ICES COOPERATIVE RESEARCH REPORT

RAPPORT DES RECHERCHES COLLECTIVES

NO.197

NINTH ICES DIALOGUE MEETING

"ATLANTIC SALMON: A DIALOGUE"

International Council for the Exploration of the Sea
Palægade 2-4, DK-1261 Copenhagen K
DENMARK

March 1994

https://doi.org/10.17895/ices.pub.5533
ISSN 2707-7144
ISBN 978-87-7482-469-5

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Table of Contents

Table of Contents (continued)

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Balmoral Hotel, Edinburgh, Scotland, UK

7-8 June 1993

INTRODUCTION

The ninth ICES Dialogue Meeting entitled "Atlantic Salmon: A Dialogue" was held as part of the first, open session of the annual meeting of the North Atlantic Salmon Conservation Organisation (NASCO). It was jointly sponsored by NASCO, the International Baltic Sea Fisheries Commission (IBSFC) and the International Council for the Exploration of the Sea (ICES).

The sponsoring organizations gratefully acknowledge financial support provided by the European Economic Community (AIR Programme).

OPENING AND WELCOME

The NASCO meeting was formally opened by Mr Børre Pettersen, the President of NASCO. His address was followed by welcoming statements by the President of the IBSFC, Mr Pekka Niskanen, the Secretary of NASCO, Dr Malcolm Windsor and the President of ICES, Mr David de G Griffith.

In his opening statement, Mr Pekka Niskanen expressed his pleasure, as Chairman of IBSFC, in participating in the Meeting and thanked ICES for making such an important item as salmon the subject of the Dialogue Meeting. He also thanked NASCO for providing an excellent forum for the debate.

He stressed the fact that, although the meeting was to deal with salmon in both the Baltic and the north Atlantic, the problems in the two areas are quite different. In the Baltic most of the salmon are taken in interceptory fisheries which do not discriminate between wild and reared salmon, the latter forming up to 90% of the total stock. He explained that it is extremely difficult in this situation to manage the wild stocks which, in spite of their small size, are of considerable importance, not least because wild salmon provide eggs for hatcheries. In the Atlantic interceptory fishing is forbidden with a few exceptions.

In both areas there is the threat of genetic disorders caused by escapees from fish farms and also of diseases. In the Atlantic there are serious problems from *Gyrodactylus*, for instance, and in the Baltic from the mysterious disorder called M-74. In the Atlantic, the objectives of proper management are undermined by fishing for salmon under flags of convenience.

Mr Niskanen ended his statement by saying that he hoped that the meeting would lead ultimately to concrete measures being applied.

Dr Malcolm Windsor added his welcome to those of Mr Pettersen and Mr Niskanen and expressed the hope that the Dialogue Meeting would provide the opportunity for a full and free debate. He then introduced Mr David de G Griffith, President of ICES, who was to act as Chairman for the rest of the Dialogue Meeting.

In his opening remarks, Mr Griffith explained the purpose and objectives of Dialogue Meetings as being for dialogue and not decision making, thereby creating an atmosphere in which open discussion is possible. He nevertheless hoped that the Dialogue might lead on to decisions at the subsequent Commission meetings. He informed delegates that the proceedings of the dialogue would be published as an ICES Cooperative Research Report and that the meeting was being taped for that purpose.

He also informed the Delegates that he had asked three discussion leaders from the main sectors represented to start the discussion at the beginning of the second day of the meeting by summarising the main points of the first day's discussions and by identifying the key questions that need addressing.

After his introduction Mr Griffith introduced the keynote speaker, Mr Magnus Magnusson.

KEYNOTE ADDRESS:
THE SALMON

by

Magnus Magnusson KBE, Chairman, Scottish Natural Heritage, Edinburgh, UK.

It must be a truly majestic creature which can command the attention and presence of so many eminent people from so many different nations. The Atlantic salmon - *Salmo salar* - is such a creature: the king of fish, no less. You are here to cerebrate - I am here to celebrate the salmon at the start of your International Dialogue.

Salmo salar: it was Pliny the Elder, the first-century Roman natural historian, who gave it the name *salmo* in his "Historia Naturalis". To the Romans it was not an obscure scientific name; it meant, simply, 'the leaper'. Few names have been more evocative or accurate.

The Atlantic salmon combines grace and beauty with power and an impression of wildness and purity, tantalisingly enveloped in an enduring mystique. The Atlantic salmon and its lifelong struggle against both natural and anthropogenic forces is positively awesome. It has attracted the attention of scientists for many, many years now, but it has never given up its secrets lightly. The basic outline of the salmon life-cycle was first described in the early 16th century, but it was not until the second half of the 19th century that final agreement on it was reached. For a very long time, many eminent scientists believed that what we now know to be the salmon parr was actually a separate species! Similarly, kelts were thought to be a different species and given the specific name, *Salmo argentatus*.

What we do know for certain is that we still have a great deal to learn about its behaviour, and that this quest for knowledge and understanding is becoming all the more urgent if we are to arrest and reverse the perceived decline in the stocks of this magnificent fish. It is not the first time this has been said. As long ago as 1852, Dugald Williamson bemoaned in an article 'the present scarcity of salmon'. That is hardly surprising: the natural world is full of well-documented cyclical phenomena, with populations of individual species rising and falling over periods of years. All things are relative: what was a 'present scarcity' to Dugald Williamson may well be considered a glut today. The one thing we <u>can</u> be sure about is that the range and scale of pressures on the salmon in 1852 cannot compare with those of today. Mother Nature may have a way of managing her stocks; it is when the greed and shortsightedness of Man comes into the frame that the problems really start.

Even after the enigma of the salmon's life-cycle was resolved, the question of where they went at sea and perhaps the even more teasing question of how they navigated and returned to their natal rivers, remained unanswered. Their international journeyings are now becoming better understood, and perhaps it is not all that surprising that such an enigmatic individual is found to be extremely cosmopolitan in its distribution.

It is an anadromous life-cycle, with fish spawning in the rivers of many nations but spending much of their life at sea in international waters mixing with fish from the rivers of many other countries - and therein lies a part of the problem. Assuming that Man has any right to claim 'ownership' of <u>any</u> wild animal, who owns the salmon?

Until about 30 years ago, allocating the salmon resource was a fairly straightforward operation and for each salmon-producing country it was purely a domestic issue. The salmon was harvested commercially only in coastal waters and river estuaries, and rod anglers (and saw-bill ducks!) took their share farther up the rivers. It was possible, to a certain extent at least, to manage the stocks: it was not perfect, but it could have been a great deal worse. In the last 30 years, however, things <u>have</u> grown a great deal worse, with the advent and escalation of the west Greenland salmon drift-net fishery which, in its early years, was to all intents and purposes unregulated. Combine this with the increasing numbers of predators, the growth of the industrial fisheries for sandeel and sprat which constitute an important element of the salmon's diet, and the general deterioration of water quality, and it is blindingly obvious that the pressures on the salmon have increased hugely. These open-sea fisheries have mercifully declined and are, in part, much better regulated now; but with salmon still being caught at sea far from their natal rivers it is very difficult to collect meaningful fishery statistics to enable proper cooperative management of the stocks.

A striking example of the international dimension can be seen in the Faroese fishery, which is now closed with the exception of one research vessel. It is worth taking a moment to consider the history of this fishery in a little more detail, because there is a number of lessons to be learned from it.

The Faroese, clinging to survival on their rocky islands (and as a native Icelander I have to declare a certain ethnic bias here!), have always been highly dependent on a good harvest of the traditional commercial stocks. As these stocks declined alarmingly in the late 1970s, they turned their attention to the salmon as an alternative resource. As is too often the case, alas, the failed management of one stock affects more than just that particular species: a replacement quarry has to be found.

Salmon captured by this new fishery had origins as wide-ranging as Norway, Sweden, France, Ireland, Iceland, the UK and even Canada and the former Soviet Union. With fish from so many different countries of origin being taken in varying, unknown quantities, it was essential not only to act locally but to think globally, as the modern adage has it. But where the social and economic well-being, and the cultural life-style, of small island communities almost wholly dependent on fish are concerned, it is not always easy to apply such lofty philosophical principles.

The solution to the problem of accommodating this new additional fishery, when it came, was positively inspired, to my mind, at least. The fishery was closed after private negotiation, when the salmon quota of the Faroe Islands was purchased through the agency of the North Atlantic Salmon Fund (which, I am proud to say, is the brainchild of one of my own countrymen from Iceland); it may not be ideal, but it may well be that the same sort of approach should be considered for other situations in the future.

But back to my theme of celebration of these magnificent creatures. When I look at a map of the journeys they undertake I can only marvel at the scale of their endeavours. They travel the great tracts of the northern oceans with Greenland at the hub, the Piccadilly Circus of the salmon world, if you like. How these wonderful fish navigate, and where they go on these epic and infinitely complex migrations, still remain, in part at least, unresolved. One theory is that out at sea they can sense electric potentials created by the movement of ocean currents in the earth's magnetic field. As they near home they use the scent of the smolts in their natal river to guide them for their last leaping swim for 100 km or more to the small burns and headwaters where they will spawn and die.

It is beyond dispute that Atlantic salmon stocks are in decline throughout the range; and while there are many factors affecting the freshwaters vital to its breeding, the major problems may be found in the oceans. Much can still be learned by using ever more sophisticated tracking equipment. With increasing sophistication, however, come increased costs and a growing need for international cooperation - a need which, I submit, should now be seen as an opportunity, not a chore.

I am sure you do not need me to tell you that there are many complications to consider and conflicts to overcome with regard to the Atlantic salmon. The salmon represents so many different things to so many different people. It has inspired a rich folklore in countless countries. It is a natural resource capable of enduring exploitation and enjoyment, for commercial purposes, for recreation, for aquaculture. It also represents a profound intellectual challenge to all of us in this three-cornered dialogue between the user groups, the scientists and the managers: especially, if I may say so, to us in Scottish Natural Heritage, established barely fifteen months ago to help to ensure the preservation, enhancement and enjoyment of Scotland's natural heritage. The salmon is a tremendously important part of the natural resource of Scotland - and also of the people whose livelihoods depend on healthy stocks and an unpolluted environment. I am sure the same can be said of many peoples in many nations where native salmon still run. Here in Scotland, the value of salmon has been appreciated since time immemorial. Laws to conserve salmon stocks go back a very long way. As early as 1030, Malcolm II of Scotland introduced a close-season on fishing from Assumption Day to Martinmas (the end of August to November 11), and there have been laws governing the taking of salmon ever since. At the beginning of the 19th century the stocks in our Scottish rivers were still very large: more than 100,000 salmon and grilse were being caught on the River Tweed each year, and the River Tay was not far behind. By the end of that century, however, the output from Scottish rivers was a mere fraction of what it had been, and salmon had disappeared entirely from many rivers. In England the situation was even worse - a far cry from the 14th century when Ranulf Higden, a monk of St Wesburg's monastery in Chester, noted in his Polychronicon that salmon were so cheap that they were fed to pigs!

With so many modern-day claims upon it, it is inevitable that there should be conflicts over it; but it is vital that all the users of the salmon are accommodated as far as is reasonably possible, and that agreement be reached. Where necessary, compromises will need to be made in the quest for a reconciliation of conflicting demands. We must seek sharing. But at the end of the day we must not lose sight of the needs of the salmon itself.

And this is the intellectual challenge. Surely our search for a solution in the face of adversity should be inspired by the example of the salmon itself. What a wonderfully courageous creature it is as, clad in its various livery, it encounters and overcomes so many obstacles, both natural and anthropogenic. In the open sea it is ambushed by men in trawlers as well as by seals and dolphins. Offshore it runs the gauntlet of invisible nylon driftnets; off rocky headlands, along loch shores and in river estuaries it must thread its way through a maze of stake nets and traps. As it struggles upstream it must ignore the tempting lure of the angler by day and evade the blazing lights, gaffs and spears of the poacher at night. We must thank providence for giving the salmon the enormous reproductive power which means that only a few adults need to survive all these vicissitudes and spawn in order to maintain the survival of the species.

Yes, a marvellously complex, courageous creature. But in any situation which is dominated by a single species it is all too easy to lose sight of the wider issues and considerations involved. We sustain our own survival by striving to find answers which will explain things which are often beyond our comprehension. But all too often we expect too much. We demand that our scientists 'prove' what we want to see proved. We look for instant definitive predictions and instant black-and-white solutions. We seek scapegoats to blame. We must all resist the temptation of expecting scientists to provide simple, even simplistic, solutions to complex problems for which we often do not even recognise all the variables.

In Scottish Natural Heritage we have to address many such problems, and to assist in our deliberations we draw upon the three principles which guide our policy thinking: environmental sustainability; integrated resource management; and partnership. All three enjoin us not to use up the natural capital of the world's resources at the expense of the future. All three require a self-denying ordinance against excessive expectations. All three promote the principle of sharing. All three embody the precautionary principle. I would commend to you these principles in the debate which will follow as you explore the means of achieving sensible conservation and thus the perpetuation of healthy stocks of Atlantic salmon.

Inevitably, difficult decisions have to be taken, and dilemmas confronted. We have them in Scotland, too. The salmon and all that it represents in Scotland rightly deserves our attention and concern. As a wild animal it is both predator and prey, and therein lies the rub. Apart from Man, the main predators of salmon are birds such as sawbills which take the young parr, and seals which some interested parties see as growing over-fat on ever-dwindling salmon stocks. Depending on your standpoint you can argue the case for the salmon or the seals or the sawbills - but maybe we should take the side of the sandeel or the capelin on which the salmon itself feeds? I do not raise this issue in order to get involved in a scientific or philosophical or even moral debate, but merely to highlight the complexity of the situation.

It is vitally important that we take as broad a view as possible of all the issues involved. To us, the essence of sustainability is that not just <u>one</u> user should use it sustainably, but that every aspect of our proper utilisation of a natural resource (extraction, or harvesting, or marketing, or recreational enjoyment) should be part of an integrated sustainability package.

Safeguarding the salmon depends on taking account of everyone's interests. The great value of a conference such as this is that it allows people to hear others' points of view, however unpalatable. It allows us to be provocative without being combative, and it offers an opportunity to seek reconciliation of conflicting interests, and to explore the systems which will put into effect an acceptable equation which does not jeopardise the salmon or its environment. And that can only be done through adhering to the principles of environmental sustainability, integrated resource management, and partnership.

If our objective is the sustainable integrated management of the salmon stocks through a range of partnerships and cooperation, then it is important to recognise that the salmon is a complex animal living in a complex environment within a complex ecosystem. Here in Scotland we have been blessed with a plentiful supply of rivers, large and small, which for the most part still run with the clear, unpolluted waters so vital for the early and final stages of the life-cycle of the salmon. Many other countries were once so blessed - Germany, Belgium, the Netherlands, Switzerland and Czechoslovakia, to name but a few - but no more so, with many rivers so badly polluted or blocked that the salmon can no longer run their gauntlet.

Freshwater is only one link in the life-cycle chain, however; pollution is much more widespread and, as with the salmon, it recognises no international boundaries. To save the salmon requires an international resolve to clean up our waters, both fresh and marine - to clean up our act, indeed. This will in the long term be to the benefit of all life. It is a massive task, but the benefits on both a global scale as well as more locally are well worth the effort. The recent return of wild salmon to the River Thames, for instance, had a remarkable effect on Londoners who have no intention or opportunity of ever trying to catch one. It was as if they felt they could sleep better o' nights knowing that salmon were back in the river, as a potent symbol of all being right with the world. This psychological 'feel-good' aspect not only unites people in a mutual feeling of exhilaration but inspires them to strive for an even better environment all round. It becomes a crusade. It becomes a totem of achievement, of the possibility that it is not too late to undo the damage of the past. With such people-power to harness, anything can be achieved.

In all international dialogues of this sort it is all too easy to dwell upon the negative points, and to accuse other parties in the argument of not pulling their weight or taking more than their fair share of the cake. That's life - but mutual recriminations are not going to get us anywhere. There is always another side to every coin. Successes and opportunities do exist. And it is on those more positive issues that I wish to dwell for the remainder of my time.

I believe we are meeting the intellectual challenge. If the number of scientific papers written on a subject, and the number of meetings of this sort, can be taken as a measure of concern and progress, we seem to be meeting the challenge head-on. It is the application of all this information which is going to be important. Scientific research is not the panacea which will provide all the answers; but it does make it possible to make informed comment, and we should not shrink from this, even if it leads to the implementation of the precautionary principle. The example set by Canada, with $24 million of federal funds being provided to restore the salmon rivers of Quebec, for instance, is something to be applauded and wherever possible emulated.

Recreation, commercial fishing and aquaculture are not, it would seem, natural bedfellows. At the end of the day, however, it is important that they all cooperate to achieve sustainable use of their common resource through integrated management based on a wider examination of the issues.

Peoples in the past, like the Inuit Indians of North America, have shown they were quite capable of exploiting the salmon in a way which accommodated the natural variations in the stock. It was necessity, not ambition or greed, which was the controlling factor. Those were simpler days, perhaps, and we must not be blinded by the sheer brilliance of the salmon or tempted by sentimentality into trying to preserve everything as it was before, in the good old days. We live in an ever-changing world, with ever greater pressures on our natural resources. With these greater pressures come even greater responsibilities to ensure the conservation of the biodiversity of all our wildlife - including, of course, the salmon - and the improvement of our deteriorating environment.

This cannot be accomplished overnight. But, if I may adapt the old platitude, 'from tiny alevins mighty salmon grow'. The scale of the challenges you are addressing here today is enormous. There have been notable successes. Now we need to do even more.

Salmo salar, the great leaper; the sovereign fish, is worthy of every effort. We would be committing a crime of global proportions if we did not accept our responsibilities and arrive at an answer which, while permitting the legitimate continuation of our 'enjoyment' of the salmon in our many differing ways, ensures that the species survives and flourishes. There are not many fish which have inspired poetry, much less from a poet as eminent as the Poet Laureate, Ted Hughes. In just a few brusque lines he encapsulates everything I have been trying to say; I leave them with you to mull over during your deliberations:

> The salmon is a miracle......
> But all that's been agreed,
> We know he is a miracle -
> But not the one we need
> To organise the baboon brains
> That govern human greed.

Thank you for listening to me. I now look forward to listening to you - and may success attend your endeavours here in Edinburgh, and for the years to come.

[I am indebted to Dr. John M Baxter (head of the Marine and Coastal section, Scottish Natural Heritage) and Dr Derek Mills (Fellow of the Institute of Ecology and Resource Management at Edinburgh University, Council member of the Atlantic Salmon Trust, and a member of the South West Region Board of SNH) for much of the information and inspiration for this Address. I am also grateful to Dr. John Hambrey, consultant ecologist, for information from his chapter on "The Seas of Plenty" in The Nature of Scotland (ed. M. Magnusson, 1991)]

HISTORY OF SALMON FISHERIES AND MANAGEMENT IN THE NORTH ATLANTIC

by

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1 INTRODUCTION

The lives of Atlantic salmon and human beings have been intertwined for centuries. Man has had a need for, a veneration of, and mutual survival dependency with Atlantic salmon. Salmon are fine food that are remarkably accessible due to their use of rivers and streams for reproduction. Salmon are great sport due to their inquisitiveness about insect-like lures when they first enter freshwater. Salmon are a point of controversy between different fishing and conservation interests due to the mixed stock nature of fisheries for them. Salmon often become, largely due to their economic and aesthetic value (Figure 1), the focus of concern when managing water resources in rivers.

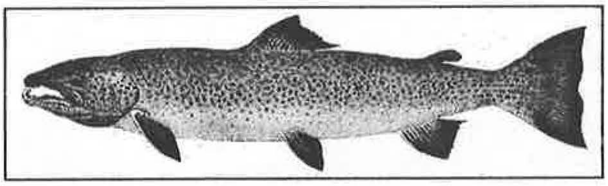

Figure 1. Male Atlantic salmon from Kendall (1934).

Salmon are cultural icons in many societies and the focus of rituals. Few other animals have such far-reaching migrations across so many different ecosystems, thus interjecting themselves into so many management arenas. For many of the uninitiated it appears that salmon receive a disproportionate amount of attention, especially when their catches are compared to those of cod or other commercial fish species. However, it is little wonder that their management receives such attention considering the impact that this species has on so many segments of our societies.

In this paper, I will give an overview of the Atlantic salmon resource including its ecology, fisheries and management. I will first describe the animal itself, how it lives and how it relates to its environment. The aspects of the biology and ecology of Atlantic salmon that I will try to highlight are those of particular interest to the management of the species. Next, I will look at the various salmon fisheries by region and provide a brief chronicle of the management used to conserve stocks. After describing the fisheries, I will discuss the assessment of salmon stocks, and describe how advice on fishing mortality, catch level, and stock status is developed. Finally, I will review some of the more important future concerns and considerations about salmon both in the freshwater and marine environments.

2 ECOLOGY OF ATLANTIC SALMON

Juvenile and adult Atlantic salmon are in many ways like two different animals and for a time were viewed by naturalists as distinct species. Their appearance and habits are so different that the link between juveniles and adults was not obvious, and the consequences often included poor management and extirpation of stocks. It is useful to discuss their river and ocean lives separately, but one must not lose sight of the important linkages between them.

2.1 Biology

The life history of Atlantic salmon is extremely complex owing to its use of both freshwater and marine habitats and long ocean migrations (Figure 2).

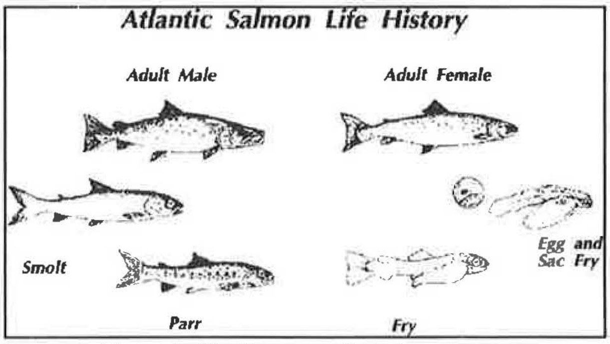

Figure 2. Atlantic salmon life history stages.

There is plasticity in life history traits throughout the species range; thus the description that follows is intended as a depiction of the average condition. Atlantic salmon typically enter their natal rivers in the spring of the year, though runs can be observed year round in some areas. Fish typically remain in freshwater until after spawning during the fall. They have elaborate secondary sex characteristics involving nest or redd pre-

preparation and spawning behaviour. Eggs and alevins (sac fry) remain in the gravel substrate of the redd over winter until they hatch and emerge as fry during spring. Juvenile salmon, commonly called parr, remain in freshwater for as little as one year to upwards of 7 years depending on growth. The freshwater residency time of parr generally increases with latitude for rivers in both North America and Europe. When parr grow to sufficient size (~11-16 cm) they undergo a physiological change into smolts and migrate to the sea. As shown by tagging data for a number of stocks, young salmon migrate extensively during their first summer in the ocean (Reddin and Short, 1991).

After its first winter at sea, part of the cohort remain at sea while the remainder become sexually mature and return to their natal rivers. Those fish that stay at sea are referred to as 1 sea-winter salmon while those that mature are called grilse. The maturing fraction varies annually and by stock in what is assumed to be a response to environmental conditions and genetics. Those of the cohort remaining at sea make long ocean migrations to feeding grounds. For North American stocks, these feeding grounds are in the Labrador Sea including the coastal areas of Newfoundland and West Greenland. For European stocks, these feeding grounds also include the Labrador Sea, principally the West Greenland area, and the Northeast Atlantic and Norwegian Sea including waters surrounding the Faroe Islands. After their second winter at sea, most of the remaining cohort return to spawn. In some stocks, life history patterns of three or more sea-winters and repeat spawning salmon do occur.

Salmon, as freshwater juveniles, grow at relatively slow rates, but after they enter saltwater their growth accelerates. Smolts are generally less than 100g in weight when they migrate to the ocean, but by the end of their first sea-winter an individual salmon can amass in excess of 2 kg of weight. Two sea-winter returns are generally over 4 kg and three sea-winter returns can be in excess of 7 kg.

A year class or cohort of salmon is defined as either an egg or smolt group. The egg group definition defines a cohort as the group of juvenile fish originating from the same spawn of eggs. This is a more classic definition which is analogous to the use of the term with other species. Smolt class, on the other hand, is defined as a group of juvenile salmon that migrate to sea during the same year. This definition is useful because we are often interested in partitioning the survival effects in freshwater and ocean environments.

2.2 River Life

River life for Atlantic salmon is a relatively tranquil prelude to the tumultuous seasons yet to come at sea (Figure 3).

Figure 3. River scene on the Devon from Houghton (1898).

This may seem like an under-estimation of the challenges salmon face in rivers and streams, but when we strip away those threats that are not part of natural freshwater systems, we see a surprising resilience.

Freshwater habitats are defined by climate and geography. Productive habitats are generally those that are warm within the requirements of salmon juveniles and are fed by steady patterns of rainfall and discharge. The contrast in freshwater production between the eastern and western continental margins of oceans is striking. The eastern margin of the North Atlantic, for example Scandinavia, Ireland, and Scotland, is bathed by moderate temperature oceanic air resulting in patterns of steady rainfall. In contrast, the western margin, Canada and the United States, is bathed by cold continental air and subject to episodic rainfall patterns. Salmon juveniles can tolerate very cold winter temperatures and live under the ice cover of frozen streams, but productivity of a stream is in part linked to temperature and the complement of vegetation and insects that feed the stream (Jensen and Johnsen 1986). Salmon are a cold water species whose southern distribution is limited by high temperatures (McCrimmon and Gots 1979).

The survival of salmon appears far less variable in freshwater then it is during the marine phase. Reddin (1988) summarized information on the river Western Arm Brook in western Newfoundland. This small river is intensively monitored to characterize the juvenile and adult migrations to and from the river. His results indicate the survival from egg stage to smolt is less variable then the survival from smolt to adult (Figure 4).

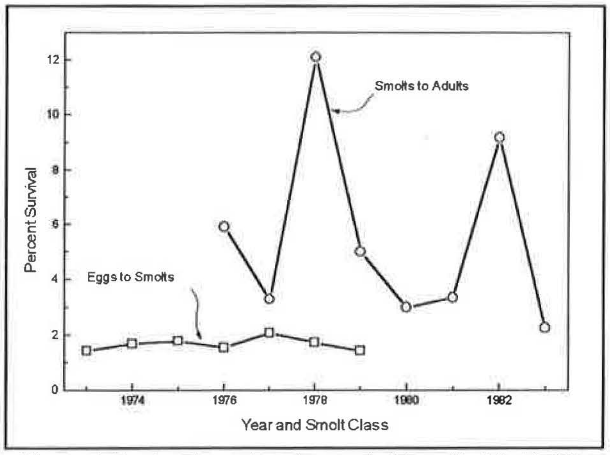

Figure 4. Freshwater and marine survival from Reddin (1988).

The natural threats to freshwater life move slowly whereas the anthropogenic threats move quickly. The last ice age, which was an astronomical event, destroyed much of the Atlantic salmon habitat in North America and Europe (Berg, 1985). However, the recession of the ice shield reminds us how adaptable the species is by its recolonization and development of stock specific adaptations to newly opened rivers. The time scale for recolonization was in excess of thousands of years, which by our standards was slow, but in geological time, was just a wink of an eye. Anthropogenic threats, which move more swiftly, are numerous and include: under-recruitment of juveniles due to recruitment over-fishing; destruction of habitat and fish by dams, pollution, and water use; and biological threats like disease, hybridization, predation by introduced species, and ecosystem imbalance.

2.3 Ocean Life

Ocean life of Atlantic salmon is marked by substantial growth and long migrations. The transformation in their feeding habits as they leave freshwater and their ability to tolerate extremely cold water allow salmon to invade northern ecosystems to utilize vast food resources with little competition. High latitude ecosystems are characterized by low species diversity, limited inter-specific competition, and explosive productivity and growth concentrated during the summer season (Valiela, 1984). Salmon appear to be opportunistic feeders that can utilize the narrow range of prey: shrimp, capelin, and sand lance associated with these northern ecosystems (Shearer and Balmain, 1967; Lear and Christensen, 1980). The forage base is so abundant and concentrated that salmon expend little energy finding or capturing prey, thereby maximizing their growth.

The oceanic migration of Atlantic salmon is still an area of fertile debate and research, but some simple principles have been established which are extremely informative in understanding feeding migrations, spawning run timing, and smolt migration timing. Salmon display a temperature preference at sea for 4°C to 8°C while on the feeding grounds (Reddin and Shearer, 1987). It is well known that maturing salmon can be commonly found in waters warmer than this preferred level as they home to their natal rivers, and that smolts tend to migrate to sea at temperatures slightly higher than 4°C to 8°C. However, the distribution of 4°C to 8°C water temperatures can be useful as a guide to the seasonal events of Atlantic salmon ocean life, especially as it pertains to the oceanic feeding migrations of the species. It should be remembered that salmon migration is a complex process that may involve a combination of solar, geomagnetic, current and odour cues used by fish returning from ocean migrations (Hansen *et al.*,1993).

The winter season, January to March, finds 4°C to 8°C water to be widely distributed in the eastern North Atlantic but only in a narrow band in the western North Atlantic (Figure 5).

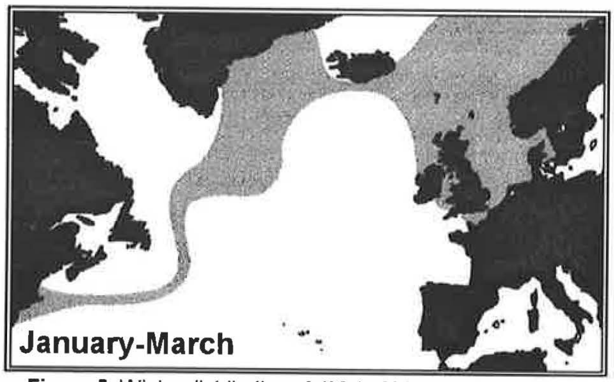

Figure 5. Winter distribution of 4°C to 8°C water in the North Atlantic.

The fisheries in the eastern Atlantic, around the Faroe Islands and along the English, Scottish, Irish, and Norwegian coasts (where restricted by management) are all active, whereas cold continental air and ice preclude fishing in the western Atlantic. Early spawning and smolt runs are underway in the southern European range of the species, for example, in Ireland and England.

As spring, April to June, arrives, warmer water begins to approach the Canadian coast that historically has allowed fisherman in the Maritime provinces and Newfoundland to begin catching salmon in June (Figure 6).

The coastal ocean around New England, Nova Scotia, and parts of New Brunswick is clear of ice, so maturing salmon can enter rivers on their spawning runs. Water temperatures in southern Europe are already warming above acceptable levels for non-maturing salmon and catches decrease in southern coastal fisheries and around the Faroes.

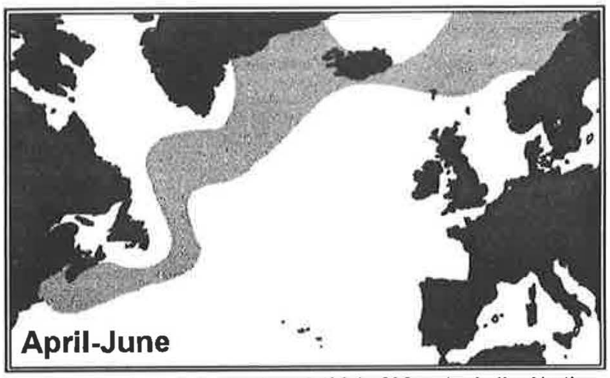

Figure 6. Spring distribution of 4°C to 8°C water in the North Atlantic.

By summer, July to August, most of the European coast is bathed by warm water and most of the fisheries are on maturing salmon heading for home rivers. The non-maturing components of European stocks are driven west to Greenland or north into the Greenland Sea (Figure 7).

Figure 7. Summer distribution of 4°C to 8°C water in the North Atlantic.

Along with North American stocks, the fish are driven in the great funnel of the Davis Straight and concentrated along either the Newfoundland-Labrador or the West Greenland coasts. Since the European stocks enter the Labrador Sea ecosystem from the east, they tend to stay on the eastern side and are thus almost exclusively found off West Greenland.

By fall, October to December, the direction of salmon migration and the distribution of 4°C to 8°C water masses are in reverse. Cold continental air from North America has driven the warmth and the salmon away from the Davis Straight (Figure 8).

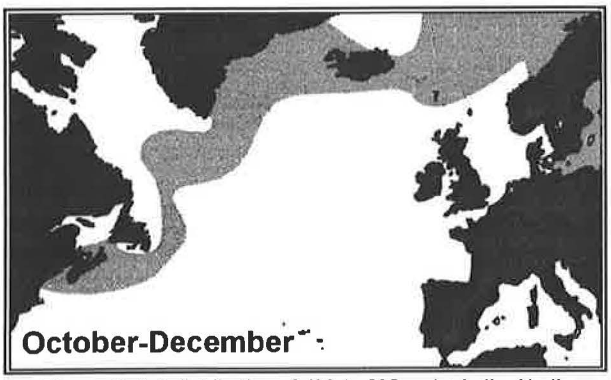

Figure 8. Fall distribution of 4°C to 8°C water in the North Atlantic.

On their reverse migration, North American salmon that were in Labrador were again exploited historically in a fall fishery along the Newfoundland coast. Water temperatures at the Faroe Islands and Norwegian coast are cooling and salmon are returning to these waters.

2.4 Post-Smolt

The relentless focus of many salmon researchers, both those studying Pacific species (Oncorhynchids) and the Atlantic salmon, is on the post-smolt stage. The reason can be stated very simply: though the loss of individuals from the egg to the parr or smolt stage is large, the loss of individuals after smolts leave their natal rivers defines the size of the salmon population. The food, predators, and constancy of environment for salmon changes so dramatically after they leave freshwater, that it is not surprising that survivorship in the marine environment changes dramatically from year to year. This variability in ocean survival can overshadow the variations of freshwater mortality and production.

Recent investigations into the link between environment and post-smolt survival of Atlantic salmon have yielded some interesting insights. Friedland and Reddin (1993) found significant relationships between the amount of suitable ocean environment, as defined by temperature, and the overall production of Atlantic salmon adults. For North American stocks, the area of 4°C to 8°C water masses extending east to a distance likely to be swum by post-smolts was significantly correlated with a composite of North American total catch and estimated removals attributed to the Greenland fishery (Figure 9). Data were available to test other seasons, but only the winter temperature data appear to be related to North American production.

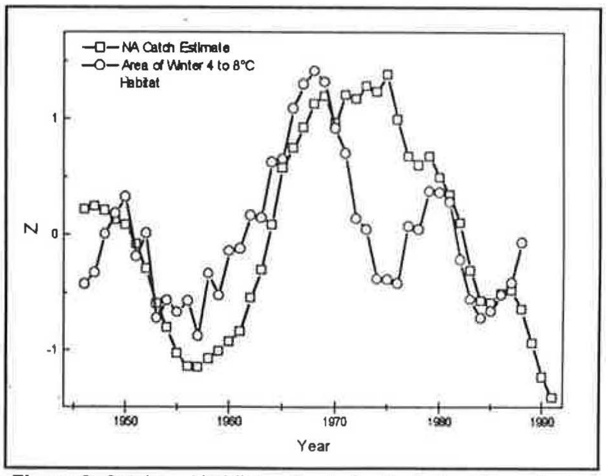

Figure 9. Catch and habitat estimate for North American stocks.

For European stocks, the environmental dataset was not adequate to test the relationship between stock production and habitat during all seasons. However, the one season that was tested yielded remarkably significant results (Figure 10). A catch estimate for European stocks was significantly correlated to a spring index of habitat constrained for likely post-smolt temperature preferences and swimming potential.

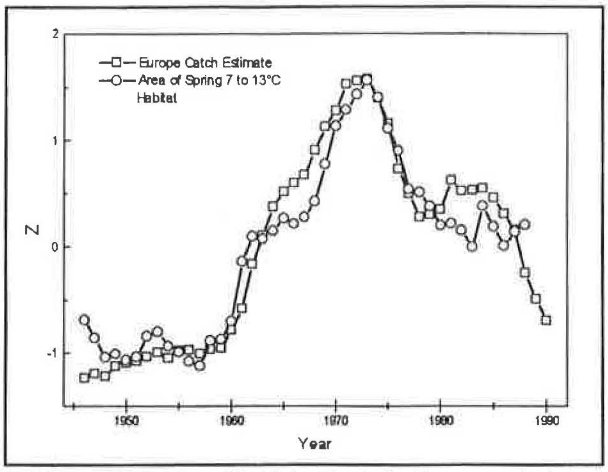

Figure 10. Catch and habitat estimate for European stocks.

These results pose more questions then they answer. What is the mechanism by which survivorship of post-smolts is determined? This potential link between environment and post-smolt survival does not tell us if the mortalities are from predation, or disease of stressed fish, or some other effect. They do offer a framework to focus questions seasonally and geographically. For example, it would appear worthwhile to investigate the feeding and distribution of North American post-smolts during winter.

3 DESCRIPTION OF THE FISHERIES

Fisheries for Atlantic salmon have been categorized into interception fisheries and homewater fisheries. This division is for the most part reflective of the stock composition of salmon harvested in the respective fisheries. Interception fisheries utilize a mixture of stocks from many nations, whereas homewater fisheries utilize stocks that are predominantly from a single country. In the North Atlantic, there are three mixed-stock fisheries that fall into the North Atlantic Salmon Conservation Organization (NASCO) management areas: the Newfoundland-Labrador fishery, the West Greenland fishery, and the Faroe Islands fishery (Figure 11).

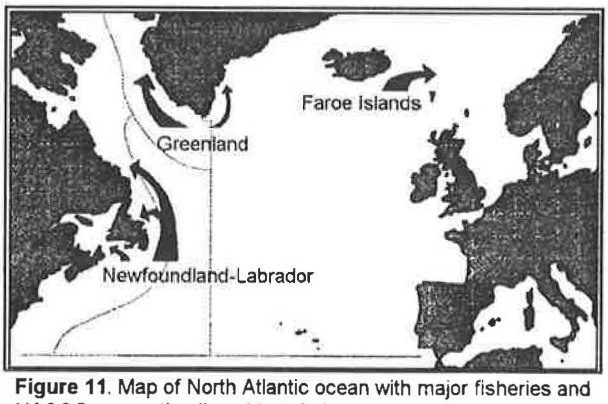

Figure 11. Map of North Atlantic ocean with major fisheries and NASCO convention lines identified.

The term stock has been used in its management context, i.e. unit stock. It is important to remember that the biological definition of stock is related to reproductively isolated populations in rivers and has a different meaning.

The total catch of Atlantic salmon in the North Atlantic area has decreased in both homewater and interception fisheries in recent years (Figure 12).

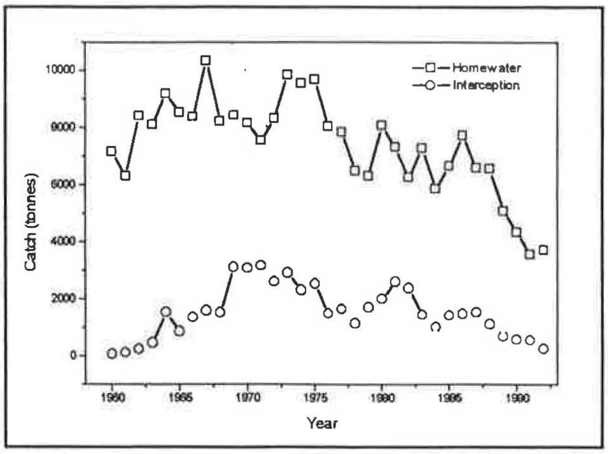

Figure 12. Homewater and interceptory fishery catches.

Homewater fisheries currently account for over 80% of the total landings, but the proportion may be much higher due to the significant non-reporting of catch (Anon., 1992). The non-reporting problem appears to be more acute in the North-East Atlantic area than in North America. The North-East homewater fisheries are dominated by landings in Norway, Scotland, and Ireland. The North American homewater landings are almost exclusively from Canada since the only legal fishery in the United States is a very limited recreational fishery. Though no attempt was made to divide the Canadian landings into homewater and interception fractions, the reader should be aware that both fisheries exist in Canada. The interception fisheries are depicted by catches in Greenland, the Faroe Islands, and the Norwegian Sea. The Norwegian Sea fishery is no longer active, but because of the mixture of nations that participated and the supposed mixture of stocks contributing to the catch, it appears appropriate to include it in this category.

3.1 Eastern North Atlantic

There are coastal and river fisheries for Atlantic salmon in Iceland, Ireland, the United Kingdom, along the Atlantic coast of Europe from the Iberian peninsula to Denmark, and along the Atlantic coast of Scandinavia and Russia. A multitude of trapping, netting, and recreational fishing gears are in use in these fisheries which often concentrate on specific stocks or a single cohort or age group. Generally, there are three types of commercial salmon fishing gears. There are fixed gears or traps which are used in inshore areas. About the only common feature shared by all the different fixed gear arrays is that they are all either anchored, stacked, hung, or attached by some means to the bottom or shore. A good example of a fixed gear, but hardly typical of the rigging of all of them is the bag net used extensively in Scotland, Norway and elsewhere (Figure 13).

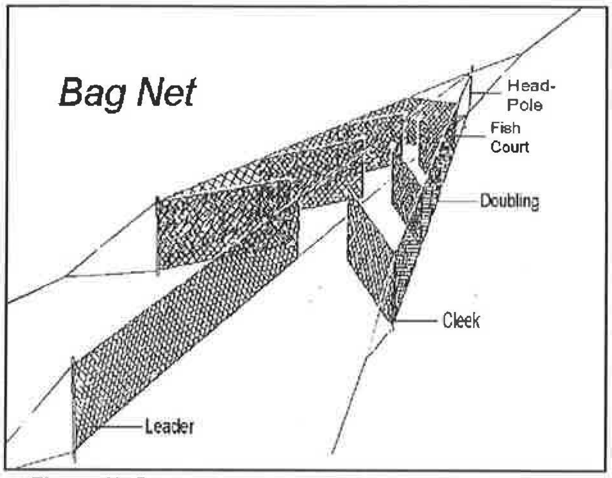

Figure 13. Bag net from Anon. 1991, top and bottom netting omitted for clarity.

The second major gear type consists of floating gears such as longlines or drift nets. These gears are free-floating arrays that are often in excess of 10 kilometers in length. The gears must often be fished as soon as they are paid out and their location must be monitored with marine electronics (Figure 14).

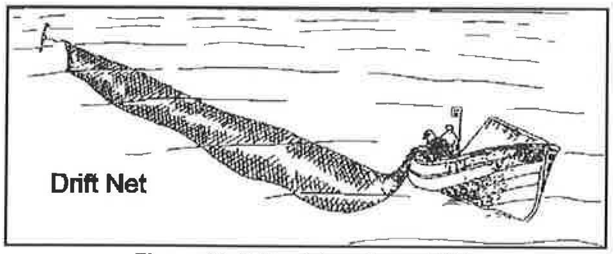

Figure 14. Drift net from Anon. 1991.

The drift nets are made of either multifilament or monofilament twine and are typically set at the surface for adult salmon. Finally, the third major gear type, seine nets, are used extensively in net-and-coble fisheries in Scotland and draft nets fisheries in Ireland. Fixed and floating gears rely on the movement of the fish, whereas seines actively sweep areas where salmon are concentrated. A review of salmon fisheries by nation provides an overview of the patterns of Atlantic salmon fishing in the Eastern North Atlantic

In Russia, salmon are taken in coastal waters with drift nets, bag nets, and seines, though bag nets are the dominant gear (Mills, 1989). River fisheries are carefully monitored at governmental counting stations or fishways. With a known fraction of the runs removed, spawning escapements and exploitations of the spawning runs are known precisely. In recent years, there has been an expanding sport fishery in a number of rivers on the Kola Peninsula.

Atlantic salmon fishing along the Atlantic coast of Scandinavia is dominated by the fishery in Norway. Norwegian fisheries have gone through some dramatic changes in recent years. Historically, drift nets and a variety of fixed traps and seines were used along the Norwegian coast and in the rivers (Hansen, 1988). In recent years the use of fixed gears in freshwater, with a few exceptions, has been banned. Furthermore, marine drift nets were phased out in 1989 and at the same time restrictions were put on other marine gears, as well as angling in freshwater. A long-line fishery in the northern Norwegian Sea (north of 67°N) ceased in 1984. The right to fish salmon in rivers and streams of Norway is either under private ownership or held by the government (Hansen and Bielby, 1988). The many fine salmon rivers in Norway support a productive sport fishery. There are smaller fisheries on Atlantic stocks of salmon in the River Tana in Finland and along the Swedish west coast. The fisheries in the Tana include a native fishery by Lapis people and also an expanding recreational fishery.

Commercial fisheries for Atlantic salmon along the coast of mainland Europe are significantly reduced from historical levels reflecting the loss of stocks and habitat in the region. A modest commercial fishery exists in France but, because most of the major salmon stocks have been extirpated, prospects for an expanded fishery seem unlikely (Prouzet, 1990). In Spain, the commercial fishery has been eliminated in favour of the sport fishery (de Leániz *et al.*, 1987).

