Arch. Ryb. Pol.	Archives of Polish Fisheries	Vol. 5	Fasc. 2	209 - 215	1997

ESTIMATION OF SEA TROUT (*Salmo trutta m. trutta*) PRODUCTION IN A SMALL POMERANIAN RIVER

Piotr Dębowski

The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn

A B S T R A C T. Abundance of one year old sea trout smolt in the Gnilna River was assessed by means of two methods. One method involved estimation of the difference between the fish abundance before smolt emigration and that after the emigration. The second method was based on a single estimate of abundance (before emigration) and on the bimodality of fish length distribution. The resulting data were compared with catches of smolt in traps. The two methods overestimated smolt abundance. The second one was less time consuming and less biased than the other one. Its accuracy depended on precision of the estimation of fish abundances in the river.

Key words: SEA TROUT, SMOLT, MIGRATION, PRODUCTION

INTRODUCTION

The knowledge of numbers of smolt migrating to the sea is of key importance to the sea trout management. The most often applied method of assessment of these numbers is catching the down migrating fish by a trap (Chełkowski, Chełkowska 1981; Chełkowski 1991; Dębowski et al. 1992). However, the migration often occurs at the time of raised water flow and it lasts about two months, what makes such catches technically difficult and time consuming, therefore expensive. The other method is to utilise fish abundance estimations before and after smolt emigration. The difference between these estimates brings about the number of smolts (Bohlin 1981). It is also possible to rely on one such estimate only (that of before smolt emigration). In that case one can take advantage of the fact that the to-be-smolt are larger that those not smolting and this is reflected in a bimodality of length distribution of sampled fish. Thorpe (1989) and Thorpe *et al.* (1980) described this phenomenon in salmon and it was used by Baglinier and Champigneulle (1986) for the estimation of smolt abundance. A similar phenomenon was established to occur in the one year old sea trout in a small Pomeranian river; in the early spring, the average length of fish which became smolt during the very year was distinctly greater than the average length of the remaining fish (Dębowski, Radtke 1994).

This paper aims at assessment of smolt abundance in a small Pomeranian river by means of all above mentioned methods.

MATERIAL AND METHODS

RESEARCH AREA

The Gnilna River is a right side tributary of the Slupia River. It is 11.5 km long and its area is c. 28 thousand m^2. The river is almost entirely regulated, it flows across meadows. Stocking with sea trout alevins is carried out every year; during the period of this investigation the amount stocked ranged from 280 to 550 thousand alevins.

POPULATION ESTIMATION

Electrofishing was conducted at always the same 13, 100 m long sites along the entire river course (for details see Dębowski and Radtke 1996). Abundance of sea trout was estimated from three successive catches (Zippin method) or, in cases of a single elecrofishing, an average catchability from catches at the very site in other years was assumed. Following Bohlin's *et al.* (1989) suggestions, the abundance in the entire river was estimated. Age of fish was determined using length distribution and scale reading. The catches analysed in this paper were carried out as follows: before smolt emigration on March 24-26 1991, on March 20-22 1992, on March 12-14 1993, and on April 6-8 1994; after smolt emigration on May 25-26 1993 and on June 6-7 1994.

ASSESSMENT OF SMOLT NUMBERS

Since almost all (99%) smolts were one year old in the Gnilna River (Dębowski, Radtke 1994) therefore this age group only was dealt with.

Differences between the abundance of one year old fish in the river before smolt migration and that after the migration were calculated for 1993 and 1994, the two available sets of data. The differences reflect in fact sums of emigration and mortality in the entire age group.

Because the average length of the fish differed among fishing sites (Dębowski, Radtke 1996) therefore the river was divided into four stretches and for each of them separate length frequency distributions of one year old fish captured before smolt emigration were produced. Then, using the method of Battacharya (1967), the Gaussian components were distinguished in these distributions. If there were two such components it was assumed that the larger fish were potential smolts. In the cases of more than two, the components showing the average length not smaller than 11.7 cm were classified as the smolts. The 11.7 cm is the average length of smolt before emigration on April 1, 1993, determined by back calculation on scales (Dębowski, Radtke 1994). On the basis of fractions of particular components and of estimated fish abundance, numbers of potential smolts in the entire river were calculated. These numbers are greater than the numbers of real smolts by that fraction of the potential smolts which have not survived until emigration.

