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RESULTS OF STOCKING OF THE BALTIC SEA WITH TAGGED RAINBOW TROUT (*SALMO GAIRDNERI* RICH.)

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45321 tagged rainbow trouts were released to the Baltic Sea, mainly to Vistula Firth, and to a few Polish rivers, mostly to the Vistula. Average returns were 8.8%, ranging from 0 to 30%. Tag returns depended on time and place of fish release, fish size and age.

INTRODUCTION

Industrial development and intensification of agriculture result in unfavourable changes in the aquatic environment. Due to excessive discharge of sewage and pollutants into the rivers, exceeding their self-purification potential, living conditions in the rivers deteriorate considerably, especially as regards the salmonids. Moreover, river regulation and development for irrigation and energy production prevent salmonid migrations to the spawning grounds, while the existing fish passes frequently are not functioning properly. As a result, natural smolt production decreases rapidly. These phenomena are observed in all rivers of the Baltic Sea catchment area. Some rivers became totally, other partly excluded from smolt production (ICES 1975).

In order to compensate for these losses rivers and the sea are stocked with sea trout and salmon smolts obtained from artificial breeding. This system of management the salmonid stocks becomes more and more popular in the Baltic Sea area, where salmon and sea trout catches depend to a large extent on stockings with the smolts. This type of management requires proper supply of the fish eggs, which is frequently difficult, ac

exemplified by sea trout from the River Vistula. In the recent years amounts of obtained trout eggs were not sufficient (Bartel 1976b, Bartel and Zieliński 1977, 1978, 1979, 1981, 1982). The problem can partly be solved by breeding the spawners in ponds (Skrochowska 1953, Bartel unpubl. data). Fish rearing up to the smolt stage is connected with considerable losses, frequently reaching in Polish conditions 60–95% (Bartel and Zieliński 1978, 1979, 1981, 1982).

In order to compensate for decreasing salmonid catches, experiments have been undertaken to introduce new specias into the Baltic Sea area.

In the Soviet Union attempts were made to introduce *Oncorhynchus gorbuscha* and sturgeons into the Baltic Sea catchment area, the results being quite good. Single specimens were caught even in Polish waters (Bartel 1968, Kairov 1975, Smirnov and Kamyšnaja 1975, Radziun K. and Radziun M. 1976).

Attempts to introduce rainbow trout into the Baltic Sea have had a longer tradition. They were undertaken by Meyer (1939) and Kulmatycki (1940) already before the II-nd World War. In both experiments only a few fishes were tagged, and the returns were very low. After the war attempts to introduce rainbow trout into the sea were carried out in Finland, but the returns were low (Toivonen – personal com.). Also the Federal Republic of Germany released 500 g rainbow trouts into Kiel Bay. The fishes migrated as far as the Norwegian coast (Instit. f. Küsten u. Binnenfisch. 1970).

In Poland the Sea Fisheries Institute undertook experimental introduction of rainbow trout into the Gulf of Gdańsk. However, due to very low returns the experiments were interrupted (Chrzan and Mańkowski – personal com.). As a results of satisfactory introduction of sea trout by the Inland Fisheries Institute in 1963 (Backiel and Bartel 1967) this Institute undertiik another experiment on introducing rainbow trout into the Gulf of Gdańsk. Other experiments were undertaken in 1971–1973 by the Agricultural Academy in Szczecin, which released 28 180 one-year old trouts into the Grabowa River, Bay of Szczecin and Pomerania Bay (Trzebiatowski, 1979).

This paper present the informations on survival of the released rainbow trout, and determines the factors affecting percentage of tag returns.

MATERIAL AND METHOD

Totally 45321 tagged rainbow trouts were released in 1963–1980, mainly to the Vistula mouth at Świbno, to the Gulf of Gdańsk near Gdańsk, near Jastarnia toward the open sea, and near mouths of the rivers Słupia and Wieprza. Age of the released fishes was 0+, 1 and 2 years, their length (*long. caud.*) varied from 11 to 49 cm. Moreover, trouts were also released to the middle Vistula (Nieszawa), to rivers Reda, Łeba, Drawa, Dunajec, to Puck Bay, Vistula Firth, Baltic Sea at Mielno, and to lakes Żarnowieckie and Lubowidzkie (Tab. 1, Fig. 1).

