

# Distribution, migrations, and growth of tagged sea trout released into the Vistula River

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**Abstract.** The aim of the study was to determine the distribution, migrations, and growth of summer Vistula sea trout, *Salmo trutta* L., released as smolts into the lower Vistula River. During the 1972-1977 period, 16985 2+ smolts with external tags were released, and 1696 tag returns were obtained (10.0%), including 1412 returns from sea trout whiting (8.3%) and 284 (1.7%) from smolts and post-smolts. Almost immediately after being released into the Vistula River, the sea trout smolts descended to the sea and then migrated throughout the Baltic mainly toward the east reaching the Bothnian Bay and the Gulf of Finland. These fish were mainly caught in the southern Baltic, especially in the region of the Gdańsk Bay and the Vistula River mouth in the second year after stocking (65.7%). They were noted in the southern part of the Gdańsk Bay and the Vistula River mouth more frequently in the first year after stocking during the period from November to March, while in the second year after stocking more were noted during the period from July to March. Most of the tag returns were received from Polish fishers (80.7%). One year after stocking the sea trout had attained a mean body length of 57 cm and a mean weight of 1523.3 g. The mean lengths and weights two and three years after stocking were 69.6 cm and 4355.7 g and 78.7 cm and 6035.7 g, respectively.

**Keywords:** sea trout, tagging, stocking, distribution, migration, growth

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## Introduction

Before World War II, sea trout, *Salmo trutta* L., was caught in abundance in the fishing grounds of the Dunajec (Dixon 1924a, 1924b) and the Raba (Lubecki and Dixon 1925) rivers. In the 1950s and 1960s, this species could still migrate to the Dunajec and Raba rivers, both of which are mountain tributaries of the Vistula (Bartel 1969, Skrochowska 1969, Pałka and Bieniarz 1983). Deteriorating environmental conditions caused by, among other factors, river pollution, gravel excavation, stream regulation, and deforestation, led to fewer and smaller spawning grounds (Bartel 1993a, 1993b) and smaller numbers of smolts descending to the sea. The number of smolts descending the Vistula to the sea in the mid twentieth century was estimated at 0.5 to 1 million individuals (Backiel and Bartel 1967). The number of spawners noted in the spawning grounds of the upper Vistula tributaries also decreased, and the last specimens were observed in the Raba and the Dunajec in 1968 (Bieniarz and Łysak 1975, Bartel 2006). The dam built on the Vistula River in Włocławek in 1968 halted all sea trout migrations to the upper regions of the Vistula River. This led to decreased sea trout catches in the Vistula, particularly upstream from the dam, where they fell to nearly zero (Wiśniewolski 1992, Bartel et al. 2007).

There are two sea trout populations inhabiting the Vistula River, and they are distinguishable by the

times at which they begin spawning migrations (Żarnecki 1964). The summer sea trout population begins its spawning migration upstream in June and it lasts until early September. The fish have enlarged gonads and are in partial breeding colors. Winter sea trout ascend the Vistula from November to February, and these individuals have silver coloring and immature gonads. The summer sea trout spawn in the same year that they ascended the river, while the winter sea trout spawn in the following year. Sea trout smolt with external tags are released into Polish rivers to track their migrations, and in the 1968-1998 period, more than 300000 sea trout smolts were tagged. The current paper was written based on experiments conducted in the 1970s, and compared to the studies conducted recently, a large number of tags were returned. The aim of the current study was to determine the distribution, migrations, and growth of sea trout smolts released into the lower Vistula River in the 1972-1977 period.

## Materials and Methods

The sea trout smolts were reared at the Stocking Center of the National Association of Fisheries Co-operatives in Kwidzyn and tagged at the Laboratory of River Fisheries, Inland Fisheries Institute and by students of the Faculty of Fisheries of the University of Agriculture in Olsztyn. The fish were fitted with Carlin tags. During the 1972-1977 period, 16985 2+ summer sea trout smolts measuring from 11 to 28 cm were released into the Vistula River near Kwidzyn (N 53 44 59,0; E 18 51 27,7) (Fig. 1).

The distribution and migrations of the tagged sea trout were considered within the parameters of ICES sub-divisions. ICES sub-division 26 and the lower Vistula were designated as the Vistula mouth, which includes the region between km 936 and 941, and the Gdańsk Bay, which includes the area within a radius of one nautical mile from the Vistula mouth. There were 1696 tag returns from the smolts that were released. Some of the tags (284) came from smolts and postsmolts, or fish that were caught in the

same year of release. The other 1412 tag returns came from fish that were caught after this period (Table 1). Tag returns from the experiment conducted in 1972 were used to determine smolt descent (74 tag returns) and sea trout migrations (1082 tag returns). Length and weight growth were determined based on 972 and 1078 returns, respectively.

## Results

### Tag returns

A total of 1696 tag returns (10%) were obtained from the 16985 smolts released into the Vistula River in the 1972-1977 period. Of these returns, 284 tags (1.7%) came from smolts and postsmolts, and 1412 (8.3%) from sea trout whiting. The number of returns in the different experiments varied from 0 to

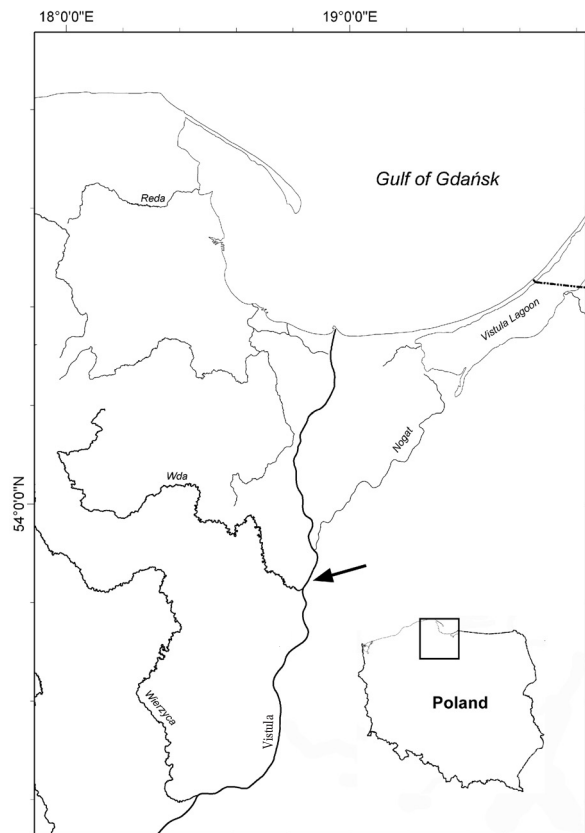


Figure 1. Release location of tagged smolts.

