# Atlantic Salmon Trust

## SALMON IN ICELAND

by Thor Gudjonsson & Derek Mills

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*THOR GUDJONSSON AND DEREK MILLS*

## INTRODUCTION

To the angler the word 'Iceland' conjures up the image of clear, fast-flowing rivers, full of bright salmon eager to take his lure. It is probably one of his main ambitions to fish the rivers of Ultima Thule - a land of the midnight sun, wild mountainous landscapes and incredibly pure air. For many this ambition may never be achieved, for others more privileged it may be an annual event.

This booklet has been written to tell those anglers whose ambition is still to be fulfilled something of the salmon scene in this distant country. It has also been produced to provide information for the salmon conservationist, manager and fish farmer in other countries who wish to know how Iceland looks after her salmon.

This work has been a joint effort by the two of us, both salmon conservationists. One of us (Thor Gudjonsson) is Director of the Institute of Freshwater Fisheries in Reykjavik and serves on the International Advisory Group of the International Atlantic Salmon Foundation, and the other (Derek Mills) is a senior lecturer in fisheries management at the University of Edinburgh and is a member of the Management Committee and Scientific Advisory panel of the Atlantic Salmon Trust. The former is a native of Iceland, the latter a good friend and visitor to the country. On one thing we are fully agreed - Iceland is a fine country.

## THE RIVERS

There are somewhere in the region of 250 rivers in Iceland of which 80 hold salmon (Fig. 1). The rivers fall into three categories - glacial, spring-fed and direct run-off. The water in the latter two is incredibly clear while that of the glacial rivers, particularly during the period of snow-melt, is turbid and grey. With one exception, the

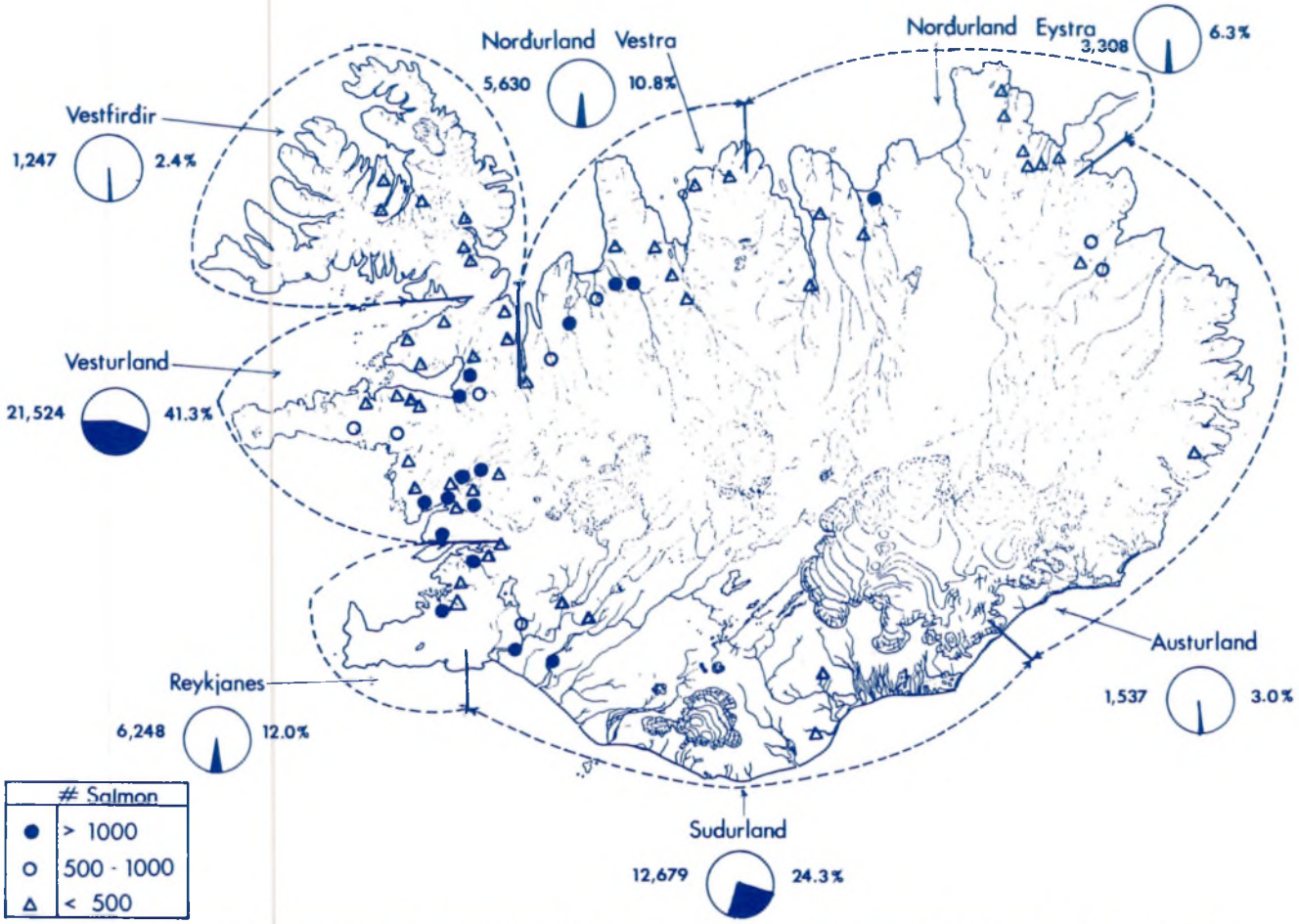



Fig. 1. Distribution of salmon producing streams in Iceland and the average catches 1966-75 summarized for each of the seven districts.