The fishes were tagged with silver tags, oval or rectangular celluloid tags 15 x 5 mm. Transparent and non-transparent tags used were white, blue, red and rosy. The tags were

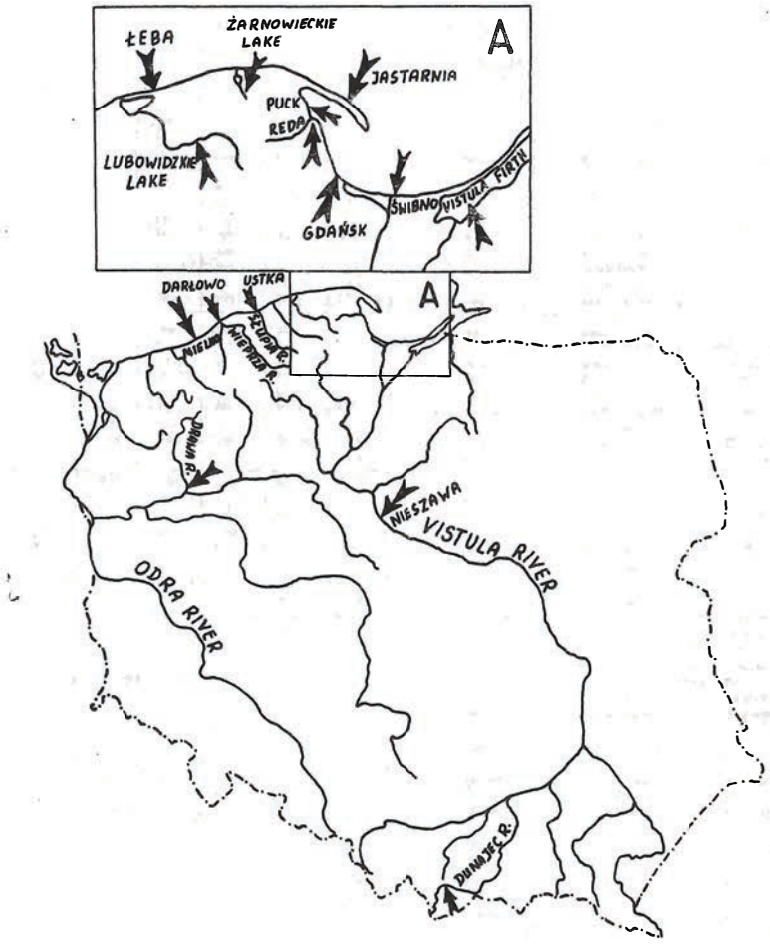

Fig. 1. Sites of releasing the rainbow trout (marked by arrows)

attached with silver or monel wire under the dorsal fin, in its front part between the second and the third basal ray (Bartel, 1963,1975). In 1968 the fishes were anaesthetized with urethan, and in the next years – with MS 222. After tagging the fishes were kept for at least 8 hours in flowing water.

Tag returns from "younger" fishes, i.e. those caught during the first 3–4 months after the release (till the end of July), and from "older" ones, i.e. those caught later on, were analysed separately. This approach was adopted due to the fact that "younger" fishes concentrated near the release sites and did not migrate toward the sea, their growth was slow, while sport and professional catches were rather intensive at that time. Consequently, these fishes did not result in an increase of the total weight of trout catches. On the contrary, their catches might have even decreased the effectiveness of stocking.