Commercial fisheries in the United Kingdom and Ireland are varied and productive, and generally account for over 50% of the total harvest of wild salmon in the eastern North Atlantic. Recreational fishing is also extensive. There are a staggering variety of gears used in river fisheries, in addition to drift net fisheries conducted on the eastern and western sides of the island system.

In Scotland, salmon fisheries operate both in river and on the coast. The rights to fish for salmon are heritable titles which may be operated by the owner or leased to fishermen. Originally, all salmon fishing rights belonged to the Crown, but many individuals now have ownership of fishing rights, the rights having been dispersed as Crown grants (Shearer, 1992). Inside estuary limits, the only permitted methods of fishing are angling and net-and-coble seining. These methods are also permitted outside estuary limits and, in addition, the use of fixed gears, or fixed engines, is allowed. An important point to note about Scottish net fisheries is that any net used must not be designed to enmesh fish.

Formal salmon management in Scotland dates back to an act in 1318 regulating trapping within rivers. The modern basis of salmon management in Scotland is the Salmon Fisheries Act of 1868. This legislation, and Acts which followed, set forth the basis for protection, permitted gears, and setting up of District Salmon Fishery Boards, each board usually, but not always, associated with a particular river catchment area. These boards, through their water bailiff representatives, institute the assessment, habitat protection, and fishery management of the resource in the watershed under their jurisdiction.

A drift net fishery for salmon began off the east coast of Scotland in 1960. The fishery was conducted with drift nets which might exceed 1 km in length and were made of monofilament nylon in some cases. Concern that this fishery posed a series threat to local stocks led to the formation of a Committee to review its effects. The Committee recommended closure of this fishery and it was banned in 1962, with subsequent legislation continuing its prohibition. In defiance of this legislation, small drift net fisheries persist in some localities, the operation being known as an "illegal" fishery (Mills, 1983).

The salmon fishery in England and Wales, unlike Scotland, is executed primarily with seines or draft nets. Fixed gear, or fixed engines, are used in only a few river fisheries. Drift nets, or trammel nets, are used extensively along the Northumberland and Yorkshire coasts. These drift net fisheries are a point of some controversy as it is known that most of the fish captured were destined for Scottish salmon rivers to the north (Potter and Swain, 1982). Salmon fishing rights are not under private ownership and the public has the right to fish the tidal portion of rivers and in the sea. Management of the salmon resource is empowered through a series of Acts, the principal one being the Salmon and Freshwater Fisheries Act of 1975. Local and regional management of salmon fisheries is the responsibility of the National Rivers Authority which has the duty to maintain and develop fisheries for anadromous and freshwater fishes (Shearer, 1992). The act also puts forth provisions for licensing, closed seasons, and other controls on effort.

Salmon are taken by a variety of methods in Ireland including seines or draft nets, fixed traps, drift and other mobile gears (Mills, 1989). The drift net fishery along the Irish west coast has been in existence for over 100 years, but its rapid expansion during the 1970s and 80s has made it the dominant homewater fishery in Ireland. The fishery now accounts for approximately 70 to 80% of the homewater catch (Anon., 1987; Twomey, 1990). Concern has been raised that this fishery may be intercepting significant numbers of salmon destined for rivers in the United Kingdom (Mills, 1983). A 1987 review of Irish salmon fisheries recommended that the sea drift net fishery be placed under quota management, that catches be tagged, and that log books be maintained by fishery participants (Vickers, 1988). The review further recommended restrictions on gear and vessels in the fishery, but did not support a ban on the use of monofilament netting.

The commercial fishery for Atlantic salmon in Iceland is limited to a fixed gill net fishery in just a few glacial rivers. There is no coastal or open ocean net fishery for Atlantic salmon in Iceland. The recreational fishery for salmon has been extensively developed throughout Iceland (Gudjonsson and Mills, 1982). Much of the catch is of sea ranched origin since Iceland has had the most aggressively developed programme of sea ranching in the North Atlantic.

3.2 Western North Atlantic

Atlantic salmon fisheries in the Western North Atlantic consist of a recreational fishery in the United States and recreational and commercial fisheries in Canada. The recreational fishery in the United States is small being limited to a few rivers in the state of Maine. Atlantic salmon fishing is prohibited on the restoration rivers of the southern New England states. An extensive recreational fishery exists throughout the Atlantic provinces of Canada from Nova Scotia to Newfoundland and Labrador. Commercial salmon fishing in Atlantic Canada was at one time a major industry, but there have been dramatic changes during the last decade. Atlantic salmon are also utilized in both the United States and Canada by native peoples. Some of these fisheries are extensive, for example, fisheries in Northern Labrador.

The commercial or food fishery utilization of Atlantic salmon in North America predates the European colonization as indicated by extensive use of the resource by native peoples (Dunfield, 1985). Commercial fisheries organized for export trade began in the 1700s in the maritime provinces and in Newfoundland-Labrador (Taylor, 1985). Significant management has been enacted by the Canadian government over the past two decades to conserve stocks. Fishing in the province of New Brunswick had been carried out with drift nets and fixed gears prior to a complete ban to protect stocks enacted in 1985 (Lear, 1993). Fishing along the Quebec North Shore is limited to the eastern portion only. There has been a decreasing trend in the number of participants in the fishery each year over the last decade.

Decline in salmon abundance resulted in moratoriums and fishery closures in the southern provinces, while the Newfoundland fishery remained open in part due to the regional dependence on fishing for income and the lack of alternative livelihoods. Salmon are harvested in Newfoundland and Labrador almost exclusively by shore-fixed gill nets. The mesh size of these nets is regulated by Salmon Fishing Area. Effort regulation, in the form of limited entry, was introduced in 1968. Extensive licence buy-back offers were made in 1972 and 1985, the latter as part of the 1984 Atlantic salmon management plan. The most recent buy-back occurred in 1992 as part of a wider set of management measures designed to increase spawning escapement into local and mainland rivers. The government of Canada has also utilized season and area closures to protect stocks. In 1991, quotas, calibrated to mean trends in catch, were first introduced in the Newfoundland fishery. The quota measures were followed in the next year by a 5-year moratorium placed on fishing around the Island of Newfoundland. The fishery in Labrador remains open, but the Labrador quota was reduced proportionally to the reduced effort associated with the voluntary licence buy-back in that area.

3.3 Mixed Stock Interception Fisheries

There are three salmon fisheries in the North Atlantic that have been of primary interest in the NASCO forum due to mixed stock nature of their catches. None of the fisheries represent a long-standing relationship between salmon producer nation and salmon host nation. The oldest fishery is the Newfoundland fishery, but its interceptory relationship with US stocks is limited by the beginning of large scale restoration efforts in the United States. Many of the aspects of the producer-host relationship are common to all three fisheries and have influenced international negotiations (Fraidenburg, 1991).

3.3.1 Faroe Islands

The Faroe Islands economy is highly dependent on its diverse harvest from the sea which in recent years included Atlantic salmon. There is a short history to salmon fishing in the Faroes since it began in the late 1970s in response to poor fishing opportunities with other resources (Mills and Smart, 1982). The fishermen in the Faroe Islands quickly determined that salmon were available in good abundance within the Faroese extended jurisdiction zone and exploitation became significant (Fraidenburg, 1991). The catch rose dramatically during the early 1980s to over 1000 metric tonnes taken by long line gear (Figure 15).

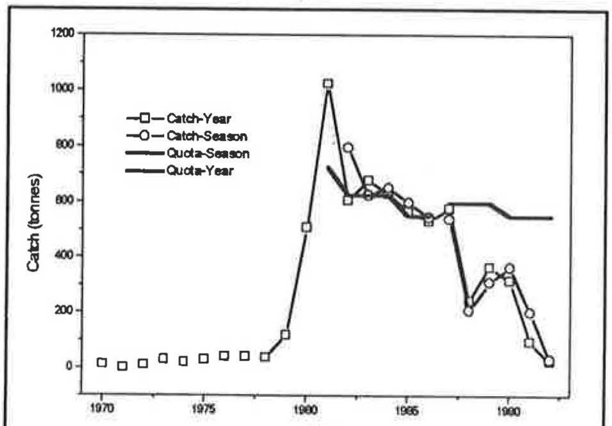

Figure 15. Faroe Islands catch and quota.

The catch is generally composed of salmon of European origin as demonstrated by tagging studies with hatchery and wild smolts. However, most of the catch is believed to originate from Scandinavia, particularly from Norwegian stocks. The catch is almost exclusively composed of 2 sea-winter salmon which reflects availability and to some extent, culling of smaller fish. The catch has declined in recent years, probably due to the combined effects of low salmon abundance, changes in export markets, and the appearance of new fishing opportunities.

Management of the Faroese long line fishery has been organized both through bilateral arrangements between the EEC and the Faroe Islands and through NASCO negotiations. There was great concern over the potential impact the fishery would have upon stocks when the fishery first began to operate, and this concern was only heightened as catches increased dramatically. In 1981, the EEC held consultations with Denmark in respect to the Faroe Islands to negotiate quota limits, to develop alternative fishing options for the Faroese (i.e. on whitefish species), and to develop a scientific assessment framework for the fishery (Fraidenburg, 1991). These access-driven agreements were not without their difficulties as different EEC members saw the agreement containing different costs and benefits for each member. Pressure to further curtail the fishery continued as negotiations were held in NASCO. Management agreements forged in NASCO have been multi-year agreements limiting the quota to below 600 t per year and limiting effort to control fishing mortality on the stock.

In 1990, the concept of purchasing the salmon fishing quota in the Faroe Islands and Greenland was introduced. The concept was embraced by the Faroese government and fishing community. The quota negotiated in NASCO was purchased by private arrangement from the quota recipients in the Faroes fishery. There has been nearly complete participation in the arrangement which took effect during the 1991/1992 season. Concurrent with the quota buy-out has been an experimental fishery and scientific cooperation between the Faroe Islands and Norway on high seas tagging experiments.

3.3.2 West Greenland

Though Atlantic salmon were known in Greenland for many years, it was not until the development of the modern fishery that they received much attention. Before the modern fishery, modest amounts of salmon were fished for local consumption (Møller Jensen, 1988). With the introduction of drift nets by non-Greenlandic fishermen during the early 1960s, and in particular monofilament nets which could be fished effectively during daylight hours, the fishery expanded rapidly (Figure 16).

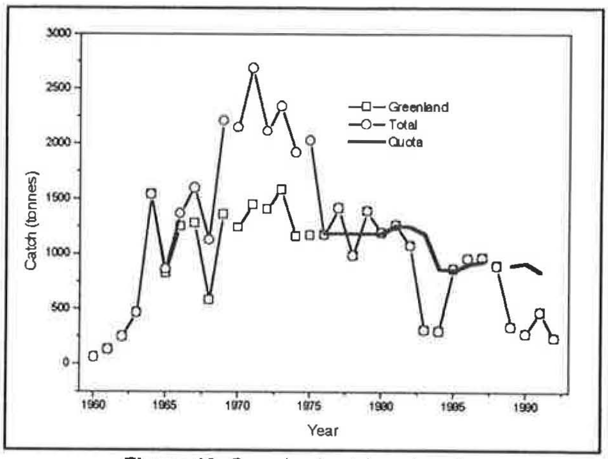

Figure 16. Greenland catch and quota.

The catch is almost exclusively 1 sea-winter salmon of both North American and European origin. The contribution to the fishery by each continental stock has been approximately 50%, but there has been considerable variation in this ratio in recent years (Anon., 1992). Though the fishery takes salmon of river ages up to 7 and 8 years, the catch is dominated by salmon of river ages 3 and less for both continents suggesting a disproportionate contribution from river stocks in the southern range of both continents.

The rapid increase in the catch of the Greenland fishery caused international alarm among public and private salmon interests. Discussions were held and proposals were developed in the International Commission for the Northwest Atlantic Fisheries (ICNAF) culminating in a 1969 ban on ocean fishing outside territorial waters. The ban was rejected by Denmark but enacted by the majority of ICNAF members. There was little progress on regulating the harvest in Greenland until the 1972 ICNAF meeting at which Denmark agreed to phase out the high seas fishery and to bring the local Greenlandic fishery under catch management. Behind this agreement was a Danish/United States bilateral arrangement involving the trade of fishery products between the two countries (Fraidenburg, 1991). The catch management agreed upon included a 1190 tonne quota for the local Greenlandic fishery, but there was some confusion on the computation of the quota during the following years. By 1976, all foreign nationals were out of the Greenland fishery. The quota was raised to 1270 tonnes in 1981. With the development of NASCO, quota negotiations for the West Greenland fishery were held in a different forum. However, the new forum did nothing to stem the decline in both the North American and European stocks. Though there have been modest reductions of the Greenland quota to 860t in recent years, the producer and host nations have yet to agree on mechanisms to set total allowable catch or allocation (Peterson, 1988; NASCO, 1992).

3.3.3 Newfoundland-Labrador

The Newfoundland-Labrador fishery is a shore-fixed gill net fishery that harvests salmon of Canadian and US origin. The fishery has a long catch history associated with it and in recent years has had dramatically decreasing catches due, among other reasons, to decreased marine survival (Figure 17). The fishery harvests a combination of local stocks that are maturing (and thus migrating to natal river systems) and non-local stocks which are not believed to mature during the fishery season. There is little evidence to suggest that European salmon make a contribution to this fishery.

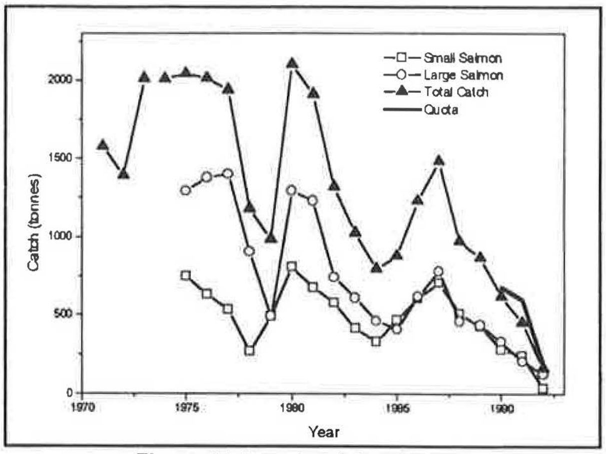

Figure 17. Canada catch and quota.

The fishery has recently been placed under severe management restrictions due to the decline in the state of the salmon resource in Canada. The fishery was placed under quota management in 1991 and this was followed by a moratorium on fishing around the Island of Newfoundland in 1992 and by an extensive effort reduction, in the form of a licence buy-back, in both Newfoundland and Labrador. The quota in Labrador will be reduced concomitantly with the reduction in effort from the licence buy-back. The future of commercial salmon fishing in Canada is uncertain.

3.4 Formation of NASCO

The management body for Atlantic salmon before NASCO was ICNAF. ICNAF was an all species commission with the remit of research and conservation of fishery resources in the Northwest Atlantic to facilitate maximum sustained catches. There are a mixture of reviews on the effectiveness of ICNAF for salmon and other fishery resources in general. The first arrangement to nationalize the Greenland harvest and develop quota guidelines was enacted through ICNAF, but ICNAF lacked the geographic scope to truly deal with salmon issues (Fraidenburg, 1991). As the level of the interceptory fisheries needed to be linked to the size of runs and fisheries in other locations, ICNAF was severely handicapped in dealing with salmon resources. With the expansion of national jurisdiction that occurred during the 1970s, much of the area of ICNAF jurisdiction was now under national management resulting in ICNAF's disbandment in 1981. This left a void in international salmon management.

In 1983, the International Convention for the Conservation of Salmon in the North Atlantic Ocean was ratified. In the following year, the inter-governmental organization NASCO was set up as a result of the convention agreement. The convention has nine parties comprising: Canada, Denmark (in respect to the Faroe Islands and Greenland), The European Economic Community, Finland, Iceland, Norway, Sweden, Russia, and the United States. The convention borrows many elements from ICNAF but is fundamentally different in dealing with issues of salmon management and conservation. First and foremost, NASCO generally deals with management of the species wherever it occurs. NASCO is organized into a Council and three Regional Commissions: the North American Commission, the West Greenland Commission, and the North-East Atlantic Commission (see Figure 11).

4 EXPLOITATION AND ASSESSMENT

Quantitative assessments of Atlantic salmon populations are in some regards very tractable and informative and in others fraught with great difficulties. Few other species are as accommodating to predictably return to a single location allowing the size of their populations to be estimated. However, for every monitored salmon stock for which we have exact data, there are scores of stocks about which we know little. There is a rich history of tagging assessments with Atlantic salmon that have been used to discern migration routes, estimate marine survival, and evaluate fishery exploitation rates. More recently, stock identification techniques have been used to develop assessments on group of stocks that share common life history traits.

The modern tools of salmon tag-based assessments are elegant in their simplicity and effectiveness. Salmon are commonly tagged with external tags that are easily visible and contain a return message and serial number, or with internal tags that are located by their magnetic fields and identified with a binary code.

Scales are routinely sampled from Atlantic salmon and, in addition to providing the age of individual fish, they yield information on stock origin (Figure 18).

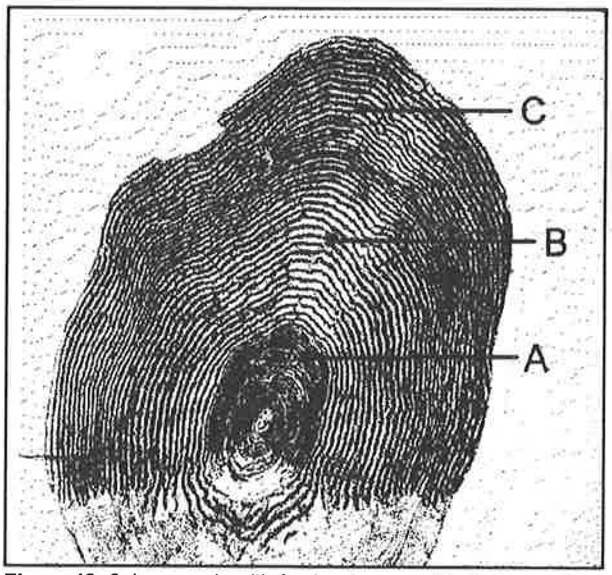

Figure 18. Salmon scale with freshwater zone (A), first sea-winter zone (B), and second sea-winter zone (C) marked.

The events and duration of juvenile life in freshwater habitats are chronicled in the freshwater zone of the scale. Because the number of years spent in freshwater varies with latitude, these ages are an indicator of the stock origin of the fish. For example, North American origin salmon with a river age of 5 or 6 years are likely to be from Labrador, whereas salmon with a river age of 2 or 3 are likely to be from Nova Scotia or New England (Lear and Misra, 1978). The number of years at sea before spawning, any previous spawning events, and the growth history of the fish during their ocean life are likewise recorded in the marine growth zones. Because European stocks have an earlier smolt migration and utilize different nursery areas than North American stocks, the first summer zone of the scale can be used as an indicator of continent of origin for salmon captured at West Greenland (Reddin *et al.*, 1988).

4.1 Exploitation Rate

The migratory behaviour and relatively short marine phase of salmon combine to make estimation of fishing mortality very difficult. For species with cohorts that appear in fisheries over successive years, fishing mortality can be estimated by age-structured assessments. In some cases, Atlantic salmon populations are available to only one fishery before returning to freshwater to spawn. A special class of virtual population analysis called run-reconstruction must be employed to estimate vital rates. These calculations are based on either single stocks, usually relying on tagging experiments; or stock complexes, usually relying on stock identification and catch data.

In the North Atlantic, there are extensive tagging databases for a number of national stocks. In North America, large rivers such as the Miramichi have extensive historical databases associated with them which provide information on migration routes and fishery contributions. Contemporary tagging programmes focus on the Saint John River in New Brunswick and on the US restoration rivers. These programmes include the use of traditional tagging systems such as Carlin tags and internal coded wire tags. In Europe, large-scale Carlin tagging experiments have been carried out in Norway, Scotland, Sweden, and France. The Norwegian tagging experiments have been especially useful in developing estimates of exploitation in the Faroe Islands fishery and understanding the migration of Norwegian stocks. Coded wire tags have been used extensively for wild stocks in Ireland and England and with hatchery stocks in Ireland and Iceland.

Exploitation of North Atlantic salmon stocks has been estimated either as an extant rate or a fishery area rate. The extant rate refers to exploitation of a stock in its totality regardless of where it occurs. These calculations clearly indicate the total impact of fisheries on the stock, but do not partition the effects of individual fisheries operating simultaneously. Fishery area exploitation rates, on the other hand, attempt to describe the impact of specific fisheries on the stock by including information on the fraction of the stock migrating to the fishery. Fishery area rates are more abstract and more difficult to estimate. For example, what criteria does one use to determine if a fish is in a particular fishery zone? If the criteria are too conservative and a large part of the stock is excluded, the exploitation rate is overestimated.

Extant exploitation rates based on tagging data can be very useful in evaluating the total impact of fisheries on stocks. If the migration pattern is sufficiently simple, as is the case of Norwegian stocks, ascribing most of the exploitation to a specific fishery is not unreasonable. Exploitation on Norwegian 2 sea-winter salmon in the Faroe Islands fishery has averaged 25% since the early 1980s (Anon., 1992). The migration routes employed by Irish, English, and mainland European stocks appear to avoid this fishery as there is little evidence of exploitation. Extant exploitation of the stock complex of Maine, USA rivers gives an indication of the combined impact of the fisheries in Canada and Greenland (Figure 19).

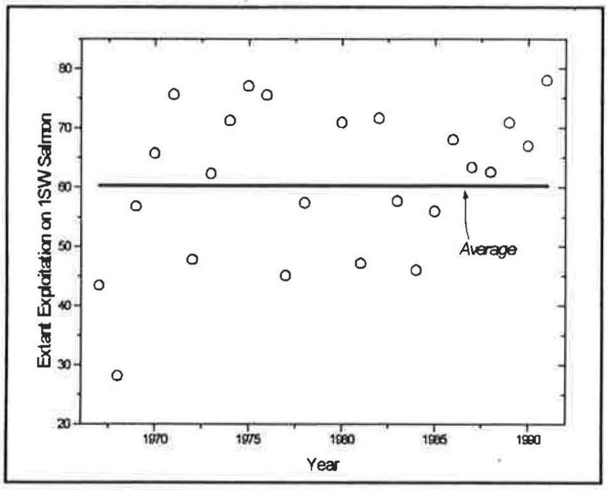

Figure 19. Extant exploitation of Maine rivers, USA, stocks.

It would appear that the migration habits of these stocks put them directly into the fishery zones off the Canadian and Greenland coasts; thus, a high fraction of the stock is subject to fishing mortality.

Fishery area exploitation rates have been more problematic, yet the results from these modeling analyses have added new insights on the behaviour of the fish and the dynamics of the fisheries. Attempts to estimate fishery area exploitation rates of the Canadian and Greenland fisheries have been made with data from tagged stocks, and catch and run data for the entire North American stock complex. In both modeling exercises, results are equivocal because of the problems associated with estimating the true migration pattern of the stocks. However, results do give a relative depiction of the time series changes in fishery impacts. If an effort- or fishing mortality-based management regime is desired for these fisheries, these relative measures of fishing mortality could be used with reasonable effectiveness to guide and monitor catch options.

4.2 Catch Advice and Management Goals

Catch advice for mixed stock fisheries of the North Atlantic has been developed around the management goal of assuring that sufficient numbers of adult spawners will reach the spawning grounds. Of the factors affecting the size of salmon populations, overfishing is the most scientifically tractable factor to control. Adjustment of fishing mortality in the gauntlet of fisheries affecting an overfished stock in order to assure that sufficient spawning escapement occurs is more than just an exercise in theoretical salmon management (Woodley, 1987). Yet when managers move from the theoretical concerns of spawning escapements and the expected impacts of effort reduction or quota regimes to the actual implementation of management, it is quickly evident that neither fish or fishermen are theoretical.

Spawning targets and escapement estimates have been developed for North American salmon stocks. Spawning targets are assessed by stock and cohort. The spawning potentials of a grilse and a multi sea-winter salmon are very different, but at the same time it is recognized that cross cohort reproduction is vital to maintain population genome heterozygosity (Caswell *et al.*, 1984; Myers, 1984). Thus, for genetic and reproduction reasons it is desirable to have a blend of different age spawners. The mean spawning target for North American 2 sea-winter salmon has been established at 196,000 fish (Anon., 1992). When this target is considered in respect of the estimated number of spawners entering North American rivers, it is evident that this age group of the stock complex has experienced recruitment overfishing in recent years (Figure 20). If the agreed management goal is a target spawning escapement, then a fixed portion of the pool of pre-fishery recruits must be protected to ensure that there are sufficient survivors to spawn.

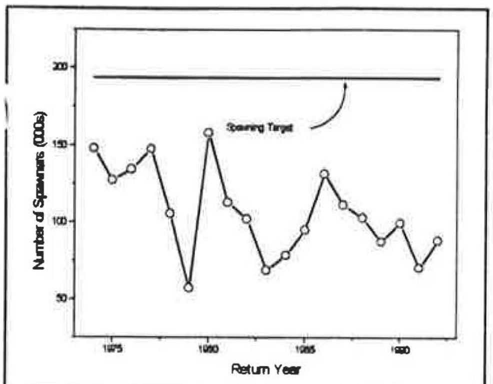

Figure 20. Target and realized spawning of North American stocks.

Fish destined to spawn and those destined to be captured in fisheries can be viewed as members of a common pool of fish which is at its maximum size immediately prior to the first fishery. If this pre-fishery abundance can be estimated, fishery removals can be planned to leave sufficient numbers of spawners. We have a historical record of this abundance by combining all the catch of the cohort as both 1 and 2 sea-winter salmon, estimates of spawners, and losses due to natural mortality (Figure 21).

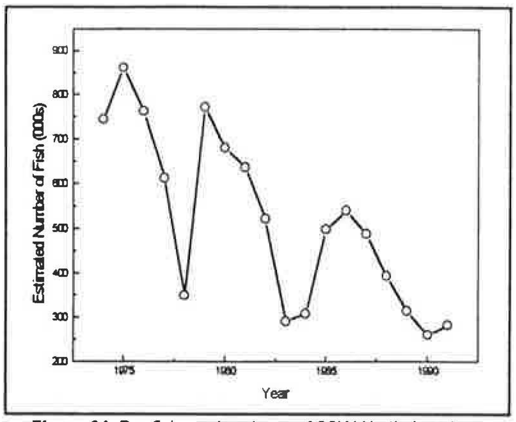

Figure 21. Pre-fishery abundance of 2SW North American stocks.

The distribution of this forecast will allow managers to evaluate the risk of not attaining the agreed management goal by knowing the probability that the pre-fishery abundance might be less than the value chosen. Once a forecast level of abundance is adopted, with its associated risk factors, the socio-political process of allocation can proceed. To be consistent with the management goal of ensuring sufficient escapement, a sufficient number of individuals allowing for natural mortality must be set aside for spawning escapement (Figure 23).

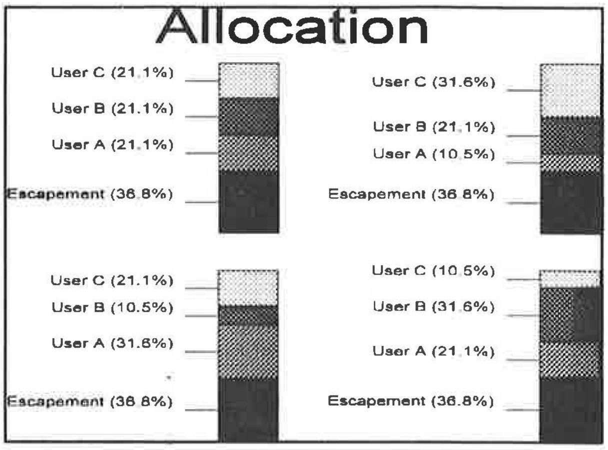

Figure 23 Hypothetical allocation schemes.

This time series of data gives an indication of the range of values expected for the pre-fishery abundance, the trend in abundance levels, and what factors affect abundance. The most striking feature of this time series is the pattern of decline in the population of North American salmon.

Catch advice may be predicated on abundance versus escapement levels, but it is actuated by the prediction of abundance some time in the future. Prediction is no less troublesome in fisheries management than it is in economics or agriculture. Yet without prediction it is difficult to go forward and we ignore our understanding developed from experience. In the case of salmon management in the North Atlantic, the quantity we must forecast is the pre-fishery abundance of salmon. From these forecast levels we can plan for fisheries and at the same time plan for spawning escapements. The prediction of pre-fishery abundance should include an estimate of forecast variability. The probability density function of the forecast will allow a statement of probability and risk associated with different management decisions. In the case of predicting the pre-fishery abundance of North American stocks, the simplest prediction model is a univariate one which bases the forecast on recent trends in the data (Figure 22).

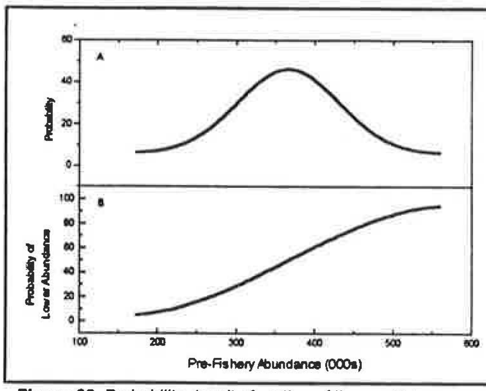

Figure 22. Probability density function of the pre-fishery abundance of 2SW North American stocks (A), and probability profile (B).

Allocations, adjusted for natural mortality as appropriate, are then decided amongst user groups. As illustrated in Figure 23, the allocation for escapement is constant in all hypothetical allocation schemes. The variation among allocation schemes is among user groups.

4.3 Evaluation

There are many indicators of stock status and abundance that reflect processes in freshwater and the marine environment. Probably the most broad scale and most difficult to interpret has been time series of catch data. Catch data can be very problematic when used to interpret trends in abundance due to variation in effort, regulations designed to reduce fishing mortality, and unreported catches (Bielak and Power, 1988; Shearer, 1988). Despite these difficulties, time series of salmon landings are considered indicative of trends in stock abundance because of their global nature and the compensatory action of related fisheries. A cohort can be exploited more than once and at different ages in a sequence of fisheries. The landings data indicate two important points: first, salmon landings have decreased in recent years well beyond any expected reduction due to management actions, and are thus taken as an indication of decreased survival; and second, abundance levels have fluctuated in the past suggesting some cyclic behaviour in the abundance of stocks (Figure 24). We have no other datasets on salmon populations that go as far back in time as the catch time series; thus, they are our only source of historical perspective.

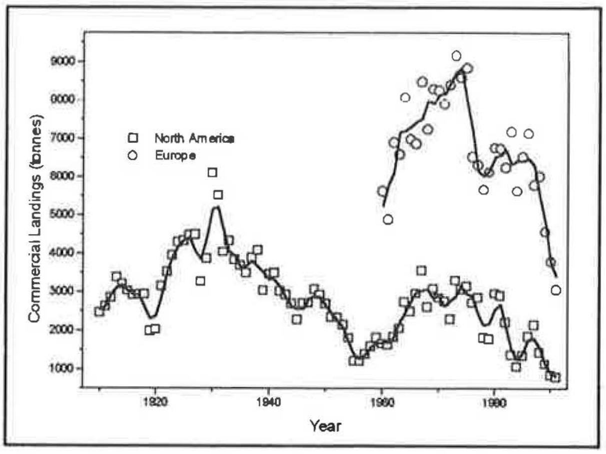

Figure 24 Landings by continent.

Some indicators of stock status are not population level indicators, but rather organism-level indicators of condition or growth. For example, it has been noted that the size of 1 sea-winter salmon captured at West Greenland has been decreasing in recent years (Figure 25).

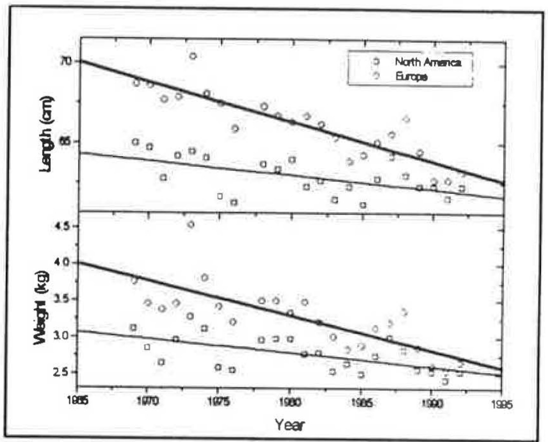

Figure 25 Weight and length of 1 sea-winter salmon at West Greenland.

This effect has been more acute for European origin salmon. What does this decrease in size indicate? One sea-winter salmon at West Greenland are overwintering survivors of the post-smolt season. If the post-smolt year had been difficult due to poor food resources or intense competition, it would be logical to expect fish to grow poorly. The observations of decreasing catches in conjunction with decreasing fish condition are in agreement, and may be interpreted as indicative of poor growth and survival in recent years.

We have very limited data with which to evaluate the status of freshwater productivity. Some effects are easily demonstrable, such as habitat destruction due to dam construction or acidification. Other effects, such as overfishing and juvenile competition, require monitoring of juvenile populations through techniques such as mark-recapture tagging and electrofishing. We are ultimately interested in the number of smolts a unit of habitat produces in a given year, but we are rarely able to measure that directly. In Europe, one well monitored river system, the North Esk in Scotland, does have data on smolt production (Figure 26).

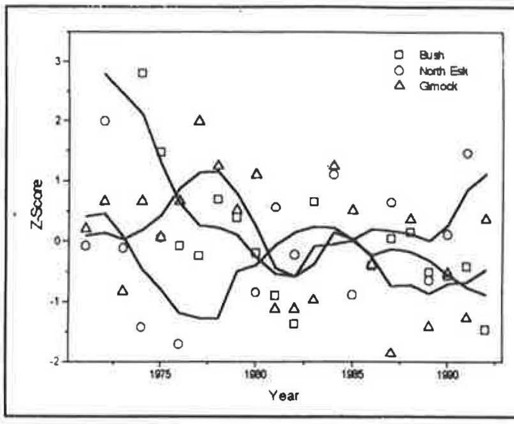

Figure 26 Smolt production for some European rivers.

Smolt production is essentially without trend in this river system over the past 20 years. However, other rivers in the United Kingdom show some evidence of a decline in freshwater production. For example, the River Bush in Northern Ireland shows a decreasing trend in smolt production. In North America, the parr populations of a number of rivers are monitored. The number of parr must be carefully interpreted as an indicator of smolt production since many factors affect the abundance of pre-smolt juveniles. Parr populations in two large North American rivers, the Miramichi and Restigouche, show a trend of increased production during the last two decades (Figure 27).

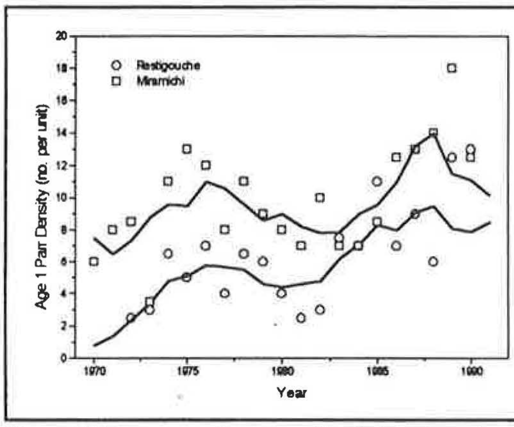

Figure 27 Parr production in two North American rivers.

The increased parr populations in Canada are probably directly attributable to the management measures implemented in Canada to increase spawning escapement. It is a startling reinforcement of the concern over survival during the post-smolt phase that despite trends that suggest stable or increased smolt populations, the number of adults in the populations of both North American and European salmon has decreased over the past two decades.

5 THE FUTURE OF SALMON STOCKS

Can overfishing cause Atlantic salmon stock extinctions by undermining the genetic integrity of low abundance stocks? What is the relationship between wild salmon and salmon mariculture? Will salmon mariculture save wild stocks by reducing the economic benefit of commercial fishing, or will salmon mariculture prove to be the bane of wild stocks by weakening stock genomes and by breeding epizootic infections that compromise wild stocks? Will the changes in world climate also result in changes to Atlantic salmon habitat so severe as to cause regional stock extinctions? The questions and challenges facing Atlantic salmon resource managers are varied and profound.

Of all the dramatic changes involving the Atlantic salmon resource in the North Atlantic during the last decade, none is more dramatic than the meteoric rise in the production of farmed Atlantic salmon (Figure 28).

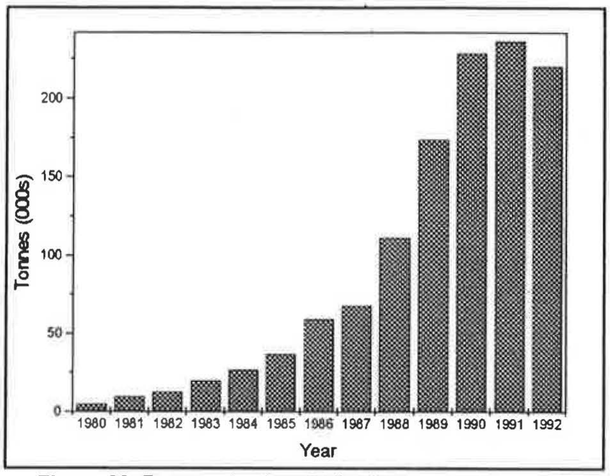

Figure 28. Farm production of Atlantic salmon in the North Atlantic area.

The production of farmed salmon now dwarfs the production of wild salmon by a factor of 50, and with farms still under development in Europe, North America, and South America, the potential production appears only limited by the market. The commercial demand for wild salmon still persists as a speciality item and in the restaurant trade. However, with the continued improvement in the quality and handling of the farmed salmon product, it is questionable how long the demand for wild salmon will last.

Overfishing, habitat destruction, climate change, and Atlantic salmon fish farming are just a few of the factors affecting the future of Atlantic salmon stocks. It is extremely important for all user groups to understand the full breadth of the problems facing Atlantic salmon stocks. It is only through a recognition by all user groups that they share a dependence on healthy and viable wild stocks, that the level of cooperation needed to avoid further stock extinctions will be developed.

5.1 Pollution and Environment

There are two well established facts related to world climate: the earth's climate changes in response to natural astronomical cycles; and mankind has released significant quantities of carbon dioxide into the atmosphere. There continues to be an active debate on which set of factors is fueling recent changes in world climate (Regier and Meisner, 1990), but regardless of the cause of these changes we know they are occurring and we must adapt to them (Figure 29).

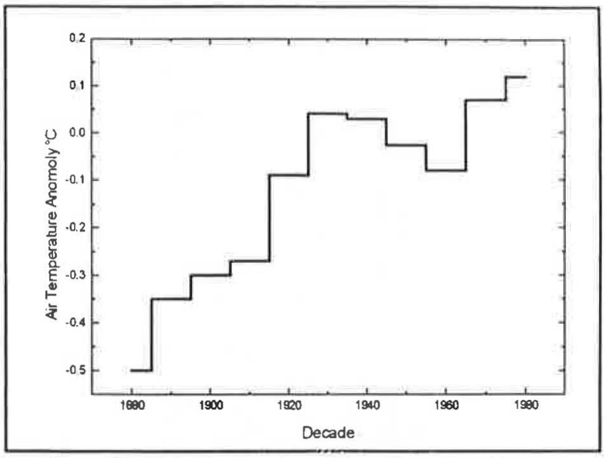

Figure 29. Global temperature change from Houghton and Woodwell (1989).

The two most troubling areas of concern involve the fate of smolts. Open ocean habitats are not likely to change dramatically in response to a 1°C change in temperature (see Figure 29), but the distribution of currents and water masses may change dramatically. Survival mechanisms for post-smolts may be intimately tied to the distribution of specific temperature ranges of water, so it is not a question of whether there will be 4 to 8°C water for salmon but whether it will continue to be in the right place at the right time.

The other area of concern for smolts relates to their entry into the marine environment. Smolt migrations are probably timed to coincide with favourable ocean conditions. The cues that smolts use to trigger their migration are mediated by their natal stream environments, which may be affected by climate changes differently from those in the ocean. Climate change may disrupt the synchrony between migration and ocean conditions, thus causing salmon smolts to migrate to the ocean during periods of less than favourable conditions.

5.2 Epizootic Infections

Since the beginning of recorded history as mankind has chosen to live in cities and thus concentrate populations in smaller areas, epidemics have occurred more frequently and with greater impact. When societies have looked to foreign lands for exploration and trade, the pathogens their citizenry harboured benignly have wreaked havoc amongst their host societies. These two observations are disturbingly analogous to the potential problems we face with the expanding use of salmon farming and ranching. Epidemics are fostered in populations that are crowded and stressed, and in populations that are exposed to unfamiliar pathogenic agents. The case of *Gyrodactylus* in Norwegian rivers is an illustration of the sort of problems we face (Figure 30).

Figure 30. *Gyrodactylus salaris* from Hansen and Bakke (1989).

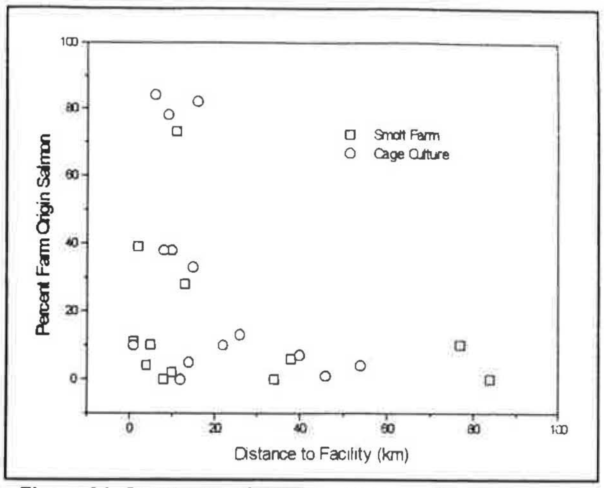

Figure 31. Occurrence of escapee salmon in Norwegian rivers from Gausen and Moen (1991).

This parasite is tolerated by native salmon stocks in the Baltic, but when Norwegian salmon stocks on the Atlantic side were exposed to it, the result was stock extinctions (Hansen and Bakke, 1989). The parasite must now be controlled with preventative poisonings and careful monitoring.

What is the lesson of *Gyrodactylus*? These stock extinctions clearly illustrate the need for transfer and disease protocols for the management of wild and farmed stocks. The practices of salmon farming and ranching have co-existed with wild salmon for over a decade and there is little reason to believe that this relationship could not become more secure with continued vigilance and improved husbandry practices.

5.3 Genetics of Stocks

There is a wealth of poignant reminders of the importance of maintaining the genetic integrity of individual salmon stocks. The reminders are each unique river stock that has been lost in Europe and North America. What makes each stock so important are the local adaptations that are specific to that stock. These local adaptations are never considered until the resolve is developed to try and restore a stock that has been lost. It is then that we discover that the smolt migration habits of the transplanted stock are not quite right for the local conditions or that age at first maturity characteristics are detrimental to stock production (Ritter, 1975). The considerable effort to preserve stock genomes with cryogenics is a poor substitute for the living carrier and in the end may not yield the desired results. Stocks should not be held in a vacuum, but allowed to continue to evolve and adapt. There is a persistent concern over the effect that fish farm escapees have on the genetics of stocks in the neighbourhood of salmon production facilities. The prevalence of escapees in river catches close to these facilities can be quite high (Figure 31).

Do these escapees interbreed and what effect will such interbreeding have on stocks? The emerging answer is "yes" and the net effect is a reduction in genetic fitness in wild stocks (Crozier, 1993). These large-scale escapes clearly point out the need for improved cage construction technology and siting practices.

6 SUMMARY

The stock status, fisheries, and management of Atlantic salmon in the North Atlantic are reviewed. Our understanding of the contrast between river and ocean life is still evolving as new research findings are beginning to explain the mechanisms controlling salmon populations. The importance of assuring adequate spawning to rivers has been reinforced by a pattern of stock and fisheries decline over the past two decades. Stock status appears to be at its lowest level since quantitative assessments of salmon stocks began.

The management of Atlantic salmon stocks was restricted to individual nations until the discovery of the salmon feeding grounds and the introduction of new gears with the capability of exploiting salmon at sea. These two events transformed salmon management because of the highly mixed stock nature of the fisheries that developed. The relationships between producer and host nations have been carried out as bilateral negotiations, as international negotiations in ICNAF, and more recently as international negotiations in the NASCO forum. A range of management measures has been employed in the mixed stock fisheries with varying effectiveness. The most recent development in salmon management has been the concept of arrangements to buy quota allocations to increase escapement from specific fisheries.

The future management of Atlantic salmon has been described as a conservation exercise as much as it is a fisheries management exercise. It is clear that the emerging issues facing managers are new challenges to save stocks and habitat. The competitive use of salmon stocks and habitat will hopefully resolve itself in compromise because, as we have seen many times before, the process of recreating evolution (i.e. restoring a specific river stock of salmon) ranges from difficult to monumental.