**Table 1**

Characteristics of hatchery-reared Vistula sea trout smolts released into the Vistula River at Korzeniewo and Carlin tag returns

Date	N	Mean (cm)	Range (cm)	Tag returns			
				sea trout whitling		smolts and postsmolts	
				indiv.	% returned	indiv.	% returned
18 Apr 1972	9984	17.4	11 - 24	1063	10.6	217	2.2
26 Apr 1973	2468	18.1	15 - 26	216	8.8	53	2.1
10 Apr 1974	2033	17.0	14 - 28	77	3.8	6	0.3
27 Apr 1976	1200	17.0	14 - 24	17	1.4	0	0
15 Mar 1977	1300	17.0	15 - 23	39	3.0	8	0.6
Total	16985	17.4	11 - 28	1412	8.3	284	1.7

2.2% for smolts and postsmolts and from 1.4 to 10.6% for sea trout whitling (Table 1).

### Seasonal distribution

The smolts released into the Vistula River near Korzeniewo immediately descended to the sea. In the first five days following release, 63.5% of the tag returns came from fish caught in the Vistula mouth or the Gdańsk Bay in the vicinity of the river mouth (Fig. 2). The fastest swimming sea trout ( $37 \text{ km d}^{-1}$ ) were caught near Mikoszewo on the third day following release. Over the next 15 days, 20.3% of the returns came from smolt caught in the vicinity of the Vistula River mouth and the Gdańsk Bay, while over the subsequent 40 days four tags were returned from this region, and one individual swam towards the north (Fig. 2).

In the first year following stocking, descending smolt were caught mainly in April and May. The smolt were noted more frequently in the Vistula mouth in April (38.4%) than in May (22.9%). However, to the east of the Vistula mouth sea trout were caught more frequently in May (71.4%) than in April (59.4%) (Fig. 3a-b). Tagged smolts were caught sporadically from June to September in the vicinity of the Vistula mouth, and they were also noted in the central and eastern parts of the main basin (Fig. 3c-f). The number of sea trout caught increased beginning in October, and 55.6% of tag returns from then until

December came from fish caught in the Vistula mouth and to the east of it. Single specimens reached the Bothnian Bay and the Gulf of Finland as well as the western parts of the main basin. Single specimens also entered the Vistula (Fig. 4a-c). In the winter of the first year following release, few specimens (17.0%) were noted outside the Vistula mouth region and the southern part of the Gdańsk Bay, and 79.3% of the tag returns came from these regions. Single specimens also entered the Vistula River (3.7%, Fig. 4e-f).

In the spring of the second year following stocking, tagged sea trout were caught mainly in the southern Baltic and the Gulf of Finland (Fig. 5a-c). Increased sea trout catches were noted in the Vistula mouth and to the east of it, and 56.8 and 68.3% of tag returns, respectively, came from these areas in April and May. In June, sea trout were caught in the western Baltic and Kattegat. The numbers of sea trout caught increased in summer. In July and August, they were caught in the southern Baltic, and in September they were also caught around the island of Gotland (46.4% of returns). In the fall of the second year following stocking, catches of sea trout were high. Nearly 42% of tag returns were noted from the vicinity of Gotland, which includes ICES sub-divisions 27 and 28 (Fig. 6a-c). In November and December, the sea trout moved around the southern Baltic. The percentage of tag returns from the vicinity of the Vistula mouth and the area to its east increased from 32.6% in October to 92.2% in December. In