Table 1

Tagging experiments on rainbow trout

No. of experiment	RELEASED				Average length cm	Length range cm	Number of fish	TAG RECOVERED			
	Date	Place	Age					"older" fish[1]		"younger" fish[2]	
								No	%	No	%
1	04.11.63	Gulf of Gdańsk	Gdańsk	0+	14.9	11–19	1804	3	0.2	99	5.5
2	14.05.64	Gulf of Gdańsk	Gdańsk	1	16.9	13–21	658	36	5.5	13	2.0
3	19.05.66	Gulf of Gdańsk	Gdańsk	1	18.3	12–23	1348	212	15.7	21	1.6
4	13.05.67	Gulf of Gdańsk	Gdańsk	1	23.5	16–27	1544	193	12.5	41	2.6
5	06.05.68	Gulf of Gdańsk	Gdańsk	1	16.0	14–21	969	101	10.4	47	4.8
6	10–11.06.68	Gulf of Gdańsk	Gdańsk	1	15.5	14–19	868	25	2.9	59	6.8
7	28.05.69	Gulf of Gdańsk	Gdańsk	1	16.7	14–24	468	15	3.2	32	6.8
8	22.04.72	Gulf of Gdańsk	Gdańsk	1	16.8	13–27	1322	68	5.1	66	5.0
9	23–24.06.72	Gulf of Gdańsk	Gdańsk	1	16.7	13–23	2394	36	1.5	61	2.5
	Total	Gulf of Gdańsk	Gdańsk	1	17.9	12–27	9571	686	7.2	340	3.6
10	5 – 13.05.67	Gulf od Gdańsk	Gdańsk	2	28.0	16–49	1124	117	10.4	26	2.3
11	30.04.68	Gulf od Gdańsk	Gdańsk	2	22.3	15–35	672	98	14.6	64	9.5
12	6 – 10.05.69	Gulf of Gdańsk	Gdańsk	2	22.3	15–30	1515	265	17.5	97	6.4
13	13.04.70	Gulf of Gdańsk	Gdańsk	2	21.3	15–29	1599	224	14.0	73	4.6
14	13.04.71	Gulf of Gdańsk	Gdańsk	2	22.3	14–37	876	165	18.8	74	8.4
15	18.03.72	Gulf of Gdańsk	Gdańsk	2	23.0	18–29	769	161	20.9	70	9.1
16	30.03.72	Gulf of Gdańsk	Gdańsk	2	25.4	17–35	201	32	15.9	17	8.5
	Total	Gulf of Gdańsk	Gdańsk	2	23.2	14–49	6756	1062	15.7	421	6.2
17	19.05.65	Vistula mouth	Świbno	1	18.7	13–24	846	41	4.8	51	6.0
18	21.05–01.06.66	Vistula mouth	Świbno	1	18.4	15–23	3099	296	9.5	225	7.3
19	18.05.67	Vistula mouth	Świbno	1	20.0	15–24	1198	91	7.6	176	14.7
20	10.05.68	Vistula mouth	Świbno	1	16.1	14–24	990	95	9.6	72	7.1
	Total	Vistula mouth	Świbno	1	18.4	13–24	6133	523	8.5	524	8.5
21	02.06.66	Gulf of Gdańsk	Jastarnia	1	18.5	17–20	1164	165	14.2	4	0.3
Total: Gulf of Gdańsk, Vistula mouth and Jastarnia				0+, 1, 2		11–49	25428	2439	9.6	1388	5.5
22	28.05.67	Vistula Firth	Suchacz	1	18.5	15–24	1338	11	0.8	27	2.0
23	09.05.68	Vistula Firth	Suchacz	1	15.8	14–20	822	1	0.1	15	1.8
	Total	Vistula Firth	Suchacz	1	17.5	14–24	2160	12	0.6	42	1.9
24	20.04.68	Vistula River	Nieszawa	1	17.0	15–22	1348	14	1.0	7	0.5
25	17.03.69	Vistula River	Nieszawa	1	14.4	12–20	988	–	–	–	0.6
26	4 – 05.05.70	Vistula River	Nieszawa	1	15.5	12–20	825	7	0.8	41	5.0
	Total	Vistula River	Nieszawa	1	15.8	12–22	3161	21	0.7	54	1.7
27	16 – 20.05.68	Reda River	Mrzezino	2	24.8	18–22	237	4	1.7	–	–
28	17.05.68	Puck Bay	Puck	2	23.2	15–27	100	1	1.0	–	–
29	17.05.68	Baltic Sea	Mielno	1	16.3	13–20	621	8	1.3	–	–
	Total			1–2		13–27	958	13	1.4	–	–
	Total experiments 1–29			0+,1,2		11–49	31707	2485	7.8	1484	4.7
30	20.05.67	Żarnowieckie Lake		1	22.3	15–27	1295	–	–	1	0.1
31	20.05.67	Żarnowieckie Lake		2	28.2	20–34	197	–	–	–	–
32	20.05.67	Lubowidzkie Lake		1	18.8	15–21	1421	–	–	10	0.7
33	18.05.68	Łeba River	Łeba	2	23.2	18–28	75	–	–	–	–
34	11.06.68	Drawa River	Głusko	1	15.3	14–18	250	–	–	2	0.8
35	29.04.69	Dunajec River		1	15.4	12–19	596	–	–	–	–
	Total			1–2		12–34	3834			13	0.3
36	06.05.78	Wieprza River	Darłowo	1	19.6	14–33	1992	8	0.4	1	0.05
37	10.05.78	Wieprza River	Darłowo	1	19.6	15–31	1999	2	0.1	–	–
38	24.04.79	Słupia River	Ustka	1	16.9	15–22	1798	2	0.1	–	–
39	30.05.80	Słupia River	Ustka	1	18.1	15–27	3991	7	0.2	1	0.02
	Total	Wieprza and Słupia Rivers		1		14–33	9780	19	0.2	2	0.02
	Total experiments 1–39			0+,1,2		11–49	45321	2504	5.5	1499	3.3

[1] fish recaptured till the end of July in the years of release [2] fish recaptured later than July in the year of release

RESULTS

Tag returns

Altogether 4003 tags were returned out of 45321 released rainbow trouts, i.e. 8.8%. In these there were 1499 tags from "younger" (3.3%) and 2504 tags from "older" fishes (5.5%). The results obtained in particular experiments with one-year old fishes released in spring were highly differentiated. Tag returns varied from 0 to 14.7% for "younger" fishes, and from 0 to 20.9% for "older" ones (Tab. 1). As regards fishes released in different years at the same site, the differences were less pronounced (Tab. 1, exp. 2–9, 10–16, 17–20). In this case differences in tag returns were up to 10-fold, as for instance for the one-year old fishes released to Gulf of Gdańsk in 1964–1972 (Tab. 1). Even smaller differences were observed in case of tag returns from two-years old trouts. Data presented in the table suggest that the results might have been affected by many factors, such as time and place of stocking, size and age of fishes, and others.

The effect of the stocking period on tag returns.

