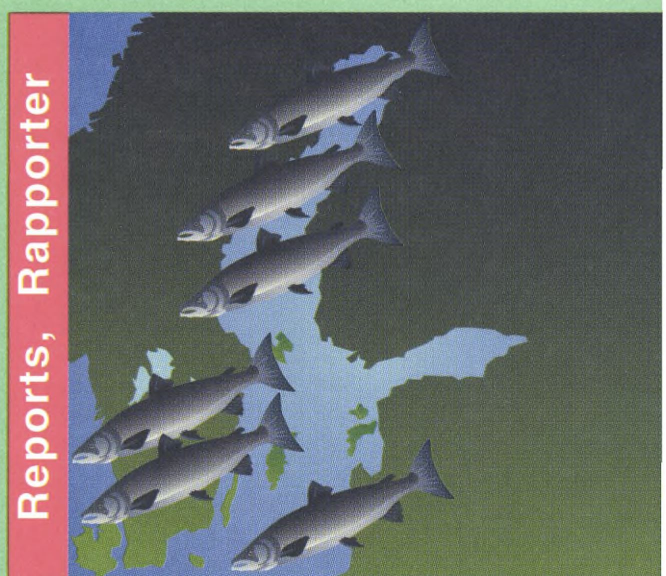
THE BALTIC SALMON 1995

The situation of the natural salmon stocks in the Baltic.



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Introduction

In a decision of 30 March 1995, the Government commissioned the National Board of Fisheries, in consultation with the National Environmental Protection Agency, to compile documentation concerning the situation of naturally reproducing salmon in the Baltic Sea.

Original Baltic natural salmon has been severely decimated during the 20th century owing to the expansion of hydroelectric power in their growing waters. There used to be a natural occurrence of salmon in about 70 watercourses round the Baltic Sea. Natural salmon populations remain today in about 26 rivers (14 Swedish, 1 Swedish-Finnish, 1 Finnish and the rest Baltic).

A comprehensive compensatory programme has been built up for the harnessed rivers as a replacement for the natural salmon production that has disappeared with the expansion of hydroelectric power. Salmon reproduction in the harnessed river is replaced through this programme by rearing of young salmon up to the size when they normally go out to sea. Today only one salmon in ten in the Baltic Sea is a natural salmon, while the rest are reared. Reared salmon has other characteristics than those that originally were favourable in natural conditions. From having coped with river life for 1-4 years before migrating out to sea, the salmon has changed to a form partially adapted to rearing, with a modified genetic base. By artificially maintaining salmon stocks in the Baltic Sea at a constantly high numerical level, salmon fishery has been able to continue and has even been intensified. Natural salmon is then caught to an equally great extent as cultivated.

Adult salmon remain in the Baltic Sea for a great part of their growth period. The longer it takes the salmon to return to natural spawning waters in the river, the more it is exploited. Estimates show that no more than a quarter of the possible production of natural salmon round the Baltic Sea is used, which can be regarded as a waste of resources, in both the short and the long term.

Internationally determined catch quotas in the Baltic Sea, together with measures taken by the National Board of Fisheries in the form of closed seasons, closed areas, restrictions on gear and redemption of fishing traps, resulted in an increase of natural salmon stocks from the end of the 1980's. The situation deteriorated, however, when M74 struck salmon stocks in 1992-93. One decisive problem is that salmon is caught internationally. Even though its spawning rivers are exclusively in Sweden, and to some extent in Finland and the Baltic states, it migrates to sea and resides as an adult all over the Baltic Sea. Swedish restrictions and efforts alone are therefore not sufficient. Swedish measures must be combined with reduced international exploitation of natural salmon in all areas. The strain on the Baltic Sea of environmental pollution is at the same time an international problem.

GOALS FOR SALMON FISHING CONSERVATION

It is the view of the National Board of Fisheries that the goal for salmon fishing conservation should in the short term be to eliminate the acute threat to genetic depletion or direct extinction that the majority of wild salmon stocks live under. In the long term the goal should be to use the entire reproduction potential of the salmon rivers while att the same time making better use of growth potential. Providing full use was made of the reproduction potential of the rivers, a further one million smolt could be produced, which would increase salmon catches by about 1 000 tons. If the average weight of the salmon caught rose by one kilo, a further 1 000 tons or so could be caught annually. In the event that the acute threats can be averted, it should eventually be possible to combine the preservation of wild salmon with substantially increased salmon fishing.

2. Biology of the Salmon.

Salmon (Salmo salar) occurs naturally along the coasts of western Europe from northern Spain to the Arctic Ocean. There are in addition isolated stocks of salmon living without contact with the sea, in Lake Vänern for example. About 8000 years ago, during the Ancylus period, the Baltic Sea salmon was separated from the Atlantic salmon. Baltic Sea salmon thus differs from Atlantic salmon, which is found among other places on the west coast of Sweden.

Salmon spawn in rapidly flowing stretches of rivers and larger streams. Spawning takes place in the autumn, earlier the further north in the country the river runs. While salmon spawning occurs at the end of September in the river Torne älv, it spawns at the beginning of November in the MîrrumsÜn. The eggs are quickly fertilized in the water and are then covered with gravel and stone by the female. The gravel riverbeds serve as an external womb that brood on the eggs during the winter. The eggs develop very slowly in the cold water, but accelerate during the spring.From February to May the eggs are hatched and a little fish fry with a large yolk sac appears. For almost a month the fry remains in the gravel bed and consumes its "provisions". It gradually learns to eat external food and creeps up out of the gravel.

The young salmon (parr) struggles to find a good place on the river bed that provides protection from the current. For the entire river stage of the salmon its food consists mainly of insects and other small bugs that drift with the water. In this way the young salmon lives in the river, normally for 2-3 (1-4) years, in constant strife with other young salmon for the best station. When the salmon has become 10-18 cms long it migrates to the sea as smolt (migratory young salmon) in order to find larger foodstuff than drifting insects. This is an important adjustment and the young salmon undergoes a number of processes, so-called smoltifying, that adapt it to a new life at sea. Smolt migration occurs during the spring (April-June) and involves considerable risks, since predators such as pike, burbot and cod line the route out to sea.

Once out at sea the salmon gradually progresses to eating fish (at first smaller quarry such as stickleback, then herring, sand launce, sprat) and grows rapidly. After the period at sea, which can last anything from one to four years, the salmon returns to its home river to spawn. Owing to the great intensity in the fishery, the salmon can only in exceptional cases reappear to spawn again. spawning migration from the sea to the river starts in April-May. This migration takes place relatively near the coast and the Baltic Sea salmon is thus subjected to coastal fishery along the entire coast of the Gulf of Bothnia. The salmon's spawn migration is a fantastic achievement in that individual fish so precisely seek out their home river and even the stretch of river where they were born. This instinct, called homing, means that local stocks easily arise as there is little exchange of genes with adjacent populations.

When the salmon fails to find its home river it is usually said to have strayed. Cultivated salmon stray to a greater extent than wild salmon. The factors that influence homing ability and the proportion that stray are, distance to nearby rivers, water pollution in the home river relative to neighbouring rivers, size of population, total length of migration, time and starting point of migration and time of return migration.

On returning to the home river the salmon seek out a suitable bed, dig a hole and together lay eggs and milt. Each female salmon produces in the order of 1 000-1 500 eggs per kilo body weight. Survival from egg to smolt is usually 0.5-5%. Survival from smolt to adult salmon is normally in the 10-20% interval.

3. Salmon genetics

3.1 Heredity and environment

Heredity factors are stored in the chromosomes as specific DNA sequences. They occur as functional units, genes, which govern the characteristics of the individual. Each gene has a special place in the chromosomes, a locus. Since chromosomes occur in pairs, inherited from the father and mother respectively, the individual has two genes in each locus. An individual can have two identical genes in a locus and is then homozygote. The two genes in a locus may differ somewhat with regard to the DNA sequence and are then called allelic genes (alleles). An individual with two alleles in a locus is heterozygote. Within the species there may be several alleles in a locus, i.e. the gene exists in a number of variants. It is this genetic variation that is fundamental to the evolutionary potential of the population and the species.

A particular gene can give rise to a particular characteristic in the individual, but usually it is several interacting genes that form the basis of the individual's characteristics. It is, however, not only the individual's genetic material, genotype, that is manifested in nature. The genotype, together with the environment, forms the phenotype, i.e. the individual's characteristics. The individual may for example have a certain genetic disposition to grow rapidly, but this is manifested only if the environment allows it, i.e. if temperature and food are adequate.

A population consists of a number of individuals with similar, but yet different, sets of genes that live in the same environment. However, the environment is not homogeneous, but varies both in time and place. Individuals that are successful, i.e. get many offspring, in a certain environment may fare worse in another. Genetic differences between individuals are therefore very important for the population, since the variation permits adaptation to a heterogeneous environment and future changes in environment.

3.2 Salmon populations of the Baltic area

Baltic salmon has distinct genetic differences compared with Atlantic salmon, which is found among other places on the west coast of Sweden. There are even genetic differences between Baltic salmon from different rivers. The salmon's pronounced homing behavior, which makes it return to its birthplace to spawn, has entailed the evolution of a unique salmon population in each river and even in parts of rivers. Each salmon population has thus adapted to its own unique environment through natural selection.

The existence of genetically different populations makes the salmon vulnerable to genetic drift and inbreeding. Genetic drift is random changes in the population's genetic composition and can result in genetic variation being lost. Both genetic drift and inbreeding are strongly dependent on the genetically effective population size. The smaller the genetically effective population the greater the risk. In recent times the risk of genetic drift and inbreeding in the wild salmon populations of the Baltic has increased, as the number of naturally reproducing salmon has declined dramatically.

In most rivers the salmon's natural reproduction has been severely disturbed by the expansion of hydroelectric power, and the salmon populations there are principally maintained by hatchery rearing and release of smolt. A considerably greater number of individuals survive in the hatchery due to the protected environment. This means that salmon which would have been subjected to natural selection survive. Moreover, individuals that are adapted to the hatchery environment are favoured. The high rate of survival and the unnatural environment mean that a reared salmon population in the long run possesses an ever declining ability for natural adaptation.

Thus wild and reared salmon are found together in the Baltic, and the reared comprise the definitely greater part. The present tendency is for the proportion of wild salmon to become smaller and smaller. Owing to this there is a great risk that the wild (naturally reproducing) salmon will be genetically impoverished.

3.3 Current threats to the genetic variation of Baltic salmon

The all too intense fishery has long been a threat to the wild salmon populations. Far too few mature salmon have reached the reproduction areas in the rivers. This has led to a continuously declining genetically effective population size up to the end of the 1980's, when the intensity of fishery was reduced and there were chances of recovery for the wild salmon populations.

Then, however, another threat was aggravated, the dramatic fry mortality called M74. In the period from 1992-1994 only 5-45% of the female salmon in the Swedish hatcheries have had offspring that have survived the alevin stage. The situation for wild salmon is probably just as serious. Even though the number of wild juveniles has not declined to a corresponding extent (due to lack of competition) the proportion of salmon that has been successful in reproduction is probably not greater among the wild salmon than among the reared, i.e. the genetically effective population has been dramatically reduced.

Other threats are acidification and other pollutions and stocking of reared salmon. Yet another threat to the wild Baltic salmon has recently been observed: hybridization with brown trout. In the MîrrumsÜn, EmÜn and Dalälven rivers the proportion of hybrids among naturally producing juveniles has been measured at 20-50% in recent years. Since the hybrids are sterile the crossbreeding of salmon and brown trout means that genetic material is wasted and the genetically effective population becomes smaller.

3.4 Conservation of genetic resources

The loss of genetic variation is in practice an irreversible process. A population that is genetically impoverished runs a greater risk of becoming extinct as its natural ability to adapt gets weaker. The loss or genetic impoverishment of an specific salmon population also entails impoverishment of the species.

There are clear reasons for conserving genetic variation, both within and between populations of Baltic salmon. Variation is a prerequisite for the future survival of the salmon, and also for the salmon's potential as regards exploitation. As things are at present, vigorous efforts must be made to eliminate or reduce the threats to the genetic diversity of the Baltic salmon. Since the causes of neither M74 nor hybridization have been explained, the only practicable way in the short run is to adjust the fishery so that each specific population is exploited without its genetic variation being jeopardized.