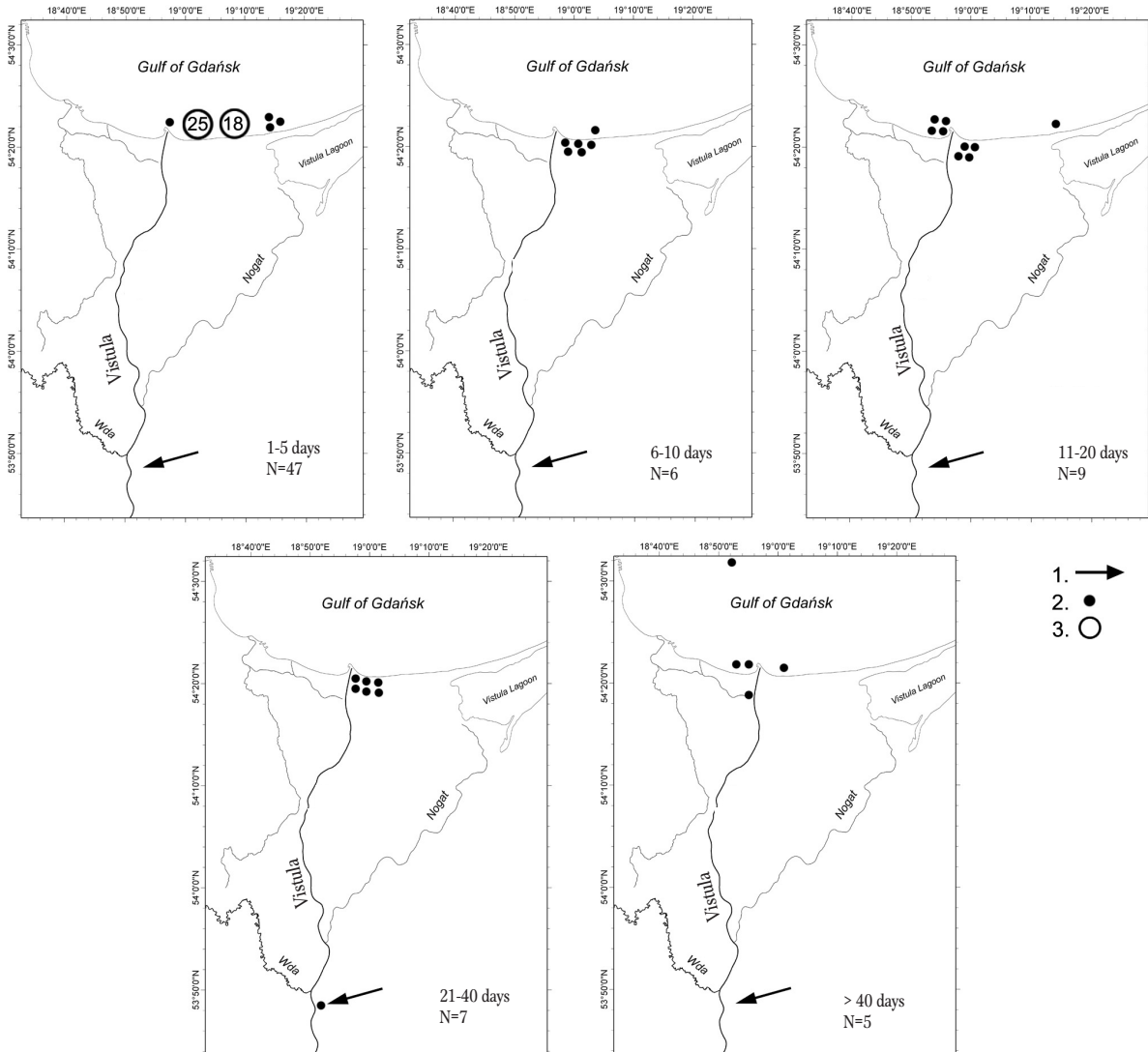


Figure 2. Catch sites of tagged smolts released in 1972: 1 – release site; 2 – catch sites of single specimens; 3 – sites of most catches, N – number of tag returns.

January, 99% of the sea trout returns came from the southern part of the Gdańsk Bay. The concentrations of sea trout were especially high in the Vistula mouth and to the east of it with a combined total of 86.6% of tag returns. Similar sea trout distribution was observed in February. Catches of sea trout in the Vistula mouth and the Gdańsk Bay decreased in March to 52.9%. In February and March, sea trout migrated to the north and west.

In the spring of the third year following stocking, few specimens were noted outside of the southern

part of the Gdańsk Bay (Fig. 7). The decided majority (from 52.4 to 57.1%) came from the Vistula mouth. They entered the Vistula in abundant numbers (from 22.2 to 33.3% of tag returns). In July and August, the sea trout were almost exclusively caught in the Vistula River and its mouth, and numerous specimens also reached the dam in Włocławek in August. In September, the few sea trout caught mostly came from the Vistula and its mouth (Fig. 7). In subsequent months of the third and fourth years following stocking, the quantity of tagged sea trout caught

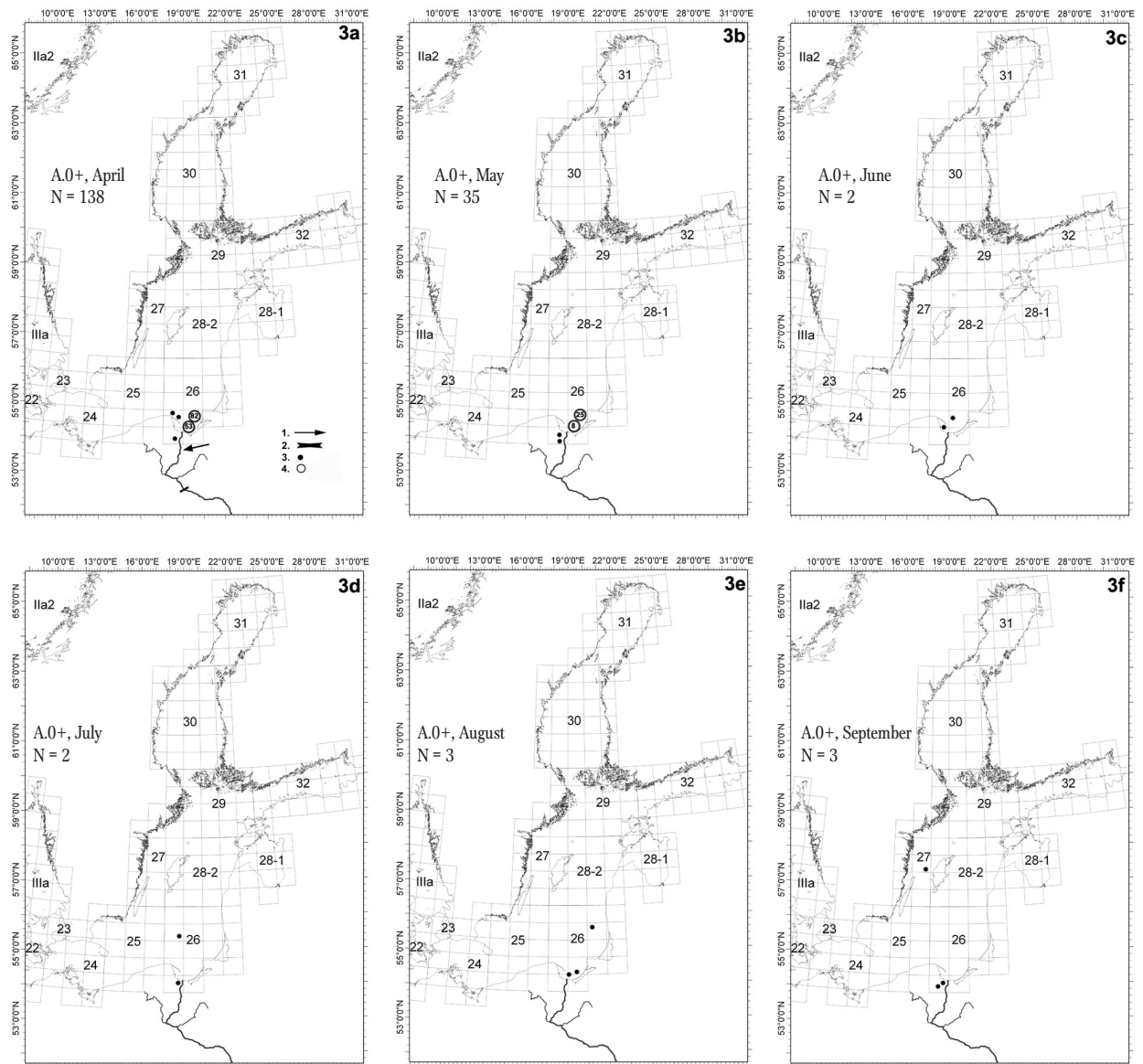


Figure 3. Catch sites of tagged Vistula trout aged A.0+ in the April-September period, N – number of sea trout caught. 1 – smolt release site in Korzeniewo; 2 – dam across the Vistula in Włocławek; 3 – catch sites of single specimens; 4 – numbers in circles indicates how many specimens were caught.

decreased. Sea trout catches in the fall of the third year were primarily from the southern Baltic (Fig. 8a), while in winter they were from the southern part of the Gdańsk Bay and the Vistula, in which sea trout catches were only recorded in March (Fig. 8b). In the fourth year from April to December, sea trout catches were noted almost exclusively in the Vistula and its mouth (Fig. 8c).