From April 1 to May 26, 1993, 1270 one year old smolts were captured in the trap located close to the mouth of the river (Dębowski, Radtke 1994). Although the trap fenced the entire breadth of the river, one cannot exclude the possibility of some, rather minor, escapement beyond the gear.

RESULTS

The abundance of one year old fish in early spring, i. e. before smolt emigration, varied between 3801 and 10724 (Tab. 1). The precision of these estimates was also quite different: 95% confidence interval ranged from ±8% in 1992 to ±44% (of the mean) in 1993. Wide confidence intervals were found for the late spring estimates of abundance,too, hence, they were also wide in the cases of estimates of smolt numbers: 2824 ±79% in 1993 and 3434 ±79% in 1994 (Tab. 1). The numbers of smolts amounted to 58% and to 32% (in respective years) of the abundance of one year old trout in the river in early spring (Tab. 3).

The examination of length frequency distributions revealed that they consisted of from 1 to 4 Gaussian components, most frequently of 2 or 3. In two cases, two distribution components were classified as smolt, in all other cases - just one. Application of this method resulted in the estimates of smolt numbers ranging from 975 to 2012 (Tab. 2), which amounted to from 10% to 40% of one year old fish in the river (Tab. 3).

TABLE 1

Numbers of one year old fish in the Gnilna River before (BM) and after smolt emigration(AM), and estimated numbers of smolts (SM). In parentheses - confidence intervals.

	1991	1992	1993	1994
BM	3801 (2918-4684)	5844 (5356-6332)	4859 (2728-6990)	10724 (9034-12414)
AM			2035 (1373-2698)	7290 (5174-9406)
SM			2824 (592-5056)	3434 (726-6142)

TABLE 2

Distinguished Gaussian components (length groups) in length frequency distributions of one year old sea trout before smolt emigration at four stretches of the river and numbers of potential smolts (column: s). Bold face - groups considered smolt

Stre-tch		1991			s	1992			s	1993			s	1994				s
1	Mean length	8.0	9.9	**12.0**	330	7.9			0	8.6		**11.7**	158	7.8	9.8		**12.1**	104
	Fraction %	50	35	**15**		100				80		**20**		70	27		**3**	
2	Mean length	8.7	11.4	**13.3**	222	9.8		**13.1**	243	10.8		**12.8**	320	8.5	10.7		**13.0**	450
	Fraction %	46	35	**19**		87		**13**		77		**23**		28	60		**12**	
3	Mean length			**13.0**	404	10.5	**12.1**	**14.9**	1136	11.3		**12.6**	1005	9.0	10.8	11.7	**13.8**	1357
	Fraction %			**100**		32	**63**	**5**		37		**63**		18	41	**36**	**5**	
4	Mean length			**12.5**	19	11.9		**14.0**	84	8.0	10.3	**12.7**	451	11.0			**12.9**	101
	Fraction %			**100**		75		**25**		12	47	**41**		85			**15**	
	Total smolt				975				1463				1934					2012

TABLE 3

Estimated abundance of smolts: I - using difference of abundance of fish in the river, II - using length distribution (polymodality), III - captured in trap. In parentheses - fraction of smolts in the fish population before the smolt emigration.

	1991	1992	1993	1994
I			2824 (58%)	3434 (32%)
II	975 (26%)	1463 (25%)	1934 (40%)	2012 (10%)
III			1270 (26%)	

Different methods produced various results (Tab. 3). The greatest smolt numbers were obtained from the method of differences between catches. They were substantially greater than the estimates by means of polymodality examination of length frequencies, and more than twice as large as the number of smolts caught in the trap (in 1993). The confidence intervals for the estimated numbers overlap but they are much narrower in the case of the second method (Tab. 3).

DISCUSSION

The investigation of size polymodality in one year old fish have shown that more than two Gaussian components could be distinguished in their length distributions. In all of that type analyses, bimodal distributions were found (Thorpe 1977; Thorpe *et al.* 1980; Krisinsson e*t al.* 1985; Baglinier, Champignuelle 1986) but most of them concerned farmed fish. The cause of polymodality in the Gnilna River could be migrations of salmonid fish parr undertaken in late fall and in early spring of the first year of life (Saunders, Gee 1973; Solomon, Templeton 1976; Beall et al. 1994). However, in all cases, distinctly differing were groups of the largest fish.

