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Report of the Working Group on the Assessment of Baltic Salmon and Trout

21–30 April 2004
Tartu, Estonia

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 INTRODUCTION

1.1 Terms of reference

The **Baltic Salmon and Trout Assessment Working Group** [WGBAST] (Chair: I. Perä, Sweden) will meet in Tartu, Estonia, from 21–30 April 2004 to:

a) assess the status of the wild and reared stocks of Baltic salmon in the light of IBSFC objectives:
   i) to gradually increase the production of wild Baltic salmon to attain by 2010 at least 50% of the natural production capacity of each river with current or potential natural production of salmon,
   ii) to maintain the Baltic salmon fishery as high as possible;

b) provide catch options in number for Baltic salmon in 2005 for the Main Basin and the Gulf of Bothnia and for the Gulf of Finland that are consistent with IBSFC management objectives, see a);

c) provide medium-term projections of yield and stock development of salmon stocks for a range of fishing mortality rates consistent with IBSFC management objectives, see a);

d) provide any new information on the state of sea trout stocks;

e) provide specific information on possible deficiencies in the 2004 assessments including, at least, any major inadequacies in the data on catches, effort or discards; any major inadequacies in research vessel surveys data, and any major difficulties in model formulation, including inadequacies in available software. The consequences of these deficiencies for the assessment of the status of the stocks and for the projection should be clarified;

f) document fully the methods to be applied in subsequent update assessments and list factors that would warrant reconsideration of doing an update, and consider doing a benchmark ahead of schedule, for stocks for which benchmark assessments are done.

1.2 Participants

Ryszard Bartel	Poland
Janis Birzaks	Latvia
Johan Dannewitz	Sweden (part of meeting)
Piotr Debowski	Poland
Riho Gross	Estonia (part of the meeting)
Frank Ivan Hansen	Denmark
Mart Kangur	Estonia
Vytautas Kesminas	Lithuania (part of meeting)
Marja-Liisa Koljonen	Finland (part of meeting)
Catherine Michielsens	Finland
Samu Mäntyniemi	Finland
Tapani Pakarinen	Finland
Stig Pedersen	Denmark
Wojciech Pelczarski	Poland
Ingemar Perä (chair)	Sweden
Atso Romakkaniemi	Finland
Stefan Stridsman	Sweden
Sergey Titov	Russia (part of meeting)
Oleg Vasin	Latvia (part of meeting)
Mari-Liis Viilmann	Estonia

2 SHORT ANSWER TO THE TERMS OF REFERENCE

In this section, short answers to the terms of reference are treated in the order they are given in Section 1.1.

a) The status of the salmon populations in the Baltic Sea is described in Section 4 (Main Basin and Gulf of Bothnia), and Section 7 (Gulf of Finland). In terms of parr densities, the status of the wild populations in most of the rivers in the Gulf of Bothnia has increased (Tables 4.2.1.9, 4.2.1.10, 4.2.1.11). However, the densities are still low in many of the weaker stocks and especially in the potential rivers (Table 4.3.1.2). In the Main Basin, the parr densities are continuously high on the west side (Table 4.2.2.1), but seems to be decreasing on the east side (Tables 4.2.2.2, 4.2.2.3). The situation in the Estonian river Pärnu is especially alarming (section 4.2.2), as are the situation in the Estonian rivers in the Gulf of Finland (Table 7.2.2.1).

Smolt production in some of the Baltic salmon rivers has been traditionally predicted in the working group using a set of different regression models and point estimates of the relevant variables, such as described in the previous reports. This procedure ignored uncertainty arising from measurement error, uncertainty about parameter values, uncertainty associated with between-river variation of model parameters and uncertainty about the model structure. Uncertainties of future stock predictions are in an essential role in risk-averse fisheries management. Therefore, the working group has decided not to use the previous regression models. A new regression method to predict smolt abundance was introduced into the working group in 2003. The model was developed further for year 2004 (section 4.2.3). Results from this model is given in table 4.2.3.1, showing estimated medians of the salmon smolt production in Baltic rivers grouped by assessment units and with the associated uncertainty of the estimated number as well as of the estimates of reproduction areas and potential production.

According to this, wild production in rivers in the Gulf of Bothnia has increased from the level of 0.5 million (median) smolts in early years up to about 1.5 million (median) smolts prevailing in the most recent years. The prediction for the year 2005 is as high as about 2.5 million (median) wild smolts, but the prediction is very uncertain. Again, there´s a difference in the development between the larger salmon rivers and the weaker stocks in that the numbers of smolt are increasing in the larger salmon rivers while it's continuously low in many weaker stocks. No predictions for the assessment unit 5 (eastern Main Basin) nor for the assessment unit 6 (Gulf of Finland) exists for wild production. In the eastern Main Basin, the assumed production of wild smolts is expected to be very low in the Estonian river Pärnu. In Gulf of Finland, the production of wild smolt is assumed to be lower in 2003 than in 2002 and very small in several of the rivers. The probability of reaching 50 % of the natural production is discussed in c).

The salmon fishery in the Baltic Sea is described in Section 3 (Main Basin and Gulf of Bothnia) and Section 7 (Gulf of Finland). There has been a decline of the total nominal catch in the Baltic Sea starting in 1990 from 5,636 tonnes decreasing to 1,547 tonnes in 2003. This is the lowest catch recorded since 1972 (Table 3.1.1). The nominal catch in the sea decreased by 8 % from 1044 tonnes in 2002 to 962 tonnes in 2003 , in the coast by 27% from 643 tonnes to 467 tonnes and in the rivers by 23 % from 154 tonnes to 118 tonnes (Table 3.1.3). The TAC of 460 000 salmon in the Main Basin and the Gulf of Bothnia was utilised only to 73 % (386 830 salmon), and by countries only in full by Denmark and Poland (Tables 3.3.1, 3.3.2 and section 3.3). The total catches in the Gulf of Finland decreased to by 19 % from 90 tonnes in 2002 to 73 tonnes in 2003, which is the lowest recorded catch since 1981 and about 11 % of the maximum recorded catch of salmon in 1991 (Table 3.1.3). The TAC of 50 000 salmon in the Gulf of Finland was utilised only to 23 % (11 407 salmon).

In spite of continuously high releases of reared salmon smolts in the Gulf of Bothnia and the Main Basin (over 5 million), and in the Gulf of Finland (over 600 000), (Table 4.6.1), catch samples from year 2003 indicate that the proportion of reared salmon was less than 50 % in many of the Baltic Sea fisheries (Table 4.10.1). On the basis on the ratio in the smolt phase, the expected proportion was about 20 %. These results suggest a significantly lower initial survival for the reared smolts compared to wild ones. According to tagging results the productivity of the salmon smolt releases has decreased in all Baltic Sea countries during the last 15 years (Table 9.2.1).

b) A projection of the development of stocks in different management areas with the present fishing mortality is described in section 6.4 and in c). In general terms, at the present catch option of 460 000 salmon in the Gulf of Bothnia and the Main Basin, it is unlikely that the objective of 50 % of the smolt production capacity will be reached by 2010 in the weakest stocks. The situation seems to be similar in the Gulf of Finland, even at the present catch option of only 35 000 salmon.

c) The projection of the salmon stocks is described in Section 6.4. Future fishing mortality rates have been assumed constant for the projections because of the large uncertainty about future salmon fisheries (section 6.4.1 and 6.4.2) and because changes in fishing morality rates have only a limited impact on the results for 2010 due to the fact that only two years remain to impact the number of spawners in 2006 which produce the smolts in 2010. The probability of reaching 50% of the natural production capacity by 2010 has been evaluated for the four first assessment areas (Section 6.2). In general, the stocks of assessment area 1, 2 and 4 are doing well when examining the probability of reaching 50% of the carrying capacity by 2010. Assessment area 2 however also contains some weak stocks i.e. stocks which did not show a clear response to changes in exploitation rates. For those stocks it is highly unlikely that 50% of the smolt production capacity will be reached by 2010. Also the wild salmon stock of assessment area 3 is at risk of not reaching 50% of the smolt production capacity by 2010.

d) The status of the sea trout stocks and the sea trout fishery in the Baltic Sea is described in section 8. In 2003, the total nominal catches of sea trout in the Baltic Sea decreased by 20 %, from 1351 tonnes in 2002 to 1086 tonnes (Tables 8.1.1 and 8.1.2.). Catches of sea trout increased from 200 tonnes in 1979 to 1869 tonnes in 1993 and have since then, except for the years 1995-1997, been at a level of 1100-1300 tons. The results of the electro fishing surveys from year 2003 indicate a precarious state for sea trout stocks on the Swedish side of the Bothnian Bay (sub-division 31) and on the Finnish side of the Gulf of Bothnia (sub-divisions 30 and 31) and Gulf of Finland (sub-division 32) (Table 8.2.1.1, 8.2.1.2 and 8.2.1.3). In many rivers, the densities of 0+ parr in the remaining wild populations are either zero or close to zero. The main reason to the precarious state of wild populations is too intensive fishery, mostly in gillnet fishing, but also in some rivers the poor quality of rearing habitat and a restricted access to the spawning habitats. To protect the sea trout populations, regional and/or local fisheries regulations should be carried out in order to decrease the exploitation.

e) Expert opinions have been used to evaluate the quality of the catch and fishing effort data and to estimate the amount of unreported discards (Section 3). The resulting conversion factors can be used in combination with the reported catch and fishing effort figures in order to obtain estimates of the true catches (including discards) and fishing effort. The uncertainty about the catch and fishing effort data is the highest for the coastal fisheries. The uncertainty in the fishing effort data has been incorporated by using a state-space formulation of the mark-recapture model and by including errors on the fishing effort in the process error. However, in the future, the uncertainty in the fishing effort could be incorporated more explicitly into the model based on these expert opinions. Section 6.5 indicates how the different inadequacies in the data, the formulation of prior distributions, the model assumptions, the model structure and the software, have an impact on the assessment results.

f) Section 6.6 lists the different methods to be applied in subsequent assessments: Bayesian data imputation to fill in missing data, using genetic stock proportion estimates, applying diagnostics for model misspecification, updating the Atlantic salmon stock-recruit function for Baltic salmon and developing a longer term stock-projection method. Section 6.7 indicates the updates to be implemented for the 2005 assessment.

3 CATCHES OF SALMON

3.1 Catches

The catch tables covers all fisheries, including all recreational fisheries, from sea, coast and river, except Tables 3.3.1 and 3.3.2 where river catches are not included.

The catches in weight from 1972-2003 by country are presented in Table 3.1.1, by area and country in Table 3.1.3 and by Sub-division in Table 3.1.5. An overview of management areas and rivers are shown in Figures 3.1.1., 6.2.1. and 6.2.2. Catches in numbers by country from 1993-2003 is presented in Table 3.1.2, by area and country from 1996 to 2003 in Table 3.1.4 and by Sub-division in Table 3.1.5. The recreational share of the catches by country is shown in Table 3.1.6. There has been a decline of the total nominal catch in the Baltic Sea starting in 1990 from 5,636 tonnes decreasing to 1,547 tonnes in 2003. This is the lowest catch recorded since 1972. There has been a tendency to decreased offshore fishery of salmon during the last decade. At the same time coastal and river fisheries increased. The total share of these fisheries is now more than half of all salmon catches in the Baltic Sea basin.

Major reasons for changes in fisheries during the last decade include the following:

- Sharp decrease of offshore fisheries in Baltic countries and Russia due to low profitability;
- Decreasing of offshore fisheries due to other reasons- fishing regulation and seal predation (Gulf of Bothnia) and low numbers of salmon (Gulf of Finland);
- Increasing of Polish coastal and partly offshore fisheries due to changes in management;
- Coastal fisheries in the Gulf of Bothnia and Gulf of Finland suffer from high impact of salmon predation by seals in fishing gear.

Overall, the salmon catch has declined since the early 1990’s. However, catches have slightly stabilised but at a lower level compared to the early 90’s.

3.2 Description of basic collection of catch data

As requested in the technical minutes by the ACFM review group in 2003, the working group in the report includes a description of the basic collection of catch data. The countries participating the salmon fishery in the Baltic are asked to deliver data on catch of salmon and sea trout, area for catch (economical zone, ICES Sub-division), type of fishery (offshore sea, coastal, river, commercial, recreational), information on discard, unreported catch and seal damage. Furthermore the catch effort is asked for in weight and number of catch in different gear (driftnet, longline, trapnet, angling or other). The effort in terms of number of days each gear was deployed is also asked for. The composition of the information provided by the countries in 2003 is summarised in the table below, containing catch in numbers.

Landing statistics from sales notes provides the most important source of information on the catches, and combined with information from logbooks it is the basis of the catch estimates. Information on effort (number of gear, type and fishing days) may be obtained only from the logbooks. Regarding catches, logbooks provide only preliminary information taken on board the vessels, where real count and weight estimates are most often difficult to obtain. The official country catch statistic is obtained from landing statistic and sales notes.

The major part of the information is provided by logbooks, especially from the commercial fishery. In total direct information on catch accounts for more than half of total catch. Extrapolated and estimated catch (partly based on solid information) provides information on approx. 1/3 of the total catch. Catch numbers only obtained by guesses accounts for only 1.4 % of total catch.

Fishery type	Logbook	Extrapolated	Estimated	Guestimated	Total	%
Commercial	221,768	108,449	7,785	5,120	343,122	92.1
Discard	356				356	0.1
Recreational	411		14,900		15,311	4.1
Seal damage	13,851				13,851	3.7
Total	236,386	108,449	22,685	5,120	372,640	100
%	63.4	29.1	6.1	1.4	100	

Catch tables are constructed by extracts from the resulting database. Because of a delay in the delivery of data from some countries, part of the information is preliminary. These data must be corrected the following year.

Effort data included in Table 3.5.1. were calculated separately for 3 different stock assessment management areas (see chapter 6). Basic data for these calculations are found in the catch database, but needs to be divided into the three stock assessment areas before calculations are made. From the year 2000, Table 3.1.1 and 3.1.2 includes a combination of registered and estimated discard catches, and from 2003 only registered discard catches. Rounding off numbers is the reason for minor differences that can be found between tables.

Catch statistics by country are collected as follows:

Denmark: The catch statistics are based on official landing reports and logbooks, combined with additional information from logbooks, e.g. type of gear for all catches, and effort for 70% of the catches, collected in a database at the Danish Institute for Fisheries Research (DIFRES) and from this the total catches are estimated. As no Danish salmon rivers discharges into the Baltic Sea, and salmon therefore rarely migrate into the close coastal areas, sports' fishing for salmon is only possible by offshore trolling. This catch was earlier extremely scarce, but the trolling has developed in the last few years and in year 2003 approximately 3,000 individuals of salmon were caught in the sea east and north east of Bornholm. The estimates of recreational catches are calculated from inquiries sent to recreational fishing clubs, recreational fishing magazines and the tourist industry and are believed to be rather close to the true value.

Estonia: The catch statistics are based on logbooks from the offshore and coastal fisheries. Data on river catches are from brood stock fishery in the river Narva. No catch data from sport fishing is available.

Finland: Catch statistics in the commercial fishery has been collected in logbooks from the offshore and coastal fishery. Catch statistics of the commercial salmon fishery for 2003 are preliminary. Catch statistics of non-commercial fishery are based on the nation-wide inquiries, which has been carried out every second year since 1980. In these statistics estimates by sub-division on the non-commercial have rather wide confidence limits. To obtain more accurate estimates on catches in rivers Tornionjoki, Simojoki and Kiiminkijoki, extensive inquiries has been conducted in some years among fishermen who have bought a fishing licence. In recent years the inquiries have been made annually in these three rivers. Catches of the recreational salmon fishing for year 2002 were updated based on the Finnish

Recreational Fishing 2002 - survey results. These data lowered the total catches presented in year 2003 report. The catches of recreational salmon fishing in year 2003 were assumed to retain the same as in year 2002.

Germany: All commercial catches of salmon and sea trout are caught as by-catches in the trawl, trap net or gillnet fishery. Only commercial catches are available.

Latvia: The Latvian salmon landing statistics are based on the logbooks and landing declarations from the offshore and coastal fisheries. Catch data from a small scale recreational fishing in the River Salaca and River Venta is based on questionnaires.

Poland: Commercial catch statistics are based on logbooks. Polish Anglers Union provides estimates on sport fishing catches in rivers.

Russia: The catch statistics are based on official landing reports, logbooks and scientific observes from the offshore and coastal commercial fisheries and broodstock fisheries in the rivers. Catches could be grossly underestimated. No recreational fishery occurs in the coastal area and rivers. Catch statistics of the salmon fishery for 2003 are preliminary.

Sweden: Swedish catch statistics are based on logbooks of licensed fishermen in coastal and offshore fisheries. Catches by non-licensed fishermen in coastal areas are estimated from the total number of gears in each coastal region and the catch in the licensed fishery in the area. On the basis of different kinds of circumstantial data, angling and trolling in the coastal and offshore areas are believed to be of small, but increasing, magnitude. Estimates of the catches in this kind of fishery are mainly based on guesses. Catch statistics are collected for all Swedish salmon rivers, but the quality depends on local conditions, size of the river and on how the river fishery is organised. Catches by non-professional fishermen and by proffesional fishermen inside the freshwater limit in some rivers are not included in the official estimate of the catch quota reported to IBSFC. Catch statistics of the salmon fishery for 2003 are preliminary.

Biological sampling from the catch of salmon is collected as follows:

Estonia: There is no Biological sampling programme in Estonia, but sampling takes place occasionally, carried out by fishermen at a very low level of 200 – 300 salmon per year from the river brood-stock fishery.

Denmark: The Danish biological sampling programme was carried out in accordance with the minimum programme in EC 1639/2001 chapter H: Biological sampling of catches: composition by age and by length and chapter I: Other biological sampling. As the sampling effort stated in this regulation is very limited, Danish samples are collected three times in the winter/spring period, and three times in the autumn/winter period. When it is possible 10-30 salmon samples are collected per size class, for size classes +11 kilo, 9-11 kilo, 7-9 kilo, 5-7 kilo, 4-5 kilo and 3,5-4 kilo per sampling, and in 2003 approximately 800 scale samples was collected. Length, age and weight are collected. From these samples the length, age and weight composition is estimated for each fishing period, based on the total catches extracted from the official landings database. As Danish samplings before 2003 only intended for estimation of age of the salmon population in the Main Basin, there has been made no sampling of length and weight per individual before 2003. The smaller size groups of salmon have not been collected earlier as the age composition of these smaller salmon was known already from previous results.

The relevant geographic area is the Baltic Sea, i.e. ICES sub-areas IIIb, c and d. Danish salmon fishery takes place in ICES SD 24-28 and it includes only offshore fisheries. The precision level is 1 sample of 50 fishes per 100 tonnes of fish and the samples taken exceed this with a factor of close to 2. As salmon from the offshore fishery is already gutted when landed, sex and gonadal maturity by age are not available from offshore samples taken in ports. As a very large part of the international salmon landings from the open sea fishery (approx. 250,000 salmon) takes place at only one company at Bornholm in Denmark, the DIFRES has continued collection of scale samples from Swedish and Finish landings at Bornholm, at a higher level than in 2002. These samples are forwarded to Sweden and Finland and are age determined in the respective countries. In 2003 the DIFRES in Charlottenlund, and the Swedish National Board of Fisheries laboratory in Karlskrona, have started a cooperation to coordinate the market sampling methods. From 2003 all Danish catch and biological data are provided in data base format at a monthly basis.

Latvia: The biological sampling of salmon are divided by two main types of fisheries: offshore and coastal. In total 1,500 – 2,000 salmon are sampled every year. Sampling from offshore fisheries are carried out from September till May, at least one time per month. In coastal fisheries salmon biological sampling are carried out from June till November in two coastal locations: near the rivers Daugava (reared population) and Salaca (wild population) outlets. From 2005 salmon sampling will be included in the Latvian National Fisheries sampling programme. Number of sampled fish exceeds EU sampling standards for salmon because more intensive sampling is important for national salmon management and fisheries regulation. Data are stored in a database at the Latvian Fisheries Research Institute.

Finland: The Finnish commercial catches of salmon in the Baltic Sea are taken from two IBSFC management units, the Gulf of Finland (ICES Sub-division 32) and the Gulf of Bothnia – Baltic Main Basin (ICES Sub-divisions 22-31), both having their own annual TACs. In both areas, two principal types of fishing are engaged, with totally different catch age and length compositions. In the coastal fishery, trap-nets and anchored gill-nets are used to capture mature salmon returning to home rivers in spring and early summer (V-VII). In the offshore fishery, drift-nets and drift-lines are used to capture feeding salmon in autumn and winter months (IX-V). Technical measures are taken to manage both these fisheries.

For the evaluation of the composition of catches in length and in age, a sampling intensity of one sample of 50 fish/ 100 tonnes is required. In 2003, Finnish commercial catches of salmon totalled 360 tonnes, thus corresponding to 4 samples and 200 individuals. However, assuming that the sampling must cover the basic data needs of stock assessment in both management areas and for both main types of fishing, a much more intense sampling scheme is needed. EU Regulation requires that sampling programmes must be implemented to estimate the share of wild and reared salmon in the catches. Besides for the evaluation of the age composition, salmon scale samples are also needed to provide these stock composition estimates. Therefore, somewhat larger sample sizes are needed in these analyses.

<u>Commercial offshore fishery</u>

The offshore fishery exploits mainly feeding salmon and the catches are relatively evenly distributed across the season from October to May. At present, about half of the Finnish commercial salmon catch has been taken in the offshore fishery, and approximately 25% of the catches are landed in foreign countries. To get representative estimates on the length and age and stock composition of the landings, sampling must be disaggregated over time and regionally. Furthermore, each sample should include fish from several fishing vessels and several fishing days. Offshore landings originating from the Baltic Main Basin (ICES Sub-division 22-28) has been sampled in Maarianhamina and Bornholm, Denmark (DIFRES). In the Gulf of Bothnia (ICES Sub-division 30-31) there has been no regular offshore fishery. In the other IBSFC management area, Gulf of Finland (ICES Sub-division 32), only a small scale offshore fishery occur in the West part of the Gulf.

3.2.1.1 Commercial coastal fishery

Coastal salmon fishery targets on spawning migrants. In a given coastal area, the fishing season lasts only about 2 months (from V-VII), but during these 2 months remarkble changes occur in the age, length and stock composition of the catches. Due to these changes, weekly sampling is needed to get representative samples. In the Gulf of Finland (ICES Sub-division 32), the most important fishing areas are situated in the eastern part of the Gulf. Catches are mainly landed in Kotka, where the sampling will also be organized.

Along the long coast-line of the Gulf of Bothnia, sampling must be disaggregated regionally. To protect spawning migrants, the fishery is opened successively in four concsecutive fishing zones, beginning from the south. To assess the success of this management scheme, catch samples must be taken from three key areas, which are 1) Åland Sea (ICES Sub-division 29), providing the overall composition of fish schools entering the Gulf; 2) sea area north of the Quark (ICES Sub-division 30-31, Pietarsaari), where fish from Swedish salmon stocks have departed from the schools; and 3) Oulu region (ICES Sub-division 31), after which salmon from different stocks start to orientate to their home rivers.

3.2.1.2 Biological sampling of salmon in rivers

Catch samples of salmon and sea trout will be collected from the fishery in the wild salmon rivers of the Gulf of Bothnia (Rivers Tornionjoki and Simojoki). This data collection is an integral part of the assessment of spawning run composition and the effects of fishery, and it is strongly linked to the corresponding sampling from the Finnish coastal fishery. The monitored variables include smolt age, sea-age, sex, origin (wild/reared) and size at capture (weight and length).

The catch sampling in 2003 is presented in the text table below:

Months	Fishery	Gear	SD22-28	SD29	SD30	SD31	SD32	Total
1-4 and 9-12	Off-shore	Longline	75				328	403
	Off-shore	driftnet	133					133
5-8	Coastal	driftnet		299				299
	Coastal	trapnet			250	383	400	1033
5-9	River					350		350
Total				208	299	733	728	3318

Germany: There is no information available on biological sampling in Germany.

Poland: Polish samples are collected several times throughout the year (both in spring and in autumn/winter period). In most cases one sample consists of approx. 50 fish. Samples are taken exclusively from landings in Polish harbours. Length, weight and scales from every fish are collected, and based on these samples the length, age and weight composition, in the total catches from the official landings database, are estimated per year.

Polish salmon fishery takes place in ICES SD 24-26 and it includes mostly offshore fisheries, however some fish from coastal fisheries can be also sampled, depending on availability. Since 2004, according to EU Sampling Regulations precision level of sampling will be of 1 sample of 50 fishes per 100 tonnes of fish. All data are stored in Sea Fisheries Institute in computerised database format.

Russia: There is no Biological sampling programme in Russia. However fish collected in the river broodstock fishery are aged and lengths and weights are recorded.

Sweden: Salmon was sampled in accordance with the minimum programme in EC 1639/2001 chapter H: Biological sampling of catches: composition by age and by length and chapter I: Other biological sampling. It also followed the Swedish National Programme for collection of fisheries data for 2003. The relevant geographic area is the Baltic Sea, i.e. ICES sub-areas IIIb, c and d. Swedish salmon fishery takes place in ICES SD 23-31 and it includes river, coastal and offshore fisheries.. The precision level is 1 sample of 50 fishes per 100 tonnes of fish and the samples taken exceed this level.

The offshore fishery takes place mainly in the 1st, 2nd and 4th quarters. Sampling of the fishery was concentrated to the driftnet fishery, which normally accounts for 70-80% of the offshore catch (75% in 2003). It takes place in the 2nd and 4th quarters. Sampling of the Swedish catches was carried out by screening of salmon landings in weight classes in ports in south Sweden. As an increasing share of the Swedish catch is landed at Bornholm in Denmark one sampling was also carried out there. This sampling scheme is in accordance with the National programme. The coastal trapnet salmon fishery straddles several quarters. Samples were taken by the fishermen themselves at two different locations in the Gulf of Bothnia (ICES SD 30-31); Skellefteå and outside Nordmaling, and by the Board of Fisheries in the archipelago of Haparanda. All data are stored in a database at the Institute of Freshwater Research.

As salmon from the offshore fishery is already gutted when landed, sex and gonadal maturity by age are not available from offshore samples taken in ports. Sexing of fish is carried out in a proper manner by some coastal fishermen. At the same time when aging of fish takes place by scale reading, it is also determined if the fish is of wild or reared origin. As a preparation of studies on stock proportions in the fishery, genetical samples were taken both in the offshore and coastal fishery.

3.3 Distribution of Catches by Fishing Zone

Until 1992 the TAC was given in tonnes. In 1991 the TAC was exceeded by 681 tonnes and in 1992 by 349 tonnes in sub-divisions 22-31. In the Gulf of Finland, the over utilisation were 218 tonnes and 99 tonnes in 1991 and 1992 respectively. From 1993 the TAC was given in numbers. The landings in numbers compared to TAC by fishing nations and by areas in 1993-2003 are given in Table 3.3.1. The distribution of catches in numbers among fishing zones in the Main Basin and the Gulf of Bothnia and nations in 2003 is given in Table 3.3.2. The TAC of 460,000 individuals in sub-division 22-31 was utilised only to 73%, (total in EU zone was 81%) according to preliminary catch figures. In the Gulf of Finland only 23 % of the TAC of 50,000 individuals was utilised. It should be noted, that there is occasionally some exchange of TAC between countries, which may result in exceeded TAC's. Only Denmark and Poland fully utilise their TAC. In 2003 the TAC for salmon in the Main Basin and Gulf of Bothnia of 460,000 individuals has been allocated to fishing zones in the following manner:

Contracting party	Quota
Estonia	9,504
Latvia	59,478
Lithuania	6,992
Poland	28,368
Russia	8,740
EU Total	346,918
Total	460,000

Allocation of EU TAC to EU member states was as follows;

Denmark	93,512
Finland	116,603
Germany	10,404
Sweden	126,400

In 2003 the TAC for salmon in the Gulf of Finland of 50,000 individuals was allocated to fishing zones in the following manner:

Contracting Party	Quota
Estonia	4,650
EU (Finland)	40,700
Russia	4,650
Total	50,000

The major part of the salmon catch in the Baltic Sea is caught by professional fishermen with drift nets or long lines in the offshore areas or by trap and gillnets in the coastal areas. The catches in the non-licensed fishery with commercial gear-types are mainly recreational for self- consumption. These catches are usually not reported through the official channels and therefore are relatively incomplete. Table 3.1.6 gives an estimate of the size of this fishery. It appears from the table that non-commercial fisheries constitute a considerable part of the total catch of salmon. In 2003 these catches constitute only 4% of the total reported salmon catches (18% in 2002) because data of recreational fisheries of salmon in Sweden was not available.

3.4 Fishing Effort

The total fishing effort by drifting gear in the offshore fishery in the Main Basin since 1987 is given in Table 3.4.1. which includes Fishing efforts of Baltic salmon at sea, at the coast and in the river in 1987-2003 in subdivision 22-31, excluding Gulf of Finland. The fishing efforts are expressed in number of geardays (number of fishing days times the number of gear) and are reported per half year (HYR). The coastal fishing effort on stocks of assessment area 1 (Chapter 6) refers to the total Finnish coastal fishing effort. The coastal fishing effort on stocks in assessment area 2 refers to the Finnish coastal fishing effort in area 3 and the Swedish coastal fishing effort in area 2. The coastal fishing effort on stocks of area 3 refers to the Finnish and Swedish coastal fishing effort in area 3.

An overview of the number of fishing vessels engaged in the offshore fishery for salmon is given in Table 3.4.2. Data are missing for Lithuania in 1999 and 2000, and for Russia and Lithuania in 2001, 2002 and 2003, but as the catches by Lithuania and Russia are small, it seems unlikely that their boats have been engaged more than occasionally in this fishery. Germany has no fishery targeting salmon directly, and is only catching salmon as a by-catch in other fisheries. Consequently data on German effort is not included in the tables of effort. In 2003 175 vessels were engaged in the fishery and this was a further decrease compared to the level in 2002 (191 vessels). In 2003 120 vessels fished less than 20 days and only 32 vessels were fishing more than 40 days. It seems likely that only the vessels, which are fishing more than 40 days per year, may get more than 50% of their annual income from the salmon fishery.

There has been a decline in effort in the drift net fishery in the Main Basin especially after 1995, when TAC was reduced from 600,000 to 500,000. Effort was reduced to approximately 1/3 of previous values. From 1995 it has remained relatively stable. Effort in the longline fishery has been more variable. From a maximum in 1987 it reached a low in mid 1990'ies. From this time it has again increased with approximately 50 %. This increase was reached in 2000 and after that time effort has remained rather stable.

The decline in the effort is mostly caused by increased efficiency of the fishery and by decreased fishing and TAC`s.

The introduction of national fishing zones in the 1980s and the adoption of a TAC in the 1990s combined with low market prices has affected the fishing effort. The catch quota was restrictive in the open-sea fisheries in some countries, which had allocated a separate quota for open-sea fishery. The restrictive quota in combination with a relatively high and raising CPUE in the Main Basin offshore fishery (see sect. 3.5 and Table 3.5.1) contributed to the decreasing fishing effort.

Regarding fishing effort, no data have been available for the Polish offshore fisheries and the Swedish coastal fisheries by other gears (predominantly gillnet fisheries) for the entire time series. The Polish effort data have been estimated based on the CPUE of the offshore fisheries by other countries and data for the Polish salmon offshore catches. Within the Polish fishery, salmon and trout are caught jointly and a more appropriate conversion of CPUE figures to fishing efforts would be obtained when using the combined Polish salmon and trout catch figures. These figures had not been available for the entire time series but have been promised for the 2005 assessment. A similar approach has been used to estimate the fishing effort data for the Swedish coastal gillnet fishery. The Finnish CPUE in the coastal gillnet fishery has been used in combination with the catch data for the Swedish coastal gillnet fishery in order to estimate the Swedish fishing effort by coastal gillnets. In addition, the WGBAST data base contained also some missing records. The missing records of fishing efforts have been estimated based on the reported catch data for those records and the CPUE for the salmon caught during the same period by the same fishery and fishing fleet. No uncertainty has been accounted for in the calculation of missing fishing effort. The uncertainty of the fishing effort figures, as reported by the fishermen, has been estimated through expert opinions (section 3.10).

3.5 Catch Per Unit Effort

Table 3.5.1 shows seasonal mean CPUE for Danish, Estonian, Finnish, Latvian, Swedish, and after 1998/1999 also Russian offshore fisheries for different periods after 1980/1981, and for various combinations of Sub-divisions in the Main Basin, the Gulf of Bothnia and the Gulf of Finland. The CPUE is presented as number of salmon per 100 nets (drift net), and number of salmon per 1000 hooks (longline).

From the fishing season 1983/1984 and onwards, the CPUE in the drift net fishery has increased significantly compared to the preceding years, however with somewhat lower levels in the mid 1990'ies. In 2003 the CPUE in both drift net and long-line fishery increased substantially in the Main Basin, especially in the Danish fishery. In the Gulf of Bothnia the CPUE`s was very close to the levels from 2002, and in the Gulf of Finland the CPUE`s decreased especially in the long-line fishery.

The development in the offshore gear has been evaluated (Anon. 2003). It was concluded that the offshore gear has not developed much since the late 1960's and that gear development has not greatly affected the overall CPUE. Increased CPUE is more likely due to improved vessels, and improved skills in fishing. Therefore, changed and varying CPUE's cannot be converted to certain gear constructions or certain periods, because the fishery as such has changed much. The variations of CPUE probably reflect also temporal and spatial changes in the distribution of salmon as well as improvement in skill, and vessel and navigational quality.

3.6 Age Composition and Mean Weight of the Catches

The age composition of the Danish and Latvian catches in the Main Basin is given as seasonal weighted means in Table 3.6.1. The age composition is estimated from scale samples covering the fishery throughout the fishing season. In Denmark scales from 1,500-2,000 individuals were sampled every year, but from 1997 and later this has been reduced to scales from approximately 1000-1500 individuals per year, and from 2001 to 800-1,000 individuals per year. In the period 1972 to 1999 the fish birthday (year of migration to the sea) was decided to be at the 1.st of July and after year 2000 at the 1.st January. For this reason, there will be a very significant shift in the Danish age readings from season 1998/1999 to 1999/2000. In Latvia all the age determinations are based on a fish birthday on 1 July. From 2004 the Latvian data will be recalculated to enable comparison to other scale reading data. In total 1,500 – 2,000 of salmon were sampled in Latvia per year including both offshore and coastal fisheries. Because of different methods, the Latvian and Danish scale readings are not comparable before the season 1999/2000 at the moment.

Polish age determinations of salmon are also available with readings of 700 individuals per year, Finnish with 2,000 per year, including samples from Finnish landings in Denmark, Swedish with approximately 1500 per year, including samples from Swedish landings in Denmark, but this information is not included in the report.

Mean weights per half year, of fish caught in the Latvian and Danish offshore fishery are given in the tables 3.6.2 and in 3.6.3 The Danish mean weights are calculated from total landings in the official Danish landings database, while the Latvian mean weights are based on biological sampling every month. The mean weight per salmon, calculated from the total Danish catches of salmon in 2003 was 4.15 kilos. In 2002 the mean weight was 4.37 kilos. This decrease in the mean weight of the caught salmon, is a result of low mean weights in the first 6 months of 2003, compared to earlier years, and can only be explained by smaller mean weight of the population in the Main Basin. This is confirmed by direct information from Danish fishermen. There has been no important change in the Danish fishing pattern in these 6 months compared to the pattern from 2002, which can explain this decrease in mean weight.

3.7 Predation on salmon by seals and damage caused by seals to fishing gears and to salmon in fishing gears

The effects of seal on salmon and salmon fishery have consequences on fishery at several different levels:

1. The direct catch loss due to damaged or escaped fish.
2. Capital losses due to damages of gear.
3. Indirect effects through changes of fishing strategy.
4. Effects on fishery through competition for the salmon resource.

All effects are difficult to quantify. Item number 1 and 2 are the parts of the total damage where the best data is available for quantitative estimate, but still with substantial uncertainty. The indirect effects can only be estimated in a very crude manner and an estimate of the seal population effect on recruitment of commercial species is not possible, since this requires a good knowledge of the total seal population size and also the composition of the diet.

In **Denmark, Russia and Poland** influence by seals on salmon fishery is insignificant. No data are available from Germany or Lithuania.

The seal impact is a problem on the economical value of the **Estonian** salmon gill net fishery. The number of damaged fish increases form year to year. Quantitative estimation of damaged fish is not available.

In **Finland** seal damaged a significant number of salmon in gears. Most of the damaged fish has to be discarded. The share of discarded fish is reported by fishermen in numbers of salmon damaged. Seals caused severe damages to fisheries mainly in sub-divisions 29-32. According to quantitative logbook records about 13,850 salmon (65 t) salmon were discarded due to seal damages, which comprised 17 % of the total commercial catch in the region. In logbooks there were also a lot of non-quantitative notifications on seal damages, making the true rate of damages higher than recorded (20-30 %).