In parallel with measures that lead to vigorous natural wild salmon populations, gene banks should be secured for each salmon population. This is in order to meet both the present threat and possible future threats. The gene banks should be built up with the broadest possible genetic base and comprise both reared fish and deep-frozen milt.

4. Natural salmon stocks.

4.1 General

Of the Baltic Sea area's previous 70 or so rivers with natural salmon reproduction, there now remain only some 20, principally in Sweden and in Latvia (Figure 1). In Sweden we have natural salmon reproduction in 14 rivers. Of these 11 are in the Bothnian Bay area of Sweden, one is in Finland, in addition to the shared river Torne älv, one in the Bothninan Sea area (Ljungan) and two in the Baltic Main Basin (Emån and Mörrumsån). In the Bothnian Bay area there is also the Simojoki in Finland and in the Baltic Main Basin area ten or so rivers, above all in Latvia. Most of the latter rivers have weak reproduction. It appears from this that Sweden has the greatest remaining potential of naturally produced Baltic salmon.

Figure 1. Remaining watercourses with wild salmon reproduction in the Baltic Sea (thick line). This figure is enlarged in the appendix.

4.2 Salmon rivers in the Bothnian Bay area

4.2.1 General

The natural salmon rivers in the Bothnian Bay area can be divided among

a) larger mountain rivers: Torne älv, Kalix älv, Pite älv and Vindelälven.

b) inland rivers: Råne älv, Åby älv, Byske älv, Sävarån, Rickleån, Öre älv and Lögde älv. In addition there are a few rivers where an introduction of salmon has been made in recent years: Sangis älv, Lillpiteälv, Kåge älv, Bure älv and Hörnån. The potential production of smolt in the Bothnian Bay rivers can be estimated to be over one million smolt.

4.2.2 Spawning stocks

Salmon catches and spawning stocks in the rivers gradually declined from the 1950's up to the end of the 1980's. Widespread sea fishery was the cause. Coastal fishery has then taken yet another share. The proportion of river fishing has declined from 15-20% in the 1930's and 1940's to just a few per cent from the 1970's and onwards. (Karlsson and Karlström 1994).

Since the end of the 1980's there has been a clear rise in salmon catches in the rivers and the salmon catches there have multiplied (figure 2). The cause can be attributed to the implementation of restrictions in the salmon fishery, of which the most important are as follows. Regulation of salmon fishery was introduced in Swedish rivers carrying natural salmon and river mouths from 1983, agreement on the so-called white zone in the Baltic was reached in 1988, pre-summer protection was introduced along the Finnish coast from 1986 (suspended in certain years) and a total allowable catch

(TAC) of salmon was introduced from 1991 in the entire Baltic area. In addition there are biological factors such as good smolt survival and good growth conditions in the Baltic for certain years, as well as a periodic general decline in fishing intensity.

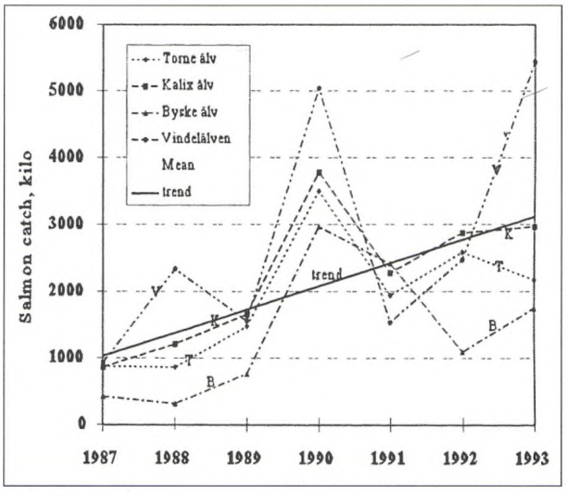

Figure 2. Salmon catches (kilo) in the river Torne Älv (Swedish catch), Kalix älv, Byske Älv and Vindelälven (fishway) in 1987-93. (Karlström 1995 b). This figure is enlarged in the appendix.

4.2.3 Reproduction

The density of parr was low in all rivers in the 1970's and 1980's (figure 3). From the 1989 hatching year class until the 1991 year class the density of young salmon rose. In some rivers the rise began as early as the 1988 generation.

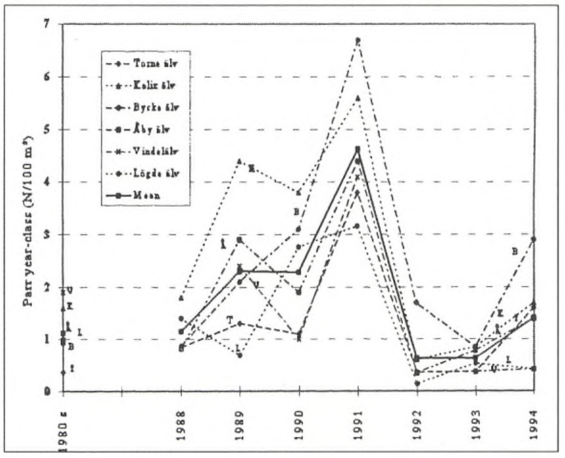

Figure 3. Generation strength in Torne älv, Kalix älv, Åby älv, Byske älv, Vindelälven and Lögde älv. Hatching generations 1988-94. The details below the figure show the smolt migration year for the generation (3-year old smolt) and the year of ascent of spawning fish for the generation (2-3 years at sea). (Karlström 1995a, b). This figure is enlarged in the appendix.

There is a clear connection between the increased salmon parr densities and the rise in spawning stocks in the rivers for the period 1988-91 (figure 4). The rise in spawning stocks has thus had a direct response in increased reproduction.

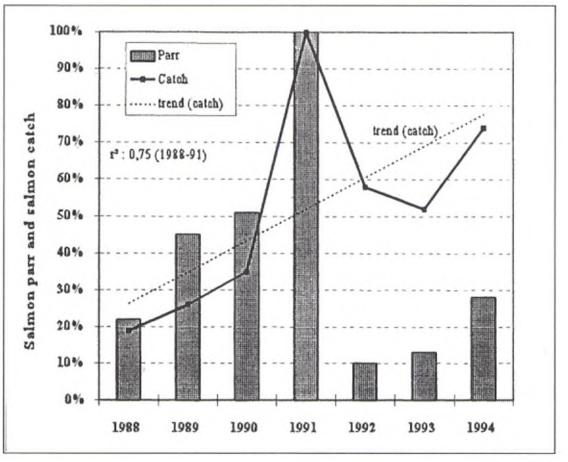

Figure 4. Parr year-classes 1988-94 and corresponding salmon catch the year before in the rivers Torne Älv, Kalix Älv, Byske Älv, Vindelälven and Lödge Älv. Relative values. (Karlström 1995 b). This figure is enlarged in the appendix.

The salmon parr year classes are again weak from hatching year class 1992, although the number of spawning fish has not declined and the decrease can thus not be explained by reduced spawning stocks. The 1992 and 1993 year classes are especially poor. The 1994 generation is better for most rivers, though not for Vindelälven, Öre älv and Lögde älv (Figure 3). Preliminary data from Torne älv indicates that the 1995 year class is poorer than that of 1994 but not as small as the extremely poor years of 1992-93. Preliminary data from Byske älv shows the 1995 year class to be roughly like the 1994 year class (Karlström 1995c).

The decrease in the salmon parr densities occurred at the same time as the so-called "M74 syndrome", with high mortality among salmon alevins, struck the Swedish salmon farms in the Baltic area. There is a good correlation (r2: 0.78) between reproduction in the rivers (adjusted to the size of spawning stocks) and M74 mortality in the salmon hatcheries (Figure 5).

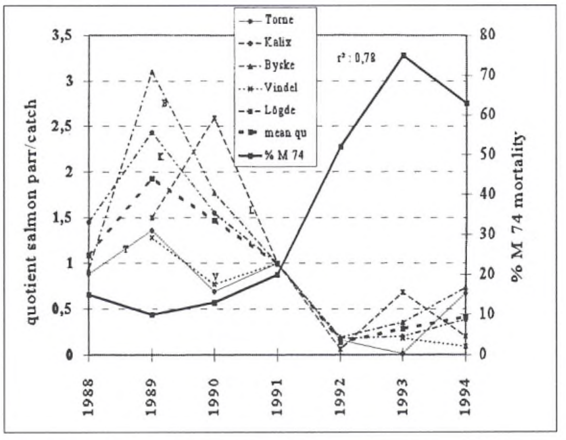

Figure 5. Salmon reproduction in wild salmon rivers in Bothnian Bay area and M 74 related motrtality in salmon rearing plants in the Gulf of Bothnia area (subdiv. 31) in 1988-94 (Karlström 1995 b). This figure is enlarged in the appendix.

The decrease between the periods 1988-1991 ("without M74") and 1992-1994 ("with M74") as an average for all rivers is about 75%. Mortality of salmon in hatcheries in the rivers Torne älv, Byske älv, Vindelälven was as great as in the reared rivers.

It is highly probable that the rivers carrying natural salmon have also been struck by fry mortality similar to that on the salmon hatcheries, despite the absence of any direct investigations into fry mortality itself in the natural rivers.

4.2.4 Smolt production

In the river Torne älv smolt migration from the river, which is the best measure of reproduction for the river as a whole, has been investigated since 1988. A comparison of year class strength through electrofishing data and smolt migration data shows a strong connection (r2: 0.90). Electrofishing surveys in the rivers can be assumed to give a measure of reproduction in the rivers as a whole.

Smolt migration from the rivers has been estimated and is shown in appendix 1. and in figure 6. Smolt production rose from the 150 000-200 000 level in the 1980's to 400 000 - 450 000 in 1994, which is 15% and 40% respectively of the potential, estimated at over one million smolt. Production for 1995 is estimated to fall below 200 000 smolt, when the weak 1992 year class migrates (3-year old smolt). Smoltmigration in 1996 is estimated at something over 100 000 smolt, which is only 10% of the potential. This is just as poor, or even poorer, than the level in the 1970-80's. Smolt migration in 1997 may be somewhat better than in 1996 in most rivers, due to the slightly better yearclass of 1994, but will still remain at a low level. Preliminary data from Torne älv for the 1995 yearclass indicates that smolt migration in 1998 will be lower than in 1997. This means that there are four consecutive weak year classes for 1992-95, with little smolt migration from 1995-98.

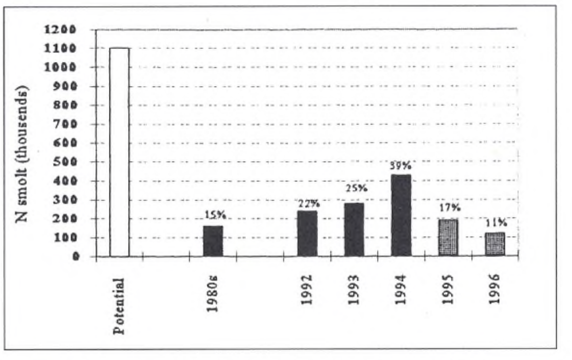

Figure 6. Estimated smolt production in northern natural salmon rivers (Gulf of Bothnia, sub-area 31) during the 1980's and the years 1992-94. Forecast for 1995-96 (Karlström 1995a, b). This figure is enlarged in the appendix.

When individual rivers are examined, it appears that many of the smaller inland rivers have production levels under 1 000 smolt. This applies above all to Råne älv, Öre älv and Lögde älv and the salmon stocks risk being knocked out. The larger rivers have a greater total production left, but even here the stocks in certain areas and certain sub-populations risk being knocked out.

At present we have a relatively good supply of spawners until 1996 and to some extent for large salmon even 1997, when the good smolt yearclasses up to the 1994 yearclass return (figure 3) and it is important to take advantage of this by effective restrictions of salmon fishery in order to build up as strong stocks as possible.

The effects of the weak smolt yearclasses from 1995 onwards will be apparent in spawning migration starting from 1997 (the grilse return earlier, in 1996) and with full effect from 1998-99, stretching 4-5 years ahead to the years 2001-2002. If there are still effects of M74 during this period, salmon reproduction will as a result risk falling to extremely low levels and there will be a risk of larger-scale elimination of salmon stocks. To avoid this it is therefore very important that effective restrictions on salmon fishery are imposed before a situation arises where it is too late. It is also of particular importance to follow the progress of wild salmon reproduction and the M74 syndrome in the years to come.

