Migration of anadromous Arctic char (*Salvelinus alpinus* L.) in a glacier river, River Blanda, North Iceland.

Sigurður Guðjónsson
Institute of Freshwater Fisheries
Iceland

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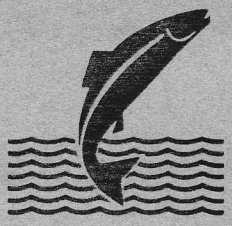

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Abstract

The majority of all anadromous arctic char migrating from the sea into River Blanda, a large glacier river system, in NW-Iceland were tagged in the summer of the years 1982-1986, inclusively.

The char generally spent two summers in the sea before becoming sexually mature. All anadromous char overwinter in freshwater.

Mature immigrants in River Blanda arrived earlier in the summer, the main run of prospective spawners being in July and early August.

The main spawning grounds are 500 m above sea level and 100 km upstream in the headwaters of glacier river Blanda and its tributary River Seydisá. The major proporition of the char population in River Blanda system were found to spawn once. The char spent from 2 to 4 years in freshwater before they migrated to sea early in the spring. Part of the male population became sexually mature as parr without leaving the river.

Immature immigrants in River Blanda arrived later in summer and in fall. The recovery pattern of tagged fish indicate that immature anadromous char overwinter in freshwater within their migratory range (within 100 km distance from River Blanda estuary), not neccessarily their home river, while mature char migrate to their native river in order to spawn. Similar migratory pattern have been observed for brown trout (<u>Salmo trutta</u> L.) in SE-Iceland.

Göngufiskarannsóknir
far á henni
sjóbleikja í Blöndu

Introduction

Artic char is found all over Iceland both stationary stocks and anadromous stocks. Anadromous char only spend the summer at sea , since this species has problems in osmoregulation in saltwater at low temperatures (Rounsefell 1958, Hoar 1976). A population of anadromous char is found in River Blanda, North Iceland. Besides the char, River Blanda has also run of Atlantic salmon (Salmo salar L.) and stationary populations of brown trout and arctic char.

Study site

The catchment area of River Blanda is 2730 km^2 thereof about 10 % is glacier. The length of the River Blanda itself is 125 km from the glacier Hofsjökull where it originates to the Húnaflói Bay where it flows into the North Atlantic Ocean. The summer discharge of River Blanda is around 60 m3\sec. River Blanda has number of tributaries, the largest are River Svarta and River Seydisa.

River Blanda is without obstacles for fish passage except for large cascades 2 km from the estuary where fish can only ascend at certain water level. A fish ladder was built around it in the thirties.

Methods

The study of the anadromous artic char in River Blanda was initated in 1982 as a part of a larger research program which is done because of planned damming of the river for power production. A fish weir was put near the upper end of the fish-ladder near the cascades. Since then all char passing through have been individually tagged with floy-tags.

In 1986 208 samples of char were taken unselectively from the population run throughout the summer in order to see its age structure (otholiths and scales), sex ratio and stage of sexual maturity (according to the system developed

by Dahl 1943. Char at stage 3 and higher were considered as prospective spawners.) The food content of the anadromous char was also examined.

Research nets were used to collect fish 40 km upstream in River Blanda in order to get the ratio of tagged-untagged char. Other tags were recovered from fishermen. The recovery locations rather show where commercial and domestic fisheries takes place rather than exact distribution of the char. The recovery of tags also depend heavily upon personal contacts to fishermen.

Results

Size of the char run

The number of char entering River Blanda each year varied. Part of the char run each year goes up the cascades past the weir. Through the years the proportion of the run going this way has ranged from 6% to 23% as seen from the ratio of tagged-untagged fish in research net fishing 40 km above the cascades (Table 1).

Table 1. The run of anadromous arctic char in River Blanda.

Year	Number of char tagged	Estimated total run
1982	436	493
1983	308	378
1984	519	586
1985	722	794
1986	764	810

Only from three to 10% of the char each year coming in the fish-weir in these years had tags from previous years and only from the year before or from two years earlier.

Recovery of char within River Blanda

Recovery of tagged char from fishery within the Blanda show that the sea run char is widespread in the system (Figure 1).

Many tagged char have been recovered in River Seydisa which has popular sportfishery. River Seydisá and the headwater of River Blanda, which have no fishery at all, are the main spawning grounds and nursery areas for juvenile anadromous char. Electrofishing surveys for juveniles support this. These nursery streams are 500 m above sea level and over 100 km upstream.

-------Insert Figure 1 around here----------

Time of migration in and out of River Blanda

The run of sea char in River Blanda starts in June reaching a peak in August and the run is over in September.