The most serious problems were met in sub-division 29 in the Åland Sea and the Archipelago Sea, in sub-division 30 in the Bothnian Sea, and in sub-division 32 in the Gulf of Finland, where seals destroyed especially trap net catches. In these areas the fishermen have been forced to give up fishing on the outermost trap net locations because of seal damages. In Sub-division 30 the drift net fishery has almost totally disappeared due to seal problems.

In **Latvia,** direct catch losses of salmon by seal damages increased significantly in 2003. In the most affected area, southern part of the Gulf of Riga, the percentage of salmon damaged by seal in coastal fishery increased from 5% in 2002 to 40% in 2003. Analyses of the age composition of grey seal, drowned in the trapnets, indicated some biological tendencies in the population of grey seal occupying the coastal waters of the Gulf of Riga, during the salmon fishing season.

1. 80% of the seals caught in the coastal fishery was immature young individuals (age <5 years);

2. There is tendency for increasing in general in the grey seal population, in the coastal waters, because increases number of older (>5 years) specimens.

The total number of damaged salmon is now at a level which impacts the economy in the fishery. The number of discarded salmon due to seal damages was in 2003 670 individuals (5 tonnes).

In Sweden the total percentage of the salmon discarded from trap net fishery, due to damage by seal is estimated based on some observations to be about 15%. The total weight and number of salmon discarded for this reason was in 2003 estimated at approx. 20 tonnes and 5,335 salmon.

In total it can be estimated that at least 19,855 salmon were discarded in the Baltic Sea in 2003 due to damages caused by seal in gears. The estimate of this discard in the Finnish fishery is shown in Table 3.7.1.

3.8 Discards of Salmon

Data on discards of salmon (mostly undersized fish) from different fisheries in the Baltic Sea are very incomplete and fragmentary. For this reason the quality of the information was judged to be insufficient and data re not included in the catch tables in 2003.

In **Denmark** there has been made no collections of trustworthy information about discard catches in 2003, but from data collected over a longer time span on discard, a guestimate is given for assessment purposes. It is known from earlier observations, that longline fishery is much less selective than driftnets, and undersized salmon may be caught much more frequently in this fishery. However, no official observers have collected discard data onboard salmon vessels for several years.

In **Polish** fisheries a number of young undersized salmon (30-40 cm) may be caught in trawl catches for cod. Feeding salmon is also caught as a by-catch in the trawl sprat fishery.

Longlines used for salmon is a much less selective gear than are driftnets and undersized salmon may be caught more frequently. However no survey on this was conducted. The coastal fishery, mostly for herring, frequently catches a number of smolts, especially tagged ones during spring time.

Taking the above into account leads to the assumption, that number of salmon discarded in the Polish fishery could be approx. 2,000 fish per year. All discards should be recorded in logbook, however, it never appears.

Salmon discards in **Finland** salmon fisheries were about 350 salmon (1 t).

Information on discarded salmon in **Estonia, Sweden, Latvia and Russian** fisheries were not available.

3.9 Description of gears used in salmon fisheries

The Group concluded, that it was important to compile information about the type of gears used in different salmon fisheries, to be able to evaluate the effect of changes in each fishery. Extensive descriptions were provided from most countries at the Workshop on Catch Control, Gear Description and Tag Reporting in Baltic Salmon (WKCGTS) in 26-28 January 2003 (Anon. 2003). All collected information regarding presently used gears in Sweden, Finland, Estonia, Latvia, Poland and Denmark, and historical gear development in the Baltic Salmon fisheries are described in the report from this meeting.

Major gears used in the offshore fishery are driftnets and longlines. In the coastal fishery trap nets and anchored floating gillnets are more commonly used. Some regional differences and development of gear used in salmon fisheries were described in Anon. (2003) report. In the offshore fisheries some of the Finnish and Polish fishermen in the 1980'ies started to use deeper driftnets with total depth of 10 - 15m in comparison with traditional driftnets (6.4 m). In the Gulf of Bothnia and Gulf of Finland trap net fisheries has been developed using new netting , and in Sweden a new type of trap has been developed (so called 'push-up trap') to protect the catch from seals.

3.10 Evaluation of the quality of the data estimates used for the assessment

3.10.1 Introduction

Within the WGBAST working group report, most data series such as catch data and fishing effort data are presented as point estimates. In reality these data series should be considered estimates since they are derived data series and have undergone varies manipulations by fisheries statisticians. Fisheries statisticians have to deal with non-reporting, missing data, discrepancies in logbooks and uncertainties regarding the actual observations. Within the working group an attempt was made to assess the quality of these point estimates i.e. how well they represent to actual catches, fishing effort, etc. This has resulted in the establishment of conversion factors which can be used in combination with the point estimates reported within the data tables to obtain estimates for the actual catches, fishing efforts or tag recoveries.

This document explains the process of eliciting and summarising the uncertainty associated with the different data estimates used within the assessment methodology for Baltic salmon. The resulting probability distributions for the uncertainty of catch, fishing effort and tagging data estimates can subsequently be used within the assessment methodology as prior probability distributions. In order to obtain general support, prior probability distributions need to have some evidence or consensus in support (Spiegelhalter *et al.*, 2004). For several of the parameters needed within the assessment methodology, data is limited (e.g. tag reporting rates) or not available (e.g. underreporting of catches). In such cases expert opinion is important. This paper documents how expert opinions have been obtained and combined to formulate prior probability distributions for the uncertainty associated to the data estimates used for the assessment model.

3.10.2 Methodology

Eliciting prior probability distributions from expert can however result in biases (Kadane and Wolfson, 1997). Chaloner (1996) provided a thorough review of methods for prior elicitation and concluded that fairly simple methods work best, i.e. using interactive feedback, providing experts with a systematic literature review, basing elicitation on 2.5th and 97.5th percentiles and using as many experts as possible. For the working group's stock assessment, expert opinions about the quality associated with different data estimates (i.e. how well they are likely to correspond to the true values) have been elicited from working group members during separate workshop (ICES, 2003). The parameters on which the experts were asked to give their opinion were thoroughly explained and participants of the workshop presented the available information (previous studies or literature) about these parameters. For each parameter, the experts have been asked to provide a most likely value and a minimum and maximum value. This information could be based on data obtained from previous studies done (if available), could come from the literature, could be based on actual data (experience) or could be a subjective expert estimation in case solid information is not available. Twelve experts in total have been asked their expert opinion. The information was asked for each country, but these country specific estimates are kept in the database of the WG. Some of the information elicited from the experts was seen to be politically sensitive, and therefore within the working group report the results from individual experts/countries are not reported. The working group decided to use simulation models to expand the given country specific probability distributions to the whole fishery, i.e. to use combined estimates of uncertainties and bias in the assessment model applied.

More specifically, the information has been analysed within @RISK, an add-in to Excel spreadsheet, which allows for the use of probability distribution to describe and present uncertain values. The prior probability distributions are triangular (using the minimum, maximum and most likely value to describe the distribution) and Monte Carlo sampling is used to sample from the different triangular prior probability distributions.

The use of multiple experts resulted in multiple priors for the different model parameters. In order to combine the knowledge from all the experts, arithmetic pooling (Genest and Zidek, 1986; Spiegelhalter *et al.*, 2004) has been applied by taking the average of the height of the prior distributions for each parameter value θ so that:

$$p(\theta) = \sum_k p_k(\theta) \Big/ K$$

where K is the number of experts.

The resulting prior has the property that the pooled probabilities for certain events are the average of the individual events.

Because the expert opinion about the quality of the catch estimates, fishing effort estimates and tag recovery estimates are country specific, the probability distributions for each country are weighted by the country's contribution to catches. The countries' contributions to catches have been calculated as point estimates obtained by calculating average catches over the last 5 years for each country, and the corresponding contribution of each country to the total catch in the different fisheries. This method requires one probability distribution for the parameter values for each country. For some countries, more then one expert had been available. In this case, the diversity of opinions about the parameter values for that country has been considered more important. Therefore the lowest and highest values over the different expert opinions for that country have been used in combination with the average as the most likely value. In case no expert opinion had been given for certain parameters, the lowest and highest values over the expert opinions of the other country had been taken in combination with the average for their most likely values. The resulting distributions have been approximated by parametric distributions.

When developing priors to be used in subsequent analyses, care should be taken not to use the same data to construct the prior probability distribution as to fit the model to. Using the same data for the prior as within the likelihood function would result in too informative posterior probability distributions. In this case, we use the estimated contribution of different countries to the catches and to the salmon production to weight the experts' opinions about the quality of the data provided by each country. The resulting probability distributions can be used as prior probability distributions within the assessment methodology unless the contributions of the different countries to the catches are also used are used a second time within the assessment methodology. The current methodology does not use this information. See also Chapter 9 and Annex 1 for use of tag reporting rates.

3.10.3 Results

The uncertainty associated to the different data series has been summarised through graphs showing the histograms of the original probability distributions together with their parametric approximations. Table A below summarises all the uncertainties and provides their distributions, the median and CV of the distribution and the kind of information sources on which the prior probability distributions of the individual experts have been based (data or subjective expert opinion). The probability distributions for the different parameters are the result of subjective expert opinions based on the available and partial data. All parametric distributions have been truncated at the lowest and highest possible values indicated by the experts.

3.10.4 Tag reporting rates

A summary of the available data on tag reporting rates can be found in (ICES, 2003). It is estimated that the reporting rates of tags by river fishermen (the probability of the river fishermen reporting a captured tag) are the highest and the associated uncertainty is the lowest (Table 1). Also reporting rate for tags from the longline fishery is estimated to be relatively high but there is more uncertainty associated to this figure. The coastal fishermen are estimated to report the lowest proportion of tags. The reporting rates of both the coastal fishery and the offshore driftnet fishery are quite uncertain. All probability distributions for the return rates could be approximated fairly well by beta distributions.

3.10.5 Conversion factors for catch estimates

ICES (2003) contain a qualitative assessment of the quality of the catch data estimates. The probability distributions for the conversion factors of catches have been primarily based on this information. These conversion factors present the belief of experts in the catch estimates. A conversion value of 1.1 for example means that the experts' belief that the real catches are 10% higher than the reported catches. The conversion factors can be used in combination with the reported point estimates for the catches in order to obtain a probabilistic estimate of the true catches. Again, underreporting is assumed to be highest for the coastal catches where it is estimated that the actual catches are on average 25% higher than the reported catches and the uncertainty regarding this figure is large (Table 1). The CV's of the probability distributions for the conversion factors of river catches, offshore catches and average catches are half the CV of the probability distribution for the conversion factor for coastal catches. The underreporting of offshore catches is assumed to be lowest. All probability distributions have been approximated by lognormal distributions. Especially the conversion factor for coastal catches has a heavy tail to the right, stating that it is possible that the actual number of salmon caught in the coastal fisheries could be more than double what is currently reported. This heavy tail of the probability distribution is not reflected by the parametric approximation.

3.10.6 Conversion factors for fishing effort estimates

The conversion factors for the fishing effort estimates indicate that the uncertainty regarding fishing effort estimates is much larger for the coastal fishing effort by gillnets than for the other fisheries (Table 1). The coastal gillnet fisheries consists predominantly of fishermen who fish for consumption within the household. The extent, to which the fishing behaviour of these fishermen is recorded in the fisheries statistics, differs from country to country. This has resulted in a very wide and bimodal probability distribution for the conversion factor for fishing effort by the coastal gillnet fishery. Uncertainties on effort have not been incorporated into the 2004 assessment, but will need to be accounted for in the future.

3.10.7 Adjustment factor for catches to account for unreported discarded catches

Within the catch Tables only the discarded catches, which have been reported in logbooks, are recorded. Therefore an adjustment factor based on the experts' opinion of the unreported discarded catches has been developed. This conversion factor can be multiplied with the estimated catches from the Tables to obtain probabilistic estimates for the total number of salmon caught, including discarded catches.

Table A: Summary of the uncertainty associated to different data series according to the expert opinions of Baltic salmon working group members backed by data (D) or based on subjective expert estimation (EE). The conversion factors can be multiplied with the observed data in order to obtain estimates for the true catches, CPUE or smolt production

Parameters	**Distribution**	**Median**	**CV**	**Source**
Tag reporting rate in the river fishery	Beta(16,6)I(0.3,0.95)	0.73	0.13	D, EE
Tag reporting rate in the coastal fishery	Beta(11,9)I(0.3,0.8)	0.55	0.19	D, EE
Tag reporting rate in the driftnet fishery	Beta(8,4)I(0.2,0.95)	0.68	0.20	D, EE
Tag reporting rate in the longline fishery	Beta(10,4)I(0.3,0.95)	0.72	0.16	D, EE
Conversion factor for river catches	logN(0.22,98)I(0.9,1.6)	1.24	0.10	D, EE
Conversion factor for coastal catches	logN(0.28, 31)I(0.8,2.2)	1.33	0.18	D, EE
Conversion factor for offshore catches	logN(0.16, 90)I(1,1.5)	1.18	0.09	D, EE
Conversion factor for average catches	logN(0.22, 74)I(1.05,1.75)	1.26	0.10	D, EE
Conversion factor for the offshore driftnet effort	logN(0.11,150)I(1,1.3)	1.13	0.06	EE
Conversion factor for the offshore longline effort	logN(0.12,155)I(1,1.3)	1.13	0.06	EE
Conversion factor for the coastal driftnet effort	logN(0.13,288)I(1,1.3)	1.14	0.05	EE
Conversion factor for the coastal trapnet effort	logN(0.21,103)I(0.9,1.5)	1.23	0.09	EE
Conversion factor for the coastal gillnet effort	logN(0.49,9)I(0.9,3)	1.72	0.27	EE
Adjustment factor for discarding bycoastal fishery	logN(0.22,168)I(1,1.5)	1.24	0.07	EE
Adjustment factor for discarding by driftnet fishery	logN(0.075,822)I(1,1.3)	1.08	0.03	D, EE
Adjustment factor for discarding by longline fishery	logN(0.2,413)I(1.1,1.5)	1.22	0.05	D, EE

Table 3.1.1 Nominal catches and registered discards (incl. seal damaged salmons) of Baltic Salmon in tonnes round fresh weight, from sea, coast and river by country in 1972-2003 in sub-division 22-32.

Year	Country										Total	discards	GT
	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden	USSR	reported catches		
1972	1045	na	403	117	na	na	13	na	477	107	2162	na	na
1973	1119	na	516	107	na	na	17	na	723	122	2604	na	na
1974	1224	na	703	52	na	na	20	na	756	176	2931	na	na
1975	1210	na	697	67	na	na	10	na	787	237	3008	na	na
1976	1410	na	688	58	na	na	7	na	665	221	3049	na	na
1977	1011	na	699	77	na	na	6	na	669	177	2639	na	na
1978	810	na	532	22	na	na	4	na	524	144	2036	na	na
1979	854	na	558	31	na	na	4	na	491	200	2138	na	na
1980	886	na	668	40	na	na	22	na	556	326	2498	na	na
1981	844	25	663	43	184	36	45	61	705		2606	na	na
1982	604	50	543	20	174	30	38	57	542		2058	na	na
1983	697	58	645	25	286	33	76	93	544		2457	na	na
1984	1145	97	1073	32	364	43	72	88	745		3659	na	na
1985	1345	91	963	30	324	41	162	84	999		4039	na	na
1986	848	76	1000	41	409	57	137	74	966		3608	na	na
1987	955	92	1051	26	395	62	267	104	1043		3995	na	na
1988	778	79	797	41	346	48	93	89	906		3177	na	na
1989	850	103	1166	52	523	70	80	141	1416		4401	na	na
1990	729	93	2294	36	607	66	195	148	1468		5636	na	na
1991	625	86	2171	28	481	62	77	177	1096		4803	na	na
1992	645	32	2121	27	278	20	170	66	1189		4548	na	na
1993 1)	575	32	1626	31	256	15	191	90	1134		3966	na	na
1994	737	10	1209	10	130	5	184	45	851		3181	na	na
1995	556	9	1324	19	139	2	133	63	795		3040	na	na
1996	525	9	1316	12	150	14	125	47	940		3138	na	na
1997	489	10	1357	38	170	5	110	27	824		3030	na	na
1998	495	8	850	42	125	5	118	36	815		2494	na	2894
1999	395	14	720	29	166	6	135	25	672		2162	na	2435
2000	421	23	757	44	149	5	144	27	771		2342	186	2528
2001	443	16	606	39	136	4	180	37	616		2077	213	2290
2002	334	16	509	29	108	11	197	66	572		1841	136	1977
2003 2)	454	10	420	29	47	3	198	22	365		1547	79	1626
Mean 1998-2002	418	15	688	37	137	6	155	38	689		2183	178	2425
Mean	783	45	958	40	259	28	101	72	801	190	3027	154	2292

All data from 1972-1994 includes sub-divisions 24-32, while it is more uncertain in which years sub-divisions 22-23 are included. The catches in sub-divisions 22-23 are normally less than one ton. From 1995 data includes sub-divisions 22-32.

Catches from the recreational fishery are included in reported catches as follows: Finland from 1980, Sweden from 1988, Denmark from 1998. Other countries have no, or recreational catches.

Danish, Finnish, German, Polish and Swedish catches are converted from gutted to round fresh weight w by multiplying by 1.1.

Estonian, Latvian, Lithuanian and Russian catches before 1981 are summarized as USSR catches.

Estonian, Latvian, Lithuanian and Russian catches are reported as whole fresh weight.

Sea trout are included in the sea catches in the order of 3 % for Denmark (before 1983), 3% for Estonia, Germany, Latvia, Lithuania, Russia, and about 5% for Poland (before 1997).

Estimated non-reported coastal catches in Sub-division 25 has from 1993 been included in the Swedish statistics.

Danish coast catches are non-profesional trolling catches.

1. In 1993 fishermen from the Faroe Islands caught 16 tonnes, which are included in total Danish catches.

Finnish, Swedish and Russian data from 2003 are preliminary.

2. Details about discard information are described in tabel 3.7.2.

From 2000 to 2002 total discards includes registered and questimated discards. From 2003 discards only includes registered di

Table 3.1.2 Nominal catches and registered discards (incl. seal damaged salmons) of Baltic Salmon in numbers from sea, coast and river by country in 1993-2003. Sub-divisions 22-32.

Year	Country									Total	discards	GT
	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden	reported		
1993 1)	111840	5400	248790	6240	47410	2320	42530	9195	202390	676115	na	na
1994	139350	1200	208000	1890	27581	895	40817	5800	158871	584404	na	na
1995	114906	1494	206856	4418	27080	468	29458	7209	161224	553113	na	na
1996	105934	1187	266521	2400	29977	2544	27701	6980	206577	649821	na	na
1997	87746	2047	245945	6840	32128	879	24501	5121	147910	553117	na	na
1998	92687	1629	154676	8379	21703	1069	26122	7237	166174	479676	na	na
1999	75956	2817	129276	5805	33368	1298	27130	5340	139558	420548	na	na
2000	84938	4485	144260	8810	33841	1460	28925	5562	165016	477297	38539	515836
2001	90388	3285	115756	7717	29002	1205	35601	7392	149391	439737	45651	485388
2002	76122	3247	104641	5762	21808	3351	39374	13230	138255	405790	32530	438320
2003 2)	108845	2055	102255	5766	11339	1040	40870	4413	95748	372331	14207	386538
Mean 98-02	84018	3093	129722	7295	27944	1677	31430	7752	151679	444610	38907	479848
Mean	98974	2622	175180	5821	28658	1503	33003	7044	157374	510177	32732	456521

All data from 1993-1994, includes sub-divisions 24-32, while it is more uncertain in which years sub-divisions 22-23 are included.
The catches in sub-divisions 22-23 are normally less than one tonnes.
From 1995 data includes sub-divisions 22-32.
Catches from the recreational fishery are included in reported catches as follows: Finland from 1980, Sweden from 1988, Denmark from 1998.
Other countries have no, or very low recreational catches.
1) In 1993 Fishermen from the Faroe Islands caught 3200 individuals, which is included in the total Danish catches.
Finnish, Swedish and Russian data from 2003 are preliminary.
2. Details about discard information are described in tabel 3.7.2.
From 2000 to 2002 total discards includes registered and questimated discards. From 2003 discards only includes registered dicards.

Table 3.1.3 Nominal catches of Baltic Salmon in tonnes round fresh weight, from sea, coast and river by country and region in 1972 - 2003. S=sea, C=coast, R=river.

Year	Main Basin (Sub-divisions 22-29)										
	Denmark	Finland	Germany	Poland	Sweden		USSR		Total		
	S	S+C	S	S	S	R	S	C+R	S	C+R	GT
1972	1034	122	117	13	277	0	0	107	1563	107	1670
1973	1107	190	107	17	407	3	0	122	1828	125	1953
1974	1224	282	52	20	403	3	21	155	2002	158	2160
1975	1112	211	67	10	352	3	43	194	1795	197	1992
1976	1372	181	58	7	332	2	84	123	2034	125	2159
1977	951	134	77	6	317	3	68	96	1553	99	1652
1978	810	191	22	4	252	2	90	48	1369	50	1419
1979	854	199	31	4	264	1	167	29	1519	30	1549
1980	886	305	40	22	325	1	303	16	1881	17	1898

Year	Main Basin (Sub-divisions 22-29)																							
	Denmark		Estonia		Finland			Germany	Latvia		Lithuania		Poland			Russia		Sweden			Total			
	S	C	S	C	S	C	R	S	S	C	S	C	S	C	R	S	C	S	C	R	S	C	R	GT
1981	844	*	23	0	310	18	0	43	167	17	36	na	45	na	na	56		401	0	1	1925	35	1	1961
1982	604	*	45	0	184	16	0	20	143	31	30	na	38	na	na	57		376	0	1	1497	47	1	1545
1983	697	*	55	0	134	18	0	25	181	105	33	na	76	na	na	93		370	0	2	1664	123	2	1789
1984	1145	*	92	0	208	29	0	32	275	89	43	na	72	na	na	81		549	0	4	2497	118	4	2619
1985	1345	*	87	0	280	26	0	30	234	90	41	na	162	na	na	64		842	0	5	3085	116	5	3206
1986	848	*	52	0	306	38	0	41	279	130	57	na	137	na	na	46		764	0	4	2530	168	4	2702
1987	955	*	82	0	446	40	0	26	327	68	62	na	267	na	na	81		887	0	4	3133	108	4	3245
1988	778	*	60	0	305	30	0	41	250	96	48	na	93	na	na	74		710	0	6	2359	126	6	2491
1989	850	*	67	0	365	35	0	52	392	131	70	na	80	na	na	104		1053	0	4	3033	166	4	3203
1990	729	*	68	0	467	46	1	36	419	188	66	na	195	na	na	109		949	0	9	3038	234	10	3282
1991	625	*	64	0	478	35	1	28	361	120	62	na	77	na	na	86		641	0	14	2422	155	15	2592
1992	645	*	19	4	354	25	1	27	204	74	20	na	170	na	na	37		694	0	7	2170	103	8	2281
1993	575	*	23	4	425	76	1	31	204	52	15	na	191	na	na	49		754	7	5	2283	139	6	2428
1994	737	*	2	4	372	80	1	10	97	33	5	na	184	na	na	29		574	11	8	2010	128	9	2147
1995	556	*	4	3	613	86	1	19	100	39	2	na	121	12	na	36		464	13	6	1915	153	7	2075
1996	525	*	2	4	306	53	1	12	97	53	14	na	124	1	na		35	551	8	5	1631	154	6	1791
1997	489	*	1	5	359	44	0	38	106	64	1	4	110	0	0		23	354	9	7	1458	149	7	1614
1998	485	10	0	4	324	14	0	42	65	60	1	4	105	9	4		33	442	3	7	1464	137	11	1612
1999	385	10	0	4	234	108	0	29	107	59	1	5	122	9	4		22	334	2	7	1212	219	11	1442
2000	411	10	1	7	282	87		44	91	58	0	5	125	13	6	23		461	2	8	1439	182	14	1635
2001	433	10	0	4	135	76	0	39	66	71	1	4	162	12	6	33		313	2	7	1181	178	13	1373
2002	319	15	0	6	154	59	0	29	47	61	1	9	178	9	10	64		228	2	6	1021	161	16	1198
2003	439	15	0	3	115	41	0	29	33	14	0	3	154	22	22	20		168	1	3	958	99	25	1082
Mean 98-02	407	11	0	5	226	69	0	37	75	62	1	5	138	10	6	40	28	356	2	7	1263	176	13	1452
Mean	670	12	32	2	311	47	0	31	185	74	26	5	130	10	7	60	28	560	3	6	1997	139	8	2144

Table 3.1.3 Continued

Year	Gulf of Bothnia (Sub-divisions 30-31)											Main Basin+Gulf of Bothnia (Sub-divs. 22-31) Total		
	Denmark	Finland			Sweden			Total						
	S	S	S+C	C	S	C	R	S	C	R	GT	S	C+R	GT
1972	11	0	143	0	9	126	65	163	126	65	354	1726	298	2024
1973	12	0	191	0	13	166	134	216	166	134	516	2044	425	2469
1974	0	0	310	0	15	180	155	325	180	155	660	2327	493	2820
1975	98	0	412	0	33	272	127	543	272	127	942	2338	596	2934
1976	38	271	0	155	22	229	80	331	384	80	795	2365	589	2954
1977	60	348	0	142	49	240	60	457	382	60	899	2010	541	2551
1978	0	127	0	145	18	212	40	145	357	40	542	1514	447	1961
1979	0	172	0	121	20	171	35	192	292	35	519	1711	357	2068
1980	0	162	0	148	23	172	35	185	320	35	540	2066	372	2438

Year	Gulf of Bothnia (Sub-divisions 30-31)										Main Basin + Gulf of Bothnia (Sub-divisions 22-31) Total			
	Finland			Sweden			Total							
	S	C	R	S	C	R	S	C	R	GT	S	C	R	GT
1981	125	157	6	26	242	35	151	399	41	591	2076	434	42	2552
1982	131	111	3	0	135	30	131	246	33	410	1628	293	34	1955
1983	176	118	4	0	140	32	176	258	36	470	1840	381	38	2259
1984	401	178	5	0	140	52	401	318	57	776	2898	436	61	3395
1985	247	151	4	0	114	38	247	265	42	554	3332	381	47	3760
1986	124	176	5	11	146	41	135	322	46	503	2665	490	50	3205
1987	66	173	6	8	106	38	74	279	44	397	3207	387	48	3642
1988	74	146	6	1	141	48	75	287	54	416	2434	413	60	2907
1989	225	207	6	10	281	68	235	488	74	797	3268	654	78	4000
1990	597	680	14	12	395	103	609	1075	117	1801	3647	1309	127	5083
1991	580	523	14	1	350	90	581	873	104	1558	3003	1028	119	4150
1992	487	746	14	7	386	95	494	1132	109	1735	2664	1235	117	4016
1993	279	426	16	10	267	91	289	693	107	1089	2572	832	113	3517
1994	238	269	14	0	185	73	238	454	87	779	2248	582	96	2926
1995	66	302	20	0	214	97	66	516	117	699	1981	669	124	2774
1996	96	350	93	5	261	110	101	611	203	915	1732	765	209	2706
1997	44	360	110	1	295	158	45	655	268	968	1503	804	275	2582
1998	57	225	43	2	224	137	59	449	180	688	1523	586	191	2300
1999	17	175	23	1	195	133	18	370	156	544	1230	589	167	1986
2000	11	170	30	0	167	133	11	337	163	511	1450	519	177	2146
2001	9	218	26	1	175	117	10	393	143	546	1191	571	157	1919
2002	5	193	20	1	233	101	6	426	121	554	1027	588	137	1752
2003	1	175	23	0	132	61	1	308	84	392	959	407	109	1474
Mean 98-02	20	196	28	1	199	124	21	395	153	568	1284	571	166	2020
Mean	176	271	22	4	214	82	181	485	104	769	2177	624	112	2913

Table 3.1.3 Continued

Year	Gulf of Finland (Sub-division 32)					Sub-division 22-32		
	Finland			USSR		Total		
	S	S+C	C	S	C+R	S	C+R	GT
1972	0	138	0	0	0	1864	298	2162
1973	0	135	0	0	0	2179	425	2604
1974	0	111	0	0	0	2438	493	2931
1975	0	74	0	0	0	2412	596	3008
1976	81	0	0	0	14	2446	603	3049
1977	75	0	0	0	13	2085	554	2639
1978	68	0	1	0	6	1582	454	2036
1979	63	0	3	0	4	1774	364	2138
1980	51	0	2	0	7	2117	381	2498

Year	Gulf of Finland (Sub-division 32)												Sub-division 22-32			
	Estonia			Finland			Russia		Total				Total			
	S	C	R	S	C	R	C	R	S	C	R	GT	S	C	R	GT
1981	0	2	0	46	1	0	5	0	51	3	0	54	2127	437	42	2606
1982	0	5	0	91	7	0	0	0	91	12	0	103	1719	305	34	2058
1983	0	3	0	163	32	0	0	0	163	35	0	198	2003	416	38	2457
1984	0	5	0	210	42	0	7	0	217	47	0	264	3115	483	61	3659
1985	0	4	0	219	34	2	20	0	239	38	2	279	3571	419	49	4039
1986	24	0	0	270	79	2	28	0	322	79	2	403	2987	569	52	3608
1987	10	0	0	257	61	2	23	0	290	61	2	353	3497	448	50	3995
1988	19	0	0	122	112	2	15	0	156	112	2	270	2590	525	62	3177
1989	36	0	0	181	145	2	37	0	254	145	2	401	3522	799	80	4401
1990	25	0	0	118	369	2	35	4	178	369	6	553	3825	1678	133	5636
1991	22	0	0	140	398	2	88	3	250	398	5	653	3253	1426	124	4803
1992	6	3	0	77	415	2	28	1	111	418	3	532	2775	1653	120	4548
1993 1)	3	1	1	91	309	3	39	2	133	310	6	449	2705	1142	119	3966
1994	3	1	0	88	141	6	15	1	106	142	7	255	2354	724	103	3181
1995	1	1	0	32	200	5	25	2	58	201	7	266	2039	870	131	3040
1996	0	3	0	83	324	10	10	2	93	327	12	432	1825	1092	221	3138
1997	0	4	0	89	341	10	4	0	93	345	10	448	1596	1149	285	3030
1998	0	4	0	21	156	10	0	3	21	160	13	194	1544	746	204	2494
1999	0	10	0	29	127	7	0	3	29	137	10	176	1259	726	177	2162
2000	0	14	1	37	130	11	0	4	37	144	16	196	1486	663	193	2342
2001	0	10	2	19	111	11	0	3	20	121	16	157	1211	693	173	2077
2002	1	10	0	17	46	15	0	2	18	56	16	90	1044	643	154	1841
2003	0	7	0	3	53	8	0	1	3	60	9	73	962	467	118	1547
Mean 98-02	0	10	1	25	114	11	0	3	25	123	14	163	1309	694	180	2183
Mean	7	4	0	104	158	5	17	1	127	162	6	296	2305	786	118	3209

* No fishery occurred.

All data from 1972-1994, includes sub-divisions 24-32, while it is more uncertain in which years sub-divisions 22-23 are included. The catches in sub-divisions 22-32 are normally less than one tonnes. From 1995 data includes

Catches from the recreational fishery are included as follow s: Finland from 1980, Sw eden from 1988, Denmark from 1998.

Other countries have no, or very low recreational catches.

Danish, Finnish, German, Polish and Sw edish catches are converted from gutted to round fresh w eight w by multiplying by 1.1.

Estonian, Latvian, Lithuanian and Russian catches before 1981 are summarized as USSR catches.

Estonian, Latvian, Lithuanian and Russian catches are reported as hole fresh w eight.

Sea trout are included in the sea catches in the order of 3 % for Denmark (before 1983), 3% for Estonia, Germany, Latvia, Lithuania, Russia, and about 5% for Poland (before 1997).

Estonian sea catches in Sub-division 32 in 1986-1991 include a small quantity of coastal catches.

Estimated non-reported coastal catches in Sub-division 25 has from 1993 been included in the Sw edish statistics.

Danish coast catches are non-profesional trolling catches.

1) In 1993 fishermen from the Faroe Islands caught 16 tonnes, which are included in total Danish catches.

Finnish, Sw edish and Russian data from 2003 are preliminary.

Table 3.1.4 Nominal catches of Baltic Salmon in numbers, from sea, coast and river by country and region in 1996-2003.
S=sea, C=coast, R=river.

Year	Main Basin (Sub-divisions 22-29)																							
	Denmark		Estonia		Finland			Germany	Latvia			Lithuania		Poland			Russia	Sweden			Main Basin (sub-divisions 22-29) Total			
	S	C	S	C	S	C	R	S	S	C	R	S	C	S	C	R	S	S	C	R	SEA	COAST	RIVER	GT
1996	105934	0	263	528	58844	8337	200	2400	19400	10577	0	1485	1059	27479	222	0	5199	121631	1322	633	342635	22045	833	365513
1997	87746	0	205	1023	61469	7018	0	6840	20033	12095	0	214	665	24436	0	65	4098	68551	1415	810	273592	22216	875	296683
1998	90687	2000	0	770	60248	2368	0	8379	13605	8098	0	288	781	23305	1927	890	6522	99407	573	940	302441	16517	1830	320788
1999	73956	2000	28	741	45652	15007	0	5805	24309	9059	0	166	1132	24435	1835	860	4330	74192	408	876	252873	30182	1736	284791
2000	82938	2000	129	1190	56141	12747	0	8810	24735	9106	0	78	1382	25051	2679	1195	4648	107719	400	1005	310249	29504	2200	341954
2001	88388	2000	122	819	26616	10706	0	7717	18194	10808	0	152	1053	33017	1764	825	6584	78873	407	890	259663	27557	1715	288935
2002	73122	3000	0	1171	32870	9503	0	5762	11942	9781	85	363	2988	35636	1804	1934	12804	60242	462	699	232741	28709	2718	264168
2003	105845	3000	16	681	24975	6533	0	5766	8843	2496	0	74	966	30886	4282	5702	3982	45874	208	411	226261	18166	6113	250540
Mean 98-02	81818	2200	56	938	44306	10066	0	7295	18557	9370	17	209	1467	28289	2002	1141	6978	84087	450	882	271594	26494	2040	300127
Mean	88577	1750	95	865	45852	9027	25	6435	17633	9003	11	353	1253	28031	1814	1434	6021	82061	649	783	275057	24362	2253	301671

Year	Gulf of Bothnia (Sub-divisions 30-31)										Main Basin + Gulf of Bothnia (Sub-divisions 22-31) Total			
	Finland			Sweden			Total							
	S	C	R	S	C	R	S	C	R	GT	SEA	COAST	RIVER	GT
1996	22196	84940	14000	1181	61239	20571	23377	146179	34571	204127	366012	168224	35404	569640
1997	8205	76683	17000	251	49724	27159	8456	126407	44159	179022	282048	148623	45034	475705
1998	11105	46269	5100	329	41487	23438	11434	87756	28538	127728	313875	104273	30368	448516
1999	3529	35348	3100	89	38447	25546	3618	73795	28646	106059	256491	103977	30382	390850
2000	2423	37755	4150	13	32588	23291	2436	70343	27441	100219	312685	99847	29641	442173
2001	1904	49497	3750	122	44077	25022	2026	93574	28772	124373	261690	121131	30487	413308
2002	864	42433	3900	174	55261	21417	1038	97694	25317	124050	233779	126403	28035	388218
2003	195	54678	4200	0	35357	13898	195	90035	18098	108328	226456	108201	24211	358868
Mean 98-02	3965	42260	4000	145	42372	23743	4111	84632	27743	116486	275704	111126	29783	416613
Mean	6303	53450	6900	270	44773	22543	6573	98223	29443	134238	281630	122585	31695	435910

Year	Gulf of Finland (Sub-division 32)												Sub-divisions 22-32 Total			
	Estonia			Finland			Russia		Total							
	S	C	R	S	C	R	C 1)	R	S	C	R	GT	SEA	COAST	RIVER	GT
1996	0	396	0	20664	55840	1500	1485	296	20664	57721	1796	80181	386676	225945	37200	649821
1997	0	819	0	19577	54493	1500	1023	0	19577	56335	1500	77412	301625	204958	46534	553117
1998	22	761	76	4210	23876	1500	65	650	4232	24702	2226	31160	318107	128975	32594	479676
1999	12	1904	132	6234	19306	1100	95	915	6246	21305	2147	29698	262737	125282	32529	420548
2000	79	2833	254	8105	21040	1900	79	835	8184	23952	2989	35124	320869	123799	32630	477297
2001	62	1965	317	3804	17578	1900	82	726	3866	19625	2943	26434	265556	140756	33430	439742
2002	108	1968	0	3652	8219	3200	18	408	3760	10205	3608	17573	237540	136608	31643	405790
2003	17	1341	0	552	9422	1700	75	356	569	10838	2056	13463	227025	119039	26267	372331
Mean 98-02	57	1886	156	5201	18004	1920	68	707	5258	19958	2783	27998	280962	131084	32565	444611
Mean	38	1498	97	8350	26222	1788	365	523	8387	28085	2408	38881	290017	150670	34103	474790

Data from the recreational fishery are included in Swedish and Finnish data. Recreational fishery are included in Danish data from 1998. Other countries have no, or very low recreational catches.
In 1996 sea trout are included in the Polish catches in the order of 5%.
1) Russian coastal catches have in earlier reports been recorded as sea catches.
Finnish, Swedish and Rusian data from 2003 are preliminary.

