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SURVIVAL OF ATLANTIC SALMON SMOLTS RELEASED IN THE COURSE OF RESTOCKING OR SEA-RANCHING EXPERIMENTS

SURVIVAL OF ATLANTIC SALMON SMOLTS RELEASED IN THE COURSE OF RESTOCKING OR SEA-RANCHING EXPERIMENTS

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Assessment and comparison of the survival rates of smolt populations ~~by means~~ either from the return rates or from the recapture rates ~~together with their comparison constitutes~~ is an exercise that is often difficult to carry out ~~in view of~~ owing to the ~~difference in the~~ variety of schedules ~~reportedly are~~ used and the variability of the factors directly or indirectly involved in the estimation of the survival rates of released smolts.

~~Therefore,~~ In the overall analysis of the different experiments carried out in the various countries mentioned below, ~~has to be accepted subject to account being taken of a~~ allowance must therefore be made for a certain ~~degree of heterogeneousness~~ lack of uniformity in the experimental conditions, and ~~to~~ reference ~~being made as far as~~ should wherever possible be made to fine analyses of the various tests mentioned.

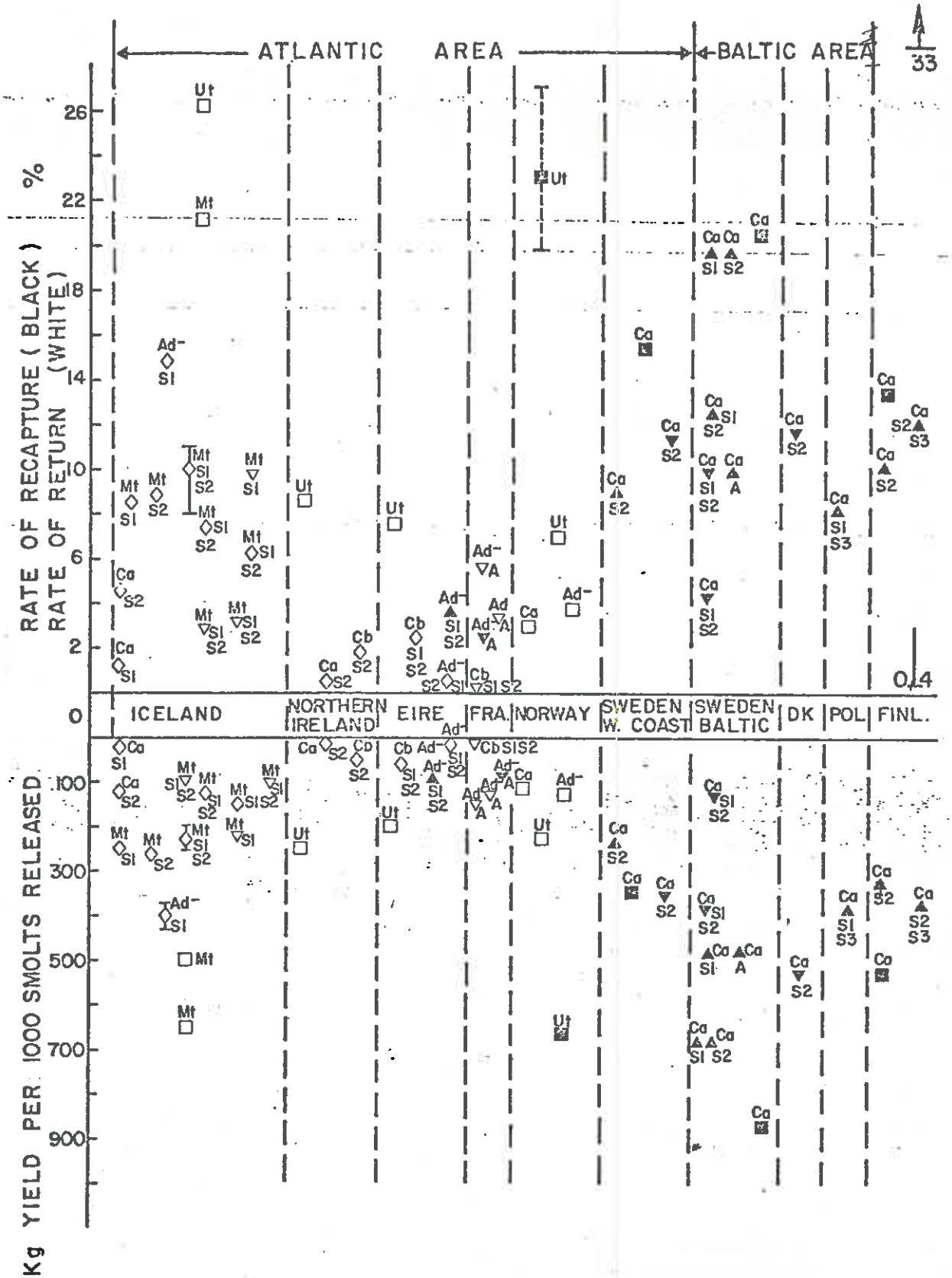
1. Return or recapture percentages and yields obtained from various sea-ranching experiments carried out in the North Atlantic (European zone) and the Baltic Sea (diagram and Table 1)