Only 3 tags were returned from "older" fishes out of 1804 trouts released at the age of 0+ to the Gulf of Gdańsk near Gdańsk, this being only 0.2% (Tab. 1, exp. 1). On the other hand, 7.2% of tags were returned on the average from "older" fishes released in spring in the same place in 1964–1972, the range of variations being 1.5–15.7% (Tab. 1, exp. 2–9). The results of spring stockings were from 7.5 (at 1.5% returns, exp. 9) to 78 times higher (5.7% returns, exp. 3) than in case of autumn releases. 7297 one-year old trouts were released near Jastarnia and to the Vistula mouth near Świbno in 1965–1968, the fish length being 16.1–20.0 cm. The returns were similar as in case of spring stocking to the Gulf of Gdańsk, i.e. from 4.8 to 14.2% (Tab. 1, exp. 17–21).

The effect of the site of stocking on tag returns.

In the above mentioned experiments the highest average returns were obtained for the fishes released at Świbno: 8.5%, at the range of 4.8 to 9.6% (Tab. 1). Slightly lower percentage, 7.2%, was obtained from one-year old trouts released near Gdańsk in 1964–1972. But the returns were highly variable, from 1.5 to 15.7%. Average percentage of tag returns for similar period (1964–1968) but for the stockings made into the Vistula mouth at Świbno amounted to 10.5% (Range 2.9–15.7%). Hence, it can be stated that the results were similar for both sites. Similarly high returns were obtained in case of trouts released at Jastarnia (Tab. 1, exp. 21).

With respect to the fishes released in other places, i.e. to the Vistula Firth at Suchacz, Baltic Sea at Mielno, Słupia and Wieprza River mouth, and to the Vistula River at Nieszawa, the returns were low, from 0.0 to 2.5%, and only once 5% (exp. 26). The best results were lower than the average return from the Gulf of Gdańsk and Świbno. Similar trends were obserwed for tag returns from two-years old trout stocked into the Gulf of Gdańsk and Puck Bay, and into the River Reda.

Table 2

Correlation coefficient between percentage of returned tags from "older" fish and the length of one-year old rainbow trout released at Gdańsk, Świbno and Jastarnia

Site of release	GDAŃSK								ŚWIBNO				Jastarnia	Total: Gdańsk, Świbno i Jastarnia
Number of expreiments	2	3	4	5	6	7	8	9	17	18	19	20	21	2–9 17–21
Range of length cm	15–20	15–23	17–27	15–20	14–18	15–21	13–23	15–22	15–23	17–23	15–24	15–20	17–20	13–27
Number of returns	36	212	191	101	25	14	64	36	41	295	91	95	164	1365
Average % of returns	5.5	15.7	12.5	10.4	2.9	3.2	5.1	1.5	4.8	9.5	7.6	9.6	14.2	8.1
Degrees of freedom	4	7	9	4	3	5	9	6	7	5	8	4	2	13
Correlation coefficient	0.498	0.850**	0.846**	0.864*	0.981**	0.911**	0.838**	0.806*	0.805**	0.253	0.841**	0.875**	0.613	0.932**

** coefficient significant of the confidence level of 0.01
* coefficient signifficant of the confidence level of 0.05

As regards the fishes released to rivers Dunajec, Drawa, Łeba, and lakes Żarnowieckie and Lubowidzkie, no tags were returned from "older" fishes. "Younger" fishes (up to 0.8%, 0.3% on the average) were caught during the first month by fishermen and anglers. Only the returns from the River Drawa were obtained in August and September. It can be assumed that the latter fishes were in smolt stage and remained in the river (exp. 30–35).

The effect of the fish age on tag returns.

Comparison can be made between the results obtained with one-year old fishes released to the Gulf of Gdańsk at Gdańsk in 1964–1972 and the results obtained with two-year old fishes released at the sampe place in 1967–1972 (Tab. 1, exp. 2–16). Noticeably better results were obtained in case of the two-year old trouts, for which the returns were 15.7% on the average, varying from 10.4 to 20.9%. Tag returns were about twice lower for one-year old fishes (7.2%, range 1.5–15.7%, Tab. 1).

The effect of the fish length on tag returns from "older" fishes.

Correlation between length of the released fishes and tag returns for "younger" fishes (in % of the released fishes) was insignificant for both: one- and two-year old fishes, amounting to $r_1 = 0.0665$ and $r_2 = 0.0899$ respectively.

Coefficient of correlation between length of the released fishes and returns for "older" fishes, calculated for 13 experiments with one-year old fishes, was highly significant in 8 cases, and significant in 2 cases (Tab. 2). As regards 7 experiments with two-year old fishes, the correlation coefficient was highly significant in 3 cases, and significant in 3 cases (Tab. 3).

Coefficients of correlation calculated for joint sets of one- and two-year old fishes were highly significant, amounting respectively to $r_1 = 0.932$ and $r_2 = 0.585$ (Tab. 2 and 3, last and pre-last column). Linear regression equations were: $R_1 = 1.104176\,L - 12.7314$ for one-year old fishes, and $R_2 = 0.59438\,L - 0.52426$ for two-year old fishes, where:

R = per cent of returns for "older" fishes,

L = length of released fishes in cm.