Table 3.1.5 Nominal catches of Baltic Salmon in tonnes round fresh weight and numbers from sea, coast and river, by country and sub-divisions in 2003. Sub-divisions 22-32. S=sea, C=coast, R=river

			COUNTRY									
Sub-division	Fishery	-	DK	EE	FI	DE	LV	LT	PL	RU	SE	Total
22	S	Weight				2						2
		Number				440						440
23	C	Weight									0	0
		Number									24	24
24	S	Weight	27		0	11						37
		Number	5927		3	2126						8056
	C	Weight							0		0	0
		Number							34		4	38
25	S	Weight	359		27	16	0		18		77	497
		Number	85560		5658	3200	70		3682		19270	117440
	C	Weight	15		0				6		0	21
		Number	3000		3				1195		56	4254
	R	Weight							20		3	23
		Number							5120		411	5531
26	S	Weight	23		55		22	0	136	20	57	314
		Number	5948		12002		6136	74	27204	3982	17017	72363
	C	Weight						3	15			18
		Number						966	3053			4019
	R	Weight							2			2
		Number							582			582
27	S	Weight	10		3						21	33
		Number	2663		703						6148	9514
	C	Weight			0						0	0
		Number			3						124	127
28	S	Weight	21	0	27		10				13	71
		Number	5747	8	6207		2637				3439	18038
	C	Weight		1			14					16
		Number		288			2496					2784
29	S	Weight		0	3							3
		Number		8	402							410
	C	Weight		2	41							43
		Number		393	6527							6920
	R	Weight			0							0
		Number										
30	S	Weight			1							1
		Number			195							195
	C	Weight			41						35	76
		Number			8451						8124	16575
	R	Weight			5						30	35
		Number			900						6548	7448
31	C	Weight			134						97	232
		Number			46227						27233	73460
	R	Weight			18						31	49
		Number			3300						7350	10650
TOTAL 24-31	S	Weight	439	0	115	27	33	0	154	20	168	956
		Number	105845	16	25170	5326	8843	74	30886	3982	45874	226016
	C	Weight	15	3	217	0	14	3	22	0	133	407
		Number	3000	681	61211	0	2496	966	4282	0	35541	108177
	R	Weight	0	0	23	0	0	0	22	0	64	109
		Number	0	0	4200	0	0	0	5702	0	14309	24211
TOTAL 22-31		Weight	439	0	115	29	33	0	154	20	168	959
		Number	105845	16	25170	5766	8843	74	30886	3982	45898	226480
32	S	Weight		0	3							3
		Number		17	552							569
	C	Weight		7	53					0		60
		Number		1341	9422					75		10838
	R	Weight			8					1		9
		Number			1700					356		2056
Total 32		Weight	0	7	65	0	0	0	0	2	0	73
		Number	0	1358	11674	0	0	0	0	431	0	13463
GRAND TOTAL	S	Weight	439	0	119	29	33	0	154	20	168	962
		Number	105845	33	25722	5766	8843	74	30886	3982	45874	227025
	C	Weight	15	10	270	0	14	3	22	0	133	467
		Number	3000	2022	70633	0	2496	966	4282	75	35565	119039
	R	Weight	0	0	31	0	0	0	22	1	64	118
		Number	0	0	5900	0	0	0	5702	356	14309	26267
NATIONAL TOTAL		Weight	454	10	420	29	47	3	198	22	365	1547
		Number	108845	2055	102255	5766	11339	1040	40870	4413	95748	372331

Data from the recreational fishery are included in Danish, Swedish and Finnish data. Other countries have no, or very low recreational catches. Finnish, Russian and Swedish data are preliminary.

Table 3.1.6. Non-commercial catches of Baltic Salmon in numbers from sea, coast and river by country in 1997-2003 in sub-division 22-31 and sub-division 32 (S = Sea, C = Coast).

Sub-divisions 22-31																				
Year	Denmark	Estonia		Finland		Germany	Latvia		Lithuania		Poland		Russia		Sweden		S+C	River	Grand
	S+C	S+C	River	S+C	River	S+C	S+C	River	S+C	River	S+C	River	S+C	River	S+C	River	Total	Total	Total
1997	na	na	na	na	17000	0	na	na	na	na	na	65	na	na	na	27969	na	45034	45034
1998	2000	na	na	na	5100	0	na	na	na	na	na	890	na	na	na	24378	2000	30368	32368
1999	2000	0	132	5100	400	0	0	0	0	0	0	100	0	0	9350	18529	16450	19161	35611
2000	2000	0	0	11667	4150	0	0	0	0	0	0	1195	0	0	8242	17064	21909	22409	44318
2001	2000	0	0	11667	4150	0	0	0	0	0	0	na	0	0	14443	22216	28110	26366	54476
2002	3000	0	0	3500	3900	0	0	85	0	0	0	na	0	0	17906	16945	24406	20930	45336
2003	3000	0	0	3500	4200	0	0	0	0	0	0	5500	0	0	na	411	6500	4611	11111
Mean 98-02	2200	0	33	7983	3540	0	0	21	0	0	0	728	0	0	12485	19826	18575	23847	42422
Mean	2333	0	26	7087	5557	0	0	17	0	0	0	1550	0	0	12485	18216	16562	24126	38322

	Sub-division 32									Sub-division 22-32		
Year	Estonia		Finland		Russia		S+C	River	Grand	S+C	River	GT
	S+C	River	S+C	River	S+C	River	Total	Total	Total	Total	Total	
1997	na	na	na	17000	na	na	na	17000	17000	na	62034	62034
1998	na	na	na	5100	na	na	na	5100	5100	2000	35468	37468
1999	0	132	10000	1100	0	0	10000	1232	11232	26450	20393	46843
2000	0	268	9300	1900	0	0	9300	2168	11468	31209	24577	55786
2001	0	na	9300	1900	0	0	9300	1900	11200	37410	28266	65676
2002	0	na	2500	3200	0	0	2500	3200	5700	26906	24130	51036
2003	0	na	2500	1700	0	0	2500	1700	4200	9000	6311	15311
Mean 98-02	0	200	7775	2640	0	0	7775	2720	8940	24795	26567	51362
Mean	0	200	6720	4557	0	0	6720	4614	9414	22162	28740	47736

Finnish, Russian and Swedish data are preliminary in 2003.

Table 3.3.1 Nominal catches of Baltic Salmon in numbers from sea and coast, excluding river catches, by country in 1993-2003 and in comparison with TAC. Sub-divisions 22-32.

Year	Baltic Main Basin and Gulf of Bothnia (Sub-divisions 22-31)											
	Fishing Nation									Total	TAC	Landing in % of TAC
	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden			
1993 1)2)	111840	5400	248790	6240	47410	2320	42530	9195	202390	676115	650000	104
1994	139350	1200	208000	1890	27581	895	40817	5800	158871	584404	600000	97
1995	114906	1494	206856	4418	27080	468	29458	7209	161224	553113	500000	111
1996	105934	791	174317	2400	29977	2509	27701	5199	185373	534201	450000	119
1997	87746	1228	153375	6840	32128	879	24436	4098	119941	430671	410000	105
1998 3)	92687	770	119990	8379	21703	1069	25232	6522	141796	418148	410000	102
1999	75956	769	99536	5805	33368	1298	26270	4330	113136	360468	410000	88
2000	84938	1319	109066	8810	33841	1460	27730	4648	140720	412532	450000	92
2001	90388	941	88724	7717	29002	1205	34781	6584	123479	382821	450000	85
2002	76122	1171	85671	5762	21723	3351	37440	12804	116139	360183	450000	80
2003	108845	697	86381	5766	11339	1040	35168	3982	81439	334657	460000	73
Mean 1998-02	84018	994	100597	7295	27927	1677	30291	6978	127054	386830	434000	89
Mean	98974	1435	143701	5821	28650	1499	31960	6397	140410	458847	476364	96

Year	Gulf of Finland (Sub-division 32)					
	Fishing Nation			Total	TAC	Landing in % of TAC
	Estonia	Finland	Russia			
1993 1)	874	98691	8200	107765	120000	90
1994	800	53487	3200	57487	120000	48
1995	338	32935	5035	38308	120000	32
1996	396	76504	1485	78385	120000	65
1997	819	74070	1023	75912	110000	69
1998	783	28086	65	28934	110000	26
1999	1916	25540	95	27551	100000	28
2000	2912	29144	79	32135	90000	36
2001	2027	21382	82	23491	70000	34
2002	2076	11871	18	13965	60000	23
2003	1358	9974	75	11407	50000	23
Mean 1998-02	1943	23205	68	25215	86000	29
Mean	1300	41971	1760	45031	97273	43

All data from 1993-1994, includes sub-divisions 24-32, while it is more uncertain in which years sub-divisions 22-23 are included.
The catches in sub-divisions 22-23 are normally less than one tonnes. From 1995 data includes sub-divisions 22-32.
Estonia: Offshore catches reported by numbers, coastal catches converted from weight. Ca from the recreational fishery are included as follows: Finland from 1980, Sweden from 1988, and Denmark from 1998. Other countries have no, or very low recreational catches.
Estimated non-reported coastal catches in sub-division 25, have from 1993 been included in the Swedish catches.
Sea trout are included in the sea catches in the order of 5% for Poland before 1997.
1) In 1993 Polish, Russian and Faroe Ilands numbers are converted from weight.
2) In 1993 Fishermen from Faroe Ilands caught 3100 salmons included in the total Danish catches.
3) In 1998 German numbers are converted from weight.
Finnish, Russian and Swedish data from 2003 are preliminary.

Table 3.3.2 Nominal catches of Baltic Salmon in numbers, from sea and coast, excluding river catches, by country and fishing zones. Sub-divisions 22-31 and 32, in 2003.

Fishing nations	Fishing zones (22-31)						Total 22-31	Fishing zones (32)			Total 32	GRAND TOTAL 22-32
	EU Total	Estonia	Latvia	Lithuania	Poland	Russia		EU Total	Estonia	Russia		
Denmark	108845						108845				0	108845
Estonia		697					697		1358		1358	2055
Finland	84753		1351	277			86381	9974			9974	96355
Germany	5766						5766				0	5766
Latvia	70		11269				11339				0	11339
Lithuania				1040			1040				0	1040
Poland					35168		35168				0	35168
Russia						3982	3982			75	75	4057
Sweden	81439						81439				0	81439
Total	280873	697	12620	1317	35168	3982	334657	9974	1358	75	11407	346064
TAC	346918	9504	59478	6992	28368	8740	460000	40700	4650	4650	50000	510000
Landings in % of TAC	81	7	21	19	124	46	73	25	29	2	23	68

Catches from the recreational fishery are included as follows: Finland, Sweden and Denmark. Other countries have no, or very low recreational catches.
The TAC numbers are the numbers allocated to fishing zones by IBSFC.
Finnish, Swedish and Russian data are preliminary.

Table 3.4.1: Fishing efforts of Baltic salmon at sea, at the coast and in the river in 1987-2003 in subdivision 22-31 (excluding Gulf of Finland). The fishing efforts are expressed in number of geardays (number of fishing days times the number of gear) and are reported per half year (HYR). The coastal fishing effort on stocks of assessment area 1 refers to the total Finnish coastal fishing effort. The coastal fishing effort on stocks of assessment area 2 refers to the Finnish coastal fishing effort in area 3 and the Swedish coastal fishing effort in area 2. The coastal fishing effort on stocks of area 3 refers to the Finnish and Swedish coastal fishing effort in area 3.

Year	HYR	Offshore driftnet	Offshore longline	Coastal driftnet	Area 1		Area 2		Area 3	
					Coastal trapnet	Coastal gillnet	Coastal trapnet	Coastal gillnet	Coastal trapnet	Coastal gillnet
1987	I	1155835	1447789	233703	14951	99171	9667	67956	9634	88375
	II	1944483	2142495	95009	43259	164084	41234	175555	30097	437726
1988	I	1476975	1568397	240296	25398	126509	17893	127284	16826	423237
	II	1546233	1173796	16092	39460	118718	48936	132120	36463	374801
1989	I	1463715	1216741	320879	26015	197177	20803	132953	17414	154266
	II	1887944	829833	57311	29927	148415	28071	251729	20063	308801
1990	I	1253121	1517064	339960	43175	120228	35247	105160	27503	135350
	II	1401553	1050816	24366	47749	140541	47096	128380	36231	144260
1991	I	1577160	1138104	398447	34855	185839	31535	139274	31492	178861
	II	1350443	534334	32973	43500	275215	53178	221086	35203	225466
1992	I	1406529	1174250	448853	53069	179395	30342	135902	29157	191465
	II	1493665	555475	24726	49407	172123	45152	146772	30569	147919
1993	I	1441225	981349	595034	51095	162849	35201	61293	35783	70857
	II	703904	338724	26783	50649	125396	51060	100180	39086	144853
1994	I	1210965	746049	538689	29200	116753	18881	110042	18667	133865
	II	1223091	215623	42617	33271	77930	52531	100885	32188	71983
1995	I	1343952	645884	394522	20053	68728	13086	66889	12847	67961
	II	751976	79567	58336	35505	83800	39916	80370	26112	73944
1996	I	615420	717898	48742	7081	46687	8535	44996	5032	41991
	II	472061	264157	29944	35670	53723	42139	47610	22809	48254
1997	I	419161	673787	87216	7402	51848	10025	43644	6452	43555
	II	358225	371084	30991	39201	55584	43746	38279	25712	41084
1998	I	844400	893800	89338	5269	3636	4341	2123	3861	1974
	II	545077	154582	23055	13463	4755	21369	3327	10374	3247
1999	I	559022	615897	101733	8553	4792	7856	2976	5460	2470
	II	370413	363780	24849	16866	4532	33945	2739	13240	2601
2000	I	535341	1079544	85034	7000	3227	6905	1571	5468	1375
	II	576412	599670	21974	16361	5096	22908	4016	12697	3996
2001	I	460812	992714	98962	8624	2088	8180	1451	6647	1305
	II	494786	465115	3695	19270	1791	26529	1210	15468	1208
2002	I	471046	875593	82572	11419	1330	11152	497	9250	445
	II	260881	683678	3785	16608	2448	30832	2811	15468	2757
2003	I	396678	663927	93501	9472	3629	10646	2985	7529	2907
	II	281532	605583	2290	25191	5430	25848	4943	14718	4427

Table 3.4.2 Number of fishing vessels in the offshore fishery for salmon by country and area from 1998-2003. Number of fishing days divided in 4 groups, from 1-9 fishing days, from 10-19 fishing days, from 20-39 fishing days and more than 40 fishing days (from year 2001also from 60 to 80 and > 80 days). Sub-divisions 22-31 and Sub-division 32.

Year	Area	Country	Effort in days per ship				
			40-	20-39	10-19	1-9	Total
			Number of fishing vessels				
1998	Sub-divisions 22-31	Denmark	6	5	6	4	21
		Estonia	0	0	0	na	na
		Finland	16	14	11	25	66
		Germany	na	na	na	na	na
		Latvia	2	6	7	12	27
		Lithuania	na	na	na	na	na
		Poland	7	16	17	46	86
		Russia	2	0	2	9	13
		Sweden	na	na	na	na	na
		Total	33	41	43	96	213
	Sub-div. 32	Finland	1	4	4	49	58
	Sub-divs. 22-32	Total	34	45	47	145	271

1999	Sub-divisions 22-31	Denmark	5	7	4	4	20
		Estonia	0	0	0	na	na
		Finland	13	13	11	20	57
		Germany	na	na	na	na	na
		Latvia	4	5	6	13	28
		Lithuania	na	na	na	na	na
		Poland	23	23	8	33	87
		Russia	2	1	2	7	12
		Sweden	10	8	9	38	65
		Total	57	57	40	115	269
	Sub-div. 32	Finland	2	3	3	39	47
	Sub-divs 22-32		59	60	43	154	316

2000	Sub-divisions 22-31	Denmark	8	9	2	9	28
		Estonia	0	0	0	4	4
		Finland	15	8	14	12	47
		Germany	0	0	0	0	0
		Latvia	3	4	10	14	31
		Lithuania	na	na	na	na	na
		Poland	40	23	12	22	97
		Russia	na	na	na	na	na
		Sweden	11	12	7	29	59
		Total	77	56	45	90	266
	Sub-div. 32	Estonia	0	0	1	0	1
		Finland	3	6	7	20	36
	Sub-divs 22-32		80	62	53	110	305

Table 3.4.2 Continued

Year	Area	Country	Effort in days per ship						
			>80 days	60- 80	40-59	20-39	10-19	1-9	Total
			Number of fishing vessels						
2001	Sub-divisions 22-31	Denmark	3	2	4	2	2	9	22
		Estonia	0	0	0	0	0	2	2
		Finland	2	1	5	12	7	10	37
		Germany	0	0	0	0	0	0	0
		Latvia	0	1	0	3	2	24	30
		Lithuania	na	na	na	na	na	na	na
		Poland	7	9	18	11	12	12	69
		Russia	na	na	na	na	na	na	na
		Sweden	4	1	2	11	8	25	51
		Total	16	14	29	39	31	82	211
	Sub-div. 32	Finland	0	0	0	4	3	15	22
	Sub-divs 22-32		16	14	29	43	34	97	233

Year	Area	Country	Effort in days per ship						
			>80 days	60- 80	40-59	20-39	10-19	1-9	Total
			Number of fishing vessels						
2002	Sub-divisions 22-31	Denmark	3	3	2	3	5	12	28
		Estonia	0	0	0	0	0	2	2
		Finland							0
		Germany	0	0	0	0	0	0	0
		Latvia	0	0	1	3	4	20	28
		Lithuania	na	na	na	na	na	na	0
		Poland							50
		Russia	na	na	na	na	na	na	0
		Sweden	2	0	1	11	11	29	54
		Total	5	3	4	17	20	63	162
	Sub-div. 32	Finland	0	0	0	5	5	19	29
	Sub-divs 22-32		5	3	4	22	25	82	191

Year	Area	Country	Effort in days per ship						
			>80 days	60- 80	40-59	20-39	10-19	1-9	Total
			Number of fishing vessels						
2003	Sub-divisions 22-31	Denmark	1	2	8	2	6	11	30
		Estonia	0	0	0	0	1	0	1
		Finland	0	3	5	10	16	21	55
		Germany	0	0	0	0	0	0	0
		Latvia	0	0	0	1	4	27	32
		Lithuania	na	na	na	na	na	na	0
		Poland							50
		Russia	na	na	na	na	na	na	0
		Sweden	3	4	6	7	5	15	40
		Total	4	9	19	20	32	74	158
	Sub-div. 32	Finland	0	0	0	3	2	12	17
	Sub-divs 22-32		4	9	19	23	34	86	175

Table 3.5.1 Catch per unit effort (CPUE) in number of salmon caught per 100 nets and per 1,000 hooks by fishing season in the Danish, Estonian, Finnish, Latvian, Russian and Swedish offshore fisheries in the Main Basin, in the Gulf of Bothnia, and in the Gulf of Finland from 1980/1981 (Denmark from 1983/84) to 2003.

Fishing season	Denmark			
	Sub-divisions 22-25		Sub-divisions 26-29	
	Driftnet	Longline	Driftnet	Longline
1983/1984	10.3	26.5	11.9	52.3
1984/1985	11.7	na	18.9	35.9
1985/1986	11.4	na	24.4	30.8
1986/1987	8.8	na	22.1	44.3
1987/1988	12.9	23.6	19.8	35.6
1988/1989	11.9	51.7	12.3	30.7
1989/1990	16.4	69.9	14.2	30.0
1990/1991	13.7	80.8	13.8	49.2
1991/1992	14.7	48.7	7.2	11.5
1992/1993	19.8	49.7	7.5	32.4
1993/1994	33.7	110.1	10.5	45.6
1994/1995	17.6	75.2	8.3	64.1
1995/1996	18.8	101.5	30.3	123.6
1996/1997	13.2	109.9	47.2	135.5
1997/1998	5.6	56.6	41.4	51.7
1998/1999	19.5	138.9	39.6	121.3
1999/2000	19.2	56.5	23.2	41.5
2000/2001	12.8	50.4	26.3	36.9
2002	11.9	69.7	18.3	63.3
2003	27.6	106.3	27.2	*
Mean 97/98-00/02	13.8	74.4	29.8	62.9
Mean	15.6	72.1	21.2	54.5

Fishing season	Finland					
	Sub-divisions 22-29		Sub-divisions 30-31		Sub-division 32	
	Driftnet	Longline	Driftnet	Longline	Driftnet	Longline
1980/1981	6.6	27.1	5.3	18.4	na	5.5
1981/1982	8.0	43.5	5.2	28.4	na	12.1
1982/1983	9.2	34.5	6.6	21.9	na	14.3
1983/1984	14.4	46.9	12.4	53.2	na	20.5
1984/1985	12.5	43.7	11.0	34.1	na	13.5
1985/1986	15.9	34.5	10.3	17.9	na	15.7
1986/1987	18.9	63.9	5.3	14.7	na	25.6
1987/1988	8.0	42.0	4.0	9.0	na	17.0
1988/1989	7.0	36.0	4.0	6.0	na	10.0
1989/1990	15.0	57.0	13.0	41.0	na	16.0
1990/1991	16.8	42.4	13.3	50.7	na	21.2
1991/1992	8.5	24.5	9.0	21.1	na	30.8
1992/1993	9.1	16.6	8.0	23.1	na	16.6
1993/1994	5.9	20.0	6.5	12.7	na	23.9
1994/1995	7.9	21.0	4.3	10.2	5.7	26.7
1995/1996	22.1	41.6	10.2	*	5.6	19.7
1996/1997	19.2	56.9	9.7	*	9.7	32.2
1997/1998	14.1	29.3	6.7	*	6.7	24.0
1998/1999	15.7	39.7	5.7	*	5.7	25.7
1999/2000	13.3	29.1	5.7	*	3.1	25.5
2000/2001	20.4	23.0	5.8	*	*	28.2
2002	11.0	43.4	3.3	*	7.8	22.0
2003	11.0	55.4	4.3	*	5.3	8.0
Mean 97/98-00/02	14.9	32.9	5.4	*	5.8	25.1
Mean	12.6	37.9	7.4	24.2	6.2	19.8

Table 3.6.1 Age composition of the Danish and Latvian salmon catches in the Baltic Main Basin sub-divisions 22-29 from 1972 - 2003.

Fishing season	Denmark				Fishing year	Latvia		
	A.+	A.1+	A.2+	A.3+ and older		A.1+	A.2+	A.3+ and older
1972/1973	0.8	84.3	14.6	0.3	1972	na	na	na
1973/1974	0.4	90.0	9.2	0.4	1973	na	na	na
1974/1975	0.4	89.3	9.8	0.4	1974	na	na	na
1975/1976	0.8	75.9	22.1	1.2	1975	na	na	na
1976/1977	0.8	77.1	21.0	1.2	1976	na	na	na
1977/1978	0.8	73.8	24.7	0.6	1977	na	na	na
1978/1979	1.4	71.5	26.7	0.4	1978	na	na	na
1979/1980	1.4	72.6	25.0	0.9	1979	na	na	na
1980/1981	2.6	65.9	30.8	0.7	1980	na	na	na
1981/1982	0.0	62.3	37.0	0.7	1981	na	na	na
1982/1983	0.0	67.2	31.9	0.9	1982	79.6	20.4	0.0
1983/1984	0.0	82.4	16.9	0.7	1983	66.4	30.6	3.0
1984/1985	0.0	87.2	12.2	0.6	1984	81.1	18.6	0.3
1985/1986	0.0	70.2	28.3	1.4	1985	80.0	17.5	2.5
1986/1987	0.0	78.1	20.3	1.6	1986	78.9	17.7	3.4
1987/1988	0.0	78.4	20.9	0.7	1987	59.0	33.0	8.0
1988/1989	2.1	75.9	21.0	1.1	1988	60.5	30.5	9.0
1989/1990	0.0	92.3	7.5	0.2	1989	57.5	38.0	4.5
1990/1991	0.1	82.8	16.1	1.1	1990	61.0	36.0	3.0
1991/1992	0.0	81.7	15.8	2.6	1991	76.5	21.5	2.0
1992/1993	0.2	88.7	10.0	0.9	1992	77.0	17.0	6.0
1993/1994	0.1	87.5	10.5	1.9	1993	64.0	31.5	4.5
1994/1995	0.7	79.9	17.1	2.3	1994	72.5	21.5	6.0
1995/1996	0.0	83.6	15.5	0.9	1995	72.0	26.5	1.5
1996/1997	0.0	85.2	14.5	0.3	1996	63.0	33.0	4.0
1997/1998	0.0	66.6	32.3	1.2	1997	58.5	33.5	8.0
1998/1999	0.0	83.1	16.1	0.8	1998	58.5	36.5	5.0
1999/2000	0.0	45.0	46.5	8.5	1999	53.5	40.0	6.5
2000/2001	0.0	50.6	39.7	9.7	2000	68.0	26.5	5.5
2001/2002	0.0	66.2	24.5	9.2	2001	58.5	34.0	7.5
2002	0.0	45.2	42.4	12.4	2002	76.5	21.5	2.0
2003	0.0	54.1	41.1	4.8	2003	72.0	24.0	4.0
Mean 98/99-2002	0.0	61.3	30.7	8.0	Mean 1998-2002	63.0	31.7	5.3

Salmon between 40 and 59 cm are included until 1980/1981.
Danish figures are given at a seasonal basis from 1972. From 2002 figures are given at an yearly basis.
From January 2000, the Danish age determination are based on a birth of the salmon at 1.1. - Before the 1.1 2000, the age determinations are based on a birth of the salmon at 1.7.

Table 3.6.2 Mean weight per half year of Baltic Salmon in kilos whole fresh weight caught in the Latvian offshore fishery 1982-2003 in sub-divisions 26 and 28.

Year	First half year	Second half year	Whole year
1982	3.0	4.4	3.3
1983	4.6	3.8	4.0
1984	4.6	4.3	4.6
1985	4.5	4.2	4.4
1986	4.7	3.8	4.3
1987	4.7	4.4	4.6
1988	4.9	4.1	4.8
1989	4.5	4.3	4.4
1990	5.6	4.9	5.5
1991	6.9	5.3	6.8
1992	5.6	4.1	5.1
1993	6.6	4.4	6.2
1994	5.1	4.0	4.6
1995	4.2	4.4	4.3
1996	4.7	3.8	4.3
1997	4.7	4.3	4.6
1998	5.2	4.1	4.7
1999	4.6	3.6	4.2
2000	4.1	4.0	4.1
2001	3.8	3.5	3.6
2002	4.3	3.9	4.1
2003	4.5	3.6	4.0
Mean 1998-2002	4.4	3.8	4.1

Table 3.6.3 Mean weight per half year of Baltic Salmon in kilos whole fresh weight, caught in the Danish offshore fishery 1995-2003 in the Main Basin.

Year	First half year	Second half year	Whole year
1995	**	**	**
1996	**	**	**
1997	**	**	**
1998	**	**	**
1999	5.38	5.01	5.21
2000	5.67	4.60	4.95
2001	6.41	3.73	4.90
2002	4.55	4.20	4.37
2003	4.43	3.95	4.15
Mean 1999-2002	5.50	4.39	4.86

** This information will be given in the report next year.

Table 3.7.1 Discard catches, (build on reported discard), (seal damaged salmon included) of Baltic Salmon in numbers from sea, coast and river in 2003. Sub-divisions 22-31 and 32.

Country	Discards						
	Due to seal damages		Other		Total		Total 22-31 and 32
	Sub-div 22-31	Sub-div 32	Sub-div 22-31	Sub-div 32	Sub-div 22-31	Sub-div 32	
Denmark	0	0	na	0	0	0	0
Estonia	na	na	na	na	na	na	na
Finland	10030	3821	354	2	10384	3823	14207
Germany	na	0	na	0	na	0	na
Latvia	na	0	na	0	na	0	na
Lithuania	na	0	na	0	na	0	na
Poland	na	0	na	0	0	0	0
Russia	na	na	na	na	na	na	na
Sweden	na	0	na	0	na	0	na
Total	10030	3821	354	2	10384	3823	14207

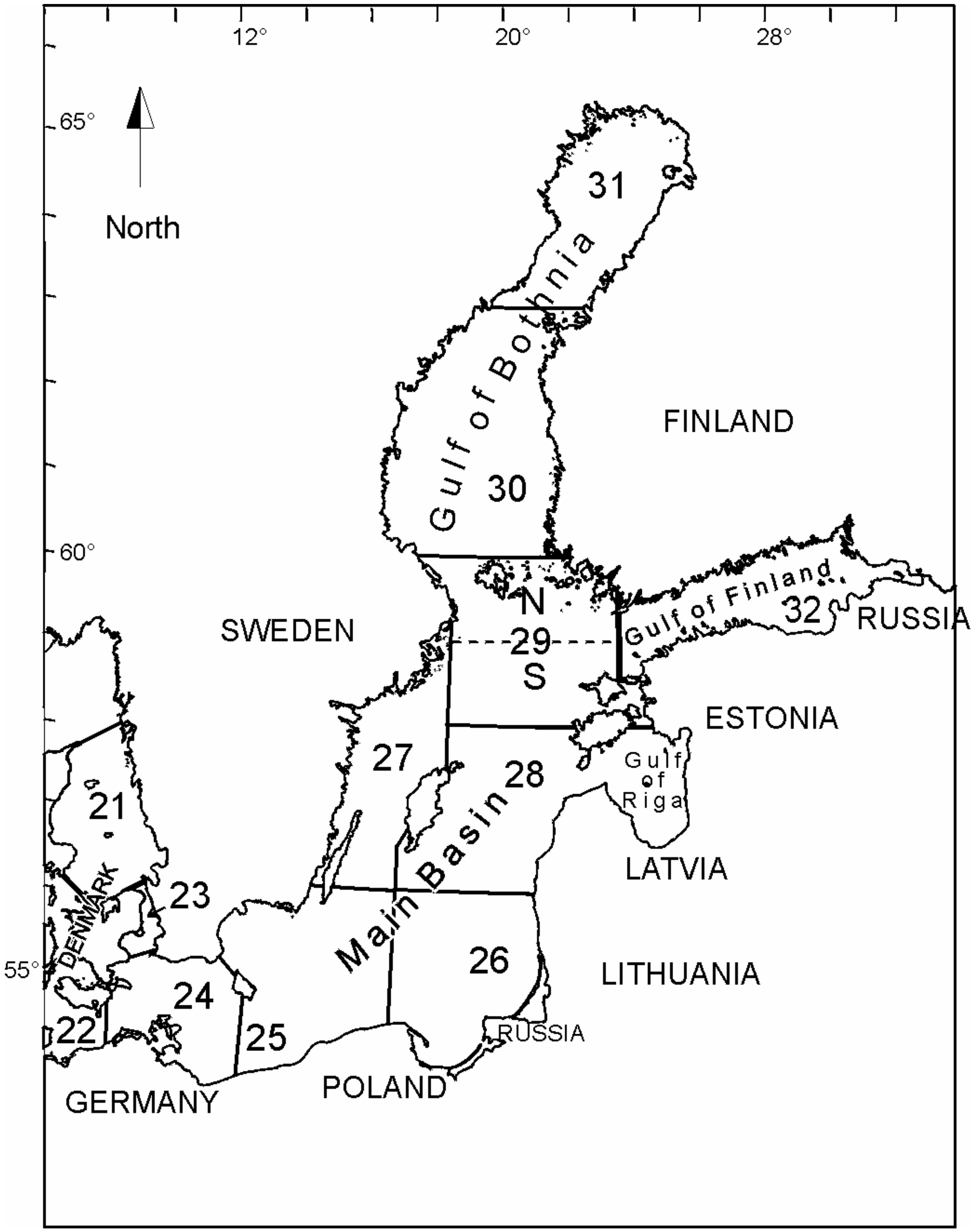


Figure 3.1.1 Current IBSFC management areas in the Baltic sea: (1) Main Basin and Gulf of Bothnia (Sub-divisions 22-29 and 30-31, respectively) and (2) Gulf of Finland (Sub-division 32).

4 STATUS OF SALMON POPULATIONS

4.1 The IBSFC Salmon Action Plan

As requested by the ACFM rewiew group, the Working Group in the report includes a short description of the IBSFC Salmon Action Plan. During a session in February 1997, IBSFC adopted the IBSFC Salmon Action Plan 1997-2010. In the plan were given several definitions and objectives. As long term objectives were given the following;

1. To prevent the extinction of wild populations, further decrease of naturally produced smolts should not be allowed.
2. The production of wild Salmon should gradually increase to attain by 2010 for each Salmon river a natural production of wild Baltic Salmon of at least 50% of the best estimate potential and within safe genetic limits, in order to achieve a better balance between wild and reared Salmon.
3. Wild Salmon populations shall be re-established in potential Salmon rivers.
4. The level of fishing should be maintained as high as possible. Only restrictions necessary to achieve the first three objectives should be implemented.
5. Reared smolts and earlier Salmon life stage releases shall be closely monitored.

Among medium and short term strategies were given the following:

The annual TAC for Salmon shall be fixed in accordance with the long term management objective.

To the greatest extent possible the fishing pattern should be shifted from the mixed wild and reared population fishery to a fishery targeting mainly reared populations.

During the XXIVth session in 1998, the IBSFC adopted the following list;

For the purpose of the IBSFC Salmon Action Plan 1997-2010, the following rivers are intended to have self-sustaining populations by 2010 :

Finland
Simojoki

Finland/Sweden
Tornionjoki/Torne älv

Sweden
Kalix älv, Råne älv, Pite älv, Åby älv, Byske älv, Rickleån, Sävarån, Ume/Vindelälven, Öre älv, Lödge älv, Emån, Mörrumsån

Estonia
Loobu, Kunda, Keila,Vasalemma

Latvia
Salaca,Vitrupe, Peterupe, Irbe,Uzava, Saka

Latvia/Lithuania
Barta/Bartuva

Lithuania
Zeimena

Russian Federation
Sista, Voronka, Kovashi

In this resolution, IBSFC also stated that this list of rivers can be amended by the Salmon Action Plan Surveillance Group in the light of further experience and improved research.

IBSFC has decided that management decisions for salmon in the Baltic should be based on the status of wild salmon populations and ICES advice to IBSFC has been based on this principle for the last few years. There was often been a lack of discrimination between wild salmon and sea trout rivers with and without reared releases in the Baltic area. If the releases in a river are of a large magnitude in relation to the present production they will inevitably influence the status of the population and as a result the assessment of whether the population is or could be self-sustaining may be biased. The Working Group have divided the Baltic salmon and sea trout rivers into four categories: **wild**, **mixed**, **reared** and **potential** rivers. The categorization is defined and discussed in the earlier working group reports, e.g., Anon. 2002.

In 1999, in its 25th session, the IBSFC adopted a list of index rivers to be established as a part of the IBSFC Salmon Action Plan. The status of wild salmon in these rivers would according to IBSFC be considered the basis for monitoring the status of wild Salmon populations. In total 12 index rivers was appointed, 4 in Gulf of Bothnia, 5 in the Main Basin and 3 in the Gulf of Bothnia. The monitoring in these rivers should consist of electrofishing, smolttrapping and counting of spawners. Other monitoring activities have also been established in some of these index rivers (Table 4.1.1).

However, in spite of several attempts, no river with both smolt trapping and counting of spawners have so far been possible to establish. The Working Group has several times stressed the importance of both these elements to occur in index rivers in all parts of the Baltic as it otherwise is difficult to monitor the actual importance of fishery for the future development of populations in these areas as well as create stock/recruitment functions and thereby calculate the actual potential smolt production capacity of the rivers.

In regard of the objective that wild salmon populations shall be reestablished in potential salmon rivers, there are no list of potential rivers adopted by the IBSFC to be included in the objective that the production of wild Salmon should gradually increase to attain by 2010 at least 50% of the best estimate potential. However, potential rivers have been officially selected by several countries to be considered within the implementation of national Salmon Action Plans (section 4.3).

