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SALMON RANCHING IN ICELAND

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RÉSUMÉ

Durant les trente dernières années, les captures de saumons atlantiques ont augmenté régulièrement en Islande pour atteindre 80.000 poissons en 1978. Cette augmentation est due à la constitution de passes à poissons, au repeuplement, mais surtout à l'interdiction totale de la pêche en mer, ce qui favorise également le développement du "sea-ranching". Les expériences de "sea-ranching" conduites depuis 1963 ont permis d'obtenir des taux de retour de 4-5 %, avec des records de 10-15 %. Plus de 90 % des poissons qui reviennent sont des castillons d'un poids moyen de 2,5 kg. Les castillons islandais se nourrissent probablement dans le voisinage de l'île contrairement aux saumons plus âgés qui migrent au large du Groenland et de la Norvège. Il semble qu'il y ait de grandes différences de taux de retour entre le Nord et le Sud de l'Islande, par suite de facteurs génétiques ou écologiques. Les différents aspects devront être pris en considération pour le développement à venir du "sea-ranching". Les problèmes concernant le lacher-recapture dans de petites rivières non colonisées par les saumons sont commentés. Enfin, l'aspect économique de ce type d'exploitation est mentionné.

Sea ranching is a term commonly used for the form of aquaculture, where fish are allowed to roam freely on their feeding migration and harvested at a specific location on their spawning migration. It can in some ways be compared to sheep or cattle ranching with the major difference, that the adult fish retrun and do not have to be rounded up.

The Atlantic salmon, along with its Pacific relatives is very well suited for sea-ranching due to its consistent spawning migration to the place of release. It migrates into freshwater in a silvery condition and can be harvested in traps, nets or by rod fishery. Commercial operation of this kind is frequently called salmon ranching.

The Icelandic salmon has a very rapid oceanic growth, with 30 grams smolts growing to 2,5 kilograms in one year and to 6 kilograms in two. If these smolts also have reasonably high return rates this type of salmon ranching should be profitable.

Since salmon ranching experiments started at the Kollafjördur Experimental Fish Farm in the early sixties, it has become increasingly clear that the Icelandic salmon stocks enjoy a higher rate of return into freshwater than salmon in other countries bordering the Atlantic. This has only been confirmed in Southwestern Iceland but the abundance of salmon in other parts suggests similar condition. Three factors are primarily responsible for the high survival rates. Firstly, there is a law, enacted in 1932, forbidding commercial fishing for salmon in the sea. Secondly, there is a high proportion of grilse wich accounts for higher oceanic survival. Finally, it is clear that there is a great abundance of suitable organisms for salmon to feed on around Iceland.

In this brief report I will try to give an overwiew of the state of the Atlantic salmon stocks in Iceland, regarding abundance, type of exploitation, as well as return rates of wild and hatchery smolts. Special emphasis will be placed on, how these relate to the salmon ranching potential in Iceland.

Abundance and Exploitation.

Figure 1 shows the total landings of salmon in Iceland for a 20 year period from 1958 to 1978. The catch has increased four fold in that period, with proportionally greater increase in the sports fishery. Catches in salmon ranching traps have been on a relatively small scale although they amounted to about 10 % of the total landings in 1975. The oceanic environment can certainly carry more salmon, so the present limit is imposed by the number of smolts produced both naturally and in rearing stations. Natural production can be enhanced by producing and releasing summer old fry above impassable waterfalls in salmon rivers. Salmon ranching catch increases, on the other hand, realy on greater production of viable smolts and building of release and recapture facilities in suitable locations.

Salmon ranching will have to be carried out in small streams wich in most cases do not foster salmon naturally due to the fact that all salmon streams in Iceland have a high price tag because of the sport fishery. All salmon ranching experiments to date have been carried out in Southern Iceland but it is of great interest to know if theses could not be performed as successfully on the north coast.

