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EFFECTS OF SOME EXTERNAL FACTORS ON THE PREDICTABILITY AND PRODUCTION CAPACITY OF BALTIC SALMON STOCKS

by

Sakari Kuikka
Finnish Game and Fisheries Research Institute, Fisheries Division
P.O. BOX 202, 00151 Helsinki, Finland

ABSTRACT

Effects of some external factors on the production capacity of reared Baltic salmon stocks were studied. The most important aim of these analysis was to decrease the large uncertainties of the assesment of the Baltic salmon stocks. Growth of the salmon appeared to be dependent on the size of the sprat stock. Both the growth of the A0+ salmon and water temperature seemed to be have a connection with the post-smolt survival of salmon. These variables are suggested to be used in the prediction of the post-smolt survival. The size of the cod stock might have a direct or indirect effect on the post-smolt survival. In catch simulations the fluctuations in growth and post-smolt survival rates caused remarkable fluctuations to the total catch. The probabilities for different catch levels were estimated by simulations.

1) Introduction

TAC based fisheries management is always problematic for species with a short life cycle. In the case of Baltic salmon, the age group A1+ constitutes usually 70 - 80 percent of the total catch. The prediction for the size of this age group has to be made by the Baltic Salmon and Trout Working Group of ICES before the releases of this year class are made. Therefore, the uncertainty of the prediction is bound to be very large. As far as the management is based on TAC, and there is a time lag of one year between the data and the TAC year, the only way to decrease the uncertainty is to use such external information, which is in connection to the size of the stock, and is available at the moment of the TAC decision. The fluctuations in the basic parameters of Baltic salmon production, i. e. growth and post-smolt survival rates, have been high. Understanding the causalities behind these fluctuations would improve the quality of the management.

The aims of this paper are as follows: 1) to analyse the dependency of growth of adult salmon on the size of the sprat stock 2) to analyse the relationship between growth and survival of post-smolts 3) to analyse the impact of temperature on the post-smolt survival of salmon 4) to analyze the effect of cod stock on the recruitment of salmon. Moreover, some simulations were made to illustrate the width of possible catch distributions. All analyses consern reared salmon stocks.

2) Material and methods

Growth rates and the number of returns per tagged fish during the first autumn were estimated by the finnish tagging data. Data consist of the returns of two year old smolts released in the northern part of the Gulf of Bothnia. These smolts represent the majority of the Finnish stocking material and the results from these releases have been quite similar in comparison to Swedish results (Anon. 1991a). The growth rates of A0+ salmon were calculated by subtracting the individual length in the return from the length at release. All returns between 1.7. - 31.12 were included to growth analyses.

Post-smolt survival rates of reared salmon were obtained from the ICES Baltic Salmon and Trout Assesment Working Group report (Anon. 1991a). The recruitment values of the total stock, reared and wild, used in fig. 4 are from an unpublished data analyzed during the working group session in 1991. This data is based on VPA analysis. Age distributions and mean weights were calculated by tagging data. Sizes of the sprat and cod stock (both for the whole Baltic Sea) are from the working group reports (Anon 1991b, 1991c).

Temperature values (monthly mean values in table 1) were obtained from four temperature stations of the Marine Research Institute of Finland. Their locations are as follows: 1) Santio: in the eastern part of the Gulf of Finland, near the border of USSR, in the archipelago area. 2) Utö: In the most southern part of the Arhipelago Sea, almost open sea circumstances 3) Seili: In the middle of the Archipelago Sea, sheltered and quite stable archipelago area. 4) Valassaaret: In Quarken, the narrowest site of Gulf of Bothnia (near the city of Vaasa), relatively open archipelago area.

Temperatures are being measured daily on each station at one meters depth near the shoreline. If the total amount of daily values of a month was less than 15, the mean value of the month was neglected from the analysis.

Because the analysed relationships were assumed non-linear, Spearman's rank correlation (e.g. Sokal & Rolf 1981) was used in the analysis. Catch simulations were made by a spreadsheet based population model, which is based on the equations of VPA (e.g. Gulland 1983). Simulations, Monte Carlo sampling, were made by @Risk program (Palisade 1990), which is an Add In -program for spreadsheet programs. Each simulation included 1000 iterations. Input values of the catch simulations are given in table 3. Highest age used was age A4+. The mean weights of age groups A3 - A4+ were based on the assumption, that the percentual increase in mean weight equals that of theagegroups A1+ - A2+. These yearclasses didn't have as fast growth in younger agegroups as the present young agegroup have (see fig. 1). In the catch simulations, the number of reared smolts released was 4 400 000, which is near the latest values for the Main Basin - Gulf of Bothnia stock. (Anon. 1991a). In 1988 the amount of smolts was 5.6 million.

Simulations were made by three different assumptions on fishing mortality levels and with two different growth levels (table 3). The post-smolt survival had a lognormal distribution by mean value of 0.25 (25 % survival) and variance of 0.10. The observed values fit quite well with the simulated distribution (fig. 5). To simulate the changes in the growth levels of one yearclass the mean weights of each agegroup were multiplied by the same parameter. This parameter had a lognormal distribution with mean value of 1 and variance of 0.2. Lognormal distribution was used, because the aim of the simulation was to predict the possible catches in the near future, with uncertainty associated with the maximum size of the salmon in each agegroup. It is possible, that salmon has not reached its full growth potential. Lognormal distribututíon gives higher probability for the high growth values than normal distribution. The distributions of post-smolt survival and growth factor are shown in figure 5.