On the basis of the results and plotted lines it can be stated that there was a more strict relationship between length of the released fishes and the returns for one-year old fishes compared to the two-years old Fig. 2). However, correlation for two-year old fishes 15–27 cm long (i.e. almost of the same length as one-year old ones, Tab. 2) was highly significant, amounting to $r_2 = 0.924$ (Tab. 3, last column). Linear regression equation for this new set was $R_2 = 1.496L - 18.262$.

New regression line plotted from this equation had the slope similar to that for one-year old fishes. This suggests that the size of fishes had a decisive effect on their survival. The results suggest also that rainbow trouts smaller than 17 om should not be stocked.

The discussed trends cannot be related to the dependence between average length of the released fishes and average returns from particular experiments. For instance, in the

Table 3

Correlation coefficient between percentage of returned tags from "older" fish and the length of two-years old rainbow trout released at Gdańsk

Site of release	GDAŃSK							All experiments	All experiments fish lengt of 15–27 cm
Number of experiments	10	11	12	13	14	15	16	10–16	10–16
Range of length cm	18–39	15–35	15–30	17–29	20–28	16–30	18–35	15–39	15–27
Number of returns	115	97	264	224	165	160	32	1057	911
Average % of returns	10.4	14.6	17.5	14.0	18.8	20.9	15.9	15.7	15.7
Degrees of freedom	10	19	14	11	7	13	16	23	11
Correlation coefficient	0.453*	0.508*	0.831**	0.849**	0.826**	0.570*	0.060	0.585**	0.924**

** – coefficient significant at the confidence level of 0.01

* – coefficient significant at the confidence level of 0.05

experiments 2 and 7–9 average length of the released one-year old trouts was very similar, amounting to 16.7–16.9 cm, while the returns varied between 1.5 and 5.5%. Similarly, there was no such dependence in the experiments 3 and 4, in which the returns from the fishes 18.3 and 23.5 cm long were 15.7% and 12.5% respectively. There are more such examples in Table 1. Considerable differences in the returns were observed even within the same length class in different years. These differences amounted in one-year old fishes 17 and 18 cm long to 0.4–15.4% and 1.7–21.2% respectively.

DISCUSSION

Factors affecting number of the returned tags.

Per cent of returned tags is determined by the environmental conditions, stocking technique, quality and size of the released fishes. Considerable variety of these factors results in significant differences in tag returns from particular fish portions, which ranged from 0 to 30%.

Totally 8.8% of tags from the "older" and "younger" fishes were returned in course of 39 experiments (Tab. 1). This result is higher than the one obtained by Trzebiatowski (1979): returns in the latter case were 6.76% (range: 5.01 to 8.42%) from spring release of trout into the Gulf of Szczecin and waters of the Middle and West Pomerania. The present results were also higher than in case of trout introductions into the Gulf of Finland, for which the returns were 0–5.7% (Toivonen, personal com.).

Similar returns (0–33.9%) were obtained during the stockings made in 1960–1974 into the Gulf of Gdańsk and Pomeranian rivers with two- and three-years old sea trout (Bartel 1977). In case of one-year old rainbow trout of the same size as two-years old sea trout the returns were lower, but they were higher for bigger, two-years old rainbow trout.

Considerable variations in the tag returns were also observed in case of salmon and sea trout introductions into coastal Swedish waters (Carlin 1955, Larsson 1977, Steffner 1979). They confirm the suggestions on a variety of factors affecting the fish survival.

Period of stocking is of considerable importance. Survival of trouts released in autumn was very low, similarly as in case of sea trout and salmon (Carlin 1955, Backiel and Bartel 1967, Bartel 1977, Larsson 1977). Proportions between spring and autumn stocking with sea trout (Gulf of Gdańsk and Vistula mouth) were 8–10-fold (Bartel 1977), and almost 4-fold in case of salmon stockings into Swedish waters (Larsson 1977).

One of the reasons for better results of spring stocking is the fact that in case of sea trout smoltification takes place only in spring. The phenomenon is connected with colour changes, also the scales fall off easily and body proportions change (Evropeiceva 1955, 1959, 1960, Evropeiceva and Zacepilova 1957, Van Velson 1974). Fishes become slimer, the condition is worse than in the pre- and post-smolt stage

(Houston 1961, Evropeicova 1959, 1960, Power and Shooner 1966). Moreover, during this period changes take place in the fat, carbohydrate, protein and water content in the body of salmon, rainbow trout, *Oncorhynchus kisutch* Walb., and *O. tschawytscha* Walb. (Farmer et al. 1977, Woo et al. 1978), as well as of chloride content in blood serum (Houston 1961). Fishes in this period are characterized by a tendency to change fresh into marine waters, and they migrate downstream. This was observed in juvenile sea trout and salmon in Poland (Żarnecki 1936, Chełkowski 1966, Skrochowska 1969, Bartel 1976a, Epler and Bieniarz 1973, Pałka 1977), reinbow trout released to the Vistula River (Bartel 1985). Migration of rainbow trout into McConaughy reservoir (USA) (Van Velson 1974) represents a similar phenomenon. In steelhead trout, apart from the dominating spring migration, also summer and to a less extent autumn migrations were observed in the rivers Sacramento, Chilliwack, and Waddell Creek (Maher and Larkin 1954, Shapovalov and Taft 1954, Hallock et al. 1961). Possibility of both spring and autumn changes was confirmed by the observations by Harache and Boeuf (1979) on high Na^+ and K^+ levels in blood and increased activity of of ATP acid in *Oncorhynchus kisutch* of proper size.