Over 75 % of the salmon are caught in Southern Iceland. Many rivers in that area have predominantly grilse populations with relatively high ocean survival. Salmon on the north coast seem to stay longer at sea, and are not as abundant as in the South. This is partly due to the fact that there are fewer good salmon producing areas on the North coast but ocean age differences certainly play an important role. The differences in ocean age may be partly genetic but one can certainly see many environmental factors which could have influence such as, freshwater age, size of smolts at migration, time of downstream migration, ocean temperatures and river discharge, just to mention a few.

Until further evidence has been acquired it seems reasonable to assume that salmon ranching potential differs between geographical regions in Iceland. This assumption becomes more valid when likely feeding areas and food of Iceland salmon are considered.

In recent years it has been commonly accepted, at least with Pacific salmon, that they stay in oceanic eddies, migrating with the current on their spawning migration. Based on such theories it seems likely that the grilse form Southern Iceland go into the Irminger Sea eddy where they, according to the literature, probably feed on lancetfish and squid. Salmon from this area staying longer in the sea go to West Greenland or the Norwegian Sea as born out in tagging experiments.

The grilse in Northern Iceland probably go into the Iceland Sea eddy where the presumably feed on capelin and sandeel, where as older salmon go into the Norwegian Sea.

The migration of two and three year-ocean salmon to West-Greenland and Norway makes them vulnerable to commercial high seas fishery. It il therefore likely that the grilse populations will be the backbone of any salmon ranching programs. In that case, however, we are dealing with two populations wich are feeding in different areas on different food items. The choice of salmon ranching location may therefore depend on the exhaustability of the food that the grilse from that certain area are feeding on.

Tagging Experiments.

The whole concept of salmon ranching depends on the return rate of salmon smolts from the ocean. It has frequently been difficult to estimate real survival at sea due to lack of suitable tags for the relatively small smolts. In 1974 the Institute of Freshwater Fisheries acquired a microtagging unit which injects small bits of metal into the snout of salmon smolts. These tags are subsequently magnetized and can be found upon return with a special detector. This technique which was developed on the West Coast of the U.S. has been a major breakthrough in the salmon ranching research in Iceland. It has enabled us to get 14,5 % return rate from hatchery smolts which only weighed 25

grams at release compared to 10 % return rates from 50 grams smolts using the Carlin tagging method. It is obvious that it is economically very important to be able to release small hatchery smolts, because it takes considerable amount of food and time to rear them the extra 25 grams. It has, on the other hand, turned out that the smaller smolts require fairly sophisticated release facilities, either concrete or plastic lined.

a) Wild Smolts.

It is of considerable interest for a salmon ranching operation to know the true return rate of wild smolts in the vicinity of the station, as these smolts demonstrate the potential that one should try to aim for in hatchery smolt return rates. The microtagging unit seemed ideal for this king of study.

In 1975 downstream migrants were tagged in Ellioaàr, a grilse stream flowing through Reykjavik, about 10 kilometers from kollafjörour Fish Farm. Hatchery smolts from the Fish Farm were also microtagged and released into the river using two different release methods. The results from that study are in figure 2, which shows the rates of return for various smolt groups.

The most striking results are a recovery rate of wild smolts exceeding 20 %. Comparable figures for hatchery smolts are 7-8 %. It is clear that these high return rates of wild smolts would never have achieved using conventional tagging methods such as external tags. Considering that the average size of the wild smolts at tagging was 12,5 cm and they were extremely silvery and difficult to handle.

b) Hatchery smolts.

The Kollafjördur Experimental Fish Fram was established in 1961 for the purpose of rearing salmon smolts and experimenting with salmon ranching. Unlike many research facilities, the station has been under pressure from the very start to be financially independent and great emphasis has been placed on mass production and sale of smolts, as well as sale of adults returning to the salmon trap shown in figure 3.

The most important contribution of the Fish Farm is the work done to determine the oceanic survival of hatchery smolts. That information has enabled fish farmers to set certain criteria with respect to smolt quality necessary for successful salmon ranching.

Most of the smolt releases at Kollafjördur have been from the release ponds shown in figure 3, but recently release ponds have been built below the salmon trap, which seems to be an improvement. These ponds offer the opportunity of pump seawater from the tidal pond for saltwater adaption of smolts before release. This method of release is being tested at the station.