4.2 Status of wild populations

4.2.1 Rivers in the Gulf of Bothnia (Sub-divisions 30-31)

River Simojoki (assessment unit 1)

During the 1980s and early 1990s, the catch in the river was only 50-200 kg/year, indicating that the escapement to the spawning grounds was very low. In 1994-1996, a clear increase in the river catches was observed (Figure 4.2.1.1). According to the fishing questionnaire the salmon catch has been at its maximum of almost 4 tonnes in 1997. Since then, catches have collapsed to about 700 kg per year in 2002-2003. One of the reasons for this drop may have been an exceptionally warm and low river water in these years, which might have affected angling success in river. Somewhat lower amount of angling licences were sold than in previous years.

In summer 2003, conditions were good for electrofishing, and 29 rapids were monitored. The mean density of wild one-summer old parr increased much from the previous year, while densities of older parr declined: the average densities were 22 one-summer old and 7,4 older parr/100 sq.m. This high densities of one-summer old parr has been observed only once before, in 1999. One-summer old parr were observed in 90% of the study sites. (Table 4.2.1.1, Figure 4.2.1.2). This high density was against expectations, because decreased river catches of 2002 indicated decreasing number of spawners. Among the reasons for this inconsistency may be an exceptionally warm and low river water in 2002 (as suggested above), but also the decline in M74 mortality (see section 4.5) can partly explain the phenomen. Mortality caused by M74 syndrome decreased much among offspring of spawners of 2002, and similar low mortality is predicted also for the offspring of the spawners of 2003.

In 1989-1994, smolt production was 10 000-20 000 smolts per year (Table 4.2.1.2 and Figure 4.2.1.3). Wild smolt production was at its lowest in 1996, probably being less than 2 000 individuals, but after that it has risen. Since the year 2000, annual wild smolt production has exceeded the level of 50 000 smolts with high certainty. In 2003, the production estimate was about 70 000 wild smolts. Declined densities of older wild parr indicate decline in the wild smolt run for the year 2004, but thereafter wild production is predicted to increase again (Table 4.2.1.2, Figure 4.2.1.3).

Number of smolts of reared origin have declined after the peak in 1996 (175 000 smolts) and in the year 2003 only 23 000 smolts were estimated to leave the river (Table 4.2.1.2). Lately, amount of reared fish stocked into the river has been decreasing. Jutila et al. (2003) studied the effects of both stocking and coastal fishing regulations on the recovery of the Simojoki salmon. They concluded that because of the much lower sea survival (wild smolts survived almost 6 times better than reared smolts) of reared fish compared to wild fish, substantial numbers of smolts should be stocked in the river to achieve any major increase in the number of ascending MSW spawners. Instead, the study revealed the clear effect of coastal fishing regulations on the number of spawning migrants reaching the rivers mouth. Thus it was concluded that regulation of fishing is clearly the most effective way to enhance the wild stock of the Simojoki (Jutila et al. 2003)

River Tornionjoki/Torne älv (assessment unit 1)

From the beginning of the 1900s to the 1940s, the total river catch was on average 50-100 tonnes per year and, in the beginning of the 1970s, about 20 tonnes a year (Figure 4.2.1.4). In the 1980s, the annual river catches were only some tons but they increased in the early 1990s to over 20 tons/year. The catches started to decrease again after 1992. A considerable increase was observed in 1996, and the catch was even higher in 1997, when it was almost 75 tonnes. Since 1997, catches have decreased again and in 2001-2002 they have been around 20 tons/year. The catch declined further in 2003 to about 17 tons (Table 4.2.1.3 and Figure 4.2.1.4).

Total river catches are probably not a reliable index of the spawning run in the river because of the changes in the total effort of the river fishery during the 1990s. In spite of the decreasing river catches in 1993-1995, the CPUE in the trolling did not decrease (Table 4.2.1.3). Instead, it increased and in 1997 the CPUE was the highest ever recorded being about ten times higher than in the early part of 1990s. After 1997, the CPUE has decreased and in 2002-2003 it was less than 30% of the peak value of 1997.

About 5 000 catch samples have been collected mainly from the Finnish river fishery of salmon since the mid-1970s. Table 4.2.1.4 shows numbers of samples, sea-age composition, sex composition and proportion of reared fish (identified either by the absence of adipose fin or by scale reading) of the data for the given time periods. In 2001-2002, caught fish were on average younger than in the late 1990s, indicating that the abundant smolt year classes of the turn of the century were contributing to the spawning runs. In 2003 ascending fish were again older, indicating declined sea survival of the smolt year classes of 1-2 previous years. Also the decreased river catches indicate that few salmon have survived from the sea migration.

The lowest parr densities in the time series of electrofishing were observed in the mid-1980s (Table 4.2.1.5, Figure 4.2.1.5). Since then, densities have increased in a cyclic pattern with two jumps. The second, higher jump started in 1996-1997. The mean density of one-summer old parr in 1997 was almost 10 times higher than in 1996, and in 1998 nearly two times higher than in 1997. In 1999-2002, the densities were decreased, but still about as high as in 1997. Densities of one-summer old parr increased again in 2003 to the same level (about 16 parr/100 sq. m.) as corresponding densities in 1998. One-summer old parr were observed in 81% of the study sites. This high density was against expectations, because decreased river catches of 2002 indicated decreasing number of spawners. Among the reasons for this inconsistency may be an exceptionally warm and low river water in 2002, which might have affected angling success in river, but also the decline in M74 mortality (see section 4.5) can partly explain the phenomen. The density of older wild parr (about 7 ind./100 sq.m.) decreased somewhat from the previous year. Spatial distribution of older parr along the river has been fairly stable. Uppermost parr have been found about 510 km from the sea.

Wild smolt runs have increased since 1996-1998 when, as a result of M74, as small wild smolt runs were observed as in the turn of 1980s and 1990s (Table 4.2.1.6, Figure 4.2.1.6). Since the year 2000, annual wild smolt production has exceeded the level of 500 000 smolts with high certainty. In 2003, the smolt trapping results indicated as high as 750 000 (mode of the posterior distribution) wild smolts. The wild smolt run was thus indicated to be two times larger than predicted on the basis of electrofishing results alone. The run estimate was imprecise in spite of extensive mark-recapture data, thus, using the electrofishing results together with the smolt trapping results indicate lower smolt production: 540 000 wild smolts (median value; Table 4.2.1.6, Figure 4.2.1.6). Many year classes of parr were abundant in the smolt run of 2003 and small 2-year old smolts were especially abundant. Declined densities of older wild parr indicate decline in the wild smolt run for the year 2004, but thereafter wild production is predicted to increase again.

Mortality caused by M74 syndrome decreased much among offspring of spawners of 2002, and similar low mortality is predicted also for the offspring of the spawners of 2003 (see section 4.5).

34 000 smolts of reared origin (released as parr or smolts) were estimated to leave the river in 2003. In total only 4 000 fin clipped reared smolts were stocked. For the first time in 2-3 decades no reared parr were stocked. Based on the catch samples of adult fish from the river fishery, stocking has yielded a substantially lower proportion of reared spawners than expected according to the composition of smolt runs. The contradiction indicates lower marine survival of stocked fish than that of wild fish (see also Romakkaniemi et al. 2003). In last years the proportion of reared fish among catch samples has decreased, which is a natural consequence of increase in past years' wild smolt abundance and simultaneous decrease in number of reared smolts.

Other rivers in the Gulf of Bothnia (Sub-divisions 30-31)

Other rivers with natural reproduction of salmon in the Gulf of Bothnia are the rivers Kalix älv (assessment unit 1), Råne älv, Pite älv, Åby älv, Byske älv, Sävarån, Rickleån, Ume/Vindelälven, Öre älv, Lögde älv (assessment unit 2) and Ljungan (assessment unit 3). Natural reproduction of salmon has also been found in the potential salmon river Kågeälven (assessment unit 2) for several years. A description of the rivers is given in Anon. 1994.

River catches and fishery

In Swedish rivers with natural reproduction of salmon in the Gulf of Bothnia, angling was allowed between 1th of January until the 31st of August.

An estimate of the catch in the river Kalix älv and Torne älv (Swedish catch) has been obtained from the same group of fisherman over the years to provide an index that can be used to compare the catches between years. The salmon catches in the rivers Torne älv (Swedish catch), Kalix älv and Byske älv in 1981-2003 are shown in Table 4.2.1.3, Table 4.2.1.7 and Figure 4.2.1.7. The catches increased noticeably in the beginning of 1990s. In 1996 and 1997 the catches were 3-4 times higher than in the 1980s in the river Kalix älv and almost 10 times higher in the river Byske älv. In 1998-2000 the catches decreased to about half of those in 1996-1997 in both the rivers.

In 2003 the reported catch in the rivers Kalix älv and Byske älv was 1385 and 204 salmon compared to 2490 and 223 in 2002. The catch in kilos was 5 600 and 816 kilos, compared to 10478 and 892 in 2002. The total catch of salmon in 2003 in the river Åby älv (10 salmon), was the same as in 2002 and in the river Lögde älv 25 salmon compared with 40 in 2002. In Pite älv the catch was 40 salmon. Earlier there has been no reporting of catches in Pite älven. In Ljungan the catch 2003 was 39 salmon compared to 2002 when the catch was only one salmon. The catches in Kåge älv and Öre älv were small. No catches of salmon was reported from the river Rickleån, Sävarån and Råne älv.

Salmon run in fish ladders

Fish ladders are present in the rivers Kalix älv (built in 1980, improved in 1994), Pite älv (new ladder built in 1992), Åby älv (built in 1995), Ume, älv/Vindelälven (built in 1960), Öre älv until 1999 (built in the 1960´s) and Rickleån (three ladders, built in 2002). The salmon run between 1973-2003 in these ladders are shown in Table 4.2.1.8, Figure 4.2.1.8 and Figure 4.2.1.9. In almost all rivers the counting is made by the electronic, infrared fishcounter "Riverwatcher", constructed by the Icelandic company Vaki Aquaculture System Ltd. In river Byske älv in the old fishladder and in river Rickleån a underwatercamera (Poro AB) is installed to measure the size from pictures of the fish. The run in 2003 was almost half of the run in 2002 in rivers Kalix älv and Ume/Vindelälven. In river Åby älv the run 2003 of MSW fish (MultiSeaWinter fish) decreased with 90 % compared to the run 2002.

In the rivers Kalix älv, Pite älv and Åby älv the total run in 2003 was 4961, 1418 and 21 salmon. The number of MSW-fish, defined as fish >60 cm, in Kalix älv and Åby älv was 3902 and 6 compared to 6190 and 52 in 2002. In Piteälven the total run 2003 increased with 40 salmon compared to the run 2002. The percentage of MSW-fish was 78 % and 28%, in Kalix and Åby river compared with 90% and 55% in 2002. No salmon has passed the ladder in Rickleån in 2003. The run in the rivers Kalix älv, Åby älv and Rickleån is a part of the run and the run in the river Pite älv is the entire run .

In the river Ume/Vindelälven, the salmon run is affected by the yearly differences in the amount of water in the old riverbed leading to the fish ladder, and therefore the possibilities for salmon and trout to find their way. The results in 1999-2002 might in part be the result of an unusually large amount of water spilled to the riverbed at the dam in Norrfors. In 2003 the total run was 2557 salmon (wild + reared). The number, 6052, of wild salmon in 2002 is the highest observed since the total run was divided into reared and wild salmon by finclipping in the beginning of the 1970´s. The number of wild female salmon in 2003 has decreased with 52% compared to 2002. The run in the fish ladder is the entire run.

No data of the run in the river Öre älv has been collected since 2000 as a part of the trap was destroyed by high water levels in 2001.

Parr densities and smolt production

The densities of salmon parr in electro fishing surveys in rivers in the Gulf of Bothnia, Sub-divisions 30-31, are shown in Table 4.2.1.9, Table 4.2.1.10, Table 4.2.1.11 and Figure 4.2.1.10. The predicted smolt production in the rivers are shown in Table 4.2.3.1. During the time series, electrofishing surveys has been done with the same kind of equipment (portable fuel powered engine and Lugab transformer), and by the same people in Torne, Kalix, Råne, Åby and Byske älv. In the others rivers, electrofishing has been done by different people. The electrofishing is carried out in the same way today as in the beginning of the monotoring surveys. The choice of electrofishing sites in all rivers was done in the beginning of the monitoring surveys when the density of parr was very low. To have a possibility to find salmon parr, rapids and sites was selected by “experts knowledge” of the possibility to find parr. When the number of sites has extended to cover the whole river system, the selection has been made in the same way as earlier. In the beginning of monitoring surveys the average size of the sites was around 500-1000 m². The reason of this was again to have some possibility to find parr. In 2003 the size of the sites in several rivers has been fixed to 300 m².

Electrofishing was made in 171 sites in 13 rivers compared with 163 sites in 13 rivers 2002. The densities of parr were higher in 2002 compared to 2001 in allmost all rivers except Åby älv, Rickleån and Sävarån. The predicted smolt production in 2004 is higher than in 2003 in many rivers because of the higher number of parr in 2001 and 2002.

River **Kalix** älv, assessment unit 1: The mean densities of one-summer old parr (0+parr), in the river Kalix älv between 1989-1996 were about 3.3 parr/100 m2. In 1997 the densities increased to 12.5 parr/100 m2. In 2003 the densites of 0+ parr was 46.9 parr/100m² compared with 6,43 parr/100 m² 2002. The predicted smolt production in 2004 is 850 000 compared with 600 000 smolt in 2003.

River **Råne** älv, assessment unit 2: The mean densities of 0+parr in the river Råne älv between 1993-1996 were about 0.2 parr/100 m2. In 1997 the densities increased to 3.0 parr/100 m2. In 2003 the densites of 0+ parr was 4,7 parr/100 m² compared with 1,57 parr/100 m² 2002. The predicted smolt production in 2004 is 30 000 smolts compared to 20 000 smolts 2003.

River **Pite** älv, assessment unit 2: No consistent electro fishing surveys has been made in the river Pite älv during the 1990´s. The predicted smolt production in 2004, estimated from the spawning run in 1999 and 2000, is 7 000 the same as in 2002. The predicted smolt production in 2004, estimated from the spawning run in 1999 and 2000, is 7 000 the same as in 2002. No electrofishing surveys are carried out in River Pite, but there are counts of the number of ascending fish from a fish ladder. It is assumed that there is the same smolt age in this river as in river Torne älv and a 1% egg-smolt survival. This was used to estimate the smolt production in the following manner.

Pite älv smolt forecast: *= (0.01 * ((eggSY-4 * 0.62) + (eggSY-5*0.38)))*

River **Åby** älv, assessment unit 2: The mean densities of 0+parr in the river Åby älv between 1989-1996 were about 3.1 parr/100 m². In 1999 the densities of 0+parr were about seven times higher than the earlier numbers or 21.8 parr/100m². In 2003 the densites of 0+ parr was 2.9/100 m² compared to 2002 when the densities of 0+ parr was 9.5 parr/100 m². The predicted smolt production in 2004 is 10 000 smolts the same as in 2003.

River **Byske** älv, assessment unit 2: The mean densities of 0+parr in the river Byske älv between 1989-1995 were about 4.7 parr/100 m². In 1996-1997 the densities increased to about 10.9 parr/100m². In 1999 the densities of 0+parr were 18.6 parr/100 m² or about 70 % higher than in 1996-1997. In 2000 the densities of 0+parr was 11.2 parr/100 m². In 2003 the densities of 0+ parr was 33.8 compared to 2002 when the densities was 17.3 parr/100 m². No electrofishing was made in 2001. The predicted smolt production in 2004 is 106 000 smolts compared to 88 000 in 2003.

River **Rickleån**, assessment unit 2: The mean densities of 0+parr in the river Rickleån between 1988-1997 were about 0.7 parr/100 m2. In 1998 the densities increased to 3.8 parr/100 m². In 2003 the densities of 0+ parr was 1.4 parr/100 m² comparing to 2002 when the densities of 0+ parr was 2.7 parr/100 m². No electrofishing was made in 2001. The predicted smolt production in 2004 is 590 smolts compared with 790 in 2003

River **Sävarån,** assessment unit 2: The mean densities of 0+-parr in the river Sävarån between 1989-1995 were about 1.4 parr/100 m². In 1996 the densities increased to 11.6 parr/100 m², but was in 1997 only 0.4 parr/100 m² and in 1998 4.1 parr/100 m². In 2000 the densities of 0+parr was 19.2 parr/100 m² compared with 0.9 0+parr/100 m² in 1999. Difficulties in the electro fishing with only some of the sites examined in 2000 might in part explain the very high number. No electrofishing was made in 2001. In 2003 the densities of 0+ parr was 3.4 parr/100 m² compared to 2002 when the densities was 5.3 parr/100 m². The predicted smolt production in 2004 is 2 700 smolts compared with 3 100 in 2003.

River **Ume /Vindelälven,** assessment unit 2: The mean densities of 0+-parr in the river Ume älv/Vindelälven between 1986-1996 were about 1.2 parr/100 m². In 1997 the densities increased to 8.0 parr/100 m². In 2002 the densities of 0+parr was 24.7 parr/100 m² compared to 2002 when the densities was 5,0 0+parr/100 m². The predicted smolt production in 2004 is 257 000 smolts compared with 260 000 in 2003.

River **Öre** älv, assessment unit 2 : The mean densities of 0+-parr in the river Öre älv between 1986-1997 were about 0.10 parr/100 m². In 1998 the densities increased to 1.5 parr/100 m². In 2000 the densities of 0+parr was 0.9 parr/100 m². No electrofishing was made in 2001. In 2003 the densities of 0+ parr was 5.1 parr/100 m² compared to 2002 when the densities was 5.3 parr/100 m². The predicted smolt production in 2004 is 8 000 smolts compared with 6 000 in 2003.

River **Lögde** älv, assessment unit 2: The mean densities of 0+-parr in the river Lögde älv between 1986-1997 were about 1.6 parr/100 m². In 1998 the densities increased to 13.7 parr/100m². In 2000 the densities of 0+parr was 4.8 parr/100 m². No electrofishing was made in 2001. In 2003 the densities of 0+ parr was 11.1 parr/100 m² compared to 2002 when the densities was 5.0 parr/100 m². The predicted smolt production in 2004 is 7 000 smolts compared with 6 000 in 2002.

River **Ljungan,** assessment unit 3: The number of salmon in the broodstock fishery is shown in Table 4.2.1.12. The number of salmon caught in the trap has increased noticeably in later years, especially in 1999 and 2000 when 200-300 salmon has been caught. However, only 16 % and 11% of the catch in 1999 and 2000 was wild salmon and the number of wild females was very low. The fishery was heavily affected by high water levels in 2001 and the catch was very low, only 23 wild and reared salmon. In 2000 and 2001, angling for both wild and reared salmon was allowed between the 19th of June and the 31st of August. 18 salmon were caught by angling in 2001 compared with 2 in 2000. The catch in the trap in 2003 was only two salmon. The mean parr densities of 0+parr in 1990-1997 was 10.9 parr/100 m². In 2000 the densities of 0+parr was 16.3. parr/100 m² compared with 19.9 0+parr/100 m² in 1999. No electrofishing was made in 2001. In 2003 densities of 0+ parr was 13.4 parr/100 m² compared to 2002 when the densities of 0+ parr was 3.8 0+ parr/100 m². The predicted smolt production in 2004 is 900 smolts compared to 1 800 in 2003.

4.2.2 Rivers in the Baltic Main Basin (Sub-divisions 24-29)

Swedish rivers

River **Emån,** assessment unit 4: In 2003 83 salmon with a total weight of 609 were caught in the river Emån compared to 143 salmon and 1147 kilos in 2002. Densities of parr in electrofishing surveys below the first partial obstacle in the river are shown in Table 4.2.2.1 and Figure 4.2.2.1. The mean density of 0+ parr in the river Emån in 1992-1996 was 35 parr/100 m2. In 1997 the density increased to 71 0+parr per 100 m² and the mean density in 1997-2000 was 58 0+parr/100 m². In 2003 the densities of 0+ parr was 46 parr/100 m² compared with 57 parr/100 m² in 2002. Data of the electrofishing has been revised in 2002.

River **Mörrumsån,** assessment unit 4: In 2003, 411 salmon with a total weight of 2667 kilos were caught in the river Mörrumsån compared to 581 salmon and 2440 kilos in 2002. Densities of parr in electrofishing surveys are shown in Table 4.2.2.1 and Figure 4.2.2.1. The mean densites of 0+ parr in the river Mörrumsån in 1992-1997 were 48 parr/100 m. In 1998 the density increased to 120 parr per 100 m². In 2003 the densities of 0+ parr was 92 parr/100 m² compared with 95 parr/100 m² in 2002. In the river Mörrumsån, hybrids between salmon and trout has been found during the electrofishing. In 1993-1994 the numbers were high, up to over 50 % in some sampling sites. The number of hybrids has varied and was in 1995 and 1996 only some percent of the total catch. In 2003 the densities of hybrids was the same (2.0 0+ parr/100 m²), as in 2002.

Estonian rivers

River **Pärnu,** assessment unit 6: The river Pärnu is the only Estonian salmon river in the Main Basin. The first obstacle for migrating salmon in the river is the Sindi dam, located 14 km from the river mouth. The dam has a fish ladder which is not effective due to the location of the entrance. In electrofishing surveys below the Sindi dam, salmon reproduction occurs in the area. In 2003 the densities of both 0+ and >0+ parr was 0 parr/100 m² compared to 2002 when the densities of 0+ and >0+parr was 4,9 and 0 parr/100 m². The smolt run desenced in 2003 as in 2002.

Latvian rivers

In the Eastern Baltic sea, most of the wild salmon rivers are situated in Latvia, mainly in the Gulf of Riga. Some rivers have been stocked with hatchery reared smolts every year with the result that the populations are a mixture of fish with natural and hatchery origin. Increased eutrophication, vegetation development and sedimentation have led to some reduction of suitable spawning and nursery grounds. Illegal fishery has lead to decreased number of spawners.

River Salaca, assessment unit 6: The wild salmon population in the river Salaca has been monitored by quantitative smolt trapping since 1964 and by electrofishing since 1993. From 1995 the coastal broodstock fishery in the Gulf of Riga near the Salaca river mouth has been closed to increase the number of wild spawners in the river. The density of wild salmon parr was estimated by using three-removal electrofishing in permanent stations. Mean density of 0+ salmon parr in 2003 was 32.8 per 100/m2 which is less than average parr production level in the period from 1997 to 2002 in the River Salaca. Density of 0+ wild salmon parrs in the Salaca tributaries varied from 2- 5 individuals per/100 m2. Density of 1+ and older salmon parr decreased and was from 10.3 to 1.3 per sampling unit in the main river. (Table 4.2.2.2).

The smolt run in the river Salaca normally starts in the end of April when the temperature of the water rises to 6-8 degrees C. In 2002 the smolt trap was in operation between the 20th of April to the 5th of June. After the 27th of May, no smolts were observed in the trap. In total, a number of 816 wild salmon smolts were caught. The catch efficiency of the trap decreased from the time of the descend maximum to the end of the migration time. In total 332 wild salmon smolts were marked for recapture experiments. The rate of the catch efficiency fluctuated from 0.04 to 0.10. An estimated total of 26 000 wild salmon smolts migrated from the river Salaca in 2002. For the years 1999-2002 the average wild smolt production were 26 000 or 80% of the potential production.

The wild salmon production in the other Latvian rivers is roughly evaluated from irregular smolt trapping in the rivers Gauja, Venta and Peterupe, finclipping of reared salmon and electrofishing of parr.

Lithuanian rivers

Lithuanian rivers are typical lowland ones. These are mainly the sandy, gravelly rivers flowing in the heights of Upper and Lower Lithuania. Nevertheless, salmonids inhabit more than 180 rivers in Lithuania (Kesminas, Virbickas, 2001). River trout inhabits 76 rivers, Baltic salmon spawned in 14-16 Lithuanian rivers. Leaning on historical data and today's situation, salmon rivers can be divided into some groups in Lithuania: 1- inhabited by wild salmon; 2 – inhabited by artificially reared salmon; 3 – inhabited by mixed salmon population; 4 - "potential" rivers, i.e. where salmon occurs occasionally; 5 – rivers, where salmon got extinct (Salmon restoration program, 1998).

During the last decade abundance of salmon migrating to Nemunas River basin varied within 7 800 – 1 700 individuals (on average 4 243). Because of unfavorable environmental conditions, in 2003 was recorded the lowest abundance of migrating salmon, 1 700 individuals. Potential smolt production in Lithuanian rivers roughly estimated in 1998 amounts to 180 000 individuals. At present only 2 rivers, Zheimena, and Neris and some small their tributaries have wild salmon smolt production, both of them belonging to Nemunas River basin. In 2003, actual salmon smolt production in Lithuanian rivers (according to electric fishing data) amounted to 1629 ind. The mean of last three years is 4492 individuals.

Electrofishing is the main monitoring method for evaluation of 0+ and elder salmon abundance. At 2003, monitoring of salmonids covers 130 sites in Lithuania. Monitoring covers all main salmon rivers (including all potential rivers) in Lithuania. 2003 salmon parr were found in 7 rivers in the Lithuania: southeastern part - Zheimena, Neris, Šventoji and small rivers - Vilnia, Mera and Siesartis. In the western Lithuania, salmon parr were found in river Šventoji (Baltic sea) and central Lithuania river Dubysa.

Density of salmon juveniles in Lithuanian rivers ranged within 0,1- 2,12 ind/100 m^2, (mean 0,81 ind/100 m^2).

River Zheimena, assessment unit 6**:** One of the main wild salmon rivers in Lithuania. The highest salmon parr density, on average 4,4-4,6 ind./100m^2 , was established in the Zheimena River in 1999-2000. However, in 2001 - 2003 it decreased to 0,66 – 0,72 ind./100m^2. The wild salmon smolts production reached up to 1500 –3000 ind, while during the last two years it decreased to 651 ind. In the Mera River (tributary of Žeimena) the density is much lower, 0,01– 0,27 ind./100m^2, and the smolt production varies between 50-200 individuals. In the Zheimena River 0+ and 1+ juveniles were found, the latter amounting only to 9,4%.

River Neris, assessment unit 6: The average wild salmon parr density in the Neris River was 0,9-2,51 ind./100m^2. The production of wild salmon mean last 3 years is 2355 smolts. In 2003 the density of parr in the Neris River was 0,27 ind./100m^2. Salmon parr are constantly being recorded in the tributaries of Neris: Šventoji and Vilnia rivers.

River B. Šventoji, assessment unit 6: This river inhabited by mixed population. After restoration work, density of salmon parr in the monitoring stations in autumn reached 1,12 ind./100 m^2, and the mean smolt run estimated in the last 3 years is 132 ind.

4.2.3 Predicting wild salmon smolt production

4.2.3.1 General development in methods

Smolt production of the Baltic salmon rivers has been traditionally predicted in the working group using a set of different regression models and point estimates of the relevant variables, such as described in the previous section. This procedure ignores uncertainty arising from measurement error, uncertainty about parameter values, uncertainty associated with between-river variation of model parameters and uncertainty about the model structure. Uncertainties of future stock predictions are in an essential role in risk-averse fisheries management. Therefore, the working group has decided not to use the previous regression models. A new regression method to predict smolt abundance was introduced into the working group in 2003. The model was developed further for year 2004 .

4.2.3.2 Hiearchical Bayesian smolt abundance model

A detailed description of the model together with the results and discussion are given in the ANNEX 2. The model connects the abundance of smolts to the relative density of 1+ and older parr in the previous year in terms of a linear regression model. Similarly, the relative density of age 2+ and older parr is connected to the 1+ parr densities in three previous years. Finally, the relative density of 1+ parr is then connected to the relative density 0+ parr in the previous year. This kind of dependence structure enables prediction of the smolt abundance two years ahead from the previous 0+ parr density estimates. River specific regression slopes are assumed to vary between rivers according to a log-normal distribution, which allows rivers to exchange information about parameter values from each other. This makes it possible to learn about the regression slope between 1+ and older parr and the smolt abundance from rivers which have both electrofishing and smolt trapping data, and apply this information to rivers which have only electrofishing data. Bayesian approach makes it possible to treat population sizes as unobservable random quantities, which enables probabilistic assessment of their values.

Required input data consist of smolt abundance estimates, which are can be derived, for example, from mark-recapture experiments or from expert opinion. A point estimate and measurement error are needed, preferably mean and CV. Electrofishing data must be expressed in terms of number of sampling sites and the estimated number of 0+, 1+ and 2+ and older parr estimated to occupy the sites. The number of sampling sites is used to assess the measurement error associated to the estimated number of parr occupying the sampling sites by assuming that the total number of parr in electrofishing sites follows a negative binomial distribution. This assumption takes into account the variation arising from the fact that only integer numbers of fish can occupy a sampling site, which was not accounted in the model presented last year. The variation of parr density between sampling sites was earlier assumed to have CV=1, but this assumption was relaxed this year by assigning a hierarchical prior distribution to the CV.

Vague prior distributions were assigned to model parameters, because of the nature of the model structure: in addition to survival, regression slopes may reflect also other factors such as possibly different representativness of electrofished sites in different rivers. The between-rivers variation of regression slopes was assumed to be similar for all slope parameters, instead of assuming that the variation in slopes between rivers would be different for different slopes (for the slopes between 0+ parr and 1+ parr and for the slopes between 2+ parr and smolts), as was assumed last year. Uniform prior distribution was assigned to this variation parameter instead of highly informative prior distribution assumed last year. Information about parr production area of each river is needed in order to scale the parr densities to be comparable with smolt abundance. Prior distributions for production areas have been extracted from the work of Uusitalo et. al. (unpubl.), in which expert opinions are used to assess the parr production areas and also the carrying capacities of Gulf of Bothnia rivers.

Outputs of the model are posterior probability distributions for all model parameters, including parr densities, smolt abundance and regression slopes, for example. It is also possible to calculate posterior distributions for joint smolt production of multiple rivers. Furthermore, smolt production estimates can be compared to carrying capacity estimates by calculating the probability that the smolt production exceeds 50% of the carrying capacity.

The method was applied to the wild salmon rivers of Gulf of Bothnia (except the River Pite älv, which lacks electrofishing data). Electrofishing results together with probabilistic estimates of smolt production of the rivers Simojoki and Tornionjoki/Torne älv were used, covering the most recent years and also years of the 1990s. In some rivers time series were available from the early 1980s onwards. MCMC simulation was implemented by using the WinBUGS 1.4. Software package was used to draw samples from the posterior distributions of model parameters. The fitness of the model was examined by inspecting the distributions of obtained Bayesian p-values, which indicated good fit.

The results (Table 4.2.3.1), illustrate the uncertainty involved in the estimation, which is a clear improvement compared to the traditional method used by the working group. Also, the new method can handle situations, where single data points are missing. In such cases, prediction uncertainty increases as information comes from other available observations through the links of the model parameters. River-specific estimates are naturally the most accurate in the rivers, where smolts have been trapped in addition to electrofishing (like in the Tornionjoki/Torne älv). Rivers with no smolt trapping and few electrofishing sites obtain the most uncertain estimates (like the Rickleån), while increased number of electrofished sites leads to more accurate smolt abundance estimates (like the Kalixälven) (Figure 4.2.3.1). Prediction of the total smolt production in the assessment unit 1 is generally more accurate than the predictions of other assessment areas, reflecting the fact that through smolt trapping and intensive electrofishing more informative data is available from this assessment unit. According to the results, total smolt abundance has shown and is also predicted to keep an increasing trend in the two first assessment units, but in some of the Gulf of Bothnia rivers smolt production is predicted to turn to decrease, as in the Ljungan, the only wild river of the assessment unit 3. (Figure 4.2.3.2). The statistic used in describing the smolt abundance in table 4.2.3.1 is mostly the median of the calculated posterior distribution of these rivers. (Figure 4.2.3.4).

The model assumes that the electrofishing sites in rivers without direct smolt trapping estimates represent parr production areas similarly (not necessary in an unbiased way) as the electrofishing sites in the rivers with smolt trapping. Smolt trapping data is currently available only from the two rivers above mentioned. In order to increase the plausibility of the assumption about similar sampling designs, only Swedish electrofishing data is used in the Tornionjoki/Torne älv (because the rivers without smolt trapping are all Swedish). Similarity of electrofishing method across the rivers sampled by Swedes is discussed in the section 4.2.1: Parr densities and smolt production. In general electrofishing in the Simojoki follow similar principles as the Swedish eletrofishing, but as a large number of sites are annually sampled in the Simojoki, it is probable that sites with constant low parr densities are more commonly sampled in the Simojoki. This does not necessary lead to any severe problems in the model, but probably only means somewhat higher uncertainty in the results. However, the issue is worth more thorough investigations. Also investigation of the option of incorporating unlinearity (density-dependence) in the modeling of parr densities is required.

4.3 Potential salmon rivers

4.3.1 General situation and recommendations

Several countries have officially appointed potential salmon rivers as suggested in the IBSFC Salmon Action Plan. Mostly, these rivers are old salmon rivers that have lost their salmon population. A renewal of potential salmon rivers has started in some countries in different ways and with varying efforts. The goal of the restoration is to re-establish natural self sustaining reproduction of salmon. The current status of the restoration programme in Baltic Sea potential salmon rivers is presented in Table 4.3.1.1.

In reply to a request from IBSFC on appropriate criteria for selecting potential salmon rivers the Working Group recommended the following criteria:

- select rivers which are known to have had salmon populations in the past;
- review information on each river to determine why the salmon population was lost;
- select rivers where the causes of loss are known and where causes could be mitigated;
- determine rivers which could be able to support salmon fisheries;
- evaluate the suitability of habitat features in the river including:
- safe ascending migration of adults and downstream descending of smolts;
- existence of spawning and nursery habitats on the basis of physical and chemical characteristics of the river;
- evaluate the level of possible predation and interactions with other fish species;
- evaluate the impact of fishery on the new stock;
- select adequate broodstock.

At present there is no good indications, except in one Swedish river (Kågeälven), of an re-establishment of salmon populations in the Baltic Sea. Releases of salmon fry, parr and smolt have resulted in natural reproduction in some rivers (Table 4.3.1.2), but there are still no actual evidence of reintroduced self sustaining salmon populations. It means that applied measures have not been adequate or not sufficient for these rivers. As the goal of Salmon Action Plan seems to be out of reach at the present level of sea and coastal fishery, the Working Group recommends that countries with appointed potential rivers should revise the applied measures and either further promote and strengthen these or revise the status of the rivers.

4.3.2 Potential rivers by country

Estonia

The rivers Valgejõgi, Jägala and Vääna were selected as potential salmon rivers for IBSFC Salmon Action Plan. In all these rivers were carried out enhancement releases. In 2003 to Valgejõgi 31 900 0+ parr, 10 500 1-yr and 10 000 2-yr old smolts, to Jägala 10 500 1-yr and 5 000 2-yr old smolts and to Vääna 19 500 1-yr old smolts were released.

In the River Valgejõgi wild parr occur in 1999-2003, in the River Jägala in 1999 and 2001, in the Rievr Vääna in 1998, 2000 and 2002 (Table 4.3.1.2). On the River Jägala, the Linnamäe power plant was restored in 2002. Soft sediments were released from water reservoir in repairing process and spawning and nursey areas below the dam were covered by silt. In 2003 summer some improvement actions were carried out. The effect is not yet evaluated.

Finland

Three potential rivers, the rivers Kuivajoki (58 hectares reproduction areas), Kiiminkijoki (110 hectares) and Pyhäjoki (98 hectares), have been selected to the Finnish Salmon Action Plan programme. All these rivers are located on the assessment unit 1 (sub-division 31). Salmon stocking with hatchery reared parr and smolt have continued for several years in these rivers. During the last years, adult salmon from these stockings has ascent to all these rivers, but the amount has stayed low. Also some natural reproduction of salmon has been detected in all the rivers over several years. However, most of the parr and smolts observed by electrofishing surveys and smolt trapping have been of reared origin. In 2003, river ascent of salmon seemed to decrease and was very poor in the river Pyhäjoki. The river catch was higher in the rivers Kiiminkijoki and Kuivajoki. Wild salmon parr were detected in Kiiminkijoki and Kuivajoki in 2003, but no more in the river Pyhäjoki. Due to the poor spawning stock, decreasing of natural reproduction in 2004 is expected in all these rivers, specially in the Pyhäjoki.

The goal of SAP (a production of at least half of the potential capacity) seems to be impossible to be reached with the present efficiency of sea fishing. There are some indications that adult salmon have faced problems to enter the potential rivers during the dry summer months. Further habitat restoration is urgently needed especially at the lowest rapid areas near the sea to improve adult salmon ascending into the rivers. Different kind of human impacts in these rivers may also restrict the natural salmon production.