4.3 Salmon rivers in the Bothnian Gulf area

The river Ljungan is the only remaining salmon river in the Bothnian Bay area. Investigations at a few sites from recent years 1990, 1991 and 1994 show weak production from 1992-1994 (Anon. 1995).

4.4 Salmon rivers in the actual Baltic Sea area

4.4.1 General

The southern salmon rivers have 10-15 times greater density of young salmon than the northern ones and also a lower smolt age (1-2 years old), which leads to 10-20 times greater potential smolt production in these rivers. The reason for this is the greater nutrition potential in the southern waters.

4.4.2 The River Emån

Salmon can swim up about 40 kms from the river mouth, past fish ladders at three power stations. The reproduction areas are estimated at about 60 hectares.

The density of one summer old salmon parr was lower in 1993 and 1994 compared with previous periods in 1967 and 1980-85, more or less a halving (figure 7). The number of ascending fish in the river has been relatively similar in recent years (Anon. 1995).

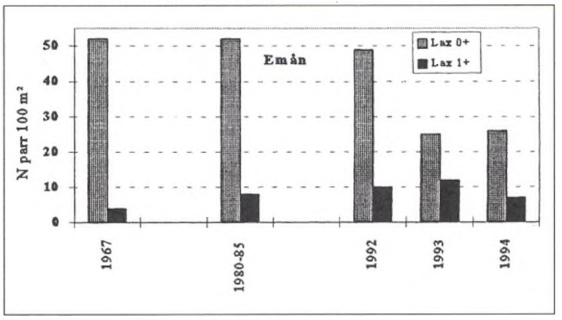

Figure 7. Density of salmon parr in the Emån, 1967, 1980-85 and 1992-94. Data from the National Board of Fisheries Research Office in Jönköping. This figure is enlarged in the appendix.

Smolt production in recent years is estimated at about 5 000 smolt, or 25% of the potential 20 000 smolt. Production is expected to decline further in the next few years. Hybrids between salmon and brown trout were found in the river in 1994.

4.4.3 The River Mörrumsån

Salmon can ascend about 20 kms from the river mouth. The reproduction areas have been estimated at about 44 hectares. There are a further 20 hectares up river from a power station where the reproduction potential is to some extent used by releasing fry.

The density of one summer old salmon parr fell sharply during the period 1992-94, compared with the period 1989-91 (figure 8). This period was to some extent influenced by liming and showed densities above the previous average, but densities for 1992-94 are nevertheless relatively low for a highly productive southern river.

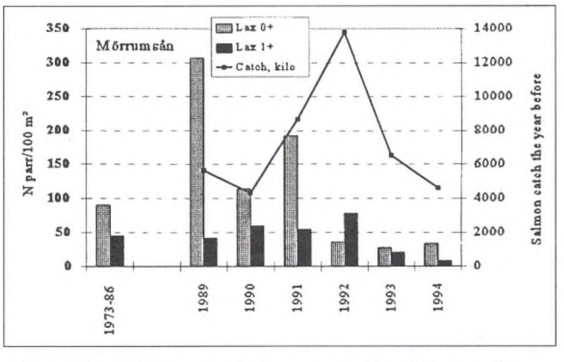

Figure 8. Density of salmon parr in the Mörrumsån from 1973-1994 and salmon catches in the river from 1988-1993. Data from the National Board of Fisheries Research Office in Jönköping. This figure is enlarged in the appendix.

Angling for salmon in the river has given large catches since 1989, with a pronounced peak in 1991 (figure 8) and the lower densities of young salmon in recent years cannot be explained by a small number of spawners. From 1991-93 a considerable part of the spawn fish died in the river as a consequence of contagious diseases (furunculosis in combination with fungus). As a result of countermeasures implemented, no new cases of disease have occurred since 1994.

In the Mörrumsån M74 mortality has been found in the hatchery in the same way as in other salmon hatcheries. M74 mortality was high even during the second half of the 1980's, however. The 1994 spawning was probably less influenced by M74 than spawning in earlier years of the 1990's. The fall in density of salmon parr in the river fom 1992-94 was probably an effect of furunculosis in combination with fungus from 1991-93 and M74. The severity of the outbreak of the disease and the fact that the density of sea trout also fell, as a result of the "disease spawning" from 1991-93, indicates this. Trout is not considered to be struck by M74 in the same way as salmon.

Hybrids between salmon and trout were found in the Mörrumsån in 1993-94. Preliminary electrofishing data during the current year does not however indicate an abnormally high frequency of hybrids (Curt Johansson personal observation).

The potential smolt production in the river Mörrumsån has been estimated at about 120 000 smolt. At the beginning of the 1990's smolt production lay close to this level. Owing to the reduced number of parr it is expected to fall to the order of 30 000 in 1995, or 25% of the potential. Since mortality from furunculosis and fungus has ceased, smolt production in 1996 may rise.

The high productivity in southern salmon rivers means that the stocks are not thinned out to such low levels as in the northern rivers. Smolt production is however falling to levels of 25% of the potential (figure 9) and even the salmon stocks in southern rivers risk being thinned out to low levels in the long run, especially if outbreaks of fish diseases occur.

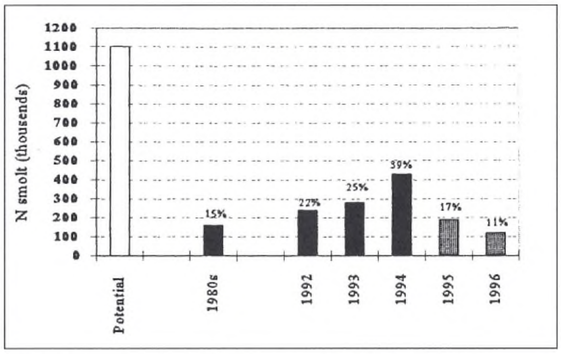

Figure 9. Estimated smolt production in Swedish salmon rivers in the Baltic Main Basin (the Emån and Mörrumsån). Data from ICES salmon working group C.M. 1995/Assess: 16. This figure is enlarged in the appendix.

CORRECTION

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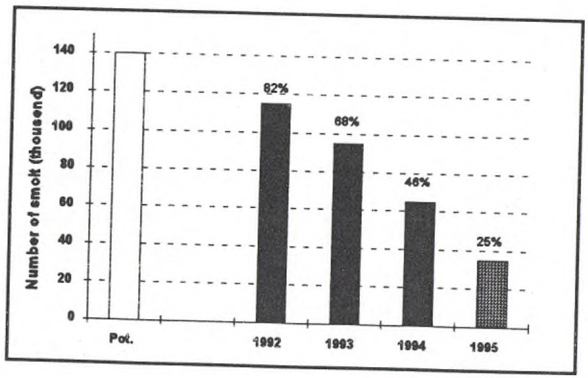

5. Compensatory rearing.

In the countries round the Baltic, primarily in Finland and Sweden, there is a comprehensive programme for the rearing of salmon smolt. The purpose of the rearing is to compensate for the loss of natural smolt production caused by human activities such as the expansion of hydroelectric power. As a rule, compensatory rearing produces smolt ready to be released in two years; in southern rivers it often only takes one year. The reared smolt are released in the spring in the rivers where compensation is to be made and are thus imprinted on their "home river", where they will later return as adults to spawn. In Sweden salmon young are most often reared by the river where they are to be released.

Water court decision in Sweden cover almost two million smolt for the Baltic. More or less the same amount is produced in Finland, while the other countries rear altogether about one million, i.e. in total about five million smolt are reared annually. A large part of the production in Finland is based on cultivated brood stock, while the other countries base their operations on migrating spawners that return to the various rivers. The Finnish method may in the long run entail a risk of unwanted genetic changes, while at the same time it safeguards in the short term the possibility of producing sufficient numbers of smolt.

In the middle of the 1980's the supply of spawners in Swedish hatcheries was scarce, while the restrictions of the fishery introduced from the end of the 1980's has meant that the supply of spawners is now better.

The major problem in Swedish and certain Finnish hatcheries has in recent years been the M74 syndrome. High mortality has implied that many hatcheries have not managed to produce sufficient smolt to meet the requirements for 1994 and 1995 of the respective water court decisions. To counteract the effects of M74, a new method (tiamin treatment of yolk sac fry) has been tried during the spring of 1995 with very good results. Since large amounts of eggs were also gathered up in the autumn of 1994, the deficit from previous years of smolt for release can be redressed, starting in 1997. We can thus look forward to large Swedish releases of reared smolt during the last years of the 20th century, while at the same time naturally reproduced (wild) smolt will decline further in numbers. Furthermore, increased rearing is planned in other countries round the Baltic Sea, so the disproportion between wild and reared salmon is expected to rise sharply (figure 10). This gives rise to great anxiety as to what will happen to the wild salmon.

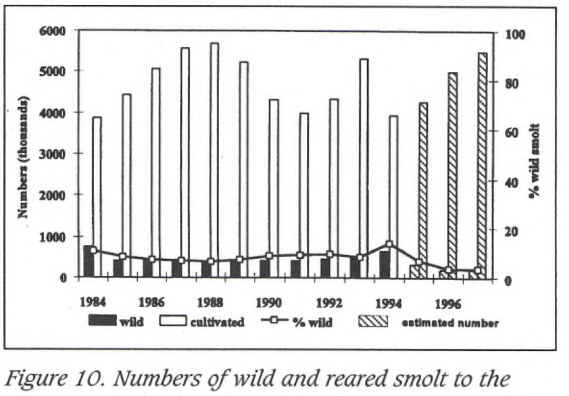

Figure 10. Numbers of wild and reared smolt to the Baltic Sea 1984-97, also with the proportion of wild smolt. Data from the Salmon Research Institute. This figure is enlarged in the appendix.

6. The M74 syndrome

6.1 Increased fry mortality

Baltic salmon in the wild has been struck by increased fry mortality since the early 70's. The symptom was discovered for the first time in 1974 on Bergeforsen salmon hatchery, on the river Indalsälven. Jonas Sahlin, the supervisor, called the symptom M74 (Milieu related disease 1974). In order to be able to check egg and fry mortality more certainly, each female's eggs and fry are kept separate nowadays on the Swedish hatcheries. The symptoms appear during the salmon fry's yolk sac resorption, i.e. before it is time for the fry to feed on external food. The fish becomes apathetic and shows little or no escape reaction. In addition the fish darkens and on closer inspection it can be seen that bleeding occurs near the heart and that the eyes often protrude. The excessive mortality found has since then varied from hatchery to hatchery and year to year, but has tended to increase gradually in recent years. Mortality in 1993 and 1994 was high (about 75 and 65% respectively on average for the rivers where compensatory planting takes place) and the forecasts for 1995 show continued high mortality, though lower (about 55%) than the preceding years. The intensive releases of reared salmon has had the effect of hiding possible influences of M74 on stocks of salmon produced wild in the sea.

Considerably more eggs than normal have had to be inserted on the hatcheries to be sure of meeting the current planting obligations. The high mortality of recent years has however meant that inserting more egg does not help, since the number of spawning females and the space for egg hatching on the hatcheries has not sufficed in certain rivers. It should be observed that the hatching results we see give a "most favourable picture" since, in rivers where there is a good supply of females, the suspect ones are avoided, assuming among other things that salmon swimming unsteadily, or pale eggs, have been hit by M74. Previously eggs were preferably taken from large salmon females, but it is also these that to the greatest extent give offspring affected by M74. There is now therefore a greater tendency to make use of smaller salmon females in breeding. Some salmon hatcheries can make a close selection of the material. Thus in Bergeforsen (Indalsälven) only 30% of the females caught were used in breeding in 1993, while certain other hatcheries are obliged to utilize all the material that can be brought in.

No corresponding problem has been noticed with salmon from the West Coast or Lake Vänern. Baltic salmon that have been kept in basins for several years to serve as brood stock have also been free of symptoms, which has led to the conclusion that it is something during the sea phase that affects the salmon females. It is worth noting that wild salmon from the Baltic have a 10 times higher content of chlorinated organic compounds than salmon reared in captivity with "non-toxic" food and salmon from the West Coast.