Total releases and returns at the Kollafjörour Fish Farm for the past 13 years are shown in table 1. Also shown are returns of the best tagged groups as well as the age of smolts in that group.

Summing up total releases and returns for these years we see that some 20 thousand salmon have returned as a result of 430 thousand smolts released. This amounts to a recapture rate of little less that 5 % which must be consedered satisfactory considering the variation in the quality of smolts released over the years. Looking at individual years it can be seen that the early releases in 1964 to 66 were better that the four years following in 1967 to 70. The success of the early years is due to exclusive use of two year smolts, which were raised in outdoor ponds during their last freshwater winter. By 1967 the emphasis was on indoor rearing of one-year-smolts which were exposed to artificial light throughout the rearing period, which in turn inhibited smoltification. (See 1970).

By 1972 techniques had been worked out for successful one-year smolts production, by speeding up the hatching process and using correct photoperiod regimes during the last 30 weeks before release. This resulted in return rates of over 14 % for tagged one-year-smolts as shown in table 1.

Although major guidelines have been worked out with respect to rearing techniques of one and two-year-smolts at the Fish Farm, there is still a great deal lacking in predictable stability of the salmon returns. Too little is known about the relationship between stage of smoltification and correct release time, especially since smoltification has frequently been speeded up by the use of tempe-

rate rearing water. The issue has further been confused by the fact that adequate funding has not been available to provide release facilities suitable for the very small one year smolts which are mostly between 12 and 13 cm in fork length. As a result the returns to the hatchery have been substantially below capacity, especially during 1978. This, however, could easily be predicted from very heavy saprolegnia outbreaks in the earthen release ponds.

Other Salmon Ranching Locations.

Although the foundation of salmon ranching has been laid at the Kollafjördur Fish Farm, it is by no means the only place in Iceland, working on salmon ranching. At Laros in Snøefellsnes there have been attempts to use a natural rearing area, provided by a large lake to rear salmon smolts and generate salmon runs. Success of this operation has been entirely limited by the rearing capacity of the lake where salmon fry have to compete with char fry in an environment better suited for char. Salmon runs to this area lie between 500 and 1000 salmon per year.

Adult traps for salmon are also located at Sugandafjörour, Sveinhusavatn and Eidsvatn, where salmon ranching has been tried using hatchery smolts fo distant origin. Most fo these areas have been releasing few smolts with no meaningful returns. Returns of 2 %, however, have been obtained at Sugandafjörour. It is likely that the distant stocks are not suited for these locations and stocks originating as close to the release location as possible should be secured.

Economics of salmon ranching.

During the spring of 1979 Mr. Andresson, and economics student at the University of Iceland did a cost-benefit analysis of the salmon ranching potential in Iceland. Some of his findings are shown in figure 4. Revenue and cost in dollars are presented on the y-axis as a function of percent returns of salmon smolts on the x-axis.

The analysis assumes that 200.000 salmon smolts are being reared and released in the same location, such as is being done at Kollafjördur Fish Farm. It also assumes an average weight of 2.6 kilograms for returning adults and a price of 5.7 dollars per kilo.

From the figure we can see that 7.2 % returns of hatchery smolts are needed for a break-even, but satisfactory profits to owners are being secured at 10 % returns. It needs hardly be pointed out that a larger operation would be more economical and the returns needed for a break-even would be consederably lower, although exact figures for that are not available.

Judging from our experience at Kollafjörour it seems that it should be possible to perform salmon ranching economically in Iceland even under the terms presented in the figure, provided that the rearing and release operations are carried out in the same location.

Conclusions.

There is no doubt that salmon ranching can be profitably performed in Iceland. The potential in soutwestern Iceland is fairly well known and success seems to be primarily dependent on the use of high quality smolts and good release techniques. Oceanic survival as a function of marine feeding conditions seems of lesser importance.

