

## ATLANTIC SALMON SEA RANCHING IN IRELAND

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### RÉSUMÉ

— Les quatre principales stations d'élevage de smolts en Irlande ont permis de développer la pêche des saumons adultes dans des pêcheries fixes d'estuaire. Mais les "recaptures" sont à l'heure actuelle à un taux insuffisant en regard des normes économiques d'une opération de "sea-ranching". L'un des principaux facteurs limitants du repeuplement à partir de saumons d'élevage est la viabilité inférieure des smolts d'élevage par rapport aux individus sauvages. Ce fait peut être dû à une combinaison de carences de la physiologie ou du comportement provoquées par les techniques d'élevage, aussi bien que par la présence de germes pathogènes à l'état latent sur les smolts libérés. Il est suggéré que l'amélioration de la qualité des smolts soit considérée comme une priorité essentielle pour les travaux de recherche futurs. Un second facteur limitant est constitué par une exploitation de plus en plus importante des saumons adultes lors de leur retour, par la pêche aux filets dérivants, légale et illégale, le long des côtes d'Irlande. Cette pêcherie est alimentée par une contribution significative (3 %) des smolts issus de "sea-ranching". Les adultes issus de smolts d'écloserie contribuent également aux captures à la ligne en eau douce. Dans ce cas, le lieu de lâcher des juvéniles peut être déterminant dans le comportement des adultes lors du retour. La pratique du "sea-ranching" commercial privé en Irlande impliquerait de trouver une solution aux difficultés d'ordre législatif et à l'heure actuelle, ces dernières peuvent être considérées comme insurmontables, en particulier en ce qui concerne l'utilisation de pièges privés en estuaires pour recapturer les adultes. Une comparaison est établie entre l'économie des deux filières : "sea-ranching" et élevage intensif en cages, qui permet d'évaluer les taux de recaptures nécessaires pour rendre le sea-ranching compétitif vis-à-vis d'une exploitation intensive conduite efficacement.

#### 1. The results of smolt-rearing operations in Ireland.

There are four major smolt-rearing stations in Ireland, situated at :

- a) Bushmills, Co. Antrim, operated by the N. Ireland Dept. of Agriculture & Fisheries,
- b) Carrigadrohid, Co. Cork, on the R. Lee, operated by the Electricity Supply Board,
- c) Parteen, on the R. Shannon, operated by the Electricity Supply Board,
- d) Salmon Research Trust, Newport, Co. Mayo, on the Burrishoole River system.

Two further stations exist, but neither has yet made any significant contribution to the total of reared smolts, in that the station at Virginia, Co. Cavan was opened in 1978, producing its first smolts in that year (20,000) but having a projected capacity of 100,000 smolts p.a. The other station, at Cong, Co. Mayo, was designed to produce early-feeding fry and underyearling parr for restocking and released its first batch (1000) of yearling smolts in 1978.

a) the rearing station at Bushmills (R. Bush) was partly operational by 1973 and produced the first yearling smolts in that year. River water quality is poor and this has been reflected in the survival rates from ova to smolts, with heavy losses from gill disease and furunculosis. Only 12.2 % of ova stock survived to end-of-year parr in 1974, 4.8 % in 1976 and 8.4 % in 1977, whilst there was a total loss of the 1975 stock. Filtering and monitoring improvements appear to have had beneficial effects in 1978. Survival rates from smolt to adult, including grilse, 2- and 3- sea-winter fish are shown in Table I, averaging 1.3 % over three years releases. Cold-branded fish survived some three times better than tagged fish, despite the unlikelihood of returns of branded fish from coastal nets. In addition, there is evidence that many tags were shed and brands were unidentifiable ; when due allowance is made for this, the tagged fish survival rate doubles and that of branded fish increases by almost 50 %.

Table I.