Table 3 gives the mean fishing mortalities of each age group in years 1980 - 1988. Coastal and open sea fishing mortalities were calculated by using the percentages of coastal and open sea catches in each agegroup. If open sea fishing would be stopped totally, the fishing mortality would be determined by the spawning migrations of the stock. The assumed fishing mortality values of such situation are given in table 3. These values are based on assumed spawning migration to the coast and on an assumption, that almost all the spawning migrators are caught by the trapnet fisheries on the coast. The real migration pattern is difficult to estimate by present data, because potential spawning migrators are caught in the open sea fisheries as well. It is also assumed, that almost all fishes left in agegroup A4+ are caught in this stage. Therefore the fishing mortality in agegroup A4+ is supposed to be 50.

3) Results and discussion

3.1 Growth of salmon

The mean weights of the A1+ and A2+ salmon (table 2) have increased remarkably. Mean weights in both agegroups have increased since 1980 - 82 to 1990 by about 70 %. The most remarkable change has occured in 1989 - 90. Number of observations was around 40 - 60 in both agegroups in 1974 - 1984. In 1985 - 1990 number of observations was usually more than 100 in both agegroups.

These fluctuations are most probably due to the changes in the abundancy of sprat (fig. 1). Spearman's correlation between the biomass of sprat stock (VPA results of the stock in sub-areas 26 - 28) and the mean weight of A1+ was 0.58 (N=17, p=0.013). Correlation with the mean weight of A2+ was 0.61 (p=0.008). The clear responses in 1983 - 84 and especially in 1988 - 1990 are, however, the strongest evidence on the connection. This connection is easy to justify, because salmon and sprat stocks live on same areas in Main Basin, and sprat is an important food item for salmon.

Because of the spawning migration behavior, the mean weight estimates obtained from different parts of the Baltic Sea are quite different (table2). For the catch predictions the areal distribution of the stock must be taken into account by using the mean values of all returns. In these analyses it is assumed, that the migration patterns will not change in accordance with growth rate.

3.2 Post-smolt survival, return rate and growth of post-smolt

Because natural mortality is usually associated with the size of the fish, the mean sizes and growth rates of post-smolts might help to predict the size of agegroup A2+ in the TAC year. Also the number of returns has been reported to indicate the size of the yearclass (Anon. 1991a). Yearly values of post-smolt survival, growth rates and number of returns per tagged smolts are given in table 2. The Spearmans' correlations of these values were as follows (correlation/probability that correlation is zero): survival - mean length at return:0.37/0.32, survival - growth of post-smolt:0.45/0.22, survival - returns/tagged smolt: -0.35/0.36.

Yearly values are shown also in figure 2. Survival and growth are somewhat related to each other. Years 1982 and 1983 are exceptions. The correlation is, however, high enough to justify the use of this information. The correlation between the number of returned post-smolts per tagged salmon and post-smoltsurvival was negative in this Finnish data. The data presented by Anon. (1991a) gived a positive correlation of 0.76, but analysis was based on joined Finnish and Swedish data.

3.3 Post-smolt survival and temperature

The Spearman's rank correlations between some of the temperature values and post-smolt survival rates are given in table 4. These values were choosed to the table, because they are _a priori_ important temperature values.

For some reason, the correlations of the post-smolt survival with the mean values of July at each station were the highest observed. The correlations with the values of Seili and Valassaaret are quite high for the Main Basin - Gulf of Bothnia stock. Correlations do not suggest temperature dependency for the Gulf of Finland stock. These dependencies can be seen also in figure 3. Temperature seems to predict low survival rates quite well, which is important for management purposes. The p-values give not high probability for the connection due to low number of observations. The increased size of the smolts (Salminen 1991) has had probably an effect on the relationship. Because of the low number of observations, correlations are sensitive to individual observations.

The low amount of observations, however, did not allow to construct a deterministic model. Therefore it is probably more reasonable to use a table which shows the variability of the data in nine classes (table 5). In this table, year 1981 is a clear exception. The table can be used, however, as a base to give a level of post-smolt survival for the prediction purposes.

The high correlation with the mean values of July mentioned above would suggest the use of these values in prediction. The author was not, however, able to find a reasonable explanation for this observation and therefore the July values are not recommended for prediction purposes.

3.4 Recruitment of salmon and cod stock

The recruitment values of salmon stock and the size of the cod stock in 1970 - 1988 are shown in figure 4. Rank correlation was not statistically significant (-0.36, p = 0.12, N=19). The increasing levels of stockings in 1980's decrease correlation values. The reared and wild stocks can not, however, be separated prior to 1980 because the separation method of wild and reared salmon (Antere & Ikonen 1983) has not been used for the samples of the 1970's (Anon. 1991a). Therefore the post-smolt survival rates cannot-be calculated for 1970's by VPA.

The high values of recruitment in the beginning of 1970's and their collapse down during the high cod stock levels do not exclude the connection between the cod stock and recruitment of salmon. Also the correlation and p-value give higher probability for the hypothesis on relationship than for the assumption that there is no relationship between cod and salmon stocks. Therefore this connection must be kept in mind in the management of the salmon. Possible reasons for the association are food competition (sprat) and predation.

3.5 Simulations of the yield

Results of the simulations for the Main Basin - Gulf of Bothnia stock by three different assumptions for the mortalities and by two assumptions for growth levels (table 3) are given in table 7. It includes the probability that the catch is in given class and the probability that the catch is less than the upper limit of each yield class. If it is assumed, that the growth and post-smolt survival rates usually stay on high levels at least for two years (see fig. 1 and fig. 3), the distribution describes quite well also the distribution of the total catch.

The distributions are very wide. There is usually a range of 3 000 tonnes, where the probability values are about the same in each class of 1 000 tonnes (about 0.2 probability). The increase in the growth level has clear effect on the catch level. By these assumptions, e.g. the probability for a catch of more than 7000 tonnes is 0.1 with mean fishing mortality values of 1980 - 1988 and 0.15 with the supposed present fishing mortality values. It is probable, that open sea fishing mortality will decrease, because present catches can be taken by lower number of fish at present growth levels. Also the quite bad market situation will probably decrease fishing mortality in the open sea area. Therefore, the assumed fishing mortality values are probably quite near the present values.