The emmigration out of River Blanda starts in April-May when immature char that have spent the winter in Blanda leave the river. This is seen by the time of capture of char at sea near Blanda estuary in the Húnaflói Bay. The char smolts have been observed to leave the river somewhat later or early in June.

The sexually mature char were generally larger (~40 cm) and entered River Blanda earlier as seen in the weir than the immature char (~35 cm). Mature char came from June to September most of them in July, the mean entering day being the second of August. Immature char came only in August and September, the mean entering day being the 28 of August.

Sea age, sex ratio and sexual maturation of char entering River Blanda

In 1986 approximately 36% of the char run in River Blanda were males and 64% females.

In 1986 68% of examined char were going to spawn in the following fall. The majority of them, 62%, had spent two summer at sea, 30% one summer at sea and eight % three summer at sea.

Of the multi sea-summer char that were sexually mature and entered River Blanda only 27% had tags from previous years.

The immature char entering River Blanda in 1986 had either spent one summer at sea, 64 %, or two summer at sea, 26 % .

The anadromous char in River Seydisa

Tagged char recovered in River Seydisa were recovered either the same year as they were tagged or one to three years later, without being observed to pass through the fish-weir again (Table 2).

Table 2. Number of tagged char recovered in River Seydisa

Time at recovery	number
a) the same summer they were tagged	57
b) one year later	33
c) two years later	4
d) three years later	1

Analysis of tagging date of char in these groups show that char from group a) are generally tagged earlier in the summer than char from the other groups.

Migration outside River Blanda

Char tagged in River Blanda have been recovered from many places in Hunafloi Bay and also in the adjacent fjord, Skagafjord (Figure 2).

----------Insert Figure 2 around here----------

Freshwater age

Age structure of the sea run char population of River Blanda only age of sexually mature char was used, since immature char can be originated from other drainage systems (Table 3).

Table 3. Age composition of sexually mature char in River Blanda examined in 1986.

Year in freshwater	Summer at sea 1	2	3	Total
2	2 %	11 %		13 %
3	26 %	51 %	8 %	85 %
4	2 %			2 %
Total	30 %	62 %	8 %	

Food of anadromous char

No food was found in any char examined.

Discussion

There are fluctuations in the number of char immigrating River Blanda each year. The strength of yearclasses of juveniles of char are very different so char-smolt production of the river differ from year to year. The survival of smolts depend heavily on the oceanic condition.

The period shortly after the smolt migrate to sea is especially critical. The oceanic condition in the sea north of Iceland vary a lot, since production in this area depend on upwelling, which only happens if a branch of the Gulfstream flows into the area (Astthorsson et. al 1983, Malmberg 1986). These are possible explanations of the variations in the char run in River Blanda.

The balance between the number of immature char from other drainages that overwinter in River Blanda and immature char from River Blanda that overwinter in other drainages can possibly be different from year to year, and thus add to the observed fluctuations.

The number of char going up the cascades each year depend on the water discharge and the turbitity of the glacier river. In a warm and wet summer there is more melting in the glacier and the water discharge and turbitity is higher and therefore fewer fish can go up the cascades.

The spawning grounds and nursery areas for juveniles of the char are mainly in the upper drainages and tributaries of River Blanda. Most recoveries of tagged char were in these areas, where there is fishery, or on the way there. Sea-run char have, however, been found elsewhere in the system as in the River Svarta system. However, recoveries from those areas are few inspite of heavy sportfishery. It is not known if sea char will spawn in those areas where non-migratory char also exists, for example in River Fossa.

Different timing of migration of mature and immature char is seen in River Blanda and would likely be more obvious if the weir was closer to the estuary, since char can spend considerable time in the river below the weir. Such different timing of migrations of spawners and non-spawners is known from other places such as in Firth River in Yukon, Canada (Glova and McCart 1974) and other places (Johnson 1980).

One peculiar phenomena is the skewed male-female ratio of immigrating char in River Blanda. Similiar sex-ratio is known from many other sea-char rivers in Iceland (J. Kristjánsson pers. comm.). Skewed sex-ratio in favour of females is known from many other places (Johnson 1980). Precocious char male parr have been found on several occasions by electro-fishing in River Seyðisá. Those males are around 13 cm in length and are 2 or 3 years old. This supports that part of the male population becomes sexual mature without going to sea, thus explaining the skewed male-female ratio of the run of char from sea. Gritsenko (1971) came up with the same explanation for (Dolly Varden?) char in rivers in Sakhalin Island.

