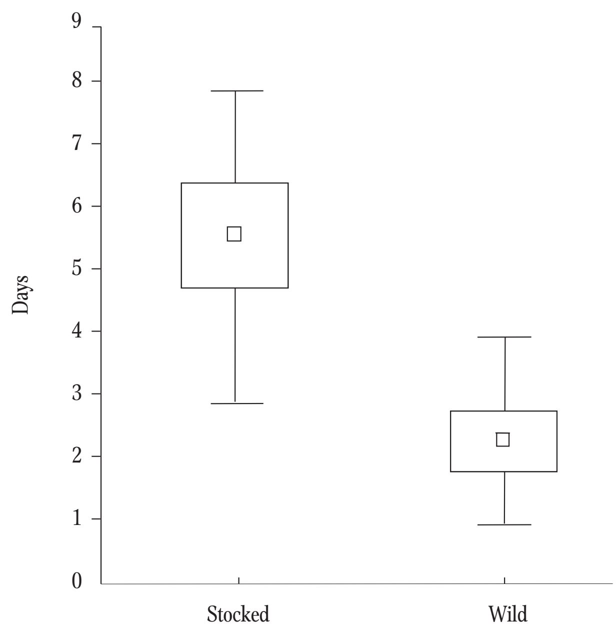

Figure 2. Time of entering river by stocked and wild fish (mean, mean±SD, range).

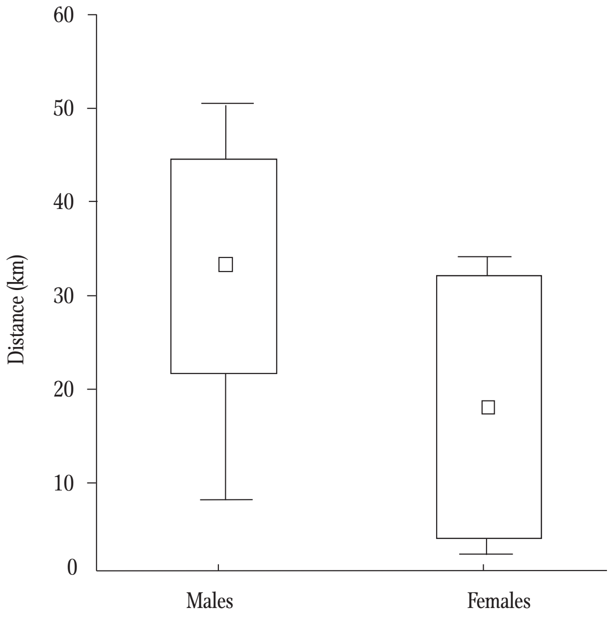

Figure 3. Maximum distance in river (km from inlet to the lake) of males and females (mean, mean±SD, range).

The mean migratory reach recorded in the two study years did not differ significantly statistically at 22.8 km in 2007 and 26.5 km in 2008 (Table 1). The males migrated distinctly farther (at an average of 33.0 km) than did the females (18.0 km; $P<0.05$) (Fig. 3). There were no significant differences either between the fish released at different sites (outlet – 26.4, inlet – 20.9 km) or between the fish from stocking and wild individuals (22.9 and 28.8 km, respectively). The migratory reach was negatively correlated to the length of the fish ($r = -0.389$; $P < 0.05$), and did not depend on either the release date or the time when the fish entered the river.

In 2007, two fish were caught in nets in the coastal zone of the sea: the first approximately 50 km to the west and the second about 35 km to the east. Of the 11 fish that were recorded in the river (Table 1), three reached the spawning grounds: one was upstream in the available segment, where it died or rid itself of its tag, and two were in the Rzechcinka, a left bank tributary, where they were poached at the spawning grounds (Fig. 1). Three fish reached the dam at km 47 and two of them were probably preyed upon by otters, while the third swam downstream and reached the lake in mid December. The next ones were not recorded in the river, but in early January were caught by angling in the lower river segment. Two fish remained in the lower run, and one of them disappeared from there five days after having entered the river, and the second swam into the lake after 16 days in the river. Two fish stayed in the low run, and probably finally swam into the lake.