Table 6 shows, that the changes in the fishing pattern have not as dramatic influence on the yields as the changes in the growth level do. Because of the selectivity of the gillnets (see Karlsson & Eriksson 1991) growth estimates used in the simulations are probably underestimates. Also the possible connection between good growth and high post-smolt survival (Salminen 1991 and table 2) will widen the probability distribution. The catch of wild salmon which is usually between 10 - 20 % of the total catch, must be added to these catches. Because of these facts, the probability for high catches is probably higher than estimated here. Even though these simulations are based on many assumptions, results demonstrate that the total catch is very sensitive to variation in post-smolt survival, growth and fishing pattern and the catch levels are supposed to fluctuate very widely.

4) Conclusions

A TAC decision is always uncertain. In the case of salmon, the latest information conserning the youngest predicted yearclasses are post-smolt returns and environmental factors, such as temperature. If the year of TAC decision is considered, the temperature related to the most important age group (A1+) can be measured before the TAC decision is made.

A classic scientific reasoning would not allow to use these results as a base for scientific advise because of low p-values. Also the correlation coefficients are not very high. This information does, however, decrease uncertainty and therefore it has also some value. Even with ten years of data, as in this paper, the use of temperature is reasonable, because the a priori knowledge on the importance of temperature on fishes supports strongly the use of temperature values. Already Svärdson (1955) has shown the connection between the salmon catches and the environmental conditions in the sea. The more detailed study on the effects of increased smolt size on post-smolt survival could be valuable and decrease the uncertainty of these results.

Even though the temperature has probably also direct influences on the post-smolts, it is likely that the connective factor between the survival and temperature is the production of food. Good growth decreases mortality. Connection of good growth and high survival (fig. 2) demonstrate this relationship.

The data on the temperature dependency of post-smolt survival are from those years, when cod stock decreased by 70 %. Therefore, if the cod stock had an effect on the recruitment, the level of post-smolt survival might be a result of both factors. Cod stock alone does not, however, explain the survival rates of 1980 - 88. Data series is too short to show the effects of these factors separately.

The temperature stations represent quite different conditions. The Utö station had clearly the most variable daily temperature values. The variance of the daily values at Seili was low. Therefore they probably represent the general temperature conditions in the sea quite well.

The use of mean values of temperature is justified because mortality occurs throughout the whole summer. The mortality is probably highest immeaditely after the release and therefore the environmental conditions during the releases must play essential role in the process. Because most of the stockings are made in the north, the mean value of May at Valassaaret should describe the living environment (e.g. food production) of the smolt at the moment of releases.

Based on these two a priori assumptions and the data of this paper I suggest the use of the mean temperature value of May at the station of Valassaaret and the mean value of May - August at the station of Seili for as an additional information in the predictions of agegroup A1+ of TAC year (table 5). For the prediction of agegroup A2+ of TAC year also the mean size of the smolts during the first year can be utilized (table 6). The growth is probably dependent on the mean temperature and therefore both of them should not be used in the table. Longer and more detailed data series and analysis are, however, needed for a quantitative modelling of the effects of the temperature.

The total catches are supposed to fluctuate widely also in the future. In 1980's the catches have mainly been quite near the expected values of the catch simulations, but it is just a matter of time when we will reach the upper or lower parts of these simulated distributions. When we take into account the collapse of the cod stock which will probably last many years, and the possible warming of the climate, record catches are probable in the near future.

During good growth present open sea catches can be taken with lower fishing pressure. If the market areas of the southern Baltic fisheries don't absorb present catches because of the Norwegian over production of salmon, a similar post-smolt survival like in years 1983 and 1988 (26 %) will increase the catches of coastal trapnet fisheries in the Gulf of Bothnia remarkably.

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Table 1. Monthly (May - August, 5 - 8) mean temperatures (celsius) on four field stations in 1974 - 1990. Locations of stations are explained in the text.

	Station															
	Santio				Utö				Seili				Valassaaret			
	Month				Month				Month				Month			
Year	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8
1974	6.9	13.5	17.3	16.0	6.4	11.8	15.3	14.8	9.3	14.4	17.0	17.6	5.6	11.2	13.9	14.4
1975	-	12.5	-	18.8	7.4	11.8	16.2	18.6	10.2	14.7	19.0	19.5	7.4	10.6	14.2	15.5
1976	7.3	10.4	14.9	-	6.9	12.1	-	-	8.9	12.9	17.5	-	5.4	9.3	13.3	16.4
1977	4.8	12.9	15.2	16.9	6.6	11.7	14.9	16.5	6.9	14.3	14.3	17.2	3.8	9.9	13.3	14.1
1978	6.2	11.7	-	16.2	7.3	13.0	15.5	16.8	7.6	15.3	17.7	17.6	-	-	12.9	14.9
1979	5.3	-	16.9	17.4	5.4	13.8	16.3	16.8	6.3	15.6	17.5	18.0	4.5	12.2	16.2	16.9
1980	5.2	14.1	16.7	-	5.2	11.2	17.4	-	8.4	16.2	19.0	19.8	3.7	12.4	18.1	16.1
1981	-	-	17.9	17.2	5.6	8.8	13.8	15.5	9.2	13.5	17.3	17.9	4.7	9.9	14.9	14.5
1982	5.1	10.4	16.7	16.6	5.0	9.9	14.7	15.8	6.3	12.6	17.0	19.1	4.3	9.9	15.7	15.3
1983	10.3	13.7	18.1	16.8	5.9	10.7	15.1	15.2	8.6	14.7	18.2	18.0	7.7	10.4	15.7	14.5
1984	9.3	15.6	17.0	17.6	6.6	12.5	15.2	17.5	10.2	16.2	17.8	18.6	7.6	13.7	15.8	16.3
1985	5.9	12.3	16.2	17.6	4.2	-	-	-	7.4	14.0	18.0	17.8	1.2	9.4	15.6	14.8
1986	7.3	15.1	16.9	16.9	6.3	-	15.0	15.0	8.2	15.2	17.7	16.8	5.2	14.1	16.8	13.2
1987	5.4	12.3	14.9	14.8	4.7	9.0	14.3	13.0	5.6	11.0	17.4	15.1	1.5	8.6	13.5	12.0
1988	8.5	15.9	-	16.3	6.8	13.5	19.2	14.9	9.7	17.1	22.0	17.6	4.0	9.8	16.9	14.0
1989	-	15.0	17.8	16.6	7.5	12.4	17.1	16.2	9.8	14.5	18.4	16.8	6.8	11.1	15.4	15.4
1990	8.8	14.7	16.9	18.1	7.7	12.6	15.2	16.7	10.4	15.4	17.4	19.0	6.4	10.4	13.8	15.8