Analysis of the results obtained in the various countries referred to shows that the production of natural populations is generally higher than that of populations reared in and then released from hatcheries. In particular, Table 2 shows that the recapture percentages of the natural populations in the Baltic Sea are 1.4 to 1.8 times as high ~~or than~~ as those of populations reared in hatcheries. As for the return percentages, a still higher multiplying factor of 2.6 to 7.8 is ~~may be~~ noted.

Furthermore, it ~~may be~~ is observed that the rates of return to the river of origin ~~production environment~~ are particularly low in countries engaged in intensive sea fishing, whereas particularly high return rates (20 to 26%) can be obtained ~~in respect of~~ with populations in countries such as Iceland where sea fishing for these fish is prohibited. These high ~~values~~ percentages are also ~~observed~~ found in ~~regard to~~ the recapture rates ~~in~~ for Norway (18 to 27%) and ~~in~~ the Baltic Sea or ~~on~~ for the west coast of Sweden, if account is taken of a number of corrective factors* (non-declaration of tags, and additional mortality ~~due to~~ caused by Carlin tagging).

As ~~for~~ regards hatchery-reared smolts, both ~~in regard to~~ the return ~~rate~~ and the recapture rate, ~~great variations may be observed~~ vary greatly according to the type of tag employed and the origin of the released fish.

*Details of these are given subsequently.


ATLANTIC AREA
BALTIC AREA
33
RATE OF RECAPTURE (BLACK)
RATE OF RETURN (WHITE)
%
Kg YIELD PER 1000 SMOLTS RELEASED
ICELAND
NORTHERN IRELAND
EIRE
FRA.
NORWAY
SWEDEN W. COAST
SWEDEN BALTIC
DK
POL
FINL.
0.4

Country	Author	Home stock	Foreign stock	Stage of development at release: Wild smolt	Hatch 1+ smolt	Hatch 2+ smolt	Others	Type of tag: UT	AJ	CB	MT	Cu	Rate of return %	Rate of recapture %	Yield [illegible]
Iceland	ISAKSSON 1980	+			+							+	1.2		[illegible]
	"	+				+						+	4.5		[illegible]
	ISAKSSON 1982	+			+						+		8.3		[illegible]
	ISAKSSON 1982	+				+					+		8.9		[illegible]
	"	+			+	+					+		(8-11)		([illegible])
	ISAKSSON 1980	+			+				+				14.8		(370-[illegible])
	ISAKSSON et al 1979	+		+							+		21		[illegible]
	"		+	+				+					20.1		[illegible]
	"	+			+	+					+		>8.2		>[illegible]
	"		+		+	+							>3		>[illegible]
	"		+		+						+		>9.6		>[illegible]
Denmark	CHRISTENSEN 1982		+			+						+		11.9	52[illegible]
Sweden (Baltic)	PETERSON 1973	+			+							+		19.4	[illegible]
	"	+				+						+		10.5	[illegible]
	P.B. LARSSON et al 1979	+			+	+						+		12.4	[illegible]
	"	+		+								+		20.4	[illegible]
	"		a		+	+						+		9.9	[illegible]
	"	+					Parr+					+		9.8	[illegible]
	"		b		+	+						+		4.2	[illegible]
Sweden (West coast)	"	+				+						+		8.4	[illegible]
	"	+		+								+		15.4	[illegible]
	"		+			+						+		11.4	[illegible]
Norway	HANSEN 1981	+		+								+	3		[illegible]
	"	+		+					+				3.7		[illegible]
	"	+		+				+					6.9		[illegible]
	JENSEN 1981	+		+				+						20[c] (18.8-28.7)	[illegible]
Poland USSR	RITAMS et RITSH 1978	+			+		Smolt 3+							0	[illegible]
Finland	IKONEN et AUVINEN 1982	+				+	Smolt 3+							(2-1350)	[illegible] (0.4-[illegible])
Northern Ireland	VICKERS 1977	+		+				+					8.5		[illegible]
	"	+				+						+	0.6		[illegible]
	"	+				+			+	+			1.9		[illegible]
Ireland	PIGGINS 1980	+		+				+					7.6		[illegible]
	"	+			+	+			+	+			2.4		(18-[illegible])
	"	+			+	+			+				0.64		[illegible]
	"	+			+	+			+				3.5		[illegible]
France	DUMAS 1973		d		+	+			+	+			0.35		[illegible]
	PROUZET 1981		e				Parr1+		+				5.5		[illegible]
	"		e				Parr1+		+				3.4		[illegible]
	PROUZET 1979		e				Smolt 1 wild		+					2.5	[illegible]