In 2008, 15 fish entered the river (Table 1). Two wild fish reached the spawning grounds in tributaries: one in the Okalica and one in the Rzechcinka. The first fish swam downstream in mid December, but it still had not entered the lake by the end of January, and the second one died or rid itself of its tag in the spawning grounds. One of the stocked fish passed the dam at km 47 and died or rid itself of its tag just a few kilometers below the spawning grounds. Five fish reached the dam, but were unable to get past it; four wild fish died or rid themselves of their tags downstream of the dam and one of the stocked fish disappeared. Seven fish (three wild and four stocked) remained in the lower reaches of the river. Four of them died or rid themselves of their tags, and three disappeared (one of them stayed in the vicinity of the inlet and might have swum into the lake).

Discussion

Unfortunately, the high conductivity of the lake water did not permit receiving signals, which presented substantial methodological problems. The lack of contact with the fish immediately following tagging and release, which, as it occurred, was a key part of the experiment, meant that many important questions remained unanswered. It is particularly difficult to interpret the fact that many of the fish were not registered upstream from the lake. One of the possibilities is that relatively few fish continued migration, and, in extreme cases, some fish died in the lake. The unwillingness of tagged fish to continue migration is a phenomenon which, to a greater or lesser degree, is noted in telemetric studies (Evans 1994, Okland et al 1995, Gerlier and Roche 1998, Aarestrup et al.

Table 1
Radio tagged fish recorded after releasing

Length FL (cm)	Sex	Origin	Date of realease	Release site	Date of river entering	Max distance in river (km)	Fate of fish
55	M		6-11-2007	Inlet	8 Nov 2007	34	Swam down
57	F		6-11-2007	Inlet	7-11	33	Caught
60	F		6-11-2007	Inlet	10-11	34	Dead
62	M		6-11-2007	Inlet	14-11	8	Swam down
63	F		6-11-2007	Inlet	11-11	33	Caught
65	F		6-11-2007	Inlet	25-11	2	Swam down
65	F		6-11-2007	Inlet	7-11	2	Swam down
55	F		6-11-2007	Outlet	18-11	15	Disappeared
55	M		6-11-2007	Outlet	9-11	34	Dead
60	M		6-11-2007	Outlet	12-11	46.5	Dead
65	F		6-11-2007	Outlet			Caught in the sea
64	F		15-11-2007	Outlet	20-11	9.5	Caught
65	M		15-11-2007	Outlet			Caught in the sea
59	M	wild	9-10-2008	Outlet	12-10	33	Dead
59	M	stocked	9-10-2008	Outlet	15-10	44	Dead
55	M	stocked	15-10-2008	Outlet	23-10	20	Dead
56	M	wild	15-10-2008	Outlet	19-10	32.5	Dead
51	M	stocked	16-10-2008	Outlet	21-10	32	Disappeared
54	M	wild	16-10-2008	Outlet	19-10	50.5	Swam down
62	M	stocked	16-10-2008	Outlet	24-10	28.5	Disappeared
55	F	wild	21-10-2008	Outlet	22-10	33.5	Dead
56	F	stocked	21-10-2008	Outlet	25-10	7	Disappeared
58	F	wild	21-10-2008	Outlet	22-10	2	Swam down
68	F	wild	21-10-2008	Outlet		31	Dead
51	F	wild	29-10-2008	Outlet		33.5	Dead
52	M	wild	29-10-2008	Outlet		33.5	Dead
55	F	stocked	29-10-2008	Outlet	1-11	6	Dead
75	F	wild	29-10-2008	Outlet	31-10	10	Dead

2000, Jokikokko 2002). This is likely the result of stress caused by capture and tagging. The methods applied in the current study appear, however, to be relatively mild. The fish were caught with trap nets, in which they remained for less than 24 hours, and the tags were placed in the stomachs, which is acknowledged to be a method that minimizes stress (McCleave et al. 1978, Bridger and Booth 2003). Additionally, the fish used in the studies were caught during their spawning migration. Based on analogous data from a neighboring Słupia River (Dębowski et al. 2008), it is likely that in the first year of the study they were caught during the end of migration, and in the second year at its peak. As confirmed by Gerlier and Roche (1998), salmon tagged at this moment refused to undertake further migration far less frequently than did fish tagged earlier. However, it is known that two tagged fish changed direction of migration as they were caught in the sea.