So far it has only been possible to establish excessive mortality in rearing. For stocks in the wild there is no quantifying of natural egg hatching frequencies, so wild salmon have to be as far as possible taken in to hatcheries for inspection. At least as high excessive mortality in M74 has been found at such inspections for wild salmon as for reared salmon. Comparisons have been made among others between the reared Umeälv salmon and the wild Vindelälv salmon.

Annual electrofishing surveys takes place in several cases in the wild salmon rivers, which can give an indirect and rough estimate of M74. It should then be noted that there is high natural mortality during the time from a hatched fry to one summer old salmon (so-called 0+ salmon). This mortality is to a large degree dependent on density, which means that if fewer fry survive hatching, owing to M74, this will partly be compensated by lower natural mortality. M74 mortality is therefore partly redressed in the natural rivers when studying one summer old salmons. Despite this there are strong indications that M74 mortality in natural stocks lies at the same high level as in rearing.

For a number of rivers the catch of potential spawners has been plotted one year and the resulting number of 0+ salmon the following year. There is usually a connection between the supply of spawners and the production of one summer old salmons. This connection was however broken in 1992 and 1993 for wild salmon stocks in the Baltic Sea. It may be observed that the water flow, water temperature or presence of older stages of trout or salmon could not explain any of the changes that were revealed for 1992 and 1993. The decline was consistently in the order of 90%, except for 1992 in Byske älv (60%).

6.2 Current state of research

In addition to the monitoring activities that are necessary to follow the progress of wild stocks and the keeping of journals on salmon farms, a special research programme "Reproductive disturbances in Baltic fish" (the FiRe project), concerning among other things M74, has been set up in consultation with the National Environmental Protection Agency, the National Board of Fisheries, the Research Council for Forestry and Agriculture, the World Wildlife Fund and the Water Power Board. The FiRe project has a total of about SEK 6.400 000 for the 18-month period 1995-1996. The Nordic Council of Ministers has also given support of DKK 745,000 to Nordic research collaboration during 1995 on disturbances in reproduction of fish (the RED-FISH project), of which certain provision has been made for the M74 problems.

Ever since M74 was first observed, a connection has been suspected with toxic substances in the environment, such as chlorinated organic compounds (PCB, dioxins, etc). The content of chlorinated organic compounds in the muscle tissue of salmon females does in fact tend to be higher as a whole for females that have offspring affected by M74 than for females that have viable fry, but no substantiated connection has yet been documented, despite great analytical efforts. It should also be pointed out that there is no covariance with the existence of M74 in the presence of just these substances in the Baltic Sea, and that they have subsided in recent years (Mats Olsson, personal communication). Preliminary results from Finnish studies (Pekka Vuorinen, personal communication) point however at a significant correlation between the content of flat PCB compounds in salmon females and the presence of M74 in the offspring. The activity of certain so-called detoxifying enzymes in the liver (the Cytochrome P450 system or so-called EROD activity) which is often used as a marker for the existence of chlorinated organic substances, also indicates that just M74 affected fry and their mothers have a higher toxic burden than normal fish. In this context, however, it is worth emphasising that correlation is not necessarily synonomous with a proven causal relation.

So far studies have not shown any link with heavy metals, parasites, bacteria or virus. A further indication that it is not a common disease is that fry dying from M74 do not infect healthy fry. The presence of, among other things, retrovirus is however to be investigated in a new project.

There is a strong connection between the pigmentation of the salmon eggs and the frequency of M74. A comparison of egg colour noted in 1977 and 1992/93 showed that pigmentation of the eggs had declined during that time (Hans

Börjesson, personal communication). Pigmentation is caused by various carotenoids and highly pigmented eggs are dark orange, while poorly pigmented eggs are pale yellow. M74 mortality for the pale eggs have escalated sharply, which now makes egg pigmentation a usable marker for forecasting M74. Several breeders have known this for quite some time, so pale (not orange) eggs have been avoided. It may be that low pigmentation is a sign of a high content of chlorinated organic compounds, since the pigments (carotenoids) are metabolised via the same cell system that is activated by chlorinated organic compounds (the Cytochrome P450 system). Another possible contributory explanation of the egg's pigmentation is the salmon's choice of food or its prey's choice of food. This has, however, not yet been investigated.

There seems to be a connection between the biomass of fish prey (esp. sprat) highly preferred by Baltic salmon and the frequency of M74 (Hans Börjesson, Gunnar Anéer, personal communication). Professional fishermen also think that salmon grow "pale" when they eat a lot of sprat. Of abiotic factors, the winter temperature in the southern Baltic appears to influence M74 frequency insofar as high winter temperatures give high M74 mortality, but with a couple of years' delay.

The Baltic environment is under heavy strain both from eutrophying emissions and known and less known/unknown toxic substances. There are several indications that other species of fish have been affected (Johansson et.al. 1994, Bengtsson et.al. 1994), for example cod, burbot and perch, although the total content of DDT and PCB in Baltic fish has diminished (Bignert et.al. 1993). The adverse effects of chlorinated toxic substances in the Baltic environment on seals and birds have previously been substantiated, but for these the situation has stabilised and possibly improved slightly (Blomqvist et.al. 1992). There are suspicions of a change in the entire Baltic ecosystem and that also may have an influence (Bengtsson et.al. 1994), so that the salmon is indirectly affected. There are thus for example suspicions that the production of plankton carotenoids decline as the Baltic is eutrophied and that the feeding habits of the salmon's prey fish have changed. Others think that a contributory cause could be an effect of widespread rearing operations.

It should be noted that reproduction defects in salmonides in conjunction with chlorinated organic toxicants in the environment are not a new problem and an intensive exchange of knowledge between American researchers round the Great Lakes and the FiRe project has been established. From this it has appeared that the symptoms previously observed (mainly during the 1970's and early eighties) in above all lake trout which have previously been explained by the presence of dioxins and plane PCBs, have changed character and resemble more and more M74. The American symptoms are generally termed EMS (Early Mortality Syndrome) and/or SUS (Swim-Up Syndrome) and appear in coho salmon (70%), chinook salmon (60%) and steelhead (35%) in Lake Michigan; in lake trout (80%) in Lake Ontario and in an isolated stock of Atlantic salmon in Finger Lakes (100%). The figures in brackets show maximum observed mortality in EMS. Various species of Pacific salmon are stated not to have been affected (Gordon McDonald, personal communication). The syndrome is now assumed not to have a direct link with the above-mentioned environmental toxicants (which like the case of the Baltic have undergone a decline in recent years), but with the diet, primarily in the form of a species of herring, alewife (Alosa pseudoharengus), and its high content of thiaminase, an enzyme which inactivates thiamin (vitamin B1). It is also from these observations that successful experimental treatment of sick fry with thiamin has been developed (John Fitzsimons, Burlington, Can.). This treatment is being applied from this season also on Swedish hatcheries, reportedly (Jonas Sahlin and others) with great success up to the time when the fry begin to feed by themselves. It is, however, still too early to say whether this treatment in the long run will result in fertile breeding fish. Another serious question is our inability to treat the fry of salmon spawning in the wild. At worst, continued non-selective sea fishing of mixed stocks in combination with thiamin treated reared salmon could be the death-blow to the remaining wild spawning salmon which even in future may be expected to be hit by M74 losses.

From results presently available from Swedish, American, Canadian and Finnish surveys we can develop the following new mutual hypotheses for the occurrence of M74 in Baltic salmon and EMS in salmonides in the Great Lakes:

1) high content of thiaminase in food
2) thiamin (vitamin B1) deficiency in food
3) substances (environmental toxicants?) in food that interfere with thiamin metabolism

Of these three the last is considered to be the most realistic. All three hypotheses are today subjects of research within the FiRe project.

An international workshop is being arranged by the FiRe project from 20-23 November 1995 in Stockholm. The purpose is to produce further knowledge of M74 (existence and possible causes) from the countries round the Baltic Sea, to acquire the latest news of EMS research in the USA and Canada and to try to optimise the use of available resources through mutual research efforts.

7. Utilization of resources and development of catches

7.1 Utilization of salmon stocks

7.1.1 General

A desirable level of the quantity of salmon that returns to the natural rivers is one where the production capacity of the rivers is fully utilized. For optimal utilization each salmon stock should at least partly be exploited separately. This is best done in a terminal fishery, i.e. fishing in or in the immediate vicinity of the home river.

Salmon is fast growing. During its first winter it reaches a weight of 1.5-2.5 kgs, after five it can reach a weight of 25-30 kgs. The average weight of salmon caught has fallen from 10 to 4.3 kgs in the past 60 years. This indicates a too intense fishery and that the salmon is caught too early. The latter particularly affects the fastest growing salmon, while the slower growing ones have a greater chance of survival. In the long run this weakens the salmon's growth potential, since a greater proportion of genes with a disposition for poorer growth will be transferred to coming generations. Growth is also influenced by other factors such as temperature. The average weight is thus a function of factors such as fishing intensity and climate.

Between 1983 and 1985 80% of the reared salmon was caught in the Baltic Main Basin, 15% in the Gulf of Bothnia and 4% in the rivers. An inspection of fish marked between 1988 and 1990 gave corresponding values of 53%, 37% and 9%.

7.1.2 Sea fishery

Before 1939 about 30% of salmon catches were made in the sea. This proportion rose to about 60% in the period 1945-1950 and to between 70 and 90% during the 1970's and 80's.

Offshore fishery with hook and net occurs in mixed stocks and does not utilize the entire growth potential of the salmon. If offshore fishery were to cease, catches of wild salmon would increase from 443 to 870 tons. The quantity of spawners would increase sixfold and the average weight from 3.8 kgs to 8.2 kgs.

Catch costs for offshore fishery are high in comparison with coastal and river fishery and inferior fish which are caught, i.e. fish under the prevailing minimum landing size, most often die when they are released. The quality of fish caught is often high and the salmon can be caught over fairly long periods of time, which gives higher prices. Offshore fishery is conducted over large areas and contributes to the livelihoods of a considerable number of professional fishermen.

7.1.3 Coastal fishery

Coastal fishery was the main form of fishing for salmon until 1945. Offshore fishery then took over, but the percentage of coastal fishing has risen in recent years.

Coastal fishery is conducted to a great extent with salmon and combi-traps within a limited area from the river mouth. Catches comprise both wild and reared fish but the catch is more selective than for fishing in the sea and the fish that are caught are fully grown. Profitability is higher for coastal fishery, the energy consumption is lower than for offshore fishery and a greater proportion of inferior fish that are released survive.

7.1.4 River fishery

River fishery is the original way of catching salmon but has diminished in importance during the post-war period. Towards the end of the 1980's there were hardly any catches but they increased slightly during the period 1989-93.

River fishery occurs in separate stocks and when the salmon is fully grown. The catches can in addition be reserved for anglers and tourists, which can generate quite considerable earnings for the district. Attractive salmon fishing for tourists, both internationally and in certain places within the country, prove that this is the case. A study of the community value of angling for salmon in Mörrumsån showed a consumer surplus of about MSEK 6 per year. In river fishery the salmon's growth potential is fully utilized and fishing can be regulated more securely to the supply of fish than is possible for coastal and sea fishery. However, were offshore fishery to be stopped and salmon only caught on the coast and in the rivers, problems might arise in the harnessed rivers, which lack space for returning fish.

7.2 Development of catches

Catches of salmon in the Baltic have generally been high since the 1950's, but they have varied sharply, from barely 2,000 tons up to about 5,500 tons to a value of MSEK 42-116, estimated on the prices per kilo given by Statistics Sweden (SCB) for Swedish landings on the East coast in 1993. The redistribution from sea to coastal and river fishery that has taken place in recent years is primarily due to the limitation in offshore fishery by means of, among other things, maximized catch quotas, TACs, which the Baltic Sea Fisheries Commission, IBSFC, has decided since 1991.

The nations that caught most salmon, excluding the Gulf of Finland, during the five-year period 1989-1993, were Finland and Sweden with 35 and 31% respectively. Then followed Denmark and Latvia with 17 and 11% respectively. Other countries caught less than 5% each. In the Gulf of Bothnia, where only Sweden and Finland fish, Finland accounted for 69% of the catches and Sweden for 31%. In the Main Basin Sweden caught 30%, followed by Denmark with 25%. Then came Finland and Latvia with 17 and 16% respectively. The remaining countries took less than 5% each.