a : Baltic stock b : West coast stock c : estimate d : Scotland e : Ireland f : Iceland

Table 1 : Review of the results concerning different Sea Ranching experiments

Country	Rate of recapture (%)		Ratio	Rate of return (%)		Ratio	Type of tag	Authors
	Wild	Hatchery		Wild	Hatchery			
Sweden (Baltic)	20.4	12.4	1.65				Carlin tag	LARSSON et al (1979)
Sweden (West coast)	15.4	8.4	1.83				Carlin tag	LARSSON et al (1979)
Finland (Simojoki river)	13.5	10.0	1.35				Carlin tag	TOIVONEN (1977)
Poland (Gulf of Riga rivers)	5.8	3.2	1.82				Carlin tag	MITANS and RIMSH (1978)
Norway (Imsa river)	11.7 20 (estimate)			3 6.9			Carlin tag unmarked	HANSEN (1981) JENSEN (1981)
Ireland (Burrishoole river)				7.5	2.4	3.13	Cold branding + fin clipped	PIGGINS (1980)
Northern Ireland (Bush river)				3.9 2.2	0.5* 0.6	7.8 3.7	Cold branding + fin clipped Carlin tag	PIGGINS (1980) VICKERS (1977)
Iceland (Ellidaar river)				20.8	8	2.6	Microtag	ISAKSSON et al (1979)

Table 2 : Ratio between the rates of recapture and the rates of return of wild and hatchery reared populations of smolts

(*) problems of furonculosis

Authors	Increase of the rate of recapture by cm of length	Increase of the rate of return by cm of length	Smolt age	Size Variation at release	Optimum size
Iceland Isaksson (1976)		1.27	2 ans	(18-21)	19-21 cm
Iceland Gudjonsson(1970)		3.66	2 ans	(12.5-17.5)	maximum length 17.5
Sweden					
Lule river	0.978				
Skellefte river	1.615				
Ume river	0.522		2 ans	(12-24)	18-24 cm
Angermanalven river	0.766				
Indal river	1.258				
Ljusnan river	1.664				
P.O. LARSSON (1977)					15.5
Indalsalven river	16.45		1 an	(12.5-15.5)	maximum length 15.5
	5.37		1 an	(12.5-15.0)	"
	3.89		2 ans	(13.5-19)	18.5-20
	4.10		2 ans	(13.5-19)	18.5-20
H.H. PETERSON(1973)	5.07		1 an	(12.5-15.5)	maximum length 15.5
Denmark C. Christensen (1982)	2.19		2 ans	(14-27.5)	22.5-27.5
Canada	0.35		1 an	(15-19)	maximum length 19
	0.16		1 an	(15-20)	maximum length 20
	0.17		2 ans	(13-17)	maximum length 17
	0.31		2 ans	(15-20)	maximum length 20
J. RITTER (1977)					