Andakilsa, netting is only carried out in the lower reaches of the largest three of these glacial rivers - the Olfusa-Hvita and Thjorsa in the south and the Hvita in the west. About 40 % of the annual salmon catch of 250 tons is taken by these nets which number about 100 (Appendix 1). When one sees the width and power of these waters and the paltry size of the gill nets which only project a short way out into the stream one is surprised that so many fish are caught by this method. The only other commercial netting is carried out at three points near Borgarnes and two points in Hvalfjordur near Akranes. These coastal nets account for only 1 % of the total catch and were permitted to continue after all other sea netting was banned in 1932 because the farms involved had a traditional income from salmon fishing. The majority of salmon rivers, therefore, are unaffected by netting and it is only those clear-water tributaries which flow into the main stem which is a glacial river that are consequently affected by netting activity. This is the position on the Olfusa-Hvita system in the south. The glacial Hvita is the main river with its upper tributaries coming from the Langjokull glacier on the central plateau. After flowing over the impressive Gullfoss Falls the Hvita is joined by two direct run-off rivers, the Litla-Laxa (a grilse river) and the Stora-Laxa (a large fish river). Further downstream the voluminous spring-fed river Bruara, whose clear cold waters limit its value as a salmon river, flows into the Hvita. There is some angling on the middle reaches of the turbid Hvita and a heavy spoon caught a fish of 42½ lb., which is unusually large for Icelandic rivers. The Sog, which flows out of Iceland's largest lake, Thingvallavatn, is a spring-fed river and is the last to join the Hvita, and where the waters meet there is a marked boundary between the clear water of the Sog and the turbid grey water of the Hvita which now becomes the Olfusa. Anglers fish along this boundary as the fish tend to move into the clear water unless disturbed.

The other river system similarly affected by netting is the Hvita in Borgarfirdi in the west and into which flow some of the best salmon rivers - the Nordura, the Thvera and the Grimsa, all direct run-off rivers with beautifully clear water. About 50 % of the total catch of this river system is taken by nets. One interesting river on this system is the Reykjadalsa which is fed by very hot water from a thermal spring near its confluence with the Hvita. About 200 litres of water a second come from this spring which puts up the temperature of the river to such an extent that it deters the salmon from ascending except during flood conditions. The hot water is now in the process of being piped to neighbouring communities and as a result the Reykjadalsa could become a better salmon river.

Many rivers in Iceland are too cold to support salmon, particularly those in the south-east of the country draining from Europe's largest glacier, Vatnajokull, and even some tributaries of good salmon rivers come into this category. For example, the Laxa in Kjos has a two-forked tributary, the Bugda which flows out of Medalfellsvatn and is a good spawning stream and its tributary the Daelisa which flows down from the mountains and whose snow-melt waters are too cold for salmon.

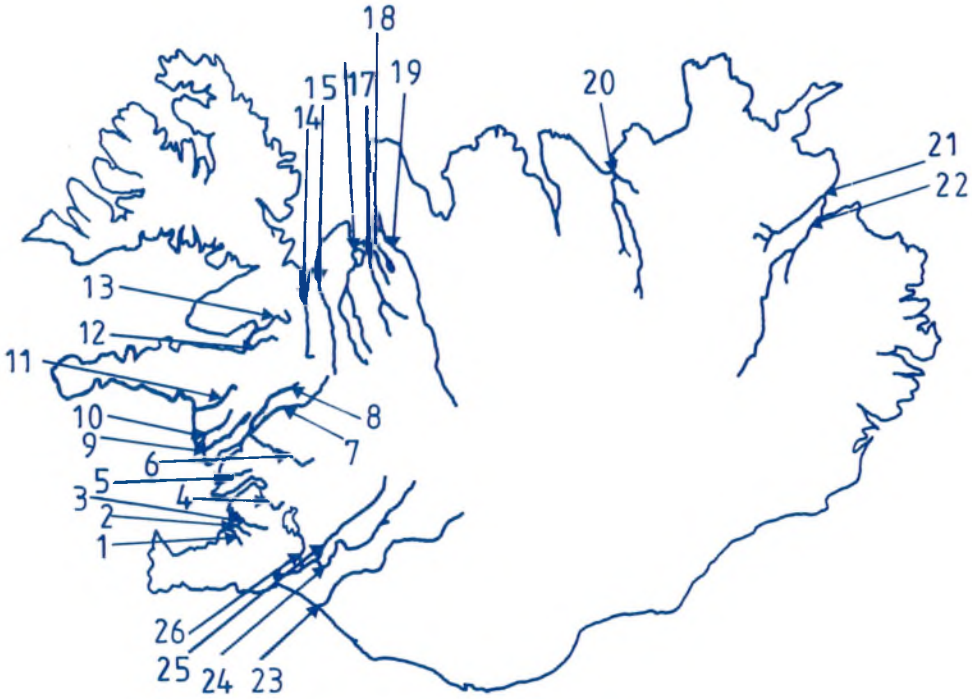



Figure 2. Map showing some of the major rivers in Iceland.

1. Ellidaar
2. Ulfarsa
3. Leirvogsa
4. Laxa in Kjos
5. Laxa in Leirarsveit
6. Grimsa and Tungua
7. Thvera
8. Nordura
9. Langa
10. Hitara
11. Haffjardara
12. Haukadalsa
13. Laxa in Dolum
14. Hrutafjardara
15. Midfjardara
16. Vididalsa and Fitja
17. Vatnsdalsa
18. Laxa a Asum
19. Blanda
20. Laxa in Adaldalur
21. Sela
22. Hofsa
23. Thjorsa
24. Stora - Laxa
25. Hvita in Arnessyslu
26. Sog

Perhaps surprisingly some glacial rivers in the south with no salmon do hold stocks of large sea trout which are still relatively unexploited.

Several clear water salmon streams are found on the West Coast north of the glacial river Hvita. The Langa, a good salmon river with rather a small flow is next to the Hvita. A little further north are the Hitara and the Haffjardara. In the district of Dalir are two well known salmon rivers the Haukadalsa and the Laxa in Dölum. On the Northwest Peninsula (Vestfirdir) there are only a few salmon streams. The best one is the Laugardalsa.

