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HOMING OF TAGGED SEA TROUT (*Salmo trutta* L.) SMOLTS RELEASED INTO POLISH RIVERS

Piotr Dębowski, Ryszard Bartel

The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn

ABSTRACT. About 183 000 sea trout smolts were tagged in 1961-1986 and released into the Vistula River system, the Pomeranian rivers, and the Gulf of Gdańsk. The Vistula River stockings showed the highest percentage of recaptures in rivers. Almost all fish were caught in the Vistula River system. A lot of sea trouts from stockings of the Pomeranian rivers went astray and were recaptured either in the Vistula River or in the Pomeranian rivers. It seems that local Pomeranian sea trout may be a mixture of populations stemming from the neighboring rivers. This concerns in particular the cases when the share of smolts from stocking is very high.

Key words: SEA TROUT, TAGGING, MIGRATION, RECOVERIES, HOMING

INTRODUCTION

The populations of sea trout (*Salmo trutta* L.) in Poland have dwindled due to river damming and increasing pollution. In order to increase the numerical force of populations, an annual compensation stocking is carried out, which reached 168 000 to 932 000 of smolts per annum in 1972-1993. The smolts were released into the river estuaries and rather seldom to the middle or upper river sectors, or directly into the sea. The spawn for smolt rearing is obtained from the spawners migrating for the spawning. These spawners show a tendency of entering the same rivers from which they came to the sea as smolts. Despite such a great precision of homing, some of the fish go astray and do not enter the mother river (Bertmar 1979). In the case of smolts released directly into the sea, we can exclusively speak about a considerable stray resulting from lack of marks enabling the fish to find their way to the river estuaries (Larsson 1977, Bertmar 1982, Einarsson et al. 1987, Anon 1992).

The aims of this work were to estimate the degree of mistaken selection of the river by the sea trout spawners migrating to the spawning grounds, and to estimate the influence of stray on mixing of sea trout populations in Polish rivers.

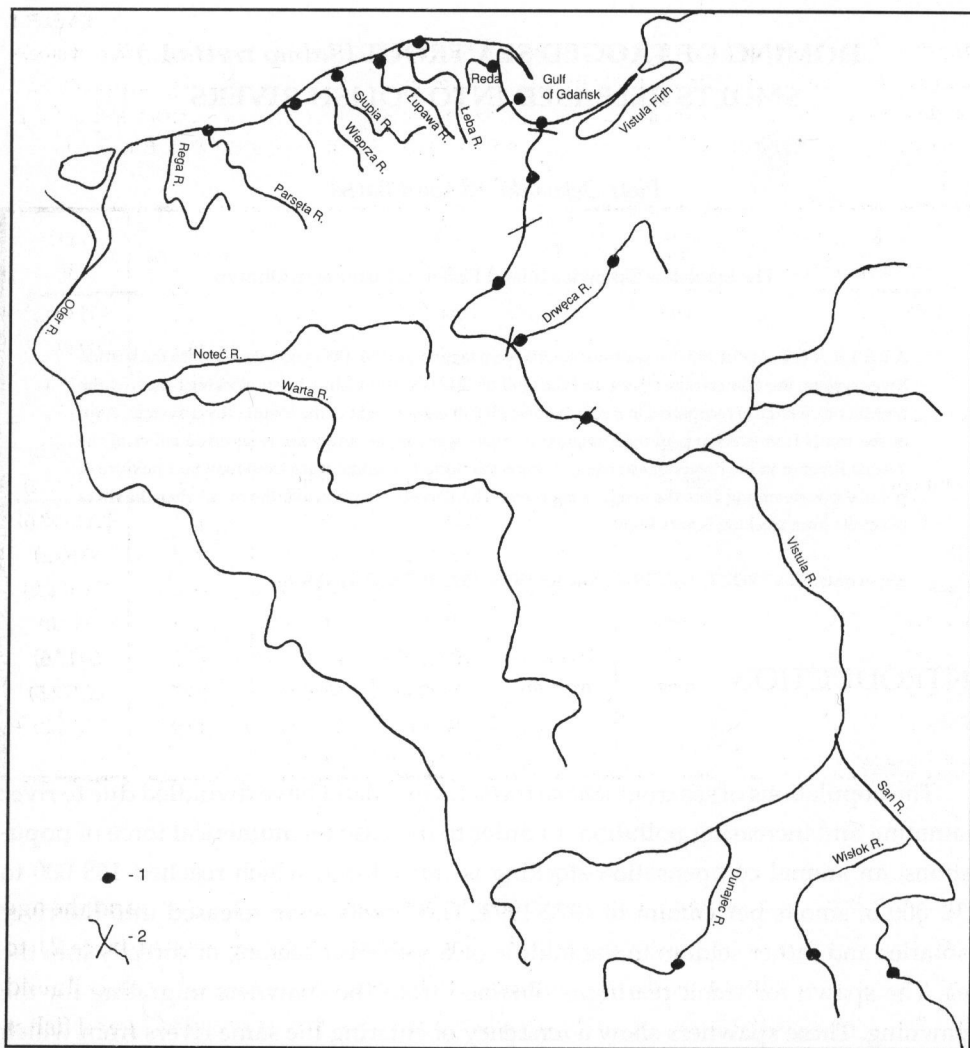


Fig. 1. Places of releasing of tagged smolts. 1 - place of releasing, 2 - borders of contractual parts of the Vistula River Basin.