Table 3 : Relationship between size and survival of smolts released

Table 4 : Impact of the different types of tag on the rate of return

Country	Type of tag					Ratio of the rates of return +/O	Smolt length (+) in cm	Smolt length (O) in cm	Smolts origin
	untagged	Adipose fin clipped	Cold branding and adipose fin clipped	Micro tag	Carlin tag				
Iceland									
ISAKSSON et BERGMAN (1979)				+	O	1.6	10-19.5	10-19.5	Hatchery
ISAKSSON (1980)				+	O	2.2			Hatchery
ISAKSSON (1982)				+	O	2	13-16.5	14.5	Hatchery
ISAKSSON (1976)		+			O	1.7	15	14.5-16.7	Hatchery
Norway									
HANSEN (1981)		+			O	1.23	-	-	Wild
HANSEN (1981)	+	O				1.9	-	-	Wild
HANSEN (1981)	+				O	2.3	-	-	Wild
Ireland									
PIGGINS (1980)		+	O			1.16	-	-	Hatchery
Northern Ireland									
VICKERS (1977)	+				O	3.9	14.3	14.3	Wild
VICKERS (1977)			+		O	3.2	14.2-17.5	14.2-17.5	Hatchery
Iceland									
ISAKSSON et al (1979)	+			O		1.25	12.5	12.5	Wild
Canada									
PRATT et al (1974)	+				O	12.3	-	-	Wild

	Type of tag	Multiplication factor
Rate of return	Adipose fin clipped	1.9
	Adipose fin clipped and cold branding	2.2 (1.9x1.16)
	Microtag	1.25
	Carlin tag (1)	1.8-2
Rate of recapture	Carlin tag (2)	2.4-2.7

(1) loss of tag included (between 10 and 25 %)
(2) loss of tag and non reporting of tag (25 %) included

Table 5 : Estimates of the multiplication factor according the type of tagging

Table 6 : Rates of return or recapture and yield's estimates from wild and hatchery-reared populations of smolts

Country	Wild population				Hatchery-reared population			
	Rate of return		Rate of recapture		Rate of return		Rate of recapture	
	%	kg/1000	%	kg/1000	%	kg/1000	%	kg/1000
Iceland	26	650	-	-	28(1) 2.3(2)	760 68	-	-
Ireland	8.6(1) 7.6(2)	240 200	-	-	4.8 1	140 34	6.7	200
France	-	-	-	-	11 0.8	285 22	5	170
Norway	7	230	23	660	-	-	-	-
Baltic area	-	-	51 34	2155 1380			49 10.5	1700 338

The use of ~~breeds different from~~ (stocks) other than the local ~~bred~~ one gives variable results in Iceland, either lower than or of the ~~same~~ order of magnitude as those obtained by releasing smolts from the population present (stemming from Home stream population) or ~~those~~ located close to the ~~releasing~~ release site of

The same applies to the Baltic Sea, where recapture rates are obtained that are sometimes just as high with a non-original ~~breed~~ stock as with the local ~~breed~~ stock. ~~We may~~ It should be noted also ~~observe~~ that, in ~~the case of certain~~ some of the experiments, recapture rates are obtained in the Baltic Sea (which are) just as high for a reared ~~breed~~ stock as for a wild ~~breed~~ stock.

Lastly, it may be noted that the use of one-year-old smolts makes it possible to obtai

return or recapture rates at least comparable with those obtained with releases of smolts aged two years and more.

As regards the ~~In respect of~~ yields obtained from the return of adults to the ~~releasing~~ release site of, two zones must be ~~differentiated as follows:~~ distinguished:

(an unfished)

- zone ~~from existing sea fishing~~ (e.g. Iceland) ~~which is adjacent to~~ where the yield approaches and sometimes considerably exceeds the minimum yield required for the amortization of the production costs of young fish (160 kg per 1 000 smolts);

- zone of intensive sea fishing (e.g. ~~Iceland~~ Iceland, Norway) in which ~~solely the exploitation~~ of a wild population could only be carried out with ~~could make it possible to~~ exceeded through this minimum yield exploitation.

In the Baltic,

The yields obtained ~~by the~~ through recapture of adult fish are high (usually between 300 and 700 kg per 1000 smolts released). On the westcoast of Sweden these yields are smaller (partly ~~due~~ owing to the lower average weight of the catches).

In short, the following points ~~can be deduced~~ emerge from the analysis of the results collected:

except in rare cases, the same productivity as that of natural populations is not obtained by the release of reared smolts.

According to the countries and the experiments, wide variations are observed in the return and recapture rates, connected with a number of factors such as the quality of the smolts produced, the breed employed, the methods of release, sea-fishing and certain approaches related to the methods of assessment used.

2. Review of the principal factors which may affect the survival rate of released smolts

2.1 Directieffect on the survival rate

2.1.1 Characteristics and quality of released fish

Many tagging trials seem to show that there is a linear relationship between the return or recapture rate and the size of the smolt (Table 3). The largest smolts usually produce a higher return rate, irrespective of their age. Nevertheless, with two-year-old smolts, this relationship is not linear for the whole range of lengths, and we usually observe a reduction in the return rate as from a certain threshold which could be due to a process of desmoltification in the largest fish.