### Geographical distribution

Sea trout were caught most frequently in the Vistula mouth and the adjacent area of the Gdańsk Bay (35.1%) and in the Vistula (15.2%), where the sea trout reached the dam in Włocławek (Fig. 9). In the Baltic, the most sea trout were caught in ICES sub-division 26 (32.5%), while 3.4 and 5.7% of the sea trout were caught in ICES sub-divisions 27 and



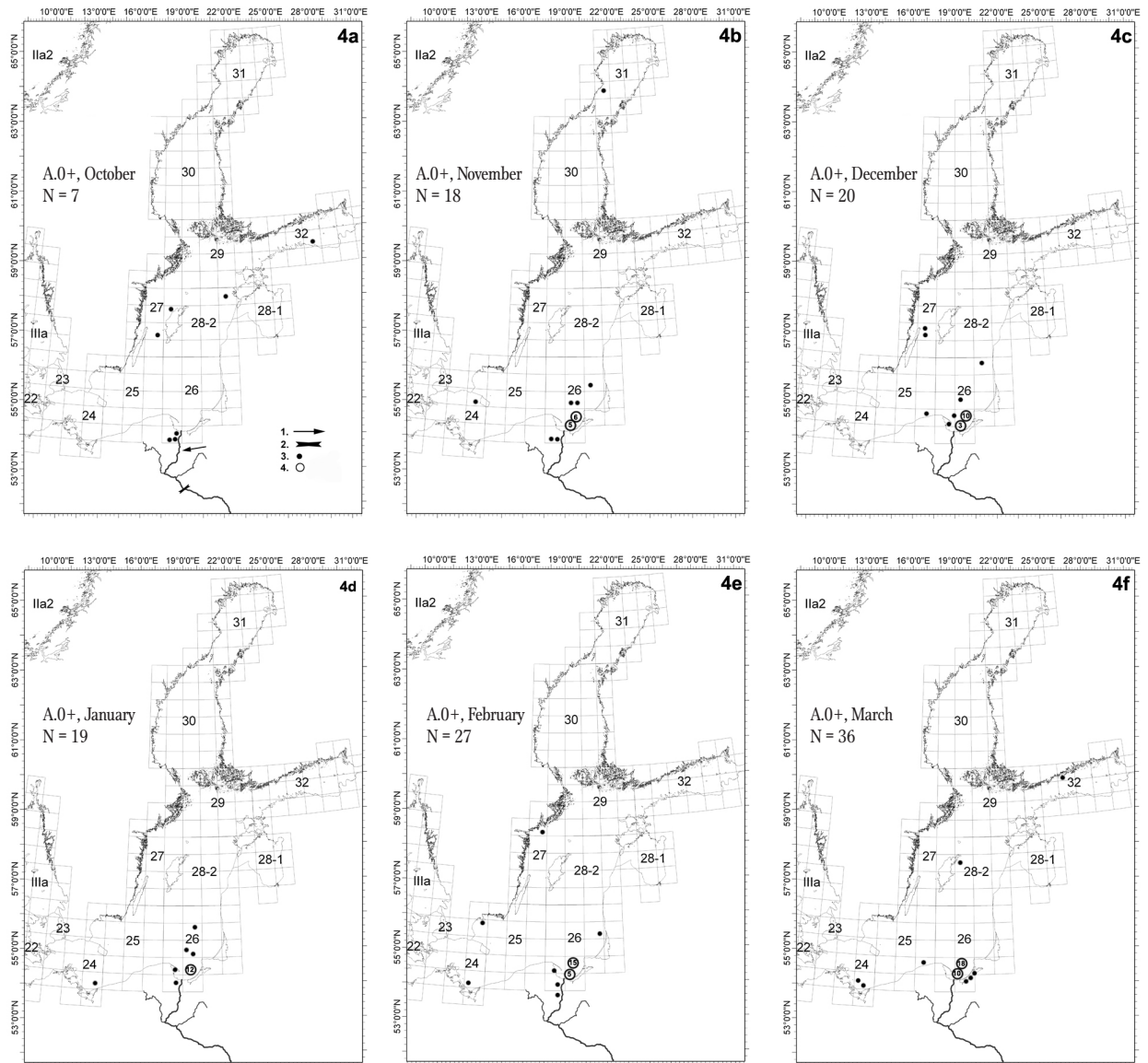


Figure 4. Catch sites of tagged Vistula trout aged A.0+ in the October-March. For legend see Figure 3.

28, respectively. The Vistula sea trout exhibited a tendency to move towards the northeast into ICES sub-divisions 27 to 32. They reached the Bothnian Bay and Gulf of Finland sporadically. They migrated towards the west less frequently, and 4.1% of tags were returned from ICES sub-divisions 21 to 25. A few specimens reached the Danish Straits and Kattegat (Fig. 9). The most tagged sea trout were caught in the second year following stocking (A.1+, 65.7%), while 15.6 and 14.6% of the sea trout were

caught in the first (summer-winter) and third (spring-winter) years following stocking, respectively. The catch share of fish aged A.3+ and A.4+ was 2.2 and 1.8%, respectively. The distribution of the tagged sea trout impacted their catch by Baltic fishers, and the most Vistula sea trout were caught by Polish fishers (80.7%). The remaining catches were made mainly by Danish (8.1%) and Swedish (5.9%) fishers.

