

Introduction of Atlantic salmon *Salmo salar* L. to the river Akerselv, Oslo

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In 1981 Carlintagged Atlantic salmon smolts from the river Imsa and river Sandvikselv stocks, and in 1984 smolts from the river Loneelv stock were released in the river Akerselv. The smolts left the river and the inner Oslofjord few weeks after release. Most adult recaptures were reported from the sea fisheries. Adults from the Imsa and Sandvikselv stocks were caught in more distant waters than fish from the Loneelv stock. The main reason for this is probably due to size selective fishery. Straying to neighbouring rivers in Oslofjord was very common, especially for the smolts released in 1981. The Loneelv smolts released in 1984 gave the best adult return to the river Akerselv. It is concluded that smolt releases in the river Akerselv particularly of a grilse stock like that of the river Loneelv may be a useful way to develop a recreational fishery in the Oslofjord and the river Akerselv.

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INTRODUCTION

The river Akerselv in Oslo, the capital city of Norway, has been heavily polluted for more than 100 years. This river condition has wiped out all fish species originally present. In recent years the local authorities have put large efforts in improving the water quality. This has resulted in increased diversity of the freshwater fauna in the system (Brittain & Saltveit 1985). In 1980 tagged brown trout stocked in the inner part of the Oslofjord entered the river Akerselv (Aass 1982). Releases of salmon smolts in the river Sandvikselv (Rosseland 1969) and in the river Glomma (Hansen 1980) have demonstrated that such releases might be a suitable way of restocking a river system. This method was chosen as a first step to reintroduce Atlantic salmon into the river Akerselv.

In 1981 and 1984 a total of 5775 tagged salmon smolts were released in the river Akerselv. This paper presents the migration pattern, growth and yields of the different groups released.

STUDY AREA

The river Akerselv runs out of the lake Maridalsvann, which is a main drinking water reservoir. From the outlet of the lake Maridalsvann to the river mouth in the center of Oslo the distance is about 8 km. There are about 20 waterfalls between the lake and the Oslofjord, and anadromous fish may migrate from the fjord to the first waterfall at Nedre Foss, a distance of about 1.5 km. In the

estuary the fish have to swim through a 100 m long tunnel.

The river Akerselv is regulated, and the minimum water discharge has been set to 1.5 m³ s⁻¹. In periods with heavy rain, the water discharge can be increased, but large natural floods are very rare.

MATERIAL AND METHODS

In the spring 1981, two years old Atlantic salmon smolts from the river Imsa (n=1956) and from the river Sandvikselv (n=1855) stocks were released in the river Akerselv, about 1000 m above the river mouth. In spring 1984 one year old smolts of the river Loneelv (n=1964) stock were released in the river Akerselv (Table 1). In order to observe possible smolt mortality, the river was surveyed for 2 days after the release.

The river Imsa is situated in Sandnes, near Stavanger in south-western Norway, while the river Sandvikselv is in the inner Oslofjord (cf. Fig. 2). Most of salmon from these stocks mature as grilse. There is, however, also a component of salmon which mature after 2 years in the sea. The river Loneelv drains an area of Osterøy north of Bergen in western Norway, and it is a typical grilse river.

The smolts were reared at the Ims Research Station by the river Imsa. A few weeks before release the smolts were anaesthetized with chlorobutanol, tagged individually with numbered Carlintags (Carlin 1955) and measured (total length). After recovery, the smolts were put in tanks and driven by truck to the river Akerselv where they

Table 1. Survey of the tagged Atlantic salmon smolts released in the river Akerselv.

Stock	Smolt age	Date of release	No. released	Average smolt length (mm)	Range
River Imsa	2+	27 April 1981	1956	171	130-340
River Sandvikselv	2+	27 April 1981	1855	175	130-360
River Loneelv	1+	9 May 1984	1964	154	130-195

were released directly in the river just before dark.

The following summer after release the river was electrofished twice, but no salmon smolts were caught. The recaptures were reported by fishermen and by local angling clubs when collecting for their brood stock.