7 ACKNOWLEDGMENTS

I thank the North Atlantic Salmon Working Group collectively and specifically the following members for their valuable advice and assistance: W. Crozier, D. Dunkley, L. Hansen, E. Potter, N. O'Maoileidigh, and E. Provost. I thank J. Read of the Atlantic Salmon Trust for valuable resource material. I thank H. Lear for sharing an early version of his review of salmon management in Canada.

8 REFERENCES

Anon. 1987. Report of the salmon review group. Presented to the Minister for the Marine. Stationery Office. Dublin Ireland. 103p.

Anon. 1991. Salmon Net Fisheries: Report of a review of salmon net fishing in the areas of the Yorkshire and Northumbria regions of the National Rivers Authority and the salmon fishery districts from the River Tweed to The River Ugie. Section 39 of the Salmon Act 1986. The House of Commons, London.

Anon. 1992. The report of the Working Group on North Atlantic salmon. ICES, C.M.1992/Assess:15.

Bielak, A.T. and G.G. Power. 1988. Catch records-facts or myths? *in* Atlantic Salmon: Planning for the future (eds. D. Mills and D. Piggins). Croon Helm, London.

Berg, O.K. 1985. The formation of non-anadromous populations of Atlantic salmon, *Salmo salar* L., in Europe. J. Fish. Biol. 27(6):805-815.

Caswell, H., R.J. Naiman and R. Morin. 1984. Evaluating the consequences of reproduction in complex salmonid life cycles. Aquaculture 43:123-34.

Crozier, W.W. 1993. Electrophoretic evidence of genetic interaction between escaped farmed salmon and wild Atlantic salmon (*Salmo salar* L.) in a Northern Irish river. Aquaculture *in press*.

de Leániz, C.G., T. Hawkins, D. Hay and J.J. Martinez. 1987. The Atlantic Salmon in Spain. Atlantic Salmon Trust, Moulin, Pitlochry, Perthshire, UK.

Dunfield, R.W. 1985. The Atlantic Salmon in the History of North America. Canadian Special Publication of Fisheries and Aquatic Sciences 80, Department of Fisheries and Oceans, Ottawa.

Fraidenburg, M.E. 1991. The Game's Afoot. The Dynamics of International Conflict over Salmon. A thesis submitted for the Master of Environmental Studies, Evergreen State College.

Friedland, K.D., and D.G. Reddin. 1993. Marine survival of Atlantic salmon from indices of post-smolt growth and sea temperature. Fourth International Atlantic Salmon Symposium, St. Andrews, Canada. *in press*.

Gausen, D., and V. Moen. 1991. Large-scale escapes of farmed Atlantic salmon (*Salmo salar*) into Norwegian rivers threaten natural populations. Can. J. Fish. Aquat. Sci. 48: 426-428.

Gudjonsson, T., and D. Mills. 1982. Salmon in Iceland. Atlantic Salmon Trust, Farnham, Surrey, UK.

Hansen, L.P. 1988. Status of exploitation of Atlantic salmon in Norway Atlantic Salmon: *in* Planning for the future, (eds. D. Mills and D. Piggins) Croom Helm, London.

Hansen, L.P., and T.A. Bakke. 1989. Flukes, Genetics and Escapees. Atlantic Salmon Journal 26, Autumn 1989, p.26-29.

Hansen, L.P., and G.H. Bielby. 1988. Salmon in Norway. Atlantic Salmon Trust. Moulin, Pitlochry, Perthshire, UK.

Hansen, L.P., N. Jonsson, and B. Jonsson. 1993. Oceanic migration in homing Atlantic salmon. Anim. Behav. *in press*.

Houghton, R. A. and G.M. Woodwell. 1989. Globale Veränderung des Klimas. Spektrum der Wissenschaft. Translation from Scientific American, June 1989:106-114.

Houghton, Rev. W. 1898. British Fresh-Water Fishes. Vol. 2, William MacKenzie, London.

Jensen, A.J. and B.O. Johnsen. 1986. Different adaptive strategies of Atlantic salmon (*Salmo salar*) populations to extreme climates with special reference to cold Norwegian rivers. Can. J. Fish. Aquat. Sci. 43(5):980-4.

Kendall, W.C. 1934. The Fishes of New England. The Salmon Family, Part 2 - The Salmons. The Society, Volume 9, Number 1.

Lear, W.H. 1993. The management of Canadian Atlantic salmon fisheries. in Challenge and Change: Perspectives on the Canadian Fisheries Management Experience. (eds. L.W. Parsons and W.H. Lear). Can. Bull. of Fish. and Aquat. Sci. *in press.*

Lear, W.H. and O. Christensen. 1980. Selectively and relative efficiency of salmon drift nets. Rapp. P.-V. Réun. Cons. Perm Int. Explor. Mer. 176:36-42.

Lear, W.H. and R.K. Misra. 1978. Clinal variation in scale characteristics of Atlantic salmon, *Salmo salar,* based on discriminant function analysis. J. Fish. Res. Bd. Can. 35(1):43-47.

McCrimmon, H.R. and B.L. Gots 1979. World distribution of Atlantic salmon, *Salmo salar.* J Fish. Res. Bd. Can. 33:2616-21.

Mills, D. 1983. Problems and Solutions in the Management of Open Seas Fisheries for Atlantic Salmon. Atlantic Salmon Trust, Farnham, Surrey, UK.

Mills, D. 1989. Ecology and Management of Atlantic Salmon. Chapman and Hall, London.

Mills, D., and N. Smart. 1982. Report on a Visit to the Faroes. Atlantic Salmon Trust, Farnham, Surrey, UK.

Møller Jensen, J. 1988. Exploitation and migration of salmon on the high seas, in relation to Greenland. *in* Atlantic Salmon: Planning for the future (eds. D. Mills and D. Piggins). Croon Helm, London.

Myers, R.A. 1984. Demographic consequences of precocious maturation of Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. 42:1349-53.

NASCO. 1992. Report of the ninth annual meeting of the Commissions. NASCO, Edinburgh, Scotland.

Peterson, A.E. 1988. Future of Atlantic salmon management: Law of the sea/fair sharing. *in* Proceedings of the Symposium on Present and Future Atlantic Salmon Management, Measuring Progress Toward International Cooperation (ed. R. Stroud), Marine Recreational Fisheries Series 12, AFS, Ipswich.

Potter, E.C.E. and A. Swain. 1982. Effects of the English north-east salmon fisheries on Scottish salmon catches. Fish. Res. Tech. Rep. Dir. Fish. Res. No. 67, 12p.

Prouzet, P. 1990. Stock characteristics of Atlantic salmon (*Salmo salar*) in France: a review. Aquat. Living Resour., 1990:3, pp.85-97.

Reddin, D.G. 1988. Ocean life of Atlantic salmon in the Northwest Atlantic. *in* Atlantic Salmon: Planning for the future (eds. D. Mills and D. Piggins). Croon Helm, London.

Reddin, D.G. and W. Shearer. 1987. Sea-surface temperature and distribution of Atlantic salmon in the Northwest Atlantic. American Fisheries Society Symposium 1:262-275.

Reddin, D.G. and P.B. Short. 1991. Postsmolt Atlantic salmon (*Salmo salar*) in the Labrador Sea. Can J. Fish. Aquat. Sci. 48(1):2-6.

Reddin, D.G., D.E. Stansbury and P.B. Short. 1988. Continent of origin of Atlantic salmon (*Salmo salar* L.) at West Greenland. J. Cons. Int. Explor. Mer. 44:180-88.

Regier, H.A. and J.D. Meisner. 1990. Anticipated effects of climate change on freshwater fishes and their habitat. Fisheries 15(6):10-15.

Ritter, J.A. 1975. Lower ocean survival rates for hatchery-reared Atlantic salmon (*Salmo salar*) stocks released in rivers other than their native streams. J. Cons. Perm. Int. Explor. Mer. 26:1-10.

Shearer, W.M. 1988. Relating catch records to stocks. *in* Atlantic Salmon: Planning for the future (eds. D. Mills and D. Piggins). Croon Helm, London.

Shearer, W.M. 1992. Natural History, Exploitation and Future Management. The Atlantic Salmon. Halsted Press, New York, Toronto.

Shearer. W.M. and K.H. Balmain. 1967. Greenland Salmon. Salmon Net III:19-24.

Taylor, V.R. 1985. The Early Atlantic Salmon Fishery in Newfoundland and Labrador. Canadian Special Publication of Fisheries and Aquatic Sciences 76, Department of Fisheries and Oceans, Ottawa.

Twomey, E. 1990. The salmon in Ireland. Went Memorial Lecture, 1989. Occasional Papers in Irish Science and Technology, Number 7.

Valiela, I. 1984. Marine ecological processes. Springer-Verlag, New York.

Vickers, K. 1988. A Review of Irish Salmon and Salmon Fisheries. The Atlantic Salmon Trust, Moulin, Pitlochry, Perthshire, UK.

Woodley, J.C. 1987. In-season management of Fraser river sockeye salmon (*Oncorhychus nerka*): meeting multiple objectives. Can. Spec. Publ. Fish. Aquat. Sci. 96:367-374.

HISTORY OF THE BALTIC SALMON, FISHERIES AND MANAGEMENT

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The 4000-5000 year old hook cut in bone, of a length of 13 cm, like the salmon hooks used for anchored lines until the middle of the 20th century was found in the Baltic Sea 2 km east of Bornholm.

1 INTRODUCTION

1.1 *Origin*

Salmon probably invaded the Baltic icelake during the Yoldia Sea period (~ 8000 BC). It is not certain whether the invasion came from the east or the west, although some slight differences in the chromosomes from a western Swedish stock running to the Atlantic suggest a possible contribution from the east (Svärdson, 1945). The Baltic salmon were probably separated from the common Atlantic salmon during the late Ancylus period, about 6000 BC (Rosen, 1946; Christensen and Larsson, 1979) and are today considered to be a geographically separated subpopulation of the North Atlantic salmon, still carrying the name *Salmo salar* L. (Davidson *et al.*, 1989).

Tagged Baltic salmon are very rarely reported from outside the Baltic area, and Baltic Salmon can thus be regarded as a "landlocked" population inhabiting brackish water.

A map showing the Baltic and its river systems is shown in Figure 1.

2 BIOLOGY

A general description of the biology of Baltic Salmon is omitted from this account as Baltic salmon do not differ significantly in this respect from Atlantic salmon living outside the Baltic.

2.1 *River Life and Smolt Migration*

Wild salmon stay as parr from one or two years in the southernmost rivers, to three to five years in the northernmost ones before migrating to the sea as smolts (Alm, 1934; Lindroth, 1977). Reared salmon smolts are predominantly kept for two years, or in the southernmost rivers also for one year. The mean length of tagged migrating natural smolts in the River Torne in the late 1980s was 160 mm. The Swedish reared smolts in the same period had an overall mean length of 180 mm at release (Eriksson, unpubl.). In Finland reared smolts had a mean length of 197 mm in ICES Sub-division 31 (Ikonen, unpubl.).

The smolt run normally occurs during the spring flow in the rivers, i.e. from late April to the middle of June depending on latitude. The major salmon rivers in the northern part of the Baltic drain into an area normally covered by ice until March - late May.

2.2 *Sea Life and Feeding Migration*

When they first enter the Baltic Sea the young salmon are presumed to feed on airborn insects on the surface (Lindroth, 1961a). Later, when they shift to a fish diet, the post smolts in the Gulf of Bothnia and Gulf of Finland mainly prey on sticklebacks. In the later stages of their life the main food items in the Main Basin are sprat, herring and sandeel (Christensen and Larsson, 1979).

From records of fish hooks of southern Baltic origin found in spawners in northern rivers, it was already evident in the middle of the 18th century that feeding Baltic salmon migrate from the southern coast of the Main Basin to northern rivers (Bonge, 1730; Gisler, 1752). The connection between the production of smolts in the northern rivers, a feeding migration to the Main Basin and the influence of the fishery in those areas on the salmon stocks was already under discussion in the second half of the 19th century (Malmgren, 1884). Studies of tagged Swedish salmon indicate that the Swedish post smolt migration follows the main currents both in the Gulf of Bothnia (Larsson and Ateshkar, 1979) and in the Main Basin through the Danish Islands up to the border of the Kattegat and then back into the Main Basin along the southern coast of Sweden (Eriksson, 1985). Recaptures of tagged salmon of the northern Finnish stocks show an initial counter current migration of post smolts in the Bothnian Bay, but a subsequent migration following the main current in the Bothnian Sea (Ikonen and Auvinen, 1985). The main feeding areas for all Baltic salmon stocks, excluding those from the Gulf of Finland, are situated in the central and southern parts of the Main Basin (Anon., 1992; Carlin, 1968; Christensen and Larsson, 1979; Christensen, 1984; Ikonen and Auvinen, 1984). A varying proportion of the salmon from the northern stocks, however, stay and feed in the Bothnian Sea. The salmon in the Gulf of Finland predominantly stay in the Gulf (Toivonen, 1973; Kallio-Nyberg and Ikonen, 1992). According to tagging experiments, less than 1% of Baltic salmon are reported outside the Baltic area (Larsson, 1984; Eriksson and Ikonen, unpubl.).

2.3 *Spawning Migration*

The spawning run starts in April-May when the salmon leave the feeding grounds and migrate towards the rivers. Formerly it was supposed that spawners migrate directly to the coastal area in the vicinity of the home river. After a period in coastal waters, the river is located and the salmon ascend (Lindroth, 1951; Carlin, 1968; Eriksson *et al.*, 1981). Recent investigations indicate that the migration of both wild and reared salmon partly occurs closer to the coastal areas than formerly suggested (Eriksson, unpubl.).

2.4 *Growth*

Before World War 2, the mean weight of grilse was estimated to be 1.6 kg. Salmon returning after two years in the sea ranged from 4-8 kg and those returning after three years in the sea ranged from 8-13 kg. Giant salmon of 15-25 kg, which had spent four or five years in the sea before homing, were not exceptional (Figure 2). The majority of spawners spent three years or more in the sea, the grilse proportion constituting only 10% (Järvi, 1939).

During and immediately after World War 2, the mean weights dropped significantly (Lindroth, 1965). Later, the highly selective drift net fishery on feeding salmon mainly during their second winter in the sea (Figure 3) prevented a fair estimation of growth. The weights of multi sea winter spawners were, however, 1-5 kg lower than in the previous period (Larsson, 1984; Eriksson 1989). Swedish tagging data, furthermore, reveal that the fishery during the most recent decades has also affected the age composition of the spawners. The proportion of grilse has increased to around 50%, while two sea winter spawners constitute 35% . The proportion of salmon which have spent four years or more in the sea is less than 1%. The growth capacity seems not to have been changed by the rearing programme, as shown by the latest data on mean weights of tagged spawners (Figure 2) and the results from some experimental delayed releases of young salmon. The offshore fishery thus seems to influence not only the age but probably also the size of spawners (Eriksson, 1989, and unpubl.).

Figure 1. Map showing Baltic Sea and its river systems.

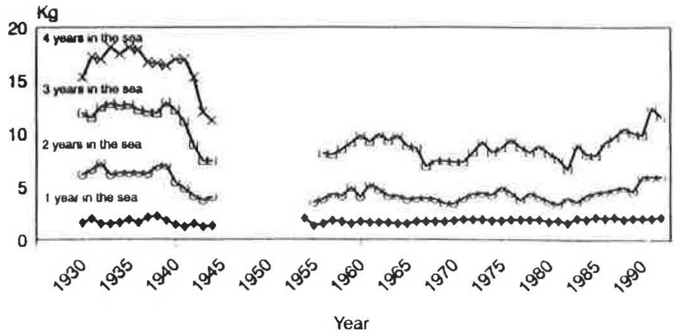

Figure 2. Annual mean weights of spawners in Rivers Oulu älv and Torne älv 1930-1944 (after Lindroth, 1965). Annual mean weights of spawners in river and coastal fishery 1953-1991 (data from Swedish tagging records). (Reports of 4-year-old salmon scarce, mean weights not given.)

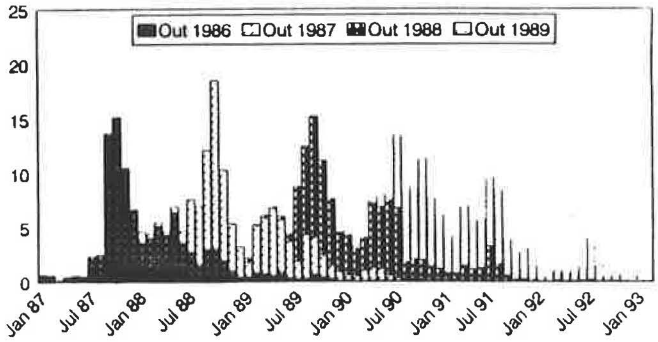

Figure 3. Sequential catch pattern of Baltic salmon based on reported recaptures from Swedish taggings 1986-1989. After Anon., 1991.

3 HUMAN INTERCEPTION

The influence of human activities on the size of stocks was not of any major importance until weirs, traps and dams were constructed in the rivers.

The development of stocks from the Middle Ages up to the 19th century is uncertain, but there exists evidence of major decreases, such as the disappearance of stocks in the upper parts of some rivers and reduced abundance of salmon in some small rivers (Anon., 1899).

Though the salmon stocks in former times were relatively undisturbed by human activities, evidence of natural fluctuations in abundance are recorded as both long-term fluctuations in overall catches (Lindroth, 1961b, 1965) and as short-term fluctuations in single rivers. In the River Byske fluctuations are reported from almost the entire 19th century, with catches peaking in cycles of ten to twelve years (Marklund, pers comm). Similar short-term cycles are noticeable in Swedish tagging experiments, in spite of many other factors influencing these results (Figure 4).

The decline in German salmon stocks started around 1860 as a consequence of pollution and damming of rivers, and by the end of the nineteenth century they were more or less extinct. In Finland also, salmon had disappeared from some small southern rivers by the beginning of this century (MacCrimmon and Gots, 1979). In spite of human interference, however, salmon still existed in around 60 rivers at the turn of the 20th century with an estimated annual production of roughly seven to 10 million wild smolts (Figure 5) (Lindroth, 1974). Almost 40 of these rivers were Swedish.

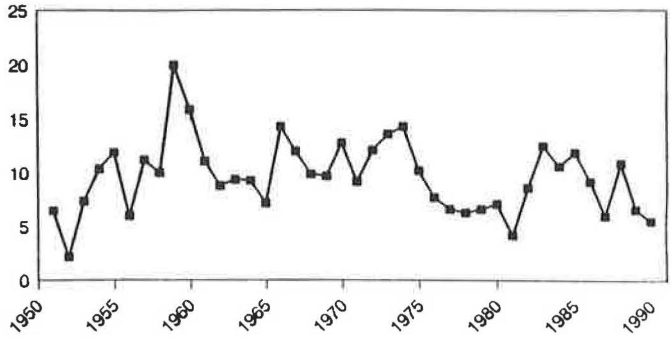

Figure 4. Return rate of Swedish taggings of Baltic salmon 1951-1990 (1990 estimated from present figure).

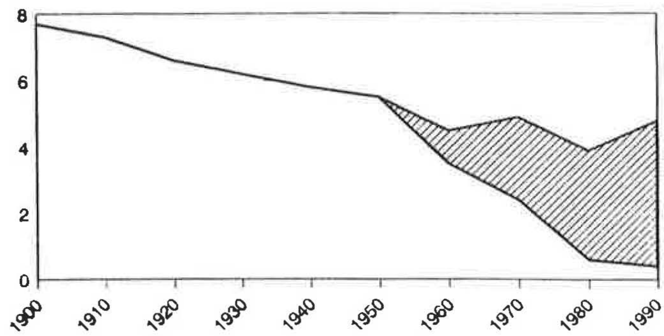

Figure 5. Estimated recruitment of salmon smolts (millions) to the Baltic in the years 1900-1990. Hatched area = hatchery reared production (partly after Lindroth, 1974).

During the 20th century, natural smolt production has decreased dramatically and in recent years has been estimated to be only around 400,000 (Figure 5). The number of rivers still carrying natural stocks has decreased to less than 20. Only in one river, the River Mörrum, is smolt production in accordance with the potential. In other rivers, the natural production of salmon smolts is generally 20 % of the carrying capacity. In the rivers in the Gulf of Finland only remnants of a natural production still exist (Anon., 1992; Karlström, 1989).

There are several reasons for the decrease in the number of rivers and reaches of rivers carrying natural smolt production. Since the beginning of the present century, most of the nursery areas in the major salmon rivers have been devastated. The two most important factors affecting natural salmon production are damming and pollution, and in some rivers also timbering. All these activities began to affect the salmon stocks in the 19th century, but the majority of the northern rivers in

Sweden and Finland were still fairly good producers of salmon up to the 1940s. While pollution mainly affects the survival of eggs and younger stages, dams for hydro electric power plants not only prevent access to spawning grounds but also transform areas of rapids into lakes unsuitable for spawning and salmon parr.

So long as only a single steep fall was dammed, fishways were established to allow ascending spawners to migrate upstream to the spawning grounds in the upper parts of the river. Later developments, however, which utilized almost all the steep falls in the rivers, necessitated other means of salmon conservation (Carlin, 1968) (see Section 6).

4 THE FISHERIES

4.1 *Earliest History*

Exploitation of salmon in the Baltic area by man probably commenced when withdrawal of the glaciers in the last glacial period made the Baltic Ice Lake and tributaries accessible to fish, and the invasion of the early hunters possible. No subfossils of salmon have been recorded from this or the following Yoldia Sea period, however.

The earliest evidence of salmon in the Baltic is from the upper River Luleå, where tools for preparation of fish skin have been identified and dated at about 6000 B.C. (Israelsson, pers. comm.). Relics of salmon dated around 4000-2500 B.C., have also been excavated from settlements on Gotland and Byske in Sweden (Munthe, 1941; Lindroth, 1985). Swedish rock carvings from 2000 B.C. also bear witness of salmon fishing. Fish spears, hooks, nets and weirs are known from at least 8000 years ago and are supposed to have been used for catching salmon. A hook of bone from the later stone age, shown on the front page of this article, and of the size used for anchored salmon lines until about 50 years ago, was found on the coast of Bornholm (Bøggild, 1983).

4.2 *River Fishery*

As salmon are most vulnerable to fishing during their upstream migration to the spawning grounds, exploitation of salmon was originally confined to the rivers and inshore waters.

In the rivers a variety of fishing gear and methods were developed. Fishing ascending salmon in the River Tornionjoki on the Finnish/Swedish border by means of trammel nets drifting downstream between two boats is known from the 15th century. The simpler seine and gill nets were probably used to catch salmon even earlier.

Seines are still operated in a few rivers in Sweden where the bottom conditions are favourable. Nowadays, recreational gill netting together with angling is responsible for the majority of catches in Finnish rivers, while in Swedish rivers similar fisheries are of minor importance.

In the early 16th century the first salmon traps consisting of weirs of grating or rough netting supported by poles from one or both river banks were established. Various constructions of the gear were developed and soon spread to the other salmon rivers. The commercial weir fishery was abandoned in most of these rivers at the beginning of this century, however, as the fishing rights were bought up by timber companies in order to allow timber floating (Vilkuna, 1974).

Spear fishing which was practised formerly is now prohibited. Today fishing for spawners to supply the hatcheries constitutes the main part of the Swedish river catches. Traps and seines are the most appropriate gear for this purpose, but brailing is also practised.

Close to the end of the 19th century river fishing was still the predominant form of salmon exploitation. Following the restriction, and in many cases total stoppage of salmon runs in the rivers resulting from the establishment of hydro-electric power plants, pollution, stream regulation and other human activities during the last century, the yield of the river fishery is now reduced to a fraction of its former magnitude.

Since 1880-1900, when salmon were abundant, the catches in the Baltic rivers have shown a general decline, only interrupted by the periods 1920-1925 and 1945-1950, when the abundance of the stocks was significantly higher than average. In 1980 only 1.5 % of the total yield of Baltic salmon was due to the river fishery. The river catches are shown in Figure 6 as 5 year averages since 1915. Complete fisheries statistics are not available before this period (Christensen and Johansson, 1975; Anon., 1981 and 1992).

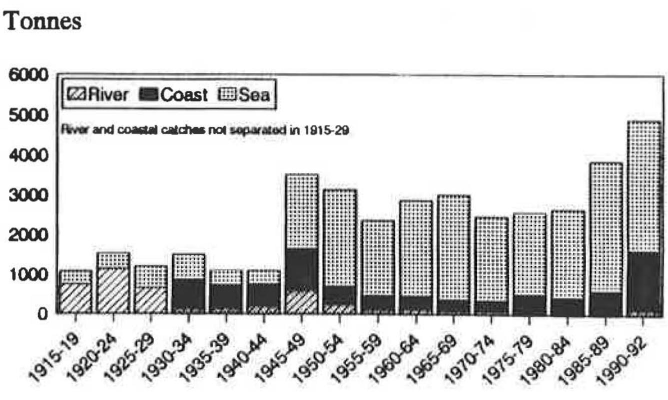

Figure 6. Distribution of total catches of Baltic salmon in river, coastal and sea fishery in 1915-1992 (Lindroth, 1985; Folke, 1986; Anon., 1993),

The increase in total yield of Baltic salmon during recent years starting in 1989, obviously a result of extremely favourable conditions for survival and growth, is reflected in a doubling of the river catches compared with the preceding period.

4.3 *Coastal Fishery*

The coastal fisheries for salmon are principally directed towards maturing salmon on their spawning migration. The fishery is carried out on the migration routes along the shores and in the estuaries.

In the coastal area salmon are predominantly caught by confinement gear. The large fyke nets, formerly the common salmon gear in the Gulf of Bothnia, are now replaced by the more efficient anchored pound nets. Fyke nets intended for other fish species, i.e. whitefish, but which catch salmon as well, are still used, however. The same is the case with pound nets in the southern Baltic, where salmon occasionally occur as by-catches.

Set gill nets for salmon, in former times widely distributed in shallow coastal waters (Henking, 1913), are now most frequently used in estuaries and along coasts where salmon rivers fall into the sea.

Fixed hooks (anchored lines with one or a few hooks) intended for catching feeding salmon inshore, as well as offshore, in the southern Baltic have been used at least since the beginning of the 18th century (Malmgren, 1884). In the late 1940s they were mainly abandoned when the hook fishery with drifting longlines was introduced. Anchored long lines carrying hundreds of hooks are still in use on a small scale in the Gulf of Bothnia (Niemelä, 1924; Forsell, 1947).

Beach seines were previously used for fishing spawning migrants near the outlet of the salmon rivers in the Gulf of Bothnia and Gulf of Finland as well as for fishing small feeding salmon on the sea shore (Henking, 1913).

While the river fisheries were declining in the present century the coastal fisheries increased and, in the years up to 1945, yielded the main part of the total catches of Baltic salmon. Coastal catches in the Baltic from 1930-1991 are shown in Figure 6. For the preceding years, 1915-1930, coastal and river catches are combined.

Since the immense expansion of the offshore fishery immediately after 1945 the coastal catches have formed a declining part of the catches and in the 1970s and 1980s constituted only about 15% of the total yield. The coastal catches in 1990 and 1991, like the river catches, not only doubled their share of the total yield of Baltic salmon compared to the previous years, but also even trebled in terms of weight (Anon., 1992).

4.4 *Sea Fishery*

The salmon sea fishery of today is generally defined as an offshore fishery mainly directed towards feeding salmon. As mentioned above, the fixed hooks used formerly were fished close to the coast as well as offshore. To a certain extent the same is the case with drift nets, the now predominant gear in the Baltic salmon fishery. As a clear cut separation between inshore and offshore salmon fishing cannot be established, the year in which the proper sea fishery for salmon started is debatable.

Whatever the original date of the sea fishery, a notable sea fishery was induced in the Baltic Main Basin by the abundant stocks of salmon in the latter part of the 19th century, but it had certainly been practised for a long time before. Drift nets were generally used in March-May, and in some places also in September-October, while anchored lines using fixed hooks baited with herring were operated in the autumn and winter months.

Construction of fishing harbours initiated by the introduction of boats with decks encouraged further replacement of the open boats with deck boats. By 1875, for example, the whole salmon line fleet of Bornholm consisted of deck boats worked by sail and oars (Zahrtmann, 1890). The drift nets were usually operated from half deck or open boats (Otterstrøm, 1904).

Generally the fishery was confined to fishing grounds sufficiently close to the shore to allow a return home at night. However, an increasing number of vessels were fishing on foreign coasts far away from their home port. Figure 7 shows the distribution of the salmon fishery in the Baltic Sea at the beginning of the 20th century.

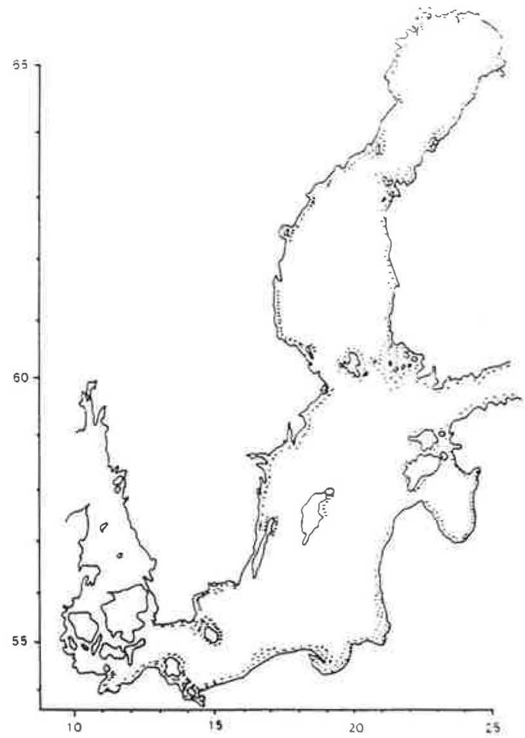

Figure 7. Distribution of the salmon fishery in the Baltic Sea at the beginning of the 20th century (after Henking, 1913).

Introduction of engines in salmon vessels, which started shortly after the turn of the century, reduced the steaming time to the fishing grounds in favour of an increased range of fishing activity and the possibility of applying a greater number of gear. Before the First World War hundreds of boats fishing salmon in the Baltic Main Basin were equipped with engines. On average 100 drift nets or 200 hooks were handled per boat (Lindroth, 1985). The increase in fishing power did not result in a corresponding increase in catches, however. The abundance of salmon available to the fishery before 1900 was succeeded by a prevailing low abundance in subsequent years. Subdued fishing activity during the two world wars also failed to promote the development of the fishery (Lindroth, 1985).

Up to 1945 the offshore salmon catches constituted about a third of the total yield of Baltic Salmon, probably the same proportion as at the beginning of the century. The extraordinary increase in abundance of the salmon stocks in the 1940s, and the presence of a large, modern fishing fleet in the southern Baltic, resulted in a sudden increase in the salmon fishery in the sea. In addition, the total fishing effort was increased by the introduction of drifting long lines and by the participation of a large number of boats from North Sea and Belt Sea harbours. The proportion of the total yield of Baltic salmon caught in the sea rose during the period 1945-1959 to two thirds (Figure 6).

The efficiency of the gear also improved. The large hooks originally used for the standing lines were soon replaced by a smaller size more suitable for catching the smaller, but more numerous specimens of salmon. Accordingly, herring as bait was replaced by sprat more appropriate for this size of hook. Until the mid-1960s the majority of landings in the offshore fishery were captured by longlines, and in 1960-1964 made up about 70% of the Danish catches.

In the first half of the 1960s the hempnets used up to then were discarded in favour of nets made of synthetic fibres. Raising the top of the net panel to sea level by removal of the strops to the floating line further increased the catchability and facilitated handling. Modernized drift nets soon replaced long lines during the main part of the autumn and spring fishery, and from the mid-1960s 70-85% of the salmon entering the sea fishery were caught by drift nets.

In the 1970s practically all offshore salmon vessels were equipped with hydraulic hauling devices for their nets, and a few years later for long lines too. At the same time Decca and Radar were installed to facilitate navigation and localization of the drifting gear. A number of boats, especially those participating in the salmon fishery in the Northeast Atlantic, had cold stores built in to increase the number of fishing days between landings, and thereby extend their fishing range. The closing of the fishery for Atlantic salmon in international waters in 1984, and the limitation of the fishery in the Baltic by the establishment of national fishing zones in 1978, however, rendered freezing installations superfluous.

As a consequence of the various improvements of vessels and gear the number of drift nets and longline hooks operated increased until 1979, when they were restricted by international agreement to 600 nets and 2000 hooks per boat. Until then 800 nets and 3000 hooks were often used per boat covering a distance of about 13 and 28 nautical miles respectively.

To give an idea of the geographical distribution of the offshore fishery before the introduction of national fishing zones, Figure 8 shows the recaptures by area and number from Swedish salmon tagging experiments in 1966-1972. As shown in the figure, the greatest number of salmon were captured east and west of Gotland, northeast of Bornholm and in Gdansk Bay, where feeding salmon, and consequently the fishery, were concentrated at different times of the year. Figure 9 shows the distribution of the sea catches after the establishment of fishing zones as shown by the distribution of tag recoveries from Swedish stocking experiments in 1987-1988. The sea fishery is now concentrated in the central part of the Main Basin east of Gotland and in the southern part north and east of Bornholm.

The catch per unit effort (CPUE) in the sea fishery in the Baltic shows great fluctuations from year to year and from one area to another. From 1960 to 1983 on average about 8 salmon were caught per 100 nets in the Main Basin; in the subsequent years the number rose by about 75%. The CPUE of longlines nearly doubled in the 1980s from a mean of about 22 salmon per 1000 hooks in the previous 20 years. In the Gulf of Bothnia the average CPUE values in the sea fishery were significantly lower than in the Main Basin during the 1980s (about 8 and 28 salmon per 100 nets and per 1000 hooks, respectively), and in the long line fishery in the Gulf of Finland 16 salmon per 1000 nets was the average catch rate in the same period (Anon. 1981 and 1992).

The annual effort in the sea fishery in the Main Basin presented in Figure 10 is estimated from total sea catches in this region and from combined CPUE figures for drift nets and long lines. The question is to what extent the obvious decline is the number of gears used since the 1960s represents a true decline in fishing effort. It cannot be ignored that the change in gear in the 1960s and 1970s mentioned above has increased the efficiency and consequently the effort per gear unit.

The effect on effort of the various international regulation measures agreed in the 1960s and 1970s to preserve the natural stocks of salmon, such as minimum size, number of gear per boat and closed seasons, has not been quantified.

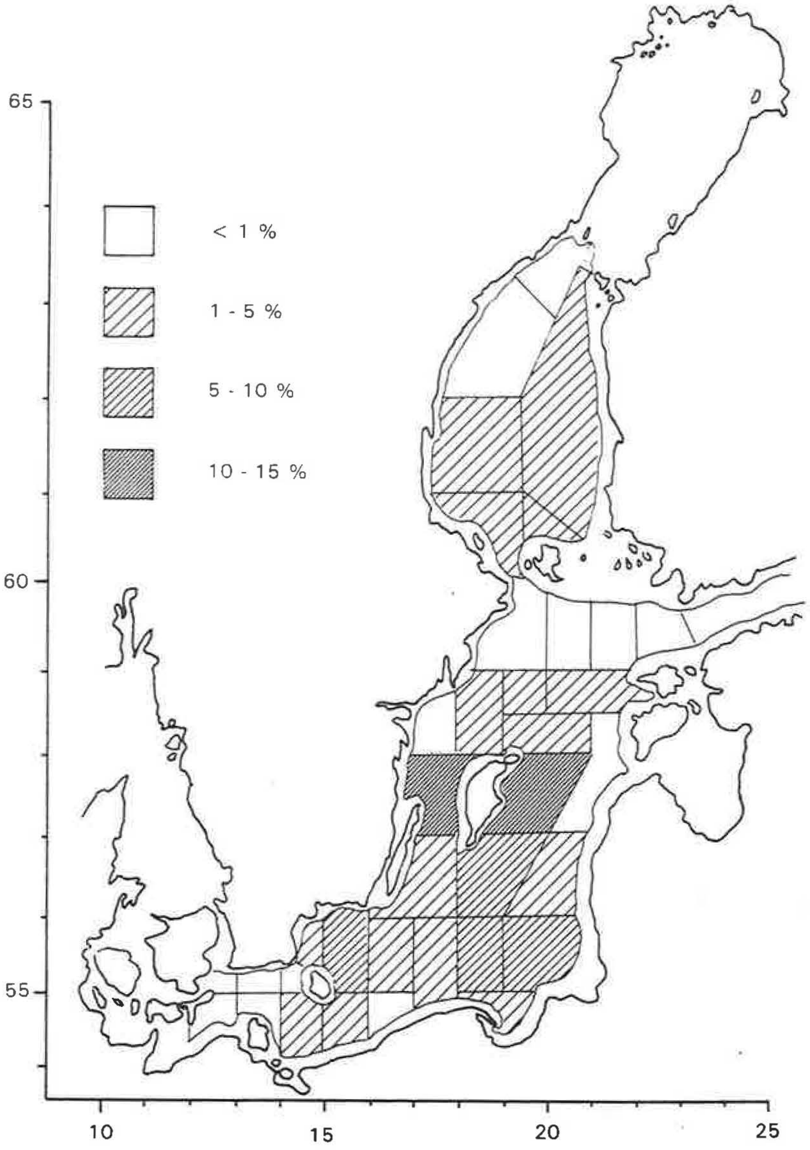

Figure 8. Distribution of recaptures of tagged salmon smolts released in Swedish rivers 1966-1972 (Christensen and Larsson, 1979).

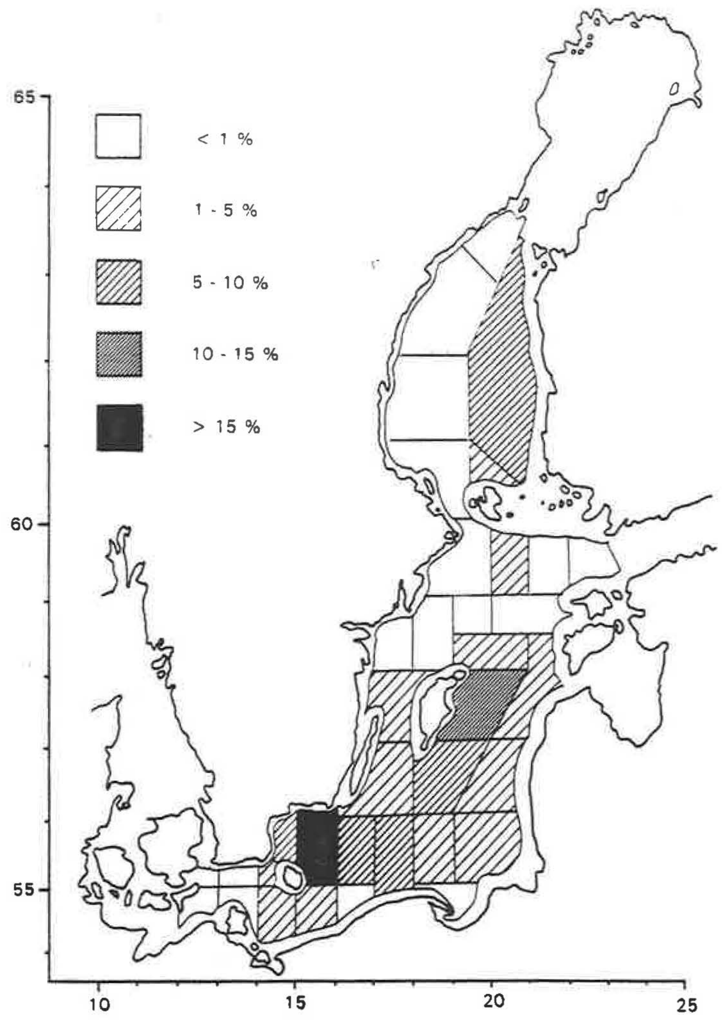

Figure 9. Distribution of recaptures of tagged salmon smolts released in River Luleå 1987-1989 (Anon., 1992).

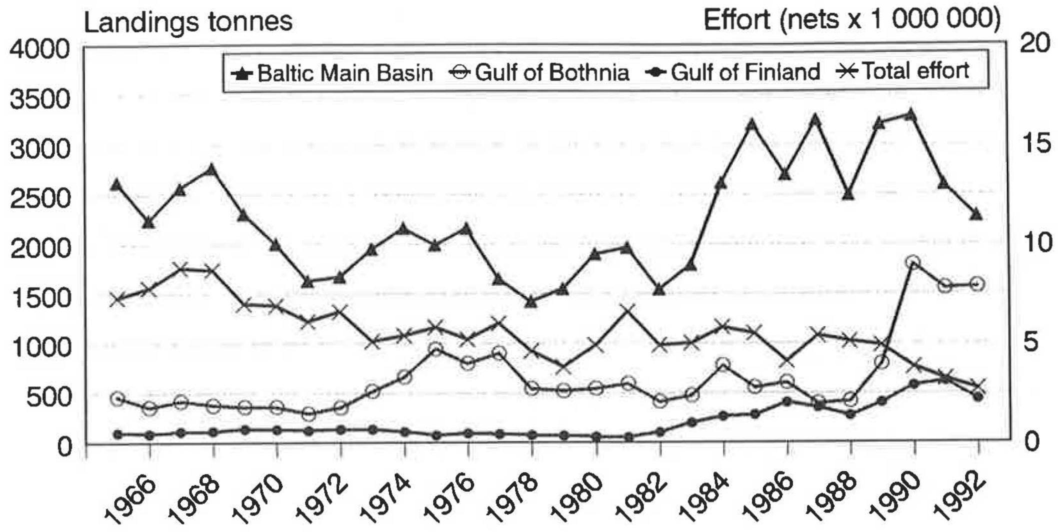

Figure 10 Total landings of Baltic salmon from the river, coastal and sea fishery distributed in the Main Basin, the Gulf of Bothnia and the Gulf of Finland 1965-1991. Also inserted is the total effort of the fishery using drifting gear in the Main Basin estimated as the number of salmon per 100 nets (longline effort converted to drift net effort).

The establishment of extended economic zones (EEZ) in the Baltic in 1978, and especially the elimination of the White Zone in 1988, until then considered as international waters, caused a significant restriction of fishing areas and consequently reduced the effort of some fleets. In recent years the low market price for landings of salmon, caused by competition with farmed salmonids, has no doubt influenced the effort as well. The declining effort in the sea fishery, however, is not reflected in a corresponding decrease in yield. As shown in Figure 6, the total offshore catches in the Main Basin, Gulf of Bothnia and Gulf of Finland, based on 5 year averages seem to have been rather stable during the period 1945-1985. The annual catches in the three regions since 1965, however, show great fluctuations from year to year, but at different levels (Figure 10). Considering the landings from the Main Basin, where more than 95% are due to the sea fishery, three levels can be distinguished after the great variations around 2000 tonnes during the years 1945-1960. In the subsequent years up to 1969 the catches fluctuated between 2000 and 2500 tonnes, followed by a decrease to 1500-2000 tonnes until 1984, after which the yield rose to around 3000 tonnes.

The landings of salmon from the Gulf of Bothnia consist partly of sea catches of feeding salmon and partly of river- and coastal catches of spawning migrants. Since 1972 when the three components can be separated statistically the sea catches have been on average about 300 tonnes, highly fluctuating but not correlated to the fluctuations in the sea fishery in the Main Basin. The same is the case with the sea catches in the Gulf of Finland, which originally constituted the main part of the total landings in this region, but which have recently been surpassed by those in the coastal fishery.

Quite recently experimental salmon trolling, as a recreational fishery, has been carried out offshore in the Baltic Main Basin as well as in the Gulf of Bothnia and Gulf of Finland with more or less success.

4.5 *The Present Situation in the Fishery for Baltic Salmon*

As a summary of the Baltic salmon fishery in recent years, Tables 1 and 2 show the total catches in the river, coastal and sea fisheries as a mean of the annual yield in 1989, 1990 and 1991 distributed on the main regions and countries exploiting the stocks of Baltic salmon.

The river catches are mainly taken in Finland and Sweden. In Finland the catches are due to a recreational fishery with gill nets and rod and line in the rivers and river mouths. In Sweden the majority of the salmon captured are utilized for breeding purposes, and are mainly procured by seining and trapping. Commercial seining occurs in a few rivers, but is exceptional.

The majority of the salmon entering the coastal fishery are fish migrating for spawning. The kinds of gear used along the shore of the Gulf of Bothnia are primarily commercially-operated pound nets. Set gill nets are chiefly used by non-commercial fishermen.

As the Baltic Main Basin is the main feeding area of all the Baltic salmon stocks except those from the rivers of the Gulf of Finland, the Main Basin is naturally also the most interesting region for the sea fishery. The offshore catches in the Main Basin make up in fact more than half the total yield of Baltic salmon. The sea fishery is carried out exclusively with drift nets and drifting longlines.

Drift nets are usually operated from September to November and from March to June, and are responsible for 70-85% of the total catches in the sea fishery. Longlines are mainly used in the winter interval. The number of gear used per boat is restricted by international convention to 600 net and 2000 longline hooks.