MATERIAL AND METHODS

This paper was based on the results from 135 tagging experiments with sea trouts, carried out by the River Fisheries Laboratory of the Inland Fisheries Institute in 1961-1986. The experiments were carried out in over twenty hatcheries where 192 682

TABLE 1

The distance between the place of release and the sea, total number of smolts released in different stocking places (n) number of experiments, number (N) and percentage ($N \times n^{-1} \%$) of recoveries, number (R) and percentage ($R \times n^{-1} \%$) of recaptures in fresh water, percentage of recoveries in fresh water to total number of recoveries ($R \times N^{-1} \%$), and the number (D) and percentage ($D \times R^{-1} \%$) of fish caught in the mother river

River Place of release	km	n	N $N \times n^{-1} \%$	R $R \times n^{-1} \%$	$R \times N^{-1} \%$	D $D \times R^{-1} \%$
Vistula	2-11	30460 (21)	2066 (6.8)	671 (2.2)	32.5	666 (99.3)
	74	18373 (7)	1873 (10.2)	621 (3.4)	33.2	609 (98.1)
	240-270	6406 (7)	402 (6.3)	152 (2.4)	37.8	149 (98.0)
Drwęca	214-223	7872 (6)	711 (9.0)	367 (4.6)	51.6	366 (99.2)
	408	11255 (5)	302 (2.7)	100 (0.9)	33.1	94 (94.0)
tribut. upper Vistula	830-951	21244 (13)	226 (1.1)	128 (0.6)	56.6	127 (99.2)
Vistula system		95610 (59)	5580 (5.8)	2039 (2.1)	36.5	2011 (98.6)
Reda	1-7	8083 (7)	122 (1.5)	13 (0.2)	10.7	9 (69.2)
Łeba	0	21076 (14)	815 (3.9)	212 (1.0)	26.0	170 (80.2)
Łupawa	0-40	4336 (4)	145 (3.3)	33 (0.8)	22.8	0 (0.0)
Słupia	0	15403 (9)	103 (0.7)	17 (0.1)	16.5	3 (17.6)
Wieprza	0-25	9121 (8)	214 (2.4)	40 (0.4)	18.7	29 (72.5)
Paręta	0	4970 (4)	94 (1.9)	28 (0.6)	29.8	3 (10.7)
Gulf of Gdańsk		24083 (30)	3043 (12.6)	286 (1.2)	9.4	

sea trout smolts were tagged, having the length between 131 and 282 mm, and the age from 1 to 3 years, mainly 2 years (Tab. 1). The number of smolts varied from 21 to 9 984 individuals in particular experiments. All smolts were tagged with celluloid tags, with single monel or silver wire, attached under the dorsal fin. The tagged fishes were released into the Vistula River or its tributaries, into the Pomeranian rivers, or into the Gulf of Gdask, in the period March - June (Fig. 1).

There were 10 116 recoveries out of the released smolts and the percentage of recaptures in particular experiments varied from 0 to 33.8%.

The analysis of the material was performed on the basis of summed up data from the experiments carried out in particular rivers in various years. The following parameters were determined: 1/ the distance between the place of release and the sea, 2/ total number of smolts released in different stocking places, 3/ number of experiments, 4/ number (N) and percentage ($N \times n^{-1} \%$) of recoveries, 5/ number (R) and

percentage ($R \times n^{-1} \%$) of recoveries in freshwater, 6/ percentage of recoveries in fresh water to a total number of recoveries ($R \times N^{-1}$), and 7/ the number (D) and percentage ($D \times R^{-1} \%$) of fish caught in the mother river (Tab. 1).

The returns of tags from the sea trout caught in the Pomeranian rivers were treated globally for each river. The sea trouts were caught below the first dam, at a small distance from the sea; the biggest distance from the sea was in the case of the Słupia River (35 km), the Parsęta River, or the Łeba River (3-5 km from the estuary; in the lake). As regards the Vistula River, the tags returns were divided into several groups; the first encompassed the returns from fish caught in the Vistula estuary, viz. in the lower Vistula and the river current in the Gulf of Gdańsk; the upper parts of the Vistula River were divided into 4 sections: the lower Vistula, the Vistula River to Drwęca inflow, the river part to the dam in Włocławek, and the Vistula River above the dam in Włocławek, with an inclusion of all the Vistula tributaries in this section. In addition to the above division, the Drwęca River was treated separately. The Vistula Firth was included to freshwater section, despite the fact that it contained brackish water (Fig. 1).

RESULTS

The highest percentage of returns was observed in the case of sea trouts released into the Vistula River, at the distance of 74 km from the river mouth, and into Drwęca mouth (214-223 km from the estuary). It was 10.2% and 9.0% respectively. The lowest tag recoveries were recorded in the case of tagged smolts released into tributaries of the upper Vistula, and into upper Drwęca; they were 1.1 and 2.7% respectively.

The results suggest that the percentage of tag recoveries decreased with increasing distance between the place of stocking and the Vistula estuary (Tab. 1).

Similarly, the highest percentage of returned tags from the fish caught in fresh water was observed in the case of fish released into the Drwęca mouth and into the Vistula River, at the distance of 74 km from the river mouth; it was 4.7 and 3.4% respectively. The lowest results were from the stockings in the upper Drwęca and the tributaries of upper Vistula: 0.9 and 0.6% respectively (Tab. 1).

The sea trouts caught in fresh water made up to 32.5 and 37.8% of all the recoveries from the stockings into lower parts of the Vistula and the upper Drwęca.