8. Control of salmon fishery

8.1 General

The purpose of the prevailing restrictions is to tend and conserve stocks so that they can form the basis of durable, maintained fishery both for professional fishing and for angling and household requirements. In the light of the precarious predicament of the wild salmon, the regulations should be formulated so that they contribute to a pattern of fishery that exploits reared salmon optimally but provides wild salmon with the necessary protection. Current regulations can broadly be divided into those that reduce the intensity in the fishery and those that increase selectivity.

8.1.1 Control of fishing intensity

1. Quotas - state a total allowable catch, TAC, per area, per category or per individual. The latter is not appropriate for Sweden.
2. Closed seasons – most often intended to protect stocks during spawning and spawning migration, but can also be used to protect young individuals.
3. Closed areas – areas where fishing is entirely or partly prohibited for the whole or parts of the year. This is often used in the river mouth areas of the natural rivers.
4. Restrictions on gear – prohibit the use of certain gear generally or in special areas. The amount of gear can also be regulated. Another model is to reserve bulk catch gear for licensed salmon fishermen.

8.1.2 Control of fishing selectivity

1. Minimum size – intended to protect young individuals and give them a greater chance to spawn at least once.
2. Design of fishing gear – regulates the length, mesh size etc. of the fishing gear.

One important instrument in tending stocks is the TACs. A TAC is determined for the whole Baltic, after which it is distributed among the various countries. The trend, however, is towards increasing limitations of catch efforts and an increase in selectivity.

Closed periods have been considered a useful step to reduce fishing intensity of one species. Closed periods in offshore fishery can however mean that the fishing intensity rises so sharply in other periods that it has no effect, but the method can be effective in coastal and river fishery.

Minimum size can be an important measure to regulate fishing for salmon. Minimum size means however that some under-sized fish must be put back, especially when fishing with a hook, since hook fishing is less selective than net fishing. The proportion of under-sized fish is on average 1-5% for net fishing and 5-17% for hook fishing.

Wild salmon remigrate earlier in the year than reared salmon, so pre-summer protection has been introduced in the Baltic. A particular date has been decided on for administrative reasons. The remigration of salmon is primarily determined by the water temperature. The time of remigration therefore varies somewhat from year to year. This means that in certain years pre-summer protection does not have the maximum intended effect.

8.2 International measures

Fishing in the Baltic is regulated by the International Baltic Sea Fishery Commission (IBSFC) which sets TACs with the guidance of scientific advice from the International Council for Exploration of the Sea (ICES). Agreement could be reached for the first time in 1990 on a

TAC for salmon in the Baltic. For 1991 it was set at 3 350 tons (about 670 000 fish), 1992 at 3 550 tons (710 000), 1993 at 688 000 fish (3 440 tons), 1994 at 659 000 fish (3 295 tons) and for 1995 at 500 000 fish (2 500 tons). TACs have so far been set higher than recommended by ICES.

The IBSFC's salmon regulations

- Minimum mesh size for nets 157 mm.
- A maximum of 600 nets, 35 m. long, per boat.
- A maximum of 2 000 hooks per boat. The hooks shall have a distance of not less than 19 mm. between the point and the shaft.
- Minimum size for salmon 60 cm.
- Fishing with drifting nets or anchored floating nets prohibited from 15 June to 15 September inclusive.
- Fishing with drifting lines prohibited from 15 April to 15 November.

8.3 Swedish measures

Through the fishery regulations that came into force in 1982, the National Board of Fisheries was authorized to issue provisions for the protection of salmon and salmon-trout. The Board has then gradually tightened up the rules for river and coastal fishery for salmon. The objective has been to reinforce the natural reproduction of salmon, above all by increasing the spawning run to rivers that have conditions for such reproduction, so that the threat to the wild stocks is averted and the reproduction capacity of the rivers is utilized to the full. The Board has in various stages introduced among others the following rules for Sweden:

- Fishing for salmon and sea trout with drifting nets, drifting lines, anchored lines and anchored floating nets is prohibited in the coastal water ares of the Gulf of Bothnia.
- Fishing for salmon and sea trout in the coastal waters between the Kullen lighthouse and Torhamn Point is prohibited from 15 September to 31 September and in the Bay of Bothnia from 1 October to 31 December.
- In the Bay of Bothnia, fishing with traps where any part is higher than 1.5 metres, and fishing with nets for salmon and sea trout is prohibited from 1 May to 10 June.
- In a large number of closed areas along the Swedish Baltic Sea coast, salmon and sea trout fishing are prohibited during certain periods, as is the use of certain types of gear.
- Total prohibition of salmon fishery (with certain exceptions for angling in 1995) was initiated in 1994 and 1995 in the rivers carrying naturally reproducing salmon stocks and their river mouth areas.
- For the period from 1 December 1994 to 31 March 1995 Sweden unilaterally introduced total ban on salmon fishery in the Baltic Sea south of latitude 60 30 N.
- The National Board of Fisheries has redeemed some permanent fishing sites in, among other places, the river mouth areas of the rivers Torne älv and Kalix älv.

8.4 Finnish measures

Finland has at various times introduced restrictions on salmon fishery. These are of great importance for Swedish salmon stocks in the Bothnian Bay, as they to a large extent follow the Finnish coast during spawning migration north. At the beginning of the 1980's the number of places where fishing traps were allowed was reduced. Since 1986 the time after the break-up of the ice when salmon traps were permitted to be set out has also been regulated. In 1988 prohibition of fishing with drifting nets in the Gulf of Bothnia and the Main Basin was extended to cover the period from 1 April to 15 November. However, these measures did not prove to be particularly effective and Finland overfished her salmon quotas substantially in the years 1991-1993 and for 1994 refused initially to accept the IBSFC's proposed salmon quotas. Further restrictions were introduced on 1 April 1994 by prohibiting, with certain exceptions, salmon fishing with drift-nets during the periods 10-16 April, 1-7 May, 20-26 May and 5-11 June north of 50° N. The prohibition did not however apply within four nautical miles from the coast. Coastal fishing with salmon traps was also restricted by deciding a first day when the fishery could start. The further north, the later was the start date. These restrictions did not however apply outside rivers carrying only reared salmon. This regulation will not entail any noticeable improvement for natural salmon stocks in Sweden.

8.5 Finnish-Swedish Boarder Rivers Commission

The commission deals with fishing matters in an area covering the part of Torne älv that forms the boundary between Sweden and Finland and the coastal area within the municipalities of Haparanda and Torneå. A particular law and fishing code apply in the area. The code was last revised in 1987, but is subject to further revision. The provisions of the code correspond by and large to the Swedish but generally speaking are stricter. The revised code may be completed in 1995. Since 1993 the commission has had pre-summer protection in the river and the entire coastal area. On the other hand, the strong protection introduced by Sweden in 1994 and 1995 in rivers carrying natural stocks was not instituted.

8.6 Other countries

8.6.1 Estonia

In Estonia fishing prohibition prevails the whole year in the river mouth areas outside rivers carrying salmon up to 500 m from the mouth and commercial fishing for salmon is forbidden in the rivers, as is angling with natural bait. A licence is required for other angling, but fishing is prohibited in the rivers Narva, Kunde, Loobu, Valge, Pirita, Keila, Vasalemma and Parnu from 1 September to 30 November. In other watercourses carrying salmon from 1 September to 31 October. Fishing is prohibited for a distance of 100-500 m downstream from dams and waterfalls.

8.6.2 Latvia

Fishing with drifting nets and salmon lines is prohibited in Latvia in the Bay of Riga and in rivers fishing for salmon is entirely prohibited. In coastal waters fishing for salmon is prohibited during the period from 1 October to 30 November. Coastal fishery is also restricted by a limitation on the quantity of salmon fishing gear and in May, October and November fishery is only allowed with small-mesh herring ground nets and floating nets.Outside all rivers carrying salmon there are closed areas with radii from 200 up to 1 000 metres.

8.6.3 Lithuania

Outside all rivers carrying salmon that run into the Baltic there are closed areas with a radius of 1 km from the mouth of the river in the sea and from 15 October to 31 December salmon fishery is prohibited in the straits between the Baltic Sea and the Bay of Kuris at Klaipeda. Furthermore, there are restrictions in salmon fishing as regards both time and gear in the Bay of Kuris and in rivers carrying salmon.

8.6.4 The Russian Federation

No details

8.6.5 Poland

The rules established by the IBSFC apply in Poland even within the 4-mile limit.

8.6.6 Germany

Minimum measurements and smallest mesh size coincide with the IBSFC's regulations. There is also a closed period for salmon within the 12-mile limit from 1 August to 31 October .

8.6.7 Denmark

In Denmark there are closed areas outside all rivers carrying salmon and sea trout with a mouth wider than 2 metres. All fishing is prohibited year round in these areas up to 500 metres from the mouth. Estuaries are usually protected by a larger zone. Fishing is prohibited for 4 months in the river mouth areas outside other rivers in connection with the return of the salmon and fishing with nets is prohibited up to 100 metres from the mouth. Fishing for salmon is prohibited from 15 November to 15 January in fresh water. In the sea this only applies to fish ready to spawn.

9. Effects of entry to the EU

According to the EU's basic regulation on fisheries (3760/92) the common fishing policy shall among other things aim at regulating stocks of marine resources. Since the EU has not previously had reproducing stocks of commercial value for fishing, it is not entirely clear what position the EU will take on the tending of Baltic salmon stocks. For three years however, the EU will contribute financially to Swedish smolt releases. It has been hinted that the natural thing would be for the EU to regulate the fishery at sea while for example Sweden and Finland regulated coastal and river fishery.

The IBSFC makes decisions on, among other things, TACs, minimum landing size and closed periods at sea. At negotiations within the IBSFC the EU is represented by the EU Commission. In the EU's negotiating delegation the member countries concerned are represented. They appear to have great influence over the EU's actions and it may be assumed that the EU will attach greater importance to fundamental biological circumstances now that the EU has acquired administrative responsibility for the overwhelming majority of salmon stocks in the Baltic area.

In the accession negotiations between Sweden and the EU, the Swedish share of salmon was set at 36.435% of the EU's salmon TAC. This was slightly more than what the Swedish salmon TAC had until then given. The Finnish share outside the Gulf of Finland was 33.611%, while Germany and Denmark share 29.954%. How much the EU has at its disposal is decided by the IBSFC.

EU directive 92/43 on the preservation of environments and species, the so-called habitat directive, aims at preserving biodiversity. The directive contains among other things rules for how natural environments and species should be protected and the Atlantic salmon appears on the list covering measures in fresh water. The salmon shall be protected by area protection and measures to conserve fishing. In all the sea areas belonging to the EU, with the exception of the Baltic, drift netting has been restricted to a maximum net length of 2.5 km per boat. The background to this restriction is the UN resolution on the protection of marine mammals. The figure for the Baltic is 21 km.

10. Delayed release

By delayed release is meant a technique where, in contrast to the normal smolt releases in river mouths in the spring, instead put the salmon juveniles in net-pens in the sea, where they spend the first summer and are then released in the late summer/autumn. This means that the young fish are protected from the predators that normally catch most of the conventionally released smolt. Moreover the salmon juveniles grow well in the brackish water and by means of this procedure survival from smolt to adult fish is very greatly increased, or 3-5 times. Smaller (one-year) parr can also be used for transfer to net-pens with this type of continued rearing. This improves financial profitability, since one-year parr are considerably cheaper to rear than two-year, but still give roughly the same catches as the latter when delayed released.

The technique of delayed release could theoretically also be used to change the pattern of fishing in the open sea and along the coast. By keeping the salmon juveniles in net-pens and releasing them, they are not designated to a river but to the coastal area where they are released. The adult fish thus return after growing up in the sea to the place where they have been kept in net-pens. Coastal fishery for salmon could thereby be created in areas where salmon is not normally present. Fishery in the Main Basin of stocks based on delayed release could then be conducted near the coast, while fishery on mixed stocks (wild/reared salmon) in the open sea would then be replaced by coastal fishery. In combination with restrictions on fishery north of Åland, this would mean that the wild salmon stocks could recover rapidly.

A fully utilized and fully developed technique of delayed release can be a good way of increasing the protection of wild salmon stocks, principally through reduced offshore fishery on mixed stocks. At the same time an opportunity is provided for continued fishery for salmon, mainly reared, in the sea.