RESULTS

Shortly after release the smolts left the river and no mortality was observed. Some of the two years old smolts released in 1981 were recaptured in the inner part of the Oslofjord a few days after release (Fig. 1). Five weeks after release two postsmolts were recaptured in the middle part of the fjord and after another two weeks two recaptures were reported caught in mackerel driftnets off the coast of southern Norway. After 20 June no postsmolts were recovered, indicating that the fish had left the fjord. Only one of the smolts released in 1984 was recaptured at postsmolt stage; 17 days after release it was caught in the middle part of the Oslofjord.

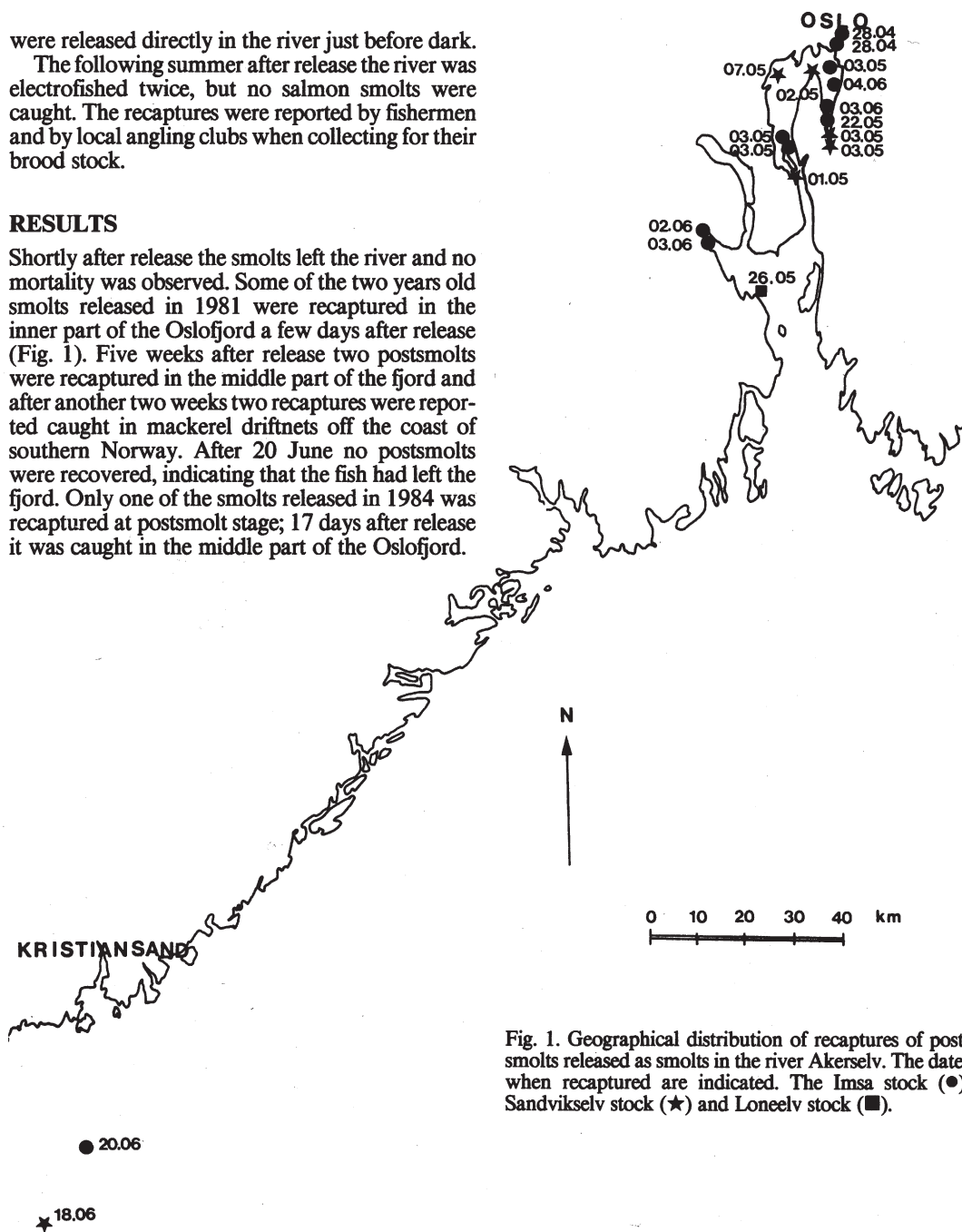


Fig. 1. Geographical distribution of recaptures of post-smolts released as smolts in the river Akerselv. The dates when recaptured are indicated. The Imsa stock (●), Sandvikselv stock (★) and Loneelv stock (■).

Table 2. Distribution of the recaptures from the different groups released.

Stock	No. recaptured as post smolts	Recaptured as adults						To no. recaptured	% recaptured