Intensive salmon stocking with hatchery reared salmon parr and smolt started in the Pyhäjoki in 1997. In 2003, 71 000 smolts and 114 000 1-year old parr were stocked in the Pyhäjoki. The stocking results were monitored by electrofishing on 22 sites. No wild 0+ salmon were found (Table 4.3.1.2). No smolt trapping were carried out in 2003. Only 29 kg salmon were caught from the Pyhäjoki in 2003, whereas the catch from sea nearby rivermouth was some 500 -1000 salmon individuals (mainly grilse). In the Kuivajoki, 56 700 smolts and 50 000 one-year old parr of the Simojoki origin were stocked in 2003, and the results were monitored by electrofishing of 15 sites. The mean density of wild 0+ salmon was 0,4 parr per 100 sq.m (Table 4.3.1.2). In the Kuivajoki, no smolt trapping has been carried out. The catch of salmon in this river was 235 kg. In the Kiiminkijoki, 88 500 smolts, 120 000 one-year old parr and 10 000 one-summer old parr of the river Iijoki origin were stocked in 2003. The results of stocking were monitored by electrofishing on 47 sites. The mean density of wild 0+ salmon, 0,7 parr per 100 sq.m, was half of the density observed in previous year (Table 4.3.1.2). The smolt production of the Kiiminkijoki was evaluated by smolt trapping. Roughly 10 000 smolts, which originated mainly from parr releases during previous years, migrated to sea. The number of ascending MSW spawners was low. The river catch of salmon, 715 kg (possibly an overestimate), consisted mainly of grilse caught in the late summer.

Apart from the selected Finnish SAP rivers, in 2003 small-scale natural reproduction was found by electrofishing also in the Merikarvianjoki river (assessment unit 3, sub-division 30) and in the Kymijoki river, the Gulf of Finland (assessment unit 6, sub-division 32). Reared smolts are annually stocked and there is some small-scale angling in these rivers.

In 2003, a Finnish national report was published describing the development of salmon stocks and management success in the Finnish SAP rivers, including the rivers with wild stocks (Erkinaro et al., 2003). The report revealed the much more positive development of the wild rivers compared to the results of rebuilding efforts in the potential rivers. It was concluded that several problems in various phases of salmon ‘s life cycle may adversely affect restoration measures, but their relative importance is difficult to assess.

Lithuania

Since 1998, artificially reared salmon juveniles are constantly being released into the following potential rivers: Shventoji, Siesartis, Virinta, Vilnia, Voke, Dubysa and Baltic Shventoji. Salmon juveniles are being released into rivers in spring (0+ fry) and in autumn (0+ parr). In May 2003 more than 100 thousand salmon fry were released into Neris, Vilnia Vokė, Šventoji, Siesartis, Virinta and Dubys rivers. In river Minija were released 8,6 thousand one year old salmon smolts. The results of stocking were monitored by electrofising. Research results revealed that restocking efficiency varies in different years. However, it is much more efficient in the small rivers.

Poland

There are no officially stated, according to IBSFC criteria, potential river in Poland. However restoration programme for salmon in Polish rivers started in 1994, based on Daugava salmon. This programme has been carried out in 7 rivers but until now there is no good evidence for successful re-establishment of self-sustaining salmon population.

In 2003 neither spawning salmon nor wild parr/smolt were observed in Vistula River system; also a number of caught spawners was very low, much lower then in previous years. It has allowed to collect less then 100,000 eggs. Totally 144,900 smolts and 160,000 parr were stocked in the drainage system.

Natural spawning was observed in the Drawa R. (the Odra R. system) but number of salmon nests were lower then in previous years and not higher then 10. Some nests, assumed to be salmon nests, were also stated in Wieprza River. Number of spawners caught in this river for breeding was in 2003 very low, much lower then in last few years. In almost all Pomeranian rivers, stocked with salmon, ascending and spent salmon were observed and caught by anglers but there was no evidence of wild parr or smolts despite of electrofishing carried out in some of them during last few years. In 2003 amount of 169,700 smolts and 60,000 parr were released into Pomeranian rivers.

Russia

The releases in the Gladyshevka River has been continued. 10,000 1-year salmon parr and 30,000 0+ salmon parr of the Narova origin were released in 2003.

Sweden

In Sweden, four rivers are considered to be potential salmon rivers. Two of them, rivers Kågeälven and Testeboån, are selected nationally as potential rivers. The others, rivers Moälven and Helgeån, have restoration efforts on regional-local levels. In these rivers, releases of salmon fry and parr were made in 2003 as well as electrofishing studies. Densities of salmon parr in rivers Testeboån and Kågeälven have improved in recent year (Table 4.3.1.2). However, most parr found in the river Testeboån is probably of reared origin. In river Helgeån most of the parr caught is orignally released as fry. However, parr originating from natural reproduction has been observed in the main river at Torsebro, below the first dam in the river system.

4.4 Status of reared populations

The section describes the status of reared salmon populations, reared and released either for compensatory purposes or sea-ranching.

The reared stocks in Sweden have been severely affected by the M74-syndrome since the spring of 1992. The mortality caused by M74 decreased in 1996-1998 and increased slightly again in 1999. As a result the Swedish compensatory releases of salmon smolts in 1995 were 60-70% of the normal, but in 1996–2003 the releases increased to normal levels (Table 4.6.1).

The broodstock fishery in Swedish rivers has earlier been considered as indexes of escapement, especially as the traps were used with equal intensity during the entire season. Because of the high number of spawners, traps are now operated for the entire season only in a few of the rivers and the catch levels not considered to be a good indicator of the abundance of fish in the rivers. In all rivers did the broodstock fishery in 2003 fill the required need of the releases. The prediction for 2004 indicates that the Swedish releases of salmon will be at the level of the water court decisions, approximately 1.8 million smolts. No estimate of the surplus of salmon in reared rivers excists for 2003.

In Finland, the production of smolts is based on broodstocks reared from eggs and kept in hatcheries. The number of spawners kept in the hatcheries is high enough to secure the total smolt production. There have been no major changes in smolt releases in 1990s. An annual renewal of the brood stocks has been regarded necessary, and consequently enforced in order to avoid inbreeding.

Yield from Finnish salmon smolt releases has been decreasing since 1994. Lower catches have been explained by reduced TAC and strong regulations in coastal fishery. However, no substantial surplus of fish has been observed in the rivers where compensatory releases have been carried out. Decrease in catches is considered to be based on reduced survival of salmon in post smolt phase. According to tagging data the return rate for year-classes since 1996 has been substantially lower than rates on average in long-term. Return rates fluctuate in the same tempo in Sweden and Finland, which indicates that long-term variation may be caused by temporary changes in the Baltic Sea ecosystem (Figure 9.2.1).

In Latvia the artificial reproduction is based on sea-run wild and hatchery origin salmon broodstock. The broodstock fishery is carried out in the coastal waters of the Gulf of Riga in October-November. The number of salmon for stripping was insufficient in 2003. The mortality of yolk sac fry has been low indicating that M74 is absent in this region.

In Poland the last salmon population extincted in the mid 1980s. A restoration programme was started in 1984 when eyed eggs of Daugava salmon was imported. Until 1995 eggs for rearing purposes were collected mainly from salmon broodstock kept in sea cages located in Puck Bay. Since then eggs were collected from spawners caught in Polish rivers and from spawners reared in the Miestko hatchery. Length of spawners varied from 32 cm to 70 cm. They yearly produce 2,5 to 3,0 million eggs. Until 1990 eggs were imported from Latvia. Stocking material, smolt, one-year old parr and one-summer old fish are reared in 5 hatcheries. Spawners are caught in the Wieprza river, Drweca river and in the mouth of Wisla river. In addition some amount of eyed eggs from Daugava salmon were imported in the end of 1990s.

In Estonia a rearing programme using the Neva salmon stock was started in 1994. Eggs were collected from the reared Narva stock, mixed Selja stock and in late 1990's also imported from Finland. One hatchery is at present engaged in salmon rearing.

According to tagging results the productivity of the salmon smolt releases has decreased in all Baltic Sea countries during the last 15 years (Table 9.2.1). Catch samples from year 2003 indicate that the proportion of reared salmon was less than 50 % in many of the Baltic Sea fisheries (Table 4.10.1). On the basis on the ratio in the smolt phase, the expected proportion was about 20 %. These results suggest a significantly lower initial survival for the reared smolts compared to wild ones.

4.5 M74

In the 1990´s there was an outbreak of the M74 syndrome in the Baltic. The syndrome resulted in a high mortality of salmon yolk-sac fry with over 50% mortality in most hatcheries in hatching years 1992-96 (Table 4.5.1). From 1997 and onwards the mean mortality has been 40% at the highest. The mortality in 2001 was about 28% and in 2002 it again increased to 40% expressed as the % of females whose offspring were affected by M74. This was based on results from three Finnish and eight Swedish rivers with a variation among rivers ranging between 19 and 69%. In Estonia in 2002 the offspring of 3 females out of 41 caught in the River Narva (7%) suffered from M74. Five females from the River Selja did not show the M74 syndrome. Offspring of 3 females from 40 caught in the River Narva in 2003 had M74 syndrome. 3 females from the River Selja were healthy. The mean yolk-sac fry mortality in Finnish rivers in 2003 was below 10%, i.e., lower than over a decade; 3−11% of spawners ascended the Rivers Simojoki, Tornionjoki and Kymijoki produced M74 offspring and M74 was mild so that only a part of the yolk-sac fry of each M74 female died.

The mortality (Table 4.5.1) has either been given as the percentage of females whose offspring were affected by M74 or the percentage of the mortality of yolk-sac fry. The estimates from Swedish rivers are in all cases given as the percentage of females affected by M74. In Rivers Simojoki and Tornionjoki/Torne älv (assessment unit 1, sub-division 31) as well as in River Kymijoki (assessment unit 6, sub-division 32), estimates of the mortality have been made in Finland using both methods. In River Simojoki in 1992–2002 the mean yolk-sac fry mortality was 53% and the proportion of M74-females was 61% indicating a mean difference of 8% between the two methods. In River Tornionjoki/Torne älv in 1994–2002 the mean yolk-sac fry mortality was 52% and the proportion of M74-females was 56% with the mean difference of 4%. In 1997–2001 there was a tendency that the M74-mortality was higher in Finland than in Sweden, but differences among stocks of about the same magnitude occur also within Sweden. Partly the difference between Finnish and Swedish estimates arises from the fact that in Finland the development of yolk-sac fry is monitored for a more extended period as day-degrees and then also milder, later appearing M74 cases are registered. The established practice results in slightly higher percentage in M74 frequency than in the mean yolk-sac fry mortality, but not in the years when M74 is severe (http://www.rktl.fi/english/fish/environment_of_fish/m_syndrome_in.html). Obviously there are river-specific differences in M74 intensity. In River Kymijoki M74 has in most years also been milder than in Rivers Simojoki and Tornionjoki/Torne älv. There is no evidence to suggest that M74 occur in Latvian salmon populations. In the Latvian main hatchery Tome, the mortality from hatching until feeding starts varied in the range 2−10% in the years 1993−1999 (Figure 4.5.1). Parr densities in the Latvian river Salaca have not decreased during the period in the 1990s when salmon reproduction in the Gulf of Bothnia was negatively influenced by M74 (Table 4.2.2.2).

There is no evidence to suggest that M74 occur in Latvian salmon populations. In the Latvian main hatchery Tome, the mortality from hatching until feeding starts varied in the range 2-10% in the years 1993-99 (Figure 4.5.1). Parr densities in the Latvian river Salaca have not decreased during the period in the 1990s when salmon reproduction in the Gulf of Bothnia was negatively influenced by M74 (Table 4.2.2.2).

It seems highly likely that M74 is linked to the diet of salmon in the Baltic and changes in the ecosystem. The incidence of M74 is statistically well correlated with parameters describing the sprat stock (Karlsson et al. 1999), but any causal connection has not been shown. The occurrence of M74 has been linked to low levels of thiamine (vitamin B1) and yolk-sac fry suffering from M74 can be restored to a healthy condition by treatment with thiamine. Also low levels of carotenoids (pale colour) in eggs is statistically linked to occurrence of M74 in female spawners, but in this case there does not seem to be any causal relation as for thiamine. The thiamine content in both herring and sprat that were of the size (13.5-15.9 cm) preferred by salmon as prey, appeared to be above the nutritional guidelines as regards the growth of salmon, but was nonetheless lower in sprat than in herring (Vuorinen et al. 2002). These fish were collected in the winter 1994-1995. The concentrations of dioxins and PCBs were higher in sprat (3-10 years old) than in herring (1-3 years old) and in particular contents of some compounds were high in all age groups of sprat. The concentrations of the same organochlorines in salmon spawners ascended River Simojoki increased coincidently with the outbreak of the M74 syndrome indicating that sprat might have been the principal source of organochlorines for salmon.

The egg colour has been shown to be a good predictor of the incidence of M74, as yellow (pale) eggs have a much higher mortality than orange ones. Eggs from Latvian salmon are more orange than eggs from Gulf of Bothnia stocks (Table 4.5.2). Between 1994 and 1997, salmon eggs became more orange both in the Gulf of Bothnia and in Latvia. This is in correspondence with the lower mortality in this period. In 2001 the egg colour of salmon in Tome was somewhat lover than in 2000, but in 2002 the egg colour increased again. The thiamine content in eggs is even better indicator of the occurrence of M74, because thiamine is measured chemically (Vuorinen and Keinänen 1999). In River Simojoki salmon the mean yolk-sac fry mortality in 1994-2003 correlates significantly ($P < 0.01$) negatively with the mean free thiamine concentration in unfertilised eggs (Figure 4.5.2), and thiamine can be used to predict the occurrence of M74 in offspring. The thiamine-based prognosis in hatching year 2004 is based on examination of thiamine concentrations of individual females and suggests a low level of M74. This is coherent with Swedish prognoses based on hatching of small batches of eggs kept in warm water. The mean value of M74 can be estimated to be in the range of 5-10% in 2004 (Table 4.5.1).

The influence of M74 on the development of wild populations particularly in the Gulf of Bothnia has been a major concern. In the Swedish river Ume/Vindelälven in the Gulf of Bothnia an estimate of the egg deposition is available together with an estimate of the parr densities derived from these brood-year-classes (Figure 4.5.3). It shows that the densities of 0+ parr were low in years 1993-1995 when the incidence of M74 was high, while parr densities were better correlated to the egg deposition in years when the incidence of M74 was low (1986-1991 and 1996-2003).

4.6 Smolt production

The salmon smolt production to the Baltic Sea originates both from hatcheries and from about 40 rivers, which still have wild production. A complete time series of the estimates of all the wild salmon rivers, either based on the smolt abundance model, section 4.2.3, or on other methods indicated in the table, covers only the years 1997-2001 (Table 4.2.3.1). During this period wild smolt production steadily increased from about 0.6 million (median) in 1997 to about 1.9 million (median) in the year 2000. Excluding Lithuania the time series also covers the years 2002-2003. In these years, the wild production has stayed at an elevated level of about 1.5 million (median) smolts. It is important to note that the uncertainty associated with these figures is high, apparently because of few direct measurements of the smolt production. The smolt production from the Gulf of Bothnia rivers covers entirely the years 1991-2005. Wild production in these rivers has increased from the level of 0.5 million (median) smolts in early years up to about 1.5 million (median) smolts prevailing in the most recent years. The prediction for the year 2005 is as high as about 2.5 million (median) wild smolts, but the prediction is very uncertain. In Sub-division 32 the production of wild smolt in 2002 was 27,000 and in 2003 21,000 (medians). It should be observed, however, that in number of rivers the production estimates have varied a lot in the last years, particularly in the Gulf of Finland. No predictions for the assessment units 4-5 (Main Basin) nor for the assessment unit 6 (Gulf of Finland) exists for wild production.

The earlier numbers of smolts was revised in the Gulf of Finland from 1987 onwards. Earlier the 1-year old smolts were counted as a whole as smolts although part of these fish stayed in the river as parr. Such young fish contribute to the smolt production first in the following year having, however, an extra natural mortality. The total number of reared smolts, including delayed releases and enhancement, released in Sub-divisions 22–31 was about 5.1 million in 2003, and their number is expected to be about the same order also in 2004. The total smolt production to Sub-divisions 22–31, including wild fish, was estimated to be 6.4 million in 2003. The total number of smolts of reared origin including Sub-division 32 was 5.8 million in 2003 and 6.0 million in 2002. The number of releases is expected to stay above 5.7 million in 2004. The total smolt production, including wild fish, was 7.1 million in 2003 and is estimated to be 6.7 million in 2004. In 1994 the proportion of wild smolts in Sub-divisions 22-31 was 13.3% of the total production. After that it halved, but it has increased being 20% in 2001 and 17% in 2002. The proportion of wild smolts in Sub-division 32 has been around 2% in the last few years.

4.7 Delayed releases

A release experiment with delayed release of salmon was conducted in the Baltic Sea at the islands of Bornholm and Møn during the years 1995 – 99. A total of 600,000 salmon smolts originating from the Finish Iijokki and the Swedish

Mörrum strain were released implementing the delayed release technique. In addition to this 208,000 salmon smolt (surplus production at the hatchery) were released as coastal release.

Just before release a part of the smolts (in total 11,963) were Carlin tagged. Observed mean recapture rates from delayed releases in all years were 15.8% and 9.0% from releases at Bornholm and Møn, respectively, but with substantial variation between years, and 8.8 % for coastal releases. Part of this variation could be ascribed to weather conditions at time of tagging and fish size (16-39 cm) of postsmolts at release.

Approx. 45.3 % of the stocked salmon were recaptured by Danish fishermen, followed by Swedish, Polish, German and Finnish fishermen. The major part (97.5 %) of the catch was in the Baltic Sea, east and north of Bornholm. A small part of the catch was done outside the Baltic Sea, partly in the Kattegatt and the Atlantic Sea and partly in freshwater.

The purpose of the experiments was to investigate if the commercial Danish fishery could be moved closer to Bornholm or the western part of the Baltic Sea targeting released fish, thus sparing wild salmon strains. It is estimated, that the releases at Møn and Bornholm have reduced the number of wild salmon caught by Danish fishermen with approx. 1000 specimen and reduced the pressure on wild salmon with approx. 11%. During the period 1995 – 2002 a steady increase in the proportion of the Danish fishery in the area close to Bornholm (ICES Squares 38G4, 38G5, 39G4 and 39G5) was observed.

Possible straying to rivers on the Swedish west-coast with outlet to the Kattegat and with wild Atlantic salmon populations was investigated using the results from the Carlin tagging and from additional investigations carried out in some Swedish west coast rivers (Pedersen unpubl.). The additional investigations were conducted in collaboration with the Swedish National Board of Fisheries and involved local anglers as well as the salmon hatchery at the river Lagan. A number of 72,000 salmon tagged with CWTs (Coded Wire Tags) and adipose fin clipped were released as delayed release fish in the summer 2000. Furthermore genetic identification of salmon was used for salmon with aberrant appearance compared to local strains in the rivers.

Targeted sampling was undertaken in the rivers Lagan (at the broodstock fishery), Ätran (in a fishladder), Göta (traps and sportsfishery), Säveån (tributary to R. Göta, sportsfishery) and Örekilselven (sportsfishery). In addition to this, results from catches in the sports fishery was used to estimate the number of spawning migrants in individual rivers. Some straying was observed from the CWT tagged salmon (maximum 0.0125% of the salmon stocked); however straying was at a much lower rate than observed in previous tagging experiments. In total 7 CWT tagged salmon from these releases were recovered in the rivers by examination of at least 9,698 salmon in traps or caught by netting. In addition to this, anglers inspected a partially unknown number. Samples from another 251 salmon were selected for genetical analysis, either because samples were taken from all wild (R. Göta) or because the fish had an aberrant appearance. From these 7 salmon were genetically determined to be of the Mörrum strain, sampled in the years 2000 (6 fish) and 2001 (1 fish).

A total of 10 Carlin tagged salmon from the releases 1995 – 99 were recovered in rivers on the Swedish west coast. Scaling this to the entire number released, yields estimates of straying from a few percent in river Ätran to between 10 and 40% in the river Nissan. In total, it is estimated that from the releases of 600,000 delayed release salmon and 208,000 coastal released salmon 1,090 (95% C.L.: 506 – 1984) salmon entered into four rivers on the Swedish west coast (Göta: 539, Ätran: 216, Nissan: 216 and Lagan: 108).

Straying occurred from all release localities and it is concluded that straying occurred, at a rate varying with time.

4.8 Summary of status of wild populations and situation in potential and index rivers

Wild smolt production versus the carrying capacity (smolt production capacity) is one of the ultimate measures of management success. Of the rivers with wild populations flowing into the Gulf of Bothnia and the Main Basin, wild smolt abundance is however measured directly only in the index rivers Simojoki and Tornionjoki/Torne älv (Gulf of Bothnia) and in the Latvian river Salaca (Main Basin, Gulf of Riga) (Table 4.1.1). Smolt runs have been occasionally directly measured also in two Finnish potential rivers (Kiiminkijoki, Pyhäjoki), where the results mostly reveal the success of juvenile releases up to smolt stage. The smolt abundance model (section 4.2.3), which utilises all available juvenile abundance data, is a rigorous tool for formal assessment of smolt production. So far the model has been applied to most of the Gulf of Bothnia rivers, but is planned to be extended also to other Baltic rivers, if possible. Meanwhile, a range of methods is used to estimate wild smolt production, resulting in some difficulties to compare rivers and also differences in assessing uncertainty connected to the estimates. Also the methods for estimation of carrying capacity vary between the rivers and the working group has repeatedly expressed its concern about the accuracy of these estimates. It is therefore important not only to compare smolt production estimates against estimates of the carrying capacity, but also other available riverine monitoring data for thorough review of the status of wild populations.

An overwiew of the development of the estimated smolt production in rivers in the Gulf of Bothnia is shown in Figure 4.2.3.2 and in all Baltic rivers in Table 4.2.3.1. There are a number of rivers where the population status is far below the management target level with high certainty, and are predicted to stay below the target also within the next 1-2 years. However, differences in the status of the wild stocks have become more apparent in recent years than before – not only in terms of the smolt production target, but also in terms of the trends in various indices of abundance.

The working group has been able to review larger monitoring data sets from the potential rivers than before. Apparent increase in wild reproduction has been documented in at least one of the rivers, but most of the potential rivers show only minuscule flickering wild reproduction in spite of even massive stocking programmes and other rebuilding efforts. Several problems in various phases of salmon‘s life cycle may adversely affect restoration measures, but their relative importance is difficult to assess. A more thorough analysis, e.g., comparing more and less successful cases of restoration is needed.

Rivers in the Gulf of Bothnia (assessment units 1-3)

The parr production in the hatching years of 1992-1996 was as low as in the 1980s (Tables 4.2.1.1, 4.2.1.5, 4.2.1.9, 4.2.1.10 and Figures 4.2.1.2, 4.2.1.5, 4.2.1.10), although the spawning run was larger (Tables 4.2.1.3, 4.2.1.8 and Figures 4.2.1.4, 4.2.1.8 and 4.2.1.9). In those years the M74 syndrome caused a high mortality (Table 4.5.1 and Figure 4.5.2), which decreased parr production considerably. In the hatching years 1997-1999, parr densities increased to higher levels, or about five to ten times higher than in the earlier years and in fact the highest levels ever recorded in some rivers. These high parr year-classes were caused by large spawning runs in 1996-1997 and a simultaneous decrease in the general level of M74. The large parr year-classes hatching in 1997-1998 resulted in higher smolt runs in 2000 and 2001 (Tables 4.2.1.2, 4.2.1.6, 4.2.3.1 and Figures 4.2.1.3, 4.2.1.6, 4.2.3.1, 4.2.3.2). In spite of some reduction on the general level of parr production during the years 1999-2002, parr densities and subsequent smolt runs have stayed on elevated level compared to the situation prevailing before the late 1990s. In 2003, densities of one-summer old parr increased in some rivers back to the peak level observed around 1998, while no similar increase was observed in other rivers. Catch statistics and fish ladder counts indicate differences in the development of the number of spawning migrants among rivers since the late 1990s (Tables 4.2.1.3, 4.2.1.7, 4.2.1.8 and Figures 4.2.1.1, 4.2.1.4, 4.2.1.7, 4.2.1.8, 4.2.1.9). Differences in the indices of abundance might be partly connected to extreme summer conditions in the rivers in 2002-2003 (see section 4.1.1). The number of salmon observed in most of the fish ladders has been higher than ever before in last three years. Meanwhile, catches in most of the rivers have decreased. Whatever the actual development in spawning runs has been, most of the Gulf of Bothnia rivers have shown increasing trends in the most recent juvenile production. The rest of the rivers (Ljungan, Åbyälven, Rickleån) have either shown slight decrease or steady development. Two these rivers are also on the lowest smolt production level when compared to the target level of at least 50 % of carrying capacity (Figure 4.2.3.3). Common to the three rivers (Ljungan, Lögdeälven, Rickleån) with lowest current production compared to the carrying capacity is that they are among the smallest salmon rivers in the Gulf of Bothnia and they are located on the Swedish coast close to the Quark area (northern Bothnian Sea, southern Bothnian Bay). They belong to assessment units 2 and 3. The recent very low level of M74 mortality has probably enabled positive development of the status of most populations.

Rivers in the Main Basin (assessment units 4-5)

The status of the Swedish salmon populations in the rivers Mörrumsån and Emån in the Main Basin differs, but they both show declining long-term trend. The outbreak of M74 mortality in early 1990s decreased smolt production in mid-1990s. After that the smolt production was estimated to somewhat increase till the turn of the century. However, parr and smolt production has turned to decrease again and the most recent parr year class in the river Mörrumsån is especially weak. When compared to the estimated carrying capacity, the smolt production of the Mörrumsån has stayed above the management target in spite of the decreased status of the population. In the river Emån the smolt production has been long below the threshold level but it depends on that insufficient numbers of salmon enter a fish ladder to reproduction area above the ladder (Tables 4.2.2.1 and 4.2.3.1).

Although no consistent time series of parr and smolt abundance is available from Lithuanian rivers, the latest monitoring results indicate reduction in wild reproduction. In 1997-1999 the parr year classes increased significantly in river Salaca in Latvia. The parr densities decreased about 30 % in 2000 but increased to the 1997-1999 levels again in 2001. In year 2002 the level of older parr increased to an all-time high at about the earliest highest value in 1993. In the 2003 the number of parr in the river Salaca decreased at the same level like in 2001. It seems to be some natural fluctuations in salmon parr production in this river caused on small number of ascending spawners in some years. From 2001 any stocking of hatchery reared salmon was stopped in the river Salaca, therefore number of adult fish may be decreased too. Admittedly, that salmon catches targeting adult salmon decreased in the last decade near river Salaca outlet, seems to be indicated decreasing of number of both wild and artificial origin salmon spawners in the river. Extremly low water level in the autumn of 2002 may be affected an effectiveness of salmon spawning. In the whole, wild salmon spawning success in the autumn of 2002 in the rivers of Latvia was less than average. Among the rivers of the Main Basin, the Pärnu river (assessment unit 5) exhibit the most precarious state of the wild population: in 2000-2002 the annual smolt production was estimated to be only 100 individuals and no wild smolts are assumed to leave the river in 2003-2005. Besides regulation of fisheries, many of the salmon rivers of the Main Basin may need different kinds of restoration and enhancement measures. For instance, in the Pärnu river cleaning of spawning grounds from extra vegetation and silt is planned to be carried out in 2004.

4.9 Genetic stock proportion in monitoring and assessment of Baltic salmon

4.9.1 Estimates of stock proportions in the Finnish Baltic salmon catches based on DNA microsatellite information

Genetic differences among Atlantic salmon stocks have been used to estimate and stock group (Table 4.9.1) proportions for Finnish catches. At present, a 9-loci microsatellite baseline database of 27 Baltic salmon stocks is available. Proportions of individual stocks and 7 from the management point of view important stock groups (Table 4.9.1) were assessed in six Finnish Baltic salmon catch samples of 2003. Genetic catch samples from Gulf of Bothnia and Gulf of Finland were drawn from total Finnish scale sample, and numbers of fish sampled were in proportion to the daily catches stratified by fish age composition, in order that the microsatellite samples would be representative of the age composition of the total catch and of the whole fishing season. Scales of the selected fish were used for the DNA-analysis. Sample from the Baltic Main Basin was taken in three random days during the year. Proportion estimates for over three years (2000, 2002, and 2003) are presented in Figure 4.9.1. Estimates from years 2002 and 2003 are results from the Finnish EU-sampling programme, and samples of 2000 were analysed with national funding. In general the 95% confidence level estimated from the posterior distribution was about ± 10% for the group estimates, which is sufficient for management purposes. Results are given as probabilistic posterior distributions. This information can also be used in the assessment model.

Gulf of Bothnia – Baltic Main Basin system. In the Gulf of Bothnia Baltic salmon catches are composed of three major units: Gulf of Bothnia wild fish and Finnish and Swedish hatchery fish. The proportion of other stock groups was less than 2%. The proportion of wild fish has had an increasing trend since 2000. In 2003 already over half of the catch was comprised of wild fish in the Åland Sea (76%), Bothnian Sea (76%) and Baltic Main Basin catches (61%). In the Bothnian Bay close to half (51%) of the catch was from wild fish. The decreasing trend in the relative proportions seemed to be stronger in the proportion of Swedish than in Finnish hatchery stocks in Finnish catches the Gulf of Bothnia area, however, in the Main Basin catches Swedish hatchery stocks made a larger proportion (Swedish: 24%, Finnish: 6%, Fig 4.9.1).

Gulf of Finland. In the Gulf of Finland the composition of catches was more diverse than in the Gulf of Bothnia and the stock composition was different for eastern and western part of the Gulf. In contrast to earlier assumptions and the data from 2002, both wild and hatchery fish originating from the Bothnian Bay rivers occurred also in the eastern Gulf of Finland catch, the proportion of this wild fish being as high as 36%. No wild fish originating from the wild stocks of Gulf of Finland could be observed in the eastern part of the Gulf. Half of the catch (51%) was, however, still from Finnish hatchery releases in these coastal trap-net catches. In the western part of the Gulf of Finland all seven stock groups could be observed. There were wild fish from both Gulf of Bothnia (13%) and from the Gulf of Finland (4%, Estonian wild stocks). A clear change to the situation in the earlier year could be seen, when the proportion of Gulf of Finland hatchery stocks had decreased from 53% to 31%. The proportion of stocks originating from the western Main Basin was the highest (41%).

4.9.2 Justifications of genetic stock proportion estimation in monitoring Baltic salmon mixed-stock fisheries

Sustainable use of fish resources means that all productive stocks should remain viable, despite the fisheries. The fisheries should be managed to allow adequate escapement of all individual stocks to ensure the continuing reproductive success of each stock. Mixed harvesting of populations is known to lead easily to the extirpation of minor stocks through high harvest rates and due to the unequal productivity of rivers. Sustainable fisheries management requires achieving a proper balance between sufficient protection of weak stocks and effective harvest of strong stocks. Information on spatial and temporal variations in stock composition in mixed-stock fisheries is therefore essential for effective fisheries management and conservation (Begg et al., 1999; Shaklee et al., 1999). In most of the Baltic Sea salmon fisheries, fish are caught in mixtures of stocks and also in mixtures of wild and hatchery stocks. There are different management goals and the needs to manage wild and hatchery-reared fish with different intensities, or with different harvest strategies. It is important in which fisheries, and in which amounts the wild fish stocks are exploited. Stock or management group specific harvest strategies are needed for resource management, for dividing fish resources and fishing rights between nations and other potential user groups. Tools are required to determine the contribution of individual stocks and management units to mixed fishery catches. Genetic differences among fish stocks can be used for estimating stock proportions in addition to the commonly used visual scale reading or Carlin-tags.

The advantages of using genetic data over external tags are: no costs associated with actual tagging, no loss of tags, and no need to consider possible effects on the viability and catchability of the fish of the external tags. Moreover, all fish are genetically "tagged" for life, which enables studies to be conducted on fishes that cannot be tagged by other methods, e.g. wild fish in remote areas or newly hatched fish in releasing programmes. By using genetic stock identification, the time and place of sampling can be chosen more freely and precisely than with external tagging, as they are not dependent on preceding tag and release programmes. There is also no need to consider changes in the tag returning probability. Genetic data can also be combined with non- genetic data (for ex. scale characteristics and, smolt age, parasite loads). Genetic stock structure information can also be used in practical fisheries management for defining management units based on genetic similarities between stocks (Koljonen et al., 1999; Koljonen 2001). For example, it is possible to estimate the proportions of wild fish in Gulf of Finland catches, originating from the Gulf of Bothnia and Gulf of Finland separately. In addition it is possible to estimate the national contributions of hatchery-reared salmon in different fisheries, for example the proportions of hatchery fish originating from Sweden and Finland separately. Most hatchery-reared salmon have had two smolt years while wild salmon show a much wider distribution of smolt years. This means that the origin (wild/reared) of a two-year-old smolt is very uncertain compared to smolts at other ages. Estimation based on genetic information does not suffer from this kind of age-specific difference in uncertainty. In addition, genetic methods can be standardised and in principle can be the same for all Baltic salmon countries.

The stock group proportion estimates are expressed in terms of probability distributions (Pella and Masuda 2001), which can be included into the assessment model. However, the direct information of stock proportions in the catch is already valuable as such by telling about the migration behaviour of the stocks and about the occurrence and proportions of river stocks and management units in different fisheries.

Recently the analysis of DNA variation has greatly increased the amount of genetic information available for stock identification. For Baltic salmon the amount of variation in DNA-microsatellite loci is about ten times higher than in previously used allozyme loci (Koljonen and McKinnell 1996, Koljonen and Pella 1997, Koljonen et al 2002.). Genetic stock identification method can be used for estimating stock proportions in Atlantic salmon catches in the Baltic Sea. With a baseline data set of 27 potentially contributing stocks and 9 DNA microsatellite loci, it is possible to analyse the proportions of the management point of view important stock groups, with high accuracy and precision.

In test runs of extra test samples not included in the baseline data there was 3% underestimation of Neva salmon and 9% underestimation of Tornionjoki wild stock from the 100% proportion. The maximum range for the 95% posterior distribution (confidence interval) was 76.4+12% for Gulf of Bothnia wild group. According to test runs it seems that almost all stocks can be identified individually. At least all six planned assessment units could be accurately identified in MSA

4.9.3 Using genetic stock proportion estimates for the assessment of Baltic salmon

Within the Baltic Sea area, the information on wild Baltic salmon through external tagging data is limited. Between 1987 and 1998, 7283 wild smolts have been tagged and released. During the next 4 years, the total number of wild tagged salmon have been increased to 17 800. However, compared to the 815,000 hatchery-reared salmon stocked in the Baltic Sea area, the information on wild Baltic salmon obtained through external tagging is limited. In addition, the data from wild tagged salmon is geographically weighted. Only wild salmon from the river Tornionjoki and the river Simojoki, located in the north-eastern rim of the Gulf of Bothnia, have been tagged. In order to compensate for the limited data on wild Baltic salmon, the current assessment methodology relies on key assumptions about the similarities/differences between wild and hatchery-reared salmon stocks in order to obtain reliable estimates of the exploitation rates of the wild salmon stocks (e.g. the homing rate of wild grilse is lower than that of hatchery-reared salmon due to the slower growth rate, the post-smolt mortality rate of hatchery-reared salmon is higher than that of wild fish, etc.). These assumptions allow the use of the information contained in the tagging data of hatchery-reared salmon for the assessment of wild salmon stocks. However, in order to update the prior beliefs about these linkages, more empirical evidence is needed. Such evidence could be obtained by comparing the proportions of smolts coming from different rivers to proportions of those fish found in the catch.

In addition, during the last few years no external tagging data have been available for Swedish salmon stocks. The temporary abundance of Swedish tagging data, and the evident decrease of the tag-reporting rate of Swedish fishermen are jeopardising the quality of the external tagging data. The genetic tagging data would therefore be a more reliable source of information about mortalities at sea then the external tagging data during current years.

Because of the lack of recent tagging data, the use of genetic stock proportion estimates is therefore a necessary data source to be used within the assessment methodology. The genetic information in combination with the external tags would improve the estimation of the exploitation rate of wild salmon from the river Tornionjoki or Simojoki salmon stocks. Within this methodology, the genetic stock proportion estimates of salmon from the river Tornionjoki or Simojoki could be used to estimate the number of wild salmon from these stocks captured by the different fisheries. Using the analogy with external tags, the estimated number of wild salmon caught by the fisheries can be regarded as the tag recoveries while the estimated number of wild smolts produced by the salmon stocks can be regarded as the number of released tagged salmon. The main uncertainties when using genetic stock proportion estimates are likely to stem from the uncertainty in the number of wild salmon smolts produced by the salmon stocks and the uncertainty in the representativeness of the catch sample to be used for genetic stock proportion estimation to the total salmon catch of different fisheries. In order to improve the representativeness of the catch sample used for genetic stock proportion estimation, it is important to have catch samples from the different fisheries and from different countries as well as to standardise genetic methods, leading to the international co-ordination of the sampling and analysis of genetic information for stock proportion purposes.