Before the method can be put to practical use, however, international agreement is required on where and how releases are to take place, how coastal fishery is to be developed and not least how releases are to be financed. The methods are described in the publication "Delayed release and closed areas - salvage of the salmon and salmon fishery in the Baltic area" (Eriksson & Eriksson 1989).

11. Present threats and scenarios

The regulation of salmon fishery that has been effected internationally and nationally since the end of the 1980's implied that some recovery of naturally reproducing salmon took place at the beginning of the 1990's (figure 10). Since the IBSFC accepted for the first time at the 1990 meeting that salmon fishery should be limited by a TAC (for 1991: 3 350 tons) developments have led to a TAC for salmon from 1993 in numbers of salmon that may be caught (for 1995: 500 000 salmon). Having a quota in numbers instead of a weight is mainly due to the fact that a TAC in weight can result in too many fish being taken if the salmon is caught early in its life cycle and therefore at a very low average weight.

The increase in M74 found in Swedish hatcheries in 1992 has as far as can be judged also struck the naturally reproducing stocks. As appears from the description of natural stocks, the number of salmon juveniles in growing areas has fallen drastically in recent years, even though the restrictions in salmon fishery have meant that more females have been able to ascend the rivers to spawn. No definite connection with M74 has been established, but the offspring of natural salmon females have in rearing shown M74 influence at the same levels as offspring of females originating from reared and released smolt. The number of natural salmon in growing areas in the Baltic Main Basin itself will therefore decline sharply in the next few years (1996-2000). The reductions in quotas until now accepted by the IBSFC will then be entirely inadequate if the natural stocks of salmon are to survive and gradually recover. In the tables below various estimates are shown of developments in coming generations.

Available data has been used in the estimates on survival in rivers from egg to smolt and recent years' survival and growth from smolt to adult salmon in the Baltic. In sparse or relatively sparse stocks river survival has been estimated at 3.2% and 1.2% respectively. Since the middle of the 1980's survival from smolt to adult in the Baltic has varied between 16% and 25%, and the average weights of adult salmon female spawners have varied between 8 and 9 kgs.

Table 1. Number of potential spawning females in the second and third generation from 100 M74 affected females (8500 eggs/female) given a total ban on fishery, various levels of M74 and low or high survival from egg to adult fish in generation 1. The M74 level is assumed to be constant in all generations.

M74 level in gen.	1 No. of potential spawning females in gen. Survival egg to adult		2 No. of potential spawning females in gen. 3. Low survival egg to adult in gen. 1 to 3.
	Low	High	
0	734	3 060	5 840
20	636	2 678	4 048
40	477	2 008	2 277
50	398	1 673	1 583
60	318	1 339	1 012
70	239	1 004	570
80	159	669	253
90	80	335	64

A completely unchanged level of M74 in several generations (5-15 years) is unlikely. Estimates are therefore shown in table 2 of the number of potential female spawners in generation 3 in the light of the most immediate levels of M74 in generation 1 and with a varying frequency of M74 in generation 2.

Table 2. Number of potential spawning females in generation 3 from 100 M74 affected females (8500 eggs/female) in generation 1 and various frequencies of M74 in generation 2. Low survival from egg to adult fish has been assumed in the estimates.

M74 level in gen. 1	M74 level in generation 2				
	50	60	70	80	90
70	950	760	570	380	190
80	632	506	380	253	127
90	318	255	191	127	64

The assumptions and estimates shown in the tables are of course not as exact as the figures suggest, but they give a comparatively good picture of the chances we have of saving the natural salmon. It is quite clear that with the present size of female spawners the natural salmon can be saved by fishery regulations in all M74 frequencies except 85-90% (and higher) in more than one generation. It is also quite clear that lesser restrictions will not be sufficient if relatively high frequencies of M74 are expected, i.e. at the present level (60-80%). If the purpose of the restrictions is to safeguard the future of natural salmon, the regulations should not be based on the most optimistic variants of the estimates but rather on the least favourable alternatives. A total ban on the exploitation of natural salmon in all areas, including rivers with natural salmon, is therefore the only logical conclusion of the estimates above.

The Advisory Committee on Fishery Management (ACFM), which is the advisory body for the ICES, recommends a ban on sea and coastal fishery on salmon in 1996. If a fishery is still to be permitted the catch should be kept as near zero as possible. Reared fish should be caught as close as possible to the place of release and where it can be done without catching natural salmon.

Such a restriction in salmon fishery would entail extremely intense fishery in and immediately outside rivers with reared salmon stocks, where large quantities of salmon will migrate. Even if these fish are initially strongly imprinted to "their" river it is fully conceivable that some of them, despite a high intensity in the fishery, might leave their home rivers and try to find adjacent rivers with spawning opportunities, i.e. rivers with natural salmon stocks, and thereby "genetically contaminate" them. In this way the natural salmon stocks may be affected by genetic changes.

12. The 1995 negotiations in the Baltic sea fisheries commission

The 21st session of the Baltic Sea Fishieries Commission was concluded on 8 September

In preparation for this year's negotiations a working group meeting on Baltic salmon was held in Sweden, Älvkarleby, from 28-30 June. At the meeting it was decided to make the following recommendations to the Commission:

a) Management objectives:

1a. Further decrease of naturally produced smolts should not be allowed in order to prevent the extinction of the wild stocks.

2a. The production of wild salmon should gradually increase to attain at least 50% of the natural production capacity of every individual river before the year 2010, this in order to achieve a better balance between wild and reared salmon.

3a. The level of fishing should be maintained as high as possible. Only restrictions necessary to achieve the first two objectives should be carried out.

b) Management strategies:

1b. To reduce the TAC for salmon for the Baltic.

2b. To introduce a ban on salmon fishery from 1 May to 31 July north of 59 30 N.

3b. To appeal to the governments of all Contracting Parties to apply time and area closure measures as decided by national authorities, in order to protect the wild salmon stocks.

4b. Having the opinion thet the level of wild salmon smolt production is too low today as compared to the level of reared smolt production, ICES is requested to give advice on the appropriateness of having a fixed ratio of wild versus reared salmon and monitor global production of reared salmon accordingly. The advice shall only cover the Main Basin and the Gulf of Bothnia.

5b. To request ICES to examine the possible effects of increased mesh sizes on the Baltic salmon stocks.

The following was decided at the meeting of the Commission:

1. To reduce the total catch quantity (TAC) from 500 000 to 450 000 salmon.

   Sweden's aim was to reduce the TAC to 300 000 salmon. Since the other EU countries were not in agreement with Sweden on how large the reduction should be, and in some cases recommended an unchanged TAC, the EU Commission took over responsibility and proposed a 20% reduction. The other Baltic Sea countries considered however that the reduction should be considerably smaller or proposed an unchanged TAC. The negotiations resulted in the Commission deciding on a 10% cutback.

2. To extend the summer ban on sea fishing by two weeks.

   Next year the ban will be from 15 June to 30 September in the southern Baltic Sea and from 1 June to 15 September in the northern Baltic Sea. Sweden proposed a substantially longer closed season in the autumn.

3. That the countries round the Baltic Sea shall report to the Fisheries Commission the extent of smolt production of both cultivated and natural stocks.

4. To recommend the member states to impose a national ban on all salmon fishing in rivers with natural salmon stocks and in their river mouth areas.

5. A special resolution was adopted by the Fisheries Commission on the management objectives recommended by the meeting in Älvkarleby.

13. Measures

13.1 Short-term measures

In the Baltic Sea Fisheries Commission Sweden has advocated substantially lower TACs for 1994 and 1995 than for the years immediately preceding. The demand was defined precisely as a 50% reduction for fishing in 1995. Only a slight reduction was decided on internationally, however, which was inadequate for natural salmon stock conservation. Sweden therefore imposed unilaterally prohibition of salmon fishery in the sea from December 1994 to March 1995.

In addition the National Board of Fisheries suspended salmon fishery in 1994 and 1995 in all rivers with natural salmon in the counties of Norrbotten, Västerbotten and Västernorrland and in the existing closed areas outside these rivers. Some angling has been permitted for a shorter period in 1995.

As long as the threat to the wild salmon stocks remains, primarily from M74, the 1995 measures concerning natural rivers with natural salmon and their river mouth areas should be repeated by means of annual decisions.

As a result of EU membership, Sweden no longer negotiates on her own on fisheries in the Baltic, but is represented by the EU Commission. Within the compass of membership, Sweden should lend her support to an international adjustment of the extent and form of salmon fishery to what is demanded for the preservation of natural stocks.

13.2 Long-term measures

Sweden should work for the development and international implementation of the method of delayed release of salmon, combined with protection of the salmon's growing areas. An opportunity would be given by this means to save the naturally spawning salmon, while at the same time maintaining and probably even increasing professional fishing of reared salmon.

13.2.1 Research on M74

The research programme drawn up in consultation with the National Board of Fisheries, the National Environmental Protection Agency, the Research Council for Forestry and Agriculture, the World Wildlife Fund and the Water Power Board should be implemented.

13.2.2 Gene bank

In order to ensure a reserve of genetic variation, gene banks with material fom the most important wild salmon breeds should be built up.

The work commenced under the auspices of the National Board of Fisheries in establishing gene banks for 14 salmon stocks should continue. The gene banks should be maintained until the threat to the wild stocks is averted.

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Appendix

Estimated smolt production in wild rivers with natural salmon in the Baltic.

Rivers	Reprod.-areal, ha	Numbers of smolt (thousands)						
		1980-talet	1992	1993	1994	1995 prognosis	1996 prognosis	Potential
BOTHNIAN BAY								
Torne älv	5000	65	100	123	199	100	65	500
Kalix älv	2500	50	90	90	130	60	30	250
Råne älv +	100					< 1	< 1	
Pite älv +	435					5	< 5	
Åby älv +	20					< 1	< 1	
Byske älv	270	10	15	20	35	10	5	60
Sävarån +						< 1	< 1	
Rickleån +						< 1	< 1	
Vindelälven	1000	25	25	20	35	15	10	200
Öre älv +	50					< 1	< 1	
Lögde älv +	45					< 1	< 1	
Summa +		10	15	20	30	10	5	100
ALL RIVERS								
BOTHNIAN BAY	**9500**	**160**	**240**	**280**	**430**	**200**	**115**	**1100**
% of pot.		15	22	25	39	18	10	
BOTHNIAN SEA								
Ljungan	60	10	10	10	15	4	4	20
MAIN BALTIC								
Emån	60		5	5	4	4	3	20
Mörrumsån	44 (64)		110	90	60	30	>30	120
SUM MB			**115**	**95**	**65**	**35**	**>35**	**140**
% of pot			82	68	46	25	25	
ALL RIVERS			**370**	**390**	**510**	**240**	**155**	**1260**

Data from ICES C.M. 1995/Assess:16 with some corrections (Karlström 1995 a,b).

Figure 1. Remaining watercourses with wild salmon reproduction in the Baltic Sea (thick line).

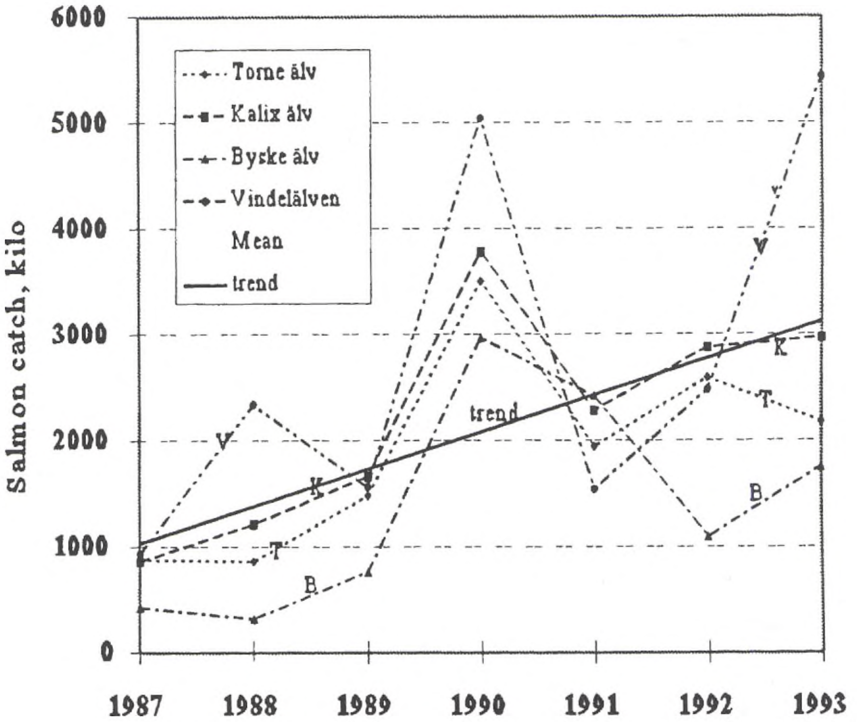


Figure 2. Salmon catches (kilo) in the river Torne Älv (Swedish catch), Kalix älv, Byske Älv and Vindelälven (fishway) in 1987-93. (Karlström 1995 b).