Table 2. Post-smolt survival values of the Main Basin - Gulf of Bothnia stock and the Gulf of Finland stock, the mean weights (kg) of A1+ and A2+ in coastal (=Gulf of Bothnia) and open sea (= Main Basin) fisheries of Main Basin - Gulf of Bothnia stocks, tag returns of A0+ salmon (% of tagged), mean length at return (cm) and mean growth of post-smolts between the release and return (cm).

Year	Post-smolt - surv. Main Basin	Post-smolt - surv. Gulf of Finl.	Mean weight of A1+ Main Basin/ Gulf of Bothn.	Mean weight of A2+ Main Basin/ Gulf of Bothn.	Post - smolt tag returns per tagged smolt (%)	Mean length at return	Mean growth of A0+
1970			2.7/1.8	- -			
1971			2.8/1.8	5.7/4.5			
1972			2.9/1.7	6.4/4.2			
1973			3.3/1.7	6.5/4.1			
1974			2.8/1.3	5.6/4.3			
1975			3.1/1.5	6.1/4.4			
1976			2.9/1.8	5.8/4.2			
1977			3.1/1.6	5.1/4.1			
1978			2.6/1.3	5.0/2.7			
1979			2.7/1.1	5.1/3.6			
1980	24.1	32.1	2.7/1.4	4.9/4.0	0.0158	31	12.4
1981	13.5	17.5	3.0/1.6	4.3/3.8	0.0180	16	1.6
1982	24.7	10.8	2.7/2.0	5.0/3.3	0.0173	20	2.2
1983	26.8	24.6	3.1/1.6	4.9/3.7	0.0092	19	2.8
1984	23.5	10.7	3.6/2.1	4.8/3.5	0.0215	33	15.8
1985	20.7	28.8	3.5/1.7	5.9/4.5	0.0449	27	6.8
1986	18.8	28.9	3.6/1.5	5.9/3.7	0.0228	27	5.9
1987	10.3	12.8	3.6/2.1	6.3/4.4	0.0251	19	1.1
1988	26.2	22.8	3.3/1.6	5.9/4.7	0.0944	34	13.9
1989	1)	1)	4.0/1.8	5.3/2.9	0.0283	27	7.9
1990	1)	1)	4.4/1.9	8.4/5.6	0.0170	31	10.7
Mean	21.0	21.0	26.4				

1) These values are not reliable, because they are determined by the choose of terminal fishing mortality in VPA analysis.

Table 3. Input values for the catch simulations and the names used in table 7.
Mean weights (kg) in 1970 - 1990 are named OLDGROWTH. Mean weights of 1990 are named NEWGROWTH and the mean fishing mortalities in 1980 - 1988 have name OLDF. The supposed present fishing mortalities are named SUPPF.
Name COASTF describes a situation of no open sea fishing.

Age	Mean weight 1970 - 1990 = OLDGROWTH	Meanweight 1990 = NEWGROWTH	Mean overall fish. mort.= OLDF	Mean open sea fish. mort.	Mean coastal fish. mort.	Supposed fishing mortality in 1990 = SUPPF	Percent to coast (rough estimate)	Coastal fishing mortality = COASTF
A0+	.40	.4	.03	.01	.02	0.05		0
A1	2.16	2.5	.04	.02	.02	0.05		0
A1+	3.04	3.5	.62	.53	.09	0.4	10	.1
A2	3.83	5.5	.60	.51	.09	0.3		0
A2+	4.91	6.9	1.14	.84	.30	0.9	60	.90
A3	6.82	9.5 1)	1.00	.75	.25	0.3		0
A3+	6.59	10.5 1)	1.35	.75	.60	2.3	90	2.3
A4	6.84	11.5 1)	.65	.42	.23	0.3		0
A4+	7.89	11.5 1)	1.20	.89	.31	50	100	50.0

1) No estimates yet, these values are based on the percentual growth changes of A1 - A2+

Table 4. Spearman's correlations for some of the temperature - post-smolt survival values.
MBSURV = post-smolt survival rate of reared salmon in the Main Basin - Gulf of Bothnia stock,
GFSURV = post-smolt survival rate of the Gulf of Finland stock
MEANSAN = mean value of the water temperature of the Santio station between 1.5. - 30.9.
MEANUTO = mean value of Utö, MEANSEIL = mean value of Seili, MEANVAL = mean value of Valassaaret
VALASMAY = mean temperature at Valassaaret in May.
Number of observations is 9 in each correlation. Under each correlation value is the probability for the assumption that correlation is zero.