In addition to improving the assessment of wild salmon stocks of the river Tornionjoki and Simojoki, the genetic stock proportion estimates could also be used to improve the estimation of the abundance and exploitation of smaller wild salmon stocks. The river specific wild smolt production estimates in combination with the exploitation estimates for the assessment unit in which they are located, could result in a stock-specific assessment of management objectives.

Using separate catch proportion estimates of wild and hatchery-reared salmon, obtained from genetic stock proportion estimation, can reduce the uncertainty in the estimates of exploitation rates and abundances of these wild salmon stocks. Reduced uncertainty in the stock assessment would result in reduced uncertainty in the resulting advice. Stock proportion estimates would therefore help the decision making process both through the genetic catch proportions as such as well as through the improved stock assessment and resulting advice.

The detailed description on how the results of the genetic stock proportion estimation will be used in future in the assessment methodology of the Baltic Salmon is in Section 6.6.2.

4.9.4 International coordination

Genetic stock composition methodology is available to all Baltic Sea countries. The dataset of control samples used for stock composition estimation, the multilocus genotype baseline, is at present available in Finland (Finnish Game and Fisheries Research Institute). Finland will take the responsibility of updating the common baseline so that all countries will have equal possibilities to use commonly collected and updated dataset of river stocks. Readiness for DNA analysis also exists in Sweden (Institute of Freshwater Research), Denmark (Danish Institute for Fisheries Research) and Estonia (Estonian Agricultural University). Cooperation among these Institutes already exists. Sweden will start standardising of DNA methodology and running of test samples in year 2004.

4.9.5 EU national data collection programmes

The present objective of the Baltic salmon management is to safeguard the wild salmon stocks and their genetic diversity by increasing the smolt production of each stock to at least 50 % of the maximum. By this definition, there is a need to monitor all stock components, and to develop the sea management system so, that also the least resilient salmon stocks will survive in the long run. The river monitoring (e.g. parr and smolt abundances) is an effective way to assess the relative changes in stock specific production rates. However, in addition to this, appropriate monitoring tools are needed at sea to permit the investigation of fishery and region specific stock composition of catches to enable the planning of more stock specific management actions.

The current development of stock assessment methodology enables the integration of stock composition data making the genetic identification an important element of the Baltic salmon stock assessments.

Genetic stock identification has been part of Finnish EU data collection national programme implemented within the framework of the Council Regulation (EC) No 1543/2000 and the Commission Regulation (EC) No 1639/2001 2002-2004. In 2003 a Subgroup on Research Need (SGRN) of the STECF gave an evaluation report in which they recommended genetic stock identification to be continued in 2004, because ICES recommended that the monitoring of Baltic salmon stock composition by genetic methodology should be done. However, SGRN stressed the fact the inclusion in the future of the DNA analysis in the national programmes should be confirmed by the results of the ICES Workshop that will take place in connection with the WGBAST meeting in 2004.

The WGBAST reviewed the presently used genetic stock proportion estimation method and approach with the help from geneticists working with the Baltic salmon in Russia, Estonia, Latvia, Sweden and Finland. The geneticists found the technique appropriate and the approach acceptable. Several advantages support the using of stock proportion estimates as a part of in the Baltic salmon stock assessment methodology. The Working Group recommends that the genetic stock proportion analysis will be continued and be expanded in the Baltic Sea salmon fisheries. All significant mixed stock salmon fisheries should be sampled and stock proportion should be analysed if possible.

4.10 Proportion of wild salmon in scale readings and genetical studies of catch samples

Sampling of commercial catches as a part of the EG data collection programme was started in 2002. Its aim is an estimate of the proportion of fish of different age and the proportion of fish of wild and reared origin. In general only wild salmon originating from the Gulf of Bothnia area are distinguished from reared salmon by this method. In 2003, samples were collected during all seasons and from several parts of the sea and coastal fishery. Results of scale readings is given in Table 4.10.1. The proportion of wild fish during two years of sampling varied between 13 % from a sample of the finnish fishery in the Gulf of Finland and 63 % from a sample of the fishery around Åland Islands. Despite of this variability, the average of all samples were quite similar between 2002 and 2003.

The proportions of wild fish by both genetical and scale samples are given in Table 4.10.2. Results obtained by the two methods are very consistent. In all parts of the Baltic sea, the increase of the share of wild fish in 2003 in comparasion with 2002 was evident and everywhere, except in the Gulf of Finland, exceeded 50 %. The proportion of wild salmon in the catch has increased since 1998 which is consistent with higher smolt production. This change in the relationship may be based on the poor survival of reared salmon (the tag return rates during the last years is the lowest observed) and a relatively lower decrease in the wils salmon survival, or in the increase of wild salmon only. The high proportion of wild salmon leads to high proportions of returning salmon that enters the rivers and not as much reared salmon surplus in the terminal areas as assumed earlier.

Table 4.1.1 Index rivers for wild salmon in the Baltic area appointed by IBSFC and present national plans for monitoring.

Country	Sub-div.	River	Electrof. survey	Count of smolts	Count of spawners	Egg dep.	Catch statistics	Tagging of smolts	Age structure smolts and/or adults
Finland	31	Simojoki	X	X			X	X	X
Finland/	31	Tornionjoki-	X	X			X	X	X
Sweden		Torne älv	X				X		
Sweden	31	Ume/Vindelälven	X		X	X	X		X
Sweden	31	Sävarån*	X	X*	X*	X*	X	X*	X*
Sweden	25	Mörrumsån	X				X		
Estonia	28	Pärnu	X						
Latvia	28	Salaca	X	X				X	X
Lithuania	26	Nemunas/Minija	X	X					
Lithuania	26	Nemunas/Zeimena	X	X					
Estonia	32	Kunda	X						
Estonia	32	Keila	X						
Russia	32	Luga **	X	X					

X = the element is carried out, empty area indicate that it is missing.
*) Planned monitoring to be started by 2005-2006.
** Luga is a mixed river.

Table 4.2.1.1 Electrofishing results from the River Simojoki (assessment unit 1). No sampling was carried out in 1992 because of summer flood. The size of a sampling site has usually been 100-500 m^2.

	Number of parr /100 m^2					
	Age 0+	Age 1+	Age >1+	Age >+0 (sum of 2 previous columns)	Sites with 0+ parr	Nr of sites
1970's				5-10*)		tot. 80
1982	4.31	****)	****)	1.65	50%	14
1983	0.83	****)	****)	2.86	57%	14
1984	0.59	****)	****)	2.73	44%	16
1985	0.11	****)	****)	1.08	8%	16
1986	0.21	****)	****)	0.58	19%	16
1987	0.82	****)	****)	0.81	27%	22
1988	2.23	2.55	0.27	2.81	36%	22
1989	2.57	1.27	0.38	1.65	41%	22
1990	1.90	1.93	0.62	2.55	36%	25
1991	4.05	1.92	0.71	2.64	32%	28
1992 **)						
1993	0.09	0.38	0.95	1.34	19%	27
1994	0.43	0.53	0.58	1.11	16%	32
1995	0.73	0.35	0.14	0.49	31%	29
1996	2.31	****)	****)	0.76	28%	29
1997	12.12	1.53	0.32	1.85	72%	29
1998***)	11.32	3.83	0.51	4.34	100%	17
1999	23.11	11.50	2.66	14.17	93%	28
2000	17.36	13.40	3.25	16.65	93%	27
2001	9.74	7.90	3.58	11.49	72%	29
2002	16.07	9.10	3.59	12.70	80%	30
2003	21.89	5.85	1.56	7.41	90%	29

*) All ages included.
**) No sampling was carried out in 1992 because of a summer flood.
***) Because of high water level only a part of rapids could be fished.
****) No age data of older parr available

Table 4.2.1.2 Smolt production in the River Simojoki (assessment unit 1) estimated by smolt trapping (mark-recapture method), and by a Bayesian regression model using both smolt trapping and electrofishing data. The coefficient of variation (CV) of the mark-recapture estimates has been assumed to be 40%, whilst the CV of the Bayesian estimates are derived by the model (see section 4.2.3). The prior median from smolt trapping is calculated based on the CV and assumption, that the original estimate reflects the modal value of a log-normal distribution; these values can be compared with the posterior median values of the Bayesian model. There are no Bayesian estimates of the smolt run of reared origin.

	Wild origin				Reared origin
	Smolt trapping, original estimate	Smolt trapping, prior median	Bayesian model, posterior median	Bayesian model, posterior CV	Smolt trapping, original estimate
1977	29,000	33,640	***)	***)	0
1978	67,000	77,720	***)	***)	0
1979	12,000	13,920	***)	***)	0
1980	14,000	16,240	***)	***)	0
1981	15,000	17,400	***)	***)	0
1982			***)	***)	
1983			2,990	315%	
1984	19,000	22,040	26,840	37%	600
1985	13,000	15,080	16,360	33%	4,400
1986	2,200	2,552	3,785	36%	3,300
1987	1,800	2,088	2,535	36%	3,200
1988	1,500	1,740	2,238	36%	6,000
1989	12,000	13,920	13,070	31%	60,000
1990	12,000	13,920	12,680	30%	43,000
1991	7,000	8,120	10,790	29%	74,000
1992	17,000	19,720	16,640	29%	19,000
1993	9,000	10,440	14,270	31%	16,000
1994	12,400	14,384	11,850	34%	22,500
1995	1,400	1,624	2,586	36%	69,000
1996	1,300	1,508	1,927	35%	174,000
1997	2,450	2,842	3,370	34%	109,000
1998	9,400	10,904	10,310	31%	77,700
1999	8,960	10,394	18,900	29%	47,500
2000	57,300	66,468	61,550	24%	76,500
2001	47,300	54,868	77,640	21%	55,000
2002	53,700	62,292	69,080	22%	42,300
2003	63,700	73,892	65,970	22%	23,300
2004			52,000	29%	
2005			77,070	45%	

***) estimates are not provided, because the used electrofishing data starts from the year 1982, thus it effectively updates smolt production estimates of 1983 and onwards.

Table 4.2.1.3 River catches (in kg) and Finnish CPUE of the trolling in the River Tornionjoki, assessment unit 1.

Year	Finland, total catches	Sweden, index catches 1)	Sweden, total catches 2)	Finland and Sweden, total catches	CPUE (g/day) of trolling, Finland
1974	7950	4900			
1975	3750	2700			
1976	3300	1500			
1977	4800	2100			
1978	4050	2300			
1979	5850	2200			
1980	11250	3100	7500	18750	
1981	3630	1000	2500	6130	
1982	2900	600	1600	4500	
1983	4400	1700	4300	8700	9
1984	3700	2000	5000	8700	8
1985	1500	1600	4000	5500	14
1986	2100	1200	3000	5100	65
1987	2000	900	2200	4200	33
1988	1800	900	2200	4000	42
1989	6200	1400	3700	9900	65
1990	8800	3100	8800	17600	113
1991	12500	2000	4900	17400	106
1992	20100	2600	6500	26600	117
1993	12400	2170	5400	17800	100
1994	9000	1294	5200	14200	97
1995	6100	1144	2900	9000	115
1996	39800	4276	12800	57600*	561[3)]/736[4)]
1997	64000	3440	10300	74300	1094
1998	39000	4180	10500	49500	508
1999	16200	3105	7760	27760	350
2000	20500	2914	7285	27785	485
2001	17500	2318	5795	23295	327
2002	12400	1895	4738	17138	300
2003	11300	1371	3427	14727	320

1) Index catches represent catches of some fishermen interviewed annually.
2) Index catches has converted to total catch estimates (starting in 1980) on the basis of the total catch estimates compiled in 1983,1993 and 1998.
3) Calculated on the basis of a fishing questionnaire similar to years before 1996.
4) Calculated on the basis of a new kind of fishing questionnaire, which is addressed to fishermen, who have bought a salmon rod fishing license.
*) 5 tonnes of illegal/unreported catch has included in total estimate.

Table 4.2.1.4 The age and sex composition of ascending salmon in the Finnish river fishery in the river Tornionjoki since the mid-1970s.

	1974-85	1986-90	1991-95	1996-2000	2001	2002	2003
N:o of samples	728	283	734	2114	505	355	244
A1 (Grilse)	9%	53%	35%	7%	33%	21%	18%
A2	60%	31%	38%	59%	51%	64%	34%
A3	29%	13%	24%	28%	12%	13%	40%
A4	2%	2%	3%	4%	2%	1%	7%
>A4	0%	1%	<1 %	2%	2%	2%	2%
Females, proportion of biomass	About 45 %	49%	75%	71%	64%	67%	77%
Reared origin, proportion of	7%	46 %*	18%	15%	21%	7%	9%

* An unusually large part of these salmon were not fin-clipped but analysed as reared on the basis of scales (probably strayers). A bulk of these was caught in 1989 as grilse.

Table 4.2.1.5 Electrofishing results concerning the wild parr production in the River Tornionjoki (assessment unit 1). Densities in 1960's and 1976-1984 are based on Swedish data. After that the results are based on combined Swedish and Finnish data.

	Number of parr /100 m^2		Number of sites	Sites with 0+ parr
	Age 0+ parr	Age 1+ & older pa		
Potential		10-15		
1960's		3-11		
1976-1984		0.4-2.8		
1986	0.22	0.75	33	
1987	0.35	0.62	31	
1988	0.63	1.01	48	46%
1989	0.94	1.29	36	47%
1990	0.58	1.25	76	40%
1991	2.74	1.67	80	69%
1992	0.27	3.42	38	16%
1993	0.54	1.31	64	44%
1994	0.95	1.90	99	43%
1995	0.52	1.89	73	48%
1996	1.02	0.99	73	39%
1997	7.67	1.85	100	78%
1998	15.64	5.35	96	92%
1999	8.76	11.90	105	85%
2000	7.41	12.12	100	83%
2001	6.72	7.55	101	78%
2002	7.57	9.72	101	78%
2003	16.09	7.08	100	81%

Table 4.2.1.6 Smolt production in the River Tornionjoki (assessment unit 1) estimated by smolt trapping, and by a Bayesian regression model using both smolt trapping and electrofishing data. The coefficient of variation (CV) of the trapping estimates has been derived from the mark-recapture model (Mäntyniemi and Romakkaniemi 2002) since 1999, but assumed to be 40% during the years before 1999. For these years, the prior median from smolt trapping is calculated based on the CV and assumption, that the original estimate reflects the modal value of a log-normal distribution (see section 4.2.3); these values can be compared with the posterior median values of the Bayesian model. There are no Bayesian estimates of the smolt run of reared origin.

	Wild origin					Reared origin
	Smolt trapping, original estimate	Smolt trapping, prior median	Smolt trapping, prior CV	Bayesian model, posterior median	Bayesian model, posterior CV	Smolt trapping, original estimate
1987	50,000 *)	58,000	40%	***)	***)	50,000
1988	66,000	76,560	40%	***)	***)	43,000
1989			40%	73,880	37%	
1990	63,000	73,080	40%	87,910	22%	98,000
1991	87,000	100,920	40%	99,290	20%	100,000
1992				111,200	21%	75,000
1993	123,000	142,680	40%	185,300	19%	61,000
1994	199,000	230,840	40%	236,600	21%	54,000
1995				146,900	26%	
1996	71,000	82,360	40%	112,800	20%	125,000
1997	50,000 **)	58,000	40%	95,250	21%	92,000
1998	144,000	167,040	40%	116,300	20%	131,000
1999	175,000	203,000	17%	213,600	16%	140,000
2000	500,000	580,000	39%	548,600	15%	97,000
2001	625,000	725,000	33%	724,200	14%	40,000
2002	550,000	638,000	12%	594,400	10%	53,000
2003	750,000	870,000	43%	536,500	14%	34,000
2004				487,100	16%	
2005				680,700	21%	

*) trap was not in use the whole period; value has been adjusted according to assumed proportion of run outside trapping period

**) Most of the reared parr released in 1995 were non-adipose fin clipped and they left the river mainly in 1997. Because the wild and reared production has been distinguished on the basis of adipose fin, the wild production in 1997 is overestimated. This was considered when the production number used by WG was estimated.

***) estimates are not provided, because the used electrofishing data starts from the year 1988, thus it effectively updates smolt production estimates of 1989 and onwards.

Table 4.2.1.7 Salmon catches (kilo), in the rivers Kalix älv and Byske älv (Sub-division 31), in 1981-2003.

	Catch, kilo	
	Kalix älv	Byske älv
1981	4175	531
1982	1710	575
1983	3753	390
1984	2583	687
1985	3775	637
1986	2608	251
1987	2155	415
1988	3033	267
1989	4153	546
1990	9460	2370
1991	5710	1857
1992	7198	1003
1993	7423	2420
1994	0	109
1995	3555	1107
1996	8712	4788
1997	10162	3045
1998	5750	1784
1999	4610	720
2000	5008	1200
2001	6738	1505
2002	10478	892
2003	5600	816

Ban of salmon fishing 1994 in Kalix älv and Byske älv.

Table 4.2.1.8 Numbers of wild salmon in fish ladders in rivers in the Gulf of Bothnia 1973-2003.

Year	Number of salmon								
	Kalix älv		Pite älv		Åby älv		Ume/Vindelälven		Öre älv
	MSW fish	Total	Females	Total	MSW fish	Total	Females	Total	Total
1973				45					
1974				15			716	1583	
1975							193	610	
1976							319	808	
1977							456	1221	
1978							700	1634	
1979							643	2119	11
1980	62	80					449	1254	1
1981	79	161					196	638	8
1982	11	45					139	424	3
1983	132	890					141	401	7
1984							177	443	14
1985				30			330	904	10
1986				28			128	227	2
1987				18			87	246	13
1988				28			256	446	23
1989				19			191	597	13
1990	139	639		130			491	1572	65
1991	122	437		59			189	356	51
1992	288	656	52	115			258	354	63
1993	158	567	14	27			573	1663	54
1994	144	806	18	30			719	1309	39
1995	736	1282	17	66			249	1164	18
1996	2736	3781	66	146	1	1	1271	1939	24
1997	5184	5961	324	658	38	39	1064	1780	51
1998	1525	2459	34	338	12	15	233	1154	30
1999	1515	2044	116	220	10	14	802	2208	52
2000	1398	2519	119	534	11	36	601	3367	
2001	4239	9367	668*	863	44	112	951	5476	
2002	6190	8930	1243*	1378	52	95	2123	6052	
2003	3902	4961		1418	6	21	1112	2557	

*) MSW fish, both male and female.

Kalix älv: The trap catch is a part of the run.
Pite älv: New fishladder built 1992. The trap catch is the entire run.
Åby älv: New fishladder built in 1995. The trap catch is a part of the run.
Ume älv/Vindelälven: The trap catch is the entire run.
Öre älv: The trap catch is a part of the run. The trap was destroyed by high water levels in 2000.

Table 4.2.1.9 Densities of salmon parr in electrofishing surveys in the rivers Torne älv, Kalix älv, Råne älv, Åby älv and Byske älv, Gulf of Bothnia (Sub-division 31), in 1988-2003.

River and year	Number of parr/100 m2			Number of sampling sites
	0+	1+	2+/old	
Torne älv				
1988	0.74	0.75	0.40	12
1989	1.40	1.00	1.00	19
1990	0.93	1.40	0.79	36
1991	3.50	1.40	1,00	42
1992	0.13	4.50	0.90	16
1993	0.32	0.50	3.30	30
1994	1.70	0.47	1.98	40
1995	0.74	1.97	1.12	39
1996	1.60	0.55	1.24	39
1997	8.20	1.80	0.89	41
1998	17.60	6.10	0.76	33
1999	7.50	9.50	4.50	41
2000	7.62	5.88	8.77	42
2001	6.20	3.54	5.44	42
2002	6.71	6.48	4.68	42
2003	16.36	4.94	3.76	42
Kalix älv				
1989	4.00	1.40	2.90	24
1990	5.40	5.70	2.20	16
1991	7.10	2.10	3.50	16
1992	3.20	6.80	4.10	7
1993	0.91	0.46	3.00	22
1994	1.94	0.94	3.41	29
1995	1.17	2.62	1.53	28
1996	2.87	0.83	1.28	27
1997	12.50	2.90	1.20	28
1998	57.2 [1])	11.80	1.87	7
1999	4.11	6.14	4.90	33
2000	6.63	4.75	8.32	30
2001	6.79	5.49	6.87	14
2002	6.43	5.94	3.62	30
2003	46.94	12.51	5.20	30
Råne älv				
1993	0.00	0.04	0.52	12
1994	0.15	0.15	0.22	9
1995	0.06	0.14	0.21	12
1996	0.70	0.48	0.31	10
1997	3.00	0.70	0.80	11
1999	0.83	2.29	2.77	12
2000	1.14	2.00	2.06	12
2001	0.34	0.45	2.36	10
2002	1.57	0.90	1.25	14
2003	4.71	3.34	1.11	14

[1]) Only 9 sites was electrofished 1998 in the upper part of Kalixälven and Ängesån because of high water level.

River and year	Number of parr/100 m2			Number of sampling sites
	0+	1+	2+/old	
Åby älv				
1989	2.40	0.14	1.20	4
1991	5.70	1.90	3.30	3
1992	2.70	2.90	0.14	1
1993	1.10	0.51	4.50	4
1994	1.60	0.52	1.59	5
1995	4.00	1.10	1.60	6
1996	4.01	3.44	1.32	6
1997	4.05	1.99	3.66	6
1999	21.80	6.78	1.75	6
2000	10.94	6.81	4.68	6
2001	9.14	1.79	4.16	4
2002	9.49	1.68	2.05	10
2003	2.93	3.73	0.83	10
Byske älv				
1989	3.90	1.00	1.30	4
1990	3.60	0.35	0.73	4
1991	10.60	3.00	2.00	4
1992	3.40	9.30	2.60	6
1993	0.84	0.85	3.30	4
1994	2.20	0.55	2.26	12
1995	2.84	1.85	1.32	11
1996	8.43	1.69	1.21	13
1997	11.60	4.76	1.53	12
1999	18.60	7.18	4.77	15
2000	11.78	9.67	4.30	12
2001*				
2002	17.33	4.03	2.25	14
2003	33.83	4.89	1.70	15

*) No electrofishing because of high water levels.

Table 4.2.1.10 Densities of salmon parr in electrofishing surveys in the rivers Ume/Vindelälven, Rickleån, Sävarån, Öre älv, Lögde älv and Ljungan, Gulf of Bothnia (Sub-divisions 30-31), in 1986-2003.

River and year	N parr/100 m²		Number of sampling sites
	0+	>0+	
Ume/Vindelälven			
1986	1.13	2.05	15
1989	1.57	1.97	3
1990	0.86	4.37	12
1991	3.42	1.06	6
1993	0.43	0.95	6
1994	0.46	0.88	25
1995	0.44	0.22	19
1996	1.54	0.92	21
1997	8.00	1.80	19
1998	32.4	10.7	6
1999	2.09	16.7	17
2000	6.80	3.80	12
2001	5.00	7.80	18
2002	24.70	14.60	18
2003	36.00	3.70	18
Rickleån			
1988	0.00	0.05	2
1989	0.51	0.0	6
1990	1.03	0.23	7
1991	0.45	0.00	7
1992	0.33	0.05	7
1993	2.44	0.14	8
1994	0.94	1.13	8
1995	0.72	0.22	8
1996	0.00	0.10	7
1997	0.19	0.87	7
1998	3.85	1.19	7
1999	2.61	0.39	7
2000	3.80	3.30	7
2001*			
2002	2.70	2.10	7
2003	1.40	0.31	7
Sävarån			
1989	0.96	0.88	4
1990	2.08	1.84	9
1991	0.23	4.64	7
1992	1.09	2.82	7
1993	2.73	1.83	7
1994	2.24	2.74	6
1995	0.44	0.81	9
1996	11.6	2.04	9
1997	0.40	2.79	9
1998	4.09	2.57	8
1999	0.89	4.03	9
2000	19.20	7.10	4
2001*			
2002	5.26	4.26	8
2003	3.43	4.22	9

River and year	N parr/100 m²		Number of sampling sites
	0+	>0+	
Öreälv			
1988	0.04	0.00	6
1989	0.00	0.01	14
1990	0.00	0.00	8
1991	0.00	0.24	8
1992	0.00	0.19	6
1993	0.00	0.03	13
1994	0.00	0.00	8
1995	0.24	0.03	10
1996	0.50	0.00	10
1997	0.36	0.56	10
1998	1.54	0.32	8
1999	0.49	0.37	10
2000	0.90	0.80	9
2001*			
2002	7.60	1.10	10
2003	5.09	2.51	10
Lögdeälv			
1988	1.40	0.15	4
1989	0.69	0.53	8
1990	2.76	0.46	9
1991	3.16	0.37	8
1992	0.14	0.79	8
1993	0.53	0.79	8
1994	0.42	0.66	8
1995	2.17	1.71	8
1996	2.64	0.87	9
1997	2.59	2.79	8
1998	13.70	3.69	6
1999	5.67	0.48	8
2000	4.80	4.10	7
2001*			
2002	5.01	1.54	7
2003	11.14	3.47	8
Ljungan			
1990	5.50	4.80	3
1991	16.50	0.60	3
1994	6.90	0.20	3
1995	11.90	0.90	3
1996	8.60	6.50	3
1997	16.20	4.30	3
1999	19.90	12.30	3
2000	16.33	9.16	3
2001*			
2002	13.8	3.8	3
2003	13.38	5.31	8

*) No electrofishing because of high water levels.

Table 4.2.1.11 Densities of 0+-parr in the rivers Torne älv, Kalix älv, Åby älv, Byske älv, Ume/Vindelälven, Öre älv and Lögde älv, Gulf of Bothnia (Sub-division 31), in 1976-2003.

Year	Densities of 0+ parr/100 m².							
	Torne älv	Kalix älv	Råne älv	Åby älv	Byske älv	Vindelälven	Öre älv	Lögde älv
1988	0.7			1.5			0.0	1.4
1989	1.4	4.0		2.4	3.9	1.6	0.0	0.7
1990	0.9	5.4			3.6	0.9	0.0	2.8
1991	3.5	7.1		5.7	10.6	3.4	0.0	3.2
1992	0.1	3.2*		2.7	3.4		0.0	0.1
1993	0.3	0.9	0.0	1.1	0.8	0.4	0.0	0.5
1994	1.7	1.9	0.2	1.6	2.2	0.5	0.0	0.4
1995	0.7	1.2	0.1	4.0	2.8	0.4	0.2	2.2
1996	1.6	2.9	0.7	4.0	8.4	1.5	0.5	2.6
1997	8.2	12.5	3.0	4.1	11.6	8.0	0.4	2.6
1998	17.6	57.2*					1.5	13.7
1999	7.5	4.1	0.8	21.8	18.6	2.1	0.5	5.7
2000	7.6	6.6	1.1	10.9	11.8	6.8	0.9	4.8
2001	6.2	6.8	0.3	9.1		5.0		
2002	6.7	6.4	1.5	9.5	17.3	24.7	7.6	5.0
2003	16.4	46.9	4.7	2.5	33.8	36	5.1	11.1

*) Only upper part of the river.

Table 4.2.1.12 Number of wild and reared salmon in the broodstock fishery in the river Ljungan (Sub-division 30), in the years 1990-2003 (wild), and 1996-2003 (reared).

	Broodstock fishery		Broodstock fishery		Sum	Sum	Total
	Wild salmon		Reared salmon				
Year	female	male	female	male	female	male	
1990	0	4			0	4	4
1991	0	3			0	3	3
1992	2	4			2	4	6
1993	0	6			0	6	6
1994	1	2			1	2	3
1995	0	1			0	1	1
1996	0	3	8	0	8	3	11
1997	1	5	13	36	14	41	55
1998	3	1	1	37	4	38	42
1999	3	28	10	149	13	177	190
2000	3	31	11	264	14	295	309
2001	0	5	6	12	6	17	23
2002	0	9	2	32	2	41	43
2003				2		2	2

Table 4.2.2.1 Densities of salmon parr in electrofishing surveys in the rivers Emån and Mörrumsån, Baltic Main Basin (Sub-divisions 25-26), in 1973 (1967)-2003.

River and year	Number of parr / 100 m² 0+	>0+	Number of sampling sites
Mörrumsån			
1973	32	33	
1974	12	21	
1975	77	13	
1976	124	29	
1977	78	57	
1978	145	49	
1979	97	65	
1980	115	60	
1981	56	50	
1982	117	31	
1983	111	74	
1984	70	67	
1985	96	42	
1986	132	39	
1987			
1988			
1989	307	42	11
1990	114	60	11
1991	192	55	11
1992	36	78	11
1993	28	21	11
1994	34	8	11
1995	61	5	11
1996	53	50	11
1997	74	15	14
1998	120	29	9
1999	107	35	9
2000	108	21	9
2001	92	22	9
2002	95	14	9
2003	92	28	9

River and year	Number of parr / 100 m² 0+	>0+	Number of sampling sites
Emån			
1967	52	4	
1980-85	52	8	
1992	49	10	
1993	37	9	2
1994	24	7	2
1995	32	4	4
1996	34	8	4
1997	71	6	4
1998	51	6	2
1999	59	7	4
2000	51	3	4
2001	37	3	4
2002	57	4	4
2003	46	4	7

Table 4.2.2.2 Densities of salmon parr in electrofishing surveys at permanent stations in the river Salaca, Gulf of Riga (Sub-division 28), in 1993-2003.

Year	Number of parr/100 m² 0+	1+/older	Total	Number of stations	Area (m²)
1993	16.7	4.9	21.8	5	641
1994	15.2	2.6	17.8	5	1004
1995	12.8	2.8	15.6	5	757
1996	25.3	0.9	26.2	6	1310
1997	74.4	3.1	77.5	5	600
1998	60.0	2.8	62.8	5	576
1999	68.7	4.0	72.7	5	579
2000	46.3	0.8	47.6	5	762
2001	65.1	4.4	69.5	5	567
2002	40.2	10.3	50.5	6	891
2003	31.5	1.3	32.8	5	684

Table 4.2.2.3 Densities of salmon parr in electrofishing surveys in the rivers Neris, Žeimena, Šventoji Mera and Siesartis in Main Baisn (Sub-divisions 22-29), in 2000-2003.

River	Year and N parr/100 m²			
	2000	2001	2002	2003
Neris	0,25	2,51	0,90	0,27
Žeimena	4,56	1,50	0,66	0,72
Šventoji	1,90	0,25	2,10	0,10
Mera	0,30	0,27	0,08	0,00
Siesartis	1,84	3,70	2,50	0,45

Table 4.2.3.1 Salmon smolt production in Baltic rivers with natural reproduction of salmon in the 1980's and 1990's grouped by assessment units used in modeling. Estimated number (x 1000) of smolts from natural reproduction with the associated uncertainty (coefficient of variation). Estimates of some rivers are based on two methods, the vertical line indicating the change in method and the subsequent change in the type of the point estimates shown. Extention of these time series backwards are made to provide longer time series as results of the modeling; the extension is based on old WGBAST reports and should be regarded as preliminary. The reproduction area and potential production estimates of the Gulf of Bothnia rivers are partly results of the Bayeasian modeling of expert knowledge of Uusitalo et al., and partly updated expert opinions collected during the meeting. Uncertainty associated with some of the estimates of the Main basin and the Gulf of Finland are still missing. Also some of the predictions of the 2004-2005 are not available.

Assessment unit, sub-division, country	Category	Reprod. area (ha, mode)	Potential (*1000)	Wild smolt production (x 1000) 1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Pred 2004	Pred 2005	Method of estimate Pot. prod.	Pres. prod.	Median (1) or mode (2)	Reared smolts 2003
Gulf of Bothnia, Sub-div. 30-31:																										
Finland:																										
Simojoki	wild	254	76	2.54	2.24	13.07	12.68	10.79	16.64	14.27	11.85	2.59	1.93	3.37	10.31	18.9	61.55	77.64	69.08	65.97	52	77.07	1	1	1	70.2
CV		8%	97%	36%	36%	31%	30%	29%	29%	31%	34%	36%	35%	34%	31%	29%	24%	21%	22%	22%	29%	45%				
Kuivajoki	potential	58	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0	0.1	0.1	7	4	2	56.7
CV			27%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%				
Kiiminkijoki	potential	110	40	0	0	0	0	+	+	+	+	+	+	+	+	1	0.1	0.1	0.8	0.8	0.8	0.8	7	4	2	88.5
CV			23%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%				
Pyhäjoki	potential	98	35	0	0	0	0	+	+	+	+	+	+	+	+	+	0.1	0.1	+	0.1	0.1	0.1	7	4	2	71
CV			35%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%				
Finland/Sweden:																										
Tornionjoki;Torne älv	wild	4997	1862	58	77	73.9	87.9	99.3	111.2	185.3	236.6	146.9	112.8	95.3	116.3	213.6	548.6	724.2	594.4	536.5	487.1	680.7	1	1	1	4
CV		14%	112%	40%	40%	37%	22%	20%	21%	19%	21%	26%	20%	21%	20%	16%	15%	14%	10%	14%	16%	21%				
Sweden:																										
Kalix älv	wild	2570	728	39	51	50	198.2	292.4	239.1	374	212.9	177.3	155	95.5	163.9	436.2	528.6	523.3	494.8	438.8	617.3	1462	1	1 (1990-) 4 (-1989)	1 (1990-) 2 (-1989)	0
CV		12%	91%	157%	157%	157%	144%	167%	161%	154%	166%	151%	145%	155%	149%	208%	164%	173%	160%	145%	157%	178%				
Assessment unit 1, total				**341**	**308**	**315**	**268**	**315**	**301**	**483**	**415**	**295**	**239**	**174**	**258**	**479**	**1006**	**1190**	**1051**	**982**	**1012**	**1801**				290.4
CV of total				220%	194%	144%	106%	131%	115%	111%	92%	95%	94%	89%	95%	152%	89%	82%	81%	72%	96%	131%				
Råne älv	wild	384	64			2	2	2	2	2	7.1	2.8	2.2	3.7	7.2	18.3	29.7	29.1	20.3	13.1	23.5	38.5	1	1 (1994-) 4 (-1993)	1 (1994-) 2 (-1993)	0
CV		9%	88%			160%	160%	160%	160%	160%	233%	179%	166%	139%	127%	135%	142%	153%	146%	178%	122%	160%				
Pite älv	wild	425	46			1	1	1	1	1	1	3	3	5	5.6	4.2	5.1	18	11.6	6.8	8.8	7.4	7	5**	2**	0
CV		9%	19%			40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%				
Åby älv	wild	84	20			3	2.4	3.0	5.0	7.0	6.2	2.7	2.7	4.8	6.0	4.7	9.2	14.5	11.0	6.5	7.2	6.1	1	1 (1990-) 4 (1989)	1 (1990-) 2 (1989)	0
CV		12%	117%			305%	253%	200%	372%	369%	292%	346%	420%	331%	452%	323%	310%	408%	551%	438%	465%	384%				
Byske älv	wild	560	199			10	25.5	21.9	36.2	76.4	59.0	26.0	24.9	25.1	46.3	78.4	94.3	115.0	94.9	64.1	76.8	162.1	1	1 (1990-) 4 (1989)	1 (1990-) 2 (1989)	0
CV		9%	127%			192%	202%	175%	235%	229%	157%	153%	186%	274%	214%	223%	207%	230%	179%	231%	181%	277%				
Rickleån	wild	15	7.5			0.1	0.02	0.02	0.02	0.01	0.02	0.1	0.1	0.04	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	1	1	1	0
CV		30%	103%			359%	550%	354%	379%	485%	379%	338%	325%	417%	314%	282%	323%	256%	272%	548%	365%	280%				
Sävarån	wild	21	4.5			0.6	0.6	0.6	0.9	0.6	0.4	0.6	0.3	0.4	1.1	0.8	1.0	1.2	1.5	1.6	1.3	1.9	1	1	1	0
CV		30%	133%			243%	280%	234%	223%	230%	239%	255%	348%	293%	286%	291%	348%	219%	257%	202%	299%	241%				
Ume/Vindelälven	wild	1242	250	40.6	29.8	37.4	65.6	68.3	38.9	44.7	35.2	19.3	11.1	15.1	24.8	141.8	259.6	137.0	169.2	180.6	172.0	339.1	1	1	1	0
CV		17%	142%	169%	1.685617	271%	216%	257%	200%	230%	189%	166%	142%	186%	162%	261%	147%	145%	192%	195%	179%	177%				
Öre älv	wild	105	20	3.0	2.0	1.5	1.2	0.9	0.9	0.8	0.7	0.6	0.6	0.7	1.2	1.2	1.6	1.7	1.9	2.5	3.7	3.8	1	1	1	0
CV		12%	134%	348%	6.203847	469%	262%	283%	285%	334%	249%	235%	278%	280%	225%	338%	269%	228%	332%	220%	204%	268%				
Lögde älv	wild	104	39	1.8	0.9	0.5	0.8	0.6	0.9	1.7	1.1	0.9	1.4	1.4	2.9	3.2	4.3	5.7	4.9	3.8	4.5	6.6	1	1	1	0
CV		13%	120%	424%	4.407753	329%	326%	343%	807%	358%	669%	422%	515%	533%	241%	299%	356%	472%	364%	356%	330%	289%				
Assessment unit 2, total						**149.51**	**91.78**	**76.99**	**78.974**	**113.79**	**106**	**56**	**42**	**44**	**83**	**191**	**375**	**284**	**266**	**220**	**266**	**495**			1	0
CV of total						127%	179%	192%	153%	163%	127%	114%	133%	160%	137%	186%	121%	125%	138%	153%	130%	145%				
Ljungan	mixed	17	5.9					0.7	0.4	0.7	0.5	0.1	0.3	0.9	1.0	1.4	1.9	1.6	1.4	0.7	0.3	0.6	1	1	1	0
CV		35%	91%					218%	232%	214%	282%	268%	220%	177%	169%	189%	168%	169%	176%	225%	232%	208%				