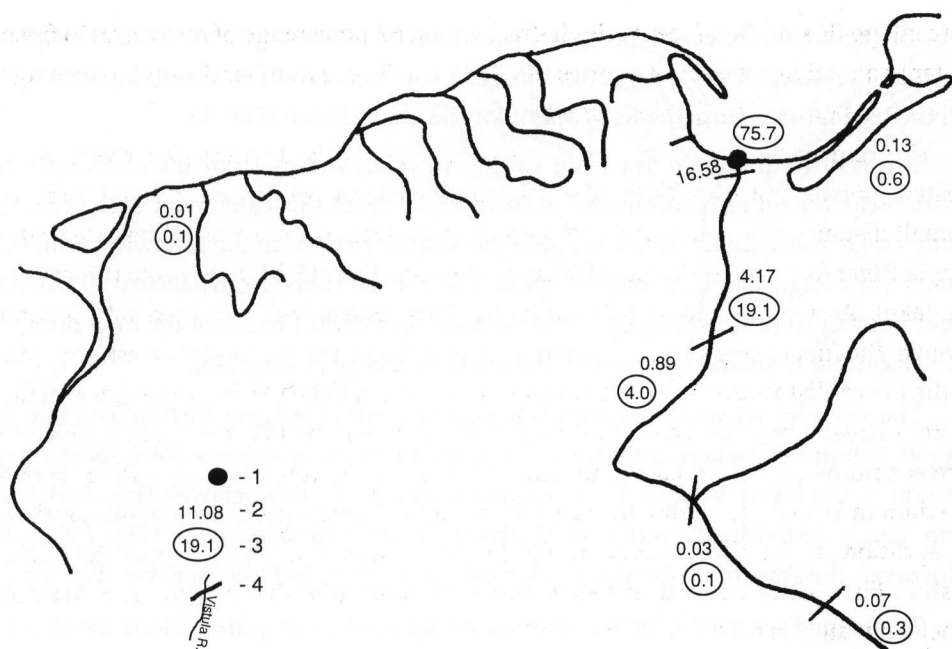


Fig. 2. Freshwater recaptures sea trout smolts released into the Vistula River mouth. 1 - place of release of sea trout smolts, 2 - freshwater recaptures in promilles from sea trout smolts, 3 - percentage of freshwater recaptures, 4 - borders of contractual parts of the Vistula River Basin

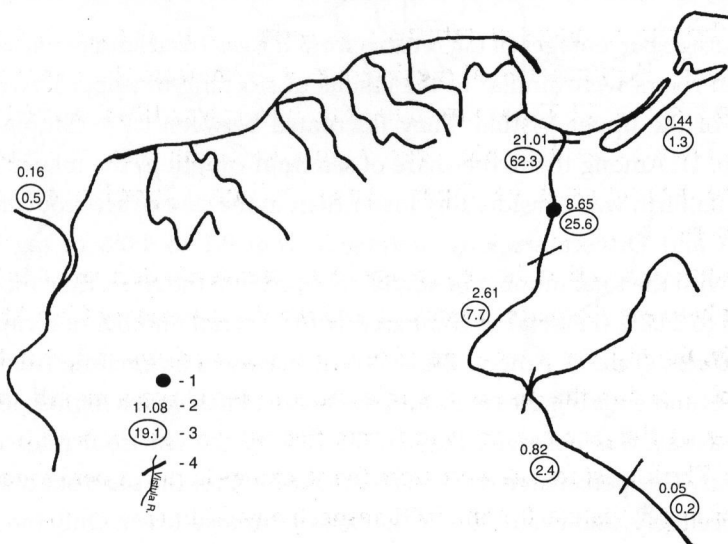


Fig. 3. Freshwater recaptures sea trout smolts released into the lower Vistula River. Explanations as in Fig. 2.

Out of the smolts released into the lower Dręca and into tributaries of the upper Vistula, the share of sea trout caught in fresh water exceeded 50% as compared with all the tags returns from the fish caught for the second time (Tab. 1).

Tag returns from the sea trout caught in fresh waters from the stocking into Vistula catchment area originated in 94 to 99.3% from this catchment area (Tab. 1). Only single individuals were caught in the Vistula Firth or in the following Pomeranian rivers: Rega, Oder, Parsęta, Wieprza. Their share varied from 0.05 to 0.60% of the total number of returns (Fig. 2-5), which made up from 0.1 to 2% of the total number of fish caught in inland waters, the Vistula Firth inclusive (Fig. 2-5).

The sea trout released into the Vistula estuary, into the lower Vistula, and into its upper tributaries, when entering the Vistula River as spawners were most often caught in the lower Vistula. They reached the vicinity of Włocławek (Fig. 2-5), and only single individuals were caught above the dam in Włocławek (Fig. 2 and 3). However, the sea trout from this stocking did not enter the Drwęca River (Fig. 2-5).

The tagged sea trout from the Drwęca stocking, when migrating along the Vistula River, were most often caught in the lower Vistula or entered the Drwęca River. The spawners originating from these stockings, when migrating towards the upper Vistula River, would only enter the Drwęca River, but they were not observed in the Vistula River, above the inflow of Drwęca (Fig. 6 and 7).

The average percentages of tag returns from the sea trout smolts released into the Pomeranian rivers were similar to the results of stocking in upper Drwęca and the tributaries of the upper Vistula. They fluctuated between 0.7% (Śłupia) and 3.9% (Łeba) (Tab. 1). Among them, the share of sea trout caught in the inland waters and in the Vistula Firth was considerably lower than in the case of sea trout catches from the Vistula and Drwęca stocking: it ranged from 0.1 to 1.0% of tag returns, as compared with the total number of smolts released into the river; they made up from 10.7 (Reda) to 29.8% (Parsęta) as compared with the total number of recaptures from particular rivers (Tab. 1). Among the sea trout spawners originating from the Pomeranian rivers and entering the rivers and the Vistula Firth, much higher percentage of fish going astray was observed than in the case of the sea trout released into the Vistula River. This percentage reached 89.3 and 82.4% for the sea trout of Parsęta and Śłupia respectively, and even 100% in the case of Łupawa River. Only the sea trout of the remaining rivers, namely of Wieprza, Reda and Łeba, showed lower percentage with respect to entering a „foreign river”, which varied from 19.8 to 30.8% (Tab. 1).