	MBSURV	GFSURV	MEANSAN	MEANUTO	MEANSEIL	MEANVAL	VALASMAY
MBSURV	1.0						
GFSURV	0.08 0.83	1.0					
MEANSAN	0.17 0.66	-0.19 0.61	1.0				
MEANUTO	0.47 0.20	-0.17 0.65	0.26 0.34	1.0			
MEANSEIL	0.62 0.07	0.21 0.58	0.57 0.02	0.46 0.08	1.0		
MEANVAL	0.65 0.06	0.03 0.93	0.24 0.38	0.58 0.02	0.71 0.02	1.0	
VALASMAY	0.33 0.38	-0.21 0.57	0.51 0.06	0.48 0.08	0.26 0.35	0.52 0.06	1.0

Table 5. Dependency of post-smolt survival on the mean temperatute of May at Valassaaret and the mean temperature of may - august at the station of Seili. The year of each observation is in parentheses. This table can be used as a base for the prediction of post-smolt survival of agegroup A1+ of TAC year.

		Mean temperature at Seili (celsius)		
		12 - 14	14 - 15	15 - 17
Mean temp. at Valassaaret in May (celsius)	1 - 4	10.3 (87)	20.7 (85)	24.1 (80)
	4 - 6	18.8 (86) 24.7 (82)	13.5 (81)	26.2 (88)
	6 - 8	-	26.8 (83)	23.5 (84)

Table 6. Dependency of post-smolt survival on the mean temperatute of May at Valassaaret and the mean growth of A0+ salmon (cm). The year of each observation is in parentheses. This table can be used for the prediction of post-smolt survival of agegroup A2+ of TAC year.

		Mean temperature at Valassaaret in May (celsius)		
		1 - 4	4 - 6	6 - 8
Mean growth of A0+ (cm)	1 - 5	10.3 (87)	13.5 (81) 24.7 (82)	26.8 (83)
	5 - 10	20.7 (85)	18.8 (86)	
	10 - 16	24.1 (80)	26.2 (88)	23.5 (84)

Table 7. Results of the catch simulations. The upper value in the table is the probability that the catch is within given catch class. The lower value is the probability that the cath is less than the upper limit of the class. The growth and fishing mortality levels used in each simulation are given in table 3.

Fishing mortality and growth level	Catch levels (in tonnes)							
	< 2000	2000 - 2999	3000 -3999	4000 4999	5000 5999	6000 6999	7000 7999	> 8000
OLDGROWTH OLDF	0.18 0.18	0.29 0.47	0.25 0.72	0.14 0.86	0.08 0.94	0.04 0.98	0.01 0.99	0.01 1
OLDGROWTH SUPPF	0.09 0.09	0.27 0.36	0.26 0.62	0.18 0.80	0.10 0.90	0.05 0.95	0.03 0.98	0.02 1
OLDGROWTH COASTF	0.10 0.10	0.2 0.3	0.22 0.52	0.18 0.70	0.10 0.80	0.10 0.90	0.05 0.95	0.05 1
NEWGROWTH OLDF	0.12 0.12	0.20 0.32	0.22 0.54	0.19 0.73	0.11 0.84	0.06 0.90	0.05 0.95	0.05 1
NEWGROWTH SUPPF	0.07 0.07	0.16 0.23	0.18 0.41	0.21 0.62	0.13 0.75	0.10 0.85	0.05 0.90	0.10 1
NEWGROWTH COASTF	0.01 0.01	0.07 0.08	0.14 0.22	0.18 0.40	0.14 0.54	0.11 0.65	0.11 0.76	0.24 1