Numbers of smolts captured in the trap can be considered as slightly underestimated. But estimates resulting from the two applied methods are definitely overestimated.

The first cause of the overestimation is low precision of estimates of fish abundance in the Gnilna River, where catches were carried out over somewhat more than 10% of its length. This is too little according to the simulations by Bohlin *et al.* (1982), particularly in the case of calculating the smolt number on the basis of two such estimates as in the first method. The second method relies on a single assessment, thus it is less labour consuming and it is easier to increase its precision by e.g. fishing in a greater number of sites.

The second cause is fish mortality during the spring period. It is probably great because the fish (including presmolt and smolt) become more vulnerable to fishing, especially in such a small river as the Gnilna, because then they forage intensively and grow (Fahy 1990; Dębowski, Radtke 1994), and after transformation they entirely change their behaviour, abandoning actual grounds and forming schools (Fried *et al.* 1978; Bakstanskij *et al.* 1980; Bakstanskij, Nesterov 1987). According to Larsson (1985) at least 50% of smolts do not reach the sea. None of the two methods takes mortality into account. In the estimates by the first method, all one year old fish that died (or were captured) during the 2 month period between catches were included. This bias is smaller in the second method because it compriseds mortality of potential smolts only.

It looks like the method of assessing smolt abundance by means of one series of e-arly spring fishing and by analysing polymodality of fish length distribution can produce estimates that are close to real numbers, provided a higher precision of the estimates (e.g. by multiplying the number of fishing sites).

REFERENCES

Bagliniere J.L., Champigneulle A. 1986 - Population estimates of juvenile Atlantic salmon, Salmo salar, as indices of smolt production in the R.Scorff, Brittany -J. Fish Biol. 29:467-482.

Bakstanskij E.L., Nekljubov M.N. 1980 - Povedenie molodi atlanticeskogo lososja Salmo salar L. v period skata -Vopr. Ikhtiol. 20:694-701.

Bakstanskij E.L., Nesterov V.D. 1987 - Formirowanie stajnowo povedenija molodi atlanticeskogo lososya Salmo salar v period pokatnoj migraci -Vopr. Ikhtiol. 27:1000.

Beall E., Dumas J., Claireaux D., Barriere L., Marty C. 1994 - Dispersal patterns and survival of Atlantic salmon (Salmo salar L.) juveniles in a nursery stream-ICES J.mar.Sci., 51:1-9.

Bhattacharya C.G. 1967- A simple method of resolution of a distribution into gaussian components-Biometrics 23:115-135.

Bohlin T. 1981- Methods of estimating total stock, smolt output and survival of salmonids using electrofishing -Rep. Inst. Freshw. Res. Drottningholm 59:5-14.

Bohlin T., Dellefors C., Faremo U. 1982 - Electrofishing for salmonids in small streams - aspect of the sampling design -Rep. Inst. Freshw. Res. Drottningholm 60:19-24.

Bohlin T., Hamrin S., Heggberget T.G., Rasmussen G., Saltveit S.J. 1989 - Electrofishing - theory and practice with special emphasis on salmonids -Hydrobiologia 173:9-43.

Chełkowski Z. 1991 - Survival rate of sea trout, *Salmo trutta* L., from hatch release to smolting in the stream Osówka -Acta Ichth. et Piscat. 21, 1:93-98.

Chełkowski Z., Chełkowska B. 1981 - Juvenile trout (*Salmo trutta* L.) survival rate from hatched fish release to smolting in river Mołstowa basin -Acta Ichth. et Piscat. 11:47-56.

Dębowski P., Goryczko K., Wiśniewolski W. 1992 - Przeżywalność i wzrost troci (*Salmo trutta* L.) wpuszczonej jako wylęg do górnej Parsęty -Rocz. Nauk. Pol. Zw. Węd. 5:125-136.

Dębowski P., Radtke G. 1994 - Spływ i charakterystyka smoltów troci (*Salmo trutta morpha trutta* L.) w rzece Gnilnej (Pomorze) -Rocz. Nauk. Pol. Zw. Węd. 7:39-50.