During the change from fresh water to marine environment differences in water salinity might be of considerable importance, as also size and age of the released fishes. Adaptation to marine environment is possible in case of rainbow trout only when the fishes are big enough (Jackson 1977). This size was determined by Farmer et al. (1977) at 12 cm for salmon, and by Houston (1961) at 16.5–17.5 cm and 35–45 g for rainbow trout. Spešilov and Agrba (1970) observed good adaptation of summer fry of migrating rainbow trout variety, at fish length of 3.1–5.4 cm and weight of 0.7 g, when the fishes were transferred from fresh water to $6^0/_{00}$ salinity, while mortalities reached 50% at water salinity of $10^0/_{00}$. On the other hand, two-years old fishes 14–16 cm long (39.2 g) survived quite well water salinity of 11.6 and $17^0/_{00}$. Osmotic pressure of the plasm increased for 6 hours after the transfer, but dropped to normal after 60 hours. It can be assumed that in case of rainbow trout introduction into the Baltic Sea differences in the salinity were of no importance as the salinity in South Baltic is rather low, about $7^0/_{00}$ (Deutches Hydrographisches Institut, Hamburg 1959, Łomnicki et al. 1975) and the released fishes were big enough. Survival of the fishes released in autumn can be significantly decreased by poorer food resources and frequent autumn and winter storms. The latter suggestion is confirmed by 3–4 times better results of autumn releases of two- and three-years old sea trout into the Vistula River mouth and the River Drwęca compared to the Gulf of Gdańsk (Bartel 1977).

Place of stocking should also be taken into consideration. In case of spring stockings the results were more satisfactory for the fishes released into the Gulf of Gdańsk (7.2%) and the Vistula River mouth (8.5%). In the extreme cases they were almost as good in case of autumn experiments. Similar trends were observed for spring stockings with two- and three-years old sea trout in the Gulf of Gdańsk, Vistula mouth, Pomerania rivers (Bartel 1977), and Swedish waters (Larsson 1977). It can be assumed that in case of trout

introductions into the Vistula Firth, River Reda, and Puck Bay abundance of predators was of considerable importance. These were pike (*Esox lucius* L.) and pike-perch (*Lucioperca lucioperca* L.). As regards the Vistula River at Nieszawa, rivers Dunajec and Drawa, and estuaries of Słupia and Wieprza, sport catches were quite important, but anglers did not return the tags. Low tag returns for "younger" and "older" trouts released into estuaries of the rivers Słupia and Wieprza might have been caused by considerable mortality of the fishes released into these areas, but consideration should also be given to intensive catches by the anglers, poachers and possibly also the fishermen soon after the fish release. These tags were not recovered as the fishes were under the legal size and the people were afraid to return the tags.

Size of the released fishes also affects their survival. Dependence between fish length and number of returned tags was highly significant in most of the experiments, for one- as well as two-year old fishes. (Tab. 2 and 3). This dependence was obserbed also for sea trout and salmon, being either linear or parabolic (Żarnecki 1936, Carlin 1955, Backiel and Bartel 1967, Bartel 1977, Pałka 1977, Sych et al. 1978).

When rainbow trout was released at the same site in spring each year better results were obtained for older fishes. The same was observed for sea trout (Bartel 1977). Older fishes were automatically bigger, and this improved their survival. This statement is confirmed by similar linear trends of the dependence between tag returns and fish length for different age groups but of the same length range (Fig. 2). This dependence suggests that about 6% return should be expected for fishes 17 cm long, the effects of introduction being thus satisfactory.

Apart from the above mentioned factors affecting the effectiveness of stocking there are many others, the effect of which might be less pronounced but which should also be taken into account in estimating this effectiveness on the basis of fish tagging.

The adopted method of tagging assured relatively low tag losses (Bartel 1963, Backiel 1964). Notwithstanding this, some sea trout spawners caught later bore signs of previous tagging. The same was observed by Saunders and Allen (1967) for adult salmon. Tag losses may increase when small fishes get entangled in the fishing nets or submerged vegetation, as observed in the fishing nets or submerged vegetation, as observed in the Vistula Firth.

The tagging procedure wounds the fishes and the wounds frequently do not heal well due to tag movements, favouring bacterial or mould infections (Roberts et al. 1973). Consequently, fish mortality may increase. Body injuries depend on the method of tagging. Saunders (1968) observed more injuries when steel wire was used instead of a nylon string, but tag returns were higher.