The most successful salmon ranching experiments have been conducted from combined rearing and release facilities. Further expansion of salmon ranching must go to small streams where a rearing station is not practical, in most instances. There are many problems associated with this expansion. The main ones are related to the use stocks suited for a specific location, the question of homing to unproductive streams with dilute chemical characteristic, as well as marketing of returning adults. The Icelandic market does not accomondate much and large export markets have to be developed.

Proper developement of the salmon ranching programs requires considerable capital which has not been available and has slowed down progress considerably. It is conceivable that the development of a large scale salmon ranching industry is too costly for the Icelandic people and international cooperation of some sort should be considered. But whatever the rate of development one must hope that salmon ranching will become a profitable industry in Iceland in the near future.

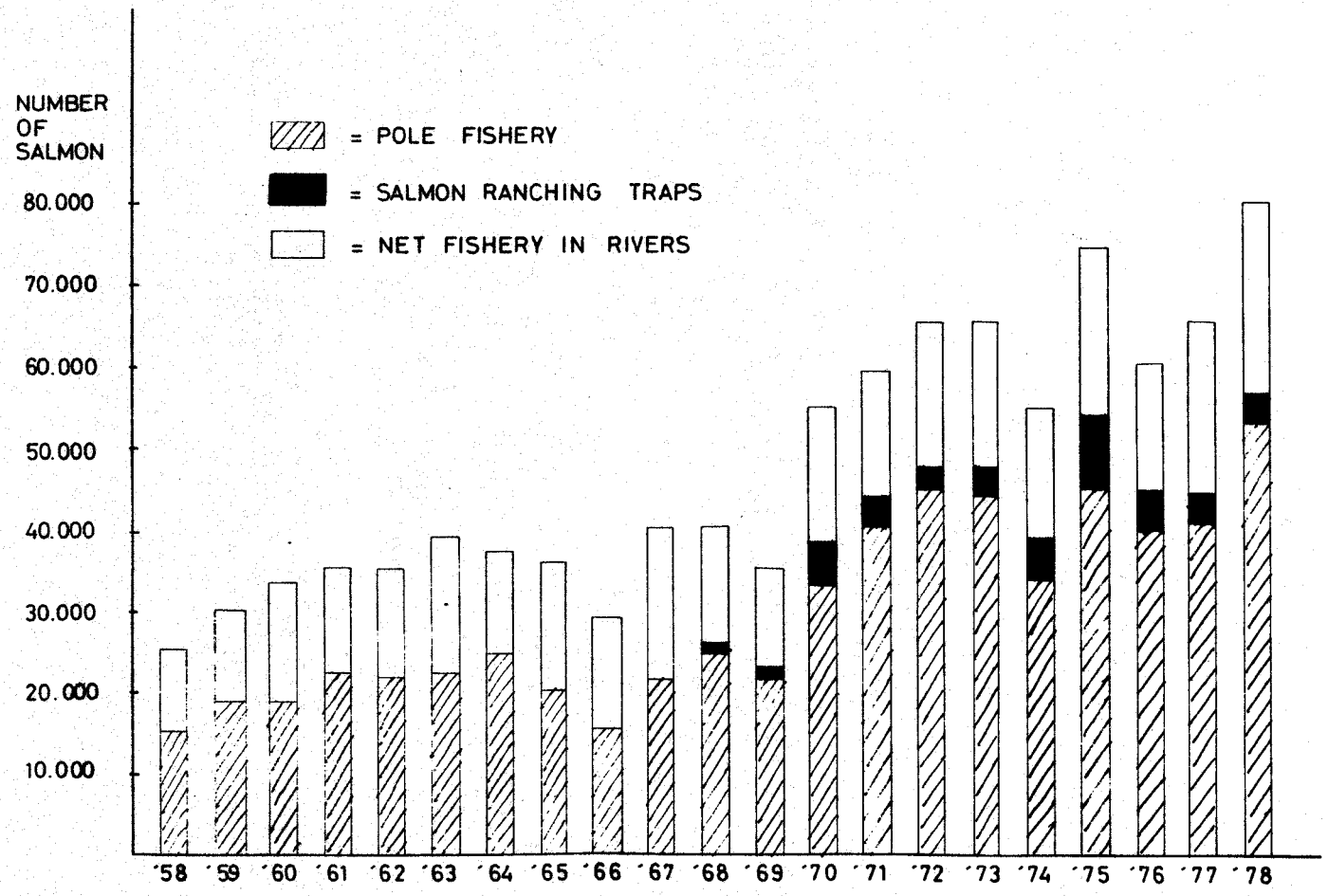

Fig. 1 Totale landings of Salmon in Iceland for the last 20 years and the distribution of the catch into the 3 major exploitation categories.

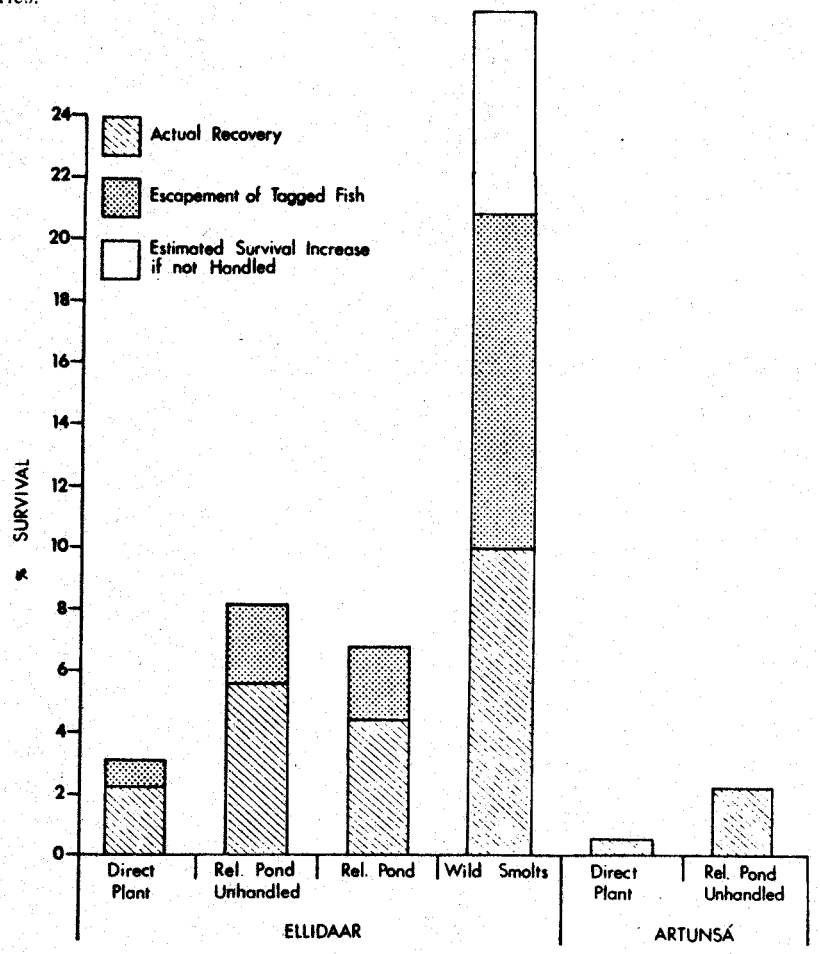

Fig. 2 Survival of microtagged hatchery and wild smolts at Ellidaar and Artunsà in the 1975 tagging experiment.