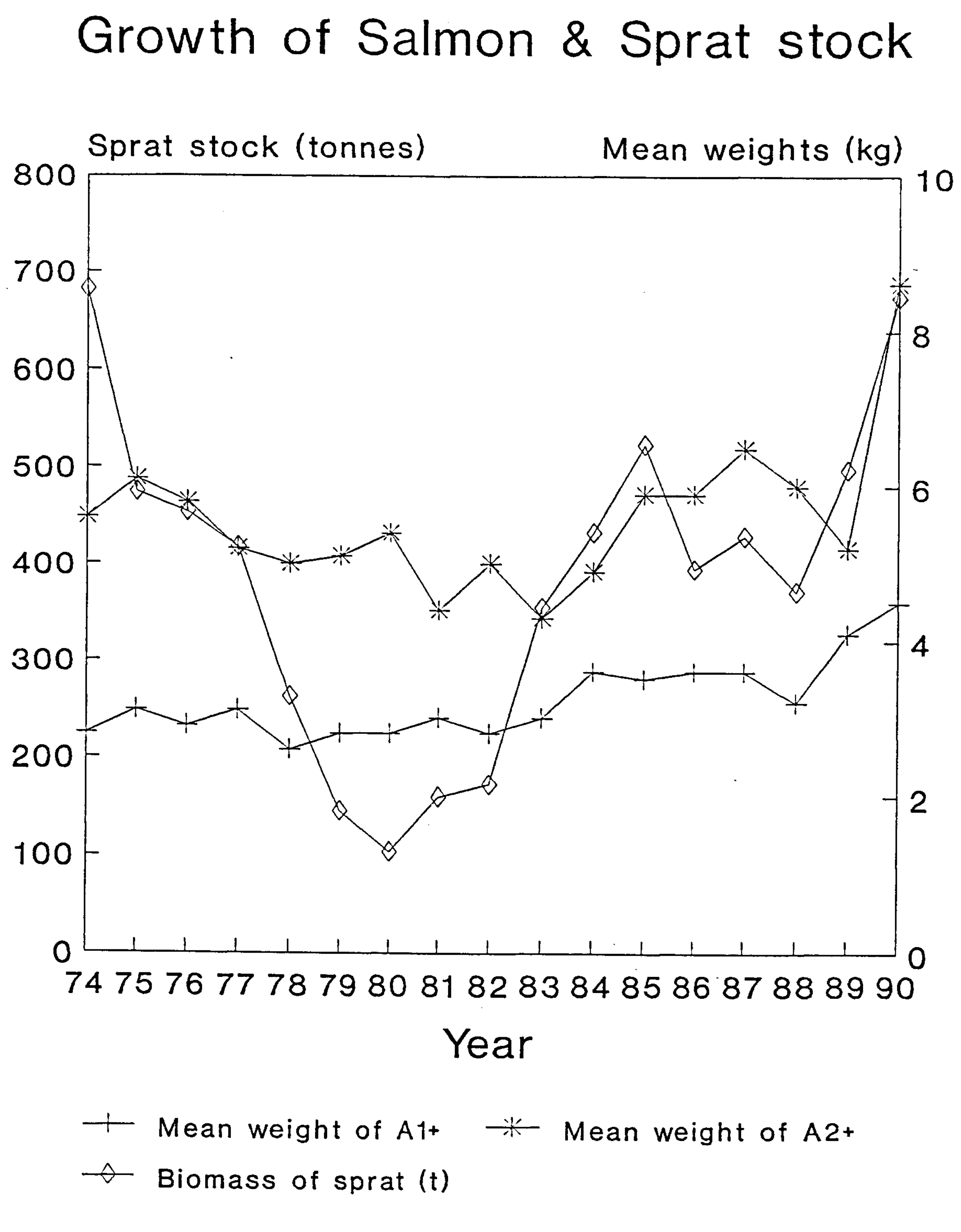

Figure 1. Mean weights (kg) of salmon in agegroups A1+ and A2+ (open sea returns from Main Basin) and the biomass (tonnes) of sprat stock in subareas 26 - 28 of ICES.

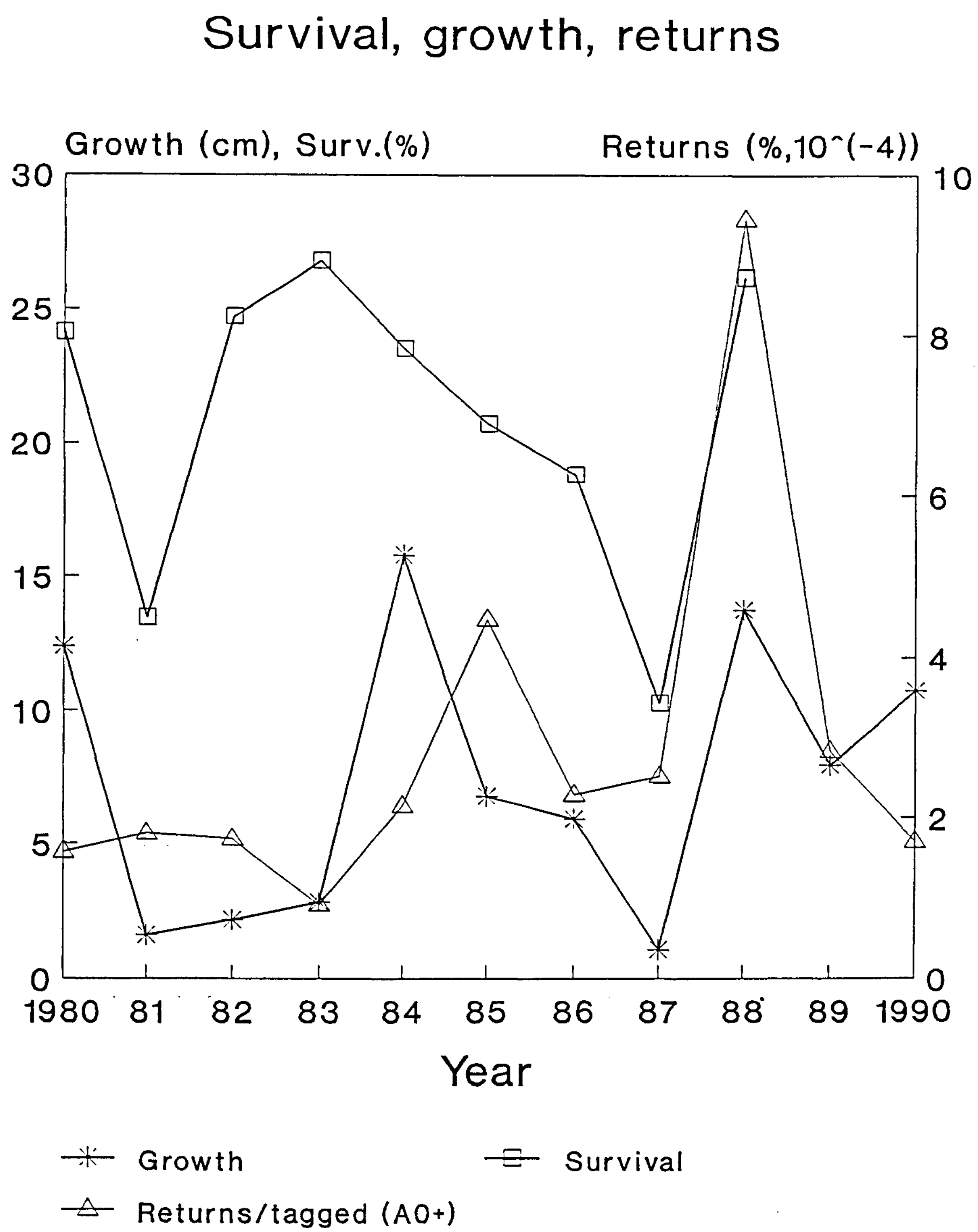

Figure 2. Post-smolt survival of reared salmon stocks (%), growth of A0+ salmon (cm) and the returns per tagged salmon (%).