Hatch year	1 + smolts released	adults recaptured	2 + smolts released	adults recaptured
1972 Tagged	181	4 2.2 %	946	22 2.3 %
Branded	94	11 11.7 %	1027	45 4.4 %
1973 Tagged	1000	8 0.8 %	1250	8 0.6 %
Branded	1250	29 2.3 %	1250	20 1.6 %
1974 Tagged	3568	0 0.0 %	5600	17 0.3 %
Branded	907	4 0.4 %	31770	445 1.4 %

b) Smolt rearing started on the R. Lee at Carrigadrohid in 1971, following a catastrophic decline in the salmon population after the river was harnessed for hydroelectric power, from an annual catch (nets and rods) of 8000 p.a. to only 292 in 1961.

The creation of shallow reservoirs caused a large increase in pike numbers, which preyed on the smolts and when the pike were eradicated, the predatory role was taken over by large brown trout. The counts of ascending salmon at Iniscarra dam fell from a high point of 914 in 1965 to only 57 in 1972.

Carrigadrohid rearing station has a capacity of 150,000 smolts p.a. and has been virtually disease free, accounting for a survival to 1+ smoltstage from the ova, of 70 %, in most years. The smolts weigh 40-50g and since the first releases in 1972, the counts of ascending salmon at Iniscarra dam have improved :

Table 2.

Year	Smolts released	Adult count
1972	119,000	—
1973	131,418	171
1974	118,800	494
1975	126,00	205
1976	150,000	419
1977	119,000	165
1978	100,000 (?)	300

As well as 1+ smolts, some 90-120,000 underyearling parr have been planted out each year in selected nursery streams. One effect of the smolt planting has been to change the type of salmon present in Lee from what were almost exclusively 2-sea-winter fish to almost exclusively grilse, at the present time.

It was noted from 1973 onwards that a very considerable number of the fish returning to Iniscarra dam were of hatchery origin and by 1977, the river was virtually dependent on hatchery-reared smolts for its continued existence as a salmon river. At the same time, there was increasing concern over the exploitation of these fish by coastal and riverine nets, accounting for the average return to the trap at Iniscarra, of 0.2 %, over the years 1973-77.

c) The rearing station at Parteen became operational in 1960, was expanded in 1966 and can produce over 200,000 smolts p.a., for restocking the R. Shannon which was also harnessed for hydroelectric power. From 1973-76, the numbers of smolts produced fell to around 120,000 p.a., due to increased commitments for smolts in sea-cage operations and to increased mortalities from disease, particularly furunculosis. The smaller parr are graded out and planted in nursery streams on an almost continuous basis so that figures are not available for the survival rates from ova to 1+ smolts.

Similarly, no precise data are available for the return rate of adults from reared smolts at Parteen but it has been suggested that some 3-4 % survive to reach the Shannon, but are then subject to exploitation by river nets and the Thomond Weir trap.

The proportion of reared fish noted in this trap has risen from 12 % (average) from 1970-76 to 20 % in 1978, indicating that wild stocks of smolts are declining by comparison with the relatively uniform numbers of reared smolts released each year. In 1975, over 55 % of the fish examined at a trap at Parteen rearing station were of hatchery origin.

As for the R. Lee, the exploitation of these reared stocks of salmon on the Shannon by legal and illegal coastal nets and by illegal river nets is causing much concern, as the smolt-rearing operations are becoming more costly each year, for a diminishing return.

d) The Salmon Research Trust of Ireland began smolt rearing operations in 1956 and expanded the installations until 1965. A later expansion was used for the production of smolts for a pilot-scale sea-cage rearing operation. Annual production ranged between 5-9000 up to 1967 but since then, has averaged 12,000 p.a., with a maximum of some 18,000. Furunculosis caused a reduction to 7000 p.a. in 1972 and 1973 and the disease has been endemic since that time. Part of the increased production was due to the use of a warmed-water facility during late incubation, alevinage and early feeding, which can increase the proportion of 1+ smolts to 60-70 % of the yearling population, compared with 20-30 % when the fish are reared at ambient temperatures. This warmed-water facility proved too expensive to run in 1979, with oil at approx. 1 FF per litre and the scarcity of supply was such that continuous running could not be guaranteed.

In a normal year, survival from ova to end-of-year parr exceeds 60 % and that of yearlings to 2+ smolts usually exceeds 80 %, although furunculosis mortality can be difficult to control by normal antibiotic treatment.