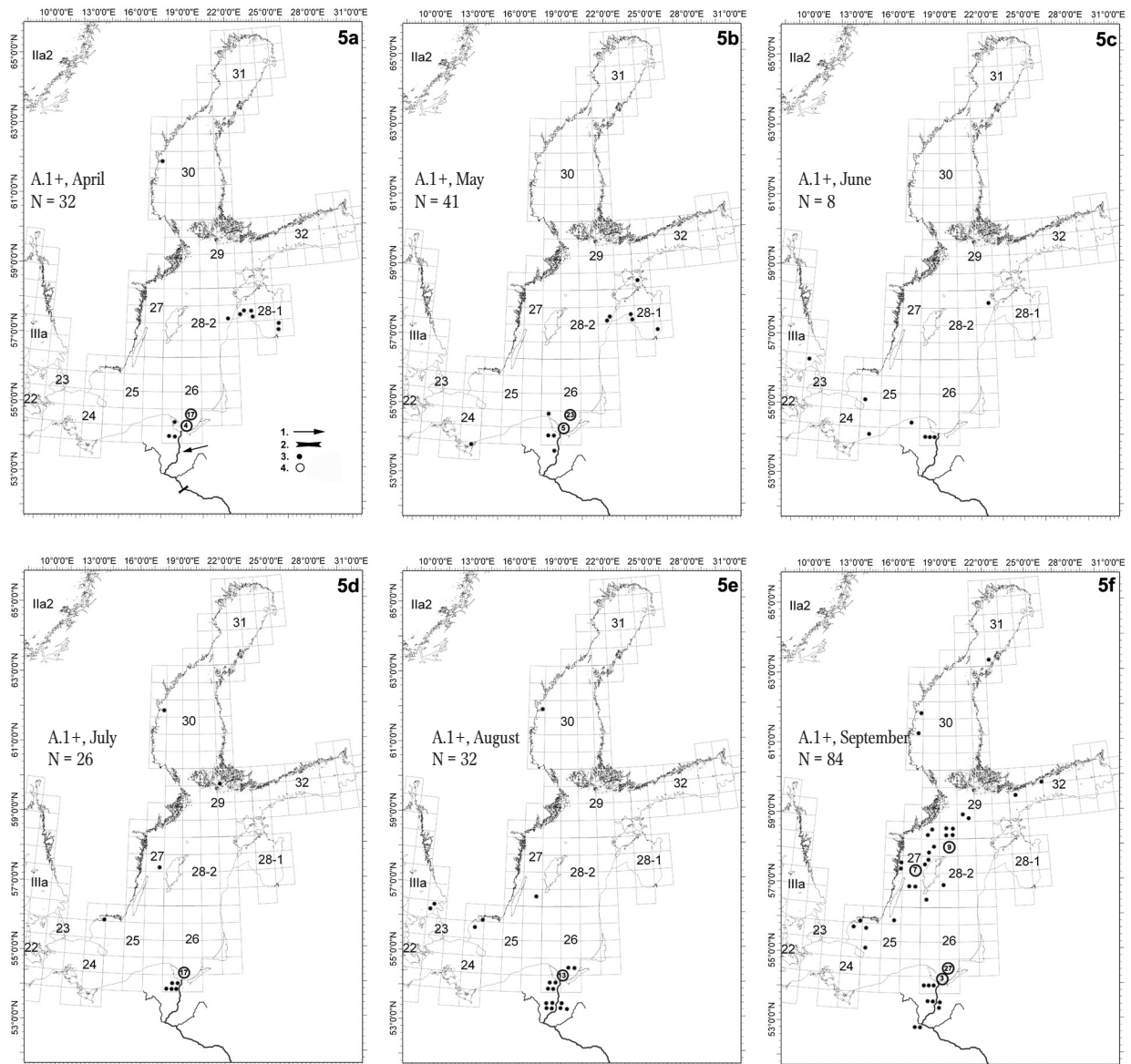


Figure 5. Catch sites of tagged Vistula trout aged A.1+ in the April-September period.

### Tagged sea trout growth

In the winter of the first year following stocking during the period from November to March, the sea trout achieved a mean length of 51 cm (range from 37 to 65 cm) and a mean weight of 1523 g (range from 700 to 2800 g). In the second year, they achieved a mean length of 69.6 cm (range from 44 to 92 cm) and a mean weight of 4356 g (range from 1500 to 9000 g). However, in the third year, the mean sea trout weight

was 6036 g (range from 2100 to 10500 g), and the mean length was 78.7 cm (range from 55 to 95 cm). The largest specimens had achieved a length of 95 cm and a weight of 10500 g (in January of the third year following stocking), 93 cm and 9500 g (in February of the third year), 91 cm and 11000 g (in July of the fourth year), and 91 cm and 9200 g (in May of the fourth year). It was confirmed that the length (Fig. 10) and weight (Fig. 11) of sea trout caught in subsequent years following stocking depended on the length of the