Many rivers in the west and north-west of the country flow through wide valleys with attractive farmland and it is only the surrounding mountains with their characteristic lava formations that remind one that it is in Iceland and not Scotland that one is fishing. Through such terrain flow the northern rivers Hrutafjardara, Midfjardara, Vididalsa with its tributary Fitja, Vatnsdalsa and Laxa a Asum immortalised by Maj. Gen. R. N. Stewart who fished them during the first half of this century (Fig. 2). Gone, however, are the farms he described on the rooves of which the hay had to be cut. The new cream-coloured farm-buildings all have a red corrugated iron covering. Probably one of the most attractive rivers is the spring-fed Laxa in Adaldalur, coming from Lake Myvatn famed for its wildfowl. It is a large deep fast-flowing river falling hundreds of feet to the Arctic Sea near Husavik. The upper reaches just below Myvatn, which are now open to salmon with the completion of the salmon ladders circumventing the three power stations in the middle reaches, are particularly attractive. The numerous islands in this part of the river are covered with the large angelica plant reminiscent of Giant Hogweed. The waters are the haunt of the gaudy harlequin duck. The Laxa in Adaldalur has, like some of our British rivers, a weed problem. In this case it is profuse growths of blanket weed covering the boulders and stones and waving to and fro in the fast flow. The cause in this case is the nutrient rich waters of Myvatn and not artificial ferilisers.

In Northeast Iceland are several salmon rivers most of which yield small catches except for the Sela and the Hofsa in Vopnafjordur district. The latter one is especially well-known, since it has been fished in recent years by His Royal Highness The Prince of Wales and other British dignitaries.

Iceland is a mountainous country. There are many cascades and waterfalls in the river courses impassable by migratory salmonids. During the last three decades about 40 fish passes have been built over partial and total obstructions in rivers. About 400 kilometres (about 250 miles) of river beds have been opened to salmon for spawning, as feeding areas for young salmon and for angling, thus adding considerably to the country's salmon production. Some rivers have also been improved for angling by releasing water from impounded lakes in their upper reaches.

Two rivers benefiting from such flows are the Hitara and Langa.

Pollution is practically non-existent in Iceland's rivers and only one small river, flowing through Hveragerdi, is seriously contaminated by sewage. One unusual form of pollution, however, did occur as a result of the eruption of the infamous volcano Hekla in 1970. Volcanic ash was blown north over the Midfjardara watershed and caused a mass mortality of juvenile salmon. This was reflected in the lower catch returns on this river for a few years. Volcanic eruptions are always a threat in Iceland and lava flows from the Krafla eruption near Myvatn in recent years stopped only a short distance from the Laxa in Adaldalur.

Erosion is more of a problem and bank slumping due to the ubiquitous sheep is much in evidence in the Grimsa valley, while loose scree and shingle bordering the Leirvogsa, Thvera, upper Grimsa and elsewhere results in extensive infilling of holding pools. Attempts to deepen these pools by excavation and croy or groyne construction is only a temporary expedient.

Iceland has no forests and the only growing timber outside the towns is birch scrub.

Hydro-electric development in Iceland is not as extensive as in Scotland although with industrial development being restricted by shortage of electricity further schemes are likely. A major scheme on the glacial river Thjorsa has no effect on angling, but controlled flows from power stations do occur on the Sog, Laxa in Adaldalur, Andakilsa and Ellidaar. Probably the greatest effect is felt on the small but productive Ellidaar which is the famous salmon stream (it is not large enough to call a river) which flows through Reykjavik under the watchful eyes of housing estates and high-rise apartment blocks. A major scheme planned for the muddy glacial river Blanda, in northern Iceland, involving the flooding of some of its upper tributaries, is meeting with stiff opposition. The Institute of Freshwater Fisheries is undertaking a major survey of this river which has yielded to anglers, using out of necessity spoons and spinners, an annual average catch of 1300 salmon in the last few years.

## ADMINISTRATION

As a result of the Freshwater Fisheries law of 1932 a directorate of freshwater fisheries was eventually set up in 1946 under the Ministry of Agriculture. Increasing protective measures were introduced with

changes in this law in 1957. This led to netting being permitted for only half of the week, 10.00 hrs on Tuesday to 22.00 hrs on Friday, and with nets of only a certain length and mesh size and a minimum distance between individual nets. Angling is limited to 12 hours a day in each river between 07.00 and 22.00 hours and usually with an enforced break in the middle of the day. Sunday fishing is permitted. The fishing effort is also kept within limits so that not too many rods are fishing each beat. The owners, who are usually farmers, have formed fishing associations for each river and there are now 145 of these associations throughout the country. These associations manage the fishing and are responsible for local conservation and management. They own or often have a share in a hatchery or small rearing station and release smolts into their rivers each year. Each association has a guard or bailiff, who is usually one of the farmers, who watches the rivers to see the correct times for fishing are observed and no more than the fixed number of rods are on the water. As the farmers own the rivers there is little poaching, the one exception being the Ellidaar which, flowing through Reykjavik, is very vulnerable. The associations arrange the let of whole rivers to angling clubs or to individuals for up to 10 years at a time. Between 40 and 50 of these associations have representatives on the River Owners' Association which tends to be the policy making organisation.

There are 23 angling clubs, all affiliated to an Association of Angling Clubs in Iceland. The largest of these is the Reykjavik Angling Club which is forty-two years old and has a membership of about 1700 and a monetary turnover of £400,000 to £500,000 a year. Four rivers come under its control - the Ellidaar, Leirvogsa, Grimsa, Nordura, Sog and Stora Laxa. It also manages the licence arrangements for several others. The club has its own offices and clubrooms as well as a hatchery producing 20,000 smolts annually. Club membership is open to everyone and there is a most comprehensive magazine published three times a year.