The second possibility is regurgitation (Smith et al. 1998, Bridger and Booth 2003). It is believed that sea trout rid themselves of tags more frequently than do salmon (Marmulla and Ingendahl 1996). This can result from feeding, but sea trout feed only sporadically during spawning migrations in the rivers of the southern Baltic (Chełkowski et al. 1990). It is possible to assume that regurgitation occurred and was the reason why the number of fish entering the river was underestimated.

One other possible reason could be the inability of the stocked fish to find the inlet of the river to the lake. The lake is very large and shallow, and the distance between the inlet and outlet is nearly 10 km. There is the lack of a distinct channel or water current, and in autumn the lake waters are mixed. The fish from stocking had never before been in the lake, and their memorized route was limited to the part of the channel that links the lake to the sea. This impairment was noted in the percentage of fish that migrated above the lake which was nearly as twice as small as that of the fish that swam down from the spawning grounds as smolts, as well as by the fact that it took them twice the time to do so. This is an anticipated result and concurs with most studies that compare wild and stocked fish: the latter decline to migrate more frequently and have difficulty in locating spawning grounds (Power and McCleave 1980, Jonsson et al. 1990, 1991, Okland et al. 1995). As long-term tagging studies have indicated, a lot of fish caught in the Łeba River came from stocking of other coastal rivers, while fish that had been stocked into the Łeba River often were caught in the neighboring rivers (Dębowski and Bartel 1995).

The main spawning grounds are located in the upper parts of the available catchment. It appears that a lot of fish reach this area and that spawning is effective (ICES 2010). However, telemetric observations indicate that the barrier in the middle reaches is not passable for many fish: of eleven fish that swam to this point, only three were noted to have continued their migrations, while most of the others died downstream from the dam.

Only single tagged fish reached the spawning grounds: three in the Rzechcinka tributary, one in the Okalica tributary and one in the Łeba. In 2008, when the origin of the fish was possible to distinguish, both of the fish at the spawning grounds came from either natural recruitment or stocking with fry. Additionally, several of the fish with which contact was lost in the Łeba River could have entered one of the very small tributaries that were stocked with fry.

The results of the current studies permit drawing a few conclusions:

1) the disadvantageous conditions for conducting radio telemetry in the lower course of the river emphasized the drawbacks of the method applied and resulted in the underestimation of the number of fish continuing migration and the maximum migration range;
2) the barrier located in the central section of the available river segment was passable for a few fish, but for most it was impossible to pass;
3) fish that were released as smolts below the lake had a lesser chance of spawning as some could not find the inlet to the lake or covering the distance across the lake took more time, and the majority of those that made it farther remained in the lower course of the river without reaching the spawning grounds.

Acknowledgements. We wish to thank Słowiński National Park for help in the organization of the study, fishers from the Łebsko Lake for providing fish, and local anglers for help in field work. The study was co-financed by the Regional Fund for Environmental Protection and Water Management in Gdańsk.

References

Aarestrup K., Jepsen N. 1998 – Spawning migration of sea trout (*Salmo trutta* L) in a Danish river – Hydrobiologia 371/372: 275-281.

Aarestrup K., Jepsen N., Rasmussen G., Okland F., Thorstad E., Holdensgaard G. 2000 – Prespawning migratory behaviour and spawning success of sea-ranched Atlantic salmon, *Salmo salar* L., in the River Gudenaa, Denmark – Fish. Manage. Ecol. 7: 387-400.

Bartel R. 1988 – Trouts in Poland – Pol. Arch. Hydrobiol. 35: 321-339.