The first significant returns from reared smolts were obtained in 1963 and in 1969, "reared" (ranch) grilse constituted almost 40 % of the population of the fishery system. In 1972, (after full trapping facilities had been installed in 1970) there was an overall return of 6.6 % from reared smolts but this has proved to be the best return to date, with recent recapture rates falling to around 1 %. It seems likely that the decline is due in part to reduced viability of the reared smolts, from residual furunculosis infection at the time of release. Although outwardly healthy, the stress of an hyperosmotic environment can cause a flare-up of the disease, with heavy losses during the first month at sea. One sea-cage operation has experienced losses of up to 60 % from this cause and in the pilot-scale operation conducted by the Trust, we lost 40 % of one batch of 2+ smolts, among which there had been scarcely any mortality during the preceding three months in fresh water.

It is possible too, that modern smolt-rearing diets are not as satisfactory now as they were in the past, when material such as FPC\* was incorporated in diets of 10-15 years ago but is now unobtainable or prohibitively expensive.

The physiological status of modern reared smolts should be rigorously compared with that of wild smolts and behavioural studies (involving telemetry) might also reveal unexpected differences.

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\* Fish protein concentrate

Apart from reduced viability of reared smolts, a second and undoubtedly serious cause of the decline in the Irish context, has been the much increased exploitation of grilse stocks by coastal drift nets in recent years.

Table 3 gives the results of smolt rearing operations by the Salmon Research Trust since 1966, when the recapture rates up to and including 1969 are the minimum figures, full trapping facilities having been available only since 1970 :

Table 3.

Year of recapture	Smolts released	Adults recaptured	% 2+ smolts	% 1+ smolts
1966	9764	62	0.62	0.83
1967	10256	194	1.87	1.09
1968	14260	490	4.41	2.91
1969	17317	654	5.20	4.02
1970	16637	312	3.64	1.25
1971	10219	136	1.27	1.65
1972	10237	682	7.00	4.08
1973	7906	117	1.55	0.85
1974	5479	60	1.10	1.08
1975	10206	354	4.18	0.80
1976	15674	253	1.62	1.60
1977	15258	96	0.48	0.79
1978	17922	182	0.91	1.07

## 2. Exploitation of reared salmon stocks.

It is apparent from the preceding section that returns of salmon derived from reared smolts to traps situated at the rearing stations have been poor. In the case of the R. Bush, for example, 618 salmon returned from 48,843 smolts, or 1.3 %.

Results from the Lee indicate that 1454 adults returned to Iniscarra trap from 645,218 smolts, or 0.22 %. Survival rates are more difficult to estimate for the Shannon but in 1975, it can be calculated that the total return to the Electricity Supply Board at Thomond Weir and the trap at Parteen did not exceed 2 % of the smolts released. Reared fish returns to the Salmon Research Trust have varied from less than 1 % in 1977 to a maximum of 6.6 % in 1972 but over the period 1966-67, 3410 adults returned from a total release of 143,213 smolts, or 2.4 %.

The reduced viability of reared smolts mentioned above, whether it be from latent disease or physiological/behavioural deficiencies resulting from intensive rearing techniques is born out by comparisons of the relative performances of wild and reared smolts. For example, during the years 1974-76, 5230 wild smolts were tagged and released in the R. Bush, with eventual recaptures of 204 salmon and grilse, or 3.9 %. Similar taggings of reared smolts during the same period gave 0.45 % returns, at 57 salmon from 12,545 smolts. The wild fish therefore survived over eight times better.

The Salmon Research Trust operates downstream traps which allow an accurate count to be made of all wild smolts migrating out to sea. Counts of returning adults (grilse and salmon) in the upstream traps during the two succeeding years have given wild smolt survival rates ranging from 4.2-12.7 %, with an average of 8.3 % for the years 1971-77. The comparable survival rate of reared (cold-branded) smolts for the same period was 2.3 %. Here the wild fish survived better by a factor of 3.6.