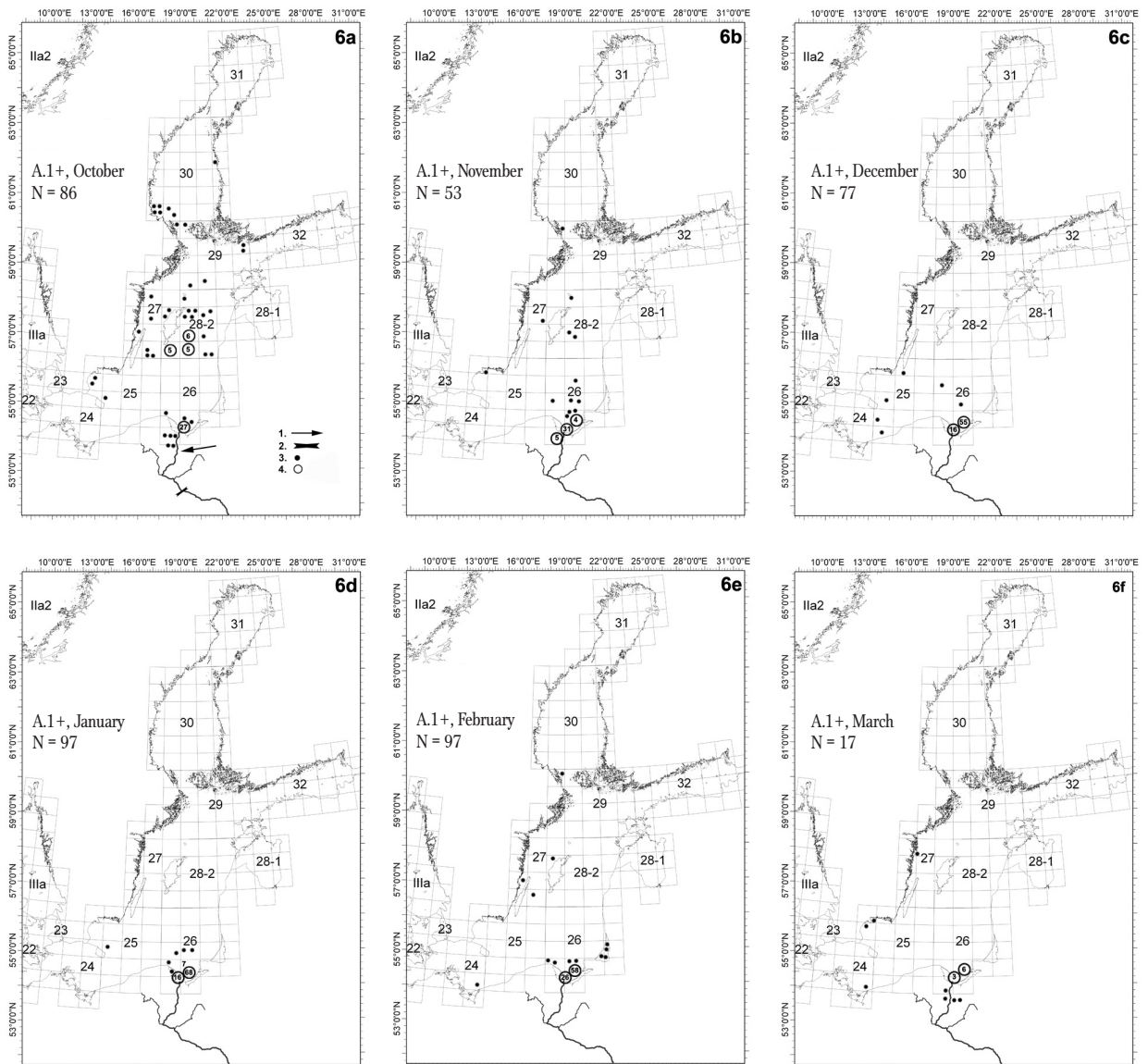


Figure 6. Catch sites of tagged Vistula trout aged A.1+ in the October-March period.

smolts released, and the longer stocking material length translated into greater mean weight and length of the sea trout adults.

## Discussion

The percentage share of tag returns (from 1.4 to 12.8) in the experiments described was similar to that

obtained in previous studies with sea trout released into the Vistula River (Backiel and Bartel 1967, Bartel 1988b, Bartel and Dębowski 1996). The Vistula sea trout smolts released at Korzeniewo immediately descended to the sea. Similar behavior was noted among sea trout smolts released into the Dunajec (Żarnecki 1937) and Raba (Skrochowska 1969) and among salmon, *Salmo salar* L., smolts released into the Drawa (Bartel 1987). The smolts discussed in the current paper as well as those released



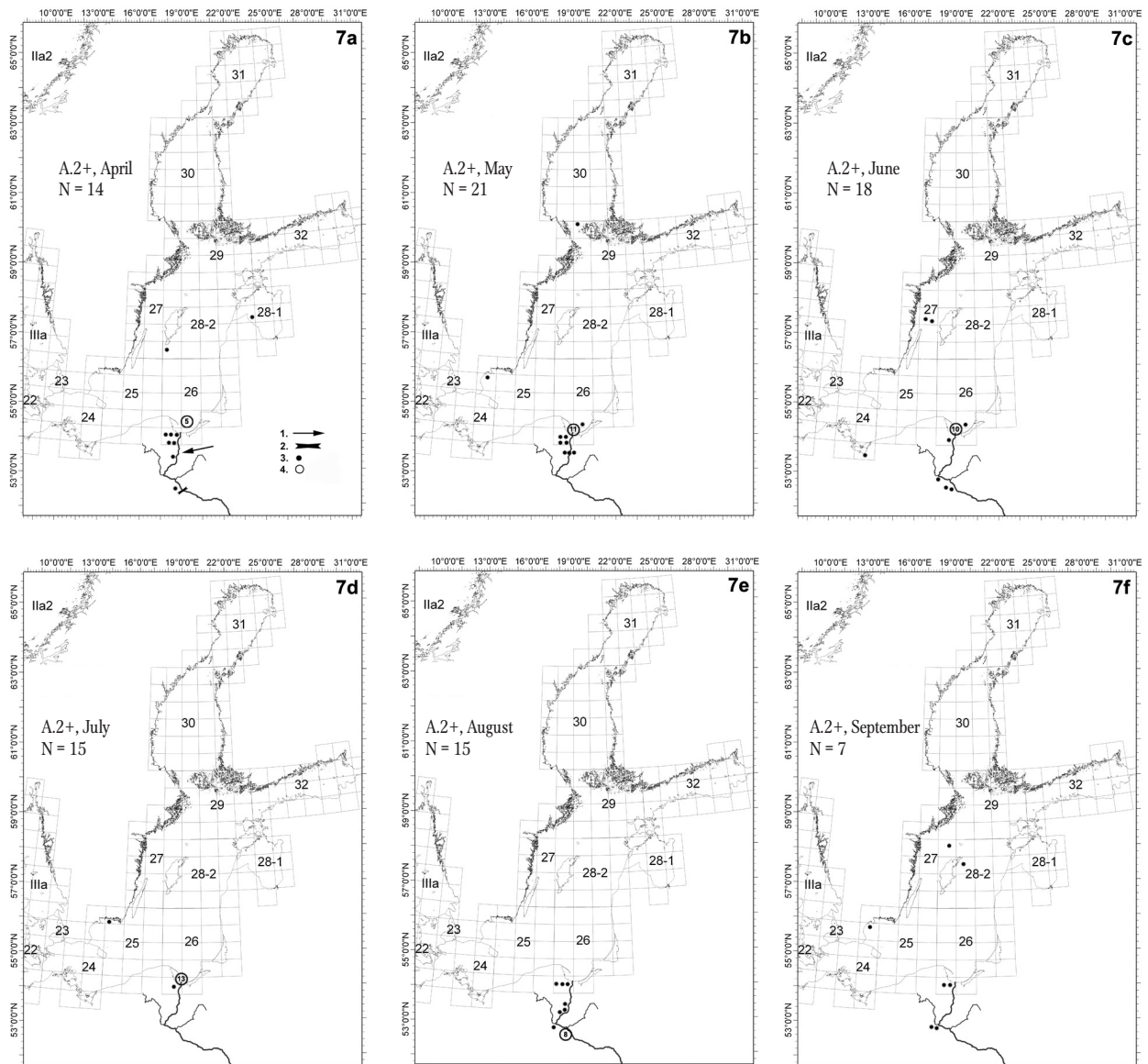


Figure 7. Catch sites of tagged Vistula trout aged A.2+ in the April-September period.

in earlier stocking events in the Vistula and its Raba and Dunajec tributaries first migrated towards the east and then to the north (Żarnecki 1937, Skrochowska 1969). Similar tendencies were noted in sea trout released into Pomeranian rivers (Żarnecki and Duszyński 1961, Bartel 1988a). The tendency for sea trout to migrate along the Vistula Spit after entering the sea can be explained by these fish remaining in the stream of Vistula waters and by

the impact of constant currents that run along the southern coast of the Baltic Sea (Demel 1951).