Bartel R. 2001 – The restoration of Atlantic salmon *Salmo salar* L. in Poland – Arch. Pol. Fish. 9: 219-228.

Bridger C., Booth R. 2003 – The effects of biotelemetry transmitter presence and attachment procedures on fish physiology and behavior – Rev. Fish. Sci. 11: 13-34.

Chełkowski Z., Domagała J., Trzebiatowski R. 1990 – Feeding of sea trout *Salmo trutta* L. migrating upstream for spawning in lower Oder river system – Acta Ichth. Piscat. 20 (2): 25-35.

Dunkley D. Shearer W. 1982 – An assessment of the performance of a resistivity fish counter – J. Fish Biol. 20: 717-737.

Dębowski P., Bartel R. 1995 – Homing of tagged sea trout *Salmo trutta* L. smolts released into Polish rivers – Arch. Pol. Fish. 3: 107-122.

Dębowski P., Bartel R. 1996 – Stocking of sea trout *Salmo trutta* m. *trutta* smolts in Poland. Part II. Factors influencing recaptures and verification of estimates – Arch. Pol. Fish. 4: 19-36.

Dębowski P., Radtke G., Grochowski A. 2002 – The ichthyofauna of the Łeba River drainage basin – Rocz. Nauk. PZW. 15: 41-65 (in Polish).

Dębowski P., Sikora B., Miller M., Wrzosek D., Bernaś R. 2008 – Using automatic fish counters to assess sea trout migration in the Słupia River in fall 2006 – In: Protection of fish in rivers with hydrotechnical building (Eds) M. Mokwa, W. Wiśniewolski, Dolnośląskie Wydawnictwo Edukacyjne, Wrocław: 175-179 (in Polish).

Evans D. 1994 – Observations on the spawning behaviour of male and female adult sea trout, *Salmo trutta* L., using radio-telemetry – Fish. Manag. Ecol. 1: 91-105.

Gerlier M., Roche P. 1998 – A radio telemetry study of the migration of Atlantic salmon *Salmo salar* L. and sea trout *Salmo trutta* L. in the upper Rhine – Hydrobiologia 371/372: 283-293.

Hara T. 1993 – Role of olfaction in fish behaviour – In: Behaviour of Teleost Fishes (Ed.) T.J. Pitcher, London: Chapman & Hall, 170-199.

Hansen M., Ruzzante D., Nielsen E., Mensberg K. 2000 – Microsatellite and mitochondrial DNA polymorphism reveals life historydependent interbreeding between hatchery and wild brown trout *Salmo trutta* L. – Mol. Ecol. 9: 583-594.

ICES. 2008 – Report of the Working Group on Baltic Salmon and Trout (WGBAST) – 1-10 April 2008, Gdynia, Poland. ICES CM 2008/ACOM:05. 229 p.

ICES. 2010 – Report of the Working Group on Baltic Salmon and Trout (WGBAST) – 24–31 March 2010, St Petersburg, Russia. ICES CM 2010/ACOM:08. 253 p. http://www.ices.dk/reports/ACOM/2010/WGBAST/wgbast_2010.pdf

Jokikokko E. 2002 – Migration of wild and reared Atlantic salmon *Salmo salar* L. in the river Simojoki, northern Finland – Fish. Res. 58: 15-23.

Jonsson B., Jonsson N., Hansen L. 1990 – Does juvenile experience affect migration and spawning of adult Atlantic salmon? – Behav. Ecol. Sociobiol. 26: 225-230.

Jonsson B., Jonsson N., Hansen L. 1991 – Differences in life history and migratory behaviour between wild and hatchery reared Atlantic salmon in nature – Aquaculture 98: 69-78.

Karppinen P., Mäkinen T., Erkinaro J., Kostin V., Sadkovskij R., Lupandin A., Kaukoranta M. 2002 – Migratory and route seeking behaviour of ascending Atlantic salmon in the regulated River Tuloma – Hydrobiologia 483: 23-30.