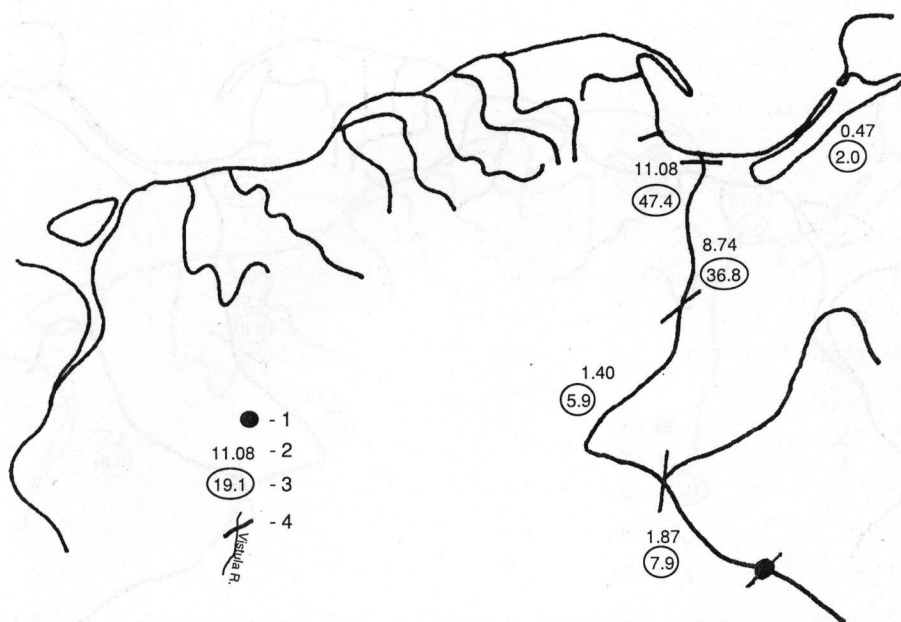


Fig. 4. Freshwater recaptures sea trout smolts released into the Vistula River, near Włocławek dam. Explanations as in Fig. 2.

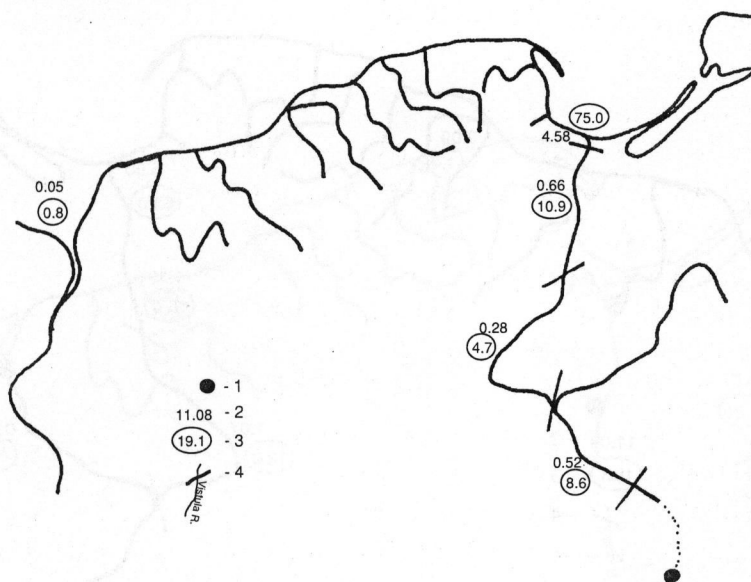


Fig. 5. Freshwater recaptures sea trout smolts released into tributaries of the upper Vistula River. Explanations as in Fig. 2.

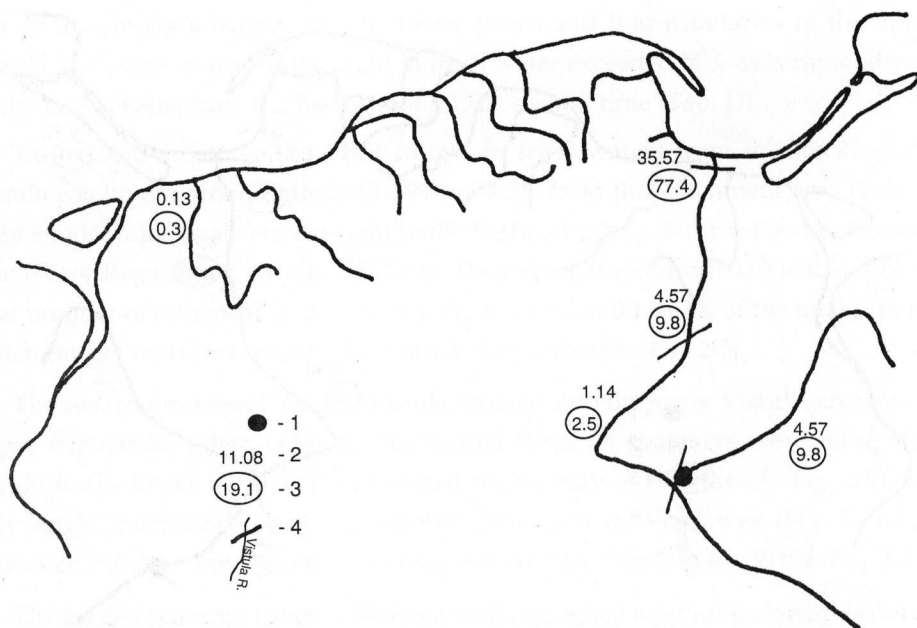


Fig. 6. Freshwater recaptures sea trout smolts released into the lower Drwęca River. Explanations as in Fig. 2.