Table 4.2.3.1.(Cont'd)

Assessment unit 3, total						**0.7**	**0.4**	**0.7**	**0.5**	**0.1**	**0.3**	**0.9**	**1.0**	**1.4**	**1.9**	**1.6**	**1.4**	**0.7**	**0.3**	**0.6**				0
CV of total						218%	232%	214%	282%	268%	220%	177%	169%	189%	168%	169%	176%	225%	232%	208%				
Total Gulf of B., Sub-divs.30-30						**469**	**450**	**696**	**584**	**380**	**310**	**250**	**396**	**833**	**1560**	**1642**	**1479**	**1354**	**1460**	**2670**			1	290.4
CV of total						103%	96%	91%	75%	79%	84%	76%	77%	113%	75%	68%	68%	66%	77%	105%				
Total Main B., Sub-divs. 22-29:																								
Sweden:																								
Emån	wild	21.7	15	5	5	5	15	5	4.5	3	2.5	4	3.5	4	5	3	3	3	2.5		7	4**	2**	0
CV			16%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%					
Mörrumsån	wild	44	90	120	120	120	100	90	60	30	35	60	60	76	98	70	67.7	55	75.5		7	4**	2**	0
CV			17%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%					
Assessment unit 4, total				**129.7**	**129.7**	**129.7**	**119.5**	**98.6**	**67.0**	**34.3**	**38.9**	**66.4**	**65.9**	**83.0**	**106.9**	**75.7**	**73.3**	**60.2**	**80.9**				1	0
CV of total				18%	18%	18%	17%	18%	18%	17%	18%	18%	18%	18%	18%	18%	18%	18%	18%					
Estonia																								
Pärnu	wild	3	3.5									3	2	1	0.1	0.1	0.1	0	0	0	3	3, 4	2	0
CV												71%	71%	71%	71%	71%	71%	71%	71%	71%				
Latvia																								
Salaca	wild		30					22	15	15	20	20	29	27	19	29	29	25			7	2	2	0
CV			8%					23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%						
Vitrupe	wild		4					5	5	5	5	5	4	4	4	2	2	2			7	5	2	0
CV			27%					37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%						
Peterupe	wild		5					5	5	5	5	5	4	4	4	2	2	2			7	2, 5	2	0
CV			27%					37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%						
Gauja	mixed		28					17	13	13	14	14	13	13	13	12	15	15			7	2, 5	2	302.1
CV			27%					23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%						
Daugava***	mixed		10					5	5	5	5	5	5	5	5	2	5	2			7	5, 7	2	600.4
CV			27%					37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%						
Irbe	wild		4					10	10	8	7	7	7	7	7	5	5	5			7	5	2	0
CV			27%					37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%						
Venta	mixed		15****					15	15	15	15	12	12	12	12	10	12	10			7	2, 5	2	38.6
CV			27%					27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%						
Saka	wild		8					10	10	10	10	8	7	7	7	2	7	2			7	5	2	0
CV			27%					27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%						
Uzava	wild		4					2	2	2	2	2	1	2	2	2	1	2			7	5	2	0
CV			27%					37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%						
Barta	wild		4					2	2	2	2	2	1	1	1	2	1	2			7	5	2	0
CV			27%					37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%						
Lithuania																								
Nemunas river basin	wild		150					20	20	20	20	20	20	2.2	5	4.2	n/a	n/a			6	3, 4	2	0
CV								10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%						
Assessment unit 5, total												**115.9**	**116.7**	**95.9**	**88.3**	**79.8**	**87.6**	**74.3**					1	941.1
CV of total												9%	9%	10%	10%	11%	11%	11%						
Total Main B., Sub-divs. 22-29												**183.5**	**183.8**	**180.5**	**197.3**	**157.0**	**161.8**	**135.3**					**1**	**941.1**
CV of total												9%	9%	10%	11%	11%	0.1028	0.1021						
Gulf of B.+Main B., Sub-divs. 22-31												**598**	**1022**	**1750**	**1863**	**1654**	**1660**	**1492**					**1**	**1231.5**
CV of total												56%	99%	69%	62%	63%	63%	61%						

Table 4.2.3.1.(Cont'd)

Gulf of Finland, Sub-div. 32:																										
Finland:																										
Kymijoki	mixed	50	100									3	3	4	4	4	4	4	4	4	4	4	7	4	2	285
CV			36%									56%	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%				
Russia:																										
Neva	mixed	20	20									7	7	7	7	7	7	6	6	6			7	6, 8	2	140.7
CV			27%									27%	27%	27%	27%	27%	27%	27%	27%	27%						
Luga	mixed	40	80									4	4	4	4	4	5	2.5	8	7.2			7	6, 8	2	88.7
CV			12%									2%	2%	2%	2%	2%	2%	2%	2%	2%						
Estonia:																										
Kunda	wild	1.5	2.1							+	+	+	+	+	+	+	1.8	0.8	1.5	0.5	0.4	0.05	2	3, 4	2	0
CV										13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%				
Selja	mixed	9	10							+	+	+	+	+	0	0	1.4	0.2	2.2	0	0.1	0	2	3, 4	2	20
CV										71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%				
Loobu	wild	6	6							+	+	+	+	+	+	0	0.3	0.3	0.2	0.04	1.2	0	2	3, 4	2	10
CV										27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%				
Pirita	mixed	10	10							+	+	+	+	+	0	0	0	0.6	0.2	0.3	1.5	0	2	3, 4	2	32
CV										19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%				
Vasalemma	wild	1	1							+	+	+	+	+	+	+	0	0.1	0.1	0.02	0	0	2	3, 4	2	0
CV										42%	42%	42%	42%	42%	42%	42%	42%	42%	42%	42%	42%	42%				
Keila	wild	3.5	4							+	+	+	+	+	+	+	0.3	1.5	0.5	0.2	0	0	2	3, 4	2	0
CV										14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%				
Valgejögi	mixed	1.5	1.7							0	0	0	0	0	0	0	0	0.1	0.2	0	0.1	0.01	2	3, 4	2	15
CV										71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%				
Jägala	mixed	0.3	1.5							0	0	0	0	0	0	0	0	0	0	0	0	0	2	3, 4	2	10
CV										0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%				
Väänа	mixed	3.5	2.5							0	0	0	0	0	0	0	0	0	0.004	0.02	0	0	2	3, 4	2	10
CV										71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%				
Sum of +, Estonia										15	15	7	7	8	6	2									2	
Assessment unit 6 (Sub-div. 32), total												**16.1**	**16.1**	**17.5**	**17.4**	**17.4**	**23.5**	**18.7**	**27.3**	**20.6**					1	611.4
CV of total												20%	20%	22%	22%	22%	18%	20%	17%	18%						
Total Baltic														**617**	**1041**	**1770**	**1889**	**1675**	**1690**	**1492**					**1**	**1842.9**
CV of total														55%	97%	68%	62%	62%	62%	61%						

+ = Low and uncertain production (not added into sub-

++ = Same method over time series; only the extension backwards preliminary

*** = Tributaries

**** = Only Latvian part, Lithuanian part of the river needs to be added

n/a No data available.

Methods of estimating production

Potential production

1. Bayesian modeling of expert knowledge
2. Estimate of reproduction area and production capacity per area.
3. Accessible linear stream length and production capacity per area.
4. Accessible linear stream length and peak production per area from other sources.
5. No data.
6. Not known.
7. Expert opinion with associated uncertainty

Present production

1. Bayesian regression model (see section 4.2.3)
2. Sampling of smolts and estimate of total smolt run size.
3. Estimate of smolt run from parr production by relation developed in the same river.
4. Estimate of smolt run from parr production by relation developed in another river.
5. Inference of smolt production from data derived from similar rivers in the region.
6. Count of spawners.
7. Estimate inferred from stocking of reared fish in the river.
8. Salmon catch, exploitation and survival estimate.

Table 4.3.1.1 Current status of reintroduction programme in Baltic Sea potential salmon rivers.

River	Description of river						Restoration programme					Results of restoration			
	Country	ICES sub-division	Old salmon river	Cause of salmon population extinction	Potential production areas (ha)	Potential smolt production (num.)	Officially selected for reintroduction	Programme initiated	Measures	Releases	Origin of population	Parr and smolt production from releases	Spawners in the river	Wild parr production	Wild smolt production
Kåge älv	SE	31	yes	3,4	39	7700-11600	yes	yes	c,f,j,n	2	Byske älv	yes	yes	>0	>0
Moälven	SE	31	yes	3,4	7	2000	no	yes	c,l	2	Byske älv	yes	yes	0	0
Testeboån	SE	30	yes	1,3	8	2100-4200	yes	yes	a,e,i	2	Dalälven	yes	yes	>0	>0
Alsterån	SE	27	yes	2,3	4	4000	no	no	c,g,l	4	**	**	yes	>0	>0
Helgeån	SE	25	yes	2,3	7	3200	no	yes	c,e,m	2	Mörrumsån	yes	yes	>0	>0
Kuivajoki	FI	31	yes	1,2	58	17000	yes	yes	b,c,e	2	Simojoki	yes	yes	yes	0
Kiiminkijoki	FI	31	yes	1,2	110	40000	yes	yes	b,c,d,e	2	Iijoki	yes	yes	yes	>0
Siikajoki	FI	31	yes	1,2	32	15000	no	yes	b,h	2	mixed	yes	*	0	0
Pyhäjoki	FI	31	yes	1,2	98	39000	yes	yes	b,c,d,e	2	Tornionjoki	yes	no	0	*
Kalajoki	FI	31	yes	1,2	33	13000	no	yes	b,e	1,4		no	*	0	0
Perhonjoki	FI	31	yes	1,2	5	2000	no	yes	b,e	1,4		no	*	0	0
Kyrönjoki	FI	30	yes	2	10	4000	no	no	b	4		no	*	0	0
Merikarvianjoki	FI	30	yes	1,2	8	2000	no	yes	b,e	2	Neva	yes	**	>0	*
Vantaanjoki	FI	32	no?	2	14	7000	no	yes	b,c,f,m	2	Neva	yes	yes	0	0
Kymijoki	FI	32	yes	2,3	38	100000	no	yes	b,c,m	2	Neva	yes	yes	yes	4000
Valgejögi	EE	32	yes	4	15	16000	yes	yes	c,l	2	Neva, Narva	yes	yes	yes	200
Jägala	EE	32	yes	2,4	2	1500	yes	yes	c,e	2	Neva, Narva	no	yes	yes	0
Vääna	EE	32	yes	4	4	5000	yes	yes	a,k	2	Neva, Narva	no	no	yes	yes
Venta	LI	28	yes	*	*	*		*	*	*	*	*	*	*	*
Sventoji	LI	26	no?	*	*	*		*	*	*	*	*	*	*	*
Minija/Veivirzas	LI	26	no?	*	*	*		*	*	*	*	*	*	*	*
Gladyshevka	RU	32	yes	*			no	yes	a,g	2	Narva	yes	*	*	*
Wisla/Drweca	PL	26	yes	1,2,3,4	*	*	no	yes	b,l,m	2	Daugava	*	yes	*	*
Slupia	PL	25	yes	1,2,3,4	*	*	no	yes	b,l,m	2	Daugava	*	yes	*	*
Wieprza	PL	25	yes	1,2,3,4	*	*	no	yes	b,m	2	Daugava	*	yes	*	*
Parseta	PL	25	yes	1,2,4	*	*	no	yes	b,n	2	Daugava	*	yes	*	*
Rega	PL	25	yes	1,2,3,4	*	*	no	yes	b	2	Daugava	*	yes	*	*
Odra/Notec/Drawa	PL	24	yes	1,2,4	*	*	no	yes	b	2	Daugava	*	yes	*	*
Reda	PL	24	yes	1,2,3,4	*	*	no	yes	b	2	Daugava	*	yes	*	*

Cause of extinction
1 Overexploitation
2 Habitat degradation
3 Dam building
4 Pollution

* No data
** Not applicable

Measures

Fisheries
a Total ban of salmon fishery in the river and river mouth
b Seasonal or areal regulation of salmon fishery
c Limited recreational salmon fishery in river mouth or river
d Professional salmon fishery allowed in river mouth or/and river

Habitat restoration
e partial
f completed
g planned
h not needed

Dam removal
i planned
j completed
k not needed

Fish ladder
l planned
m completed
n not needed

Releases
1 Has been carried out, now finished
2 Going on
3 Planned
4 Not planned

Table 4.3.1.2 Densities of salmon parr in electrofishing surveys in the potentials rivers

River and year	Number of parr /100 m² 0+	Number of parr /100 m² >0+	Number of sampling sites
Kågeälven			
1987	0	0	5
1988	0	0	1
1989	0	0	3
1990	0	0	1
1991	0.6	0	4
1992	1.8	0.4	2
1993	0	1.1	5
1994	0	0.3	5
1999	22.2	11.3	26
2000	2.2	2.9	10
2001	14.2	6.8	9
2002	9.8	4.5	26
2003	12.5	1.1	26
Testeboån			
2000	17.6	1	7
2001	32.7	17.2	7
2002	40	14.1	10
2003	16.7	10.6	10
Kuivajoki *			
1999	0	n/a	
2000	0	n/a	8
2001	0.1	n/a	16
2002	0.4	n/a	15
2003	0.9	n/a	
Kiiminkijoki *			
1999	1.2	n/a	
2000	4.8	n/a	31
2001	1.3	n/a	26
2002	0.2	n/a	47
2003	0.3	n/a	

River and year	Number of parr /100 m² 0+	Number of parr /100 m² >0+	Number of sampling sites
Pyhäjoki *			
1999	0.3	n/a	
2000	0.2	n/a	23
2001	0.8	n/a	18
2002	1.8	n/a	20
2003	0	n/a	
Valgejögi			
1999	2.2	0	3
2000	0.4	1	3
2001	4.4	1.6	4
2002	7.1	0	1
2003	0.2	0.8	3
Jägala			
1999	0.5	0	1
2000	0	0	1
2001	16.2	0	1
2002	0	0	1
2003	0	0	1
Vääna			
1999	0	0	4
2000	0.1	0	4
2001	0	0	2
2002	0	0	4
2003	0	0	4

* n/a = reared parr, which are stocked, are not marked; natural parr densities can be monitored only from 0+ parr

Table 4.5.1 The M74 frequency or the mean offspring M74-mortality (in %) of searun female spawners belonging to reared populations of Baltic salmon in hatching years 1985-2003 with projections for year 2004. All data originate from hatcheries.

River	Sub-div	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Simojoki (2)	31		*6*	2	6	*3*	*14*	4	53	74	*53*	92	*86*	91	31	59	44	41	47	7	(6-12)
Torne älv (2)	31				5	6	1	29	70	76	89	76			*25*	*61*	34	41	69	3	0
Lule älv	31								58	66	62	50	52	38	6	34	21	29	37	4	4
Skellefteälven	31								40	49	69	49	77	16	5	42	12	17	19	7	
Ume/Vindelälven	30	40	20	25	19	16	31	45	77	88	90	69	78	37	16	53	45	39	38	15	
Angermanälven	30								50	77	66	46	63	21	4	28	21	25	46	13	
Indalsälven	30	4	7	8	7	3	8	7	45	72	68	41	64	22	1	20	22	6	20	4	
Ljungan	30								64	*96*	*50*	56	28	*29*	10	25	10	0	55	0	
Ljusnan	30							17	33	75	64	56	72	22	9	41	25	46	32	17	
Dalälven	30	28	8	9	20	11	9	21	79	85	56	55	57	38	17	33	20	33	37	13	7
Mörrumsan	25	47	49	65	46	58	72	65	55	90	*80*	63	*56*	23							
Neva/?land (2)	29									70	50										
Neva/Kymijoki (2)	32								45	60-70		57	40	79	42	42	23		43	*11*	*(6-11)*
Mean River Simojoki and Torne Älv			6	2	5.5	4.5	7.5	16.5	61.5	75	71	84	86	91	28	60	39	41	58.0		
Mean River Lule, Indalsälven, Dalälven (5)		16.0	7.5	8.5	13.5	7.0	8.5	14.0	60.7	74.3	62.0	48.7	57.7	32.7	8.0	29.0	21.0	22.7	31.3	7.0	5.5
Mean total		29.8	18.0	21.8	17.2	16.2	22.5	26.9	55.8	76.5	66.4	59.2	61.2	37.8	15.1	39.8	25.2	27.7	40.3	8.5	

1) All estimates known to be based on material from less than 20 females in italics.
2) The estimates in the rivers Simojoki, Tornionjoki/Torne älv and Kymijoki are, if possible, given as the percentage of females affected by M74 and secondly, as the mean percentage of yolk-sac-fry mortality.
3) River Lule älv missing before 1992.
4) In parentheses (year 2004) prognoses based on the thiamine concentration in eggs.

Table 4.5.2 Roe color and number of females used in the Swedish breeding program of of Baltic salmon in 1995 - 1999 (year of stripping) and in the Latvian program for river Daugava in 1993 - 2003.

Roe colour	Yellow (x1)		Pale orange (x2)		Orange (x4)		Dark orange (x6)		Total		
River	Females	Color value	Females	Color value	Females	Color value	Females	Color value	Females	Color value	Mean color
S Sweden - 95	113	113	606	1212	342	1368	37	222	1098	2915	2.65
S Sweden - 96	11	11	489	978	500	2000	49	294	1049	3283	3.13
S Sweden - 97	5	5	298	596	636	2544	92	552	1031	3697	3.59
S Sweden - 98	1	1	276	552	534	2136	109	654	920	3343	3.63
S Sweden - 99	22	22	344	688	531	2124	91	546	988	3380	3.42
S Sweden 1995-1999	152	152	2013	4026	2543	10172	378	2268	5086	16618	3.27
Daugava - 93	0	0	28	56	30	120	2	12	60	188	3.13
Daugava - 94	1	1	35	70	49	196	5	30	90	297	3.30
Daugava - 95	0	0	48	96	148	592	12	72	208	760	3.65
Daugava - 96	0	0	32	64	88	352	35	210	155	626	4.04
Daugava - 97	0	0	12	24	93	372	25	150	130	546	4.20
Daugava - 98	0	0	5	10	75	300	12	72	92	382	4.15
Daugava - 99	0	0	5	10	56	224	14	84	75	318	4.24
Daugava - 2000	0	0	4	8	59	236	27	162	90	406	4.51
Daugava - 2001	0	0	12	24	64	256	23	138	99	418	4.22
Daugava-2002	0	0	5	10	73	292	27	162	105	464	4.42
Daugava-2003	0	0	1	2	48	192	16	96	65	290	4.46
S Daugava - 93-2002	1	1	187	374	783	3132	198	1188	1169	4695	4.02

Table 4.6.1 Production of reared salmon smolts by country in Sub-divisions 22-32 (x1000).

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004 4)
SUB-DIVS. 22-31																		
DENMARK																		
1 yr Hatchery reared	62	60	46	60	13	64	80	0	70	0	103	30	35	72	0	0	14	15
2 yr Hatchery reared	8	10	10	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	70	70	56	72	24	64	80	0	70	0	103	30	35	72	0	0	14	15
EU (6) (7)																		
1 yr Hatchery reared		25	107	60	109	40	0	0	0	7	0	0	0	0	0	0	0	0
2 yr Hatchery reared (1)		26	192	149	164	124	332	165	2	28	0	0	0	0	0	0	0	0
Total hatchery reared		51	299	209	273	164	332	165	2	35	0	0	0	0	0	0	0	0
Delayed releases (5)		0	0	0	0	276	204	42	193	176	120	120	120	0	0	0	0	0
Total		51	299	209	273	440	536	207	195	211	120	120	120	0	0	0	0	0
FINLAND																		
1 yr Hatchery reared	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 yr Hatchery reared (1)	1683	1966	1584	1103	1186	1279	1237	1146	1520	1419	1406	1645	1433	1679	1630	1618	1435	1400
1 yr river Neva stock (2)	0	0	0	113	100	146	115	73	49	47	0	0	0	0	15	0	0	0
2 yr river Neva stock (2)	577	415	242	345	186	181	225	172	244	256	119	192	228	207	240	136	83	80
Total Hatchery reared	2260	2381	1826	1561	1472	1606	1577	1391	1813	1722	1525	1837	1661	1886	1885	1754	1518	1480
Total (3)	2260	2381	1826	1561	1472	1606	1577	1391	1813	1722	1525	1837	1661	1886	1885	1754	1518	1480
POLAND																		
1 yr Hatchery reared	0	1	0	0	0	0	0	22	129	40	280	458	194	369	230	186	262	221
2 yr Hatchery reared	0	0	0	0	0	0	0	2	107	77	30	80	175	60	24	86	53	80
Total Hatchery reared	0	1	0	0	0	0	0	24	236	117	310	538	369	429	254	272	315	301
Total	0	1	0	0	0	0	0	24	236	117	310	538	369	429	254	272	315	301
SWEDEN																		
1 yr Hatchery reared	117	64	37	28	11	84	160	14	137	73	124	46	56	46	52	85	162	80
2 yr Hatchery reared (1)	2200	2044	1811	1717	1676	1776	2093	1557	1134	1698	1922	1878	1648	1754	1736	1674	1664	1670
Total Hatchery reared	2317	2108	1848	1745	1687	1860	2253	1571	1271	1771	2046	1924	1704	1800	1788	1759	1826	1750
Total	2317	2108	1848	1745	1687	1860	2253	1571	1271	1771	2046	1924	1704	1800	1788	1759	1826	1750
ESTONIA (6)																		
1 yr Hatchery reared			17	18	15	18	15	0	0	0	0	0	0	0	0	0	0	0
2 yr Hatchery reared			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Hatchery reared			17	18	15	18	15	0	0	0	0	0	0	0	0	0	0	0
Total			17	18	15	18	15	0	0	0	0	0	0	0	0	0	0	0
LATVIA																		
1 yr Hatchery reared	686	1015	1145	668	479	580	634	616	793	699	932	902	1100	1060	1069	867	961	860
2 yr Hatchery reared	224	49	39	36	31	34	86	58	33	60	8	49	41	46	0	64	34	60
Total Hatchery reared	910	1064	1184	704	510	614	720	674	826	759	940	951	1141	1106	1069	931	994	920
Total	910	1064	1184	704	510	614	720	674	826	759	940	951	1141	1106	1069	931	994	920
LITHUANIA																		
1 yr Hatchery reared	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	9	0
2 yr Hatchery reared	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	9	0
TOTAL SUB-DIVS. 22-31																		
1 yr Hatchery reared	865	1165	1352	947	727	932	1004	725	1178	866	1439	1436	1396	1547	1366	1138	1398	1176
2 yr Hatchery reared (1)	4692	4510	3878	3362	3254	3394	3973	3100	3040	3538	3485	3844	3525	3746	3630	3578	3268	3290
Total Hatchery reared	5557	5675	5230	4309	3981	4326	4977	3825	4218	4404	4924	5280	4921	5293	4996	4716	4666	4466
Enhancement (9)				80	110	105	188	77	81	161	156	447	471	382	484	602	470	560
Delayed releases (5)						276	204	42	193	176	120	120	120	0	0	0	0	0
Total reared	5557	5675	5230	4389	4091	4707	5369	3944	4492	4741	5200	5847	5512	5675	5480	5318	5136	5026

Table 4.6.1 continued

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004 4)
SUB-DIV. 32																		
ESTONIA																		
1 yr hatchery reared	0	0	0	0	0	0	22	33	0	30	18	52	36	69	129	101	86	85
2 yr hatchery reared	0	1	0	0	0	0	0	0	0	0	29	90	58	35	34	40	35	35
Total hatchery reared	0	1	0	0	0	0	22	33	0	30	47	142	94	104	163	141	121	120
Wild	15	15	15	15	15	15	15	15	7	7	8	6	2	4	4	5	5	5
Total	15	16	15	15	15	15	37	48	7	37	55	148	96	108	166	146	126	125
FINLAND																		
1 yr hatchery reared	141	81	84	50	41	149	80	165	120	124	76	60	109	78	85	89	86	85
2 yr hatchery reared	363	407	265	302	202	203	200	157	270	337	222	293	318	345	394	334.5	264	260
Total hatchery reared	504	488	349	352	243	352	280	322	390	461	298	353	427	423	479	423	350	345
Wild	+	+	+	+	+	+	+	+	3	3	4	4	4	4	4	4	4	4
Total	504	488	349	352	243	352	280	322	393	464	302	357	431	427	483	427	354	349
RUSSIAN FEDERATION																		
1 yr hatchery reared	85	113	81	100	102	13	128	78	124	102	174	85	165	77	103	136	70	70
2 yr hatchery reared	3	2	2	30	0	0	9	22	18	18	6	12	12	41	135	1	107	100
Total hatchery reared	88	115	83	130	102	13	137	100	142	120	180	97	177	118	238	137	177	170
Wild	na	na	na	na	na	na	na	na	11	11	11	11	11	12	8	14	14	14
Total	88	115	83	130	102	13	137	100	153	131	191	108	188	130	246	151	191	184
TOTAL SUB-DIV. 32																		
1 yr hatchery reared	226	194	165	150	143	162	230	276	244	256	268	197	310	224	317	326	242	240
2 yr hatchery reared	366	410	267	332	202	203	209	179	288	355	257	395	388	421	563	376	406	395
Total hatchery reared	592	604	432	482	345	365	439	455	532	611	525	592	698	645	879	702	648	635
Enhancement								25	11	10	5	9	19	28	18	12	40	76
Total reared	592	604	432	482	345	365	439	480	543	621	530	601	717	673	897	714	688	711
TOTAL SUB-DIVS. 22-32																		
1 yr Hatchery reared	1091	1359	1517	1097	870	1094	1234	1001	1422	1122	1707	1633	1706	1771	1683	1464	1640	1416
2 yr Hatchery reared (1)	5058	4920	4145	3694	3456	3597	4182	3279	3328	3893	3742	4239	3913	4167	4193	3954	3674	3685
Total Hatchery reared	6149	6279	5662	4791	4326	4691	5416	4280	4750	5015	5449	5872	5619	5938	5875	5418	5314	5101
Enhancement (9)				80	110	105	188	102	92	171	161	456	490	410	501	614	510	636
Delayed releases (5)						276	204	42	193	176	120	120	120	0	0	0	0	0
Total reared	6149	6279	5662	4871	4436	5072	5808	4424	5035	5362	5730	6448	6229	6348	6377	6031	5825	5737

(1)= 2 years and older.
(2)= River Neva stock releases to the Gulf of Bothnia contribute only to a minor degree to the Main Basin Fisheries.
(3)= Total includes River Neva stock.
(4)= Estimated.
(5)= Delayed releases in normal smolt releases until 1992.
(6)= Data from EU before 1988, Estonia before 1989 and Russia before 1996 are not available.
(7)= Releases paid by EU, independent of country of release.
(8) = see Table 4.2.5.1.
(9)= added from Table 4.6.2.
\+ Minor production exists
na No data available

Table 4.6.2 Release of salmon eggs, alevins, fry and parr to Baltic rivers in 2003.

Sub-division and country	Eyed egg	Alevin	Fry	Parr 1-s old	Parr 1-y old	Parr 2-s old	Smolt in year 2004	2005	2006	Total
Sub-divs. 22-29	(1)	(2)	(3)	(4)	(5)					
Lithuania	0	0	108500	0	0	0	0	3255	1628	4883
Latvia	0	0	0	295000	0	0	0	17700	8850	26550
Poland	0	0	0	220000	0	0	0	13200	6600	19800
Finland	0	0	0	0	0	30500	6100	0	0	6100
Sweden	0	0	0	0	0	0	0	0	0	0
Total	0	0	108500	515000	0	30500	6100	34155	17078	57333
Sub-divs. 30-31	(6)	(7)	(8)	(9)	(10)					
Finland	0	0	0	0	383000	10000	47960	47160	0	95120
Sweden	0	1007400	0	275000	64900	0	7788	24288	18324	50400
Total	0	1007400	0	275000	447900	10000	55748	71448	18324	145520
Total Sub-divs. 22-3	0	1007400	108500	790000	447900	40500	61848	105603	35401.5	202852.5
Sub-div. 32	(1)	(2)	(3)	(4)	(5)	(11)				
Estonia	0	0	0	210000	86100	0	10332	12600	0	22932
Finland	21200	120000	0	0	85600	0	10272	2012	106	12390
Russia	0	0	120000	30000	69900	35400	15468	5400	0	20868
Total	21200	120000	120000	240000	241600	35400	36072	20012	106	56190
Grand total Sub-divs. 22-32	21200	1127400	228500	1030000	689500	75900	97920	125615	35508	259043

Total number of smolts originating from enhancement in 2001-2003

	Year 2004	Year 2005	Year 2006
Sub-divs. 22-31			
Lithuania	12666	11820	1628
Latvia	104967	22566	8850
Finland	59810	48510	0
Poland	98417	51138	6600
Sweden	284217	72672	18324
Total	560077	206705	35402
Sub-div. 32			
Estonia	21060	12600	0
Finland	12002	2112	106
Russia	43122	5400	0
Total	76184	20112	106
Grand Total Sub-divs. 22-32	636261	226817	35508

(1) Rate of survival to smolt 1%. Time to smoltification 2 years.
(2) Rate of survival to smolt 1.5%. Time to smoltification 2 years.
(3) Rate of survival to smolt 3%. Time to smoltification 2 years.
(4) Rate of survival to smolt 6%. Time to smoltification 2 years.
(5) Rate of survival to smolt 12%. Time to smoltfication 1 year.
(6) Rate of survival to smolt 0.5%. Time to smoltification 3 years.
(7) Rate of survival to smolt 1%. Time to smoltification 3 years.
(8) Rate of survival to smolt 2%. Time to smoltification 3 years.
(9) Rate of survival to smolt 6%. Time to smoltification 3 years.
(10) Rate of survival to smolt 12%. Time to smoltification 2 years.
(11) Rate of survival to smolt 20%. Time to smoltification <1year.

Table 4.9.1 Stock group proportions in Finnish Atlantic salmon catch samples in 2003 based on data of 9 DNA microsatellite loci. Samples 1 - 5 proportional to Finnish catches.

1. Åland Islands, 60°10'N, 19°20E. May 22 - June 26, drift net, N = 209.

Origin of stock group	% of catch	SD	2.5%	Median	97.5%	scale reading % wild
1. Gulf of Bothnia, wild	**76.4**	5.6	64.4	76.8	86.4	63.6
2. Gulf of Bothnia, hatchery, Finnish	**16.3**	4.8	8.1	15.9	26.7	
3. Gulf of Bothnia, hatchery, Swedish	6.7	2.9	1.6	6.4	13.1	
4. Gulf of Finland, wild	0.0	0.1	0.0	0.0	0.4	
5. Gulf of Finland, hatchery	0.0	0.1	0.0	0.0	0.2	
6. Western Main Basin, wild, Swedish	0.0	0.1	0.0	0.0	0.4	
7. Eastern Main Basin	0.5	0.5	0.0	0.4	1.9	

2. Bothnian Sea, 62°00'N, 21°15'E. May 20 - September 17, trap-net, N = 218.

Origin of stock group	% of catch	SD	2.5%	Median	97.5%	scale reading % wild
1. Gulf of Bothnia, wild	**75.6**	4.2	66.7	75.8	83.1	64.2
2. Gulf of Bothnia, hatchery, Finnish	**22.9**	4.1	15.6	22.7	31.7	
3. Gulf of Bothnia, hatchery, Swedish	0.3	0.5	0.0	0.1	1.8	
4. Gulf of Finland, wild	0.0	0.1	0.0	0.0	0.4	
5. Gulf of Finland, hatchery	0.1	0.5	0.0	0.0	1.6	
6. Western Main Basin, wild, Swedish	0.1	0.2	0.0	0.0	0.5	
7. Eastern Main Basin	1.0	0.7	0.1	0.9	2.6	

3. Bothnian Bay, 63°45'N, 22°30'E and 65°00'N, 24°30'E.
June 23 - September 1, 2003, trap-net, N = 203.

Stock group	% of catch	SD	2.5%	Median	97.5%	scale reading % wild
1. Gulf of Bothnia, wild	**51.8**	5.4	41.5	51.7	62.5	37.4
2. Gulf of Bothnia, hatchery, Finnish	**38.4**	5.2	28.2	38.4	48.5	
3. Gulf of Bothnia, hatchery, Swedish	9.5	2.7	4.8	9.4	15.3	
4. Gulf of Finland, wild	0.0	0.2	0.0	0.0	0.4	
5. Gulf of Finland, hatchery	0.0	0.1	0.0	0.0	0.2	
6. Western Main Basin, wild, Swedish	0.0	0.1	0.0	0.0	0.4	
7. Eastern Main Basin	0.2	0.4	0.0	0.0	1.4	

4. Gulf of Finland (east), 60°20'N, 27°00E. May 30 - September 25, trap-net, N = 448.

Origin of stock group	% of catch	SD	2.5%	Median	97.5%	scale reading % wild
1. Gulf of Bothnia, wild	**36.3**	3.2	29.9	36.3	42.3	31.5
2. Gulf of Bothnia, hatchery, Finnish	**11.0**	10.3	4.6	9.0	60.3	
3. Gulf of Bothnia, hatchery, Swedish	0.6	0.6	0.0	0.5	2.3	
4. Gulf of Finland, wild	0.1	0.3	0.0	0.0	0.9	
5. Gulf of Finland, hatchery	**51.0**	10.3	0.0	52.9	57.6	
6. Western Main Basin, wild, Swedish	0.0	0.1	0.0	0.0	0.2	
7. Eastern Main Basin	1.0	0.5	0.3	0.9	2.1	

5. Gulf of Finland (west), 59°40'N, 23°00E. May 20 - December 3, long-line, N = 148.

Origin of stock group	% of catch	SD	2.5%	Median	97.5%	scale reading % wild
1. Gulf of Bothnia, wild	**13.5**	3.5	7.1	13.4	20.6	10.1
2. Gulf of Bothnia, hatchery, Finnish	3.2	6.6	0.0	1.4	32.1	
3. Gulf of Bothnia, hatchery, Swedish	5.3	2.2	1.7	5.1	10.2	
4. Gulf of Finland, wild	4.1	1.9	1.2	3.9	8.4	
5. Gulf of Finland, hatchery	**31.3**	7.2	0.0	32.3	40.2	
6. Western Main Basin, wild, Swedish	1.4	1.0	0.2	1.2	3.9	
7. Eastern Main Basin	**41.1**	4.1	33.3	41.1	49.3	

6. Baltic Main Basin, 55°15'N, 16°00E. Feb.18, Oct. 3. Nov. 18, drift-net, N = 215.

Origin of stock group	% of catch	SD	2.5%	Median	97.5%	scale reading % wild
1. Gulf of Bothnia, wild	**60,7**	5,3	49,7	60,9	70,7	48,8
2. Gulf of Bothnia, hatchery, Finnish	6,4	3,8	1,6	5,4	15,8	
3. Gulf of Bothnia, hatchery, Swedish	**24,1**	4,2	15,3	24,2	32,2	
4. Gulf of Finland, wild	0,0	0,2	0,0	0,0	0,5	
5. Gulf of Finland, hatchery	0,4	0,5	0,0	0,1	1,9	
6. Western Main Basin, wild, Swedish	5,1	1,6	2,4	5,0	8,7	
7. Eastern Main Basin	3,4	1,2	1,4	3,2	6,1	

Stocks included in the groups in genetic estimates:

1. Gulf of Bothnia Wild: Tornionjoki, W; Simojoki, Kalix, Byske, Vindel, Lögde, Ljungan (7).
2. Gulf of Bothnia hatchery Finnish: Tornionjoki, H; Iijoki, Oulujoki, (Neva) (4).
3. Gulf of Bothnia hatchery Swedish: Lule, Skellefte, Ume, Ångerman, Indals, Ljusnan, Dal (7).
4. Gulf of Finland, wild : Kunda, Keila (2)
5. Gulf of Finland, hatchery: Neva Fi, Neva Rus (2).
6. Western Main Basin: Emån, Mörrumsån (2).
7. Eastern Main Basin: Pärnu, Gauja, Daugava, Venta (4).