Dębowski P., Radtke G. 1996 - Wzrost i zagęszczenie młodocianej troci (*Salmo trutta morpha trutta* L.) w rzece Gnilna (Pomorze) -Rocz. Nauk. Pol. Zw. Węd. 9:51-62.

Fahy E. 1990 - Spring growing period as a regulator of the size of the smolt run in trout (*Salmo trutta*) -Arch. Hydrobiol. 119:325-330.

Fried S.M., McCleave J.D., LaBar G.W. 1978 - Seaward migration of hatchery reared Atlantic salmon, *Salmo salar*, smolts in the Penobscot River estuary, Maine: riverine movements -J. Fish. Res. Bd Can. 35:76-87.

Kristinsson J.B., Saunders R.L., Wiggs A.J. 1985 - Growth dynamics during the development of bimodal length-frequency distribution in juvenile Atlantic salmon (*Salmo salar* L.) -Aquaculture 45:1-20.

Larsson P.O. 1985 - Predation on migrating smolt as a regulating factor in Baltic salmon, *Salmo salar* L., population -J. Fish Biol. 26:391-397.

LeCren E.D. 1973 - The population dynamics of young trout (Salmo trutta) in relation to density and territorial behavior-Rap. P. -V. Reun. Cons. Int. Explor. Mer 164:241-246.

Saunders R.L., Gee J.H. 1964 - Movements of young Atlantic salmon in a small stream -J. Fish. Res. Bd Can. 21:27-36.

Solomon D.J., Templeton R.G. 1976 - Movements of brown trout S*almo trutta* L. in a chalk stream -J. Fish Biol. 9:411-423.

Thorpe J.E. 1977 - Bimodal distribution of length of juvenile Atlantic salmon (*Salmo salar* L.) under artifical rearing conditions -J. Fish Biol. 11:175-184.

Thorpe J.E. 1989 - Developmental variation in salmonid populations -J. Fish Biol. 35 (Suppl.A):295-303.

Thorpe J.E., Morgan R.I.G., Ottaway E.M., Miles M.S. 1980 - Time of divergence of growth groups between potential 1+ and 2+ smolts among sibling Atlantic salmon -J. Fish. Biol. 17:13-23.

STRESZCZENIE

OCENA PRODUKCJI SMOLTÓW TROCI (*Salmo trutta m.trutta* L.) W MAŁEJ RZECE POMORSKIEJ.

Dokonano oceny liczby spływających z rzeki Gnilnej (dopływ Słupii, Pomorze) jednorocznych smoltów troci dwoma metodami. Pierwsza metoda oparta jest na różnicy między liczebnościami ryb w rzece oszacowanymi przed i po spływie smoltów. Druga metoda opiera się na zjawisku różnic we wzroście potencjalnych smoltów i niesmoltów co przejawia się w bimodalności długości. Z rozkładu długości ryb złowionych przed spływem smoltów wyodrębniono metodą Bhattacharya (1967) takie grupy, obliczono ich udział procentowy i, opierając się o oszacowane liczebności, liczby potencjalnych smoltów. Pierwszą z metod zastosowano dla lat 1993 i 94 a drugą dla lat od 1991 do 94. Wyniki zestawiono z liczbą smoltów złowionych w pułapkę w roku 1993.

Wyniki uzyskane pierwszą metodą były znacznie wyższe od wyników metody drugiej i ponad dwukrotnie wyższe od rzeczywistej liczby smoltów za jaką uznać można połowy pułapkowe (tab.3). W obu metodach powodem tego przeszacowywania jest niemożność odróżnienia emigracji od śmiertelności. W metodzie pierwszej jest to śmiertelność wszystkich ryb jednorocznych w okresie między połowami (ok.2 miesiące) a w drugiej - potencjalnych smoltów od pierwszego połowu do spływu.

Druga z metod pod warunkiem poprawy precyzji oszacowań liczebności ryb wydaje się być dokładniejsza i z racji mniejszej pracochłonności lepsza od pierwszej a także od rzadko możliwych do zastosowania i bardzo kosztownych połowów w pułapkę.

ADRES AUTORÓW:

Dr Piotr Dębowski
Instytut Rybactwa Śródlądowego
Pracownia Rybactwa Rzecznego
80-761 GDAŃSK, ul. Reduta Żbik 5