Apart, however, from this reduced viability of reared smolts, a further factor which affects the return of adults to a smolt rearing station is the degree of exploitation by high-seas and coastal nets. There is no evidence to suggest that ranched salmon are more susceptible to exploitation by nets than wild fish but sea-ranching, as a commercial enterprise would depend upon harvesting the maximum yield, with a small contribution as possible to the public fishery, unless the operation were entirely State-sponsored.

The drift-net fishery off the north, west and south coasts of Ireland has undergone a rapid expansion during recent years, with the employment of larger boats, longer nets and other technological advances. The catch has increased from about 136 tonnes in the late 1950's to 1514 tonnes in 1975, falling to around 1000 tonnes in 1977. The number of drift-net licences issued reached 1046 in 1975 and is not thought to have increased significantly since then, being subject to some restrictions since 1974. The restrictions have had the unfortunate effect of increasing the number of illegal drift-nets where the proportion of illegally caught fish marketed in 1978 has been estimated at between 20-50 %. The drift net fishery now accounts for over 75 % of the total catch of Irish salmon.

From a number of samples of salmon and grilse caught by commercial nets during the summer of 1977, the Irish Dept. of Fisheries estimated that ranched (fin-clipped) fish constituted 3 % of the catch. If the commercial catch is taken as some 300,000 fish in that year, it would mean that some 9,000 ranched fish were taken by commercial nets. Returns to all four rearing stations in Ireland totalled less than 2000 fish from a total smolt release of about 312,000 that year, with 85 % of the return to Irish coastal waters going to commercial nets and 15 % to the rearing stations.

More recently, a sample of 7567 salmon was examined in Galway by the Dept. of Fisheries between June 19 and July 20, 1978 and 592 ranched fish were noted, constituting 7.73 % of the total catch during that period. The grilse returning to Carrigadrohid station on the R. Lee appear to be particularly heavily exploited by local nets and in 1975, one bag net recorded almost 29 % of its catch of 326, as fin-clipped fish.

This heavy exploitation rate is also having an effect on wild stocks. The Salmon Research Trust is able to calculate the survival rate between successive generations of wild grilse and we find that current values are only about half that required for a self-sustaining population. For example, the survival from one female grilse spawner in 1971 fell within the range 2.83-3.29, showing a healthy surplus over the self-sustaining rate of 2.0. The values for the succeeding three years have averaged 1.03.

Salmon derived from reared smolts can make an important contribution to rod-fishing and in our own fishery, the exploitation rate has been close to (and has sometimes exceeded) that of wild fish. It should be noted that the release point for reared smolts has a pronounced effect on their behaviour as adults, in that fish which have been forced to pass their "homing-point" are generally dour and little interested in anglers lures. If reared smolts are released at the bottom of a river, in order to minimise riverine predation or pollution risks, the returning adults would be unlikely to contribute much to rod catches in the upper reaches of the river.

### **1. Legislative restrictions to commercial sea-ranching.**

Sea ranching of salmon, in the sense of a commercially orientated operation, with total culling of returning stock is not practised in Ireland and indeed, would not be possible under existing legislation, in the Republic of Ireland. A number of river traps operate commercially on some nine different rivers but with the exception of Thomond Weir on the Shannon, part of the river must be left untrapped (the "Free Gap") and traps are lifted for 48 hours at weekend close times. At Thomond Weir, the Electricity Supply Board is allowed to take 28 % of the total run until July 19, each year.

A similar situation exists on the R. Bush in N. Ireland where all ascending fish are trapped and a fixed proportion is released upstream as a spawning escapement, the surplus being sold commercially or maintained as hatchery broodstock. Whilst most of the catch consists of wild fish, there is an element of ranched fish in the catch and this would constitute the closest approach to a true sea-ranching operation in Ireland.

Total trapping facilities exist also the Salmon Research Trust's installations but these traps are used solely for monitoring annual runs of salmon and sea trout and whilst broodstock is taken from ranched fish caught in the traps, no commercial culling of the stocks is permitted.