The average CPUE for the Danish, Finnish and former USSR fleets in the 1988/1989, 1989/1990 and 1990/1991 seasons is estimated to have been 14 salmon per 100 nets and 50 salmon per 1000 hooks.

In the Gulf of Bothnia the corresponding average values for the Finnish fishery amounted to 9 salmon per 100 nets and 33 salmon per 1000 hooks.

In the Gulf of Finland only longlines are operated offshore resulting in an average catch in the years in question of 15 salmon per 1000 hooks.

5 MANAGEMENT

5.1 *Fishery Regulations in the Rivers and River Mouths*

Already in the 11th and 12th centuries salmon fishing rights in the northernmost rivers were owned by the states of Sweden and Novkorod (Vilkuna, 1974).The fishermen were obliged to pay taxes for all fish caught in state-owned waters. During medieval times also the Catholic church collected taxes from the salmon fishery. Because of the substantial revenue from taxation, the states involved were highly interested in safeguarding their income by regulating the salmon fishery.

In Sweden, no fishing gear was allowed to extend further than one third of the river width from the banks. The middle section was known as the "King's Fishways".

As the trammel net fishery, known from the River Tornionjoki since the 16th century, was taxed by the state, a competing gill net fishery was later banned (Anon., 1898). In the same river, salmon weirs were prohibited in the river mouth in 1617 and their number was reduced from 83 to 69. Later the number was further restricted to 8 in accordance with a decision of the Fishermen's Union (Anon., 1898).

5.2 *The Historical Background to Sea Fishery Regulations*

The reason why the number of salmon entering the River Tornionjoki was decreasing was identified as the increasing coastal fishery in the river mouth (Anon., 1899). On the Finnish side of the river mouth the number of fishermen and gears was licensed by the state. On the Swedish side the riparian owners had the fishing rights since 1858, and the fishery consequently developed without any restrictions. At the end of the 19th century the number and size of the gears had increased and the construction of the gear was changed to improve efficiency.

During the last decades of the 19th century the number of salmon passing over the eight weirs in the lower reaches of the River Tornionjoki was decreasing, probably because of the increased river mouth fishery (Anon., 1899). Previously, when the fishery was not carried out so extensively, the early running salmon managed to enter the river during overflow, when the weirs were not in use. The most favourable spawning grounds were situated in the upper reaches of the river into which a decreasing number managed to ascend. This development and the effect on the salmon stocks was also observed in many other rivers. Up to the end of the previous century a redistribution of the catches was required. On account of the effective fishery in the lower reaches of the rivers, in the river mouths and in the sea, the fishermen upstream strongly demanded regulatory measures to be enforced in these areas.

Although the River Tornionjoki became the boundary between Sweden and Russian-occupied Finland in 1809 the fishery was continued as previously. In 1897 an agreement on the river fishery was established between Sweden and Finland with the following fishing rules for salmon (Anon. 1897):

> Closed period from 1 September to the disappearance of the ice cover in spring.
> Minimum size of salmon: 245 mm.
> Selling and buying of salmon during the closed period and of salmon below the minium size was not allowed.
> Spear fishing was not allowed.
> The fyke net fishery in the archipelago outside the river mouths was not allowed.
> Weirs should be removed by 25 September.

The salmon fishery rules in other rivers were almost the same as in the River Tornionjoki. In the Rivers Tornionjoki, Kemijoki, Kokemäenjoki and Kymijoki one third of the width of the rivers should be left free from all fishing gear. In several other rivers weirs were permitted to close the whole width of the river, but in those rivers the weirs had to be open every week from Saturday 6 pm to Sunday 6 pm, a rule based on old traditions. The existence of salmon in the totally barred rivers was based on the fact that the weirs could not be established before the spring flow had ceased (Sandman, 1897).

Where the state owned fishing rights, licenses for salmon fishing were originally given on the condition that taxes were paid. At the end of the 19th century only the most effective weirs were licensed.

The fishing regulations described from the Finnish rivers were similar also in the rivers in Sweden.

Nowadays, ascending salmon spawners in the rivers are protected by means of closed seasons. The duration and dates of closure vary from country to country and from river to river.

As a national restriction, Finland postponed the beginning of the coastal trap net fishery in the Gulf of Bothnia in 1986-1991 to allow spawners first entering the coastal fishery to migrate freely to the home rivers. Among these early running spawners was a larger share of wild-origin salmon than among the later running spawners. Sweden has accepted similar regulatory measures for 1993-1994 in the Swedish coastal fishery in the Gulf of Bothnia.

5.3 *Regulation of the Sea Fishery, International Measures*

As salmon originating in the northern Baltic rivers, where fishery regulations during the spawning run were enforced, were caught in the hook and net fishery in the southern Baltic, a need for an international agreement on the regulation of the salmon sea fishery was evident and first recommended by Malmgren (1884).

The decline of salmon stocks at the end of the 19th century and the establishment of the International Council for the Exploration of the Sea (ICES) in 1902 initiated international salmon research. Already in 1903 a Subcommittee within the ICES Baltic Sea Committee was formed to consider the salmon and sea trout problems.

In 1906 ICES was requested to consider if:

a) a size-limit for the catch and sale of marketable salmon and trout could be recommended.

b) breeding of salmon and trout in the rivers falling into the Baltic should be recommended to the fishery authorities of Finland, Russia, Prussia, Denmark and Sweden.

In 1912 a special group of representatives from the Baltic countries was formed to consider the reason for the decline of the stocks in the Baltic rivers and the possibilities of an improvement in the situation. For this purpose five rivers situated in Russia, Sweden, Denmark, Finland and Germany were chosen as subjects for observations and investigations (Henking, 1913).

At the ICES meeting in 1927 it was resolved that a meeting of the Transition Area Committee and the Baltic Area Committee should take place in order to discuss the scientific basis for practical measures to be taken regarding salmon. Several proposals for the protection of salmon and sea trout in the Baltic Sea were presented and an international size limit for salmon and sea trout in the Baltic Sea was recommended (Christensen and Johansson, 1975).

Järvi (1928) stated that salmon during the spawning run are seldom smaller than 50 cm (0.5 - 1 kg). He, therefore, supported a proposal for an international regulation to limit the minimum landing size of salmon in the Baltic Sea to 50 cm.

In 1933 a Sub-Committee of the ICES Salmon and Trout Committee recommended that the questions concerning the protection and improvement of salmon stocks in the Baltic should be treated in the Baltic Committee (Christensen and Johansson, 1975).

At the ICES meeting in 1945 the increase in the Baltic salmon stock and catches increased the interest in the Baltic salmon. At the same time, the natural propagation was menaced by the development of the hydro-electric projects going on in Finnish and Swedish Rivers. This also, in Sweden, led to the establishment of a Migratory Fish Committee (later to become "The Salmon Research Institute"). At the ICES meeting in 1946 a cooperation between this body and the Salmon and Trout Committee was proposed (Christensen and Johansson, 1975).

At the ICES meeting in 1953 a paper on the subject of the necessity to impose restrictions on the capture of salmon in the Baltic Sea was communicated. The suggestions, comprising a closed season, a minimum size for salmon and minimum mesh and hook sizes were approved by the Sub-Committee and adopted by the Consultative Committee.

After negotiations in 1953, 1954 and 1957 between the Governments of Denmark, the Federal Republic of Germany, Finland and Sweden, an international agreement was drafted in 1962. The agreement - "The Baltic Salmon Fisheries Convention of 1962" - was ratified by Denmark, the Federal Republic of Germany and Sweden in 1963 and came into force in 1966. The most important articles emphasize the following:

> The convention area included the whole Baltic Sea, to a line between the southern Danish Islands.
>
> The minimum mesh size of salmon drift nets of natural and synthetic fibres was 170 mm and 160 mm, respectively.

The minimum hook size (shortest distance between point and shaft) was 19 mm.

The minimum length of salmon was 60 cm.

The duty of a Permanent Commission, in which each Contracting Party was represented, was to establish contacts with scientists and research institutes in order to promote conservation and rational exploitation of the stock of Baltic salmon and to consider the expediency of changes in, and additions to, the convention (Christensen and Johansson, 1975).

At a Symposium held in Charlottenlund in Denmark in 1958 in connection with the Annual Meeting of ICES, proposals were made about the establishment of a standing committee on Baltic Salmon problems in order to promote cooperation in research and management of the Baltic salmon stock. The proposal was adopted as one of the recommendations of the Symposium and approved by the Salmon and Trout Committee and Council, and it reads as follows:

"That the Salmon and Trout Committee should establish a Working Group to consider the problems of salmon and sea trout in the Baltic".

In 1969, the Permanent Commission for the Baltic Salmon Fisheries Convention of 1962 agreed on a recommendation about closed seasons and the prohibition of pelagic trawling for salmon. In 1971 Poland also joined the Convention. Already in 1964 Finland enacted regulatory rules similar to the Articles of the Convention.

"The Baltic Sea Conference 1972" was held in Stockholm in 1972. The Conference stressed that strict protective measures were urgently required if the natural resource represented by salmon was not to be lost. The Conference agreed that each state should, therefore, restore, or by stocking compensate for, their former smolt production, establish new spawning areas by construction of fish ways, investigate the effect of different fishing methods, follow the fishery statistically and not allow too intensive a fishery. As the most urgent step the Conference agreed that all states should ratify the Baltic Salmon Fisheries Convention and, in addition, proposed closed seasons and provisions regarding details of gear mounting and the maximum number of gears per fishing vessel (Christensen and Johansson, 1975).

In 1976 the articles of the "Baltic Salmon Fisheries Convention of 1962" and recommendations of the Permanent Commission of this Convention were adopted by the "International Baltic Sea Fishery Commission" and included as Fishery Rule 14 of the Convention on Fishing and Conservation of the Living Resources in the Baltic Sea and the Belts" (Christensen and Larsson, 1979).

In 1978 the number of foreign boats was limited inside the Swedish fishing zone and also the amount of gear operated per boat, i.e. a maximum of 600 drift net and 2000 long line hooks. Also catch quotas for foreign vessels were introduced (Christensen and Larsson, 1979). In 1979 the same rule was accepted internationally (Anon., 1979).

Fishery Rule 14 of the International Baltic Sea Fishery Commission dealing with the salmon fishery in 1993 is as follows:

"Drifting nets and anchored floating nets for salmon fishery must have a minimum mesh-size of 165 mm when made of natural fibres and of 157 mm when made of synthetic fibres.

In fishing with drifting nets and anchored floating nets, no more than 600 nets per vessel may be used. The length of each net may not exceed 35 metres. Number of reserve nets kept on board are not allowed to exceed 100.

In fishing with drifting lines or anchored lines the number of hooks is restricted to 2000 hooks per vessel. A number of 200 reserve hooks may be kept on board. Hooks on drifting lines and fixed lines shall have a minimum distance between the point and the shaft (gap) of at least 19mm.

Salmon having a size less than 60 cm (measured from the tip of the snout to the tip of the tail fin) must not be kept on board. Furthermore, salmon smaller than 60 cm is not allowed to bring ashore, to offer, to keep for sale, to sell, to transfer in other way or to buy for re-sale.

The rules above shall not apply to fishery which takes place for scientific purpose of for management of the stock.

Summer closure of fishing with drifting and anchored floating nets is from 15 June to 15 September and with drifting lines and anchored lines from 1 April to 15 November. In the Gulf of Finland fishing with drifting lines and anchored lines is prohibited from 1 July to 15 September."

In 1989 the Baltic Salmon and Trout Assessment Working Group prepared a plan for conducting a drift net selection experiment to assess the effect of different mesh sizes in the salmon fishery on yield and stock size (Anon., 1989). The experiment carried out by Sweden in 1990 resulted in a recommendation of an increase of the mesh size in salmon drift nets (Karlsson and Eriksson, 1991). The recommendation was, however, not adopted by the Commission (Anon., 1991).

Since 1980 the Baltic Salmon and Trout Assessment Working Group and the ICES Advisory Committee on Fishery Management have annually recommended a TAC for the Baltic salmon fishery except for the year 1991, when alternatively a recommendation on technical regulatory measures was presented.

TACs for the salmon fishery in 1991, 1992 and 1993 (in 1993 expressed in number, not weight) were accepted by the Commission, but, as a consequence of problems with allocation of the recommended TACs between the contracting parties, they were not easily adopted for the preceding years. An *ad hoc* Working Group has been established by the Commission to consider equitable criteria for allocation of the TACs (Anon., 1992).

6 HATCHERY REARING AND STOCKINGS

The technique of artificial rearing by collecting eggs and milt of spawners was first developed in Germany in the late 18th century. From the middle of the 19th century, many rivers in the Baltic were stocked with eyed ova and/or newly-hatched fry. In the early years of the 20th century, also, one-summer-old parr were released. As the number of spawners and their offspring, at this time, were assumed to correspond to the carrying capacity of larger parr in the rivers, the stockings of these stages were of no, or very modest effect (Lindroth, 1974). During the last decade, the decline of spawners in rivers carrying natural stocks stimulated releases of parr in those rivers (Anon., 1992).

Rearing of salmon to the smolt stage was proposed in Sweden early in the present century (Nordqvist, 1917). The requirement for electric power after World War 2 emphasized the need for replacement of natural smolt production in the rivers with releases of reared smolts. According to the Swedish water course legislation, the lost production of migratory fish should be fully compensated by releases. With improved rearing techniques a successful smolt production was developed (Carlin, 1968), later to be followed by other countries. Today the production of reared young salmon amounts to almost five million smolts annually, i.e. about two thirds of the total production of salmon smolt at the beginning of this century (Figure 5). Combined with the decrease in natural smolt production, the reared component of Baltic salmon now constitutes more than 90% of the total production of salmon smolts in the Baltic area (Anon., 1992).

The releases have certainly maintained the salmon stocks, but this rather stable supply of salmon has also supported a heavy offshore fishery on the mixed stocks feeding in the Main Basin (Section 4.4). Combined with an effective coastal fishery on migrating adult salmon, the fishing pressure has resulted both in an insufficient number of spawners ascending rivers to maintain the natural production (Figure 11) and a lower age of spawners (Ackefors *et al.*, 1991; Anon., 1980-1992; Eriksson, unpubl.). From a genetic point of view, the loss of variation in age of spawners, combined with an almost static age of the released smolts, implies that the reproduction relies almost entirely on discrete generations (Jansson, pers comm).

Another threat to the maintenance of Baltic salmon is the development of net-pen rearing of salmonids for human consumption and the consequent spread of serious fish diseases. Furunculosis is now resident around the Island of Åland in the Archipelago Sea and in at least four Swedish salmon rivers, including two major rivers carrying natural stocks (Anon., 1992).

In contrast to the Swedish approach in which spawners are captured for supplying the hatcheries with eggs and milt (Ackefors *et al.*, 1991), the Finnish rearing programme is based on brood stocks kept in hatcheries (Ikonen, unpubl.). Since 1974 a so far unexplained increase in mortality rate of salmon alevins, connected to individual females, has been observed in Swedish hatcheries. The syndrome associated with this increase in mortality has been termed M-74. Up to the beginning of the 1990s, the increased mortality in the yolk sac stage could be compensated by improved rearing techniques and an increase in the number of eggs collected. However, in 1992, the hatching of salmon ova was so poor that a loss ranging from 60-95% occurred, compared with an earlier mortality of 10-30%. Some southern stocks of sea trout were affected by the same problems. Electrofishing surveys conducted in the autumn of 1992 in a number of rivers carrying natural salmon, indicate an almost complete absence of one-summer-old fry in some areas, in spite of a relatively large number of spawners in 1991 (Anon., 1993).

The research work carried out in Sweden so far indicates that a poisoning factor may be involved in the process. As the shorter-migrating sea trout stocks in the Gulf of Bothnia have not yet suffered the same disturbance, it seems likely that certain organic xenobiotics, i.e. PCB, PCN, DDT, accumulated by the females on the feeding grounds in the Baltic proper (Norrgren *et al.*, 1993), are the factors causing the trouble.

The situation implies that, if hatching does not improve in the near future, the Swedish production of reared smolts will also have to be based on reared brood stocks. The prospects for the naturally produced salmon stocks are then rather gloomy and the possibility of preserving these stocks will be highly dependent on very strict fishery regulations allowing a huge surplus of spawners to ascend the rivers.

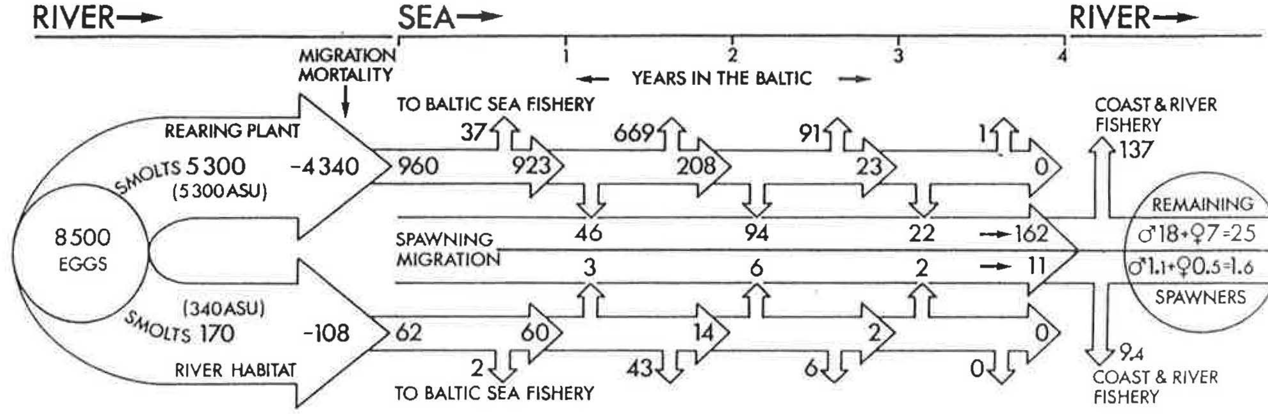

Figure 11. A model for the current exploitation of the Baltic stock illustrating the fate of the progeny from one average salmon (fecundity 8500) in a river (lower arm) and hatchery (upper arm) (Ackefors *et al.*, 1991).

7 REFERENCES

Ackefors, H., N. Johansson and B. Wahlberg. 1991. The Swedish compensatory programme for salmon in the Baltic - an action plan with biological and economical implications. ICES mar. Sci. Symp., 192:109-119.

Alm, G. 1934. Salmon in the Baltic precincts. Rapp. p.-v. Reun. Cons. int. Explor. Mer, 91:17-18.

Anon. 1897. Konventionen angående samfälldt brukande af laxfisket i Torneå elf. Fiskeritidskrift för Finland 9:143-151. Bøggild, H. 1983. Fiskerne på Bornholm. Rønne 1983

Anon. 1898. Tornionjoen lohikalastus (Salmon fishery in the River Tornionjoki). Suomen kalastuslehti 7; 156-162.

Anon. 1899. Tornionjoen lohikalastus (Salmon fishery in the River Tornionjoki) Suomen kalastuslehti 7,8,9:113-125.

Anon. 1979-1992. Proceedings of the sixth - eighteenth sessions in 1979 - 1992. International Baltic Sea Fishery Commission.

Anon,. 1980-1993. Report of the Salmon and Trout Assessment Working Group. ICES C.M.

Bonge, D. 1730. Salmonum Eorumque Apud Ostrobothniensis Piscatione. Diss. Upsala, Präs. L. Roberg.

Bøggild, H. 1983.Fiskerne på Bornholm. Rønne 1983.

Carlin, B. 1968. Salmon tagging experiments. Series of lectures. The Atlantic Salm. Ass. Montreal, Canada. (Swedish Salmon Res. Inst. Rep. 3/1969.)

Christensen, O. 1984. Danish salmon stockings experiments in two Swedish rivers. ICES C.M. 1984/-M:16, 6pp.

Christensen, O. and N. Johansson. 1975. Reference Report on Baltic Salmon. ICES Coop. Res. Rep., No.45.

Christensen, O. and P-O. Larsson. 1979. Review of Baltic Salmon Research. ICES, Coop. Res. Rep., No.89.

Davidsson, W.S., T.B. Birt and J.M. Green. 1989. A review of genetic variation in Atlantic salmon, *Salmo salar* L., and its importance for stock identification, enhancement programmes and aquaculture. J.Fish. Biol. 34(4):547-660.

Eriksson, C. 1985. Migration of Salmon Postsmolt (*Salmo salar* L.) through the Baltic Main Basin. Swedish Salmon Res. Inst. Rep. 4. 8pp.

Eriksson, C. 1989. Delayed release of salmon smolts (*Salmo salar* L.) of different ages at the coast of Gotland, Baltic Main Basin. Nordic J. Freshw. Res. 65:80-87.

Eriksson, C., S. Hallgren and S. Uppman. 1981. Lekvandring hos odlad lax (*Salmo salar*) utsatt som smolt i Ljusnan och dess mynningsområde. Swedish Salmon Res. Inst. 3. 16pp.

Folke, C. 1986. The Ecology of the Baltic Salmon (*Salmo salar*) and the compiling to the Economy. Contribution from the Askö Laboratory. University of Stockholm. Sweden. No. 29.

Forsell, F. 1947. Laxfiske med långrev. Fiskeritidsskrift för Finland, 54:37-40.

Gisler, N. 1752. Rön om Laxens natur och fiskande i de norrländska älfvarna. Kungl. Sv. Vet. Akad. Handl. 1751-52; 12, 13.

Henking, H. 1913. Die Lachsfrage im Ostseegebiet.I. Rapp.P.-v. Réun.Cons.int.Explor.Mer 16(6).

Ikonen, E. and H. Auvinen. 1984. Migration of salmon postsmolts in the Baltic Sea, based on Finnish tagging experiments. ICES, C.M.1984/M:4, 14pp.

Ikonen, E. and H. Auvinen, 1985. Migration of salmon postsmolts (*Salmo salar* L.) in the Baltic Sea. ICES, C.M.1985/M:5, 8pp.

Järvi, T.H. 1928. 3. Remarks as to the question of a size limit for the salmon in the Baltic. Rapp.P.-v. Réun. Cons.int.Explor.Mer 48:103-104.

Järvi, T.H. 1939. Om Bottenhavets laxar och laxfångst. Finlands Jakt och Fiskeritidskrift 34:204-210.

Kallio-Nyberg, I. and E. Ikonen. 1992. Migration pattern of two salmon stocks in the Baltic Sea. ICES J. mar. Sci., 49:191-198.

Karlsson, L. and C. Eriksson 1991. Experimental fishery with salmon drift nets of different mesh sizes in the Baltic in the autumn 1990. ICES C.M. 1991/M:13, 21pp.

Karlström, 0. 1989. Situationen för de naturliga laxälvarnas laxbestånd. Fiskeristyrelsen, Utredningskontoret, Sverige. Medd 5./1989.

Larsson, P-O. 1984 Growth of Baltic salmon in the sea. Ph. D of thesis, Univ. of Stockholm, Sweden. 80pp.

Larsson, P-O. and S. Ateshkar. 1979. Laxsmoltens vandring från Luleälven. Fiskeritidskrift för Finland 23(1) 8-9.

Lindroth, A. 1951. Salmon tagging experiments in Sundsvall Bay of the Baltic in 1950. Rep. Inst. Freshw. Res. Drottningholm. No 29.

Lindroth, A. 1961a. Sea food of Baltic smolts. ICES C.M.1961/No.8.

Lindroth, A. 1961b. On growth fluctuations in Baltic salmon releases in the Baltic. Vattenfall. Stockholm 1985.

Lindroth, A. 1965. The Baltic salmon stock. Its natural and artificial regulation. Mitt. Internat. Verein. Limnol., 13:163-192.

Lindroth, A. 1974. Appraisal of the artificial salmon reproduction in Sweden. Swedish Salmon Res. Inst. Rep. 6, 8pp.

Lindroth, A. 1977. The smolt migration in the River Mörrumsån (Sweden) 1963-1966. ICES C.M. 1977/M:8, 11pp.

Lindroth, A. 1985. The Swedish salmon smolt releases in the Baltic. Vattenfall. Stockholm 1985.

MacCrimmon. H.R. and B.L. Gots. 1979. World Distribution of Atlantic Salmon, *Salmo salar*. Journ. Fish. Res. Bd. Can. 36/4:422-457.

Malmgren, A.J. 1884. The Migration of the Salmon (*Salmo salar* L.) in the Baltic. Bulletin of the United States Fish Comm. 4:322-328.

Munthe, H. 1941. Om Nordens, främst Balticums senkvartäre utvikling ock stenåldersbebyggelse. K. Svenska Vetensk. Akad. Handl., 3 Serie 19(1).

Niemelä, J. 1924. Laxfiske med långrev vid Pitkäpaasi. Fiskeritidskrift för Finland. 9:113-114.

Nordqvist, O. 1917. Vattendragens överbyggande och fiskeriintressets tillvaratagande. Svenska Vkf. Publ. 90, 33pp.

Norrgren L., T. Andersson, P.-A. Bergqvist and I. Björklund. 1993. Studies of adult feral Baltic salmon (*Salmo salar*) and yolk-sac fry suffering from abnormal mortality. Env. Con. Tox. Accepted for publication.

Otterstrøm, A. 1904. Die Ostsee-Fischerei in Ihrer jetzigen Lage. Cons.int.Explor.Mer. Publ. d.Circ. No. 13A.

Rosen, N. 1946. Har vår lax kommit från två håll?. Svensk Fiskeritidskr. 55(7), 155.

Sandman, J.A. 1897. Joitakuita näkökohtia maamme lohikalastuksen vastaisen järjestelyn suhteen (Some observations about the arrangement of salmon fishery in the future). Suomen kalastuslehti 10,11:151-157.

Svärdson, G. 1945. Chromosome studies on Salmonidae. Rep. Inst. Freshw. Res. Drottningholm, 23(1):1-151.

Toivonen, J. 1973. The stock of salmon in the Gulf of Finland. ICES C.M.1973/M:17

Vilkuna, K. 1974. Lohi (Salmon). Keuruu, 424 pp.

Zahrtmann, H. 1890. Fiskerihavne på Bornholm. Fiskeritidende (Dansk Fiskeriforening) 13:97-101.

Table 1 Total catches of Baltic salmon in the river, coastal and sea fisheries distributed by main areas of the Baltic Sea. The figures are annual means over the years 1989, 1990 and 1991 (Anon., 1992).

	River catches	Coastal catches	Sea catches	Total
Gulf of Bothnia	91*	810	476	1377
Gulf of Finland	18	306	208	532
Baltic Main Basin	11	185	2803	2999
Total	120	1301	3487	4908

*) Main part brood stock fishery.

Table 2 Total catches of Baltic salmon in the river, coastal and sea fisheries distributed by country. The figures are annual means over the years 1989, 1990 and 1991 (Anon., 1992).

	River catches	Coastal catches	Sea catches	Total
Denmark	-	-	735	735
Finland	31	822	1054	1907
Germany	-	-	39	39
Poland	-	-	117	117
Sweden	89	333	865	1287
USSR*	-	146	678	824
Total	120	1301	3487	4908

*) In 1992 divided in Estonian, Latvian, Lithuanian and Russian catches.

DISCUSSION OF KEYNOTE ADDRESS AND REVIEW PAPERS

Dr John Anderson, Atlantic Salmon Federation, Canada, asked for clarification of what was meant by "environmental causes" of the mortality factor M-74.

Mr Curt Eriksson said that experiments in which fat from affected eggs had been injected into unaffected alevins had induced M-74 and that the cause therefore appeared to be some factor present in the eggs of affected females. He explained that the occurrence of M-74 also seemed to be linked to a change in the pattern of catches in the Baltic. Earlier most of the catches were taken in the Main Basin, which is more polluted, whereas now most of the fishery takes place in the Gulf of Bothnia. An explanation of the increase in M-74 could thus be that more fish from the polluted areas of the Main Basin are surviving to return to the northern rivers. In addition, when the fishery was mainly in the Main Basin, fish from the northern rivers were available as broodstock.

The Chairman asked Dr Friedland if the rather wide annual fluctuations in the exploitation of 1-sea-winter salmon belonging to Maine river stocks in the USA, which appeared to be almost cyclical in nature, was related to environmental factors or to changes in the fishing pattern.

Dr Friedland replied that there is no clear relationship between the total exploitation level on this group of stocks and other factors but that, when the effects of the West Greenland and Newfoundland/Labrador fisheries are partitioned out, the West Greenland time-series picks up the effect of the environmentally poor years in the early 1980s and the pattern is similar to that shown by all North American stocks as shown in the run-reconstruction model used by the ICES Working Group. The main features of the changes in this index stock reflected the changes in all stocks in this area.

Dr Wilfred Carter, Atlantic Salmon Federation, Canada, asked Mr Eriksson if he had understood correctly that the attempt to protect wild salmon stocks in the Baltic through hatchery programmes appeared to have been a failure largely because of environmental problems in the ocean that had caused high mortality in brood stocks.

Mr Eriksson replied that this depends what exactly is meant by "wild stocks". By keeping brood stocks it is possible to maintain the wild stocks but the natural production of wild stocks in the rivers might be lost.

Mr Kjartan Hoydal, Faroese Home Government, supported Mr Magnusson's ideas about sustainability, integration and the right of all users to the resource, but did not agree with the idea of salmon being held up as a "totem".

The Chairman queried how effective reared smolt production had been in the Baltic and quoted the estimate that a wild smolt was two and half times more effective in biological terms than a reared smolt.

Mr Eriksson compared the relatively low production of wild smolts in the Baltic (ca 500,000) with the five million produced by rearing. He further emphasised the point that the fishery could not have developed to its present size in the absence of smolt rearing, although the wild stocks might have been in better shape. He also pointed out the fact that the growth and survival rate of reared smolts has improved and that the differential quoted by the Chairman no longer pertains.

Dr Lars Hansen, Norwegian Institute for Nature Research, expressed his concern about the small number of wild runs in the Baltic and asked if he was correct in believing that these wild fish are so overexploited in the mixed stock fisheries in the marine environment that the only way of replenishing them is by the release of reared fish, even in those rivers that support wild stocks.

Mr Eriksson responded by saying that there has in fact been an enhancement programme in some rivers involving the release of fry and one-summer-old parr. To maintain wild salmon production, however, he said that it is necessary to reduce the fisheries in all areas.

Dr John Anderson made the point that hatchery-reared fish will inevitably mate with truly "wild" fish and that ultimately there will be no truly "wild" salmon left in any of the Swedish rivers. This is already the situation in Maine rivers in the USA and also in Canada. In response, Mr Eriksson pointed out that there are still some Swedish rivers in which very few reared fish have been released and which therefore probably still have truly wild populations.

COMPARISON OF THE SALMON SITUATION IN THE NORTH ATLANTIC AND THE BALTIC: DISCUSSION LED BY DR K. FRIEDLAND AND MR C.ERIKSSON

Curt: The development of stocks in the Baltic during the latter part of the 1980s and the early 1990s reveals somewhat contradictory patterns. While the few wild stocks seemed to benefit from the decrease in fishing pressure, the Finnish and Swedish reared stocks revealed a substantial difference in sea survival. This difference in survival of the reared stocks seems complex and is not easy to explain. In general, growth in the sea was the best since the second World War.

Kevin: Indications are that the survival of salmon has been extremely poor in recent years for both North American and European stocks. Many small or low productivity stocks are at critically low levels and one must wonder what their condition would be if the array of fishing restrictions enacted during the last decade had not come into force. The encouraging aspect of this recent trend is that it may be part of a cycle. We have seen the stocks in the North Atlantic go through periods of low productivity and rebound again. If environment is the driving factor, we must be vigilant of the role that global trends in environment, i.e. global warming, play in shaping salmon habitat and life history. However, we cannot ignore the effect of fishing since the relationship between stock and recruitment for stocks is not well understood.

Curt, is there a future for wild stocks of salmon in the Baltic?

Curt: Habitat destruction has taken the main toll of the wild salmon. Since the second World War, the fishery has been more and more based on reared salmon and this fishery has caused a decrease in the number of the few remaining wild stocks. Very recently, environmental disturbances might be the final blow to the possibility of saving natural production of salmon smolts. As a consequence, the Baltic salmon stocks might have to be maintained entirely by rearing of spawners.

Kevin: That appears to be a bleak prognosis. Is there a strategy in place to avoid the loss of wild stocks?

Curt: No, not yet. We have suggested a drastic change in exploitation, i.e. to harvest most of the salmon in the rivers or river mouths, but it has not yet been accepted. Besides that, some action to sample parr for rearing of brood stocks has been going on.

The North Atlantic is not without its stock extinctions. What are the present threats and what can be done?

Kevin: Disease, acidification and habitat destruction have all taken their toll on North Atlantic stocks. The greatest losses occurred during the Industrial Revolution, and in recent years regions have been subject to specific threats. The threat of stock loss has slowed, but it is still present and now mainly takes the form of genetic and disease concerns. The most important thing is a recognition by all user groups of the value of viable wild stocks. Growers have as much a stake in preserving wild stocks as fishermen.

Curt, who uses salmon in the Baltic?

Curt: In the Baltic, professional and semi-professional fishermen harvest most of the salmon. Low prices and fishery regulations have now reduced the offshore fishery, implying a shift towards coastal fisheries. Even though anglers show great interest in salmon, many rivers are nowadays not very fit for salmon angling. In recent years, trolling in coastal waters close to some rivers has proved to be a rather productive method of catching salmon on a rod.

Kevin: Atlantic salmon is mainly identified with angler user groups. The species still commands great admiration in sportsmen's circles. Though greatly diminished, commercial fisheries for mostly wild fish are still active, but they are greatly overshadowed by the production of farmed salmon. Wild salmon are also used by native peoples for ceremony and subsistence. A growing interest in the species is related to environmental concerns for river ecosystems. Many people who will probably never see or catch a salmon have an interest in ensuring the survival of the species.

Curt: I have always marvelled at the long oceanic migrations salmon make in the North Atlantic. Baltic salmon rarely leave the Baltic area. In that respect, the stocks can be regarded as "landlocked" in brackish water. The migration pattern is mainly directed to and within the feeding area in the Main Basin. Would you say this is the only major contrast between the two "races" of salmon?

Kevin: The basic aspects of North Atlantic salmon life history are similar to those of fish in the Baltic. But one cannot emphasize enough the importance of migration to both groups of fishes. Whether the migration brings them across a sea or an ocean, once the migration moves them from freshwater to estuarine and marine ecosystems, they cross significant management jurisdictions and they begin to complicate their, and our, lives.

Curt: The management of the Baltic salmon was for many years based on regulatory measures, for example number of gears per vessel and closed periods. No limits on the number of vessels have been enforced. Consequently the catches were based on the abundance of reared salmon. During the 1980s the Finnish rearing programme implied an increase in abundance, the total catch rose and an all time high catch was recorded for 1990. Since then a TAC has somewhat limited the catches. Low salmon prices and TACs, causing periodical cessation of the fishery, make the future of commercial salmon fishing rather uncertain.

Kevin: The playing board for managers has been continually changing during the last decade. The price and supply of salmon has changed due to the prolific production of salmon fish farms. The abundance of salmon available to fisheries has decreased. Angler user-groups have galvanized support for greater sport utilization of the resource. Buy-out schemes have evolved as a mechanism to reduce fishing mortality on the stocks. The future of commercial salmon fishing is uncertain.

PAPERS BY USER-GROUPS

MANAGEMENT CHALLENGES AND ECONOMIC INTERESTS OF RIPARIAN OWNERS IN NORWAY

by

Bjørnulf Kristiansen, Norwegian Farmers Union, Oslo, Norway.

Norway is a country with many small private properties. Most landowners are farmers.The fishing rights in Norwegian salmon rivers belong to the landowners.

Sportfishing for salmon and sea trout have always been very important as a supplementary income for the farmers along the best salmon rivers, particularly in Western and Central Norway. It has also been important to the local economy.

After a long period with strong political consensus behind the agricultural policy, a policy that has been based on subsidies to strengthen the local economy and to secure the future of people living in rural areas, the policy has swung towards more market orientation for agricultural products. The result will be reduced subsidies and more imports of food.

For more than twenty years, the farmers have been engaged in developing schemes to improve the management of their fish and wildlife resources through cooperation, both in order to increase their revenue to meet new demands from society, and to satisfy the demand for outdoor recreation from Norwegian society which enjoys fishing, hunting and other outdoor activities. It is also part of our strategy to adapt to sustained development in agriculture.

The new economic situation will make it necessary to look more closely at our salmon rivers as this resource is by far the most important economically.

The Norwegian Farmers Union, which represents the landowners, realises that the sportfishing organisations are somewhat reluctant to support this development since increased commercialisation may lead to higher prices for salmon fishing and create competition between Norwegians and foreign sportfishermen, who come to Norway to enjoy what is probably the best salmon fishing in Europe.

Today, the situation facing the wild Atlantic salmon in Norway is more serious than it has ever been. A number of factors have contributed to this deplorable situation: hydro-electric power development after the war combined with enhancement programmes to compensate for losses but which have led to genetic mixing of salmon populations and parasite infections (*Gyrodactylus salaris*, mainly); diseases and genetic mixing caused by escaped salmon from fish farming.

Aquaculture has developed without adequate controls.Between 12,000 and 13,000 persons are employed in aquaculture and related activities at the moment.This means that fish farming is a very important and positive factor in districts along the coast. Today, there are about 600 farm units and 228 smolt production units in operation. On the other hand we who represent the wild salmon interests will not accept a continued development of fish farming without a more responsible attitude from the business in preventing escapes and diseases. The situation has improved somewhat during the last couple of years. This development is more or less accidental, however, and can largely be attributed to the economic crisis and internal problems. Also, severe winter storms during the last two years provided an involuntary "removal" of fish farm units of questionable quality. We are willing to give the fish farmers a chance to prove their good intentions. More recently, illegal driftnetting of unknown dimensions along the coast has posed a new problem. Acid rain is also still a major threat.

The political struggle to end the commercial salt water fisheries for salmon along the coast took almost twenty years, even though it became evident that this fishery was threathening the future of Atlantic salmon. When political action was finally taken in 1986 it took another three years before the legislation took effect. For the river owners it was very dissappointing that they also had to accept severe restrictions in order to reduce the political impact caused by strong resistance from the commercial fishermen along the coast. As a user group with responsibility for the management of the spawning grounds they felt that their interests had been ignored to satisfy the commercial interests in the sea. This lack of courage on the part of former governments in taking a stand against the commercial interests at a much earlier stage is deplorable and very unfortunate.

The current reluctance of sportfishing interests to take part in a more active development of sportfishing, or to finance restoration of the salmon resource, is a problem for the riparian owners. We are very much aware of the sportfishing traditions in our country and of the political goals to provide fishing for all. It is a fact, however, that the salmon is in serious trouble in many rivers and the riparian owners are responsible for the future of salmon on their land. We cannot satisfy the needs of groups whose main interests are to secure low-priced fishing and reduce landowner influence in the management of salmon. The evidence that such a policy exists was clearly demonstrated in connection with the political initiatives taken when the new Norwegian salmon and freshwater fishery act was put into effect on 1 January 1993.

In the summer of 1992 a new organisation for the salmon rivers was established with the assistance of the farming and forestry organisations. At the moment about 50 of the most important salmon rivers have applied for membership in the new organisation, the name of which is NORSKE LAKSEELVER (Norwegian Salmon Rivers).

Together, the organisations have a strategy in common. First, we want to establish a basis for a more methodical organisation of the activities in the salmon rivers, particularly a stronger emphasis on the economic returns from sportfishing and on the creation of tourism. This will benefit both the landowners and the local communities. At the same time we want to increase the influence of landowners in the management of the resource by demonstrating the economic benefits of sportfishing and the dependence on cooperation with local interests.

The economic potential of sportfishing for salmon in Norway has been reported on by NASCO several times. I would like to provide some additional information: Norwegians spend 1 1/2 million days fishing for salmon and sea trout annually. The number of foreign sportfishermen is also considerable. In the River Namsen 62 % of the anglers in 1989 were foreigners. In connection with this river it was found that the anglers spent about 10 million kroner or about £1 million annually in the two communities Grong and Overhalla on hotels, food, etc in addition to paying for the fishing. An additional £150 000 was spent on boatmen. This adds up to a total of about 40 to 50 fulltime jobs in the two communities alone. Norwegian anglers spent about £55 and foreigners £82 in the two communities every day.

A central task will be to develop management plans for each river or river system. To accomplish this we will probably have to develop management models and hope to establish close cooperation with the salmon research facilities. We realise that future management plans will require a lot more basic information than has been put into the present plans. The production "goals" will have to be well within harvest safety margins, based on spawning capacity and taking into account the salmon as a species in the river ecosystems as well as ethical and aesthetic requirements.

The needs to restore the salmon in many rivers, to restore spawning grounds and to protect vegetation along the river banks are important; so is the need to regulate the removal of gravel and other activities detrimental to salmon production.

We demand changes in fish farming policy in order to prevent the massive escapes of domestic salmon which are a major threat to wild salmon management. Further efforts must be made to replace marine facilities with land-based fish farms. We still feel that improvements can be made on marine farms but the ultimate goal will be to establish land-based units.

Commercial salmon fishing in the sea is regarded as a thing of the past. However,our salmon management interests include a very small group of landowners with very old traditions in using purse seines. This fishery is very limited, but the operators maintain what I consider to be a cultural tradition which we want to preserve. The purse seiners have their own organisation, affiliated to the farmers union. This organisation will be invited to discuss participation in the management plans.The purse seiners may be very useful as part of an emergency task force which may be put into action to capture farm salmon when massive escapes occur.

In the current situation we would like to see more government activity in stopping other salmon fishing of unknown volume along our coasts. These fishermen use gear ranging from nets set for species other than salmon to trolling activities. As with the commercial fishermen, the government is reluctant to deal with the "leisure crowd". We demand more investigations into this fishery as we suspect that the annual catch is substantial.

To us the development of the salmon resource as a sportfishing activity goes further than just generating more money. The international emphasis on sustained development will require a new dimension in resource management. For the Norwegian farmer this means basing his or her living on the wise use of all resources on the farm and not just on the conventional production of food and timber.Hopefully, this will lead to a safer future for the Atlantic salmon and a better future for all.

During the NASCO meeting in Washington D.C. in 1992 it was disturbing to hear representatives from ICES indicate that they did not know why the salmon stocks in the North Atlantic are still declining. It is difficult to generate enthusiasm at grass roots level when the messages from the scientists are so discouraging.

We would also like to see more involvement of international management experts, both at the scientific and managerial levels, in order to provide new angles on the problems at hand. NASCO has concentrated a lot of its activities in international waters up till now. We would like to see more attention drawn towards coastal areas.

The Atlantic salmon is an international resource and consequently an international responsibility. This will certainly provide for very interesting discussions and actions by NASCO in the future.

HOPE RENEWED

A BETTER WAY TO MANAGE ATLANTIC SALMON

by

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SUMMARY

Because of its grass-roots support, and the administrative structure which allows it to speak on behalf of the Atlantic salmon angling/conservation community in North America, the Atlantic Salmon Federation has played a key role in persuading Government to take drastic actions to conserve, and rebuild, salmon stocks.

Governments have a new appreciation of the value of healthy stocks of Atlantic salmon. The $72.3 million spent to date in Canada to buy out the commercial salmon fisheries, and the more than $50 million spent in the US on fishways, are aimed at restoring salmon populations for which recreational fisheries are seen as the most socio-economically valuable use of the resource.

Increasingly, governments in Canada are turning to the public, in particular non-governmental organizations, for assistance in the management of natural resources. An example is the Atlantic Salmon Federation's contract to deliver an Education and Public Awareness programme in support of the recreational fisheries in Atlantic Canada. Another example is the larger Atlantic Sportfishery Enhancement Programme where strong emphasis is placed on the involvement of conservation-oriented organizations.

Several other management priorities are identified and discussed. They are:

- river specific management
- Reduction of negative impacts on habitats
- reduction of poaching
- research on sea survival
- cessation of remaining high-seas harvest of mixed stocks.

In 1948, a group of anglers concerned with the survival of the Atlantic salmon gathered in Montreal to found the Atlantic Salmon Association (ASA), a charitable organization in Canada. In 1982, ASA joined with another salmon conservation organization, the International Atlantic Salmon Foundation, which was formed in 1968 by U.S.-based salmon enthusiasts, to create an extremely powerful voice for the Atlantic salmon. That extremely powerful voice is the Atlantic Salmon Federation, with tax exempt status in both the United States and Canada.

Intent on increasing its advocacy effectiveness and centralizing conservation efforts, the Atlantic Salmon Federation (ASF) reached out to include numerous salmon conservation and angling associations that had evolved throughout eastern Canada and New England. A network was formed, which includes four national affiliates, seven regional councils and 131 river-based groups (Figure 1).