Sea trout from the rivers of the southern Baltic basin undertake significant migrations, and a considerable percentage of sea trout from the Vistula and Pomeranian rivers are caught far from the Polish coast (Backiel and Bartel 1967, Skrochowska 1969, Pałka and Bieniarz 1983, Bartel 1988a). The sea trout released into the Vistula at Korzeniewo remained primarily in the region of the Gdańsk Bay

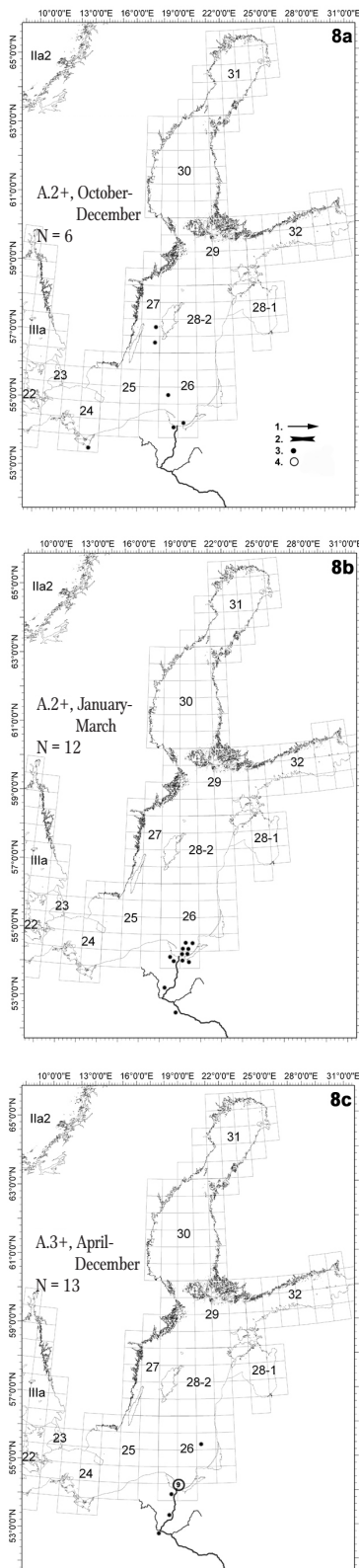


Figure 8. Catch sites of tagged Vistula trout aged A.2+ in the October-March period, and aged A.3+ in the April-December period.

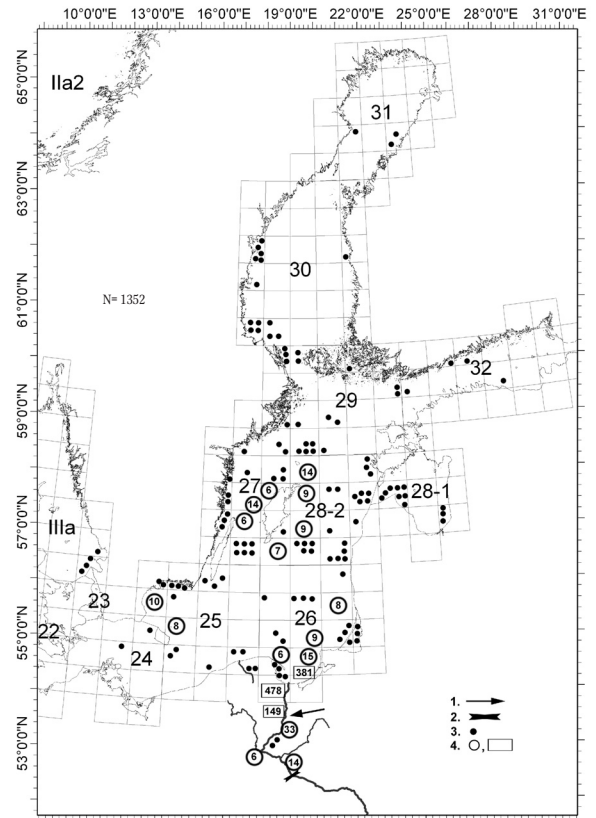


Figure 9. Catch sites of sea trout whiting tagged Vistula trout released in 1972-1977 into the Vistula River near Korzeniewo: 1 – smolt release site; 2 – dam in Włocławek; 3 – catch sites of single specimens; 4 catch sites of more specimens; N= number of tag returns.

and the Vistula mouth. Only in September and October in the second year following stocking was a substantial percentage of them noted outside the area of the Gdańsk Bay and Vistula mouth, mainly in the vicinity of Gotland. While sea trout from Polish rivers undertake distant migrations, those from Finnish rivers only migrate short distances (Ikonen and Auvinen 1984b), and it is plausible that these differences in the distribution of sea trout are influenced by the open shape of the Polish coastline and that of the Finnish coast, which has numerous islands and bays. This hypothesis would be confirmed by the results of releasing sea trout smolts from the Finnish Isojoki River (Gulf of Finland) reared at the Hanka Taimen hatchery into the Vistula mouth. More than 79% of these sea trout were caught in ICES sub-division 26, while 64.5% of the Vistula sea trout

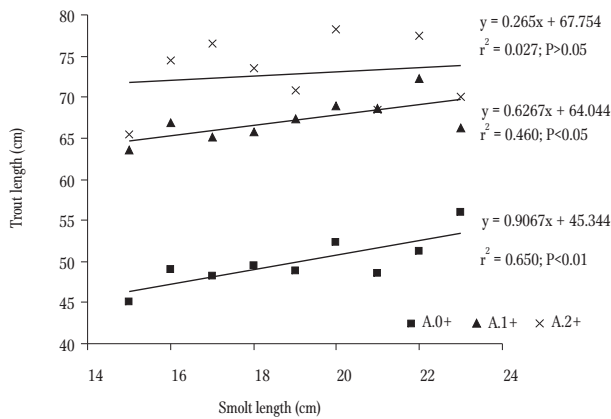


Figure 10. Dependence between length of sea trout caught and the length of smolts released: A.0+, A.1+, A.2+ – mean length of sea trout whiting in subsequent years following release.

were caught in this sub-division. Of the Finnish sea trout released into the Gulf of Finland near Helsinki, more than 71% were caught in the Gulf of Finland (Bartel et al. 2001).