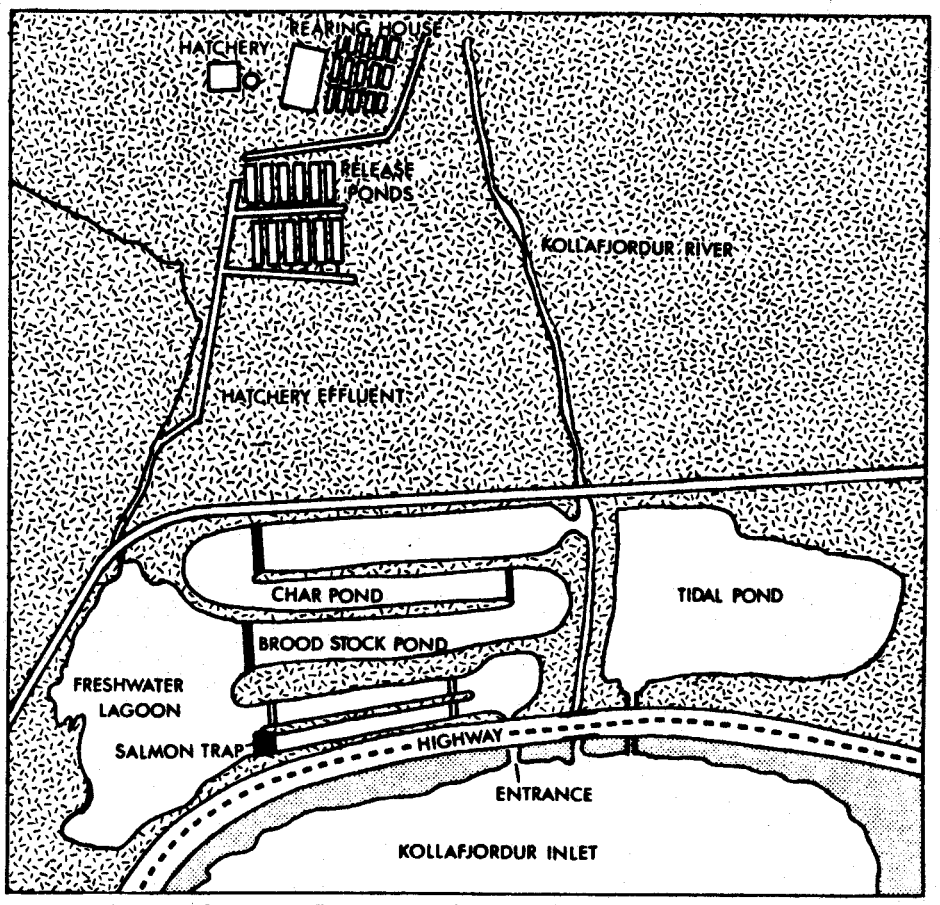

Fig. 3 Diagram of the Kollafjördur Experimental Fish Farm, showing the major rearing facilities, release site and adult trap. Most smolt releases have been performed from the release ponds although some have been released below the salmon trap.