Tags can restrict fish movements. Rainbow trouts of the migrating variety tagged with Petersen tags were not able to swim as well as previously. The tagged fishes did not attain full swimming ability even 6–10 days after tagging (Clancy 1963).

In the present experiments silver and celluloid tags were used, the latter being transparent and non transparent, and of different colour. It was difficult to state whether

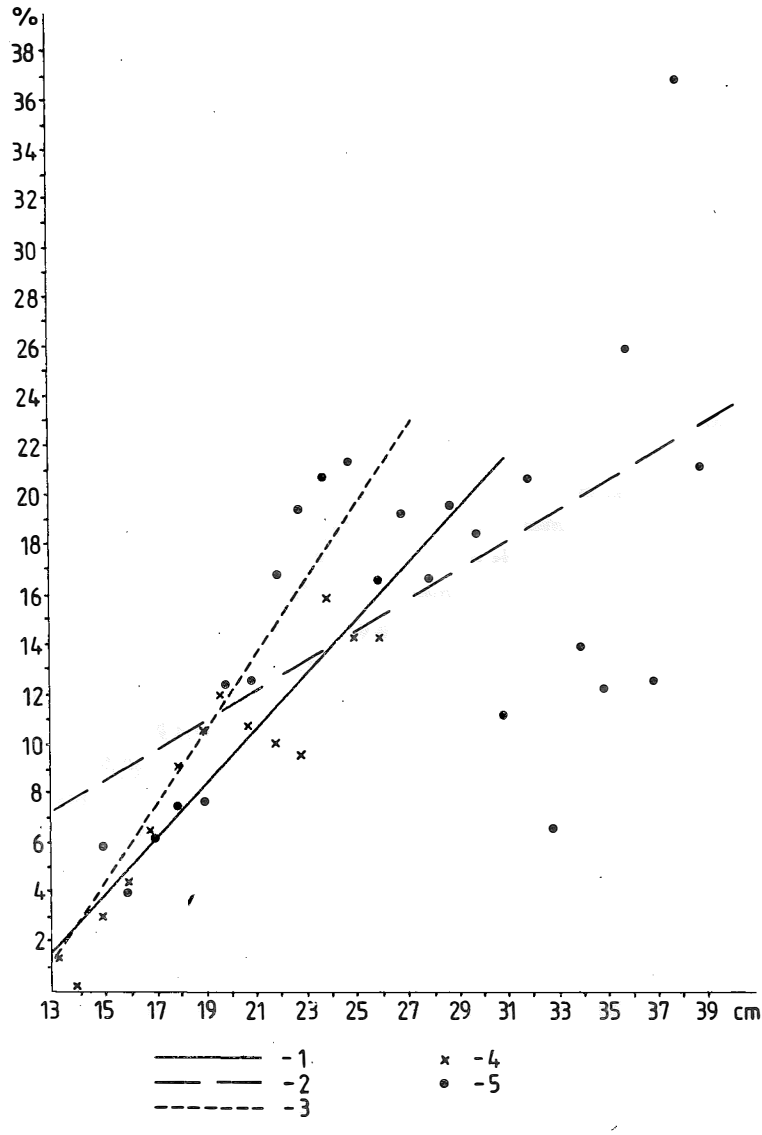

Fig. 2. Comparison of regression: percentage of returns of "older" fish (R) in relation to length of the released rainbow trout (L). 1 – for one year old fish R_1 = 1,104176 L – 12.7314, 2 – for two years old fish of length 15 – 39 cm, R_2 = 0,59438 L – 0,52426, 3 – for two years old fish of length 15–27 cm, R_2 = 1,496 L – 18,262, 4 – percentage of returns of one year old rainbow trout of varying length (L) at the moment of release, 5 – percentage of returns of two years old rainbow trout of varying length (L) at the moment of release

the tag colour affected the returns as the fishes were released in different years and at different locations. Still, this effect cannot be excluded. Experiments on perch (*Perca flavescens*) and *Catostomus commensoni* (the first being smaller than 15 cm, the latter bigger than 17 cm) revealed that lower tag returns were obtained for smaller fishes tagged with non-transparent tags. Lawler and Smith (1963) suggested that this resulted from increased predation by pike on fishes with non-transparent tags.

Larsson (1979) did not find significant differences in tag returns of different colours, but noticed some differences between dark and light tags.

Tag returns are also affected by capability of the people. Rainbow trouts were tagged by the employees of the Inland Fisheries Insitute and by students. who were much less capable. As a result tag losses increased even during fish storage before the release.