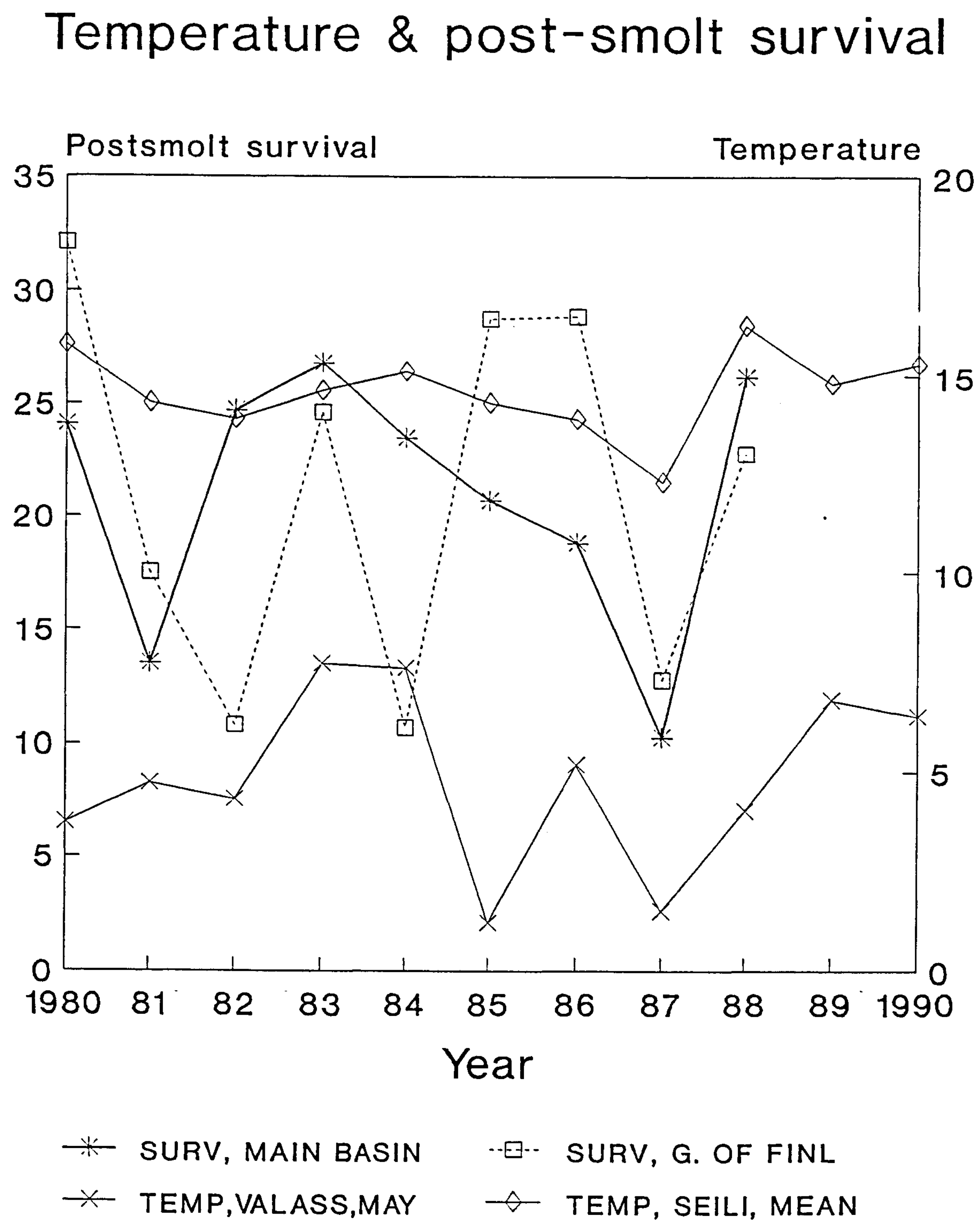

Figure 3. Post-smolt survival of reared salmon stocks in the Main Basin and in the Gulf of Finland (%), mean temperature values at Valassaaret in May and the mean temperature of Seili in May - August (celsius).