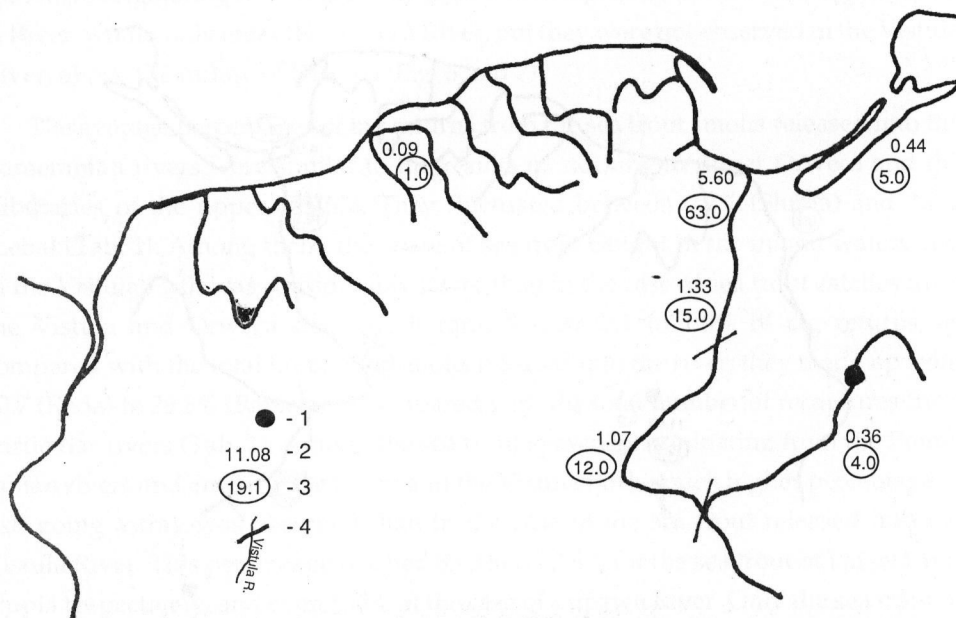


Fig. 7. Freshwater recaptures sea trout smolts released into the upper Drwęca River. Explanations as in Fig. 2.

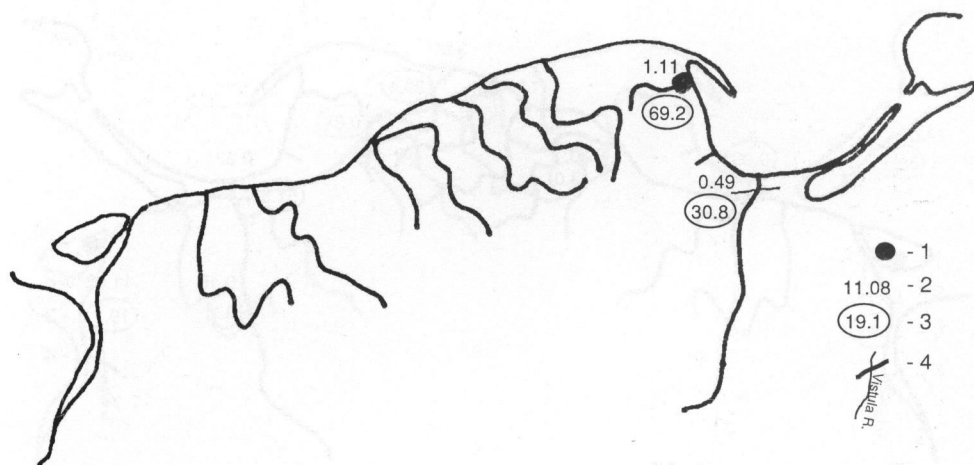


Fig. 8. Freshwater recaptures sea trout smolts released into the Reda River. Explanations as in Fig. 2.

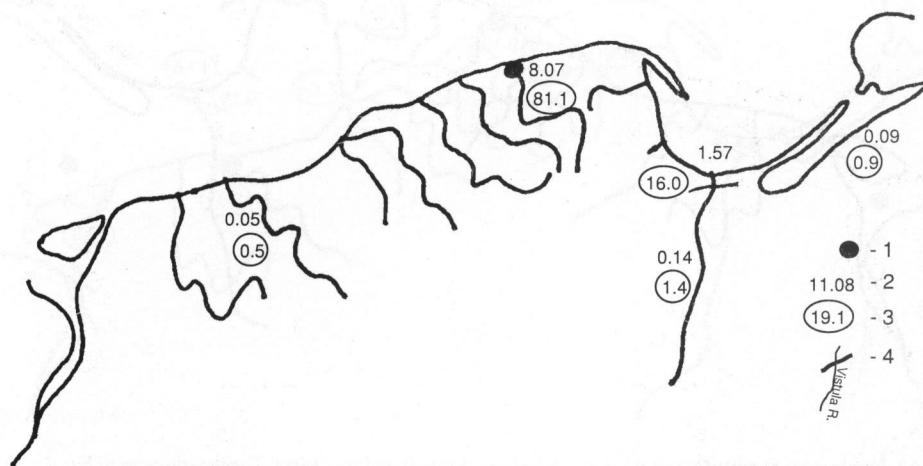


Fig. 9. Freshwater recaptures sea trout smolts released into the Leba River. Explanations as in Fig. 2.