## ANGLING

Most rivers have a fishing lodge at which anglers stay. One of the most luxurious and impressive is the one on the Grimsa overlooking the Laxfoss pool and designed by Ernest Schwiebert. Lodge life has to be experienced to be believed. The day starts at 6.30 with a hurried breakfast after which there is a mass exodus of anglers to their allocated beats to arrive by the water at 7.00. At 13.00 hrs fishing stops and at 13.30 there is lunch, the fish having been weighed and placed on the racks in the cold store. Fe et up until 15.30 and then a good tea and back on the next beat by 16.00. At 22.00 one willingly stops fishing and after a quick bath one is dining at 22.30. Bed by 23.30 - or later. The whole process starts again next day and by the third day the pace starts to tell (Figure 3).

Fly-fishing is the most popular method of fishing with overseas visitors. Small rods of 9 feet are most frequently used but large rods of 12 to 13 feet are useful on the larger rivers and during windy conditions for which Iceland is noted. The most successful flies are those with some blue in the dressing and consequently Blue Charm is one of the favourites. For example, out of 624 fish taken from the Grimsa on fly in 1977, 82 were caught on a Blue Charm, 51 on a Green Butt and 39 on a Sweep. However, on the neighbouring Nordura, of 710 fish taken on fly the Francis caught 235, the Collie Dog 97 and the Blue Charm only 39. The Francis is a prawn-like creation with a body of either red, green, blue or yellow.

Overseas anglers wishing to obtain salmon fishing can contact the Director of the Institute of Freshwater Fisheries in Reykjavik or the Secretary of the Reykjavik Angling Club.

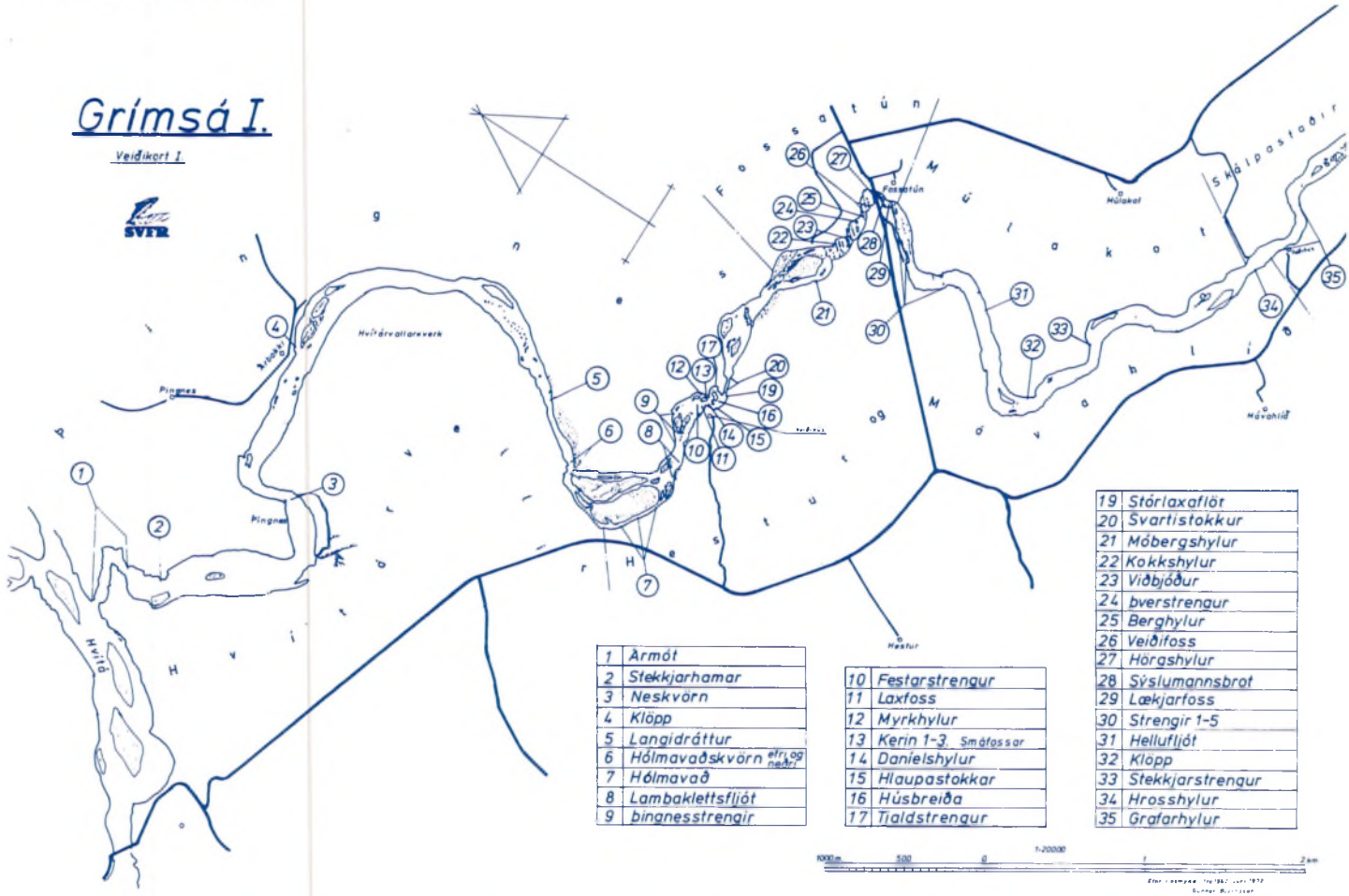
Icelandic salmon have not suffered from UDN and to try and prevent the introduction of this disease angling equipment must be disinfected with formalin before being brought into the country and the production of a vet's certificate to this effect has to be produced on entry to the country. The Council of Fish Diseases of the Ministry of Agriculture will then issue to the angler a Certificate of Inspection and levy a fee of £3.00.

In Veidimadurinn, the magazine of the Reykjavik Angling Club, a study of annual salmon catch statistics, based on figures compiled by the Institute of Freshwater Fisheries, shows that over the last four years (1977 to 1980) the top five rivers have been the Thvera, Laxa in Adaldalur, Midfjardara, Nordura and Langa (Table 1). The rivers producing the heaviest salmon are Laxa in Adaldalur (av. wt. 12.4 lb) and Vatnsdalsa (12.3) and those producing the smallest fish are the Ulfarsa (4.9) and Ellidaar (5.3). (Table 2).