This relationship between size and return rate was usually obtained with Carlin tags. As Isaksson and Bergman (1979) suggested, this relationship could partly be due to an artefact connected with the use of the Carlin tag, the loss of which, according to Eisner and Ritter (1979), depends on the size of the fish. In particular, Isaksson (1982) noted that this relationship was much less marked in smolt populations tagged with the Microtag. Furthermore, Petersson (1979) pointed out that very high return rates could be obtained with little smolts (average length 13.5 cm).

will vary according to the type of tag used (Table 4), the size of the tagged fish and the environmental conditions at the time of the tagging (Morgan and Roberts, 1976). The Carlin tag with a stainless steel or plastic clip causes a lesion which leaves the door open to pathogen~~s agents~~ (Roberts et al., 1973). According to Morgan and Roberts (1976) the injury caused could ~~probably make it very~~ give rise to major difficult~~y to~~ in the control of osmosis and ~~on balance.~~ ~~in its equilibrium.~~

2.2 Effect on the assessment of the survival rate

2.2.1 Loss of ~~a~~ tag

This varies according to the type of tag ~~employed:~~ used, amounting to between 10 and 25% of the fish ~~tagged with the~~ in the case of Carlin tag~~, according to~~ given Eisner and Ritter (1979), ~~and~~ Isaksson and Bergman (1979)), but to only 1.7% ~~with~~ in the case of the Microtag (Isaksson and Bergman, 1979). On the other hand, with a ~~particular type~~ given method of tagging, such as ~~tagging with the~~ Carlin, ~~tag,~~ there ~~may~~ can be variable losses which depend~~ing~~ to some extent on the experience of the tagging team (Shearer, 1977).

2.2.2 Declaration of the tags and local~~ity~~ tion of the fisheries

Comparison of the sea survival rates of the ~~different~~ various batches of released smolts (~~by means of the~~ through estimation of the recapture rates) depends heavily on the declaration of the tags. According to Eisenr and Ritter (1979), ~~it~~ this is the variable which gives rise to the ~~most important factor~~ greatest distortion. It varies according to the fisheries, being ~~i.e.~~ between 25 and 30% in the case of the Baltic Sea (Larsson et al., 1979), 50% according to Gray (1973) and Turner (1975), but only 16% ~~according to~~ (Jensen, 1979), in the case of the Greenland fishery.

Dahl (1959) and Pyefinch (1966) ~~also pointed out~~ reported, moreover, that the rate of recapture of tagged fish ~~might~~ can vary according to the intensity of fishing and, in particular, ~~according to~~ the ~~site of fishing~~ location of the fishery.

3. Attempted assessment of the ~~actual production potentialities~~ true potential of adult fish ~~by means of~~ production by salmon ranching

The survival rates assessed from indices such as the return and recapture rates obtained ~~from~~ in tagging experiments are fraught with errors which one ~~may~~ can attempt to ~~partly to compensate~~ offset in part by the use of correction factors ~~which~~ that allow for reduced survival ~~connected with~~ due to handling and tagging and for the ~~factors~~ distortion due to losses ~~of tags~~ tag and, ~~in~~ in the case of recapture rates, ~~where~~ as non-declaration of tagged fish, ~~were not declared.~~

The correction factors ~~employed~~ applied were ~~assessed from~~ estimated on the basis of the results ~~which were compiled~~ set out in Table 4 and ~~shown~~ are given in Table 5.

Analysis of Table 6 reveals that:

- the wild populations have survival rates, ~~varying in accordance with~~ which vary by a factor of ~~from~~ of between 7% ~~to~~ and 26%, according to the intensity of sea fishing. These populations can lead to ~~a~~ an production ~~of~~ adult fish of between 200 and 650 kg per 100 smolts produced.

Their rates of recapture in the Baltic ~~sea~~ fluctuate between 34% and 51%, and the production of adult fish ranges ~~between~~ from 1380 ~~and~~ to ~~2155 KG PER~~ (2155 kg per) 1000 smolts ~~produced.~~

- the reared populations have more variable return rates which fluctuate between 1% and 28%, depending on the country. The production ranges from 20 to 760 kg per 1000 released smolts.