Tag returns are also considerably affected by the effectiveness of spreading the knowledge on the tagging action. In order to achieve this radio and press were taken advantage of, as also direct contacts with the fishermen and anglers. Special attention was devoted to wide publicity as to the aim of tagging. Effects of these steps were quite noticeable in the region of the Vistula River mouth, Gdańsk and Gdynia. However, direct contacts with the fishermen revealed that some of them did not return the tags, and that many tags were lost. A premium was paid for each tag, but for many fishermen it was of no importance, and some stated that it did not "compensate" for the effort of collecting and sending in the information. The author is of the opinion that level of the premium is quite important, although Dell (1974) stated in his tagging experiments with rainbow trout (migrating variety) from Lake Washington that level of the premium (1 and 10 dollars) was of no importance. Butler (1962) obtained 53% returns when 5 dollar premium was paid, and only 33.1% when no premium was paid. On the other hand, similar returns were obtained in lakes Pilsbury and Big Bear when there was a premium or nothing was paid for the returned tags, the respective percentages being 21.2% and 68 and 66.9%.

CONCLUSIONS

1. Tag returns varied from 0 to 30% and depended on:
   - the season. Satisfactory results were obtained only for spring stockings;
   - location of the fish release. Satisfactory results were obtained for the Gulf of Gdańsk, and the Vistula River mouth. Poor results were obtained for the locations at which the fishes were too exploited and remained under heavy pressure of predators;
   - length of the released fishes. This dependence was positive and highly significant.
2. Tag returns were also affected by the technique of tagging and proper publicity on the tagging experiments among the potential tag suppliers.

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WYNIKI ZARYBIANIA BAŁTYKU ZNAKOWANYMI PSTRĄGAMI TĘCZOWYMI (*SALMO GAIRDNERI* RICH)

STRESZCZENIE

Celem pracy było zdobycie informacji o przeżyciach wsiedlonych pstrągów tęczowych oraz określenie czynników wpływających na wysokość procentów zwracanych znaczków.

W latach 1963–1980, poznakowano 45 321 pstrągów tęczowych w wieku 0+, 1 i 2 lata o długościach od 11 do 49 cm i wypuszczono głównie do ujścia Wisły i Zatoki Gdańskiej oraz do ujścia Słupi i Wieprzy. Mniejsze liczby ryb wypuszczono do środkowej Wisły, Redy, Łeby, Drawy, Dunajca, Zatoki Puckiej, Zalewu Wiślanego, Bałtyku w Mielnie oraz jezior Żarnowieckiego i Lubowidzkiego.

Otrzymano 1.499 (3,3) znaczków z ryb „młodszych" łowionych do końca lipca w roku zarybienia i 2.504 (5,5%) zwrotów z ryb „starszych" łowionych po tym terminie.

Procent zwrotów ryb „starszych" uzależniony był od pory roku, wieku i miejsca zarybienia oraz od wielkości a więc i od wieku znakowanych ryb. Najlepsze rezultaty uzyskano z pstrągów wypuszczonych wiosną do Zatoki Gdańskiej i ujścia Wisły skąd średnio dwukrotnie wyższe procenty wzrostów uzyskano z dwurocznych ryb (15,7%) niż z jednorocznych (7,2%). Procent zwracanych znaczków był silnie dodatnio skorelowany z długością wypuszczonych osobników (r_1 = 0,932 dla jednorocznych i r_2 = 0,924 dla dwurocznych o zbliżonych długościach jak jednoroczne). Obliczone równanie regresji prostoliniowej mają postać odpowiednio R_1 = 1,10476L – 12,7314 i R_2 = 0,59438L – 0,52426.

Р. Бартэль

РЕЗУЛЬТАТЫ ЗАРЫБЛЕНИЯ БАЛТИКИ МЕЧЕНОЙ РАДУЖНОЙ ФОРЕЛЬЮ (SALMO GAIRDNERI RICH.)

Резюме

Целью работы являлось получение информации о выживании вселяемой радужной форели, а также определение факторов, влияющих на процентное количество возвращаемых меток. В течение 1963-80гг. пометили 45321 особей радужной форели, 0+, 1 и 2 годовиков, длиной от 11 до 49 см. Ими зарыбляли,

в основном, устье Вислы, Гданьский залив, а также устья рек Слупи и Вепши. Меньшее количество особей было выпущено в Средней Висле, Реде, Лабе, Драве, Дунайце, Пуцком заливе, Вислинском заливе, в Балтике в районе Мельно, а также в озёра Жарновецке и Любовицке.

Получено 1499 (3,3%) меток с рыб „младших", выловленных в конце июля в год зарыбления и 2504 (5,5%) меток с рыб „старших", выловленных позже.

Процент возвращаемых меток рыб „старших" зависел от времени года, возраста и места зарыбления, а также от размера особей и, соответственно, от возраста меченых рыб. Наилучшие результаты получены от исследования форели, выпущенной весной в Гданьский залив и устье Вислы, откуда в среднем два раза выше процент возвращаемых меток от двугодовиков (15,7%), чем от одногодовиков (7,2). Процент возвращаемых меток имел чётко выраженную положительную корреляцию с длиной выпускаемых особей (r_1 = 0,932 - для годовиков; r_2 = 0,924 - для двугодовиков, с приближённой длиной к годовикам). Получено уравнение прямолинейной регрессии, имеющее вид: $R_1 = 1{,}10476L - 12{,}7314$
$R_2 = 0{,}59438L - 0{,}52426$.

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