The majority of the char run (68%) in 1986 were prospective spawners. Only 27 % of the prospective spawners had tags from previous years. This indicates that part of the immature sea-char population of River Blanda might spend the winter after the first summer at sea in other freshwater systems, since the majority of the mature char had spent more than one summer at sea.

Some immature char migrate at least 40 km upstream as seen in the research nets. It is possible that they migrate all the way to the spawning grounds and become sexually mature the year after without going to sea again. Recovery of char in River Seydisa an year or years later than they were tagged supports that some char do not spawn until the year or even years later than they migrate to the spawning streams. It is also possible that char once having reached sexual maturity does not have to migrate to sea to do so again and spawn. There are insufficient information on the stage of sexual maturity of recovered tagged char to conclude on this matter. The former explanation is more likely, since repeated spawners have not been observed.

The recovery locations rather show where commercial and

domestic fisheries takes place rather than exact distribution of the char. The char is probably distributed all over the the area within its migratory range, which seems to be mostly limited with Hunafloi Bay. This is agreement with most other reports on the size of migratory range of the artic char (Grainger 1953, Nordeng 1961, Glova and McCart 1978, Dempson 1981).

Most tagged char recovered outside River Blanda were caught the year after they were tagged and most of them were tagged late in the summer in River Blanda indicating that they entered River Blanda as immature char to spend the winter there. They were caught the year after either at sea during feeding migration or in freshwater in which they migrated probably in order to spawn, and most likely in those cases it was their native river.

Similiar migration behaviour as seen for the char in River Blanda has been observed for iteropareous anadromous brown trout in Southeastern Iceland. A small hatchery uses the wild trout for brood stock. Sexually mature fish are stripped, tagged and released again. These fish have been recovered on exactly the same location an year or two later when they are returning to spawn again. Tagged immature fish and resting fish are recovered from numerous locations in a number of drainages within the migratory range so only spawners seem to home propely. The others simply do not have to until they are ready to spawn.

Still more complex migratory pattern of salmonids have been described (Armstrong 1981, Johnson 1980).

The char in River Blanda demonstrates great variability in their life history. Individuals of one yearclass can spawn during a period of several years. The char spend from two to four years in freshwater. The char spend from one summer to three years migrating to and from sea and

sometimes staying in other drainages in the winter. Some char stay one to three years at the spawning ground before they spawn. Finally some males become mature without going to sea. The stock can therefore surrvive reproductive failure through several years. If spawning stock is small the effective spawning stock is larger since several yearclasses take part in the spawning. This is probably an adaptation to fluctuating environment. Similiar phenomena are known for Atlantic salmon (Saunders and Schom 1985).

Char migrating into freshwater do not seem to feed. The food of sea char at sea in Iceland has been described and consisted mainly of copepods and amphipods (Gudmundsson 1981).

The migration pattern of the char in River Blanda show how difficult fishery management, including ocean ranching of such stock can be and how careful such mangement must be.

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Litterature cited

Armstrong, R. H. 1981. Migration of anadromous Dolly Varden charr Southeastern Alaska- A manager's nightmare. In L. Johnson and B. Burns (eds.) Biology of the arctic charr: Proceedings of the international symposium on arctic charr. The University of Manitoba Press. Winnipeg.

Astthorsson, O. S., I. Hallgrimsson and G. S. Jonsson 1983. Variation in zooplankton densities in Icelandic waters in spring during the years 1961-1982, Rit Fiskideildar 7:73-113.

Dempson, J. B. 1981. Indentification of anadromous arctic charr stocks in coastal areas of Northern Labrador. In L. Johnson and B. Burns (eds.) Biology of the arctic charr: Proceedings of the international symposium on arctic charr. The University of Manitoba Press. Winnipeg.

Glova, G. and P. McCart. 1974. Life history of arctic char (Salvelinus alpinus) in the Firth River, Yukon Territory. In. P.J. McCart(ed.) Life histories of anadromous and freshwater fish in the western Arctic. Canadian Arctic Gas Study Ltd. Biological Report Series Vol. 20.

Grainінger, E. H. 1953. On the age, growth, migration, reproductive potential and feeding habits of the arctic char (Salvelinus alpinus) of Frobisher Bay, Baffin Island, Canada. j. Fish. Res. Board Can. 10:326-370.

Gritsenko, O.F. 1971. Growth, maturation and fecundity of the char, Salvelinus alpinus (L.) of rivers on Sakhalin Island. J. Ichtyol. 11: 555-568.

Gudmundsson, J. 1981. The food of anadomous arctic char (Salvelinus alpinus L.) in Onundarfjordur, West Iceland. Thesis. 23p. University of Iceland. (In Icelandic).