Their recapture rates vary between 5% and 49% and correspond to productions of between 170 and 1700 kg per 1000 released smolts.

The estimates obtained for the Baltic are particularly high, but may seem reasonable if reference is made to results obtained →

in the course of ~~during~~ releases ~~either in~~ Both into the river Morrum (48% and 2 123 kg per 1000 two year-old smolts released; Larsson et al., 1979) ~~or~~ or ~~in~~ into the ~~river~~ Indalsälven (up to 67% in the case of a category; ~~the~~ specific size Peterson, 1973).

The smolt's age does not appear to be a ~~determining~~ factor ~~acting at least~~ that determines - at any rate - directly ~~on~~ the survival of the fish, for Peterson (1973), Chadwick et al. (1978) and Isaksson (1982) obtained high rates of return with young smolts.

Nevertheless, ~~the fact of obtaining~~ when ~~[illegible]~~ older smolts are released ~~[illegible]~~ smolts ~~of small growth~~ in ~~fresh water~~, there ~~usually makes it possible to obtain~~ is generally a higher percentage of grilse (Piggins, 1973; Ritter, 1975; Isaksson, 1982), which have a higher sea survival rate than spring salmon owing to their shorter stay at sea.

In fact, the quality of the smolt (~~from the physical~~ development and health ~~points of view~~) probably plays a ~~leading~~ major part in determining its survival rate. Peterson (1973) ~~pointed out~~ reported that smolts fed on ~~food~~ a diet rich in lipids had higher survival rates than those given normal food.

Wendt and Saunders (1973) pointed out that smolts ~~subject~~ exposed to ~~a fast flow of water~~ a strong current have higher sea survival rates than those which have not ~~been subject to~~ undergone this type of "training." Frantsi et al. (1977), Piggins (1980) and Isaksson (1982) noted very low survival rates among ~~patches~~ schools of smolts affected by various epidemics.

2.1.2 Site and time of release

Pyefinch (1966) pointed out that, during the international tagging campaign of 1959-1963, there had been proportionally more recaptures ~~following~~ after releases into the sea than ~~following~~ after releases into rivers. This finding was confirmed by ~~Peterson (1973), then Larsson (1977), more usually in Sweden and Isaksson (1982) in Iceland confirmed this observation.~~ Peterson (1973), then Larsson (1977) - mostly in Sweden - and subsequently by Isaksson (1982) in Iceland.

According to Larsson (1977), the time of release is also a factor to be taken into consideration. According to this author, the best time for release ~~was~~ is

~~particularly~~ between the middle of May and the beginning of June. In Iceland, Isaksson and Bergman (1979) specified this same time slot ~~interval~~, which corresponds to the peak of the descent of smolts under natural conditions (Gudjonsson, 1954). The effect of the time of release on the survival rate could be attributable to ~~due to the effect of~~ two groups ~~types~~ of factors:

- degree of smoltification of the released fish
- thermal conditions of the neighbouring coastal zone ~~area~~, which may affect the survival of the smolts, as was reported ~~stated~~ by Gudjonsson (1978) in Iceland and by Ikonen and Auvinen (1982) in the Baltic region.

2.1.3 Transplantation of a stock

In Canada, Ritter (1975) observed that the transplantation of a stock led to a decrease in recapture rates which was the greater as ~~more considerable when~~ the distance from the river of origin increased ~~was greater~~. Larsson (1979) arrived at similar ~~finally made observations~~ findings ~~of the same kind~~ and pointed out that the transplantation of Swedish stocks from the Baltic region gave good results in the Baltic Sea, but that the transplantation of Swedish stocks from the west coast to the Baltic Sea gave ~~led to distinctly poorer~~ less satisfactory results.

In Iceland, Isaksson (1982) obtained ~~from~~ transplantations results which were very variable and ~~which~~ depended upon the river in which the fish were released ~~placed~~. In France, Prouzet (1982) obtained ~~quite~~ a not insignificant considerable return rate with yearlings reared in a nursery stream and originating from an Irish stock ~~breed~~.

2.1.4 Handling and tagging

Any handling before release causes a reduction in the survival rate which was assessed ~~evaluated~~ by Isaksson and Bergman (1979) at 25‰ in the case of a population of wild smolts. Severe Handling usually entails ~~involves~~ a loss of scales which, according to Parker et al. (1963), can, if it is severe, give rise to osmoregulator stresses. Tagging also causes an increase in mortality which →