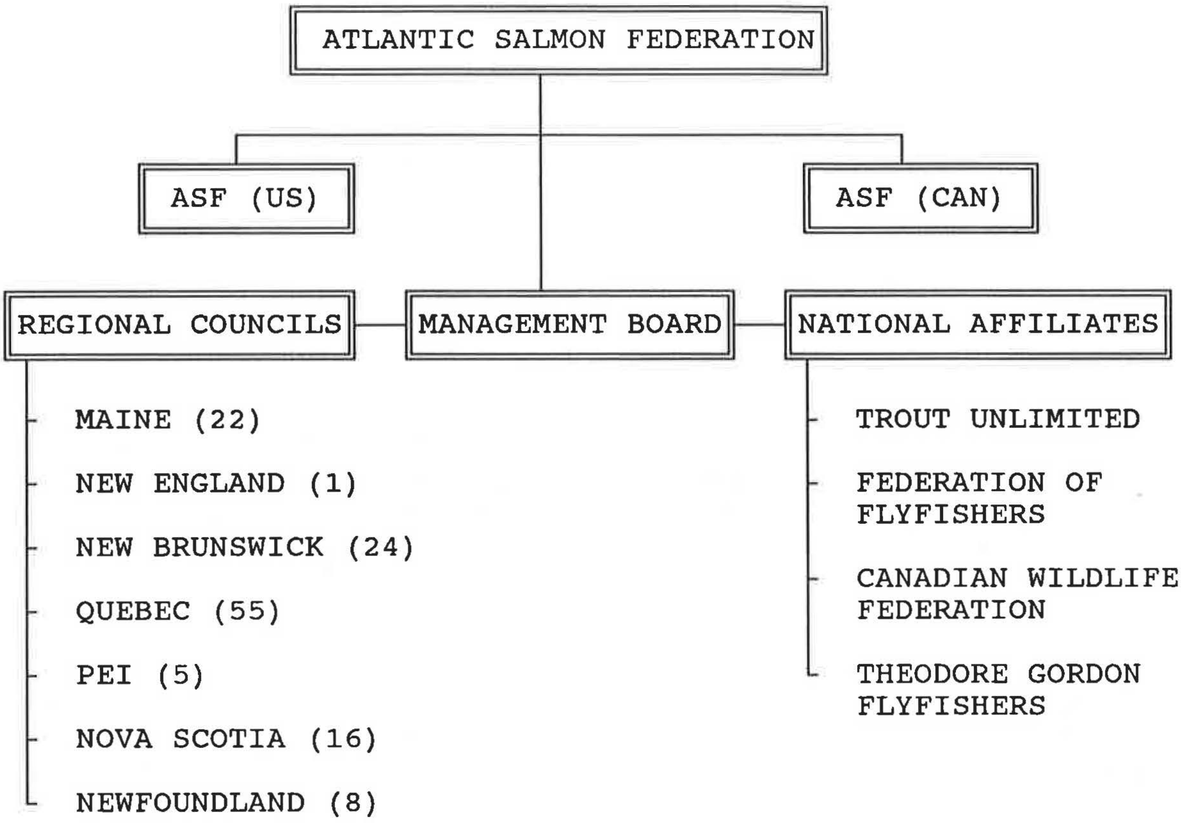

Figure 1. The Atlantic Salmon Federation (ASF) was formed by the merger of two pre-existing organizations, one with legal status in the US and the other with legal status in Canada. Both are now controlled by a common Management Board. ASF extended its coverage by creating 7 Regional Councils, each consisting of pre-existing conservation organizations (numbers given in brackets). Also associated with ASF are four national organizations called National Affiliates.

Under the federation's leadership, this arrangement has proven very effective in identifying management priorities, and in encouraging government to implement policy that promotes sustainable development of the Atlantic salmon resource.

The merger of two organizations to form ASF is of much more than parochial interest. While other organizations have played important roles, there is no question that ASF - the only organization capable of speaking on behalf of the Atlantic salmon angling/conservation community in North America - played a lead role in persuading governments to take drastic action to conserve, and start rebuilding, salmon stocks. There is power in unity.

ASF promoted the release of large salmon (63cm or more in length) as a conservation measure. With the exception of Québec, catch-and-release is now mandatory in all four Canadian Atlantic provinces, and the State of Maine.

But the most impressive change ASF has been a party to bringing about is a shift in attitude of the Canadian government concerning the importance of the commercial fishery versus the recreational fishery. The commercial fishery in Canada has historically had a powerful lobby, and Departments of Fisheries have seen their role as protecting its interests against recreational fishing interests, which were often seen as frivolous. Not any more! The salmon recreational fishery is now recognized as being several times more valuable than the commercial fishery. And it is now accepted that it has been the commercial fishery, which traditionally took 90% of the catch but only contributed about 10% of the value, that has been primarily responsible for the plight of salmon stocks.

In 1992, Canada imposed a five-year moratorium on the Newfoundland commercial fishery and a buy-back program on 2,979 Newfoundland and Labrador commercial licenses. By the deadline for selling the licenses, 31 December 1992, 91 percent of the commercial salmon fishermen of Newfoundland and Labrador had received payments totalling approximately $38 million. These recent actions were preceded by previous buy-outs in Newfoundland, Nova Scotia, New Brunswick, Prince Edward Island and Québec. Figure 2 (page 4) summarizes federal/provincial government initiatives in Canada taking commercial salmon nets out of the water. To date, of an initial 5,010 licences, all but 631 have been retired, at a cost of $72.3 million.

New England has also put dollars where its interest in restoring salmon stocks is. Here, a combination of commercial fishing, pollution, and hydro dams without fishways, so decimated stocks that commercial salmon fishing had its final death knell (in Maine) in 1947. But the salmon are coming back, from Connecticut to Maine. Since 1968, when restoration efforts began in earnest, $111 million (US) has been spent by State and Federal agencies, more than $50 million on fishways. Currently, about $1 million is spent annually.

On the high seas, private interests arranged in 1991 a three-year buy-out of the Faroes Island salmon fishery at a cost of $1.2 million U.S. Negotiations by the same group are now underway to buy out the Greenland fishery.

No example of the strength of the Federation's regional council structure is more poignant than the process that led to the buy-out of commercial licences in Newfoundland and Labrador. It was not easy to convince a province dependent on commercial fishing since its discovery in the fifteenth century that the jig was up as far as salmon were concerned. There were just too few salmon, especially the large breeders, which are targeted by the gill nets. ASF's regional council, the Salmonid Council of Newfoundland and Labrador, used many arguments in convincing governments of the need for a moratorium. Perhaps the most convincing to a province desperate for economic incentives was the fact that studies proved that a salmon caught in the sport fishery was worth about ten times more than a salmon caught in a commercial net. A carefully regulated sportfishery, with bag limits and promotion of hook and release fishing, is in the realm of sustainable development and could net the province a lot of money through tourism.

There is a growing trend to involving the public in the management of our natural resources. Government finances and personnel are stretched to the limit. The Canadian government is encouraging non-governmental organizations to identify the problems and be part of the solutions. The Department of Fisheries and Oceans and the Atlantic Canada Opportunities Agency recently embarked on a program to develop the recreational fishery in the Atlantic region. To get the most for its money, government is involving the private sector in improving the recreational fisheries resource base through enhancement, assessment, habitat improvement and co-operative enforcement.

The Atlantic Salmon Federation was engaged for a five-year period to promote public awareness of the importance of recreational fishery resources, challenge public apathy and change public attitudes. This program has been operating for a year, and has developed programs for educating school children and the public generally. Eight regional coordinators serving the Atlantic area are working with local communities, teachers and volunteers, helping them organize projects to educate young people, clean rivers and lakes, and restore aquatic habitat. One of the coordinators is devoted specifically to working with native bands to develop cooperative programs to conserve Atlantic salmon. ASF is encouraging harvesting by trap nets instead of gills nets to achieve the Minister of Fisheries and Oceans John Crosbie's goal of a grilse-only native food fishery. Natives are assisting government in assessment and enhancement programs, and ventures in support of recreational fishing, such as lodges, guiding and outfitting, are being promoted to benefit native communities economically.

Display systems, slide shows, public speaking engagements to community groups, travelling minstrels, a newsletter and the media are all avenues being utilized to reach the public. Curriculum and teachers' aid materials directed at grades 3 to 5 are being introduced into the schools, along with fish egg incubation systems which give children a first-hand look at the life cycle of Atlan-tic salmon and trout. This unique program is summarized in Figure 3.

Figure 2.	TAKING THE NETS OUT OF THE WATER		
PROVINCE	COMMERCIAL LICENSES		COST (MILLIONS)
	RETIRED	REMAINING	
Québec	261	147	3.7
New Brunswick	481	12	8.5
P.E.I.	4	1	0.5
Nova Scotia	172	43	2.8
Newfoundland	4,092	428	43.2
SUBTOTAL	5,010	631	58.7
Special Compensation Payments			13.6
TOTAL SPENT TO DATE			$72.3

EDUCATION AND PUBLIC AWARENESS PROGRAM
Director and 8 Regional Coordinators

YOUTH EDUCATION

- Teacher Workshops
- Classroom Incubation Units
- Travelling Minstrel
- Summer Conservation Camps Video

PUBLIC EDUCATION

- On The Rise (Newsletter)
- Displays
- Ads, Brochures,
- Partners in Conservation (Program re Aboriginals)

Figure 3. Summary of programs making up ASF's Education and Public Awareness Program (EPAP) in support of the recreational fisheries in Canada's four Atlantic Provinces.

ASF's educational program is part of a larger, Atlantic Sportsfishery Enhancement Program (ASEP) where the focus is on hands-on field work, with heavy reliance on conservation-oriented organizations for the identification of enhancement opportunities, translating them to programs, and playing an active role in their implementation. The total value of 5-year ASEP agreements signed to date for Newfoundland, Prince Edward Island, and New Brunswick is $39.2 million. Québec has a similar five-year program worth $24 million.

While reduction in commercial fishing effort, enhancement projects which aspire to maximum natural production and public awareness campaigns bring us closer to optimum returns, there are several management priorities which must be attained before our goal is reached. Among these are river specific management, reduction of negative impacts on habitat, elimination of poaching, improvement in sea survival of Atlantic salmon, and the cessation of the remaining high seas harvest of mixed stocks by gill and drift nets.

River Specific Management

River specific management enables recommendations relevant to season, quotas, allocations, access, enhancement action, level of surplus and harvesting techniques to be made while taking into account the health, spawning and rearing capabilities of the individual river. For making management decisions on specific rivers, new and more accurate data collection techniques are needed. Methods of counting and predicting returns and determining adequate spawning escapement levels and production capacity need re-assessment. And finally, management of a river can be better accomplished by representatives of the residents along the river, who have a vested interest in keeping it healthy, working cooperatively with a sympathetic and responsive government.

Negative Impacts on Habitat

The demand for electric power for industries and homes has had a devastating effect on salmon rivers since the days of the Industrial Revolution. The demand continues today despite the knowledge of what happens to healthy runs of fish when their spawning grounds are blocked off. Sometimes the power being generated is not needed for the consumption of the people living along the river, but for sale to another province or another country. Often the power is being produced on speculation that it will have a market in the future - a market which may never materialize. Many power companies have not bought into energy conservation, a move which would negate the need for construction of hydro electric facilities. Dams seriously deplete salmon runs by diverting water which contains spawning and nursery areas, causing siltation of habitat, limiting the salmon's ability to get upstream even with fish passes, and killing salmon smolts in turbine blades during migration downstream to the sea.

Communities along rivers must be authorized to ensure that their river is not contaminated by agricultural pesticides and fertilizers, clear cutting of forests, municipal wastes, and industrial pollution. Governments must ensure that environmental regulations and assessment procedures are strong enough to support communities in their clean up efforts. Governments must continue to support educational programs and conservation organizations that encourage environmentally friendly behaviour.

Reduction of poaching

Attitudes toward poaching are beginning to change. Behaviour that was once seen as traditional and even naughtily romantic in its ability to "put one over" on law enforcers is no longer acceptable. People are recognizing the fragility of our natural resources. Citizens involved in river watch programs are cooperating with enforcement agencies to monitor illegal activities along rivers. Government is increasing enforcement activities, and the courts are handing down stiff sentences to offenders. In November, a salmon poacher in Quebec received a fine of $24,500 and three months in prison. In New Brunswick, two men were fined $1,000 each for assisting a native woman who was netting salmon on the Miramichi River. In October, a Newfoundland angler was fined $5000 or two years in jail for possessing a salmon over 63 cm long. Three commercial fishermen who contravened fisheries management regulations were fined a total of $9000 for catching four salmon in a cod trap.

The Atlantic Salmon Federation conducted an anti-poaching campaign in newspapers throughout Atlantic Canada, warning the public that being in possession of an illegally-caught salmon could cost as much as half a million dollars. As it worked out, the fines did not get that high, but they were a lot higher than $350, which was the average for the 1991 season.

Research on Sea Survival of Atlantic Salmon

A step toward solving the puzzle of what happens to salmon at sea was taken at a major international symposium in St. Andrews in June 1992. More than 200 delegates from 14 countries gave general recognition to the imperative of research into the marine phase of the Atlantic salmon's life. There is a need for all salmon-producing countries to cooperate in research programs that look at the physical, chemical and biological elements that relate to each other, and to both salmon and their food supply.

To that end, 24 scientists and engineers from Scandinavia, Britain and Canada attended a workshop in December at the headquarters of the North Atlantic Salmon Conservation Organization in Edinburgh. Methods of tracking salmon in the high seas were explored. A follow-up meeting of Canadian scientists and the Department of National Defense took place in Halifax. As a result, a research project is being proposed for experimental testing in 1993 to see if submarine-detection sonabuoys can be retrofitted for practical use in tracking salmon containing acoustic tags.

No research into the salmon's survival at sea is complete without studying the health of its food supply. Determination of the prosperity of the species the salmon ats, such as krill, sandeels and capelin, and control of their exploitation is imperative if we are to be successful in saving the Atlantic salmon. The ability to track salmon will provide insight into its feeding habits and the whereabouts and abundance of its food supply.

If all goes well, by 1994, significant application of some of the technologies discussed so far will be used by a multinational research program in the North Sea.

Elimination of remaining high seas fisheries

The Committee for the Purchase of Open Seas Salmon Quotas led by Icelander and ASF director, Orri Vigfusson, is negotiating with the Organization of Hunters and Fishermen in Greenland for the purchase of the Greenland salmon quotas during 1993 and beyond.

The same Committee is urging the National Rivers Authority in England to eliminate the English drift net fishery in order to address serious declines in the Atlantic salmon runs of the United Kingdom, a move supported by the Atlantic Salmon Trust and the Atlantic Salmon Federation.

The Federation, as an observer to NASCO, strongly supports NASCO's efforts to encourage Panama and Poland to stop fishing salmon in international waters and adopt the Protocol Open for Signature by States not Parties to the Convention for the Conservation of Salmon in the North Atlantic Ocean.

The Atlantic Salmon Federation has called upon the Honorable John Crosbie, Minister of Fisheries and Oceans, to ensure that interception of salmon stocks does not occur in the French-controlled marine management zone adjacent to the islands of St. Pierre and Miquelon.

The Atlantic salmon's fate depends on the enlightened action of every country with which it comes in contact. A lot of headway has been made, and 1992 was an encouraging year for conservationists, but the future is still uncertain. The salmon's continued survival is a symbol of hope for the environment. Whether its fate is the same as the passenger pigeon, the dodo bird and the whooping crane is up to us. The key to healthy stocks lies in international environmental action, control of harvest, and cooperative multinational research efforts.

THE FISHERMAN - THE SALMON'S BEST FRIEND

by

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1. The fisherman or user takes a leading role in the protection and management of salmon stocks. The maintenance of economically viable salmon fisheries is of fundamental importance in safeguarding wild salmon stocks for the future.

2. Management of salmon fisheries is not commonly the responsibility of scientists. The fisherman often has the greatest opportunity to exert management influence but relies upon the advice of the scientists in doing so.

3. Scientific research should be directed in such a way as to have the prospect of tangible benefit from the user's point of view.

4. To allow effective management of salmon fisheries it is necessary to have legal powers to implement management decisions quickly, and there is a need for scientists to be more prepared to look forward and to predict the likely outcome of current events.

5. Advantage can be taken of payments presently made to restrict agricultural over-production under the EC Common Agricultural Policy to establish riparian buffer zones. In this way the capacity of rivers to support a population of juvenile salmonids can be enhanced.

6. Indiscriminate interceptory drift netting for salmon should cease.

7. International agreement should be reached and then be enforced to ensure that no uncontrolled fishing for salmon takes place on the high seas.

8. There is a need for greater research into the marine phase of the salmon's life cycle. Greater attention should be given to the interaction of salmon stocks with other species.

9. All possible steps must be taken to minimise the impact of salmon aquaculture, commensurate with the maintenance of an economically viable salmon farming industry.

10. User groups should have wider representation within the delegations to NASCO.

The declining number of salmon returning to home waters, evidenced by falling catch statistics, is a matter of grave concern to all who share an interest in the welfare of the Atlantic Salmon. Historically salmon stocks when measured by catches taken by anglers or netsmen have fluctuated both in abundance and run-timing but there is nothing to suggest from past records that stocks have been depleted to the extent that appears to have occurred over the last 20 years.

Celebrated for its determination to succeed in the face of adversity, the salmon is held in special affection not only by fishermen but by all who enjoy and appreciate nature. Adapted through evolution to have the best possible chance of sustaining its species the salmon has survived and still returns to rivers where environmental conditions may be far from ideal.

Throughout much of Europe the prodigious runs of salmon of the past have been lost, perhaps not for ever, by the actions of Man. Only where the quality of the natural environment has been preserved, and fishing effort has been regulated, have salmon survived and their ultimate survival will be assured only if their freshwater environment is safeguarded in future.

Maintenance of a stock of salmon or, more particularly, the return of salmon to rivers where they were once abundant is taken by many as being indicative of a healthy or improved natural environment.

The true wildness of the Atlantic Salmon is perhaps the reason for it being such a prized quarry but the fact that it forms part of a stock shared between many "users" explains why argument, jealousy and bitterness may so often surround the exploitation of this valuable resource.

Despite the fact that we live in a time of increasing interest in the natural environment the salmon still faces many threats that result from the degradation of its freshwater habitat. Radical changes in land use, particularly afforestation, have led to greatly increased siltation of spawning tributaries. Pollution and water abstraction for agricultural irrigation and for both domestic and industrial consumption have catastrophically damaged many salmon rivers. Now generation of power from renewable energy resources may also pose a threat to salmon stocks. In particular, run of river hydro-electric schemes and tidal barrages, whilst admirable in concept, may seriously impede the migration of adult salmon or cause substantial losses of juveniles.

In the protection of the salmon's freshwater environment the fisherman or "user" takes a leading role. Acting as watchdog and lobbyist he may often be the first to identify the need to take action to preserve salmon stocks. Furthermore, it is often the expenditure of the fishermen that provides funds for protection and enhancement of stocks.

In many countries, and certainly in Scotland, insufficient financial resources are available to adequately support the management of salmon fisheries. Substantial expenditure of public funds is directed towards scientific research and law enforcement both of which are essential if salmon stocks are to be maintained. It is highly unlikely that this expenditure would be made available if it were not for the very considerable contribution that salmon fisheries make to national tourist industries and to the generation of economic activity and of employment often in remote rural areas.

Accordingly, the maintenance of economically viable salmon fisheries is fundamental to the future survival of the wild Atlantic Salmon. No matter how responsibly others may harvest wild salmon or the lesser species upon which they prey, unless the freshwater habitat and the salmon themselves are protected in this phase of their life cycle their ultimate survival cannot be assured.

Recently in Scotland, following the very disappointing returns of fish derived from the smolt year classes of 1989 and 1990, valuable fishings have been unlet on some major rivers denying rental income to the proprietors. Whilst the exceptionally high levels of marine mortality that appear to have afflicted these year classes may not of themselves pose any threat to the survival of salmon stocks the loss of income to proprietors may restrict their ability to finance protection and enhancement of the stock at the very time when this funding is most urgently required.

To support economically viable fisheries requires returning runs of salmon to be far more abundant than are simply necessary to ensure the survival of the species or even that spawning stocks are sufficient for the river's natural juvenile carrying capacity to be achieved.

Currently in most rivers the number of early running salmon has declined with a large component of the stocks returning to their rivers of origin as grilse or summer salmon. Evidence suggests that this may be the result of a cycle driven by natural phenomena but this pattern of return migration reduces the value of fisheries.

Much excellent scientific research is directed towards increasing our knowledge and understanding of the salmon and its environmental requirements. From the user's point of view it is important that this research is targeted in a direction where there is ultimately a prospect of tangible benefit being derived from this investment. Put simply, the user aspires only to having more fish available to catch, preferably distributed more evenly throughout the permitted fishing season.

Management, or more often administration, of salmon fisheries is not commonly the responsibility of scientists. However, the advice of experienced scientists is essential if correct management decisions are to be taken. Effective management implies a capacity to react swiftly to situations that prevail or are predicted to occur but often this is not possible in relation to the management of salmon fisheries. In Scotland, for example, District Salmon Fishery Boards do not have the legal powers necessary to actively manage salmon stocks. Whilst mechanisms exist to introduce new byelaws and regulations the procedure for implementing these if often too slow to enable effective management action to be taken.

Just as legislative constraints may inhibit effective management so an understandable reluctance on the part of the scientist to offer an opinion until he is entirely satisfied that his case is proven beyond doubt frustrates attempts to manage fisheries. It would be very helpful to fisheries managers if there were to be a greater willingness on the part of experienced scientists to look forward and to predict the likely outcome of current events in such a way that management action can, where necessary, be taken early enough in time to be effective.

In practice it is often the "user" in the form of fishery proprietor or fisherman who has the greatest opportunity to exert direct management influence upon salmon stocks by means of limiting netting or angling pressure. Delayed opening of the netting season, adoption of a policy of fly fishing only or early closure of fisheries in the autumn can all, where appropriate, make a significant contribution towards improved management of salmon stocks. The practices of catch and release and limitation of catches are not commonly adopted in EC salmon fisheries but are policies followed by some proprietors.

The majority of EC salmon fisheries are privately owned. Recognising that management action may impinge upon an individual's property, fishery managers require far more factual information about the status of salmon stocks than is generally available to them at present. If managers are to successfully impose restrictions upon exploitation which may adversely affect the interests of fishery proprietors, at least in the short term, they must be able to convincingly justify the measures they wish to introduce. To this end development of fish counters, preferably of a design that does not require expensive civil engineering work to be carried out within rivers, must be given high priority.

Fishery proprietors often have an interest in land within their river's catchment. They appreciate the extent to which changes in land use may affect salmon fisheries. Much of the land in river catchments, however, may be owned and managed by parties having no interest in salmon fisheries. The move towards the concept of integrated catchment management is most welcome and should be encouraged. At a time of agricultural over-production a valuable opportunity is now given to encourage permanent set-aside of river banks and exclusion of grazing livestock. Massive expenditure is incurred each year under the EC Common Agricultural Policy to restrict agricultural production. If a small proportion of this expenditure were directed towards the establishment of well managed riparian "buffer zones" this could make a very valuable contribution towards the improvement of fisheries management.

To complement integrated catchment management, recognising that each river contains its own discrete stock or series of sub-stocks of salmon, there is a very strong argument to support management of salmon on a catchment-by-catchment basis also. Where possible exploitation of wild salmon stocks should be on an in-river or catchment basis and the current trend to curtail and buy off commercial netting in the sea should be encouraged, not least because the food requirement for salmon can be met from farmed sources. It must be recognised, however, that, where coastal net fisheries are subject to proprietorial rights, as in Scotland, the interests of those proprietors must be respected.

Indiscriminate interceptory salmon fisheries entirely contradict all currently held views upon sound fisheries management. Consequently the present attempt to close the Faroese and West Greenland fisheries is welcomed. Continuation of the English and Irish drift net fisheries, despite all the efforts that have been made to achieve closure, is highly unsatisfactory. It is disappointing that, whereas the Governments of the USA, Canada and Norway have contributed substantial funds to achieve the closure of interceptory fisheries, no such assistance has been forthcoming from UK public funds. NASCO is urged to take all possible steps to achieve the cessation of interceptory drift netting.

At a time when substantial sums of money are being directed towards the closure of the Faroese and West Greenland fisheries it is most unsatisfactory that some unregulated salmon fishing continues on the High Seas. Steps must be taken to reach international agreement that there shall be no fishing for salmon on the High Seas. Rigorous surveillance, undoubtedly available through new military intelligence technology, should be used to ensure that these Agreements are observed.

Much scientific research has been directed towards the freshwater phase of the salmon's life cycle and benefiting from this there is now a greater understanding of how managers might best concentrate their limited resources with a view to maximising juvenile recruitment which should be their primary objective.

Once smolts have emigrated to sea comparatively little is known about them but it is evident that salmon are subject to wide variations in the incidence of marine mortality over a period of years. High marine mortality and consequent poor runs of returning adults can have severe implications for the viability of fisheries, as referred to previously.

Despite the inevitable costs involved there is a pressing need for greater knowledge about the marine phase of the salmon's life cycle and in particular a clear understanding of the mechanisms that were responsible for the exceptionally poor survival of the 1989 and 1990 smolt year classes apparently widespread throughout the range of Atlantic Salmon. There is scope perhaps for greater attention to be given to the interaction of marine species upon each other and of the indirect effect upon salmon or other fish species of large scale industrial fisheries. There would be merit in encouraging dialogue between representatives of all scientific groups engaged in marine biological research and in a greater exchange of information between nations about the commercial catches of all marine species.

Just as salmon fishing makes a significant contribution to the welfare of remote rural communities so also does the salmon farming industry. Salmon aquaculture has expanded dramatically during the last 10 years but with this expansion has come the risk of great damage to wild salmon stocks. Experience in Norway and in the Baltic serves as a constant reminder that all possible steps must be taken to minimise the potential impact of salmon aquaculture upon wild fish stocks, commensurate with maintenance of an economically viable salmon farming industry. These measures should include the establishment of mandatory rules to ensure that no salmon are reared in sea cages within designated exclusion zones around river mouths.

The risks of transmission of disease or parasitic infestation from farmed to wild salmon stocks, or the prospect of loss of genetic integrity following cross-breeding of wild salmon with fish farm escapees are well known. From the point of view of the fisherman, however, there is the prospect of dilution of the real wildness of the Atlantic Salmon. Few sportsmen relish the thought of catching poor condition fish recently escaped from sea farm cages, but this has already occurred on a significant scale in some Scottish rivers. Equally, the salmon netsman has no wish to have fish of farmed origin forming a component of his catch. Of course the salmon farmer would prefer that his stock should not escape from sea cages but inevitably this occurs and more effective measures than presently exist should be made available to salmon farmers or to fishery managers to enable them to recapture caged reared salmon following large scale escapes.

User groups have much to contribute in relation to the management of salmon stocks. It is therefore regrettable that they should not form part of some of the Delegations to NASCO including that of the EC.

There is also the difficulty that within the EC Delegation representing several separate salmon-producing nations there cannot be debate in NASCO on any conflict of interest that may be between them.

In conclusion the perspective of the fisherman as user of the salmon resource cannot be separated from that of the manager as suggested in the framework for this Dialogue Meeting. In some EC countries, and in Scotland in particular, users and managers are one and the same. The advice given by the scientist is essential in making management decisions but above all it is the fisherman and the maintenance of economically viable salmon fisheries upon which the future of the salmon depends.

FISHING YIELD OF BALTIC SEA SALMON IN RELATION TO FISHING METHODS AND RESTOCKING

by

Mr. Birger Rasmussen, Chairman of Bornholm and Christiansø
Fishery Association and the Salmon Foundation, Denmark

INTRODUCTION

Bornholm is a small Danish island situated south of Sweden in the middle of the Baltic Sea and isolated from the rest of Denmark.

The inhabitants of the island number approximately 50,000 of which 20% are dependent indirectly or directly on fisheries, compared with the national average which is approximately 2%. In other words, Bornholm is the most fisheries-dependent area in Denmark.

More that 95% of the Danish salmon landings are made from the Main Basin in the Baltic Sea. All of these are caught by fishermen from Bornholm.

This year (1993) Danish fishermen are allowed to catch 165,690 salmon in Danish fisheries territories and Swedish areas.

HISTORIC BACKGROUND

- 1700: The fishing of salmon in the waters around Bornholm started. Only smaller boats such as dories took part in the fisheries.

1700 - 1867: Salmon were caught in stationary fishing gear, such as fixed hooks and fixed nets.

1867 - 1877: Deck-boats were introduced in the area, with great success.

1877: Local fishermen realized that it would be necessary to introduce regulations to protect the salmon, and proposed regulations on mesh size and the number of nets to be used. In addition, they proposed the introduction of a minimum length of 47 cm.

1907: The Danish authorities introduced a minimum length of 31.38 cm.

1947: The minimum length was changed to 37 cm, but not all States around the Baltic Sea could accept this. The fishermen on Bornholm raised demands for more protection of the salmon stock.

Drift-nets were introduced in the fisheries.

1954: The International Baltic Sea Fisheries Commission's working group on salmon became a reality, and new regulations were established.

1971: Fishermen on Bornholm established the Salmon Foundation.

SALMON FISHERIES TODAY

The fleet of local vessels has been improved, so almost all of the ships now in use are more than 20 tonnes and equipped with the most modern navigation and communications gear.

The fisheries for salmon today use both drift-nets and drift-hooks.

Drift-nets used in the Baltic Sea differ from those used in other areas because they lack the sink-line in the bottom. This means that the nets are no threat to sea-mammals and seabirds in the Baltic Sea. It has been observed that even rather small seabirds such as Guillemots are capable, when entangled, of lifting the net to the surface so that they can breathe until they are released by the fishermen.

The salmon fishery is primarily an offshore fishery, following the natural migration route of the River Mörrum salmon stock.

RESTOCKING/SEA-RANCHING:

Knowing that "using without contributing" is a bad policy, the fishermen on Bornholm in 1971 established the Salmon Foundation. The Salmon Foundation is based on volunteer payments from the local salmon fishermen, who pay 1 dkr. per kilo salmon landed. The purpose of the Foundation is to improve the Danish salmon fisheries by protection of the natural salmon stock, and by sea-ranching.

In cooperation with the Danish Institute for Fisheries and Marine Research, the Foundation has carried out restocking programmes in the Swedish River Mörrum and in the last three years by delayed release experiments.

Restocking:

Because of the lack of rivers large enough to carry salmon stocks on Bornholm, and the fact that most of the salmon caught by Danish fishermen come from the Swedish River Mörrum, the Foundation has primarily invested in restocking programmes in this river.

The restocking programme involved the release of approximately 70,000 smolts annually in the River Mörrum and in Pukaviken, a bay just outside the rivermouth.

Since 1971 approximately 1,500,000 smolts have been released in these areas, on behalf on the Salmon Foundation.

Delayed release

This method has been introduced to:

- establish a fishery on mature salmon on spawning migration in local waters around Bornholm.
- reduce the fishing rate on the mixed population in the Baltic Proper.
- reduce the distance to the fishing areas, and thereby reduce the costs of fuel etc.

The experiment started in 1990, in which year the Foundation invested in a sea-cage on the east side of Bornholm. The salmon used for the experiments were bought in Sweden (River Mörrum) as parr and transferred to Bornholm. After three months in the cage, all of the salmon had smoltified and were released on location.

During the time in the cage the mean weight of the salmon increased from 35 g in April to approximately 300 g in September, when they were released.

In 1991 and 1992 the experiments were continued, and at the present time there are 20,000 smolts in the cages.

Whether this programme of releases will have any influence on the fisheries is still unknown because it is too early to draw any conclusions from the recaptures.

RESULT OF THE SALMON FOUNDATIONS WORK

Year	Area	Recaptured %	Mean Weight (kg)
1986:	Mörrum	21.9	4.7
	Pukaviken	21.7	4.6
	Pukaviken DR	26.6	4.1
1987:	Mörrum	16.2	5.1
	Pukaviken	5.1	4.4
1988:6	Mörrum	20.2	7.0
	Pukaviken	27.8	7.5
	Pukaviken 2 yr.	40.4	5.3
1989:	Mörrum	9.1	5.9
	Pukaviken	1.8	8.9
	Pukaviken 2 yr.	28.8	7.4
1990:	Mörrum	4.5	5.8
	Pukaviken	4.3	5.4
	Bornholm DR	15.7	5.0

Using information from the ICES Baltic Salmon and Trout Assessment Working Group, a correction factor of 1.65 has been used to compensate for lost tags and those caught but not reported. The delayed release experiment on Bornholm shows a recapture rate in the first year of 25.9%. This is extremely high, because of an enormous mortality in connection with the tagging procedure.

The results from the experiments in 1991 and 1992 are not yet available.

FUTURE PLANS

- Continuation of the delayed release experiments, and upscaling if results are positive.
- Planting salmon ova out in the upper River Mörrum, where there is today no production because of the presence of the dam.
- Financing a fish bypass in the River Mörrum, so that it will be possible for the local salmon stock to enter a 6-7 km long good spawning area.
- Release smolts in Latvian waters against Salmon licenses in Latvian territories.

THE GREENLAND FISHERMEN'S PERSPECTIVE - SEEN FROM KNAPK

by

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Greenland Hunter's and Fishermen's Organization (KNAPK)
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During recent years the interest in salmon fishing has declined in Greenland, owing especially to the reduced number of salmon and to declining prices.

The decline in catches and in the level of salmon fishing activity has partly been due to the fact that the biologists have concluded that the number of salmon is declining and, in some ways, this conclusion is correct. But it is not realistic to conclude that the number of salmon will stabilize if only the Greenland salmon fishery stops. In drawing this conclusion we were thinking of rivers where the salmon spawn, as well as the seals and whales.

We are aware that the rivers in which salmon spawn are not kept as clean as before, and we will therefore not comment on this issue. However, we are able to judge that this does influence the balance in some ways.

The competing Whales

We would also like to make some comments regarding whales and seals.

In the western part of Greenland sandeels, which are a very important food resource for salmon, are also consumed in great quantities by the whales. During recent years, when whales have been protected, we have observed that the number of whales in Greenland has gradually increased. This increasing number of whales means that fishermen have problems keeping their equipment in order. And even if it may sound exaggerated, it should be mentioned that we have examples showing that the increasing number of whales is creating problems for people at sea in their boats, and we know that people have been in tremendously dangerous situations as a result of whales.

Therefore, we would briefly like to comment on the increasing number of whales, because the whales are - when you are talking about food resources - very serious competitors of the salmon. Sandeels - a very important food resource for salmon - at the same time happen to be an important food resource for the whales as well. When we think about the size of the whales, we can imagine the quantity of sandeels they are able to consume. The above mentioned competition for food resources must also be taken into consideration when talking about the reasons for the decreasing number of salmon.

Talking about whales, there are other factors you cannot pass by in silence. As an example, we can mention that in East Greenland a whale has been caught with 18 salmon in its stomach. This shows that whales are not only competitors for food resources, but they are also an important factor when we are talking about reasons for the decline in the number of salmon.

Salmon-eating Seals

Apart from whales as consumers of salmon, we have to mention the seals which are growing in great numbers. Like the whales, seals do a lot of damage to fishermen's equipment in Greenland. The seals not only destroy the fishermen's nets, but they have also learned to enter the fishermen's pound-nets in large numbers. This really causes trouble for the Greenland fishermen.

The seals create other kinds of trouble as well. We have to admit that the organizations for the preservation of different species of animals, including seals, have done good work. They have been so successful that the animals have grown in numbers to the extent that they eat everything up.

There is no doubt that the great number of seals also consumes a massive number of spawning salmon and no doubt the seals also consume a lot of pre-spawning salmon.

Organizations for the Preservation of Animals

I have mentioned above that whales and seals, apart from being competitors of salmon with regard to feeding, consume salmon in great numbers. The declining number of salmon greatly affects us whose existence depends on fishing and hunting at sea, and we feel daily how limited our fishing opportunities have become as a result of the efforts of the environmental organizations.

It is also obvious, when we are talking about salmon, whales and seals, that it is the same countries again and again which are trying to limit and disturb our possibilities for fishing salmon, for catching whales and for selling sealskin products to the outside world. These countries must learn to understand that changes among renewable resources are a consequence of both the fact that the animals are consuming each other and the fact that they are consumed by human beings. This kind of understanding is vital to us who exist on fishing and hunting.

The real facts are as follows:

The number of whales is increasing, and because the whales are consuming salmon, the number of salmon is decreasing in such a way that it really hurts the aboriginal populations in the area.

The number of sandeels is declining in the northern part of the Atlantic Ocean, and the number has declined so much that young puffins in the Faroe Islands are dying of starvation.

Campaigns to preserve seals are conducted in such a way that even the possibilities for selling sealskins to other countries are being ruined. Furthermore, seals are consuming pre-spawning salmon on a much larger scale than human beings can fish.

In short, there are now several countries where new overall considerations should be made on the issue of how we should be allowed to use the environment and the renewable resources.

DISCUSSION OF PAPERS BY USER-GROUPS

Admiral John MacKenzie, Atlantic Salmon Trust, Scotland, urged NASCO Delegates and UK administrators to allow Non-Governmental Organisations (NGOs) to participate in NASCO meetings. Secondly, he stressed that there is a growing body of opinion that considers that the EEC delegation to NASCO should include representatives of the user-groups. Thirdly, he argued that the probable extension of the European Community has major implications for the number of delegations on NASCO and that consideration needs to be given by NASCO to ensuring that the needs of salmon conservation and management are adequately represented.

Mr Jim Maxwell, Federation of Irish Salmon and Sea-Trout Anglers, endorsed the statement by Admiral MacKenzie with regard to the composition of the European Community delegation in NASCO and suggested that the salmon-producing countries in the EC should be made individually responsible for their action, and inaction, in relation to salmon management.

Mr Henrik Schmiegelow, Commission of the European Communities, replied to comments on the composition of the EC delegation to NASCO by saying that the Commission of the EC had taken note of the views of the NGOs present. He also assured participants that the European Community is well aware of its dependence on the knowledge, experience and commitment of the leaders of the NGOs connected to NASCO. The Commission also welcomes contacts from representatives of these organisations.

The Chairman asked Dr John Anderson how the education and publicity programmes about the Government buy-out of coastal netting had been received in the coastal fishing communities that have been affected.

Mr John Anderson replied that the purpose of the payments to buy out the commercial fishery had been to restore the stocks so that they can be of greater socioeconomic value in recreational fisheries. After one year, he said that the public awareness scheme had been highly successful, particularly in schools. He had also found that the scheme had provided an awareness of salmon conservation among the salmon interests.

Mr Frank Doyle, Irish Fishermen's Association, representing commercial fishermen, felt that there had been too much concentration on the anglers' point of view in the papers by user-groups. In response the Chairman pointed out that commercial fishing interests were to be given a fair hearing in papers later in the meeting.

Mr Michael Breathnach, Central Board of Fisheries, Ireland, asked if, in the face of declining salmon stocks, the simplest way of providing adequate fish would not be to have more hatcheries.

Dr John Anderson, in reply, stated that hatcheries had not helped in the case of the coho salmon in the Pacific; in fact they had been counter-productive. In the case of the Baltic, moreover, he concluded that the stocks of wild fish had decreased as more hatchery fish had been released. While accepting the role of hatcheries, they should be limited to providing eggs and first-feeding fry as the material for natural selection. It is therefore necessary to consider once again whether stock enhancement by release from hatcheries is wise, since it may have been having the opposite effect of that desired.

In response to Dr Anderson's remarks about hatcheries, Mr Robert Clerk reminded participants that hatcheries had been considered to be an effective means of restoring stocks in the past, for example after the UDN outbreak in the 1960s. Only in more recent years had the effectiveness of hatcheries been questioned, and the number had waned in the past 20 years. What he thought was important was to investigate how to use hatcheries to strengthen that component of the stock that is weak at the present time, ie the early-running or "spring" component. The state of salmon stocks is not well understood, however, and until more is known about hatcheries and there is a means of measuring the effect of hatcheries, he suggested that financial resources would be better spent on habitat improvement, allowing nature to take its own course.

Mr M. Jørgensen, Danish Anglers Federation welcomed the opportunity provided by the Dialogue Meeting for anglers to discuss salmon management with NASCO and with professional scientists. He stressed, nevertheless, that discussions had been going on for many years without achieving any concrete results. Citing a symposium about Baltic salmon held in Stockholm in 1987, he said that there had been agreement about the problems which were exactly the same then as were being discussed at the present meeting, yet very little action had been taken. Although scientists have been more aware of the problems since that symposium took place, there is still no resolution to the conflict between the commercial fishermen and the anglers. He finished by stating that protection of the fish must come first and that he welcomed the opportunity for anglers to influence those concerned with salmon management in both the Atlantic and the Baltic.

The Chairman emphasized the point made in Dr John Anderson's presentation that it is essential for European users, and particularly the angling sector, to become better organised if they are to achieve the successes already seen in Canada. There they have faced up to the difficult implications and attracted the support of the Canadian Government to commit financial resources on a scale unheard of in Europe, but which may nevertheless be required if the problems are to be solved. He also stressed the need for all user-groups to accept the principle of sharing of the resource and referred to the plea to NASCO to allow NGOs and user-groups to have an involvement in the management process.

Mr Pekka Niskanen, commenting on the paper by Mr Birger Rasmussen, said that, although reference had been made to the one and a half million smolts produced by Danish fishermen over a period of 20 years, the stocking that had really sustained the fisheries was from the Swedish and Finnish production of around 4 million smolts per year.

In response, Mr Rasmussen pointed out that the Danish releases differ from those made in Sweden and Finland in being financed by voluntary payments from the 170 salmon fishermen and not by state aid.

In connection with the discussion about the fishermen's fund set up on Bornholm, Mr Jim Maxwell asked whether fishermen from those nations still participating in drift-netting should not set up similar funds, whether they be drift-netsmen, estuary or in-river netsmen.

Mr Helgi Agustsson, Icelandic Ambassador to the United Kingdom, supplemented the comments made by Mr Heilmann and pointed out that whales in the Iceland area feed over a period of about 100 days per year and each whale, weighing anything up to 40-80 tonnes, takes 4% of its weight every day. About 50-70,000 whales thus require millions of tonnes of food per year.

In response to Dr John Anderson's suggestion that salmon management should only be carried out on a river basis, i.e. allowing only those fisheries where the river origin of the fish is known, Mr Kjartan Hoydal stated that this can be no basis for a dialogue with the offshore fishermen and many of the other users. In his view, it must be accepted that there are more users of the resource than the river anglers alone.

IS SCIENTIFICALLY-BASED MANAGEMENT OF SALMON POSSIBLE IN THE ATLANTIC AREA?

by

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INTRODUCTION

The introduction of management measures for salmon fisheries has invariably depended upon some understanding, however limited, of the biology of the fish. Laws dating back many hundreds of years reflect the early realisation that stocks would not survive if too many of the salmon moving upstream to spawn were caught (Mills, 1971), and the principles embodied in Scottish salmon fisheries laws as early as the 14th century clearly show that management was already based on a general understanding of the life cycle of the salmon (Williamson, 1991).

Since then scientists have made great advances in their understanding of salmon biology and ecology, but much salmon fishery management is still based on empirical principles; if catches are being maintained then levels of exploitation are generally thought to be satisfactory. This approach may not be adequate at a time when the production of some stocks is being restricted by both human and environmental pressures.

It is not the role of the scientist to manage stocks but rather to advise on management options and on the possible effects of different actions. Scientists have been providing such advice, both nationally and internationally for many years. This paper will seek to examine the problems of providing the more detailed advice required as pressures on the stocks increase. It will therefore begin by examining the objectives of fishery management before considering the specific problems of managing salmon. It will then outline the role that scientists can play both in formulating and operating a more comprehensive management strategy.

OBJECTIVES OF FISHERIES MANAGEMENT

Although it has long been recognised that fisheries need to be managed, clear objectives have often been elusive. This is because fisheries management encompasses a range of complex and conflicting biological, political, social and economic aims. None of these can be precisely stated, and differences of opinion about their relative importance abound. However, development of a rational management policy can only start from an understanding of its overall objectives.

At a general level, most people would accept that the overall aim of fisheries management is to make the best use of limited fish stocks, or at least to avoid making poor use of them. In marine fisheries, managers have often been cautious about trying to maximise fishery yields, tending instead to concentrate upon the maintenance of the *status quo*. Thus, for example, the goals of the European Community's Common Fisheries Policy (Anon., 1991) include increasing productivity and assuring availability of supplies but not optimisation of yields. However, implicit in these aims is the need to conserve and protect the fish stocks.

The Pacific salmon fisheries in North America are some of the most intensively managed fisheries in the world. Here, different management objectives have been defined for the fisheries in various regions (e.g. Sprout and Kadowaki, 1987; Minard and Meachum, 1987; Woodey, 1987). These objectives contain a number of themes, including:

- conservation of the resource;
- optimisation of spawning escapement;
- maximisation of economic and social benefits; and
- rehabilitation of depleted stocks.

A framework has also been agreed for the management of salmon in the Baltic, where the International Baltic Sea Fishery Commission has decided that the aim should be to 'safeguard wild salmon stocks'. In each case these objectives provide the framework within which more detailed management advice can be provided by scientists and other interested parties.