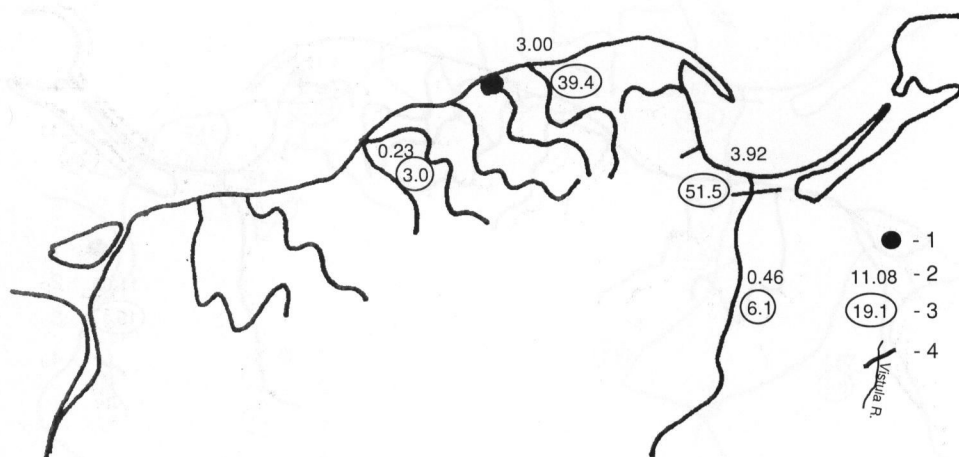


Fig. 10. Freshwater recaptures sea trout smolts released into the Łupawa River. Explanations as in Fig. 2.

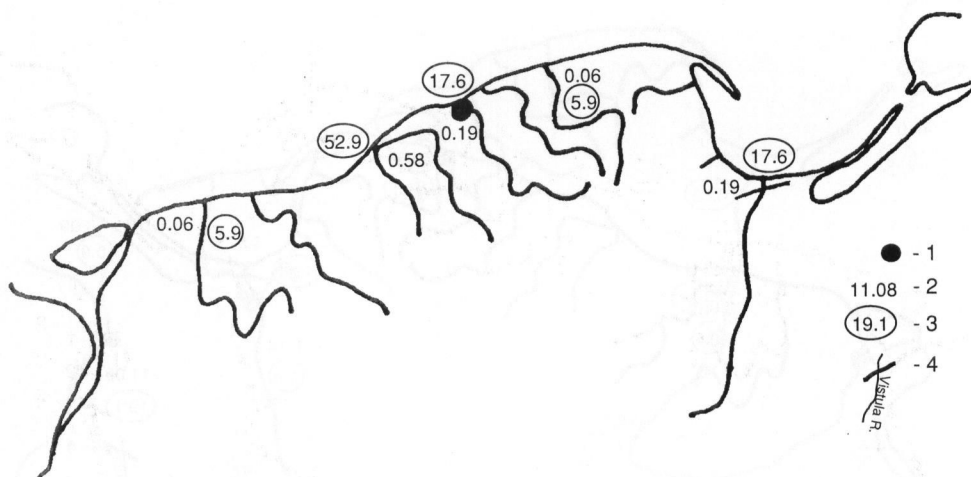


Fig. 11. Freshwater recaptures sea trout smolts released into the Stupia River. Explanations as in Fig. 2.

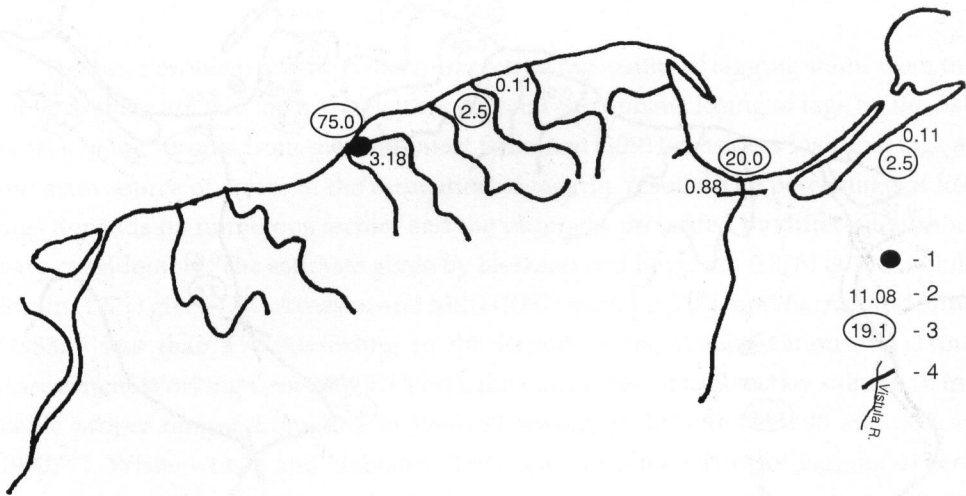


Fig. 12. Freshwater recaptures sea trout smolts released into the Wieprza River. Explanations as in Fig. 2.