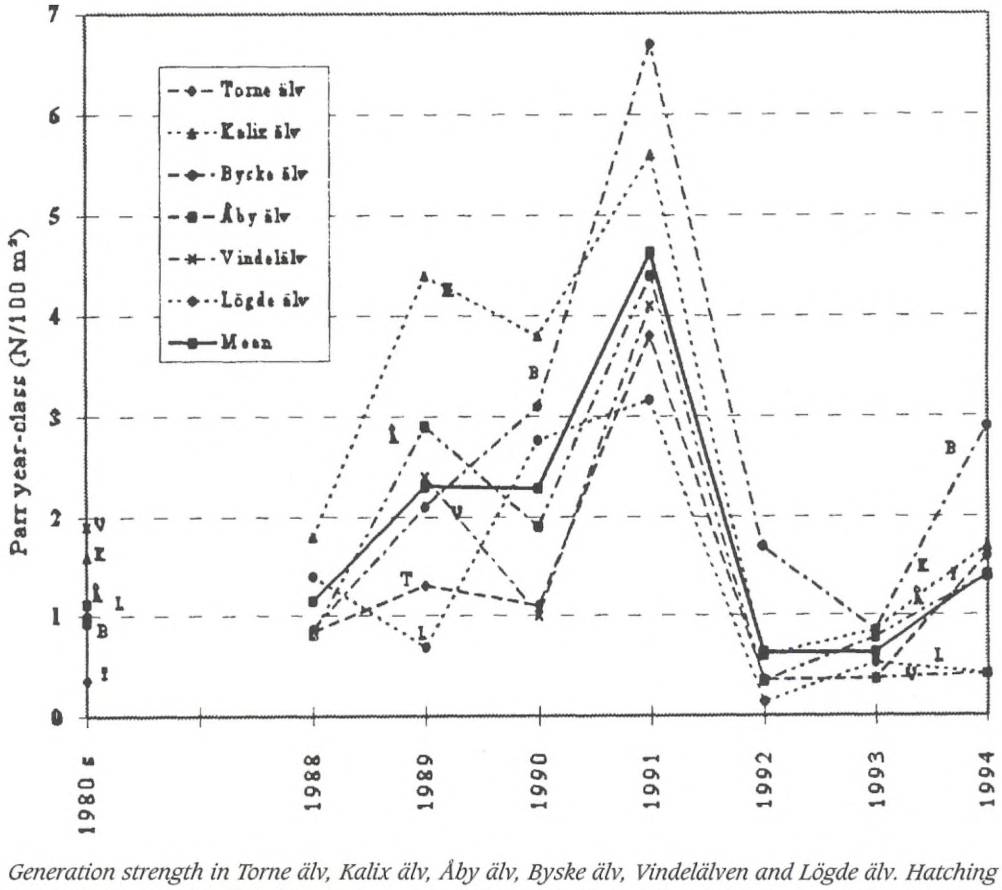


Figure 3. Generation strength in Torne älv, Kalix älv, Åby älv, Byske älv, Vindelälven and Lögde älv. Hatching generations 1988-94. The details below the figure show the smolt migration year for the generation (3-year old smolt) and the year of ascent of spawning fish for the generation (2-3 years at sea). (Karlström 1995a, b)

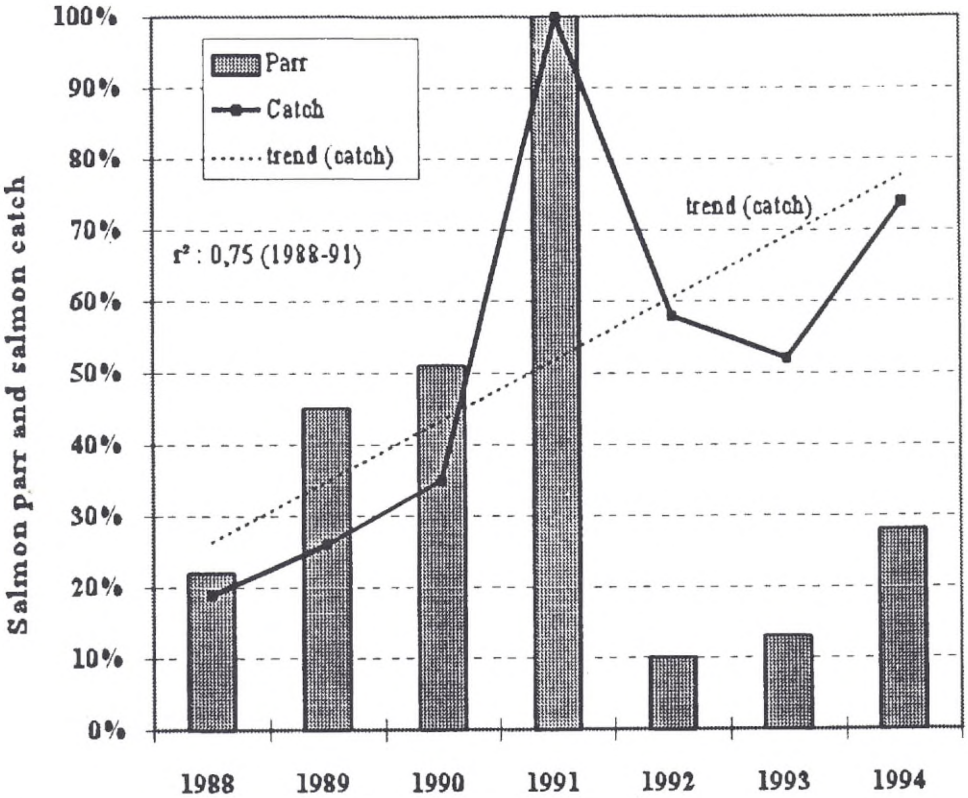


Figure 4. Parr year-classes 1988-94 and corresponding salmon catch the year before in the rivers Torne Älv, Kalix Älv, Byske Älv, Vindelälven and Lödge Älv. Relative values. (Karlström 1995 b).

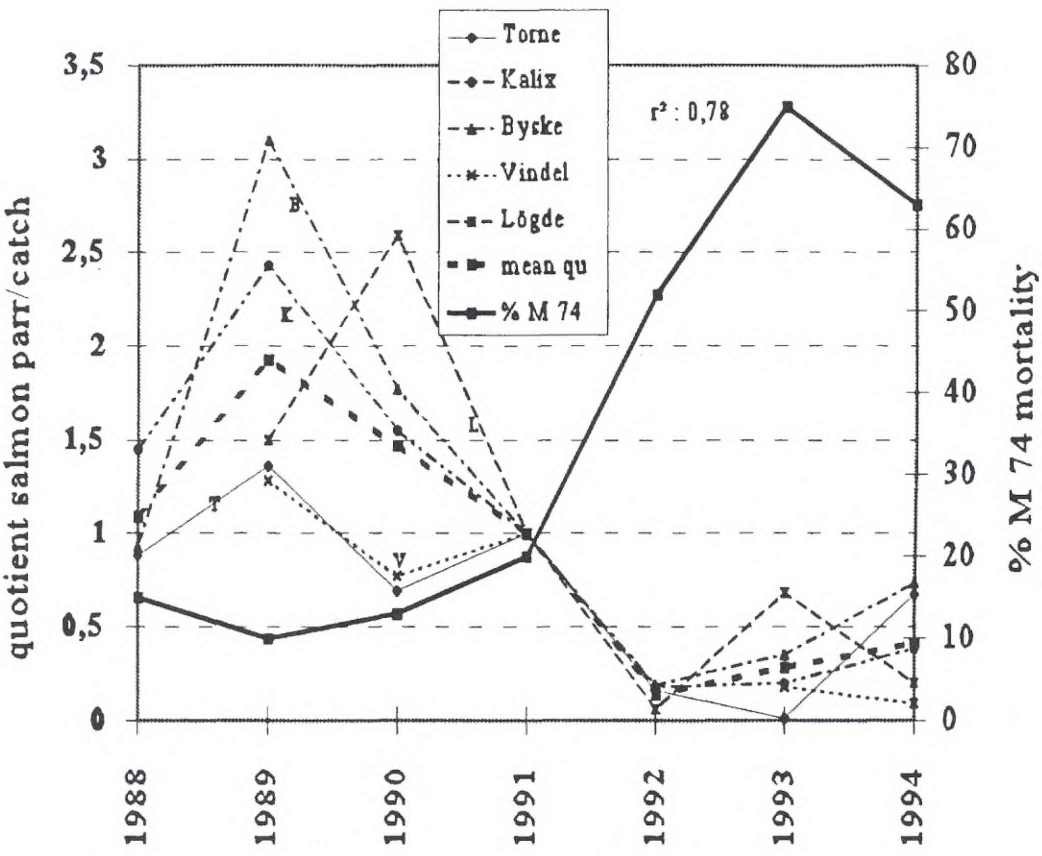


Figure 5. Salmon reproduction in wild salmon rivers in Bothnian Bay area and M 74 related motrtality in salmon rearing plants in the Gulf of Bothnia area (subdiv. 31) in 1988-94 (Karlström 1995 b).

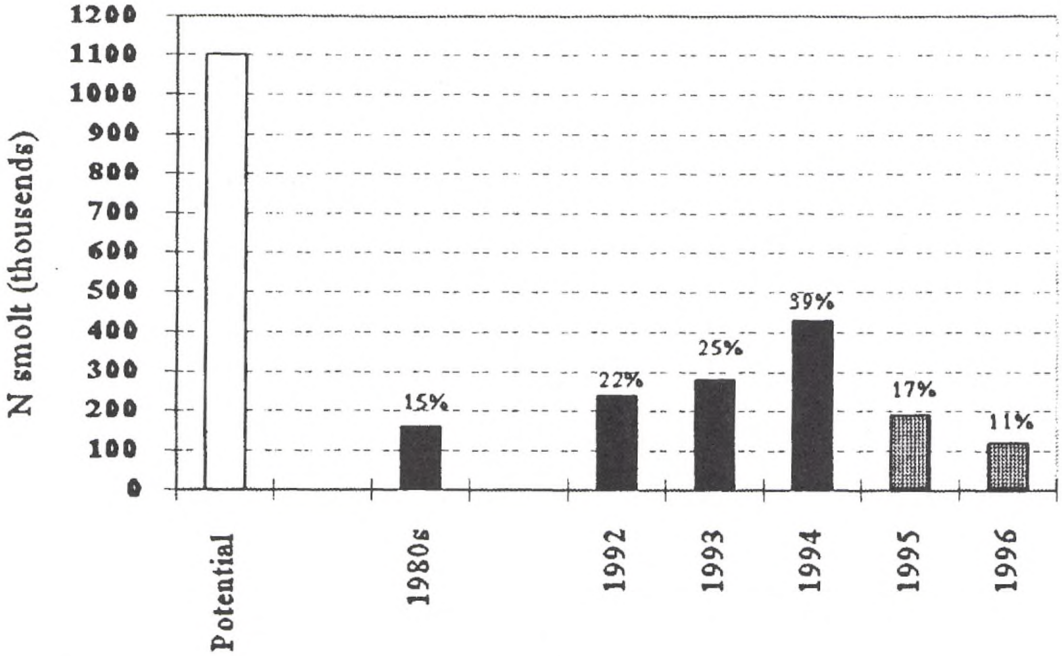


Figure 6. Estimated smolt production in northern natural salmon rivers (Gulf of Bothnia, sub-area 31) during the 1980's and the years 1992-94. Forecast for 1995-96 (Karlström 1995a, b).