The catches in most rivers in 1980 and 1981 were well below average and many anglers blamed the Faroese long-line fishery. Some are of the opinion that the poor catches were partly due to cold weather in 1979 which resulted in poor grilse returns in 1980 and poor salmon returns in 1981. This seems to have been borne out by the fact that while the catches in nearly all the rivers showed this pattern the returns at the Kollafjordur Experimental Fish Farm were normal. This suggests that it is adverse river conditions that have been responsible as well as any situation occuring at sea. (Table 2).

# Grímsá I.

Veiðikort 1




| | |
|---|---|
| 1 | Ármót |
| 2 | Stekkjarhamar |
| 3 | Neskvörn |
| 4 | Klöpp |
| 5 | Langidráttur |
| 6 | Hólmavaðskvörn efri og neðri |
| 7 | Hólmavað |
| 8 | Lambaklettsfljót |
| 9 | þingnesstrengir |

| | |
|---|---|
| 10 | Festarstrengur |
| 11 | Laxfoss |
| 12 | Myrkhylur |
| 13 | Kerin 1-3 Smáfossar |
| 14 | Danielshylur |
| 15 | Hlaupastokkar |
| 16 | Húsbreiða |
| 17 | Tjaldstrengur |

| | |
|---|---|
| 19 | Stórlaxaflót |
| 20 | Svartistokkur |
| 21 | Móbergshylur |
| 22 | Kokkshylur |
| 23 | Viðbjóður |
| 24 | þverstrengur |
| 25 | Berghylur |
| 26 | Veiðifoss |
| 27 | Hörgshylur |
| 28 | Sýslumannsbrot |
| 29 | Lækjarfoss |
| 30 | Strengir 1-5 |
| 31 | Hellufljót |
| 32 | Klöpp |
| 33 | Stekkjarstrengur |
| 34 | Hrosshylur |
| 35 | Grafarhylur |

Fig. 3. A river section of Grímsá which is leased by Reykjavík Sports Fishing Club. Each fishing spot has a number and a name which is entered into the logbook together with the weight of captured salmon.


Sugandafjordur
Skagafjordur
Reykjafjordur
Saudarkrokur
Laros
Hvalfjordur
Kollafjordur
Ellidaar
Straumsvik
Keflavik
Grindavik

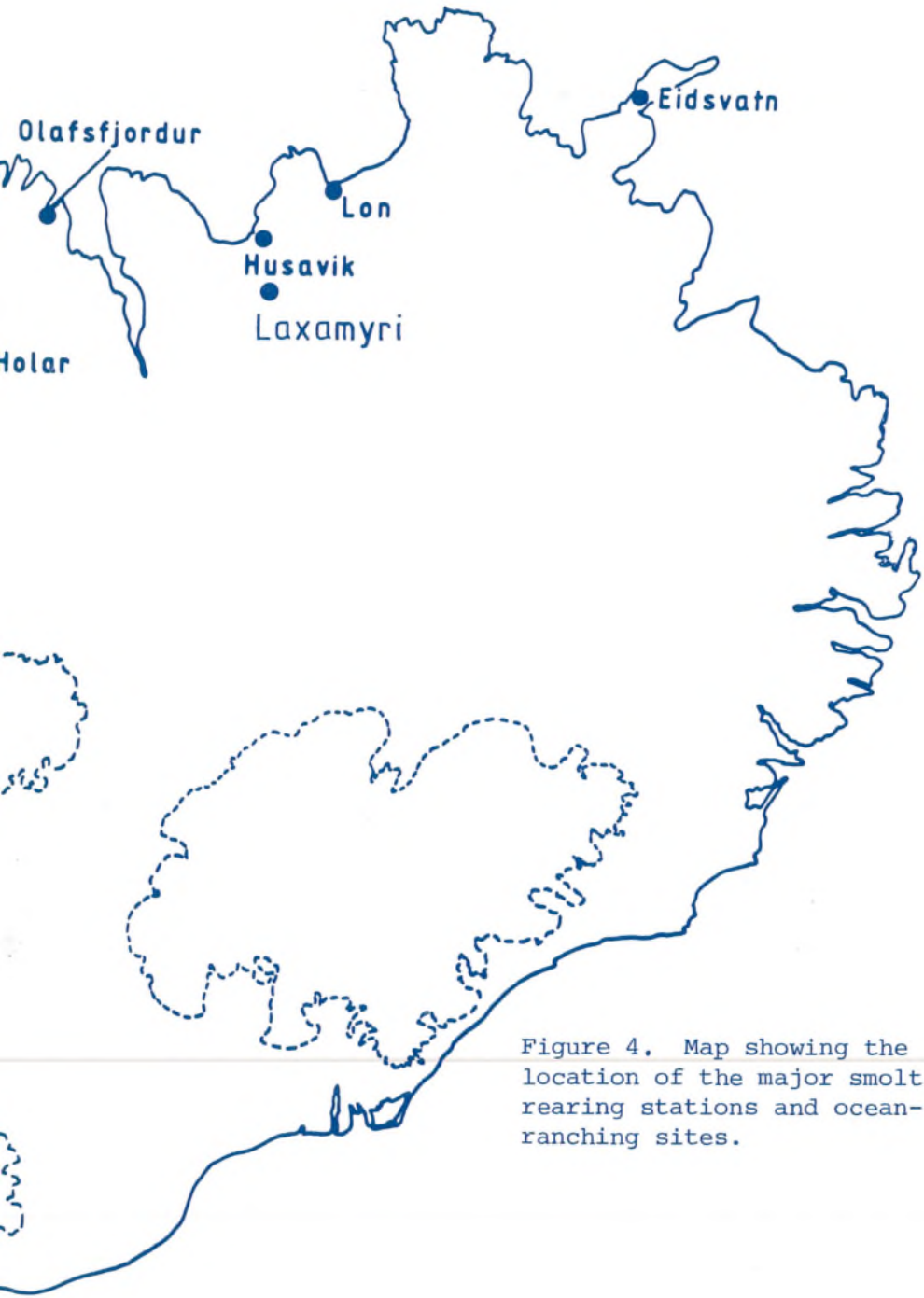



Figure 4. Map showing the location of the major smolt rearing stations and ocean-ranching sites.