OBJECTIVES FOR THE MANAGEMENT OF ATLANTIC SALMON

Objectives such as those outlined above have not been agreed upon for the overall management of salmon stocks in the North Atlantic. Article 3 of the Convention of the North Atlantic Salmon Conservation Organisation (NASCO) states that 'the objective of the Organisation shall be to contribute through consultation and co-operation to the conservation, restoration, enhancement and rational management of salmon stocks' (NASCO, 1988). However, this provides relatively little guidance for the management of the fisheries.

In 1988, NASCO asked ICES to consider scientifically based approaches for managing salmon in the North Atlantic. The Working Group on North Atlantic Salmon (Anon., 1988) recognised the need for these to be based upon clear objectives and identified the following three principal aims:

- to conserve stocks;
- to optimise the total fishery yield from the stocks;
- to stabilise yields for individual fisheries.

These are similar to some of the objectives given for other salmon fisheries above, but none has yet been adopted by NASCO. Even if they are accepted in the future, they will need further clarification because the terms used are not clearly defined and may not be mutually compatible. For example, to some people, conservation means safeguarding stocks from the risk of extinction or setting safe biological limits for any exploitation. To others, it may mean trying to maintain spawning stocks at a level that will optimise recruitment (Anon., 1988). Neither definition can be regarded as incorrect, but management options will be significantly affected by the approach that is adopted.

Similarly, it may appear obvious that it would be desirable to maximise long-term yields, but there may be pressures to safeguard employment or maintain the *status quo* in the short term. There may also be differences in the value of salmon from different sources, perhaps because they provide fish at different times of year or because they supply different markets. In recreational fisheries, for example, it may not be the carcass value of the fish which is the best measure of yield but the incidental expenditure generated, while in other fisheries the social importance of the fishery may greatly outweigh the economic value.

The third objective, that of maintaining stability, is widely accepted as being beneficial, but as Shepherd (1990) says, 'none has told the fish what they are supposed to do'. Recruitment to most fish stocks varies enormously, and most of the variation is for reasons that are not understood and cannot therefore be predicted. The results of this instability are that scientists have to make annual assessments of how many fish can be caught; politicians have to renegotiate quotas; and fishermen have to accept large variations in annual landings and earnings.

PROBLEMS FOR SALMON STOCK ASSESSMENT

If scientists are to be able to advise managers on how to manage salmon stocks they need an understanding of the current state of the stocks and of how management might influence this in the future. For example, to provide the simplest advice on the risk of extinction they would need at least some relative idea of escapement levels. More detailed scientific advice may require greater knowledge of the numbers, growth, migration and mortality of the stocks.

Although regulation of salmon fisheries must pre-date the control of most marine fisheries by hundreds of years, the development of scientific approaches to the management of Atlantic salmon has lagged behind studies of marine species. This may be because the complexity of the salmon life cycle and stock structure presents particular problems for management science. Briefly these problems can be listed as follows:

- salmon exist as a very large number of discrete breeding populations (stocks);

- mixing between stocks is inadequate to safeguard them against over-exploitation;

- some stocks may be less resilient to exploitation than others because of differences in productivity, largely related to differences in their river environments;

- during the marine phase, salmon are widely dispersed and thus difficult to study;

- components of stocks may go to different areas of the sea (e.g. potential MSW fish to West Greenland) and be subject to different environmental conditions as well as different patterns of exploitation;

- marine fish are often exploited by the same fishery over a number of years which helps to build up a time series of the abundance of fish; this approach is not available for salmon;

- salmon are exploited in a series of gauntlet fisheries; the catch in one fishery will therefore be influenced by catches in preceding fisheries;

- salmon have to be exploited before they spawn, while marine fish may be given the chance to spawn at least once before being exploited.

There are, however, also some points on the positive side:

- recruitment to salmon stocks is generally less variable than for marine species;

- smolt production is limited by the holding capacity of the river for juveniles; parallels may therefore be drawn between rivers to allow prediction of optimal production levels;

- smolts and the returning spawners conveniently migrate through a relatively small bottleneck at the river mouth which can simplify the assessment of abundance.

SCIENTIFIC BASIS OF SALMON FISHERY MANAGEMENT

In considering the types of advice that scientists can provide for the management of salmon stocks, it will be helpful to develop the problem gradually, by first considering the constraints on managing a single stock with a single fishery and then expanding this to look at multiple and mixed stock fisheries.

Exploitation of a single stock by one fishery:

In the short term, increasing the effort in a fishery will normally result in an increase in the catch and a decrease in the spawning escapement. However, it has long been realised that the yield from fisheries obey the laws of diminishing returns (Pope, 1982). If twice as many vessels go fishing for a particular stock, the catch will not double; in fact, in the long term both the catch and the spawning escapement may decrease.

Figure 1 (line 'a') illustrates the general form of the relationship between total fishing effort and the sustainable yield from a fish population.

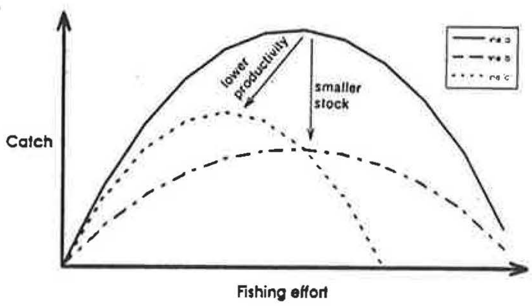

Figure 1. The relationship between long-term catch and fishing effort for (a) reference stock, (b) a smaller stock and (c) a stock with lower productivity.

This shows that there is a level of fishing effort that will maximise the sustainable yield from the fishery. With less effort, a smaller catch will be taken, but the stock should remain fairly healthy. If effort is increased, however, the spawning escapement will be reduced to below the optimal (target) level and subsequent recruitment will be affected; further increases in effort may even drive the stock to extinction.

Figure 1 also shows how the relationship between fishing effort and yield may be different for different salmon stocks. Line 'b' shows the yield curve for a second, smaller stock with a lower maximum recruitment level. The optimum yield from this stock will be less than for stock 'a' even though the effort required to take it may be the same.

The other parameter that will affect the yield curve is the proportion of the potential adult production (in the absence of fisheries) that must be left in order to provide sufficient spawning escapement for the stock just to survive. Chadwick (1982) has estimated that this value is about 11% for the salmon stock in the Western Arm Brook, a small Newfoundland river, but stocks under greater environmental pressures may have lower productivity. The effect of having a lower adult production per 1000 eggs deposited is shown by line 'c'; not only is the optimal yield reduced, but the levels of exploitation that will i) produce this yield, ii) reduce the escapement below optimal levels or iii) force the stock to extinction are also lowered.

The total fishery production will also be affected by the stage in the life cycle at which the exploitation occurs. As time passes some fish die but the remainder will grow. Because growth is thought to exceed natural mortality after salmon reach an exploitable size (after about 9 months in the sea), the maximum sustainable yield in tonnes will be increased by delaying exploitation until later in the marine phase. For example, the ICES Working Group have estimated that each tonne of European one-sea-winter salmon in the sea at West Greenland will produce 1.29 to 1.75 tonnes of multi-sea-winter fish returning to home waters (Anon., 1984); the equivalent values for North American fish are 1.47 to 2.00 t. However, as will be discussed further below, it may not be appropriate to discuss yields purely in terms of tonnage.

Exploitation of a single stock by more than one fishery:

The principles described above for exploitation by a single fishery may be developed to look at more than one fishery. We have seen that the sustainable yield of a salmon stock (by weight) will be maximised if exploitation is delayed until late in the life cycle. Thus, if the total stock is available to two fisheries operating sequentially the sustainable yield will be maximised when the effort in the first fishery is zero (Figure 2). If exploitation in the first fishery is too high, any additional exploitation by the second fishery may reduce the long-term yield.

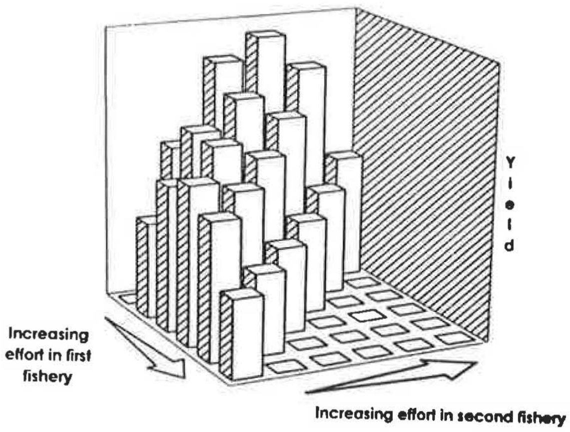

Figure 2. The relationship between sustainable yield and fishing effort in two sequential fisheries.

If only part of the stock (e.g. 30%) is available to the first fishery, however, the yield curve will change (Figure 3). The total sustainable yield is still optimised when effort in the first fishery is zero. However, the first fishery will not be able to take a large proportion of the total potential yield.

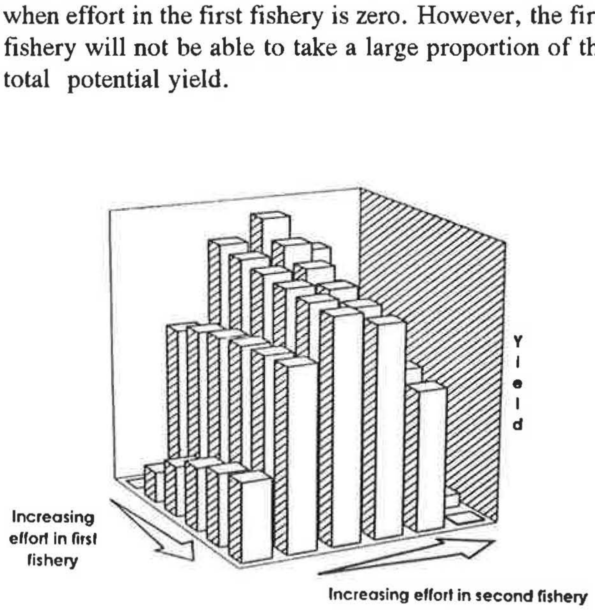

Figure 3. The relationship between sustainable yield and fishing effort in two sequential fisheries but with only 30% of the stock available to the first fishery.

In Figures 2 and 3, fishery yields are measured in weight. However, the economic and social value of catches may vary between the fisheries. This may result in the value of the fishery being optimised by a different pattern of exploitation to that which will give the optimal yield. These problems complicate the task of providing catch advice since the total recommended catch will depend upon what proportion will be taken in each fishery. However, catch advice can be provided in the form of a graph or formula showing the relationship between the allowable catch in two or more fisheries. Such advice has been provided by the Working Group on North Atlantic Salmon (Anon., 1993).

Fisheries exploiting mixed stocks

Exploiting a large number of stocks at the same time clearly complicates the assessment problems. However, it should not be assumed that there is anything fundamentally wrong with fisheries that exploit a mixture of stocks. If the salmon from different stocks were easily distinguishable (e.g. if they were different colours), then it would be relatively easy to assess the total catch of fish from each stock, wherever they were taken. In such a situation, mixed stock fisheries could be managed almost as easily as single stock fisheries. It would not be possible to exploit all stocks optimally in the mixed stock fisheries, of course, because the levels of exploitation on each would be affected by the relative proportions of each stock present. Also, stocks with different productivity characteristics cannot sustain the same levels of exploitation. However, such a fishery could in theory be managed to ensure that no stock (colour of salmon) was over-exploited; overall levels of exploitation could then be fine-tuned in secondary, discrete-stock fisheries.

The approach to managing such mixed stock fisheries, and thus the requirements for scientific advice, depend mainly upon the management objectives. If one of the objectives is to optimise the spawning escapement in all rivers, as is usually the case for Pacific salmon, then exploitation in the mixed stock fishery must be kept below safe biological limits for the most vulnerable stocks. These will be the stocks with the highest proportion of their extant numbers in the fishery area and with the lowest productivity rates; they will not necessarily be the smallest stocks. However, while sustaining the principles of management, such an approach would have significant effects on the secondary fisheries. The stocks that are most vulnerable to the mixed stock fishery will be able to sustain the lowest levels of additional exploitation in the discrete stock fisheries. In fact, some may not be able to sustain any additional exploitation without reducing spawning escapement below the target level.

If an alternative management approach was adopted based, for example, upon optimising yields from the largest stocks present, then the more vulnerable stocks would be over-exploited and the sustainable yields from these would be reduced. Similarly, if quotas were based on average stock characteristics, such as changes in the overall abundance of salmon in the fishery area, this would have the same effect. Clearly the management objectives adopted will affect the nature of the scientific advice required.

SCIENTIFIC MANAGEMENT OF ATLANTIC SALMON

In an ideal world it would not only be possible to distinguish the fish from each stock but also to forecast the abundance of each stock before the fish were recruited to the fishery and set catch limits on the basis of their distribution and target spawning requirements. Sadly, salmon from different rivers are not different colours; in fact, despite the best endeavours of the scientists the only population discrimination that has proved at all reliable has been that between North American and European fish (Reddin, 1986). Also, even if stocks could be identified, the costs of monitoring the production of even a modest number of rivers would be high.

For these reasons, much of the raw data for management will have to come from monitoring and marking fish from a limited number of 'indicator' stocks (Anon., 1988). These stocks will need to be representative of groups of stocks from rivers of a similar type or from the same geographic area. A number of 'monitored' rivers (Anon., 1990) are already used to provide much of the data currently employed in the assessments carried out by ICES (e.g. Anon., 1992b). Models have been developed to describe the exploitation of these stocks and their contribution to mixed stock fisheries. Some of the monitored rivers are thought to provide reasonably representative information for a larger number of stocks (e.g. the River Bush for Northern Ireland, Crozier and Kennedy, 1989), but for others there are severe doubts. Models have been developed to overcome some of the problems associated with data being only partly representative (e.g. Potter and Dunkley, in press), but such models may require extensive tagging and sampling programmes if results are to be at all precise. More indicator rivers are, therefore, likely to be required.

Estimates will also have to be made of the numbers of spawners required to optimise the production of smolts from monitored rivers. Such spawning targets have been set for many Atlantic salmon stocks in Canada using general data on the productivity of riverine and lacustrine habitats (Anon., 1992a). In the northeast Atlantic targets have only been set for the River Bush in Northern Ireland (Kennedy and Crozier, 1993), but the Working Group on North Atlantic Salmon (Anon., 1993) has recommended that the development of spawning targets should be a principal objective in the coming years. This will permit scientific assessments of the state of the stocks rather than the more qualitative assessments that have been provided hitherto.

Efforts are also being made to develop predictive models in order to be able to estimate pre-fishery abundance for these stocks. In this context, it is likely that useful lessons may be learnt from the management of Pacific salmon, where a variety of methods have been used including (e.g. Sprout and Kadowaki, 1987; Minard and Meachum, 1987; Woodey, 1987):

- spawning stock estimates;
- smolt counts;
- test fishing;
- catches in the commercial fisheries.

These approaches either attempt to forecast stock abundance from estimates or counts made earlier in the life cycle or to estimate the abundance through sampling close to the time of the fishery. Predictive models have advantages for fishery managers because they allow management actions to be decided well in advance rather than just before the fishery or even after it has begun. However, the earlier predictions may be less precise than estimates based upon sampling and may, therefore, require greater error margins to be taken into account.

In the Atlantic, attempts have also been made to forecast the abundance of two-sea-winter fish (the stock components most heavily exploited at West Greenland and Faroes) from returns of one-sea-winter fish to homewaters. Run-reconstruction modelling has suggested that this may be possible because the age at maturity is one of the more stable biological parameters in individual salmon stocks (Potter and Dunkley, in press). Although such approaches have not proved successful in Scottish studies (Anon., 1992a), in most rivers examined in northern Iceland, catches of two-sea-winter salmon in freshwater were highly correlated with the catches of grilse in the previous year (Scarnecchia *et al.*, 1989). Similar approaches have also been used on a number of rivers in Canada, and some of these incorporate data on sea temperature and mean fork length (Anon., 1993).

Environmental data are also being used in predictive models in the Baltic, where smolt survival has been shown to be related to sea surface temperatures around the time of emigration (Anon., 1992a). Work carried out by Friedland and Reddin (in press) suggests that similar factors may affect the pre-fishery abundance of Canadian salmon stocks, and they have also suggested that sea temperature may have an important effect on the abundance of European salmon stocks. Such approaches, if they can be developed and refined, may greatly improve our ability to predict the availability of fish before the fisheries begin.

In the absence of suitable indicator stocks, assessments must be based upon groups of stocks, such as those from a country or region. Currently much of the ICES advice on the West Greenland fishery is based upon North American stocks (e.g. Anon., 1992b). This is because the behaviour and distribution of these stocks and the information available on them allows particular types of models to be used which are not applicable to European stocks. This year, advice has been given on the estimated abundance of non-maturing one-sea-winter salmon of North American origin prior to the 1993 fishery at West Greenland (Anon., 1993). Two predictive methods were examined and alternative approaches proposed. On this basis catch advice has been provided for this component of the stocks contributing to the West Greenland fishery.

ASSESSMENT OF RISKS

As models improve and the time series of available data increase, the precision of the forecasts of stock abundance will improve. However, all assessments will have some degree of error around them, and this introduces a measure of risk into any management actions based upon them. The Working Group on North Atlantic Salmon has already begun to provide advice with associated risk boundaries (Anon., 1993). These currently address the uncertainty over the estimates of stock abundance, but future assessments may also need to take into account the variation in the vulnerability of stocks to the fisheries.

The confidence limits on the forecasts of stock abundance may be used to estimate the probability that a particular stock size will be achieved. This, therefore, provides a measure of the probability of reaching spawning escapement targets given alternative allocations among fisheries. Thus, if catch limits are based upon the mean forecast estimate, for example, there will be a 50% chance that the true abundance will be lower and that overall escapement targets will not be met.

We have seen above that basing advice on regional or national data will benefit some individual stocks but increase the risks to others because they will not all be equally resilient to exploitation. As more data are collected on the variability in productivity of different stocks, this could also be incorporated into the risk assessment. This may be particularly important if there are regional variations in productivity related to environmental differences.

Thus scientifically-based management of salmon is possible in the Atlantic area, but management strategies will have to take account of these risks. Managers will have to decide what levels of risk they can accept for individual stocks or groups of stocks. Scientific advice might also be developed on levels of risk that might be biologically acceptable based upon the natural resilience of stocks to periodic pressures.

SUMMARY

1. Salmon fishery regulations dating back several hundred years have been based upon understandings of the biology of the species. However, as stocks are put under increasing pressure from fisheries and environmental changes there is a greater need for a more detailed understanding of the biology and dynamics of salmon stocks.

2. Clear frameworks of management objectives have been agreed upon for the management of salmon stocks in the Baltic and Pacific but not in the North Atlantic.

3. Conservation is enshrined in the NASCO convention but is not clearly defined. Thus management attitudes to conservation and protection need to be clearly defined in the context of fisheries that exploit mixtures of stocks at different rates.

4. Atlantic salmon comprise a large number of separate breeding stocks which differ in their productivity and thus in their vulnerability to exploitation and other pressures.

5. It will not be possible to assess the status of every, or even a modest proportion of the salmon stocks in the North Atlantic. Both scientific assessments and management actions will thus have to be based on data from groups of stocks or a limited number of indicator stocks.

6. Such advice is already being provided by the ICES Working Group on North Atlantic Salmon and future work on salmon stock dynamics and the effects of the environment on growth, survival and maturation will allow advice to be progressively improved.

7. All assessments will have some degree of error around them, and this introduces a measure of risk into any management actions based upon them. If assessments have to be based on limited sampling, some stocks will be poorly represented in the samples. This will widen the confidence limits on the assessments, which will in turn increase the risks associated with the advice. As a result appropriate additional safeguards must be included in the implementation of the advice.

8. Scientifically-based management of salmon is possible in the Atlantic area, but there is an urgent need for management objectives to be agreed upon. This will provide the framework within which scientists can give the most appropriate advice.

REFERENCES

Anon. 1984. Report of meeting of the Working Group on North Atlantic Salmon. Aberdeen, 20 April - 4 May 1984. ICES, Doc. C.M.1984/Assess:16.

Anon. 1987. Report of the Working Group on North Atlantic Salmon. Copenhagen, 9-20 March, 1987. ICES Doc. C.M.1987/Assess:12.

Anon. 1988. Report of the Working Group on North Atlantic Salmon. Copenhagen, 21-31 March, 1988. ICES Doc. C.M.1988/Assess:16.

Anon. 1990. Report of the Working Group on North Atlantic Salmon. Copenhagen, 15-22 March, 1990. ICES, Doc. C.M.1990/Assess:11.

Anon. 1991. Report 1991 from the Commission to the Council and the European Parliament on the Common Fisheries Policy. Brussels, SEC(91) 2288.

Anon. 1992a. Report of the Workshop on Salmon Assessment Methodology. Dublin, 2-4 March, 1992. ICES, Doc. C.M.1992/M:8.

Anon. 1992b. Report of the Working Group on North Atlantic Salmon. Dublin, 5-12 March, 1992. ICES Doc. C.M.1992/Assess:15.

Anon, 1993. Report of the Working Group on North Atlantic Salmon. Copenhagen, 5-12 March, 1993. ICES, Doc. C.M.1993/Assess:10.

Chadwick, E.M.P. 1982. Stock-Recruitment relationship for Atlantic salmon (*Salmo salar*) in Newfoundland rivers. Can. J. Fish. Aquat. Sci. 39: 1496-1501.

Crozier, W.W. and Kennedy, G.J.A. 1989. The River Bush as an index river. ICES Working Group on North Atlantic Salmon. Working Document 1989/3, 17pp.

Friedland, K and Reddin, D.G. In press. Marine survival of Atlantic salmon from indices of post smolt growth and sea temperature. Proc. of the Fourth International Atlantic Salmon Symposium, 15-17 June 1992, St. Andrews, Canada.

Kennedy, G.J.A. and Crozier, W.W. 1993. Juvenile Atlantic salmon (*Salmo salar*) - Production and prediction. In: R.J.Gibson and R.E.Cutting (ed.) Production of juvenile Atlantic salmon, *Salmo salar*, in natural waters. Can. Spec. Publ. Fish. Aquat. Sci. 118:179-187.

Mills, D. 1971. Salmon and Trout: A resource, its ecology, conservation and management. Oliver and Boyd, Edinburgh. 351 pp.

Minard, R.E. and Meachum, C.P. 1987. Sockeye salmon (*Oncorhynchus nerka*) management in Bristol Bay, Alaska. In: H.D. Smith, L. Margolis, and C.C Wood (eds.) Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96:336-342.

NASCO. 1988. Handbook/Manuel, Basic texts/Textes Fondamentaux, North Atlantic Salmon Conservation Organisation (NASCO), Edinburgh. 136pp. (Eng.), (Fr.)

Pope, J.G. 1982. Background to scientific advice on fisheries management. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft (54), 26 pp.

Potter, E.C.E and Dunkley, D.A. In press. Evaluation of marine exploitation of salmon in Europe. Proc. of the Fourth International Atlantic Salmon Symposium, 15-17 June 1992, St. Andrews, Canada.

Reddin, D.G. 1986. Discrimination between Atlantic salmon (*Salmo salar* L.) of North American and European origin. J. Cons. int. Explor. Mer., 43: 50-58.

Scarnecchia, D.L., Isaksson, A. and White, S.E. 1989. New and revised catch forecasts for two-sea-winter Atlantic salmon (*Salmo salar*) in Icelandic rivers. J. Appl. Ichtyol., 5:101-110.

Shepherd, J.G. 1990. Stability and the objectives of fisheries management: the scientific background. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft (64): 16pp.

Sprout, P.E. and Kadowaki, R.K. 1987. Managing the Skeena River sockeye salmon (*Oncorhynchus nerka*) Fishery - the process and the problems. In H.D. Smith, L. Margolis, and C.C Wood (eds.). Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci., 96: 367-374.

Williamson, R. 1991. Salmon fisheries in Scotland. Atlantic Salmon Trust, Perth.

Woodey, J.C. 1987. In-season management of Fraser River sockeye salmon (*Oncorhynchus nerka*): meeting multiple objectives. In: H.D. Smith, L. Margolis, and C.C Wood (eds.) Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci., 96:385-395.

CAN WILD BALTIC SALMON BE DRIVEN TO EXTINCTION?

by

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Yes, it can.

1 INTRODUCTION

The International Baltic Sea Fishery Commission has decided that its aim in relation to salmon is "to safeguard wild salmon stocks". To achieve this goal, IBSFC decided to set Total Allowable Catches (TAC) for the years 1991 - 1993. The ICES produces part of the information needed in the negotiations. In the case of salmon, the uncertainties in all management options are very high. For example, due to the uncertainties in the predictions, the TAC can be too large or too small to ensure that enough spawners survive to enter the rivers. It is also difficult to predict the consequences of a change in the drift net mesh size. A larger mesh size would probably save some of the salmon in the open sea fishery (Karlsson and Eriksson, 1991). However, the increased biomass on the coast could result in increased fishing pressure in the trapnet fishery as a result of the fishermen's response to the higher catch per unit effort (CPUE). Thus, the state of the resource is not the only source of uncertainty for management.

It is easy to answer the question in the title of my paper. The answer is certainly "Yes". This conclusion can be see in many ICES Baltic salmon working group reports. However, this answer is probably insufficient and the users of the information (managers) want to know more. The next questions could be: "What is the probability of extinction? How much do we reduce the probability by deciding on a TAC of 640,000 salmon?" To those questions I might answer: "I believe that this probability is 0.4 for the next ten years. With a TAC of 640,000 fish in the TAC year 1993, you will reduce the probability by 0.08 compared to totally free fishing."

Even though these answers are important to the managers, it is probable that some scientists would give totally different kinds of answers. The problem is that no one will ever know the right answers to these questions because a possible collapse or survival of the wild stocks will not prove whether the probabilities were right or wrong. In this respect, these kinds of probabilities are always subjective. However, managers need these probabilities, and scientists have the best information. It is the duty of the scientists to answer such questions.

Classical statistics is not a very useful base for scientific advice in this kind of situation. The reason for this is simple: we can lose one wild salmon stock only once. Because the stock has not yet disappeared, we do not have the experience that could be studied by the methods of classical statistics to assess the probabilities of losing the stock. Therefore, experts have to assess subjectively a large part of the essential information needed in management.

Moreover, classical statistics is usually based on the use of expected values. The risk attitude of the managers should, however, be risk averse, and other parts of the probability distributions are therefore more important than the expected values. If the goal of management is "to safeguard wild salmon stocks", the managers should not allow a fifty-fifty chance of losing wild stocks.

The main idea of this paper is to show how the most important variables (the state of the wild stock, coastal and open sea catches) will change if different kinds of management options are used. Moreover, I have tried to look at the most crucial variables behind the management advice and to consider which variables are inadequately monitored. I hope that this paper will show that it is possible to have wild Baltic salmon stocks in the future, too.

2 GENERAL STATE OF THE WILD STOCKS - BACKGROUND OF THE ANALYSIS

A chart showing the most important areas referred to in this paper is given in Figure 1.

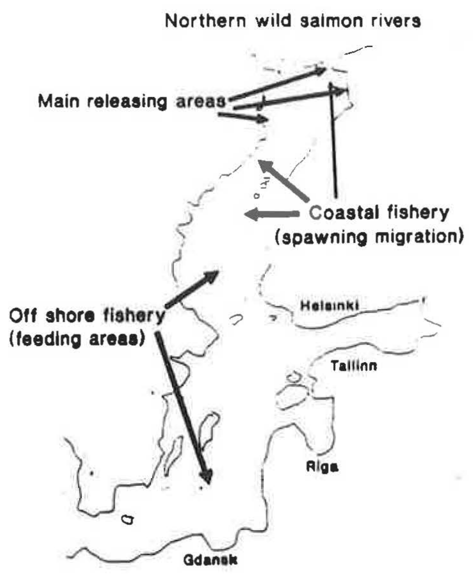

Figure 1. The Baltic Sea and the most important fishing and release areas of northern salmon stocks.

The share of the reared stock in the whole stock has increased remarkably during the last 10-20 years. In 1980, the recruitment of wild stock to the fishery was about 20% of the total recruitment, but in 1988-1989 it was only about 9% (Anon., 1992a, Tables 7.2.5.2.1 and 7.2.6.2.1). Around 35% of the wild recruitment comes from the northernmost rivers, which means that the mean production of these rivers is around 50,000 adult salmon (Anon., 1992a). For the southernmost rivers, the corresponding figure was 90,000 salmon. During the most recent years, recruitment to the reared stocks has been estimated to be around one million.

Lack of spawners is an obvious reason for the poor state of the northernmost stocks. However, the rivers of the Main Basin are not suffering from a lack of spawners (Anon., 1992a). The most probable reason for the large difference between the state of the northern and southern stocks is simply the shape of the Baltic Sea. The spawners from the northernmost rivers must swim through an intensive trapnet fishery along the coasts of the Bothnian Sea and Bothnian Bay, while the spawners of the Main Basin rivers can swim almost directly from the open sea to the rivers. This difference is important to keep in mind: northern wild stocks have to survive two intensive fisheries which have totally different kinds of dynamics. It has been estimated that the survival of the spawners swimming through the whole coastal fisheries of the Bothnian Sea and Bothnian Bay was around 8-9 % in the beginning of the 1980s (Kuikka, 1992). At this time, around 80% of the total stock (of northern origin) was already being fished in the open sea fishery of the Main Basin (Anon., 1992a, Table 5.6.4). Thus, the overall survival of the adults of these salmon stocks was around 1-2%. Assuming that survival from egg to smolt (Anon., 1993) is 2% and that post smolt survival is 40%, the survival of adult salmon should be 5% to reach a sustainable state for these stocks. This means that survival should be 2.5 times higher than it was in the beginning of the 1980s.

It must be kept in mind that the northernmost wild stocks are in the most critical state. These stocks must, therefore, be used as a yardstick when the allowable fishing mortality is defined. The monitoring of these stocks should be effective. The northernmost areas also happen to be very important releasing areas for reared salmon, and the fishing pressure on the returning adult salmon is therefore very intense in these areas (the CPUE values for trapnets remain at high levels owing to the reared stock).

3 METHODS OF ANALYSIS AND DATA

3.1 Data

The data used in this analysis are mainly derived from two different sources: the Report of the Baltic Salmon and Trout Working Group (Anon., 1992a) and Kuikka (1992). Migration patterns (homing migration) were estimated by a run-reconstruction model (described below) using data from Finnish tagging experiments. Since the main aim of this paper is briefly to describe the most important effects of different management alternatives details of the calculation procedures and data analysis are not explained.

3.2 Run-Reconstruction Model

A simple run-reconstruction spreadsheet model (e.g. Anon., 1992b; Anon., 1993) was used to estimate the effects of different management options. The model was a forward-calculating simulation model, but also a backward-calculating model was used to estimate the spawning migration patterns (maturation percentage per age group) of the stock and the fishing mortality values in the open sea fishery. Critical fishing mortality values in the coastal fisheries were based on the estimates made by Kuikka (1992). The results of the VPA analysis (Anon., 1992a) were also used in assessing the present fishing mortality values.

The main idea of a run-reconstruction model is to describe the whole life cycle of the salmon in order to assess the effects of areal management options. I divided the Baltic Sea into four different areas: open sea fishing in the Main Basin, open sea fishing in the Gulf of Bothnia, coastal fishing in the Bothnian Sea (Sub-division 30) and coastal fishing in the Bothnian Bay (Sub-division 31).

The aim of the modelling is to show what management measures are needed to safeguard the wild northern stocks which are in a more critical state than the southern ones. The model includes three "stocks": the wild stocks of the northernmost part of the Bothnian Bay, the reared stocks of the same area and the reared stocks released into the Bothnian Sea (River Neva stock). The wild and reared stocks of the Main Basin were not included in the model, since the wild stocks of the Main Basin can withstand such fishing pressure.

The most important life cycle parameters of the model are given in Table 1. These estimates (growth, migration pattern, mortality) seem to be quite variable. The reason for the variability is not totally understood. It is, therefore, impossible to predict the future values of these variables. In my analysis, I used the mean values of the last two-three years, and in cases where no estimate was available, the variables are just my subjective choices. A Monte Carlo simulation analysis (@ Risk software package, Palisade 1990) was carried out to study the overall uncertainty of the results. The assumed distribution and standard deviation figures are given in Table 1.

Table 1. Most important parameters used in simulations.

Parameter	Expected value of the parameter	Distribution	Standard deviation
Survival of the eggs and parr to smolts	2.0%	Lognormal	3.0
Total number of smolts released	4,500,000		
Fishing mortality of A1 in open sea fishing of the Main Basin (1/year)	0.25		
Fishing mortality of other age groups in the Main Basin (1/year)	0.6		
Fishing mortality in the coastal fishery in Sub-division 30 (1/year)	0.37	Lognormal	0.07[1]
Fishing mortality in the coastal fishery in Sub-division 31 (1/year)	1.7	Lognormal	0.34[1]
River fishing mortality (1/year)	0.5		
Post smolt survival of wild stocks	40%	Lognormal	8.0
Post smolt survival of reared stocks	20%		
A1 spawning migration percentage	10%		
A2 spawning migration percentage	40%		
A3 spawning migration percentage	75%		
A4 spawning migration percentage	100%		

[1]Coefficient of variation was assumed to be 0.2

3.3 Management Options

Three different options were used to describe the effects of changes in areal fishing mortalities:

a) The fishing mortalities in all areas were changed by the same percentage proportion. In practice, this means, for example, a combination of a restrictive TAC and technical management on the coast.

b) Only the fishing mortality in the open sea fishery is changed. This is actually the situation with one overall TAC (usually an annual TAC does not restrict the coastal fishery because coastal fishing takes place in the middle of the year).

c) Only the fishing mortality in the coastal fishery is changed. This represents a situation in which only technical management (fishing time restrictions) is used.

In each alternative, the present fishing mortality estimates describe a situation in which the TAC used is that adopted in 1991 and 1992 and the technical management is that used in 1986-1991 in Finland. Thus, fishing mortality of 100% (=unchanged fishing pressure) in these calculations does not describe a totally free fishing situation.

4 RESULTS

4.1 Changes in Areal Fishing Mortalities

The effects of the percentage changes in areal fishing mortalities are given in Tables 3, 4 and 5. These results describe the effects of different management options (management in all areas or only in one area) on some of the most important variables. Corresponding absolute values with present fishing mortalities are given in Table 2. If the fishing mortality is changed in the same proportion in every area (including river fishing), a percentage decrease of 35% is required to reach a sustainable stock for the northernmost wild salmon populations (compared to present fishing mortalities). With the present fishing pressure, the estimated decrease in wild smolt production is about 90% in ten years.

A reduction of 35% in the overall fishing mortality would lead to quite a large change in the wild river stocks and also in the so-called "surplus" stocks of reared salmon. This would mean a stock of almost 100,000 reared salmon entering into releasing rivers or releasing areas. This is around 15% of the total catch. These salmon could be utilized at the end of the spawning migration season when wild spawners have already entered the rivers. If the results in Tables 4 and 5 are compared, it can be seen that the percentage change in fishing mortality in the coastal fishery has a greater effect on smolt production than the same percentage change in the open sea fishery.

However, it is not profitable for an individual fisherman to reduce fishing effort if other fishermen do not do the same. A reduction in fishing effort should therefore be based on the actions of managers. It is very important that the fishermen are informed of these economic interactions and that these relationships are studied in detail to make management more acceptable to the fishermen.

Table 2. Values of some variables calculated by the present input values of the simulation model. These results describe the present situation (in Tables 3 - 5 this is equivalent to a fishing mortality of 100%)

Variable	Mean value with present fishing pressure
Open sea catch (numbers)	476,000
Open sea catch (tonnes)	1,790
Coast catch (no.)	227,000
Coast catch (tonnes)	1,010
Recruitment of wild population after 10 years (in numbers, present value = 125,000)	10,800
Mean weight	4.0
River stocks before fishing in rivers (reared & wild)[1]	30,000
Catch of reared stocks (tonnes)	2,800
Total catch	2,800

[1]This figure would be realized if all salmon were released into rivers. Otherwise, this stock is the so-called "terminal" stock in the releasing areas.

Table 3. Effects of a change in fishing mortality values in the whole fishery on catches, recruitment of northern wild populations, mean weights, river stocks, catch from the reared stock and total catch. Mean values of the present situation are given in Table 2.

		Percentage change in fishing mortality					
Variable		**+20%**	**+10%**	**-10%**	**-20%**	**-30%**	**-40%**
Open sea catch (numbers)	%	+10	+5	-6	-12	-19	-27
Open sea catch (t)	%	+5	+3	-4	-8	-13	-6[1]
Coast catch (no.)	%	-10	-5	+5	+9	+12	+14
Coast catch (t)	%	-14	-7	+7	+13	+20	+49[1]
Recruitment of wild population after 10 years (in no., present value=125,000)		2,700	5,400	21,000	43,000	86,000	173,000
Mean weight	%	-5	-3	+3	+5	+8	+11
River stock before fishing	%	-44	-25	+34	+81	+147	+344
Catch of reared stocks	%	-2	-1	0	0	-2	-5
Total catch	%	-2	-1	0	0	-1	+13[1]

[1]Catch increases due to higher recruitment of wild stocks.

Table 4. Effects of a change in fishing mortality values in the coastal fishery on catches, recruitment of northern wild populations, mean weights, river stocks, catch from the reared stock and total catch. In these calculations, it is assumed that all other fishing mortalities are the same as in the present management situation. Mean values of the present situation are given in Table 2.

		Percentage change in fishing mortality					
Variable		**+20%**	**+10%**	**-10%**	**-20%**	**-30%**	**-40%**
Open sea catch (numbers)	%	0	0	0	0	0	0
Open sea catch (t)	%	0	0	0	0	0	0
Coast catch (no.)	%	+6	+3	-4	-8	-14	-20
Coast catch (t)	%	+5	+3	-4	-8	-13	-19
Recruitment of wild population after 10 years (in no., present value=125,000)		5,000	7,000	16,000	24,000	36,000	55,000
Mean weight	%	0	0	0	0	0	0
River stock before fishing	%	-34	-19	+23	+51	+86	+129
Catch of reared stocks	%	+2	+1	-1	-3	-5	-7
Total catch	%	+2	+1	-1	-3	-5	-7

Table 5. Effects of a change in fishing mortality values in the open sea fishery on catches, recruitment of northern wild populations, mean weights, river stocks, catch from the reared stock and total catch. In these calculations, it is assumed that all other fishing mortalities are the same as in the present management situation. Mean values of the present situation are given in Table 2.

		Percentage change in fishing mortality					
Variable		**+20%**	**+10%**	**-10%**	**-20%**	**-30%**	**-40%**
Open sea catch (numbers)	%	+10	+5	-6	-12	-19	-27
Open sea catch (t)	%	+5	+3	-4	-8	-14	-20
Coast catch (no.)	%	-15	-8	-+9	+19	+29	+42
Coast catch (t)	%	-18	-10	+11	+23	+37	+52
Recruitment of wild population after 10 years (in no., present value=125,000)		7,400	8,900	13,000	16,000	19,000	23,000
Mean weight	%	-5	-3	+3	+5	+8	+11
River stock before fishing	%	-16	-8	+9	+19	+31	+44
Catch of reared stocks	%	-3	-2	+2	+3	+4	+6
Total catch	%	-3	-2	+2	+3	+4	+6

4.2 Environmental Changes

The results above are very sensitive to changes in egg and parr mortalities. These mortalities might change as a result of environmental changes in the rivers or changes in the condition of spawners (e.g. M-74 disease, see Christensen *et al.* (1993) and Anon. (1993)). This sensitivity was studied by changing the survival from egg to smolt (Table 6). Table 6 shows the reduction in fishing mortality required to prevent the collapse of the wild stocks and the corresponding long-term TAC figures, if fishing mortality is changed by the same proportion in each area.

With the highest survival values the catch in the coastal fishery decreases, because the open sea fishing can be so effective that it reduces the coastal catches. It must be kept in mind that these TAC figures should be used only for those parts of the fishery (time & place) where wild and reared stocks are mixed.

4.3 Risk Analysis

Figure 2 shows the simulated probability distribution of smolt production when the fishing mortality is reduced by 35% in each area and only the uncertainty in the post-smolt survival is taken into account. Figure 3 shows the uncertainty caused by the assumed uncertainty of egg and fry mortality (from egg to smolt). The mean egg mortality is 2.0% (Anon., 1993) and the standard deviation is 0.4, which is actually quite an optimistic assumption. This uncertainty is such a crucial part of the overall uncertainty that other sources of uncertainty are insignificant. Using a reduction of fishing mortality of 35% in all fisheries there is still a probability of 0.7 that this management action will not be sufficiently effective. With a probability of 0.35 the smolt production will be between 50,000 and 150,000, while the present production is 125,000 (Figure 3).

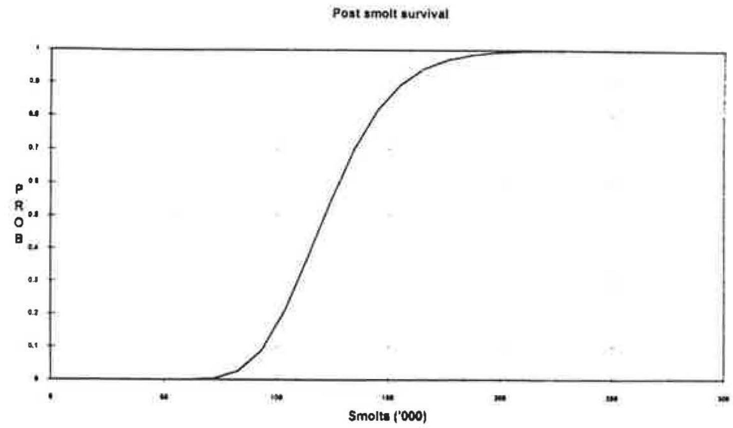

Figure 2 Cumulative probability distribution of wild smolt production if fishing mortality is reduced by 35% in every fishing area and post smolt survival has the distribution given in Table 1. Sustainable production (present state) is 125,000 smolts.

Table 6. Effect of the survival from egg to smolt on the percentage reduction in fishing mortality required to reach a sustainable parent stock level. Corresponding catches are calculated by the reduced fishing mortality values.

Survival of the eggs to smolts (%)	Reduction in F(%) required	Catch in open sea fishery ('000)	Catch in coastal fishery ('000)
0.2	99.5	2	4
0.5	74	180	206
1.0	55	280	260
1.5	43	330	260
2.0[1]	**35**	**360**	**260**
2.5	28	385	250
3.0	24	400	250
3.5	20	420	245
4.0	16	430	240

[1]This value was used as an assumption for the present situation.

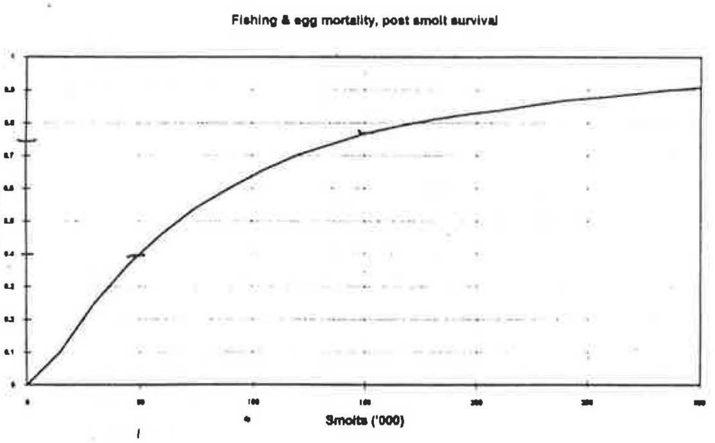

Figure 3 Cumulative probability distribution of wild smolt production if fishing mortality is reduced by 35% in every fishing area and the survival from egg to smolt, fishing mortality in the coastal fishery and post smolt survival have the values and distributions given in Table 1. Sustainable production (present state) is 125,000 smolts.

5 DISCUSSION

Even though the above results are very uncertain (see simulation results), they indicate that large overall changes in fishing effort must be made to keep wild populations at sustainable levels. Observed changes in the wild smolt production of the northernmost wild populations to some extent support the decrease predicted by the model (90% in 10 years). In Anon. (1975), the total production in the River Tornionjoki was estimated to be 325,000 smolts per year in 1975, while the estimates at the end of the 1980s were around 75,000 (Anon., 1992a). In the River Simojoki, the figures were 45,000 and 2,000 respectively. Thus, both the observations and the results from this model support the conclusion that northern wild salmon populations will be driven to extinction if very effective management is not established.

Even though a 35% reduction in fishing mortality would lead to an increasing trend in the recruitment of the northern wild populations, this change would be very slow, and this result is quite uncertain owing to environmental changes (egg and parr survival, post-smolt survival). With a reduction of 35%, there is still a high risk (around 70%) of losing the northern wild stocks. If the aim is really "to safeguard wild salmon stocks", the attitude of the management should be risk averse. This means that fishing mortality should be reduced by even more than 35%.