Linnik V., Malinin L., Wozniewski M., Sych R., Dębowski P. 1998 – Movements of adult sea trout *Salmo trutta* L. in the tailrace of a low-head dam at Wloclawek hydroelectric station on the Vistula River, Poland – Hydrobiologia 371/372: 335-337.

Marmulla G., Ingendahl D. 1996 – Preliminary results of a radio telemetry study of returning Atlantic salmon Salmo salar L. and sea trout *Salmo trutta trutta* L. in River Sieg, tributary of River Rhine in Germany – In: Proc. the First Conference and Workshop on Fish Telemetry in Europe, Underwater biotelemetry (Eds) E. Baras, J.C. Philippart, University of Liege, Belgium: 109-119.

McCleave J., Power J., Rommel Jr. S. 1978 – Use of radio telemetry for studying upriver migration of adult Atlantic salmon *Salmo salar* – J. Fish Biol. 12: 549-558.

Mellas E., Haynes J. 1985 – Swimming performance and behaviour of rainbow trout Salmo gairdneri and white perch *Morone americana*: effects of attaching telemetry transmitters – Can. J. Fish. Aquat. Sci. 42: 488-493.

Okland F., Heggberget T., Jonsson B. 1995 – Migratory behaviour of wild and farmed Atlantic salmon *Salmo salar* during spawning – J. Fish Biol. 46: 1-7.

Power J., McCleave J. 1980 – Riverine movements of hatchery-reared Atlantic salmon *Salmo salar* upon return as adults – Environ. Biol. Fish 5: 3-13.

Rivinoja P., Leonardsson K., Lundqvist H. 2006 – Migration success and migration time of gastrically radio-tagged v. PIT-tagged adult Atlantic salmon – J. Fish Biol. 69: 304-311.

Smith G., Campbell R., MacLaine J. 1998 – Regurgitation rates of intragastric transmitters by adult Atlantic salmon *Salmo salar* L. during riverine migration – Hydrobiologia 371/372: 117-121.

Svendsen J., Koed A., Aarestrup K. 2004 – Factor influencing the spawning migration of female anadromous brown trout – J. Fish Biol. 64: 528-540.

Webb J. 1990 – The behaviour of adult Atlantic salmon ascending the Rivers Tay and Tummel to Pitlochry dam – Scott. Fish. Res. Rep. 48: 1-27.

Streszczenie

Badania radiotelemetryczne migracji tarłowej troci wędrownej *Salmo trutta* L. w rzece Łebie (północna Polska)

Rzeka Łeba przed ujściem do Bałtyku przepływa przez słonawe eutroficzne jezioro Łebsko. W dorzeczu występuje 21 gatunków ryb i minogów z dominującym pstrągiem potokowym, ciernikiem i cierniczkiem. Od 1960 roku prowadzone są zarybienia trocią wędrowną, której liczebność w wyniku zabudowy hydrotechnicznej rzeki systematycznie malała. Głównymi celami badań była ocena wpływu przegród znajdujących się w dorzeczu na migrację tarłową troci oraz zbadanie ewentualnych różnic w sposobie migracji pomiędzy rybami pochodzącymi z naturalnego tarła i zarybień smoltami. W latach 2007 i 2008 poznakowano znaczkami radiowymi 72 tarlaki troci wędrownej, które wypuszczano do jeziora. Migrację ryb śledzono przy zastosowaniu dwóch stacji automatycznych (ASL) i telemetrii aktywnej. Tylko 26 sztuk troci popłynęło w górę rzeki, z czego 5 osobników dotarło do tarlisk. Stwierdzono, że trocie pochodzące z naturalnego tarła łatwiej odnajdują drogę przez jezioro do rzeki (45% w ciągu 2-3 dni) niż te pochodzące z zarybień smoltami (24% w przeciągu 5-7 dni). Dodatkowo wykazano, że znajdujący się w środkowym biegu rzeki Łeby jaz w Chocielewku, pomimo posiadania przepławki jest poważną przeszkodą w migracjach troci.