Table 2. Average weight (lbs.) of salmon in 30 of Iceland's rivers in years 1977 - 1979 and in 1980.

| River | Average Weight 1977-79 | 1980* |
|---|---|---|
| 1. Laxa in Adaldalur | 9.4 | 12.4 |
| 2. Vatnsdalsa | 8.1 | 12.3 |
| 3. Hvita in Arnessyslu | 8.6 | 11.7 |
| 4. Vididalsa and Fitja | 8.3 | 11.6 |
| 5. Hofsa | 8.3 | 11.2 |
| 6. Blanda | 8.2 | 11.1 |
| 7. Fnjoska | 8.0 | 10.9 |
| 8. Laxa in Dolum | 7.9 | 10.6 |
| 9. Hrutafjardara and Sika | 6.6 | 10.5 |
| 10. Sela | 7.9 | 10.4 |
| 11. Stora-Laxa | 7.3 | 10.4 |
| 12. Midfjardara | 7.1 | 10.3 |
| 13. Vesturdalsa | 7.0 | 9.9 |
| 14. Thvera | 6.9 | 9.8 |
| 15. Laugardalsa | 6.3 | 9.1 |
| 16. Haffjardara | 7.8 | 8.8 |
| 17. Bruara | 6.8 | 8.5 |
| 18. Sog | 8.1 | 8.4 |
| 19. Laxa in Kjos | 6.4 | 8.2 |
| 20. Straumfjardara | 7.0 | 8.0 |
| 21. Hitara | 7.2 | 7.8 |
| 22. Reykjadalsa | 5.9 | 7.6 |
| 23. Nordura | 5.9 | 7.6 |
| 24. Hvita in Borgafirdi | 6.7 | 7.4 |
| 25. Laxa in Leirarsveit | 6.2 | 7.4 |
| 26. Leirvogsa | 4.9 | 6.5 |
| 27. Langa | 5.5 | 6.4 |
| 28. Grimsa and Tungua | 5.9 | 6.4 |
| 29. Ellidaar | 5.5 | 5.3 |
| 30. Ulfarsa | 4.4 | 4.9 |

* 1980 was a poor grilse year

Table 1. Iceland's 20 Best Salmon Rivers ("The Top Twenty")

| | River | Average Rod Catch (1976-1980) |
|---|---|---|
| 1. | Thvera | 2665 |
| 2. | Laxa in Adaldalur | 2447 |
| 3. | Midfjardara | 2073 |
| 4. | Nordura | 1762 |
| 5. | Langa | 1727 |
| 6. | Vididalsa | 1650 |
| 7. | Laxa in Kjos | 1551 |
| 8. | Laxa a Asum | 1434 |
| 9. | Grimsa | 1378 |
| 10. | Blanda | 1337 |
| 11. | Ellidaar | 1335 |
| 12. | Vatnsdalsa | 1137 |
| 13. | Laxa in Leirarsveit | 1060 |
| 14. | Sela | 1021 |
| 15. | Hofsa | 1015 |
| 16. | Hvita in Arnessyslu | 914 |
| 17. | Haukadalsa | 747 |
| 18. | Haffjardara | 673 |
| 19. | Hvita in Borgarfirdi | 541 |
| 20. | Laugardalsa | 500 |

## SALMON CULTURE

In recent years salmon angling in Iceland has become very expensive and large sums of money are now paid by both visiting and local anglers to fish in the pollution-free rivers. Both the maintenance of and the increase in the salmon stocks has therefore been a concern of the fishing associations for some years, and to this end firstly fry and more recently parr and smolts have been released into most of the salmon rivers and tributaries at one time or another.

Although salmon culture started in Iceland in 1885 it was not until 50 years ago that efficient hatcheries were built to incubate ova for the subsequent release of unfed fry and only in the 1960's were rearing stations constructed for the production of smolts. More recently, and partly following on the increase in the number of smolt-rearing stations, great interest has been centred on the use of smolts for ocean-ranching, cage-rearing of adults and the rearing of adults in tanks supplied with sea water.

## SMOLT PRODUCTION

At the moment there are eight smolt-rearing stations in the country and when two of the most recently established farms are in full production somewhere in the region of 1 million smolts will be produced annually. (Fig. 4). This figure is likely to increase as two more units may be constructed in the near future. The main rearing stations are the Kollafjordur Experimental Fish Farm 12 miles north of Reykjavik and under the control of the Institute of Freshwater Fisheries, Nordurlax at Laxamyri near Husavik, Fiskeldi near Husavik, and Polarlax at Straumsvik near Reykjavik and at Holar in the north. Among the smaller units is one run by the Reykjavik Angling Club by the side of the Ellidaar river in Reykjavik. At all the rearing stations there are hatchery facilities, the eggs being obtained from either local river stock or from Kollafjordur which collects its eggs from selected fish returning to the trap. As more ocean-ranching sites are established so more associated rearing units will have independent sources of eggs.

One advantage Iceland has over other countries rearing smolts artificially is the presence of numerous thermal springs resulting from the considerable natural thermal energy underground. This thermal energy, for example, provides all householders in Reykjavik with naturally heated water and about 75 % of the houses in Iceland similarly benefit from this resource. Much of the water is at temperatures of between 80 $^{o}$C and 120 $^{o}$C and so has to be cooled by mixing with the abundant cool, bacteria-free, spring water before being used. However, as some of the thermal spring water has hydrogen sulphide present most of the smolt-rearing units use heat exchangers to raise the temperature of the cold spring water supply from 4 $^{o}$C to an optimum and constant 13 $^{o}$C. Supersaturation of air in the spring water caused by the heating is kept down by aerators of the same type used in Swedish hatcheries. Polarlax at Straumsvik, however, is able to use cooling water of 14 $^{o}$C to 16 $^{o}$C from the neighbouring aluminium smelter direct and mix it with cold spring water.