It should be noted that a reduction of 35% in fishing effort by all fishing methods probably does not lead to a reduction of 35% in fishing mortality because the catchability of the trapnets seems to be much higher in the northern part of the Gulf of Bothnia than in the south (Kuikka, 1992). If fishing pressure near the river mouths is not managed properly, fishing mortality of the wild stocks does not decrease sufficiently. It is also possible that the fishing mortality in the open sea fishery does not have a linear relationship with fishing effort. Studies concerning these relationships should be carried out to show what such changes mean in practice.

Compared to open sea management, management of the coastal fishery in the Gulf of Bothnia is more effective. This is only to be expected, because salmon surviving the coastal fishery enter the river directly, while the salmon leaving the open sea fishing areas must still survive the coastal fishery. The coastal fishery is very effective, especially in the northernmost area of the Gulf of Bothnia. The fishing mortality of spawning migrants in this area has been estimated to be about 85% during those years when fishing was managed by time restrictions. However, Table 4 shows that even a decrease of 40% in the coastal fishing mortality would not be sufficient to achievesustainability. The decrease required should be 60%, which would lead to a total catch 40% lower in coastal fishery than in the present situation. Since such large changes are very difficult to carry out, it is important that fishing mortality is reduced in every fishing area.

Simulation results (Table 5) suggest that even reared salmon stocks are economically overfished in the open sea fishery. A 30% reduction in fishing mortality would only lead to a reduction of 20% in open sea catches, even though the migration to the north (= escape from the open sea fishery) is taken into account. If the price elasticity of salmon is also taken into account (prices go up when catches go down), these results suggest that the overall economic returns from the fishery would be higher with a lower fishing pressure. Monthly CPUE values in the open sea fishery (Anon., 1992a, Table 5.8.2) suggest that the fishing pressure has usually been so high that the biomass decreases to half its original level in three or four months.

The economic returns from the coastal fishery would not change very dramatically either because the total catch would be higher. A shorter fishing season and higher total catch would lead to a decline in prices, but this change would have to be more than 15% to reduce the value of the total catch. If the salmon catches could be processed by the industry so that the peak in the markets for fresh salmon were lower, the decrease in the price level would not be as dramatic as in the absence of any processing industry.

It is important to note that the management of the coastal fishery must be very effective. This means that Finland and Sweden have a great responsibility for the future of the stocks. However, these countries cannot alone carry out effective management. If the open sea fishery pressure is not reduced, the management arrangements required (i.e. almost total closure of the fisheries) cannot be carried out.

The estimated reductions in fishing mortalities required strongly depend on the assumption of egg survival (Table 6). These results underline the need to monitor egg mortalities and parr and smolt densities in the rivers. If the only way to monitor the state of the wild stocks is to follow the size of the returning parent stock, this information might come too late to be used in managing the fishery. If the monitoring system for parr and smolt densities is effective, the first indications of poor wild year classes can be obtained 4-5 years before these year classes form an essential part of the parent stock.

Risk analysis showed that it is not possible to ensure a certain result with a particular management option. Uncertainties caused by the unknown effects of M-74 and other possible diseases are very high, and this might be the most important problem for salmon management in the future. Estimation of the real uncertainties is impossible, and the results summarised here indicate that uncertainties are high. The probability distribution of smolt production is very dependent on the assumed distribution of survival (normal, lognormal, etc.). Existing data series are too short to be used to judge the right distribution.

6 CONCLUSIONS

1. If fishing mortality is reduced in each area by the same amount, the overall reduction would need to be 35% to reach a sustainable situation for the northern wild stocks. Even in this case, the state of the stocks would improve only very slowly.

2. If fishing effort reductions are only carried out in either the coastal or the open sea fisheries, these reductions must be extremely effective to safeguard wild salmon stocks.

3. The management measures required are very sensitive to changes in egg and parr mortality. These variables should therefore be regularly monitored.

4. Studies concerning the economic results of low fishing pressure should be made. Otherwise it will be difficult to expect fishermen to accept changes in fishing opportunities.

7 REFERENCES

Anon. 1975. Reference report of Baltic salmon. ICES Cooperative Research report. 45:145 pp.

Anon. 1992a. Report of the Baltic Salmon and Trout Assessment Working Group. ICES, Doc. C.M.1992/Assess:10.

Anon. 1992b. Report of the Workshop on Salmon Assessment Methodology. ICES, Doc. C.M.1992/-M:8.

Anon. 1993. Report of the Baltic Salmon and Trout Assessment Working Group. ICES, Doc. C.M. 1993/14

Christensen, O., Eriksson, C. and Ikonen, E. 1993. History of the Baltic Salmon, Fisheries and Management. This volume pp. 23-29

Karlsson, L. and Eriksson, C. 1991. Experimental fishery with drift nets of different mesh sizes in the Baltic in the autumn 1990. ICES, Doc. C.M.1991-/M:13.

Kuikka, S. 1992. Development and dynamics of Finnish salmon trapnet fisheries in the Gulf of Bothnia. ICES, Doc. C.M.1992/M:15.

Palisade, 1990. @Risk. Risk Analysis and Simulation add-In for Microsoft Excel. Address of the company: Palisade Corporation, 31 Decker Road, Newfield, NY USA 14867.

Mr Pekka Iskanen argued that, as 99% of the salmon in the Gulf of Finland are reared, the fishery can be considered as sea ranching and that there is no reason why the fishery in that area should be regulated by the IBSFC.

Pursuing this subject further, Dr Fredric Serchuk, Chairman of the ICES Advisory Committee on Fishery Management (ACFM), stated that he believed that suitable environment for the restoration of the Gulf of Finland wild stocks may be inadequate. In view of the fact that only 1% of the Gulf of Finland stocks are wild fish, whereas 10% are from wild stocks in the main part of the Baltic, he questioned at what critical level restoration is considered to have become impossible and hence no further efforts to restore stocks are worth making. In response, Mr Kuikka and Mr Potter indicated that this is a political and not a scientific decision because it involves balancing the costs of protecting the wild fish against the loss of income from catching reared fish.

In response to a question from Dr Lars Hansen, Norway, Dr Friedland stated that there are about 1,500 river stocks in the Atlantic, but that for management advice purposes these are considered as belonging to two stock complexes, one on each side of the Atlantic. However, it would in principle be possible to give advice on the northern and southern stocks in Canada. Ideally, Dr Friedland stated that management should be based on individual river stocks as these are the evolutionary units. Commenting on this, the Chairman pointed out that this would not be feasible but that the use of index stocks may be an alternative.

Mr Jan Arge Jacobsen, Fisheries Laboratory of the Faroes, commented on Mr Potter's statement that the danger of extinction is greater in slow- than in fast-growing salmon stocks. He said that research in the Faroes had shown that salmon from different stocks were mixed in the sea and that, as a result, the chances of catching fish from very small stocks are much smaller than those of catching fish from larger stocks. Following from this, he argued that the danger of small stocks becoming extinct through exploitation in mixed fisheries is no greater than that for large stocks.

In reply, Mr Potter stated that this assumes that all stocks are equally available to the fisheries. He drew the distinction between small stocks and low-productivity stocks, ie those that do not produce the same relative number of adults. In this case, a low-productivity stock may not be able to support the same fishing effort as a high-productivity stock.

In view of the above comments, Dr John Anderson asked Mr Potter how it is possible to manage mixed stock fisheries and maintain the uniqueness of each stock. Mr Potter responded that a scientist cannot say that mixed stock fisheries are unacceptable, but he can point out the difficulties this poses to managers if management is required on an individual stock basis. It, therefore, has to be accepted that management on the basis of stock complexes rather than individual stocks presents risks to fisheries managers.

Directing a question to the Managers, the Chairman pointed out that one of the management objectives in the Pacific salmon fisheries is the maximisation of socio-economic benefits. He asked for whose benefit this maximisation should be provided - individual user-groups or fishermen as a whole. As individual user-groups might claim that benefits should be aimed at their sector, he asked what type of justification the user-groups can make for their claims. He also asked what compensation would user groups be prepared to offer to disadvantaged user-groups. In that connection, he observed that the awareness of the needs of other users tends to diminish as you move from the sea fishermen to the river fishermen. The argument used by river fishermen and riparian owners is that the economic benefits are spread more widely among the community than those obtained in the sea fisheries. This seemed to him unbalanced in view of the need to share the resource.

Lt Col Robert Campbell, Dee District Salmon Fishery Board, provided a detailed example of how river proprietors view the sharing of the allowable catch which can be defined as the total stock less the quantity required for spawning. He firstly made the point that it is the river proprietors who have the responsibility for ensuring that sufficient salmon reach the spawning beds. He stressed that, in contrast to the sea fisheries, salmon management in Scottish rivers is primarily dependent on the river proprietors who have to provide the resources needed to manage each river. In the River Dee, Scotland, over £250,000 have to be raised each year from among the 50 or so proprietors. At present catch levels, which are only 40% of what they were 25 years ago, the Fishery Board charges rod proprietors an average of £60 per fish to manage the river, which together with other costs makes a total cost to the proprietor of around £200 per fish, and this does not include any costs of stock enhancement or river protection. If the number of fish caught were to double, the returns to the proprietor would be about £100 per fish and this compares with a flesh value of only about £20 per fish caught in commercial nets. In addition, the revenue from anglers who fish in the river supports about 440 jobs in the Dee valley. In response to the Chairman's question, therefore, greater benefits for the rod proprietors would result in better management of the spawning stock and increased juvenile production. Moreover, if the stocks improved to the levels of 25 years ago, then more salmon would be available for all user-groups.

Mr M. Jørgensen argued that the scientists do not want to take the responsibility of giving firm advice. If scientists do not state their concerns about the state of salmon stocks, however, then management decisions will be taken solely on the basis of economic considerations. An extreme solution to the problems identified at the meeting would be to stop all fishing until the stocks improve to a level at which sharing of the resource would be possible.

Mr Kuikka agreed that the scientists have a responsibility, but that this responsibility is to provide clear information, not to make the management decisions.

Mr Karl-Erik Berntsson said that regulation is needed in all phases of the fishery in the Baltic, ie in the offshore, coastal and river fisheries.

Mr Bjørnulf Kristiansen argued that it is very difficult to consider sharing the resource with commercial fishermen because their attitude to the resource is completely different from that of the river fishermen. In his view, the opportunity for sharing has gone and it is now too late for dialogue. In response to the Chairman's question about compensation for other user-groups, he said that what could be given in return for improved benefits would be improved safety for the salmon and a more tolerant attitude towards fish farming interests, so long as it was conducted in a responsible manner.

Mr Frank Doyle, Irish Fishermen's Association, commented that one can always guarantee emotive and extreme views when the subject of salmon is being discussed. All those interested in the resource agree on the need for conservation, but not necessarily on which user-group the salmon are being conserved for. The central argument in the Dialogue is thus about who catches the salmon. There appears to be a perception among the angling community that it is the commercial fishermen who are the "culprits". However, in using the value of a single salmon as an argument whether salmon should be caught by commercial fishermen or rod anglers, it cannot be assumed that all salmon that escape nets will be caught by anglers. In his view, what is needed is, therefore, a full evaluation of the problem from all points of view, rather than selective arguments from the point of view of a single user-group.

Dr Michael Vickers, United Kingdom, stated that the economics of salmon fishing are irrefutable, as demonstrated earlier for the River Dee. The difficult situation faced by this and other rivers in Scotland is also demonstrated by the fact that more and more anglers are going to Russia and other countries for their sport. It is the recreational fishery that provides revenue, and the commercial fisheries are not needed because any requirements for fish for food can be satisfied by farmed salmon.

The Chairman agreed that a number of economic studies have demonstrated that the gains to the respective countries' economies would be maximised by promoting the river fisheries and closing the coastal netting fisheries. However, although this may be correct from the economic standpoint of individual countries, he asked what can be offered in recompense to Greenland fishermen. In response, Dr Vickers said that his understanding was that alternative employment opportunities were available to the coastal communities in Greenland as a result of the interests of the USA in maintaining strategic bases.

PAPERS BY MANAGERS

THE HOST STATE PERSPECTIVE - SEEN FROM GREENLAND

by

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1 WE ARE CORNERED

Why are administrators asked to participate in this Dialogue Meeting? According to the organizers: in order to let them speak more freely and frankly than during NASCO meetings.

I shall try to do exactly that.

My starting point is that in this issue - and particularly in this issue - we in Greenland find ourselves cornered. For our opponents, this is not only a matter of biology, not only a matter of getting as much as possible in a negotiation. We feel that for our opponents, this is also an attempt to undermine our lifestyle, our means of subsistence.

Wealthy city-dwellers far away force us to fight an endless battle to be able to continue our traditional whale hunt. Wealthy city-dwellers far away prevent us from marketing one of our few plentiful resources, seal skins. Wealthy city-dwellers far away are now trying to impose a complete end to commercial salmon fishing in our country.

In short: If you want to promote Dialogue on salmon, you need to convince us that Greenland is not the target of yet another crusade, based upon cultural imperialism.

2 OUR PEOPLE

In Greenland, salmon are fished by small fishermen. Salmon constitute a significant part of their annual cash income. While salmon catches have decreased in the last years, cod has virtually disappeared. This means that salmon has maintained its relative importance.

Greenlanders speak a language which is not only different from yours, but quite another type of language, different from the type of all of your languages - a polysynthetic language.

Greenland is overwhelmingly dependent on marine living resources. Almost every constituent is related to a fisher man. These are the people you are trying to engage in a Dialogue.

3 OUR DIALOGUE PARTNERS

a) The Scientists

I will commend the scientists for having tried in the last few years to create an overview rather than getting lost in detailed studies of single phenomena.

A few words of criticism:

- You are writing in English - the mother tongue of our main opponents. It would facilitate understanding if you would write in Greenlandic every now and then. (And it would contribute to equity if you would write in French.)

- The ACFM (Advisory Committee on Fishery Management) report is issued too late in relation to the NASCO Annual Meetings. We have only a few weeks to read and digest it and to obtain a mandate from our politicians. It is my impression that the decision-making procedure is easier for our opponents: cut the Greenland quota as much as possible.

- NASCO uses considerable time to formulate questions to ICES. But nowhere can we find the answers from ICES by starting from the questions.

Having said this, I am looking forward (this was written in January 1993) to seeing the answers to last year's questions. I have the feeling that full answers to the questions will bring us closer to agreement on management.

b) The other parties

The basic problem with our partners (they are the same as our opponents) is that it is difficult to establish a Dialogue. We have repeatedly raised *i.a.* the following issues:

- In the past, even substantial cutbacks in the Greenland catches have not improved the situation in the home waters. There is no reason to anticipate that future cutbacks would.

- It is not reasonable to request that a mixed stock fishery shall be conducted in such a way that all river stocks, even the poorest, are protected.

- The amount of unreported catches in countries of origin is of such magnitude that it falsifies the picture of the situation in those countries.

The reply from our partners to these and other questions has been silence.

Instead, they have - in all of NASCO's lifetime - requested a reduction of the Greenland quota. Some are even requesting the complete cessation of fishing of every salmon which is not eaten by "native" Greenlanders. In other words, they are requesting our poor fisherman to refrain from utilizing the fish under his boat, in order to increase the number that rich anglers can take in other countries.

I shall not at this stage comment upon the request for a cessation of the Greenland fishery. I think the representative of KNAPK - the Organization of Hunters and Fishermen in Greenland - will have a few remarks (Heilmann, this volume). I shall only mention that this request is contrary to the NASCO Convention (which presupposes a Greenland commercial fishery), and contrary to the International Covenant on Economic, Social and Cultural Rights of 1966, which has been adopted by all Parties and Member States of NASCO.

All this means that we do not see much of a Dialogue in NASCO. There are rather two monologues, but that hardly constitutes a Dialogue.

Our latest attempt to create a Dialogue took place at the 1992 NASCO Meeting. We proposed a list of criteria which we found relevant to incorporate into a model, and according to which Greenland's quota should move up or down in relation to the stock situation. (Our proposal is given at the end of this intervention.)

Our proposal reflected a year's discussion between administrators and fishermen in Greenland. It was meant as a contribution to a Dialogue within NASCO. However, even this effort was silenced by NASCO. Only one Party commented - in the following words (and I think this is a full quotation): "We can agree to some of the proposed criteria, but not to others".

In spite of this, we have not given up our attempts to create a Dialogue on this point. We will table our proposal again in this year's meeting.

c) Salmon

I have listed the salmon as a Dialogue partner because it certainly would be useful if a Dialogue could be established with them:

- What happens to the millions of smolts leaving the rivers before a few of them reach our "Open Air West Greenland Restaurant" and grow to salmon?

- How many of those we do not fish in Greenland are really going back to spawn?

- How does full achievement of "target spawning biomass" relate to smolt output in the real world?

- How many are not going to Greenland, but grow to "salmon" elsewhere in the North Atlantic? - The answer to this could have an impact on the question of appropriate management in Greenland. We have proposed a survey of other feeding areas in the North Atlantic - but nobody else seems interested in finding such areas.

Fisheries management is often described as "management by looking in the back mirror". However, for the NASCO vehicle a back mirror would certainly constitute a significant improvement.

4 SUMMARY

- to the general public: Salmon are not sacred cows.

- to ACFM: Please write understandably.

- to our opponents: Please respond to our viewpoints.

- to the salmon: Please behave more predictably.

DRAFT PROPOSAL BY DENMARK (IN RESPECT OF THE FAROE ISLANDS AND GREENLAND) FOR DEVELOPING A RATIONAL APPROACH TO THE MANAGEMENT OF SALMON AT WEST GREENLAND

As declared at the 1991 Annual Meeting, Greenland is prepared to discuss a model according to which Greenland's quota will move up or down in relation to the situation of the stock.

With a view to implementing such a model, some principles are listed below on which Greenland would like an agreement to be reached (I). Moreover, there are some questions to ICES, which Greenland wants NASCO to ask (II):

I. Principles

1. The quota should be higher if the situation improves.

2. The basis of any movements up or down should be the present level of the quota (840 t).

3. Importance should be attached to the situation in the rivers which are major contributors to the salmon fishing near Greenland. The situation in other rivers is irrelevant.

4. Any aggravation of the situation, which is beyond Greenland's control, should not have negative effects for the Greenland quota (for example poaching, illegal high-sea fishing, acid rain, negative influence from farmed salmon).

5. Measures taken in homewaters must be expected (on account of the short distance to the rivers) to influence the situation of the stock to a higher degree than measures taken near Greenland, cf. Question II.2. This should be reflected in the size of the movements in the Greenland quota.

6. The socio-economic value of angler catches, for a given quantity of salmon, may be higher than of commercial catches. Measures taken in homewaters which aim at an even higher increase in the rivers with a view to change from commercial fishing to angling should not influence the Greenland quota.

II. Questions to ICES

1. Which rivers are major contributors to salmon fishing near Greenland?

2. The relative importance to the stocks of the regulatory measures in homewaters and near Greenland, respectively.

3. To what extent is the situation with a view to grilse relevant for the salmon that come to Greenland?

ATLANTIC SALMON - A CANADIAN MANAGEMENT PERSPECTIVE

by

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1 INTRODUCTION

This paper presents a Canadian management perspective on the conservation and allocation of wild Atlantic salmon stocks. Although references are made to the United States, no attempt is made to address management from that perspective. Canada, with its aboriginal, commercial and recreational fisheries for Atlantic salmon, presents a very different management situation than the recreational fishery found in the United States.

2 THE MANAGEMENT CONTEXT

The Canadian management perspective is a product of the evolution of management and the obligations that are imposed by legislation and policy. These have led to a process that

- conserves salmon for the greatest possible sustained use; and
- allocates access to and exploitation of the salmon stocks.

2.1 An Historical Perspective

Before Europeans started to fish in North American waters, the aboriginal peoples were using the Atlantic salmon as a significant food resource. Although they used weirs, traps and nets of various types, the spear was the most common means of fishing. The fishery was mainly of a subsistence nature and did not involve a great deal of large-scale resource harvesting or require a great degree of resource management.

As French and English settlements were established in the 17th century, people began using nets and weirs to harvest salmon both for their own subsistence and for trade. At that time, a form of management did exist, not for conservation purposes, but to protect the commercial interests of individuals by limiting participation. This management was first in the form of exclusive royal grants or monopolies given to companies or individuals to fish certain areas and later in berths, which were a form of property to be bought and sold. Regulations of nets and berth locations existed mainly to resolve conflicts among fishermen rather than out of concern for what was an abundant resource.

Management for conservation reasons began to emerge late in the 18th century. Nets strung entirely across river mouths, dams, sawmills and gristmills had all exacted a toll on salmon stocks. Controls began to be put in place in each watershed in reaction to the particular problems that arose. By the middle of the 19th century, close times, size restrictions and gear prohibitions had been introduced in various rivers. Since then, management has gradually developed into the more comprehensive regime that exists today.

In the last two decades, decreases in wild stocks of Atlantic salmon have forced greater degrees of intervention, such as limits to access, effort and catches. This intervention has been in the form of licence controls and retirements, regulation (of gear, quotas, seasons and locations) and measures to enhance and restore the habitat and the stocks. The most important recent management actions concerning Atlantic salmon have been the closures of commercial fisheries and the retirement of commercial fishing licences.

The closure of major commercial Atlantic salmon fisheries began in 1972 with the banning of the driftnet fisheries in Newfoundland and New Brunswick. After earlier closures and re-openings, the commercial salmon fisheries were entirely closed in the Maritimes and the Gaspé by 1985. In 1992, the Newfoundland commercial salmon fishery was closed for a five-year period. An exception was made for the Labrador commercial fishery because of the high dependence of northern communities on salmon and limited prospects for fisheries diversification. However, about 20 per cent of salmon licences were retired in southern Labrador before the 1992 season and quotas were reduced to reflect these retirements. Commercial quotas in southern Labrador will be further reduced in 1993 to reflect an approximate participation reduction of 60 per cent through licence retirement.

Over 6,800 commercial salmon licences have been retired since 1972 in Atlantic Canada and Québec. In 1992, alone, more than 2,730 of 3,006 commercial salmon fishermen in Newfoundland and southern Labrador retired their licences. In New Brunswick, 38 of the 50 remaining commercial salmon licences were also retired. As of the start of 1993, there were about 720 commercial salmon fishing licences left in Canada and more of these licences will be retired over the next couple of years.

Anglers have also been subjected to management measures in recent years. Catch, possession and seasonal limits have all become more stringent and closures and shorter seasons have been imposed in various locations. In 1992, area catch quotas were introduced for anglers in Newfoundland and Labrador and this resulted in areas being closed to retention as early as the first week in July.

2.2 Legislative Framework

International obligations and domestic legislation and policy effectively define the parameters of management.

International

The Law of the Sea provides states of origin of anadromous stocks with the right to establish management measures throughout their migratory range. It also recognizes coastal state rights where stocks originating in other countries migrate into that coastal state's zone. The conventions and protocols of the various organisations such as ICES and NASCO must also be respected.

Domestic

The domestic obligations are more complex because of the constitutional and statutory delimitations of authority. The division of authority can overlap. For example, the federal government has the constitutional authority respecting the coastal and inland fisheries. The Provinces, however, have proprietary rights that allow them some control over fisheries within the tidal high water mark. Examples of the exercise of these rights are the provincially-administered angling licences and, in some provinces, requirements for non-resident anglers to have provincially licensed guides.

Many Canadian jurisdictional difficulties have been dealt with by the delegation of some federal fisheries responsibilities to the provinces in freshwater areas and, in Québec, for tidal areas as well. However, the federal government continues its key role in the management of salmon because of its financial and technical resources as well as its constitutional responsibility.

Aboriginal rights also impose obligations. An important Supreme Court ruling in 1990, the Sparrow decision, did much to clarify our responsibilities in Canada. The court affirmed that aboriginal people have, subject to conservation requirements, a right of access to fish stocks for food, social and ceremonial purposes. Management must recognize this right of access and accord it first priority to aboriginal user groups after conservation considerations in any allocation decisions.

3 THE MANAGEMENT PROCESS

The conservation and resource allocation objectives of the Canadian management process for Atlantic salmon are obligations established in government policy. The annual Atlantic Salmon Management Plan sets out the means of carrying out those objectives by setting out the actual allocation decisions and the principal regulatory measures needed for the Plan's implementation.

Scientific Advice

The development of the annual management plan starts with the scientific advice. Major importance is attached to catches and counts from the previous season. This information can be critical to good consultations and policy decisions. However, because it takes time to gather and assess data, scientific assessments are not usually complete until after the annual consultation process has been initiated.

Consultation

In Canada, we rely on local and regional advisory committees and an inter-regional Atlantic Salmon Advisory Board to provide advice on all aspects of fisheries management. These committees are composed of representatives from user groups in the aboriginal, commercial and recreational fisheries, as well as the provincial and federal governments. The results of scientific assessments and advice are shared with user groups and they tend to forthrightly offer their thoughts on management. This provides management with valuable insight for future management decisions.

Allocation Decisions

Resource allocation concerns both access to and exploitation of the Atlantic salmon resource for all user groups (aboriginal, commercial and recreational). Licensing and quotas are the major means of allocating salmon. Allocation decisions affect what people view as their rights, freedoms and livelihood. Therefore, they must be carefully considered. Considerations can include aboriginal rights, traditional practices, community reliance, equity, value and contributions to and impact on the conservation of the resource. As stated earlier, the Sparrow decision gives first priority to the aboriginal peoples for food, social and ceremonial purposes after conservation needs are met. Only then can the needs and desires of the other user groups be dealt with.

Allocation is largely a domestic concern, except where it concerns the interception of migratory stocks of home-water countries. As noted above, this is provided for in the Law of the Sea, but it does pose a conservation concern for Canada.

4 THE CONSERVATION OBJECTIVE

Conservation applies to both the Atlantic salmon stocks and to their habitat. In Canada, conservation includes protection, preservation, restoration and enhancement. In our management doctrine, conservation is for the purpose of sustained resource use as well as for biological preservation.

4.1 Scientific Requirements

Incomplete information about Atlantic salmon stocks is one of the greatest constraints on effective, focused management action. We know that stocks have suffered as a result of overharvesting, habitat degradation and changing marine conditions. In some cases, such as a dam construction or the acidification of a river, we can understand why a stock has disappeared. However, with so many uncertainties, such as at-sea-mortality, climatic effects and prey/predator relationships, we do not know or understand, in most instances, the degrees of cause and effect of many of our actions.

To conserve and use a stock effectively, there should be some measure or standard of conservation. Ideally, there would be a detailed knowledge of the amount of escapement needed in each watershed in order to have a real grasp on what can be harvested. Obtaining this knowledge is complicated by considerations such as the spawning conditions and the relative numbers of various stocks and stock components (e.g., multi-sea-winter salmon) within each watershed. Canadian scientists have developed minimum egg deposition standards to help us measure conservation, but there is an information "jump" from one year to the next (forecasting) and there are further "jumps" from egg deposition targets to escapement requirements (because the biological characteristics change from year to year) and then to acceptable rates of harvest. These all make the information base for any decision less than perfect. Therefore, there has been a reliance on general indicators such as previous catch rates and smolt and salmon counts at fences and barriers on index rivers. These indicators have been used as a basis for adjusting existing harvesting seasons, locations and methods. Increasingly, in this less than ideal situation, management has come to realize that it must err more on the side of conservation in its adjustments.

4.2 Conservation-Oriented Initiatives

To protect fish stocks, the resource should be taken in the most conservation-oriented manner. Harvesting needs to be as selective as possible. This can be accomplished by restricting seasons, locations of fishing and gear types. Each year, Canada adjusts restrictions in its home waters to try to improve selectivity. These adjustments are also made to fisheries for other species of fish to reduce the incidental catch of Atlantic salmon.

The use of gillnets in rivers and interceptory fisheries pose special difficulties for Canada. Fish caught in gillnets generally die. In a river, this means that particular stocks or stock components that we would like to safeguard cannot be effectively returned by the harvester. The aboriginal people are the only users permitted to net fish in-river and they are being encouraged to switch to traps.

Interceptory fisheries harvest fish regardless of their river of origin. They take from depleted as well as healthy stocks. This was one reason why Canada has taken such extreme measures as to close the bulk of its commercial salmon fisheries. It is also one reason why both Canada and the United States are concerned with the West Greenland fishery.

Concern about selectivity is not limited to commercial and aboriginal harvesting. Even with their much smaller individual catch rates, anglers have also been called on to be selective. For example, salmon over 63 cm in length can only be retained in Labrador and Québec. Proper hook and release fishing is being promoted, as well, for all sizes of fish.

Any management measures to ensure a selective and acceptable harvest must be accompanied by effective education, enforcement and monitoring. These can be costly. In times of financial restraint, therefore, there is an increasing reliance on the users themselves to contribute to these activities. The public in Canada, for example, is being encouraged to assist in enforcement and report offences through programs such as River Watch and Crimestoppers. Further examples of public involvement can also be found in our efforts to restore and protect fish habitat.

It is not enough to protect fish from excess harvesting. Fish habitat must also be protected and restored. Over centuries of settlement and development, dams have been built and industries have been established without any regard for the conservation of fish habitat. Public awareness of the depleted fish stocks and degraded fish habitat has done much to bring about a change in thinking. There is a more critical eye on industrial and commercial development. Over the last few years, there has been a rapid development and refinement of environment legislation and policy. Our resources are starting to get the stringent protection they need.

Canada is not seeking just to maintain the current productive capacity of fish habitats; it is also seeking to rehabilitate and create and improve fish habitats. The involvement of angling and conservation organisations and Native groups has been invaluable in projects ranging from small stream stabilisation projects to the construction and maintenance of fishways.

Enhancement is another means to address conservation concerns. Hatcheries can be used to help stocks rebuild, but great care must be taken not to compromise the genetic integrity of existing stocks. Measures such as kelt reconditioning and satellite rearing are being tried and assessed as means to augment existing stocks without affecting their integrity. Once again, there is a great reliance on the participation of angling and conservation organisations and Native groups.

4.3 International Conservation

Management measures can be in vain if external threats such as acid rain, international interceptions, disease and genetic mixing are not controlled. Canadians are spending well over 100 million dollars over five years to help rebuild Atlantic salmon stocks. Likewise, millions of dollars have been spent in the United States to rebuild and re-introduce salmon stocks. These efforts should not be undermined by influences beyond our direct control. NASCO is an important forum to help us deal with such influences.

There are three important concerns for Canada in this regard:

a) a need to cooperate with other states in the conservation and rebuilding of stocks;

b) a need to ensure that management practices, such as transfers and genetic manipulation, in one nation do not unduly threaten the stocks of another; and

c) external threats, such as pollution, originating in one nation must be mitigated to prevent damage to fish habitat in another nation.

Recent NASCO efforts have dealt with these concerns. To deal with high-seas interceptions, we have seen the adoption of a protocol for states not party to the Convention for the Conservation of Salmon in the North Atlantic Ocean. In the North American Commission, protocols have been developed to deal with the introduction and transfer of salmonids and there is ongoing discussion of acid rain questions. Still, the issue of cooperation with other states in our efforts to rebuild stocks needs further work, particularly in light of the state of the stocks off West Greenland.

5 RECENT DECISIONS

The five-year closure of the Newfoundland commercial salmon fishery provides some insight into a difficult decision affecting both conservation and resource allocation. Important factors in this decision included:

a) the interception by that fishery of stocks from all over Atlantic Canada and the northeastern U.S., affecting extensive stock recovery efforts;

b) the decline in the commercial fishery in the face of competition from a rapidly growing aquaculture sector;

c) a generous licence retirement offer to affected fishermen;

d) the high reliance of southern Labrador communities on the fishery and the lack of other fisheries' opportunities;

e) the mixed char/salmon fishery carried out by highly dependent, mostly Native communities in northern Labrador; and

f) in the interests of equity, the need for recreational fishing interests to make sacrifices (i.e., area quotas, early closures and more stringent limits) to rebuild the stocks.

As a result of these factors, the closure did not include Labrador. Instead, a voluntary commercial salmon licence retirement was undertaken and substantial quota reductions were and are being made to reflect decreased participation in the Labrador commercial salmon fishery.

Almost any major management action brings criticism. In the example of the closure, complaints were received from commercial fishermen who said it was too extreme and from anglers who said it did not go far enough. Seldom is everyone satisfied. However, consultation and communication are vital to making everyone understand what problems must be addressed and why certain decisions are made. Scientific advice is a critical component in this regard, both as a basis for the decision and as a means to explain it.

6 MANAGING INTO THE FUTURE

In Canada during the last few years, there has been:

- a general decline in the commercial salmon fishery;
- a tremendous growth in the aquaculture salmon industry;
- growth in the recreational fishing sector;
- an increase in the conservation orientation of the public;
- a clarification of aboriginal fishing rights; and
- the development of cooperative management.

All of these are tremendous changes that demand responses.

There are several examples of how Canada is dealing with changes. These include:

- commercial licence retirement programs;
- the improvement and promotion of aquaculture;
- the investment of over 100 million dollars over a five-year period to restore stocks, improve habitat and provide education and public awareness; and
- the adoption of an Aboriginal Fisheries Strategy to involve Native groups in co-management agreements to conserve and protect the resource.

Notably, many recent Canadian efforts have depended on a cooperative approach with the various users and the other jurisdictions. Government cannot afford to do much of the work that needs to be done and is increasingly acting as a facilitator. To that end, the public must be increasingly involved in the conservation and wise use of a valuable resource.

To conclude, we are hopeful of the same growth in international cooperation and respect for the valuable salmon resource. Canada has taken and will continue to take costly action to conserve Atlantic salmon stocks. It would like other nations that benefit from this resource to take similar action.

THE BALTIC SALMON - A SWEDISH MANAGEMENT PERSPECTIVE

by

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Abstract

The Baltic salmon is a biologically and economically important natural resource which displays many interesting examples of complex interaction between various factors such as ecology, environmental deterioration and natural resource utilization. Salmon management has turned out to be difficult, especially in comparison with other species of fish, due to the wide habitat of the salmon (rivers, coastal areas and open seas in different stages of its life cycle), varied fishing patterns (the same stock fished by different categories of fishermen in different regions using different fishing methods), risks of extinction of wild stocks, competing user interests, controversies and strong feelings, strong public interest, political sensibility etc.

1 INTRODUCTION

This paper presents a Swedish management perspective on the conservation and utilization of the wild. i.e. naturally reproduced salmon (*Salmo salar*) stocks of the Baltic Sea. Since wild stocks constitute only about 10% of the total Baltic stock (90% are reared) and since most of the fisheries are based on mixed stocks, the paper also has to take the reared stocks into consideration.

2 THE PRESENT STATE OF THE WILD BALTIC SALMON

Natural reproduction of salmon formerly took place in many rivers in the Baltic area. The salmon fishery, mainly in the rivers, has for centuries played an important role in the national economy in Sweden as well as in other countries around the Baltic.

However, environmental degradation such as that created by dams and river regulation (mainly for hydropower development purposes) and pollution etc. has reduced the number of rivers supporting wild stocks from about 70 to about 20. Most of these rivers are situated in the northern part of Sweden. The construction of power plants is the main reason for the decreased number of salmon-producing rivers. The Swedish hydro-electric power companies were, however, obliged by law to compensate the natural production of salmon in the rivers exploited. Rearing stations were built and the compensatory releases proved to be successful in maintaining a fair amount of salmon in the Baltic. The production of reared young salmon amounts nowadays to almost five million smolts annually.

The ranching technique is widely used in many parts of the world to enhance wild stocks of various fish and shellfish species in lake and sea areas. The ranching technique *per se* is very common for migratory, usually anadromous, species. Such species are usually harvested at or near the point of release on their spawning migration. However, in some areas like the Baltic, an offshore fishery is also allowed far away from the point of release. The bulk of catches is nowadays taken in offshore areas and the comprehensive compensatory salmon smolt release programme in the Baltic can thus be called a fisheries enhancement technique to support a common sea fishery. This technique, however, implies adverse effects on the wild salmon stocks. The number of salmon that return to the remaining rivers with wild stocks has decreased considerably during the last decades. The actual smolt production is only 10-20% of the potential (i.e. the smolt carrying capacity) due to the low number of spawning salmon ascending the rivers. In some small rivers and in the upper stretches of the large ones the wild salmon could be close to extinction.

The reduction of the remaining wild stocks is mainly due to overfishing in the sea which in its turn is due to increasing releases of reared smolts. Both the number of released reared smolts and the total salmon catch doubled in 10-15 years in the seventies and eighties. Wild and reared salmon appear in mixed stocks (in the Baltic as a whole 10% wild and 90% reared). Increasing stocks of reared salmon give rise to increasing fishing effort, which means overfishing and a reduction of wild stocks. The existence of mixed stocks, therefore, constitutes specific and difficult management problems. Both the coastal and sea fisheries are carried out among intermixed populations without any possibility of being able to distinguish the natural salmon. Consequently the mechanism which implies that, for biological and economic reasons, fishing shall cease when a fish population becomes too weak does not function in this case. This is a dilemma of an interception fishery.

3 OBJECTIVES OF THE SWEDISH MANAGEMENT POLICY

There are many reasons for the conservation of Baltic salmon. According to the national policy of Sweden the overall objective of fisheries management is to bring about long-term conservation and sustainable utilization of fish stocks in a way which contributes to food supply and the common welfare. It has further been stated that naturally occurring species should be kept in vigorous, balanced populations. The International Baltic Sea Fishery Commission has reached agreement that the aim of management is to safeguard wild salmon stocks. Of special importance in the context of the protection of the Baltic salmon is the conservation of genetic diversity.

Genetic diversity

In view of the comprehensive sea ranching there is a special need to preserve the genetic diversity of the Baltic salmon. The interaction between different genes gives each individual its characteristics. Among others, variations in speed of growth also have a complex genetic background. The loss of a single strain, or too few individuals in a population, leads to the disappearance of certain variants of genes. Thus the genetic variation of the species decreases. Lost genetic variants cannot be recreated. A population that loses its genetic variation will rapidly disappear. An extinct population or species implies a decreased stability in an ecosystem.

A wealth of genetic variation is a condition for salmon breeding and thus also for the comprehensive enhancement of Baltic salmon. Furthermore, such breeding cannot be based on one single type of salmon. Different types are needed for compensation-breeding, sport fishing and the breeding of fish for human food.

The following general motives for the maintenance of genetic variation may be stated:

* For reasons of nature conservation as much as possible of the genetic variation should be maintained. An environment rich in species is more stable.

* It is necessary to keep the different strains separate from each other as they can be presumed to have built up special combinations of interacting genes which provide good adaptation to the local environment. When there is an extensive intermixture such combinations are rapidly broken down. The genetic variation decreases.

* A threatened strain cannot be saved by artificial breeding except for a short period of time as such breeding selects the individuals best suited for the breeding environment concerned. This causes the genetic variation to decrease.

* The economic yield from different waters can be maintained. Low genetic variation produces badly adapted strains which function worse in a variable environment.

* A wide selection of characteristics is required for future compensation-breeding and breeding for sport fishing and food. The strains bred must be supplied continually with new genetic material from wild populations.

The Board of Fisheries has submitted guidelines to minimise the threats to wild stocks from salmon aquaculture. These guidelines comprise a list of a total of 34 salmon populations recognized as national protection objects, regulations for issuing permits for fish aquaculture plants and regulations on the release of fish.

To sum up it can be stated that every watercourse has a unique strain of salmon which carries unique genetic variants that constitute a condition for a high long-term yield - both for natural and artificial salmon. Lost genetic variation can never be recreated.

4 THREATS AND STRATEGIES

4.1 Overfishing and Depletion of the Salmon Stock

The rearing of salmon has not only maintained the salmon stocks, but the rather stable release of salmon smolts has also supported a heavy offshore fishery on the mixed stocks feeding in the Main Basin. In combination with an effective coastal fishery on migrating adult salmon, the high fishing pressure has resulted both in an insufficient number of spawners ascending rivers to maintain natural production and a lower age in spawners from the reared stocks. In 1988-1989 the recruitment of wild stocks to the fishery was only 9% of the total recruitment. It is important to recognize the fact that the northern river stocks have to survive when passing two heavy fisheries, while the spawners from the rivers entering the Main Basin can migrate directly from the open sea to the rivers.

Strategies

Total Allowable Catch (TAC)

On the initiative of Sweden a number of restrictions relating to the amount of gear operated per boat were adopted by the International Baltic Sea Fishery Commission in 1979. Sweden later proposed an increased mesh size in salmon drift nets. During the 1980s the Commission tried in vain to reach an agreement on a salmon TAC and quota allocations. The failure was due to disagreement about the distribution of a TAC and about the considerable unregulated fishery in the disputed area between Sweden and the former Soviet Union - the so called White Zone. Not until 1990 did the Commission succeed for the first time in its efforts and a TAC was established for 1991. One biological improvement in 1992 was that the TAC for 1993 was expressed in numbers and not in weight.

The Swedish policy has been that, as a first step in the process of reducing the salmon fishery, a TAC has to be internationally agreed upon. In the Swedish fishery zone in the Main Basin there was in 1991 a reduction of the sea fishery by 35%. On the other hand there was that year overfishing by one state by more than 100%. It is quite clear that the TAC-method is not a sufficient instrument for reducing and stabilizing the salmon fishery.

Neither has it been possible to find any mutually acceptable principle on how a TAC should be divided between the IBSFC contracting parties. According to Sweden and other "producer countries" the smolt production should constitute an important factor in such a TAC distribution.

The use of catch quotas as the fundamental regulatory measure has been favoured because of the simplicity of the concept itself, the possibility of dividing it into national quotas and the ease with which it can be linked with the maximum sustainable yield (MSY). Permanent monitoring of the state of resources, as well as of fishing effort changes should constitute the basis for quota establishment. The practice of using catch quotas has, however, pointed to a number of fundamental flaws in this method.

Regulations in the Coastal Fishery

There are reasons to believe that considerable quantities of salmon are caught in the coastal non-commercial fishery. This is a very serious threat to the wild populations as the main part of the salmon entering the coastal fishery are spawning migrants. Recently the Board of Fisheries decided to introduce an early summer close season for salmon fishing along the coast of the Gulf of Bothnia. This decision may be seen as a second step in a series of intended measures to be taken to protect the Baltic salmon. This close season does not *per se* imply any reduced Swedish salmon fishery in the Baltic, the quantity of which is internationally agreed upon. On the other hand the decision implies a certain redistribution of the salmon fishery from the north to the south, i.e., from a fishery on salmon with a high proportion of naturally produced fish to a fishery on salmon with a lower proportion of such fish. The redistribution also implies a reallocation from the non-commercial to the commercial fishery. At the same time there are clear biological advantages with the early summer close season as more naturally produced salmon can now enter the rivers and spawn. An increased natural reproduction may in some years lead to more salmon in the Baltic.

This year (1993) a new Swedish fishery law will be implemented, by which it will be possible to limit the number of gears used in the non-commercial coastal fishery. Initially, the regulations of the Swedish salmon fishery aimed at an allocation of catches between different categories of fishermen. Gradually, the regulations have switched aiming at the protection of the stock. Thus it can be concluded that the principle of allocation of catches is now being implemented to increase the protection of the salmon stock.

Regulations in the River and Estuarine Fisheries

In all river systems along the Swedish coast of the Baltic Sea special regulations for migratory species of fish have been introduced. There is thus an instrument already in place for the protection of the expected increase in the number of spawners. These regulations comprise close areas, close seasons/days, gear limitations etc. In some river mouths the salmon fishery has been bought out implying a permanent closure of the commercial fishery.

Delayed Release and Closed Areas

In 1985 a major project to investigate the possibilities of delayed release of young salmon in the Baltic area was initiated by the National Board of Fisheries, Sweden. The commission to plan and perform the project was given to the Swedish Salmon Research Institute. The experiments within the project were mainly concentrated on investigating the following topics:

- is it possible to transfer one-year-old salmon to a net-pen for rearing in brackish water during the summer and release in the autumn?

- can the use of different stocks of salmon be of major importance for survival and growth after release?

- is it possible to optimize the results obtained (time in the net-pen)? Is the optimization dependent on the age of the young salmon transferred?

- what migratory pattern will be shown by the young salmon with delayed release? How many will appear in rivers, especially salmon rivers?

The project was run during the years 1985–1988 with releases of young salmon at 10 places along the Swedish coast.

Major results of the experiments

The experiments show that delayed release of young salmon in the Baltic area gives excellent results concerning survival and growth after release.

The overall reported recapture rates for the releases in the Main Basin in 1985 and 1986 range from 20-40% or from 800 to 1700 kg per thousand released. It can be estimated that these figures should be multiplied by a factor of 1.5 to compensate for unreported tags. Thus, the real catch can be calculated to be about 40% or 1400 kg per thousand released.

As the reporting rates are almost equal for both one-year-old and two-year-old salmon, it is possible to use one-year-olds for delayed release in the Baltic area. The low salinity (< 10 ‰) also implies that a transfer to net-pens is possible even at very low water temperatures (1-2°C).

However, no evidence could be found of any increase in benefit by using salmon from a special stock. The major factor influencing survival and growth in the sea after release was found to be individual length at release. It seems that this factor is not absolute, but depends on time of release and relative size within the released group. For the young salmon released in the autumn a very low survival was found for those below a length of 22–23 cm at release.

