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Carlin's model of the Baltic salmon population. A recalculation with up-to-date base data

by

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When Carlin (1962) made his model of the Baltic salmon population he used the results of the 1957 tagging experiments as a base. The model was constructed in an empirical way. The aim was then to use the model for simulations of changes in effort in the Baltic fishery in order to make assesments of the effect of the changes. Such assessments and more complex and detailed ones are now easier feasible with for instance the model presented by Sych (1972) and Sych, Bartel and Majkowski (1974) which has a more commercial design. Carlins model has like the one presented by Thurow (1966) a more biological approach primarily trying to give a picture of the status of the Balic salmon population.

Since Carlin made his model the material of data from tagging experiments has increased so much that we considered it valuable to recalculate the model with results from a ten-years period in order to obtain a base-model for comparisons with for instance single years in that period and future periods. The period 1958 - 1967 years of smolt release both inclusive was chosen and the recapture records from those years are shown in table 1. The obtained mean percentages have to be adjusted in order to estimate the real proportions between seasons and areas. Following Carlin I have made the adjustments as indicated in table 2. The values for the Baltic have been increased with 10 % to compensate for not reported recaptures, lost tags and so on. In addition to that the values for river and coast must be further increased to compensate for salmon caught in the Bothnian Sea but being spawning migrators and for some escapement. Grilse are small enough not to be caught by some gears in the rivers and therefore Carlin estimated the needed increase to be as high as 100 %. The grilse/salmon proportion will then be in accordance with that in the catches of non selective gears in the rivers.

Year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	Total	%	1957
Number released	63390	92355	78166	109542	72434	44296	48832	43300	60730	110334	723380		82723
Recaptured													
1:st winter	133 (0,21)	217 (0,23)	225 (0,29)	166 (0,15)	73 (0,10)	44 (0,10)	35 (0,07)	47 (0,11)	98 (0,16)	93 (0,08)	1131	0,16	96 (0,12)
in 2:nd "	2879 (4,54)	6469 (7,00)	5777 (7,39)	5307 (5,31)	3179 (4,39)	2041 (4,61)	2596 (5,32)	1910 (4,41)	4649 (7,66)	7530 (6,82)	42337	5,85	4460 (5,39)
the 3:rd "	1107 (1,75)	1804 (1,95)	1459 (1,87)	1661 (1,52)	1427 (1,97)	787 (1,78)	868 (1,78)	570 (1,32)	1311 (2,16)	2400 (2,18)	13394	1,85	2070 (2,50)
Bal- 4:th "	72 (0,11)	114 (0,12)	59 (0,08)	102 (0,09)	78 (0,11)	27 (0,06)	42 (0,09)	22 (0,05)	66 (0,11)	91 (0,08)	673	0,09	84 (0,10)
tic 5:th "	10 (0,02)	20[x] (0,02)	10[x] (0,01)	16[x] (0,01)	4[x] (0,01)	12[x] (0,03)	6 (0,01)	2 (0,005)	1 (0,002)	4 (0,004)	85 (97)[x]	0,012	12 (0,02)
in 2:nd summer	720 (1,14)	2826 (3,06)	2331 (2,98)	1641 (1,50)	396 (0,55)	311 (0,70)	333 (0,68)	98 (0,23)	573 (0,94)	772 (0,70)	9961	1,38	587 (0,71)
river 3:rd "	502 (0,79)	1927 (2,09)	682 (0,87)	916 (0,84)	469 (0,65)	332 (0,75)	178 (0,36)	206 (0,48)	432 (0,71)	493 (0,45)	6137	0,85	986 (1,19)
and 4:th "	350 (0,55)	875 (0,95)	395 (0,51)	491 (0,45)	130 (0,18)	72 (0,16)	89 (0,18)	42 (0,10)	136 (0,22)	178 (0,16)	2758	0,38	427 (0,52)
at 5:th "	9 (0,01)	77[x] (0,08)	41[x] (0,05)	59[x] (0,05)	20 (0,03)	9[x] (0,02)	9[x] (0,02)	4 (0,01)	20 (0,03)	13 (0,01)	261 (300)[x]	0,04	60 (0,07)
coast Total	5782 (9,12)	14329 (15,52)	10979 (14,05)	10359 (9,46)	5776 (7,97)	3635 (8,21)	4156 (8,51)	2901 (6,70)	7286 (12,00)	11574 (10,49)	76777	10,61	8782 (10,62)
In the Bothnian	529 (0,83)	4141 (4,48)	1426 (1,82)	1745 (1,59)	601 (0,83)	513 (1,16)	363 (0,74)	183 (0,42)	1390 (2,29)	1493 (1,35)	12384	1,71	460 (0,56)
Grand total	6311 (9,96)	18470 (20,00)	12405 (15,87)	12104 (11,05)	6377 (8,80)	4148 (9,36)	4519 (9,25)	3084 (7,12)	8676 (14,29)	13067 (11,84)	89161	12,32	9242 (11,17)

x Plus a few recaptured later.