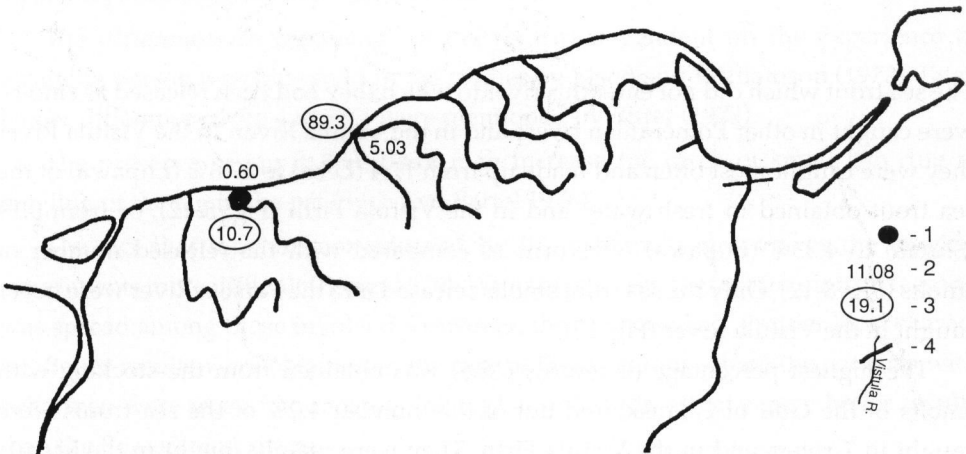


Fig. 13. Freshwater recaptures sea trout smolts released into the Parsęta River. Explanations as in Fig. 2.

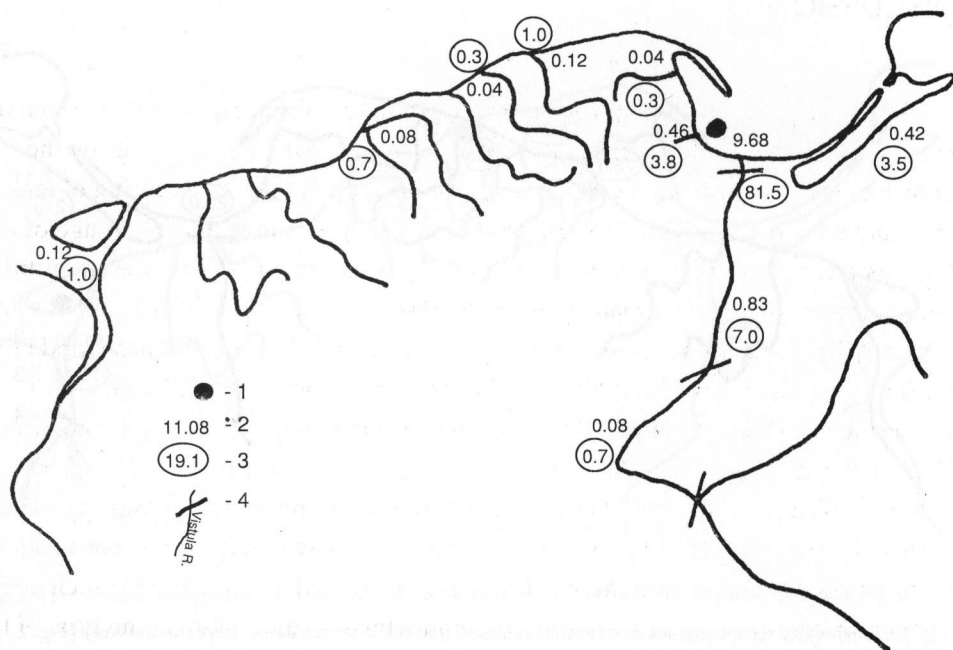


Fig. 14. Freshwater recaptures sea trout smolts released into the Gulf of Gdańsk. Explanations as in Fig. 2.

The sea trout which did not enter this river to which they had been released as smolts, were caught in other Pomeranian rivers and in the Vistula River. In the Vistula River they were caught most often and made up from 17.4 (Łeba) to 57.6% (Łupawa) of the sea trout obtained in fresh water and in the Vistula Firth (Fig. 8-12), or from 0.19 (Słupia) to 4.33% (Łupawa) of returns as compared with the released number of smolts (Fig. 8-12). Only the sea trout smolts released into the Parsęta River were never caught in the Vistula River (Fig. 13).

The highest percentage of returns (12.6) was obtained from the stocking with smolts of the Gulf of Gdańsk, and out of this number 1.2% of the sea trouts were caught in 7 rivers and in the Vistula Firth. They were mainly caught in the Vistula estuary and in the Vistula River (10.59‰). The release of smolts into the Gulf of Gdańsk, at the distance of a few km westwards of the Vistula estuary, resulted in the fact that among the sea trouts entering the fresh water as many as 89.2% were caught in the Vistula River (Fig. 14).

DISCUSSION

The basic problem arising when interpreting the results of tagging stems from the fact that there are two factors which are difficult to estimate: losing of tags by the fish or lack of tag returns from the fishermen. Salminen (1991) considers losing of tags as the main source of errors in the estimation of tagging results. The percentage of lost tags depends on numerous factors and the estimates presented by different authors vary considerably. The estimate given by Issakson and Bergman (1978) is 10%, while Swain (1971) gives 17%, Arnason and Mills (1987) from 1 to 70%, and Earnes and Hino (1983) - less than 4%. According to the Report of the Baltic Salmon and Trout Assessment Working Group (ICES 1991), the percentage of tags lost by salmon in the Baltic proper ranged from 20% in 1988/89 season, to 10% in 1989/90 and 30% in 1990/91. Wiśniewolski and Nabiałek (1993) stated on the basins of tagging experiments of *Cyprinidae* kept in ponds that losing of tags may result in erroneous estimation of mortality. Therefore, these authors have proposed a correction for such errors by the application of a mathematical function which would consider the type of tag and the time which passed since the tagging experiment. The tag attachment to fish body is considerably affected by both, the tagging technique and the experience of a person performing the experiment (Shearer 1977).

The differences in percentage of tag returns dependent on the experience of a tagging person were threefold in the studies by Elson and Williamson (1972). Even bigger differences from 4 to 95% were mentioned by Ritter (1973).

The presence of tag in fish body may increase the catch of small fish due to tangling of the tag in the net (Sych and Bartel 1976).