As a result of this warm water supply most smolts now produced at these units are 1+ years old. In the first year parr usually reach 11.0 to 13.5 cm by the end of the first summer. At Kollafjordur the parr are put into outside ponds for the winter where the temperature of the cold spring water supply will be around 3 $^{o}$C.

Eggs are usually disinfected immediately after stripping. At the new rearing units at Fiskeldi and Polarlax all fish that have been stripped are killed and examined for disease. If disease was diagnosed the eggs from the affected fish would be destroyed. The fish themselves receive no prophylactic treatment. The strict observance of disease prevention at these two stations is exemplary and the standard of hygiene could not be surpassed.

Most of the fish are reared indoors in rectangular fibre glass tanks but frequently on grading are transferred to larger circular concrete tanks. Two rearing units have now the deep circular concrete tanks as used in Norway. An interesting adjunct to these are the fibre glass cones suspended over the tanks and which can be lowered to the surface and result in a more even dispersal of fish in the tank and also prevent them from jumping out.

Those fishing associations which own or have a share in the rearing units, such as the Ellidaar or Nordurlax, release some of their smolts into neighbouring rivers and it is common practice to liberate them into release ponds built alongside and connected to the river so that the fish can disperse in their own time. The remainder of the smolt production is either used for associated ocean-ranching schemes (Kollafjordur, Fiskeldi and Polarlax) or sold to other fishing associations, other ocean-ranching sites, or overseas. Nordurlax, for example, has sold smolts to Norway, the fish having a 4-hour flight in plastic bags supplied with oxygen. The average price of a smolt is 8 Icelandic Kroner (57 p).

In future a greater proportion of the smolts produced will be used for ocean-ranching or adult production in controlled conditions.

## ADULT PRODUCTION

### (a) Ocean-ranching

There are now quite a number of ocean-ranching sites in Iceland, most of them in the north and west of the coutnry. These include Kollafjordur, Laros, Sugandafjordur, Reykjafjordur, Skagafjordur, Olafsfjordur and Lon. (Figure 4).

The Kollafjordur Experimental Fish Farm has been engaged in ocean-ranching since 1963 and up to 1975 436,850 smolts had been released of which 21,260 (4.9 %) returned as adult fish, with annual recapture rates ranging from 0.01 to 14.8 %. A large proportion of the smolts are micro-tagged before release. Initially the smolts were put in earth release ponds outside the hatchery from which they could move into the tidal lagoon and from there out to sea. The adults returning entered the lagoon and were subsequently trapped. Recently it has been found that the best return rate has been from smolts released in the farm's brackish water lagoon close to the Kollafjordur inlet and fish trap rather than from the freshwater release ponds close to the hatchery which are now no longer used; and in 1981 there was a 10 % recapture from a previous release of 30,000 smolts. One thing which has become

most apparent from the results of these experiments is that an adequate and efficient recapture site is important.

Most of the release methods at the other sites mentioned involve a smallunproductive stream, a lagoon into which the stream flows and in some cases the retention of smolts in cages on site until they are considered ready for release. In some instances the recapture arrangements involving a trap have not been entirely satisfactory. However, one site which has given particularly encouraging results is that at Laros near Grundafjord. In 1965 a dyke 300 metres long was built across a tidal flat creating a 165 - hectare lake. A spillway and adult trap were built at one end of the dyke. In the first few years the release of large numbers of salmon parr and smolts into the lake gave encouraging returns of adult fish, but then in 1972 unfed fry produced at an associated hatchery on the side of the lagoon were released each year instead and these gave much poorer returns of adults. The reasons for this included predation by cormorants and a large population of char in the lake, and also a poor initial survival of fry on the clay bed of the lake. In the last few years, however, smolts have again been released in the lagoon and adult returns have improved. It was found in one experiment that better return rates were achieved from smolts retained in cages anchored close to the dyke, and also on the seaward side of the dyke, than from those released directly into the lagoon. The cages are made of polythene piping and are 5 m. in diameter and 1½ to 2 m. deep. Each cage can hold 5,000 smolts.

Two new stations belonging to Polarlax and Fiskeldi are planning to build fish passes between the sea and the hatchery to enable fish to return to constructed ponds where they can be trapped, and selected brood stock retained in D-ended 12 x 3 m. tanks.

About 12 tons of ocean-ranched salmon were taken in 1981 and sold locally at 65 IKr. per kilo (£2.64/lb). In the case of the Kollafjordur Farm the money so obtained goes into the maintenance and running of the unit.

There is no doubt that the success of ocean-ranching in Iceland is chiefly due to the absence of commercial netting at sea and along the coast but also, in part, to the proximity of rich feeding grounds.

(b) Cage-rearing

Cage-rearing of salmon as practised in Scotland and Norway has met with little success in Iceland. This is partly due to a shortage of sheltered sites. Attempts at cage-rearing were made at what seemed suitable sites in Hvalfjordur north of Reykjavik and in a sheltered fjord near Keflavik, but severe gales and near-freezing sea temperatures resulted in damage to the cages, with some being swept out to sea, and

death of the fish. Other factors going against the success of cage-rearing in Iceland are the large tidal ranges experienced and high suspended solids from glacial rivers in some of the fjords.

Some attempts at cage-rearing are still being made at Lón near Husavik by the Norwegian-Icelandic firm Tungulax (ISNO). The lagoon being used is brackish and has upwelling hot spring water. Some cages are being used for bringing on smolts for ocean-ranching while others are used for rearing adults.