Table 1. Numbers and procent (in brackets) recaptured from tagging experiments 1958 - 1967 and 1957

	Recaptured in sea					Recaptured in rivers and at coast			
	1:st w	2:nd w	3:rd w	4:th w	5:th w	2:nd s	3:rd s	4:th s	5:th s
Reported recaptures % (from table 1)	0,16	5,85	1,85	0,09	0,012	1,38	0,85	0,38	0,04
Increased with %	10	10	10	10	10	100	30	30	30
Adjusted values 1958 - 1967	0,17	6,44	2,04	0,10	0,01	2,75	1,10	0,50	0,05
Adjusted values 1957 (Carlin)	0,13	5,93	2,75	0,11	0,02	1,42	1,55	0,68	0,09

Table 2. Adjusted recapture percentages. 1958 - 1967 and 1957.

Apart from fishery and spawning migration the Baltic population is also reduced by natural mortality in which any cause but fishery to mortality is included. About that factor no direct information can be obtained from recapture data but it is possible to test different mortality rates to see which result is most reasonable. It is also obvious that the mortality is high during the first year (specially during the first weeks after release) and much lower and rather constant the following years. Carlin calculated with 10, 20 and 30 % natural mortality after the first year. In this case 10 % means that of the number of salmon from one year-class present in the beginning of a season 10 % will die from other causes than fishery during the following season. One season equals to one year starting about the 1:st of June when the main part of the spawning migrators (except for grilse) have left the Baltic proper.

According to the results obtained by Carlin and comparing with the mortality rate found by Thurow (1966) and Christensen (1964) 10 % seems to be the most realistic figure.

For the calculation of mortality during the first year after release Carlin presumed that from one year-class there are no salmon left in the Baltic after five years. I have considered the figure 0,08 %, as the remaining part of one year-class after four years, as safe enough to make the calculation from. The backward calculation from that figure will then give a first year mortality of 85,35 %. With Carlins method there is only a slight difference, the value then being 85,58 %.

The model resulting from the recalculation is shown in table 3 and figure 1.

Table 3. Model of the Baltic salmon population. Figures in Columns 3 and 5 from table 2.

	Percent of number of released smolt					Percent of number at the beginning of the year		
1	2	3	4	5	6	7	8	9
Year	At the beginning of the year	Spawning migration	Remaining	Catch in sea	Mortality	Spawning migration	Catch in sea	Mortality
1	100			0.17				85.35
2	14.48	2.75	11.73	6.44	1.17	18.99	54.90	10
3	4.12	1.10	3.02	2.04	0.30	26.17	67.55	10
4	0.68	0.50	0.18	0.10	0.02	73.53	55.56	10
5	0.08	0.05	0.03	0.01				

In table 2 the values from 1957 are included for comparison. It is obvious that the increasing fishing intensity during the 1960:s has increased the exploitation of the A.1 + sea-age-class, with a corresponding decrease for older salmon in the sea and spawning migrators (except for grilse).

The mean yearly smolt production to the Baltic is estimated by Lindroth (1972) to about 5.500.000 during the years of current interest. If that figure is applied to the model the obtained yields in the Baltic and at the coasts corresponds very well with actual catch statistics (differens 1 % and 5 % respectively) (Larsson, 1973).

In comparison with Thurow's model the main difference regards the spawning migrators. Applying mean weights of spawners of different ages to the numbers obtained by Thurow it is necessary to presuppose an escapement rate of more than 50 % to come close to the catch statistics. No estimates of escapement rates have been done in Swedish rivers but it can hardly exceed 20 %.

It seems to me that it should be valuable with a cooperation between model builders to obtain a useful and reliable model of the Baltic salmon population.

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Figure 1. Model of the Baltic salmon population. Base data from tagging experiments 1958 - 1967.