Recaptures from the delayed releases at the coast showed a low number of fish returning to any river. The results do not indicate any significant difference in straying frequency between river- and coastal-released fish when balanced against the number of fish recaptured. Furthermore, the migratory patterns imply that mixing with natural Baltic stocks can be minimized if the releases in the Baltic Main Basin are made in selected areas away from natural rivers.

The results confirm that delayed release of young salmon is a highly profitable method in the Baltic. The main objective of the investigation was, however, to explore the possibility of using delayed release as a method to save the naturally produced salmon in the Baltic. This method is applicable if it is combined with regulatory measures such as:

- Protection of salmon in the main feeding areas where the interception fishery takes place. This can be done by introducing a sanctuary (wholly or partially) covering the present feeding area in the Baltic proper. This means, however, a staggering blow for the commercial fishermen who are dependent on that fishery. However, by using a delayed release technique in the southern Baltic, a coastal fishery can be established as a compensation for the lost offshore fishery.

- Strict regulation of the fishery north of latitude 60°N.

- Closed areas off all rivers in which there are salmon or sea trout.

- Professional gear for salmon fishing may only be used by professional fishermen.

4.2 Environmental Degradation

4.2.1 River exploitation

The construction of power plants is, as mentioned above, the main reason for the decreased number of salmon producing rivers. Naturally, the river ecosystem changes drastically when the river is exploited and effects on the production of parr, on the mortality of migrating smolts and on the spawning migrations are observed. These changes affect the salmon both directly and indirectly as the timing within and between biological and environmental processes will change. If a river is exploited the possibilities for successful salmon production in the river are either significantly reduced or totally destroyed.

Another type of environment management that affects the salmon rivers is lumbering and clearing. Deforestation changes the characteristics of the whole drainage system causing extreme variations in water velocity. Logging may also negatively affect the salmon's nursery and spawning areas due to regulation dams which are often built in order to achieve a steady water flow. Nowadays logging has practically ceased in Sweden and considerable economic resources have been spent on restoration measures.

Drainage and exploitation of swamps and wetlands have also negatively affected the salmon river or stream habitats. In drained swamps the water flow is radically changed to a water flow with a spring pulse and very low or no flow in dry summers. Nowadays there are, however, stricter rules regulating logging activities.

Strategies

The Swedish hydro-electric power companies were by law obliged to compensate for the loss in natural production of salmon in the rivers exploited. Rearing stations were built and the compensation release proved to be successful in maintaining a fair amount of salmon in the Baltic. In several rivers effective salmon ladders have been built, partly by means of money from the state. In the near future it will, however, be possible by law to renegotiate the conditions for the water flow conditions.

In July 1987 a Law on Natural Resources entered into force. According to this law certain river systems are exempted from hydro-electric power exploitation. Among them the Torne River, the Kalix River, the Pite River and the Vindel River have been appointed "national" rivers. These four rivers still have naturally propagating salmon stocks.

4.2.2 Acidification, eutrophication and toxic substances

In Sweden acid rain has affected the waters from the River Ume southwards. Large rivers are more resistant to acidification than small ones. No acidification damage has been documented in the northern salmon rivers of Sweden. However, the upper parts of the River Mörrumsån and the River Emån show symptoms of acidification.

The eutrophication of the salmon rivers might today be considered a minor problem. Only local effects are observed.

Streams and rivers are often subjected to heavy metal stress or pollution from other toxic substances and waste water discharges. The salmon and its habitat have thus been adversely affected. Moreover, the salmon is more sensitive to pollution than most other fish species. In the late 1960s it was found that the reproductive ability of female salmon was reduced by PCBs accumulated during their sea life. PCBs are still a problem in the Baltic.

Strategies

Liming measures and reduced discharges of nutrients and toxic substances will lead to improved environmental conditions for the salmon.

4.2.3 Diseases

Since 1974 a so far unexplained increase in mortality rate of salmon alevins (M-74), connected to individual females, has been observed in Swedish hatcheries. In 1992 the hatching of salmon ova was so poor that, from the eyed ova stage to feeding fry, a total loss of 60 to 95% was observed. A normal value for the mortality amounts to 10-15%. Electrofishing surveys in the summer of 1992 in rivers carrying naturally producing salmon indicate an almost complete absence of one-summer-old fry. The number of spawners in 1992 was relatively high. The research work so far carried out in Sweden indicates that a poisoning factor is involved in the process. It seems likely that the factors causing the effects are organochlorine substances accumulated by the females in the feeding grounds in the Baltic proper. If there is no improvement in hatching in the near future, the production of reared smolts will also have to be based on reared brood stocks. Thus Baltic salmon managers are now facing a **new problem with very severe genetic implications.**

It is possible that the 1993 and 1994 smolt year classes are the last year classes with a relatively high production in comparison to the situation in the mid 1980s. If the disease M-74 hits future year classes even harder the 1993 and 1994 year classes will also be the last buffer against depletion of yet more salmon stocks. That is why regulation of the fishery on these year classes must have the highest priority.

Strategies

On the basis of the available information it is estimated that the disease M-74 today causes a reproduction loss of about 70%. The following action plan has been proposed:

a) Follow-up of the status of the naturally reproducing salmon.

   * The relationship between the number of spawning salmon and their progeny before the outburst of M-74 was established.

   * A comprehensive electrofishing survey of the density of two-summer old parr (1+) is to be carried out in the beginning of the autumn 1993 to estimate the effects of M-74.

   * All the data have to be collated before the Meeting of the International Baltic Sea Fishery Commission in September 1993 as a basis for regulations to be decided.

b) Regulations of the fishery

   * A more complete evaluation of the measures required can be made when the electrofishing survey in the autumn of 1993 has been conducted.

* On the basis of the present conditions all fisheries on naturally produced salmon should be closed for 3-4 years. (It could be that a fishery based on the delayed release experiments has to be implemented).

* Regulation of the fishery on salmon emanating from the 1993 and 1994 year classes must be given the highest priority and should be very restrictive.

c) Establishment of a gene bank

    * A detailed plan for the establishment of a gene bank and its related costs has to be elaborated as soon as possible.

    * Collection of fish destined for the gene bank has to start during the autumn of 1993.

THE MANAGEMENT OF THE BALTIC SALMON - THE FINNISH PERSPECTIVE

by

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1 INTRODUCTION

The Baltic salmon has always been a very important but also a highly contradictory element in the Finnish fishing industry. The written history of salmon fishing, starting from the 16th century, describes in detail different kinds of disputes between the state and salmon fishermen and between the church and salmon fishermen as well as disagreements among fishermen from different areas.

The situation has not changed since those times, except that the church no longer has the power to levy taxes on salmon fishing in Finland.

A new feature of salmon fishing in the Baltic Sea is the competition among the coastal states of the Baltic Sea in exploiting the salmon stock. Since the International Baltic Sea Fishery Commission (IBSFC) was established, heated discussions have at times been conducted in this forum since 1974 about salmon stocks, their genetic purity, the farming and stocking of salmon, the cost of stockings, the TAC and the TAC shares of different countries as well as about different ways of regulating salmon fishing.

As far as the quantity and value of the Baltic Sea fish resources are concerned, the salmon catch is neither the largest nor the most valuable catch. However, dealing with the salmon question internationally, and also nationally in Finland, is difficult and requires a great deal of work, very often without leading to any feasible results.

I shall deal with the subject, according to the title given to me, first by touching on Finland's own difficult problems relating to the salmon question and after that by discussing the international questions regarding salmon that are problematic from Finland's point of view. As Finland is one of the countries that rears the most salmon smolts and fishes the most salmon in the Baltic Sea, this is no doubt justified.

2 NATIONAL QUESTIONS CAUSING PROBLEMS

2.1 The Problems of Stocking under Obligation

After the Second World War the reconstruction of the country required plenty of electric energy which was obtained by damming rivers that contained salmon and that emptied into the Gulf of Bothnia. As a result of the damming the River Kemijoki stock was lost and the River Iijoki stock was saved only as mother fish in fish farming facilities.

Finnish legal rules require that the party causing damage should fully compensate for the losses it has caused. In 1980 a final, legally valid, decision was made by which power plants were obliged to farm and stock smolts. The annual total quantity of smolts in the Rivers Kemijoki and Iijoki is almost 1.0 million per year.

In Finland it is also required that the parties suffering damage, in this case the coastal fishermen fishing in the Rivers Kemijoki and Iijoki, receive compensation for their losses by being allowed to fish reared fish that are full-grown and have migrated. This has not been realized at all adequately, as about 60-70% of the total catch originating from reared smolts is caught in the main basin of the Baltic Sea (mainly by other than Finnish fishermen) and only 10-15% is caught by the trapnets of fishermen who have suffered losses.

The fishermen who have suffered losses due to damming but who have profited from the stocking have suggested that, when stocking fish, salmon be replaced at least partly by sea-trout, so that their catches would grow. Would this be a feasible way to improve the profitability of fishing in the northern part of the Gulf of Bothnia and at the same time to ease the fishing pressure on the salmon stocks in the Baltic Sea?

2.2 National Restrictions on Salmon Fishing

In order to encourage wild salmon to migrate upstream in those rivers in a natural state flowing into the Gulf of Bothnia, Finland nationally restricted the salmon trapnet fishery on the coast of the Gulf of Bothnia in 1986-1991. However, Finnish fishermen who use trapnets considered the extra catching restrictions to be extremely unjust. For socio-economic as well as political reasons trapnet fishery restrictions were not maintained in 1992 and 1993. A working group set up by the Ministry of Agriculture and Forestry has to make proposals for regulatory measures concerning salmon fisheries in the Finnish zone.

According to our research institute, more salmon than hitherto have been able to migrate into the Rivers Torniojoki and Simojoki as a result of the restriction.

In order to protect wild salmon, the fishing of reared salmon has also had to be restricted. The costs of these restrictions on fishing have been compensated by government funds on the grounds that they are special restrictions directed at Finnish fishermen only; fishermen from the other Baltic countries have not been affected. The fact that large sums have been invested in salmon rearing and stocking and then the fishing of fish resulting from this stocking has been restricted has frustrated Finnish fishermen.

Wide support has been given in Finland to the idea that the Gulf of Bothnia could as a whole be released from quota restrictions concerning salmon fishing after a certain date every year (e.g. 15 July), since the wild salmon stocks of the area have by that date migrated to their spawning areas in rivers in a natural state, and the sea contains almost exclusively reared fish. These salmon cannot move upstream in the dammed rivers, so they should be caught as efficiently as possible in order to maximize the results of stocking and the economic profit.

3 INTERNATIONAL OPEN QUESTIONS

3.1 Sharing the Costs of Stocking Salmon

Finland took up this question at the 18th session of the IBSFC because the convention requires that when fish stocks have to be artificially replenished in an area belonging to the convention area, the parties are jointly and equally responsible for the resulting costs. Finland's initiative did not meet with much enthusiasm, nor did it lead to a very animated discussion.

The fact remains, however, that more than 90% of the salmon in the Baltic Sea originate from farming.

All the countries fish farmed salmon as well, although only Finland, Sweden and Latvia farm and stock substantial quantities of salmon, and the EEC pays a part of Sweden's farming costs and receives in exchange a defined salmon fishing quota in Sweden's economic zone. What should the shares of the other countries fishing salmon in the Baltic Sea be in this respect?

I wish to bring up this question - which is very important to Finland - also in this forum, although the matter is still pending at the Commission. I am not aware whether there are similar cases in any other parts of the world and, if there are, how they have been solved.

It is considered in Finland that the principle of state of origin adopted by the Law of the Sea is not realized adequately in this matter. In our opinion those countries in which the natural resources originate have the primary right to exploit them as well as the responsibility to preserve these natural resources.

3.2 The Salmon Stocks of Certain Rivers Remain Uncompensated

Once, some 70 rivers produced salmon that entered the Baltic Sea. Presumably, less than 20 of these rivers are left. The line of action in Finland has been to try to compensate by fully making up the losses of all rivers that formerly contained salmon by stocking. In Finland the quantity of stocked smolts is about 2 million per year.

There are rivers emptying into the Baltic Sea, especially in the south, which were earlier known as rivers where salmon bred. Finland finds it strange that no measures have been taken or planned to compensate for the losses caused by the damming and pollution of these rivers. In our view certain countries have thus run into debt to the Baltic salmon and salmon fishermen. When shall we see measures to remedy this situation?

3.3 The TAC as a Means of Regulation

The International Baltic Sea Fishery Commission tried - in vain - to agree on a TAC of salmon for 1974-1990. This succeeded finally for 1991. The Commission felt very satisfied, and the atmosphere was almost festive. After long and exhausting negotiations the TAC and its allocation between contracting parties was set, faultily based only on the realized catches of the individual countries in earlier years.

During the meeting in September 1990 none of the delegates or their experts had access to sufficient information about what had already happened in the Baltic Sea as regards salmon. The information needed concerned the following:

The smolt stockings of 1987 and 1988 which in Finland exceeded the normal amount; the larger average size of stocked smolts; the reduced mortality of the post-smolt phase; and the faster growth of salmon in the sea. All these factors worked in the same direction. As a result in 1990 a record-breaking total catch was made. Finland in particular benefited from the extensive stockings.

Once the entire situation became apparent to the Finnish authorities and salmon researchers, not much could be done for 1991 either. Fishing was stopped on 15 November 1991, but the catch quota had already been exceeded. The same happened again in 1992: fishing was stopped too late.

The situation is clear in the sense that Finland has twice committed itself to its quota (in order to save the poor compromise reached at the Commission) and then exceeded it. The same applies to our quota in the Gulf of Finland where nearly all the salmon are of stocked origin.

Finland expressed to the Commission its dissatisfaction with its insufficient quota, which had been defined without taking into account the large quantity of smolt stockings. In the previous years Finland had stocked salmon which it was not allowed to fish due to pressure from other member countries. In our opinion the same applies to Sweden, which in the past two years has stopped its salmon fishing, thus failing to gain fair advantage from its plantings.

The strangest aspect in our view is that the majority of the members of the Commission set a Baltic salmon quota in the Gulf of Finland for the three countries - Finland, Estonia and the Russian Federation - which can only fish in this area a separate stock in their own fishing zones and which countries opposed the setting of the quota!

In our opinion the above shows that the TAC is not a wholly viable way of regulating salmon fishing. It is poorly suited to a situation where all the salmon to be caught consist of reared fish.

It is considered very important in Finland that salmon of natural origin be protected. In this respect Finland has done much good work, particularly in collaboration with Sweden in the River Torniojoki.

The International Baltic Sea Fishery Commission is the central international organisation when attempting to create jointly accepted measures for regulating salmon fishing. Finland hopes that all countries will make their best possible salmon expertise available not only to the Commission but also to the working groups of ICES dealing with salmon.

DISCUSSION OF PAPERS BY MANAGERS

Mr Allen Peterson, National Marine Fisheries Service, USA, responded to the paper by Mr Lemche by making the following points:

1. Home water managers should not be seen as opponents of Greenland fishermen, but as members of a partnership whose responsibility is to resolve conflicting objectives in an equitable fashion.

2. The charge of cultural imperialism is not justified; the USA is concerned about the well-being of native peoples both outside and within its own borders.

3. The salmon programme is supported by many lay people.

4. The USA want to see a reduction in the catch at Greenland because the scientific assessment demonstrates that there is a problem with salmon stocks. This problem has been recognised in the restrictive measures taken by the home-water states. It is unfortunate that Greenland cannot itself recognise this from the decrease in catches in its own fishery.

Mr Orri Vigfusson, Association of Icelandic Fishing Clubs, considered that the salmon stock at West Greenland has been subject to heavy overfishing as shown by the marked decrease in catches. (The figures he cited for the catches by Greenland, however, were challenged as being incorrect by Mr Lemche.) He criticised Mr Lemche's argument that the traditional life-style of Greenlanders was being undermined, pointing out that there was no traditional fishery for salmon in Greenland. While Greenland is being asked to reduce its catch of salmon, he accepted that it would be appropriate for Greenland salmon quotas to be increased as the stocks improve.

Mr Lemche responded to Mr Peterson's comments on his paper by stating that it is not always easy to differentiate between the various partners in the debate.

The Chairman summarised his own views on the papers by managers by making two points. Firstly, although strong views are held as a result of the losses in income to some groups, and as a result of the expenses incurred in restorative measures, he pointed out that the perceptions of different user-groups are not always correct. Strong views are held by people who have never been in contact with the realities of the situation faced, for example, by fishing communities in Greenland, maritime Canada or Iceland. Equally, it is quite wrong to suppose that salmon fishing is still the preserve only of the wealthy components of society. Secondly, it should be recognised that different groups have a case that should be taken into consideration when trying to improve the present state of salmon resources.

Noting the effects of politicisation in other fora such as the International Whaling Commission, Mr Allen Peterson paid a tribute to ICES as a non-political body that has provided the rational basis on which judgments can be made. Although NASCO had started out with the intention of basing its decisions on ICES advice, he was concerned that NASCO had not responded correctly to the advice. He pointed out that if NASCO does not take the opportunities to take the necessary action, then future action will be controlled by extremists.

Mr Richard Behal, Federation of Irish Salmon and Sea-Trout Anglers, congratulated NASCO on setting up the Dialogue Meeting as a way of moving towards better understandings. He recognised, however, that a major area of mistrust lies between anglers and the fish farming industry. Using as his example the severe state of the sea trout fisheries off the Irish Coast which had been affected by lice infestation associated with salmon farms, he said that the concerns of anglers about disease and genetic threats to wild salmon stocks are simply not being recognised. He also pointed to the need for better local controls to safeguard the nursery grounds of salmon in the rivers.

The Chairman expanded on points made earlier about which countries are responsible for the production of salmon by stressing that there are two inseparable aspects to wild salmon production - the production that occurs on the feeding grounds and the production of smolts in the rivers.

Research Perspectives

Dr Vaughn Anthony, National Marine Fisheries Service, USA, presented a summary of the discussion seen from the perspective of the fishery scientist.

He considered that the status of the stocks in both the Atlantic and Baltic are well known from the work carried out by ICES Working Groups. He therefore challenged the view that the incompleteness of the data was one of the greatest constraints on effective management. While the scientific data required for management are available, he agreed that communication between scientists and fishermen has been poor and that scientists have failed in their responsibility to promote clear advice.

He accepted that the timing of the advice is a problem for managers, but did not accept that it would be appropriate to use other languages for the advice.

Dr Anthony identified a gap in knowledge about the causes of marine mortality, and suggested that poor growth caused by poor food supplies may be responsible. An important question is what salmon eat and what the status is of their prey populations. There also appear to be relationships between the abundance of certain fish populations and he suggested that sandeels may be one of the key species.

It appeared that the main marine mortality takes place primarily in the early post-smolt phase and that food and disease may be implicated. To investigate this further tracking studies are needed at sea as well as multispecies research and modelling studies. More research is also needed on smaller stock groups and on indicator rivers and, if real-time monitoring is to be possible, as it is in the Pacific, then more at-sea monitoring is required. He also commented on the problems of unreported catches (about a third of the total in the northeast Atlantic). In Dr Anthony's view hatcheries have not been successful. Their main usefulness appears to be for the restoration of lost stocks and even in that case it is probably better to release the fry before the first feeding stage has been reached. There are also indications that hatchery-reared salmon do not have the behavioural characteristics of wild salmon. In this connection NASCO needs to define its objectives in relation to the genetics of wild salmon.

Mixed fisheries are also a problem because of the need for different exploitation rates on stocks varying in productivity. Although there is a need to maximise returns and spread runs out through the year, there is also still a need to define minimum spawning targets.

Turning to the views of user-groups, Dr Anthony pointed out that various views had been expressed and that there are allocation and social problems. To solve these problems requires sociological, not just economic research to determine the social benefits of these fisheries. There is therefore a need for social scientists

Problems in salmon management that had not been mentioned were acid rain, the effects of diseases and parasites and the effect of fish farm escapees. In his view M-74 is unlikely to be caused by organochlorines because the syndrome is not of recent origin.

Finally, Dr Anthony commended the work of the scientists and identified the key questions in the list below that require further attention from scientists.

1. Where is science deficient for management - catch data, spawning targets in the North-east Atlantic?
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3. How can scientists communicate better?
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6. What should be the future use of hatcheries with respect to wild salmon?
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14. What is the economic value of smolt-producing and salmon-producing areas?

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Mr Kjartan Hoydal presented an overview of the discussion from the perspective of interception fisheries and oceanic management.

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The perspectives of offshore fishermen

Mr Kjartan Hoydal presented an overview of the discussion from the perspective of interception fisheries and oceanic management.

He began his presentation by reiterating the common interests of all those groups who use salmon, ie the preservation of healthy salmon stocks. Against this, however, there are a number of factors affecting salmon stocks, including:

a. power stations and other industries compete with salmon for the rivers;

b. anglers, netsmen and poachers compete for salmon in the rivers;

c. commercial fishermen, birds and seals compete for salmon in the sea phase;

d. industrial fisheries, other fish species and whales compete with salmon for food.

Assuming that there is a common interest and recognising the legitimate interests of other user-groups, Mr Hoydal agreed with Mr Magnus Magnusson's focussing on sustainable use, integrated management and partnership. In finding ways of resolving the conflicts, Mr Hoydal said that fair treatment is needed in all phases of the management process. In the scientific phase, it is important that ICES remains non-political. This has not always been the case with salmon, however, but the situation is now much improved.

In the NASCO convention, there is a recognition of the interests of the interception fisheries. There is equally an understanding on the part of the communities taking part in the interceptory fisheries that they can destroy the stocks for all users, but it is not so widely recognised that this is possible in the rivers as well.

If it is true that the interceptory fisheries do represent a threat to the stocks then the communities concerned would have to recognise this and if necessary accept reduced quotas. The main concern in the countries concerned, however, is the survival of the communities concerned and this has in some cases taken precedence over the concerns about the state of the fish stocks.

There has been a gradual acknowledgment of the right of communities to use the salmon stocks the existence of buy-out schemes effectively recognising the right to a share of the stocks and the right to compensation if they do not use that share. However, it should be recognised that the buy-out schemes are alien to the fishing communities.

The perspectives of the riparian users and anglers

Dr Derek Mills, Atlantic Salmon Trust, gave an overview of the discussion from the perspective of the riparian landowners and rod anglers.

In his presentation he listed the concerns of anglers and river proprietors that had emerged.

1. Drift-netting, particularly in northeast England;

2. Seals (in common with the Greenlanders);

3. Salmon farming and associated pollution and genetic problems;

4. *Gyrodactylus* and its recent spread to northern Finnish rivers;

5. Land use, particularly forestry and drainage;

6. Water abstraction schemes and hydroelectric plants;

7. Pollution and particularly M-74 and acid rain;

8. Illegal fishing;

9. Sawbills which were becoming an increasing problem.

As remedial measures he listed:

1. Habitat management;

2. Stock enhancement;

3. Quota purchase;

4. Netting buy-out schemes;

5. Catch and release fisheries.

In relation to all these factors there is a complex management web (Figure 1). In the case of all users of the salmon resource, however, there is a need for a commonality of understanding which can be enhanced by communication and education. There are also a number of common concerns among several user-groups, including the threats posed by seals, fisheries on food fisheries, eg industrial fisheries and etc. (Table 1).

Summing up

In his summing up, the Chairman considered that the flowchart in Figure 1 summarises most of the main points from the Dialogue Meeting and that the common concerns listed in Table 1 could act as a recognition of legitimate interests of the different user-groups and thereby form the basis for a joint approach in the attempt to reconcile the differing and often conflicting interests. In his view the source of many of the conflicts stems from a lack of understanding and awareness of the reality of the situation as it affects other user groups.

Table 1

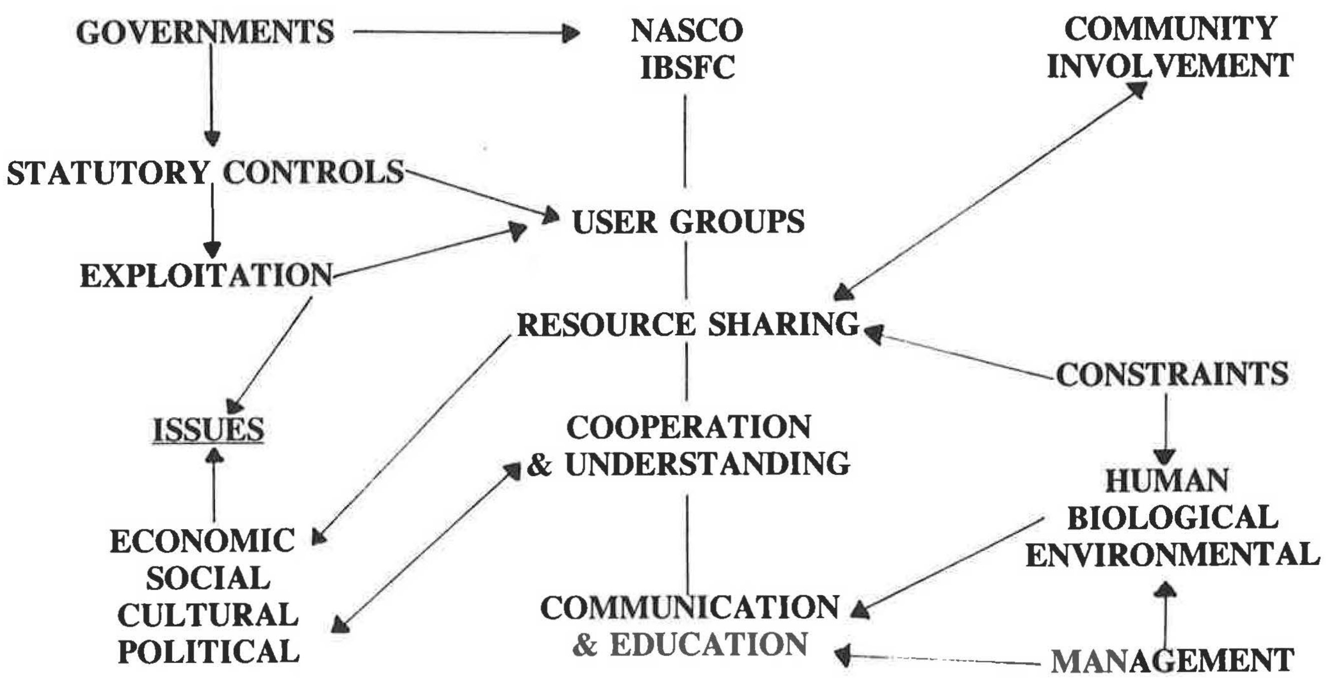
USER GROUPS

COMMON INTERESTS

	GREENLAND, FAROES	COASTAL	RIVER
WHALES	X	(X)	(X)
SEALS	X	X	X
SAWBILLS			X
FOOD SPP.	X	X	X
POLLUTION	X	X	X
"ANTIS"	X	X	X
MORE SALMON	X	X	X

AIM OF CONSERVATION IS TO PROMOTE SUSTAINABILITY

Figure 1



OPEN DISCUSSION

Mr Arni Isaksson, Institute of Freshwater Fisheries, Iceland, commented on the impact of sea ranching and farming of salmon. In Iceland there has been a ban on commercial fisheries for salmon in territorial waters for several decades and the only fisheries are terminal fisheries in the rivers. This has created the opportunity for commercial ranching of salmon and over 75% of the Icelandic salmon catch is now of ranched origin. Those who carry out ranching, however, require guarantees that the fish will not be excessively harvested on the feeding grounds. He also pointed out that in the convention on the law of the sea there is a "grazing-fee" principle which means that coastal states nurturing migrating stocks are entitled to a just fee for the service they provide. He considered that this principle needs to be addressed in order to achieve a fair sharing of the resource and that, when achieved, it will provide a measure of predictability for fishery managers and those ranching salmon. If ranching increases it may be difficult to base quotas on the productivity of rivers in the countries of origin. The original intention in the Icelandic sea ranching scheme was to promote multi-sea-winter fish, but this has now been abandoned in favour of the production of large 1-sea-winter salmon which are relatively safe from exploitation in interception fisheries.

Mr Orri Vigfusson corrected an earlier misunderstanding about the purpose of compensation schemes. He said that there was no intention to prevent local communities from having work and that, in Iceland, compensation is designed to create alternative employment and development schemes to help those who give up the right to fish.

Mr Bob Williamson, The Scottish Office Agriculture and Fisheries Department (Inspectorate of Salmon Fisheries), said that any major development in ranching in the Atlantic coupled with the imposition of a ranching or grazing fee could cause the same problems as those in the Baltic because wild stocks may be badly affected by a fishery that is sustained by large-scale stocking. The Chairman followed this comment up by asking whether restocking (hatcheries) and ranching do not in fact create more problems than opportunities.

In response, Mr Arni Isaksson said that it is not the intention of ranching to supply the offshore interception fisheries with large extra quantities of fish. The idea is that a "grazing fee" should be no larger than is necessary to protect the smallest wild stocks. When the fish enter Greenland waters they are already 2-3 kg and they grow in their second sea winter. He therefore felt that it is necessary to solve the anticipated problems of ranching before they arise. To solve the problems, a formula is needed to take wild stocks into account but there should be no increase in quotas to allow for ranched fish.

Dr John Anderson drew a distinction between fish farm escapees and fish released for stock enhancement. In the former case, the genetic composition of the fish has been changed out of all recognition from that of the original wild stock. The potential for genetic "pollution" is thus very real when cultured fish interbreed with wild fish. Sea ranching based on hatchery-reared fish, on the other hand, does not pose the same problem because the parents have been subjected to the same natural selection processes as wild fish. Thus enhancement based on hatchery fish does not pose the same problems and it has already been in existence in practice for over 100 years.

Mr John Browne, Fisheries Research Centre, Ireland, agreed that sea ranching for rehabilitation purposes has not made any difference in home waters. He nevertheless saw the concept of large-scale releases of smolts at the mouth of rivers for ranching purposes as creating a problem because it will attract increased exploitation and predation of wild stocks in home waters as well as in offshore interception fisheries.

Mr Sofus Poulsen, the Faroese Commercial Attaché in Scotland, said that he believed there is a lack of understanding of small communities, for example at the Faroes and Greenland and other countries. For a future Dialogue Meeting, he suggested that an evaluation of the situation in these communities should be carried out and that this could be backed up, for example, by the production of video-films of each community.

In view of the different views expressed about hatcheries, Mr Einar Lemche asked for a clear answer to the question of whether hatchery fish are a problem or not.

Mr M Jørgensen said that in his view hatcheries create a problem, but they are at present necessary to maintain reasonable stock levels both for anglers and coastal fishermen.

Mr Derek Mills pointed out that some rivers which had lost their salmon entirely have been restored by means of hatchery fish and cited the example of the River Thames. Wherever juvenile production can be increased by habitat management that would be preferable, but there are many rivers in which hatcheries are of value so long as the source of the fish is appropriate. He mentioned the example of some Faroese rivers that had never had salmon which have been stocked by fish from Iceland.

Dr Ken Whelan, Salmon Research Trust, Ireland, said that it is rearing stations for smolts that create the problems not hatcheries. To avoid misunderstandings, he suggested that there need to be clearer definitions of some of the terms used:

a. "Fish farming" is commercial pen rearing for the whole life of the salmon;

b. "Ranching" has been carried out for a number of purposes and it is ranching for enhancement of spawning stocks, ie smolt release at the mouths of rivers, that has been a failure. A better definition of ranching is needed to restrict its meaning to the provision of fish for the sea fisheries and angling for commercial purposes.

c. "Enhancement" is a better term for stocking with eggs, fry or parr, the objective of which is to improve spawning stocks.

Admiral John MacKenzie supported Mr Whelan and said that the Atlantic Salmon Trust had reached the conclusion that the source of the broodstock needs to be carefully controlled and that it is essential to use fish from the same river. He also asked anglers not to pressurize managers to set up hatcheries.

Dr Jamie Geiger, US Fish and Wildlife Service, said that hatcheries are just a tool and that some of the problems have resulted from their improper use and design. Hatcheries have a value when they are based on sound scientific principles and it should be recognised that their existence played an important part in the development of aquaculture. Aquaculture also has an important place in its own right, not just for commercial rearing purposes, but also in the development of fish health and in toxicological and disease research. The real problems in salmon management are in the science (stock status, ecosystem perspective) and in the lack of political will.

Mr Sakari Kuikka said that rearing removes the dangers of the stock-recruitment relationship and that it is very important in relation to the mixed fisheries.

Mr Allen Peterson said that ranching/aquaculture is in his view the biggest single threat to wild salmon populations and that a longer-term view is needed. In his view there is an inevitability about the development of ranching and therefore he considered that we need to know what it means for wild salmon in the future. It may also not be possible for wild salmon populations and ranching ultimately to coexist unless a decision is made to protect wild salmon. A decision is therefore needed now whether wild salmon stocks are wanted, and if so whether society is prepared to pay the price.

The Chairman asked if sea ranching should only be considered as a medium-term restorative measure or if it should be considered as an integral component of salmon management strategy.

Dr Vaughn Anthony recognised that hatcheries will continue but stressed that great care is needed if they are to be used in sustaining the truly wild strains of salmon because of the genetic problems inherent in using exotic fish (ie fish from other rivers) for this purpose. He pointed out, for example, that return rates from hatcheries have tended to be very poor. He also made the additional comment that he disagreed with an earlier speaker who had suggested that the main problems of salmon management lay in inadequate science.

Dr Michael Vickers said that the principles of hatcheries set out by Samuel Wilmot in the 1860s had been used to restore stocks in some North American rivers. While agreeing that ranching and salmon farming will undoubtedly continue, he referred to a resolution passed at an international salmon symposium in 1986 that wild salmon should be preserved for recreational purposes. He asked what had led Iceland to move away from commercial netting in the 1930s and what is needed to get a similar change in the United Kingdom.

The Chairman pointed out that many of the issues raised by the previous speaker and others were national issues.

Mr Pekka Niskanen, addressing the question of whether ranching is only an interim measure, said that this would not be the case in the Baltic because over 90% of the salmon there are now of reared origin and ranching must continue to maintain the fishery. Although a simplistic solution to the problem of protecting the wild stocks in the Baltic might be to stop ranching, this is not possible because of the number of fishermen dependent on the salmon fishery. In the IBSFC there has been an attempt to find a compromise but so far this has not been successful. TACs on their own have not been successful because of overshooting (in Finland by 100% in the two years in which there has been a TAC). In his view, Individual Transferable Quotas (ITQs) are more likely to be successful in the Baltic - but they would have to be accepted by all countries fishing the Baltic salmon stocks.

The Chairman then announced that the next theme in the discussion would be the allocation of the resource and the accommodation of the aspirations and needs of the different user-groups. He asked how a dialogue can begin on this.

Mr John Browne said that the scientists' role is to produce data and that, if there is to be a dialogue on the issues raised at the meeting, it is important that they do not take sides. There could thus be a danger in scientists making too strong statements about management.

Admiral MacKenzie agreed with Mr Browne but said that managers must not delay action until scientists have provided the proof of their conclusions and that they, the managers, must be prepared to take risks.

Mr Mogens Jorgensen said that dialogue cannot go on for ever and that ultimately the dialogue must result in action.

The Chairman said that the scientific advice must be objective and independent but he agreed that the clarity of the advice can be improved to avoid vague statements and to provide a clearer message. To this end he said that clearer writing is needed. To improve the scientific advice he advocated the provision of confidence limits on the advice which indicate the risk limits to managers. For this reason the scientists also need to spell out the deficiencies in the data and the assumptions on which the advice is based.

Mr Kjartan Hoydal said that ICES had wisely agreed some years ago to move away from giving what was termed "normative" advice to giving "exploratory" advice, a move which protected the scientists from being involved in the political process. In response to calls for urgent action, he asked for clarification of the need for urgency and of what sort of action should be taken.

Admiral MacKenzie said that, in Scotland at least, the managers do not have the necessary legislative powers to curb exploitation if it appears to be necessary. In his view, the need for action is clearly demonstrated by the decline in catch in the North Atlantic.

Mr Bob Williamson said that the claim that there is a lack of powers to take emergency action in Scotland is not correct. Drift-netting was stopped in Scotland, for example, whereas it has not been stopped in England.

Mr Michael Breathnach said that the allocation of the resource depends on national objectives and that priorities differ between countries. In Ireland, the creation of employment is important, eg. by means of tourism and sport fisheries. In terms of management, Ireland differs from Scotland, for example, in that very few river managers own the fishing. Also the regional fishery boards have powers and responsibilities for conservation, development, management and protection.

Mr Jim Maxwell said that there is a clear correlation between the incidence of sea lice, particularly on sea trout, and the increase in the number of salmon farms. The salmon farmers had been asked to give an optimum distance between cages to prevent the spread of the lice. As this problem is now serious there is an urgent need for controls.

Captain Jeremy Read, Atlantic Salmon Trust, said that, in view of the need for more information on the behaviour and feeding of salmon in the marine phase a proposal for a collaborative project using a British research vessel and international financial support had been formally put forward to NASCO.

Mr Jan Arge Jacobsen supported this and said that research on the marine phase of salmon can help to understand the effects of the mixed fisheries.

Mr Tom Barnes, Salmon and Trout Association, said that there is an imbalance between the commercial and rod fishing interests in the United Kingdom, the latter creating about 90% of the income from less than 50% of the catch. He stated that the NASCO policy with regard to drift-net fishing is not clear and he could not understand why NASCO would not support conservation organisations such as the one he represented in their representations to Ministers to reduce the North-east English drift-net fishery over a much shorter period than the 30 years proposed. He therefore asked NASCO to make a statement that they do not approve of interception fisheries.

Impressions by Bjørnur Pettersen, President of NASCO

I was glad when I heard Mr Magnus Magnusson use the notions "sustainable management" and the "precautionary principle". But, is it possible to use the natural resources in a sustainable context? To be more specific - is it possible to manage the wild stocks of salmon with sustainability?

After one and a half days of dialogue, I can draw one conclusion: there are a lot of feelings present in the dialogue on the wild salmon. There is nothing wrong with feelings - but if the purpose of a dialogue is to build up a common ground of understanding and action, we all have to move beyond the area of feelings.

One year back - in June 1992 - most contracting parties to NASCO and IBSFC signed the Convention of Biological Diversity in Rio. That is, and will be for time to come, a major document for all contracting parties. To manage the wild stocks of salmon in a sustainable way is an important part of what the nations of the world agreed in Rio. One of the researchers pointed out yesterday that there must be sustainable naturally-reproducing stocks of wild salmon. Therefore, we must sense the reality - to know the state of the wild stocks at any point in time. But that is not an issue in itself.

We must not collect data simply for the sake of collecting data. I am very aware of the gaps that exist between collecting information and assessing it - and being able to use it as a management tool. Surely our focus must be on providing early warning, getting the information to those who need it, when they need it and in a format which can be used to support sound decision-making both in NASCO, IBSFC and in our domestic fields.

Sustainable management of wild salmon demands us all to make decisions on behalf of the diversity of the stocks and for generations to come and for the benefit of anglers and commercial fishermen. Sustainable management must, therefore, be built on the precautionary principle. We can harvest the profit of natural production, but never use the basic capital. It also means that we all have to act on behalf of the wild salmon stocks - when facts are scarce.

Most of the main issues mentioned in this first Dialogue Meeting are on the agenda of the NASCO Council meeting. In this respect, the Dialogue Meeting has been an important prelude to NASCO's Tenth annual meeting. As Malcolm Windsor put it, NASCO is not going to be a salmon CONVERSATION organization.

We already have substantial knowledge of the main threats and problems with Atlantic salmon stocks. The Dialogue Meeting has demonstrated and strengthened our knowledge about the threats and poor status of Atlantic salmon. Therefore, the time has come to move further in our efforts.

We must take action based on available facts and on the precautionary principle to build a sustainable conservation policy, which fits the main principles in environmental policy in other important issues we are facing for our common future.

This has been a most interesting and useful meeting. I am greatly encouraged by the international support there is to conserve the wild salmon. I am impressed by the breadth of knowledge and experience in this room. You have all given us much new information, ideas and food for thought. I can assure you that the NASCO organization will take this very seriously. We will look very carefully at all the views expressed here and I know that our Secretary will bring this back to our Council so that we can respond effectively. As many of you know we have the will in NASCO to act, we have the cooperation at an international level and we have built an Organization with a good spirit. So I can promise you that your contribution will be taken forward.

Impressions by Mr. Pekka Iskanen, President of IBSFC

I am not quite sure if impressions of the meeting are needed from myself personally or in my capacity as Chairman of IBSFC. But, either way I have some remarks regarding our one and half day meeting. Firstly, this meeting has been far better than I expected. We have had frank speaking and exchange of views. We have had more information than I expected and we have also highlighted the differences between the Atlantic and the Baltic. This meeting has been a most stimulating dialogue. It is clear that there are real problems facing the Baltic salmon and that difficult decisions will have to taken in the Baltic Commission to meet its objectives to save the wild salmon stocks. To save wild salmon stocks is almost the only common feature we have in these two areas because in the Atlantic you have a lot of problems; so do we in the Baltic, but our problems are different from yours.

In the Baltic you could see the Baltic basin as a huge rearing facility because we have to sustain viable salmon stocks for commercial fisheries. We are facing in the Baltic a new threat which has been referred to earlier - M-74. This was detected in 1974, but in recent years it has become more serious. Finland and Sweden are the main stocking states for artificial smolts in the Baltic; also Latvia has its share. But we have a great difference in our methods of salmon stocking. In Sweden they rear their smolts directly from the eggs of wild salmon. In Finland we have broodstocks in hatcheries. Earlier it was mentioned that to have only broodstocks would narrow the genetic diversity, which it certainly does, but in Finland we renew our broodstocks from time to time so as to preserve these genetic strains. Now M-74 has shown that in Finland we are more on the safe side than today in Sweden because M-74 is severely attacking the wild eggs, but our broodstocks are saved from this disorder.

Mr Chairman, I have learned something from this meeting, and that is that this kind of dialogue should also be held in the Baltic context only. We have had only one and a half days and we have had very broad discussions of very many problems. So, in a sense, we have just scratched the surface. In the Baltic we should also have a dialogue with all interested parties - administrators, scientists, users and so on and therefore I am going to pursue the possibility that this kind of meeting should also take place there. Thank you, Mr Chairman.

Impressions by Dr David Griffith, President of ICES

For me the meeting identified several things and, above all, the recognition that this is really only a beginning. I would not pretend for a moment that this is the first time that people have identified the problems we have talked about, but I meant a beginning in bringing everyone together in an open atmosphere, where the difficulties, fears and misunderstandings and real problems can be identified and shared, so that we can go forward together to attempt to put in place a shared solution. That will not be easy so we must recognise the difficulties that face us as well as the targets and the ways of achieving our objectives.

I suppose the phrase that would encapsulate what I feel about the conference is the term the "multispecies approach". We heard of that with regard to the marine ecosystems, but I am talking of it not only in that regard but also including mankind as a "species" in the multispecies approach, including the human communities dependent on, or involved in some way with the salmon resource and its management, sustenance and harvesting. We must define objectives and, when I say we in these remarks, I mean all the user groups and all the responsibility groups - the scientific advisers, the managers, the politicians, the administrators, the fishermen themselves. We must define objectives, realisable objectives, not just what we call motherhood and apple pie objectives that everybody agrees with but they are somebody else's responsibility and we do not need to do any work to achieve them. We must define realisable objectives and they must be defined not only in a way which makes it clear what they are, but in a way which allows one to see what must be done to achieve them. The objectives must establish who benefits, and they must be defined in such a way that progress towards them can be measured and the resources must be made available, and the commitment put in, to measure that progress towards the objectives and the targets.

Concepts seem to have evolved during the Dialogue Meeting from the way they were first presented to the feelings that have been expressed this morning. There has been an evolutionary process, I think, even over the short space of time we have been here. They have evolved to a point where the different user-groups are at least more aware of each other's needs, each other's aspirations, and the respective opportunities for action to reconcile interests which have often been in conflict and to some extent still are in conflict, but which need not be and indeed cannot remain in conflict if we are to rebuild the North Atlantic salmon stock to levels where all user aspirations can be accommodated. I would quote John Anderson's paper in which he says "Society must decide how best to use the resource", and in that regard I would bring you back to the very beginning to Magnus Magnusson's splendid introduction. Magnus Magnusson went on to say "It is vital that all the users of the salmon are accommodated as far as is reasonably possible and that agreement be reached. Where necessary, compromises will need to be made in the quest for reconciliation of conflicting demands. We must seek to share.

In conclusion, I would point out that all this represents a challenge which must be met head on. It will not go away. It calls for more dialogue but above all it calls for action. We must have the two running side by side - continue the dialogue and continue and initiate fresh action. It also calls for the financial and political commitment to finish the job. It will not be done for free; it will not be done without courageous political commitment and that involves money as well. It is your money and it is mine too, but that is what it calls for to finish the job. And it is up to all of us here, the scientists, the different user-groups, the managers, the administrators and the facilitators, if I can refer to NASCO and similar organisations in those terms. It is up to all of us here to ensure that those commitments are met.

Thank you all very much for your participation.

Dr Malcolm Windsor, Secretary of NASCO

In closing the Dialogue Meeting, Dr Windsor thanked Mr Griffith for chairing the meeting and closed the open session of the NASCO meeting at 14.30 hrs.

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