The fact that tags are not returned by the fishermen also makes the tagging experiments more difficult (Porter 1979). With this respect, the information on tagging was spread among those involved. However, the response had a rather local character. Better results were obtained in the case of those regions where the contacts with fishermen were more frequent e.g. the region of Vistula estuary gave better results than the Pomeranian rivers.

The obtained results give rise to the question to what an extent the sea trout straying may affect the genetic purity of sea trout in Polish rivers. This problem should be dealt with separately for the populations of Vistula and Pomeranian rivers. As concerns the latter, the returns of migrating fish to the spawning grounds of rivers

into which they had been released as smolts is much less evident than in the case of trout released into the Vistula River. The smolts released into the Pomeranian rivers estuaries with low flow rate ($2.25 \text{ m}^3/\text{sec}$ at Reda estuary; $5.68 \text{ m}^3/\text{sec}$ - Łupawa; $14.6 \text{ m}^3/\text{sec}$ - Parsęta, Kostrzewa 1972), are less affected than the smolts released into the Vistula estuary, where the lowest average flow rate reaches $371 \text{ m}^3/\text{sec}$ (Kostrzewa 1972).

The smolts which have entered the Gulf of Gdańsk remain, for some time, in the stream of the Vistula. This factor may have a decisive influence on high percentage of sea trout returns to their mother river. The obtained results allow to state that the stocking of estuaries of the Pomeranian rivers with smolts leads to mixing of the populations. However, the share of Pomeranian trouts in population of the Vistula trout is insignificant.

The available materials do not allow to treat the trout from the Pomeranian rivers as one population; it cannot be excluded that the spawners originating from natural spawning or from stockings with fry might have visibly higher percentage of returns to their mother river. The sea trout which come from different rivers and enter the Vistula River are of less importance as they are more often caught in the lower Vistula, and only some individuals reach the spawning grounds. Possible influence of those spawners of foreign origin is reduced by increased numbers of smolts introduced into the Vistula River, which are 2-3 times higher than the number of smolts introduced into the Pomeranian rivers.

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STRESZCZENIE

HOMING ZNAKOWANYCH SMOLTÓW TROCI (*SALMO TRUTTA* L.) WYPUSZCZANYCH DO RZEK POLSKICH

Celem pracy było określenie stopnia „błędnego” wybierania rzeki przez tarlaki troci wędrującej na tarło i wypływu ryb „błądzących” na mieszanie populacji troci w polskich rzekach.

W pracy wykorzystano wyniki znakowania 183 000 smoltów troci wypuszczanych w latach 1961-1986 do rzek pomorskich, Wisły i do Zatoki Gdańskiej (tab. 1, rys. 1).

Z wypuszczonych smoltów otrzymano 10 116 znaczków z odłowionych ryb. Procenty zwrotów z poszczególnych partii znakowanych ryb wahały się od 0,0 do 33,8.

Procent zwracanych znaczków z ryb odłowionych najwyższy był ze smoltów wypuszczonych do Zatoki Gdańskiej (12,6); wysokie procenty zwrotów otrzymano z ryb wypuszczonych do dolnej Wisły i dolnej Drwęcy odpowiednio 10,2 i 9,0, a najniższe z górnej Drwęcy i dopływów górnej Wisły odpowiednio 2,7 i 1,1% (tab. 1). Ze smoltów troci wypuszczanych do rzek pomorskich średnie procenty zwrotów były niskie i wahały się od 0,7 do 5,8 (tab. 1).

Ze smoltów wypuszczonych do środkowej, dolnej Wisły i jej ujścia oraz do dopływów górnej Wisły żaden z tarlaków troci wędrującej w górę Wisły nie wpłynął do Drwęcy (rys. 2-5). Natomiast ze smoltów

troci wypuszczonych do Drwęcy tarlaki były łowione jedynie w dolnej Wiśle i Drwęcy, żadna z tych troci nie była złowiona w Wiśle powyżej ujścia Drwęcy (rys. 6-7).

Najwyższe procenty zwrotów z ryb łowionych w wodzie słodkiej notowano ze smoltów w wypuszczonych do dolnej Drwęcy i do dopływów górnej Wisły, powyżej 50%. Z innych 4 miejsc zarybienia Wisły i górnej Drwęcy wahał się od 32,5 do 37,8%.

Procent tarlaków złowionych w rzece macierzystej - Wiśle w stosunku do zwrotów słodkowodnych był bardzo wysoki i wynosił od 94,0 do 99,3 (tab. 1).

Wraz ze wzrostem odległości miejsca zarybienia od morza zmniejszał się procent ryb łowionych w ujściu Wisły i dolnej Wiśle, a zwiększał się w środkowej Wiśle (rys. 2-5).

Ze smoltów troci wypuszczonych do rzek pomorskich procent ryb łowionych w wodzie słodkiej był niski i wahał się od 0,1 do 2,1 (tab. 1). Udział zwrotów z wody słodkiej w stosunku do ogólnej liczby zwrotów był również niski i wynosił od 10,7 do 29,8 (tab. 1). Procent ryb powracających do rzeki macierzystej był wyraźnie niższy niż w przypadku zarybienia Wisły i wynosił od 0,0 (Łupawa) do 80,2 (Łeba) (tab. 1, rys. 8-13).

Tarlaki troci ze smoltów wypuszczonych do zatoki Gdańskiej były poławiane w większości rzek polskich (rys. 14).

Adres Autorów:

Dr Piotr Dębowski

Prof. dr hab. Ryszard Bartel

Instytut Rybactwa Śródlądowego

Pracownia Rybactwa Rzecznego

ul. Reduta Żbik 5

80-761 Gdańsk