The sea trout in the experiments discussed herein were characterized by similar length and body weight growth in comparison to sea trout released earlier into the Vistula, Dunajec, and Raba rivers (Backiel and Bartel 1967, Pałka and Bieniarz 1983) and to salmon from rivers that flow into the Gulf of Finland and the Bothnian Bay (Ikonen and Auvinen 1984b), but growth was faster than that of sea trout from the Reda (Bartel 2000) and Grabowa (Bartel 1988a) rivers. The length and weight growth of sea trout whiting depended on the length of the smolts released. Pałka and Bieniarz (1983) noted a similar dependency among tagged sea trout released into the Dunajec River, and concluded that there is a statistically significant correlation between the length and weight of smolts and those of the specimens they grew into.

The most tagged Vistula sea trout was caught in the Vistula mouth in the second half of the year. This finding concurs with the results of studies on the occurrence of sea trout in the Vistula mouth in the 1992-1994 period (Bartel et al. 1996). Pałka and Bieniarz (1983) also confirmed in the 1960s that sea trout returned to the Vistula River from the Dunajec at various intensities throughout the year. Slightly different results were obtained by Żarnecki (1964), who studied commercial catches of sea trout in the Vistula

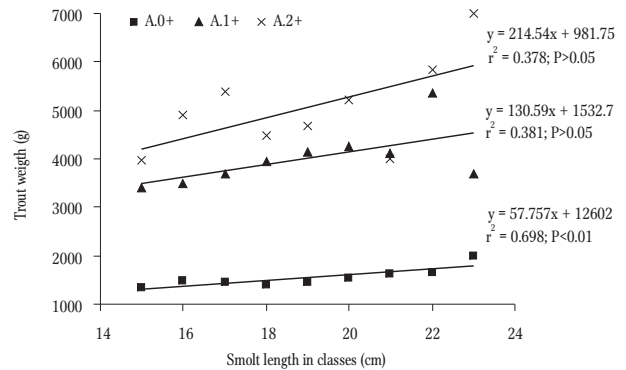


Figure 11. Dependence between weight of sea trout caught and the length of smolts released: A.0+, A.1+, A.2+ – mean weight of sea trout whiting in subsequent years following release.

mouth, and, according to him, the summer sea trout spawning run begins in the Vistula mouth in June and then usually ends in the first half of October. In other months, winter trout were noted almost exclusively.

Most of the tagged sea trout from Korzeniewo were caught in the second year following release. Similar results were obtained by the following: Skrochowska (1969) for sea trout, a sea trout × rainbow trout hybrid, and brook trout released into the Raba; by Pałka and Bieniarz (1983) for sea trout from the Dunajec; Bartel (1987) for salmon from the Drawa. Backiel and Bartel (1967) reported similar results and concluded that most marine and lake sea trout were caught in either the second or the second and third years of life in the sea. Bartel (1988a) noted a different tag return distribution in subsequent years following the release of sea trout into the Grabowa and Wieprza rivers. Most of these sea trout (52.9%) were caught in the first year following release. Most of the rainbow trout, *Oncorhynchus mykiss* Walbaum, released into the Vistula mouth or the Gdańsk Bay were caught either in the first or first and second years following stocking (Bartel 1981). Similar results were obtained by Bartel and Dębowski (1996) for sea trout from the Vistula and Pomeranian Rivers; according to them, most catches of sea trout from Vistula basin stocking were made in the second year following release (39%), while most catches were noted in Pomeranian rivers in the first year following release (56%).

## Conclusions

1. The sea trout smolts descended to the sea immediately after release.
2. Vistula sea trout concentrated in the southern Baltic, mainly near the Gdańsk Bay and the Vistula mouth, which is where 65% of sea trout whitling tag returns were obtained.
3. Vistula sea trout were caught mainly in the second year after stocking.
4. The tagged sea trout released near Korzeniewo were characterized by very fast growth rates. In the third year following release they achieved a mean body weight of 6036 g and length of 78.7 cm.
5. Sea trout growth was correlated with the size of the smolts released. Longer smolts at release grew into adult sea trout with greater mean weights and lengths.

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## Streszczenie

### Rozsiedlenie, wędrówki i wzrost znakowanych troci wiślanych wypuszczonych do Wisły

Celem pracy było określenie rozsiedlenia i wędrówek oraz wzrostu troci wiślanych *Salmo trutta* L. letnich wypuszczonych jako smolty do dolnej Wisły. W latach 1972-1977 wpuszczono 16985 dwurocznych smoltów poznakowanych znaczkami zewnętrznymi. Otrzymano 1696 zwrotów (10,0%), w tym 1412 (8,3%) zwrotów z ryb starszych i 284 (1,7%) ze smoltów i postsmoltów. Smolty troci po wypuszczeniu do Wisły niemal natychmiast zaczęły spływać do morza i dalej wędrowały po całym Bałtyku, głównie w kierunku wschodnim docierając do Zatoki Botnickiej i Fińskiej. W największym

stopniu były poławiane w południowym Bałtyku, a szczególnie w rejonie Zatoki Gdańskiej i ujściu Wisły, w drugim roku po zarybieniu (65,7%). W okolicach ujścia Wisły i w południowej części Zatoki Gdańskiej były obserwowane częściej w pierwszym roku po zarybieniu w okresie od listopada do marca, natomiast w drugim roku w okresie od lipca do marca. Najwięcej zwrotów znaczków otrzymano od polskich rybaków (80,7%). Po pierwszym roku od zarybienia trocie osiągnęły średnią długość ciała 57 cm i masę 1523,3 g, po drugim 69,6 cm i 4355,7 g, a po trzecim 78,7 cm i 6035,7 g.