		Norw. home waters	Sweden/Denmark	Faroes	R. Akerselv	Other rivers	Unknown		
River Imsa	11	47	1	8	5	5	0	66	3.4
River Sandvikselv	6	54	4	10	2	11	0	81	4.4
River Loneelv	1	49	2	1	22	14	1	89	4.5

Most of the recaptures were reported from the sea fisheries in Norwegian home waters (Table 2). At the Faroes salmon from the Imsa and the Sandvikselv stocks were recaptured more frequently

than fish from the Loneelv stock. Another striking difference between Loneelv stock and the two other stocks was, that the first group was recaptured in a much higher frequency in freshwater. Figures 2, 3



Fig. 2. Geographical distribution of recaptures of adult salmon of the Imsa stock released in the river Akerselv 1981.

- Recaptures after 1 year in the sea
- ★ Recaptures after 2 years in the sea
- * Recaptures after 3 years in the sea.

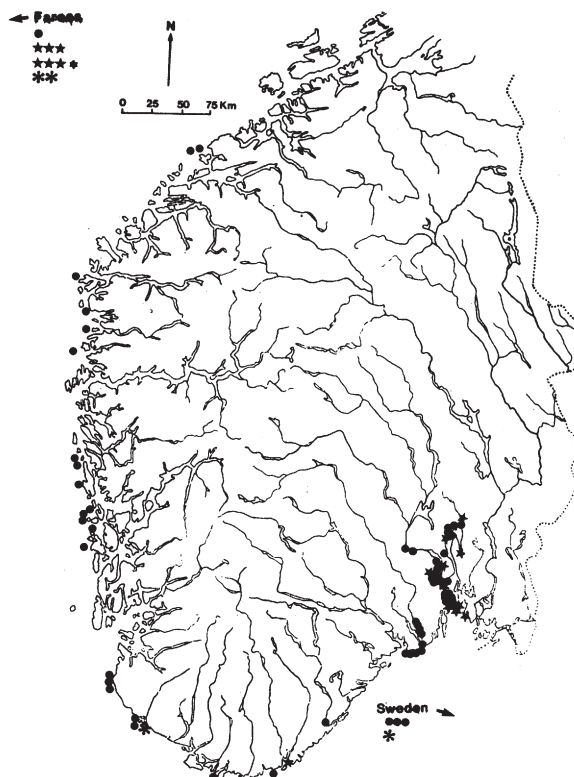


Fig. 3. Geographical distribution of recaptures of adult salmon of the Sandvikselv stock released in the river Akerselv 1981.

- Recaptures after 1 year in the sea
- ★ Recaptures after 2 years in the sea
- * Recaptures after 3 years in the sea.