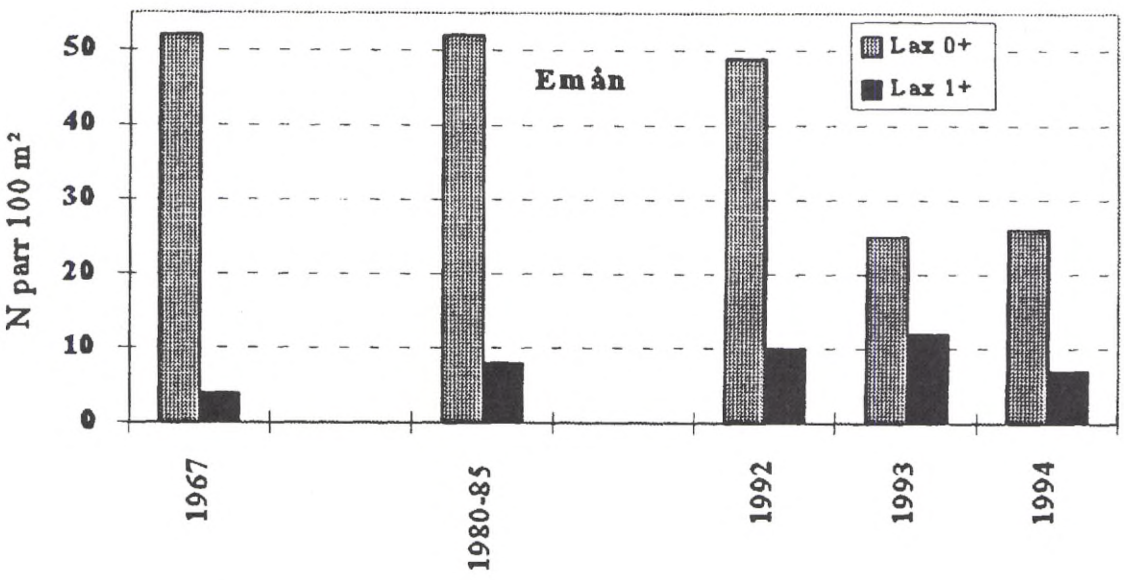


Figure 7. Density of salmon parr in the Emån, 1967, 1980-85 and 1992-94. Data from the National Board of Fisheries Research Office in Jönköping.

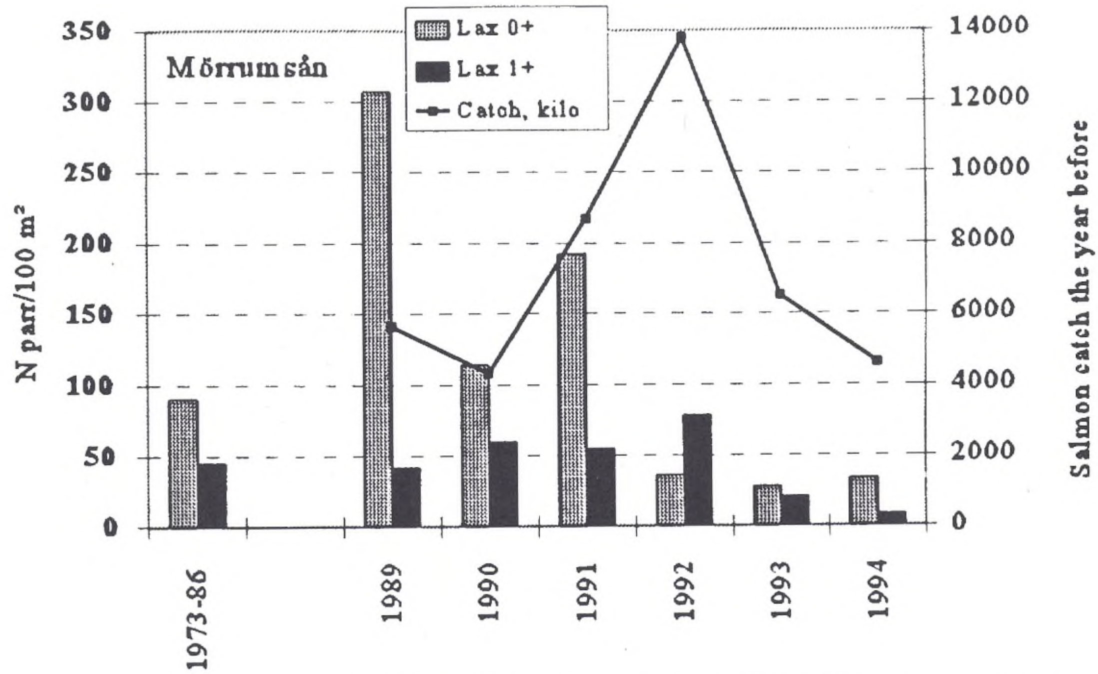


Figure 8. Density of salmon parr in the Mörrumsån from 1973-1994 and salmon catches in the river from 1988-1993. Data from the National Board of Fisheries Research Office in Jönköping.

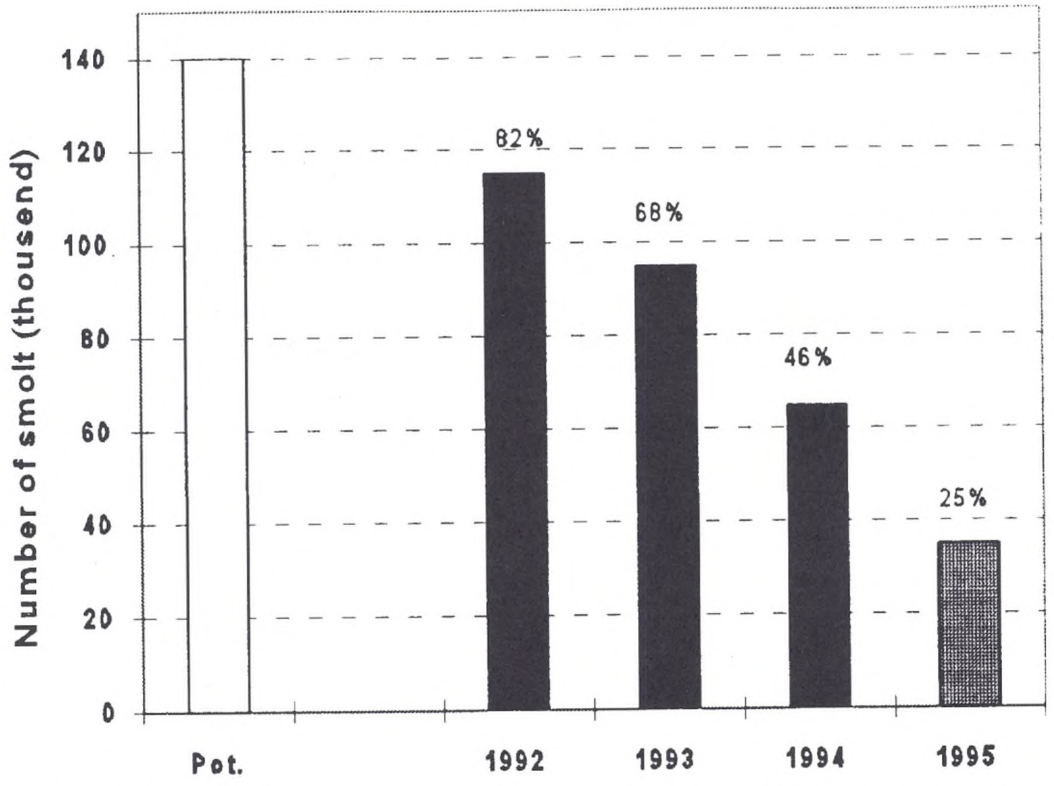


Figure 9. Estimated smolt production in Swedish salmon rivers in the Baltic Main Basin (the Emån and Mörrumsån). Data from ICES salmon working group C.M. 1995/Assess: 16.

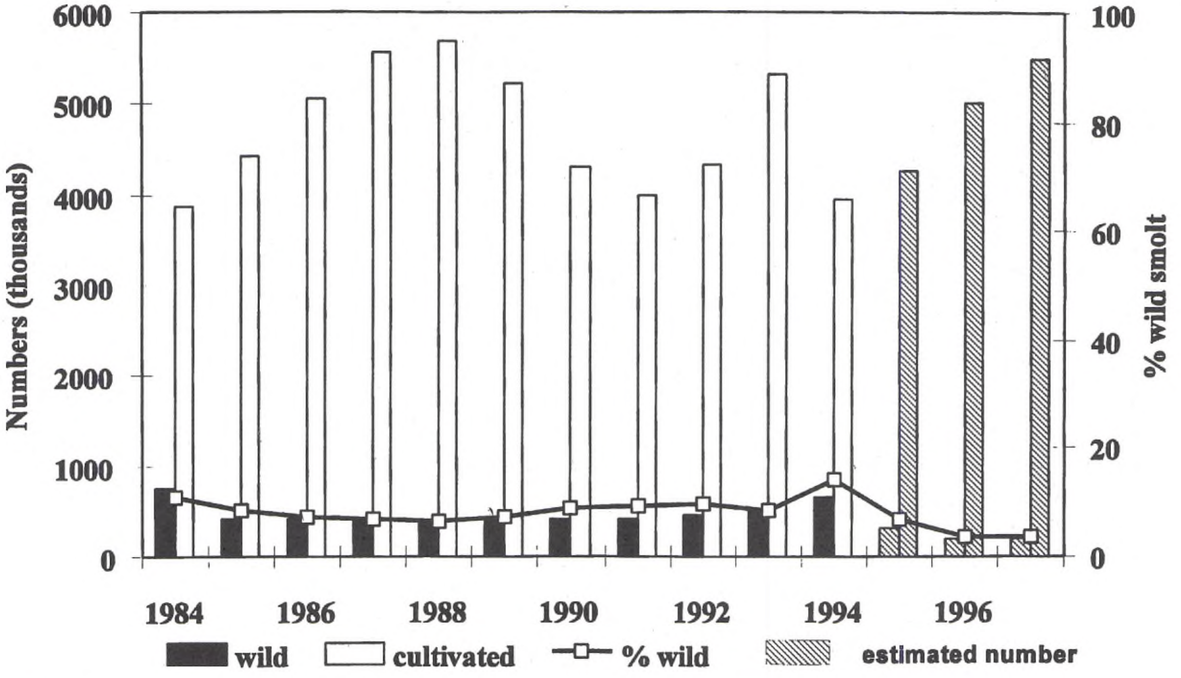
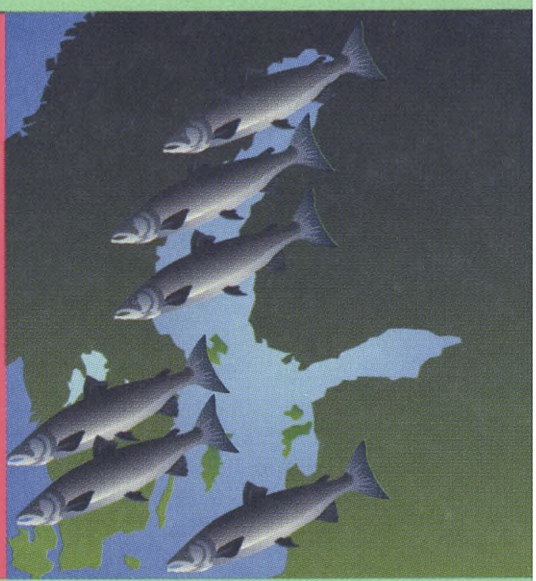


Figure 10. Numbers of wild and reared smolt to the Baltic Sea 1984-97, also with the proportion of wild smolt. Data from the Salmon Research Institute.

The National Board of Fisheries is the governmental authority responsible for matters relating to fisheries and their conservation in Sweden. The primery aim is to ensure the proper exploitaition of our fish resources so that they can be utilized for different kinds of fishing on a long-term basis.

Fishery conservation is an important part of our environmental protection efforts. The National Board of Fisheries carries the main responsibility for fish conservation which means to protect and improve the environment for different fish species and thus achieve a well developed fishery, fishing industry and recreational fishing. Furthermore, fish is an important and nutritious part of our diet, and fishing itself a recreational activity of great social and economic significance.

Reports, Rapporter



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