It would be difficult to formulate the necessary amending legislation for the Republic of Ireland which would enable commercial operators to cull an entire run of ranched salmon. Of necessity, the rearing and release operations for smolts would require a site close to an ample freshwater supply and in Ireland, this would involve wild stocks of salmon and sea trout. The separation of wild and ranched stocks at a trap would almost certainly have to be done under official supervision, in order to safeguard the rights of upstream riparian owners.

#### 4. Economics of ranching salmon in Ireland.

N.B. Exchange rate 9.00 FF = £ 1.00

Any commercial sea-ranching operation requires large-scale annual outputs of smolts and production costs of these fish would constitute one of the major debit items on the balance-sheet. Costings have been produced for a unit to produce 50,000 smolts per annum, examining various alternatives such as production of 1+ smolts only, with sale or planting-out of yearling parr, or the production of mixed 2+ and 1+ smolts. The latter alternative, in the proportion 70:30 2+ to 1+, appeared to be the most economical and updated costings (1978) gave a figure of 4.50 FF each. In a ranching operation, the smolt cost is fixed and is unlikely ever to decrease but increased viability of the smolts produced will give economic returns in that the cost per adult return will decrease.

Using a unit of 1000 smolts in a rough assessment of cost-benefit, the initial outgoings on smolt production are 4500 FF, to which must be added sums for erection and maintenance of a trapping device, rates, taxes and hopefully, a profit margin.

The market price of salmon and grilse to Irish fishermen during 1978 averaged 13.50 FF so that to reach only the break-even point of smolt costs, one would require :

- 6.6 % return of 2.2 kg grilse
- 5.6 % return of 2.7 kg grilse
- or 3.7 % return of 4.1 kg salmon.

Present return rates of salmon and grilse to a smolt-rearing stations in Ireland make it unlikely that sea ranching of salmon will ever find a commercial backer for an Irish enterprise.

As a State-sponsored operation however, various other options and factors become operative, such as the maintenance of coastal salmon fisheries as a social obligation, disposal of surplus yearling parr as a national restocking policy and the use of an entire river system for smolt production, with culling of all surplus adults, as is being attempted on the R. Bush in N. Ireland.

It is interesting to compare the costings of a private commercial sea-ranching operation with those of a sea-farming operation, where these latter have been derived by extrapolation from the actual costings of the pilot-scale scheme undertaken by the Salmon Research Trust from 1974-78. This operation is now being carried on by a private commercial undertaking.

Taking the same unit of 1000 smolts, the minimum expected yield after one year (or less) in sea cages would be 700 fish averaging 1.3 kg in weight. This is thought to be a conservative estimate as the actual survival rate in the 1978/79 season was over 95 %. By marketing before and after the wild grilse run, these fish should realise a minimum of 22,500 FF at 1978 prices. A rough breakdown of production costs for this weight of salmon flesh would be :

smolts .....	4500 FF
food .....	7650 FF
labour .....	2700 FF
cages & moorings .....	1260 FF
supervision .....	900 FF
TOTAL .....	17,010 FF

This leaves a profit margin of some 5500 FF. If this sum were added to the minimum production costs (4500 FF for smolts) of a sea-ranching operation, it would be necessary to achieve a recapture rate of over 12 % of 2.7 kg grilse from these smolts, in order to achieve a comparable income.

## 5. Conclusions

Sea-ranching of Atlantic salmon, as a private commercial enterprise in Ireland, would seem, at present, to be a non-viable proposition, in that :

- (a) amended legislation would be required for the operation of privately-owned river-mouth traps, to cull the entire returning stock of ranched fish, separating them from the accompanying wild stock.
- (b) Survival rates of reared smolts to the adult stage are poor, due to a combination of low viability of such smolts and increasingly heavy exploitation by legal and illegal coastal nets.

As a State-sponsored enterprise, however, with benefits accruing to all sections of the salmon fishing industry, some large-scale enterprises could be justified and may well prove necessary, as a conservation measure. There are indications that artificially reared smolts have made a significant contribution to the total commercial catch in 1978. The only problem remaining is that of increasing the viability of reared smolts. This is the area in which considerable research work remains to be done on physiological and behavioural deficiencies, allied with disease prophylaxis by means of vaccines, rather than the current techniques of antibiotic and chemo-therapy.

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