Hoar, W.S. 1976. Smolt transformation: evolution, behavior and physiology. J. Fish. Res. Board Can. 33: 1233-1252.

Johnson, L. 1980. The arctic charr, Salvelinus alpinus. In E.K. Balon (ed.) Charrs, Salmonid fishes of the genus Salvelinus. Dr. W. Junk Publishers. The Hague.

Malmberg, S. A. 1986. The ecological impact of the East Greenland current on the North Icelandic waters. In S. Skreslet (ed.) The role of freshwater outflow in coastal marine ecosystem. Springer-Verlab Berlin.

Nordeng, H. 1961. On the biology of char (Salmo alpinus L.) in Salangen, North Norway. I. Age and spawning frequency determined from scales and otoliths. Nytt Magasin for Zoologi 10: 67-123.

Roumsefell, G. A. 1958. Anadromy in North American Salmonidae. U.S. Fish Wildl. Serv. Fish Bull. 58:171-185.

Saunders, R. L. and C. B. Schom 1985. Importance of the variation in life history parameters of Atlantic salmon (Salmo salar). Cam. J. Fish. Aquat. Sci. 42: 615-618.

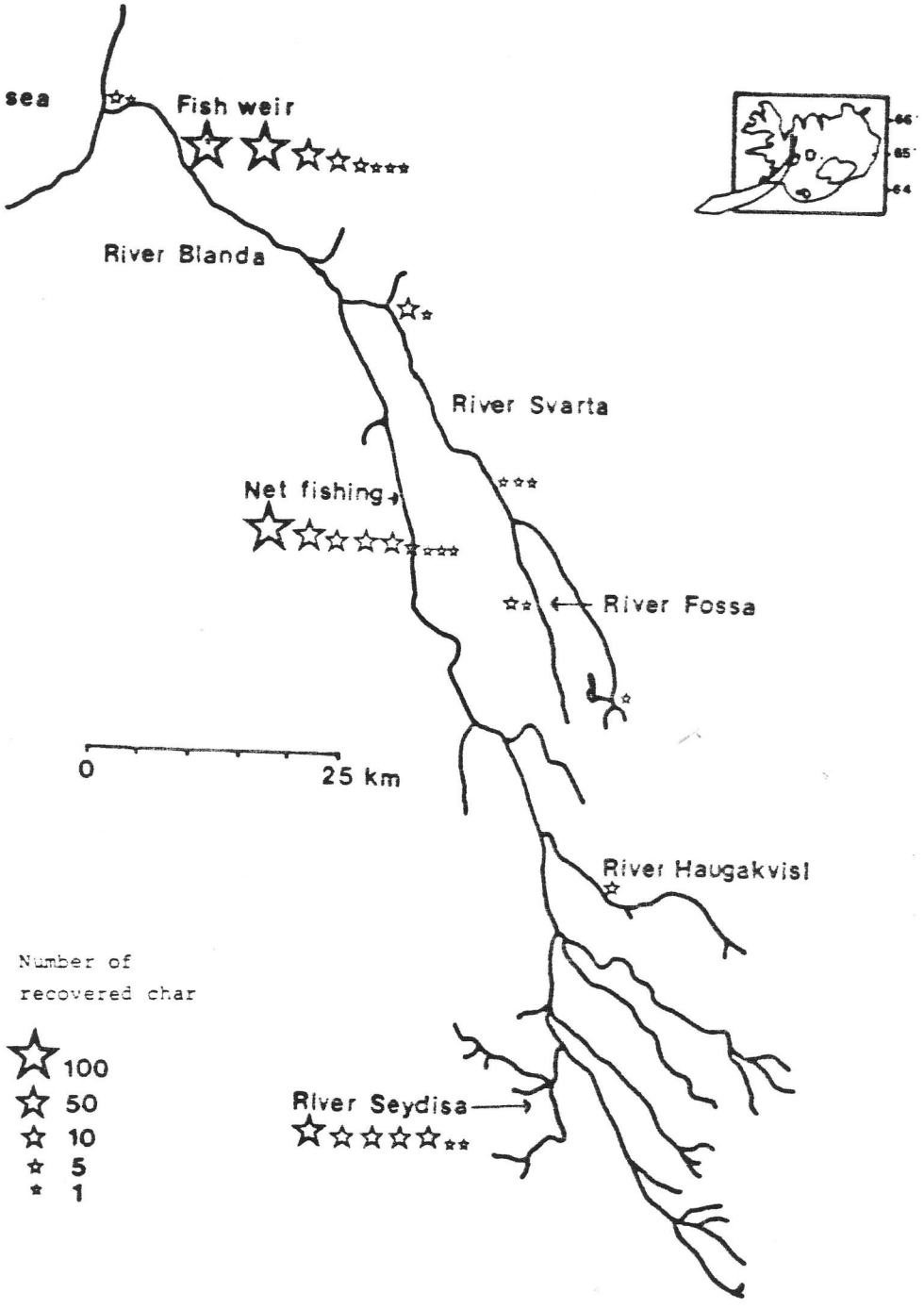

Figure 1. Recoveries of tagged char within River Blanda in the years 1982 to 1986.