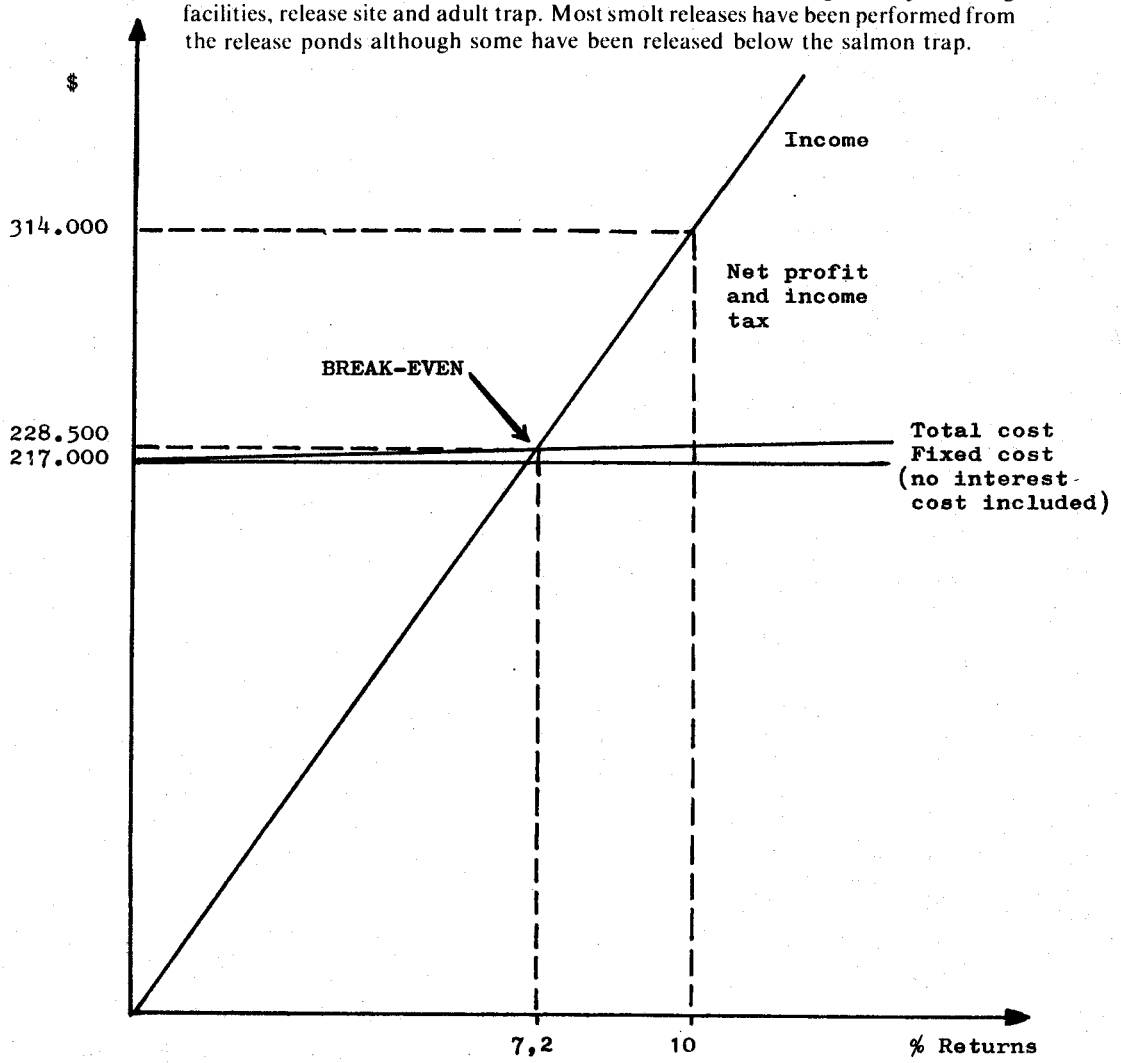

Fig. 4 When average price per kg is $ 5,7, 7,2 % returns are required to reach "BREAK-EVEN". For being able to distribute 15 % of average capital (annually) to owners, 10 % returns are required. Fixed cost is the cost of producing 200.000 smolts.

Table 1. Yearly releases of smolts from Kollafjörour Experimental Fish Farm from 1963 through 1975 and subsequent returns to the adult trap.

Year of release	Number of smolts released	Number of adult return	Number returning as grilse	% return as grilse	Highest returns of tagged smolts %	Age of smolts in best group	Lowest returns of tagged smolts %
1963 a)	300	4	4	1,3	-	-	-
1964 a)	1.000	57	57	5,7	-	-	-
1965 a)	12.250	704	640	5,2	8,2	2-years	-
1966 a)	11.500	610	550	4,8	2,5	2-years	0
1967 a)	11.300	203	190	1,7	0,6	2-years	0
1968 a)	16.000	263	230	1,4	1,7	2-years	0,1
1969 a)	125.700	4187	4100	3,3	10,5	2-years	0,1
1970	95.000	516	350	0,4	0,01	1-year	-
1971 b)	17.500	681	600	3,4	4,7	2-years	0
1972 b)	14.000	1956	1600	11,0	9,8	2-years	1,9
1973 b)	23.300	3065	2850	13,0	14,8	1-year	3,5
1974	82.600	6920	6400	8,0	13,0	2-years	0,1
1975	26.400	2094	1500	5,7	14,4	1-year	0,5
Total	436.850	21.260 (4,9 %)	19071	4,4	-	-	-

a) Guöjònsson 1973
b) Isaksson 1976