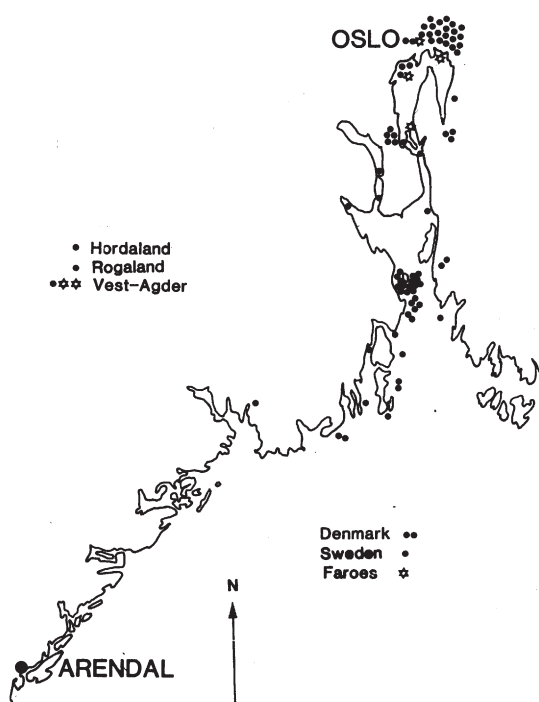


Fig. 4. Geographical distribution of recaptures of adult salmon of the Loneelv stock released in the river Akerselv 1984.

- Recaptures after 1 year in the sea
- * Recaptures after 2 years in the sea.

and 4 show the geographical distribution of reported recaptures of adult salmon where exact place of recapture is known. Of the Imsa and the Sandvikselv stocks also a much higher frequency of the recaptures was reported from the west coast of Norway, while the great majority of the recaptures of the Loneelv stock were reported from the Oslo-fjord.

Straying to other rivers and streams was common, particularly for the fish from the Sandvikselv stock. Most of the adults from this stock were reported caught in other rivers than the river Akerselv. The Loneelv stock had the lowest straying rate; however, even this group showed marked straying. The majority of the strayers were, however, recaptured in rivers not far away from the river Akerselv (see Table 3 for details).

The mean weight of salmon from the three different stocks recaptured 1 and 2 years after release is shown in Table 4. Most salmon were recaptured as grilse, and the Loneelv stock had a much lower growth rate than other stocks.

In total the Sandvikselv stock showed the highest yield per 1000 smolts released, while the Loneelv stock gave the lowest yield (Table 5).

DISCUSSION

The smolts released in the river Akerselv migrated to the sea just after release, which is consistent with experiments performed in the river Imsa (Hansen et al. 1984, Hansen & Jonsson 1985) and in the river Bush, Northern Ireland (Kennedy et al. 1984). Although an active migration out of eddies or backwaters may occur (Solomon 1978, Hansen & Jons-

Table 3. Number of adult Atlantic salmon tagged and released as smolts in the river Akerselv, recaptured in different rivers.

River of recapture	R. Imsa stock		R. Sandvikselv stock		River Loneelv stock	
	Years after release		Years after release		Years after release	
	1	2	1	2	1	2
R. Akerselv	2	3	1	1	21	1
R. Sandvikselv	0	1	1	0	0	0
R. Lysakerelv	1	0	1	0	2	0
R. Gjersøelv	2	0	0	0	1	0
R. Årungsølv	0	1	0	1	3	0
R. Årosølv	0	0	1	0	5	0
R. Drammensølv	0	0	2	0	0	0
R. Numedalslågen	0	0	4	0	0	0
R. Nidelv, Arendal	0	0	1	0	0	0
R. Mosseølv	0	0	0	0	2	0
R. Herregårdbekken						
Telemark	0	0	0	0	1	0

Table 4. Mean weight (kg) of adult salmon recaptured 1 and 2 years after release. N = number of weight observations.

Stock	1 years after release		2 years after release		Total	
	Mean weight	N	Mean weight	N	Mean weight	N
R. Imsa	2.7	41	5.7	8	3.2	49
R. Sandvikselv	2.8	52	4.6	8	3.0	60
R. Loneelv	1.6	78	2.1	6	1.6	84

Table 5. Estimated kgs of salmon recaptured per 1000 smolts released.