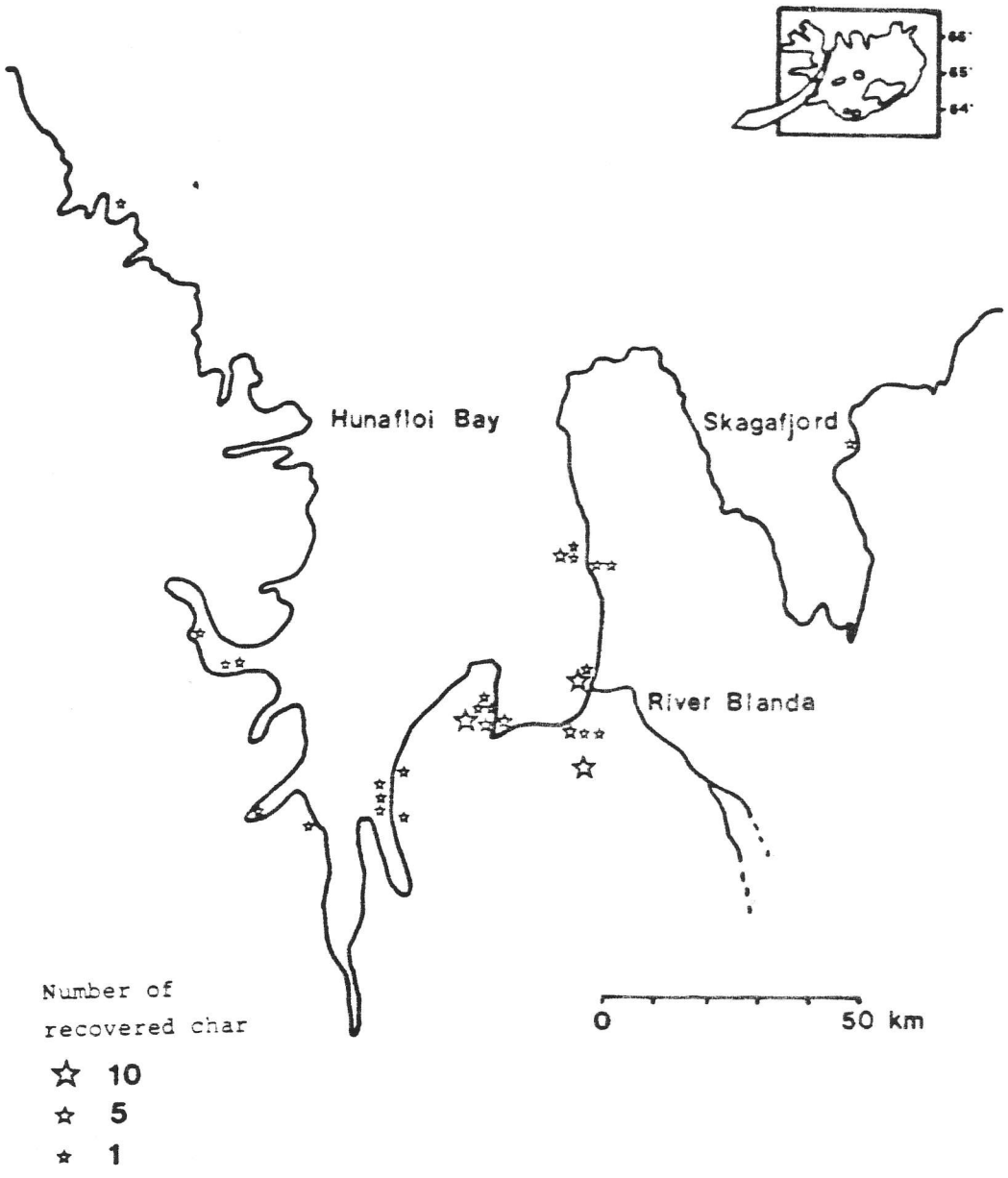

Figure 2. Recoveries of tagged char outside River Blanda in the years 1982 to 1986.