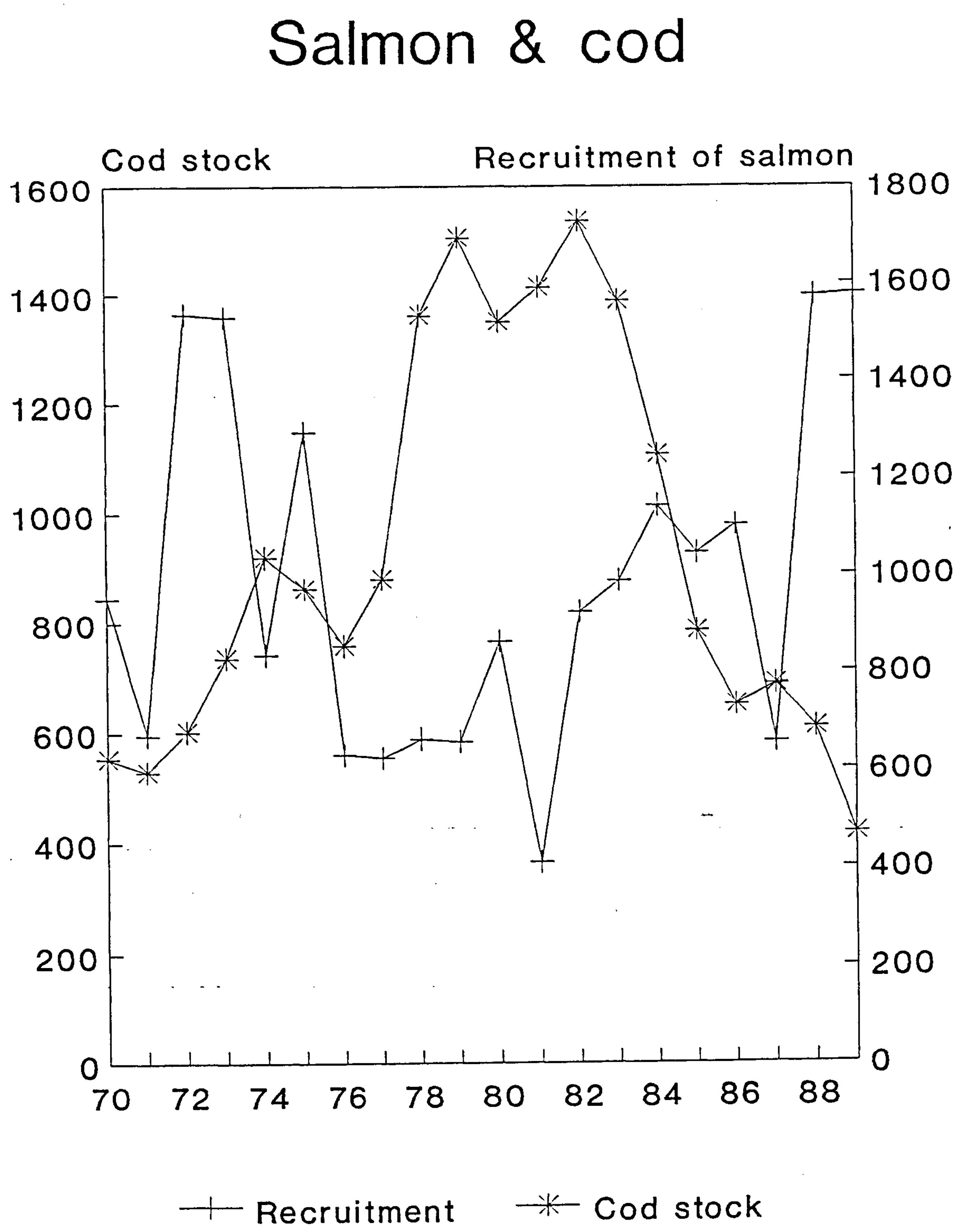

Figure 4. Size of the cod stock in numbers (thousands) and the recruitment of salmon (thousands). Recruitment value is the joined value of reared and wild stock.

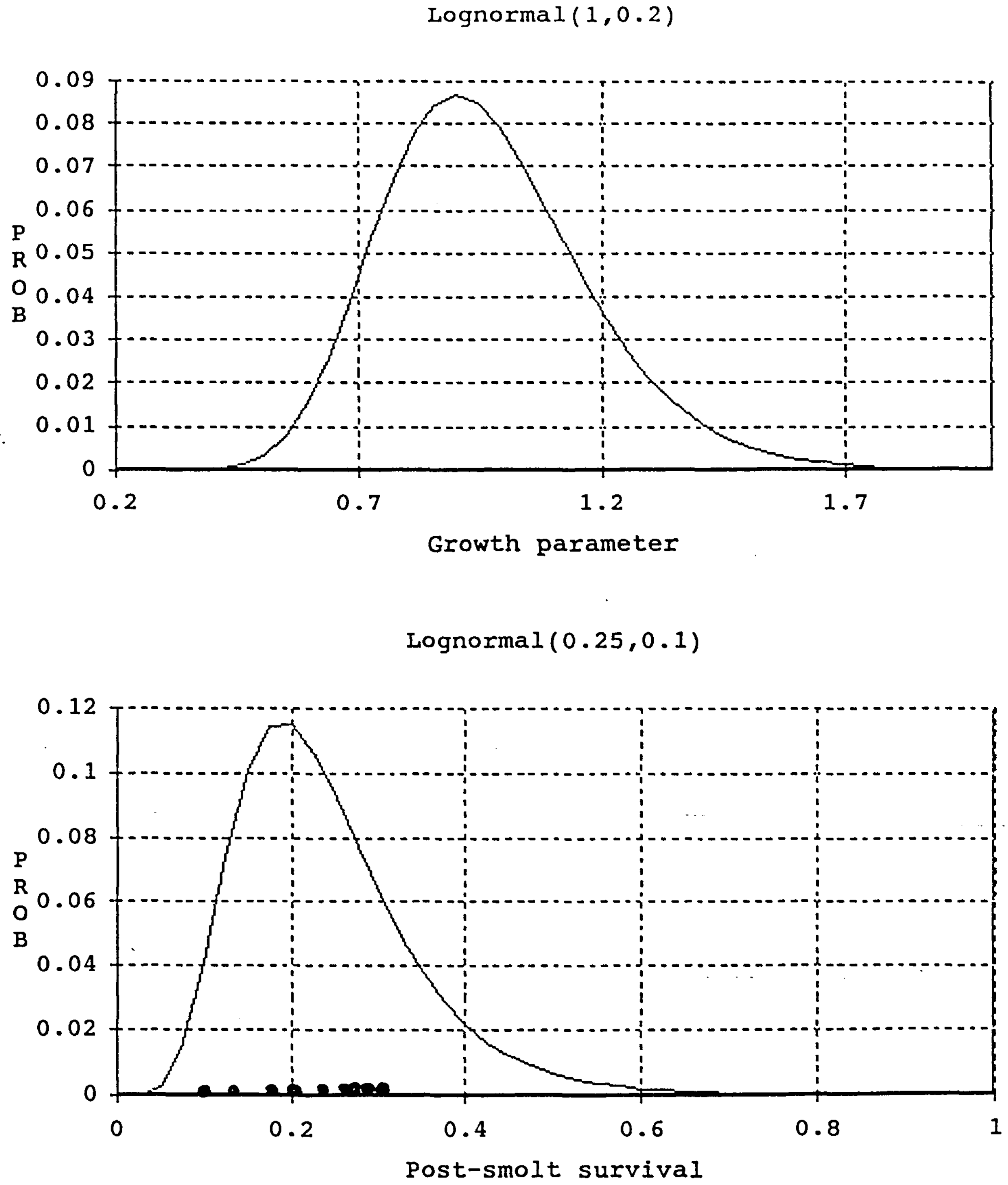

Figure 5. Probability distributions used in the simulations. Upper figure shows the probability distribution of the growth parameter and lower figure shows the probability distribution of the post-smolt survival. The observed post-smolt survival values are marked by a point to the x - axis.