An interesting experiment carried out at Kollafjordur recently involved releasing the adult brood stock, after stripping, into cages anchored in the tidal pond. Aproximately 250 kelts were placed in each cage with a diameter of 5 m. and a depth of 1½ to 2 m. After an initial and almost immediate 10% mortality the 90% fish surviving soon started to feed on chopped Capelin and were eventually killed the following August as they stopped feeding on approaching maturation. The fish were marketed locally for smoking and sold at 37 IKr. a kilo (£1.30/lb.). The flesh of these fish tends to be rather pale but this could have probably been overcome by adding shrimp meal to their diet. The fish were also more the colour of brown trout than salmon.

(c) Tank-rearing

One most promising venture being undertaken by a one-time lecturer in animal physiology at the University of Reykjavik is the rearing of adults in tanks supplied with saline water and thermal spring water pump -ed up from the ground. The site is near Grindavik and lies very close to the sea and is practically at sea level. By mixing the saline and warm water in various proportions it is possible to control both the temperature and the salinity. The temperature is normally kept at 10 - 11°C in summer and while this temperature can be maintained in the winter it is generally reduced to 4°C at that time. The venture has only been in operation since 1979 but the results to date are good, with very fast growth rates being achieved. Two-year old smolts of 100 g in June have reached 300 g in August, and last year 100 g smolts reached 2250 g (5 lb) in seven months. The food used is chopped-up Capelin and shrimp and Nephrops shell. Capelin is cheap at 50p/stone (1 IKr/kilo). The owner produced over ½ ton of fish in his first year of operation and plans to increase this eventually to 45 tons when all his hexagonal, 7 m. diameter concrete tanks are in use. A recently completed hatchery will enable him to use his own brood stock. One interesting observation regarding the adults was that 40% of the fish weighing around 5 lb showed no signs of maturation when killed in March.

Before farmers can set up a rearing unit and ocean-ranching site they have to have their plans approved by the Director of the Freshwater Fisheries Institute. Farmers can receive a grant of 1/3 of the estimated costs as assessed by an architect. The grant comes from a government fund to which fishing associations and hydro-electric companies have contributed.

## THE FUTURE

With the advent of so many smolt-rearing stations in Iceland the position could arise where their production exceeds local demand. Fishing associations will probably continue to take a proportion for stocking their rivers, but as only in a few instances has it been shown that there is a consequent increase in the number of returning adults it is unlikely that the demand from this sector of the industry will increase. Although ocean-ranching and tank-rearing sites may absorb the majority of the production there may be a limit here also as an increase in the numbers of salmon from this source together with those taken by rods and nets could well exceed local requirements and result in a surplus. It is considered that the present annual catch of 250 tons just about meets the home demand. This is unlikely to increase substantially as Iceland, with a population of only 230,000, has large marine fish resources within her 200 mile fishing limits. If surplus salmon either fresh or uncured were exported to the EEC they would face a tariff barrier of 3½% for unprocessed fish and this might offset some of the profit for the salmon farmers. Exports to countries outside the EEC is a possibility if transport arrangements are satisfactory.

An increase in the overseas sales of smolts is of course a possibility and some firms have expressed a desire to sell smolts to Scotland. This unfortunately is impossible as Section 1 of the Diseases of Fish Act, 1937, states quite categorically that no live fish of the family Salmonidae can be imported into Great Britain. In any case is is likely that home production of smolts will more than meet the present local demand providing the problem of IPN can be resolved.

A more satisfactory arrangement is foreign investment which has already made some progress through the setting-up of joint fish farming ventures with other countries. The Norwegian company Mowi runs the salmon ranching and cage-rearing unit at Lon jointly with Iceland as the firm Tungulax or ISNO, and the United States firm of Weyerhauser is making plans to establish a rearing and ranching unit in Iceland. Any such arrangement has to be on a shareholder basis where Iceland has the majority ownership, so that the foreign country can hold a maximum of 49% of the shares. However, there are many points in favour of this type of venture, the water quality and quantity is excellent and cheap, electricity is cheap, although presently not as cheap as it is for those engaged in agriculture, and a fish disease service is available through the Veterinary Institute's fish hatchery and fish disease unit at Keldur near Reykjavik. Export of fish could be through the other country's markets and so to areas where tariff barriers do not exist.

There is probably no other salmon-producing country which has such good requirements for successful smolt-rearing and ocean-ranching as has Iceland. Its thermal springs and reliable supply of uncontaminated ground water are certainly unique, and the absence of commercial netting

at sea and along the coast guarantee the maximum return of ocean-ranched salmon. These are points which should encourage any enterprising fish farming company to engage in a successful partnership with Iceland.

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## APPENDIX 1

Table 3: Total Catch of Icelandic Salmon, 1971-1980

| Year | Number | Weight (metric tons) |
|---|---|---|
| 1971 | 58874 | 203.704 |
| 1972 | 65726 | 249.921 |
| 1973 | 66162 | 255.904 |
| 1974 | 55913 | 225.069 |
| 1975 | 74004 | 265.679 |
| 1976 | 59633 | 224.695 |
| 1977 | 64575 | 229.747 |
| 1978 | 80578 | 290.853 |
| 1979 | 64228 | 225.280 |
| 1980 | 52137 | 248.492 |

9th December, 1981

Table 4: Atlantic Salmon Catch in Iceland 1971-1980

| Year | Total Catch | Commercial Catch | Rod Catch |
|---|---|---|---|
| 1971 | 58874 | 18251 | 40623 |
| 1972 | 65726 | 20375 | 45351 |
| 1973 | 66162 | 22495 | 43667 |
| 1974 | 55913 | 21806 | 34107 |
| 1975 | 74004 | 28122 | 45882 |
| 1976 | 59633 | 20384 | 39249 |
| 1977 | 64575 | 23273 | 41302 |
| 1978 | 80578 | 27899 | 52679 |
| 1979 | 64228 | 20273 | 43955 |
| 1980 | 52137 | 22130 | 30007 |

Average weight is about 7-8 lbs. (3.5 - 4.0 kilo)

28th April, 1981