Stock	Est. no. of kgs. recaptured	No. of kgs recaptured/1000 smolts released
River Imsa	211	108
River Sandvikselv	243	131
River Loneelv	142	72

son 1985), it is clear that smolts are moving slower than does the river water (Tytler et al. 1978, Hansen & Jonsson 1985). Thus smolt migration is mainly a result of passive displacement. Also in estuaries and inner fjord areas there are some evidence to suggest that migration is a result of passive displacement (LaBar et al. 1978, Holm et al. 1982). Detailed hydrographic data are not available from the different parts of the Oslofjord during the period of smolt migration. The recapture data, however, suggest some aggregation of postsmolts in the innermost Oslofjord the first weeks after release and an increased migration speed after the postsmolts reached the outer fjord areas.

The difference in the recapture pattern between the Imsa and Sandvikselv stocks and the Loneelv stock is probably due to the size of the fish. The Loneelv stock mature almost entirely as small sized grilse, and the few fish from this stock caught 2 years after they were released as smolts are previous spawners (Hansen unpubl. data). For the other stocks the size (i.e. weight) of the two sea winter fish shows that these had been in the sea continuously for two years. Both the long line fishery at Faroes and the Norwegian home water fishery with different types of nets are size selective. The long line fishery is carried out with sprats (12–14 cm in length) as baits. The result of this is that the Faroese fishery, which is carried out from 1 October to 31 May, is mainly catching 2 sea winter fish because pregrilse are too small to prey on large sprat. The minimum legal mesh size in drift nets, bag nets and bend nets in Norway is 58 mm knot to knot. This

mesh size is, however, rare in the drift net fishery operating between the base line and the 12 mile limit along the Norwegian coast, where the majority of the nets have mesh size about 66 mm. The exploitation rate in the Norwegian net fisheries of small grilse is therefore smaller than of large grilse and salmon. This mode of exploitation is probably the main reason for the small proportion of the Loneelv stock caught in distant fisheries compared with the Imsa and Sandvikselv stocks.

The straying rate to rivers other than the river Akerselv was very high, especially for the smolts released in 1981, although most of the strayers were reported from rivers and streams in the Oslofjord, i.e. fairly close to the river Akerselv. One of the reasons for this might be the lack of salmon parr in the river (White 1934, Nordeng 1971). The river system is still considerably polluted (Brittain & Saltveit 1985). This, combined with low water discharge and the warm summers 1982 and 1983, might also be one reason why a large part of salmon avoided to enter the river Akerselv. In 1982 and 1983 there were very few anglers in the river Akerselv and thus a low fishing effort. A total of 10 spawning and tag carrying salmon were, however, observed in the river. In 1985 more than 20 tagged spawners were found. Because there were no other smolt taggings carried out in the inner Oslofjord during the same periods, these fish were interpreted as returns from the smolts released in the river Akerselv. With a higher fishing effort in the river the straying rate thus might be lower than that observed.

The proportion of the reported tags from the Norwegian home water fishery is probably about 50%–70% (Rosseland 1973). Isaksson & Bergman (1978), working in Iceland with one year old reared smolts, observed 1.6 return of microtagged fish for each Carlintagged, indicating that the mortality by using Carlintags might be considerable. The same pattern has also been demonstrated by comparing untagged and Carlintagged wild smolts (Saunders & Allen 1967, Hansen 1981). The reported recapture rates from the river Akerselv are thus considered as underestimates due to unreported tags and

tagging mortality. There are also reasons to believe that some fish lose their external tags.

When taking these sources of error into consideration we can probably double the reported recapture rate of Carlintagged fish when estimating recapture rate of untagged fish. If the yield data presented in Table 5 are doubled, a total of 216, 262 and 144 kgs salmon of the Imsa, Sandvikselv and Loneelv stocks are harvested per 1000 smolts released. The cost/benefit ratio is highly dependent on smolt prices, salmon prices, recreational value etc. However, the present data suggest that releases of salmon smolts in the river Akerselv might be a useful strategy in order to develop a salmon recreational fishery both in the Oslofjord and the river Akerselv. The results so far indicate that a grilse stock such as the river Loneelv stock should be chosen as that stock gave the best returns to the local area.

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