Table 4.10.1 Results from sampling and scale reading of the proportion of wild salmon in samples from spring 2002 until winter 2003-04.

W=wild, R=reared.

Sampling date/period	Fishing nation	Subdiv	Gear	Age 1			Age 2			Age 3			Total	% wild	Season
				W	R	Total	W	R	Total	W	R	Total			
20020426	Sw	25	Drift net	3	3	6	11	22	33	0	5	5	44	43%	
20020514	Sw	26	Drift net	1	3	4	12	21	33	1	0	1	38	34%	Spring 2002
20020515	Sw	25	Drift net	4	4	8	11	20	31	1	2	3	42	40%	
200206-07	Sw	31	Trap net	28	52	80	72	78	150	9	12	21	251	45%	Summer 2002
20021018	Sw	27	Drift net	12	16	28	7	10	17				45	42%	Autumn 2002
20021121	Sw	25	Drift net	20	15	35	6	9	15				50	52%	
20021203	Fi	26	Long line	18	18	36	14	15	29	2	0	2	67	48%	
20021210	Sw	26	Long line	22	19	41	7	17	24	3	5	8	73	47%	Winter 2002-03
20021220	Sw	25	Drift net	15	19	34	7	5	12	1	0	1	47	47%	
20030200	Lv	26	Drift net				8	46	54	4	9	13	67	25%	
20030218	Fi	26	Long line	22	20	42	10	15	25	3	3	6	73	48%	
20030418	Sw	25-26	Drift net	13	21	33	7	10	17	1	2	3	53	42%	
20030500	Lv	26	Drift net				22	91	113	17	35	52	165	35%	Spring 2003
20030512	Sw	25-26	Drift net				13	24	37	7	12	19	56	45%	
200305-06	Fi	29	Drift net				147	87	234	42	23	65	299	57%	
200305-12	Fi	32**	Long line	4	67	71	23	207	230	6	14	20	321	13%	***
200306-08	Fi	30	Trap net	31	112	143	754	265	1019	122	47	169	1331	63%	
200306-08	Fi	31	Trap net	4	22	26	33	24	57	22	12	34	117	42%	
200306-07	Fi	31	Trap net	1	2	3	23	16	39	1	0	1	43	56%	Summer 2003
200306-09	Fi	31	Trap net	60	180	240	46	72	118	14	11	25	383	31%	
200306-09	Fi	32*	Trap net	42	223	265	164	192	356	8	36	44	665	36%	
200306-07	Sw	31	Trap net	79	39	118	38	29	67	15	10	25	210	60%	
20030922	Sw	25-26	Drift net	17	20	37	7	8	15				52	46%	
20031000	Lv	26	Drift net	12	48	60	3	4	7				67	22%	
20030900	Lv	28	Drift net	7	33	40	2	8	10				50	18%	Autumn 2003
20031100	Lv	26	Drift net	36	98	134	16	31	47	3	0	3	184	28%	
20031007	Fi	26	Drift net	19	20	39	15	9	24	0	2	2	65	55%	
20031114	Sw	25-26	Drift net	19	13	32	9	12	21	4	1	5	58	50%	
20031118	Fi	26	Drift net	28	21	49	4	13	17	2	0	2	68	47%	
20031121	Sw	25-26	Drift net	24	15	39	1	4	5	0	1	1	45	58%	Winter 2003-04
20031128	Sw	25-26	Drift net	23	43	66	17	27	44	10	5	15	125	36%	
20040115	Fi	26	Long line				27	20	47	9	12	21	68	57%	
200401-02	Sw	25-26	Drift net	19	24	43	7	15	22	2	2	4	69	41%	
2002	All	25-29	All	95	97	192	75	119	194	8	12	20	406	45%	
2002	All	30-31	All	28	130	238	137	211	348	21	28	49	635	30%	
2002	All	32	All												
2003	All	25-29	All	239	376	614	315	424	739	104	107	211	1564	42%	
2003	All	30-31	All	175	355	530	894	406	1300	174	80	254	2084	55%	
2003	All	32	All	46	290	336	187	399	586	14	50	64	986	29%	

* East GoF
** West GoF
*** summer and autumn

Table 4.10.2. The summary table of the proportions of wild salmon in the 2002 and 2003 catches. The data is collected from table 4.2.5.1 and 4.2.5.2.

Area	Year	Proportion of wild salmon by genetic samples	Proportion of wild salmon by scale readings
Bothnian Bay	2002	43 % (summer) (n=180)	32-45 % (summer) (n=331)
	2003	52 % (summer) (n=203)	31-60 % (summer) (n=753)
Bothnian Sea	2002	40 % (summer) (n=179)	43 % (summer) (n=179)
	2003	76 % (summer) (n=218)	63 % (summer) (n=1331)
Aland Islands	2002	69 % (spring) (n=218)	58 % (spring) (n=218)
	2003	76 % (spring) (n=209)	57 % (summer) (n=299)
Gulf of Finland East	2002	2 % (summer) (n=150)	6 % (summer) (n=150)
	2003	36 % (summer) (n=448)	36 % (summer) (n=665)
Gulf of Finland West	2002		
	2003	19 % (summer) (n=148)	13 % (summer-autumn) (n=321)
Main Basin	2002	48 % (winter) (n=71)	34-43 % (spring) (n=124) 42-52 % (autumn) (n=95) 25-48 % (winter) (n=327)
	2003	66 % (autumn-winter) (n=215)	35-45 % (spring) (n=274) 18-58 % (autumn) (n=714) 41-57 % (winter) (n=137)

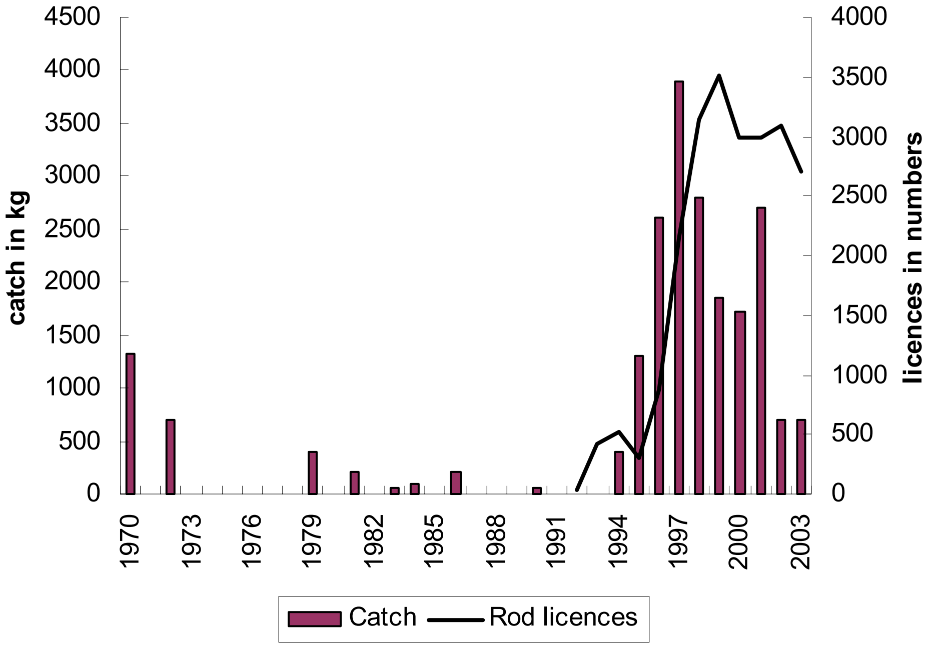


Figure 4.2.1.1 Salmon catches in the River Simojoki (assessment unit 1). Estimates are based on fishing questionnaires, which were not made annually before 1994.
In 2001 and 2002 the inquiry was made for fishermen, who bought a licence in the lower p
of the river, where in previous years over 80% of the total catch has been caught.
The estimation of the total catch was based on these proportions between the lower and upper part of the river. The 2003 catch estimate is preliminary.

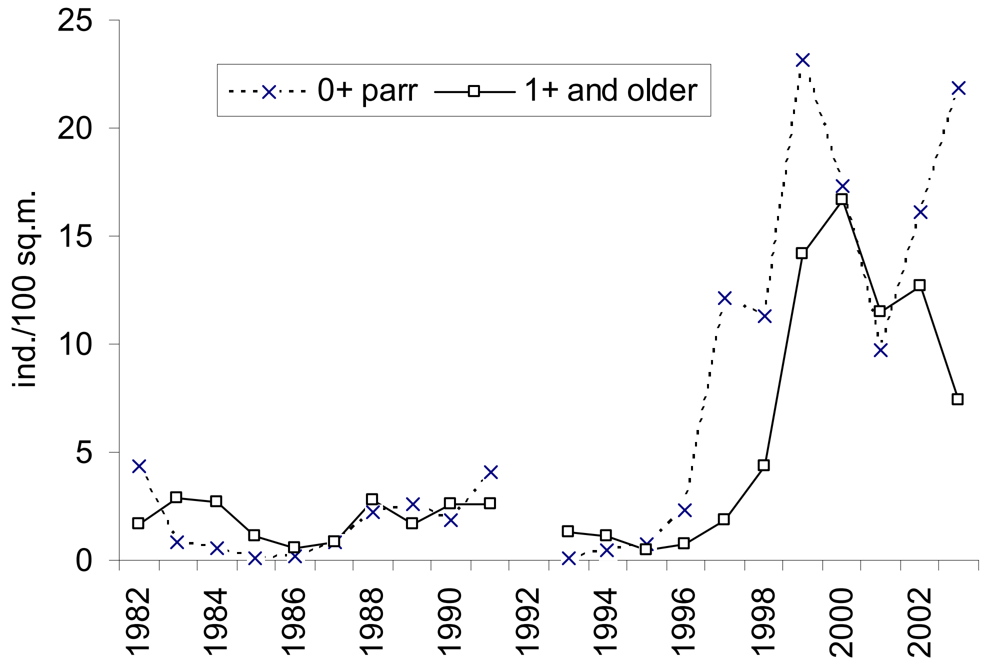


Figure 4.2.1.2 Wild salmon parr densities in the River Simojoki (assessment unit 1). No sampling was carried out in 1992 because of summer flood. The data for the figure is presented in table 4.2.1.1. The density level in 1970's has been 5-10 parr per 100 sq. m. (all age groups included).

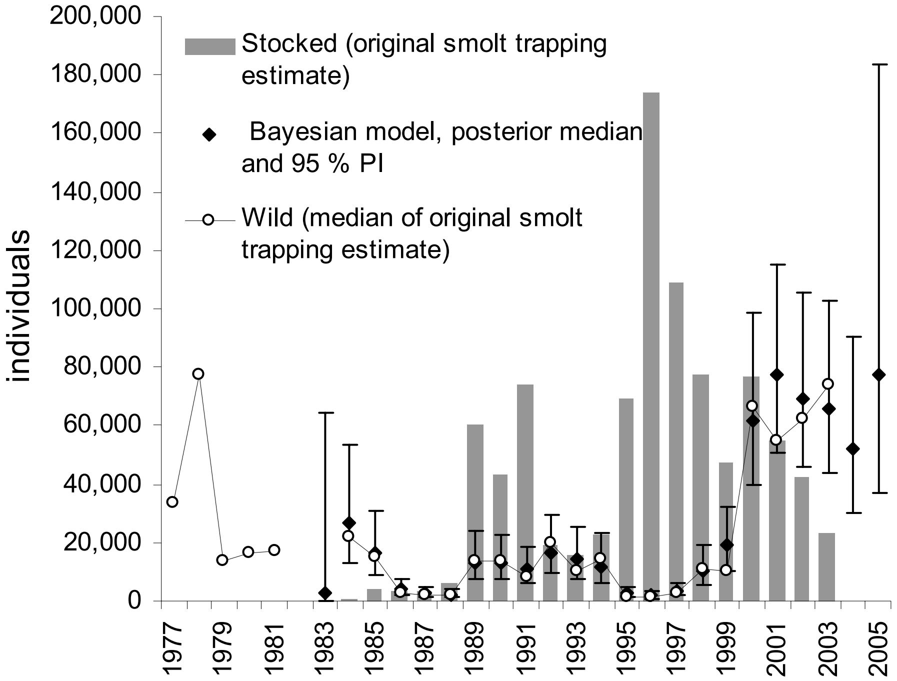


Figure 4.2.1.3 Smolt production estimates in the River Simojoki (assessment unit 1) estimated by mark-recapture method and by the Bayesian model using both smolt trapping and electrofishing data (see section 4.2.3).

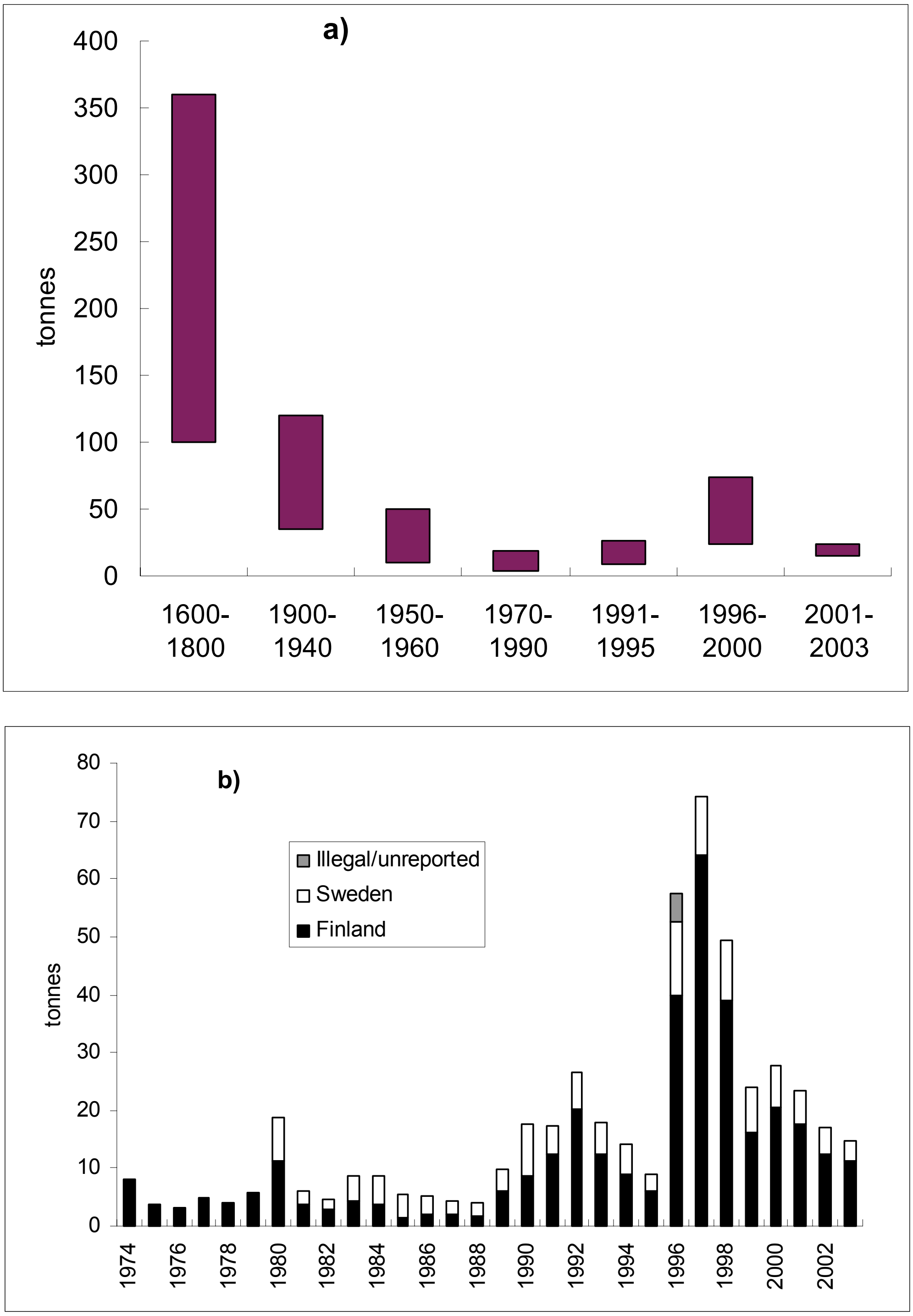


Figure 4.2.1.4 Total river catches in the River Tornionjoki (assessment unit 1). a) Comparison of the periods from 1600 to present. b) 1974-2003. Swedish total catch estimates are provided from 1980 onwards.

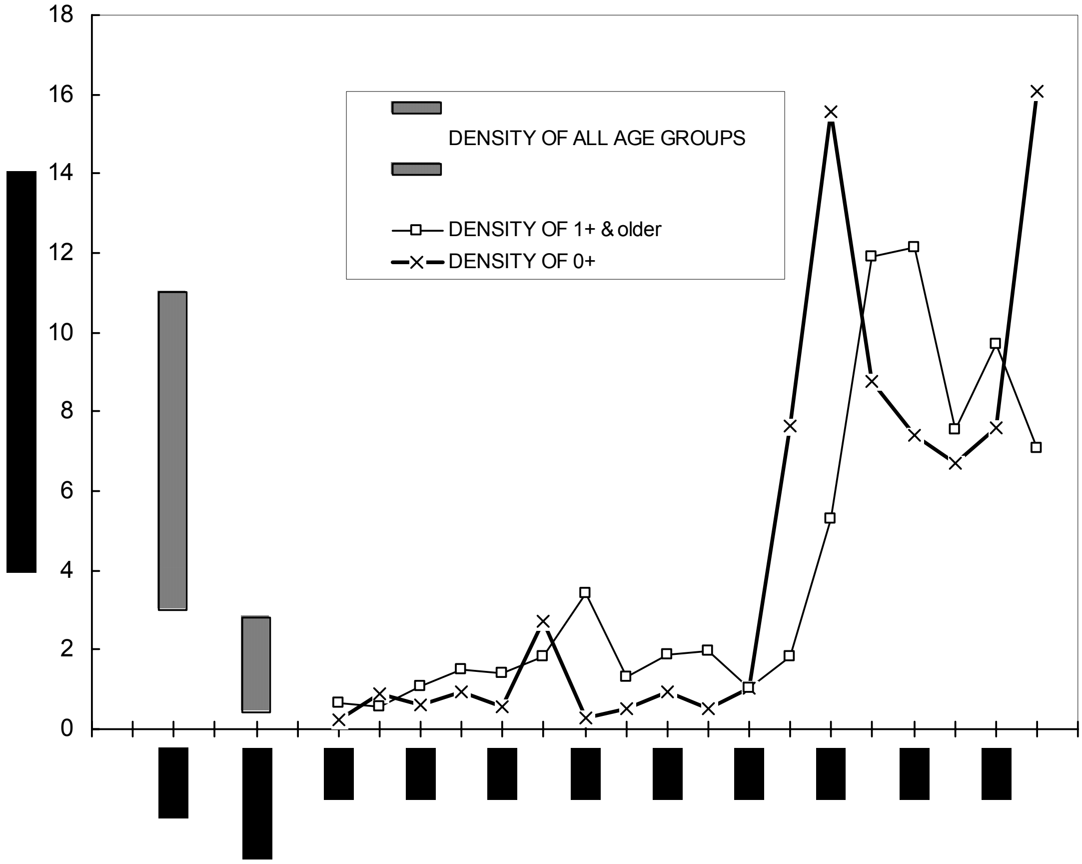


Figure 4.2.1.5. Wild salmon parr densities estimated by electrofishing in the River Tornionjoki (assessment unit 1). The results from 1960's and 1976-1984 are based on Swedish data. After that the results are based on combined Swedish and Finnish data.

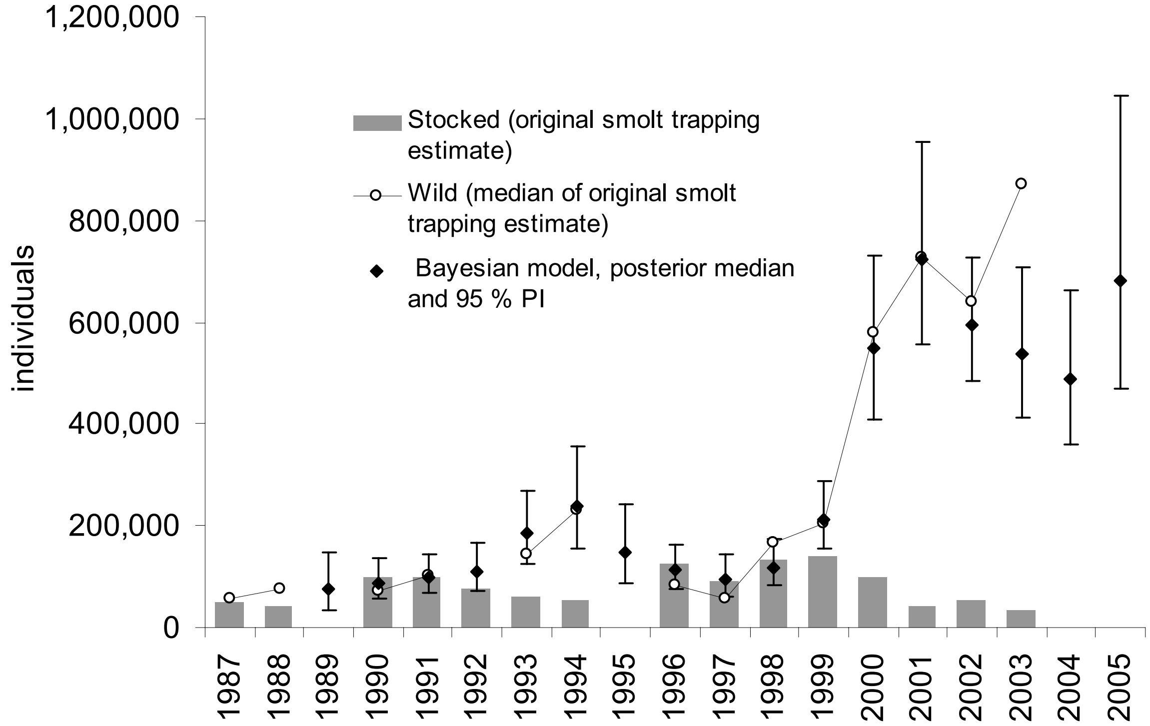


Figure 4.2.1.6 Smolt production estimates in the River Tornionjoki (assessment unit 1) estimated by mark-recapture method and by the Bayesian model using both smolt trapping and electrofishing data (see section 4.2.3).

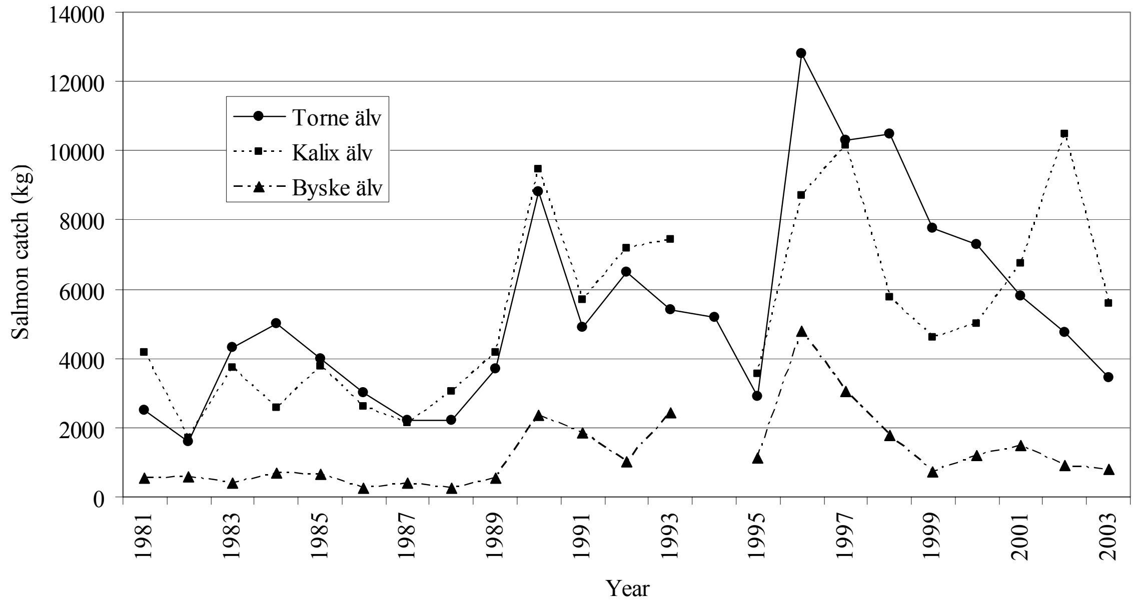


Figure 4.2.1.7 Salmon catch in the rivers Torne älv (Swedish catch), Kalix älv and Byske älv, Gulf of Bothnia, (Subdivision 31), in 1981-2003. Ban of salmon fishing 1994 in the rivers Kalix älv and Byske älv.

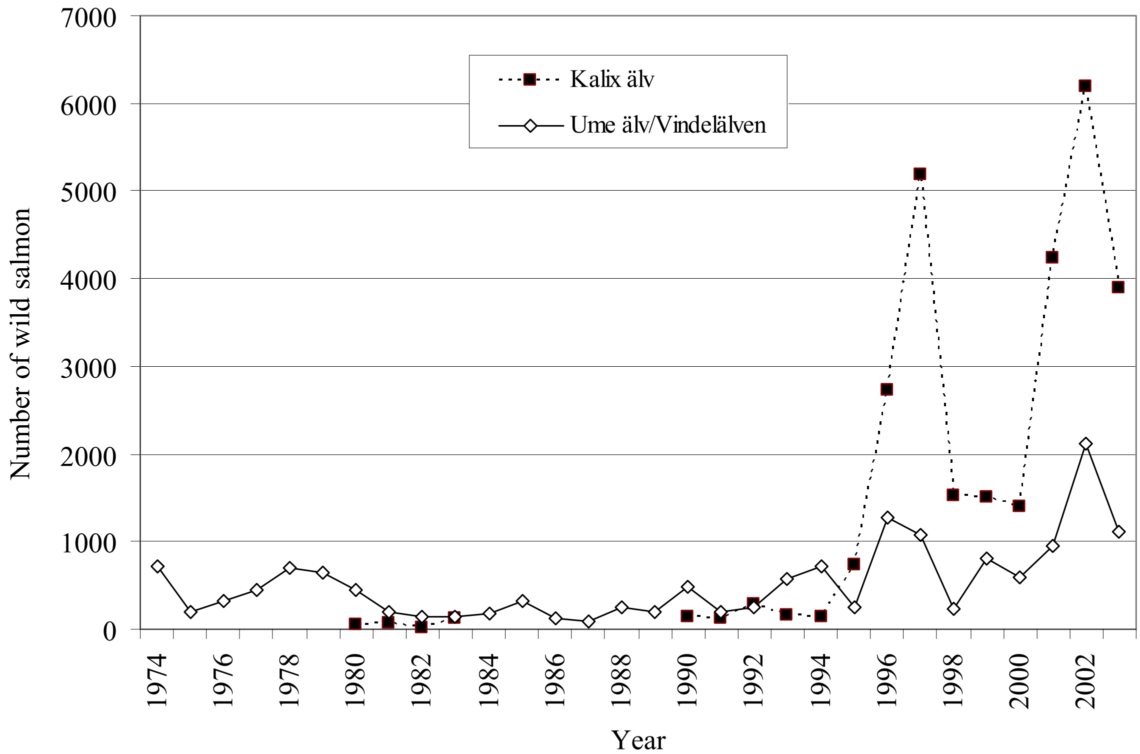


Figure 4.2.1.8 Wild salmon run in fish ladders in the river Kalix älv (MSW fish), and Ume älv/Vindelälven (females), (Sub-division 31), in 1974-2003.

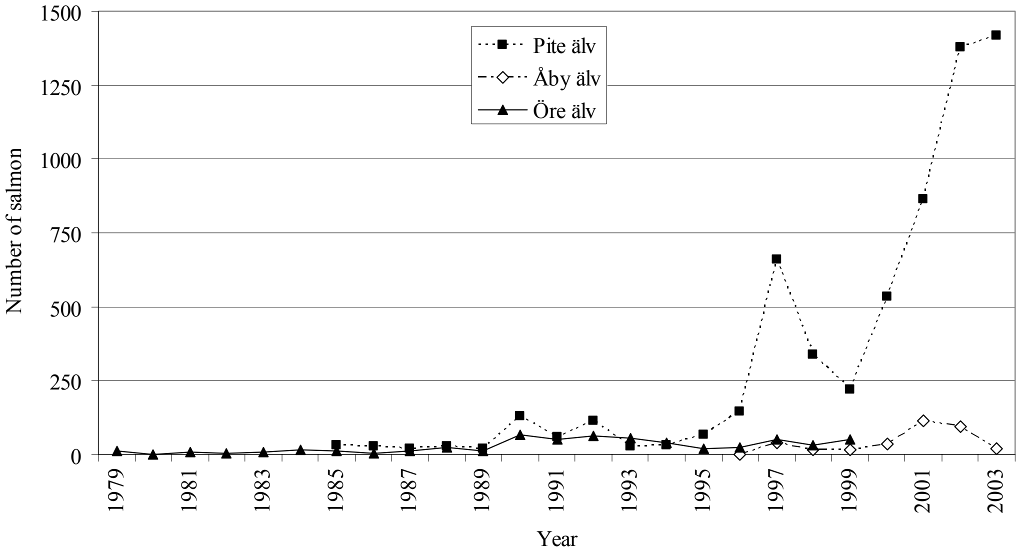


Figure 4.2.1.9 Salmon run in fish ladders in the rivers Pite älv, Åby älv, and Öre älv, Gulf of Bothnia, (Sub-division 31), in 1979-2003.

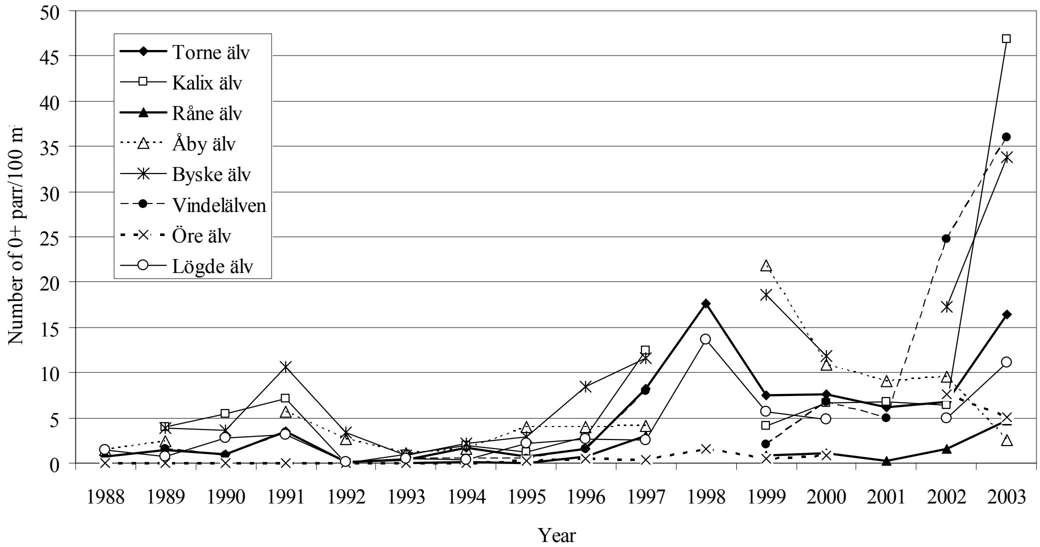


Figure 4.2.1.10 Densities of 0+ parr in rivers in the Gulf of Bothnia (Sub-division 31), in 1988-2003.

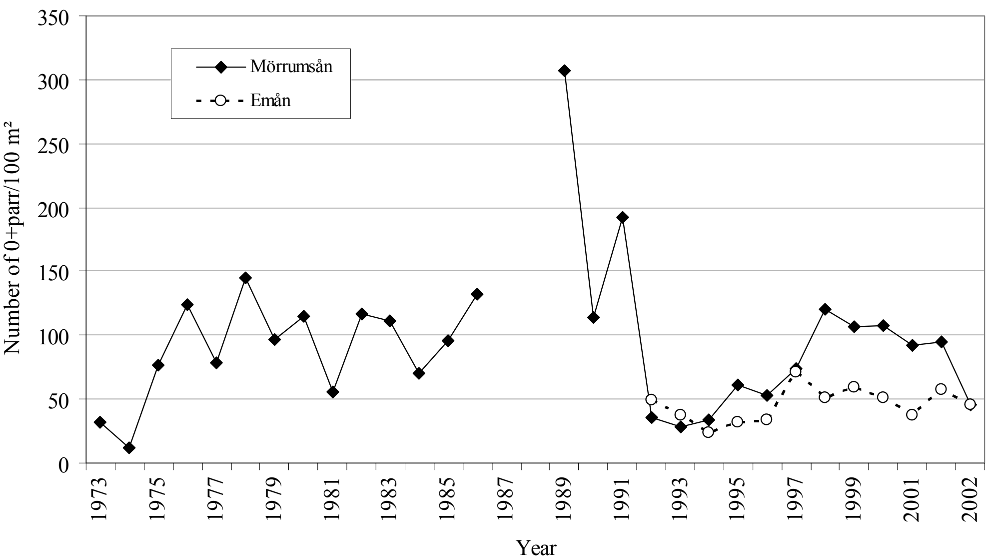


Figure 4.2.2.1 Densities of 0+ parr in the rivers Emån and Mörrumsån, Baltic Main Basin, (Sub-divisions 25-26), in 1973-2003.

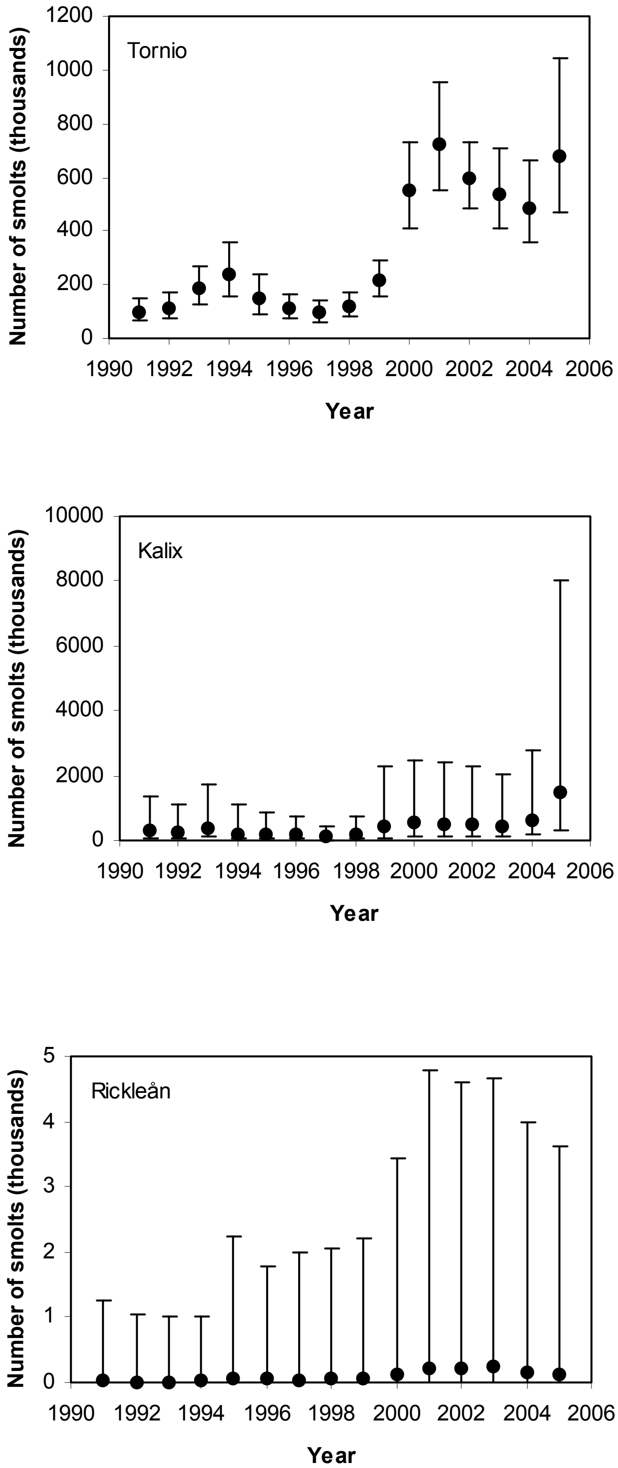


Figure. 4.2.3.1. Posterior quantiles (2.5%,50%,97.5%) of annual smolt production from rivers Tornio, Kalix and Rickleån between years 1991-2005.

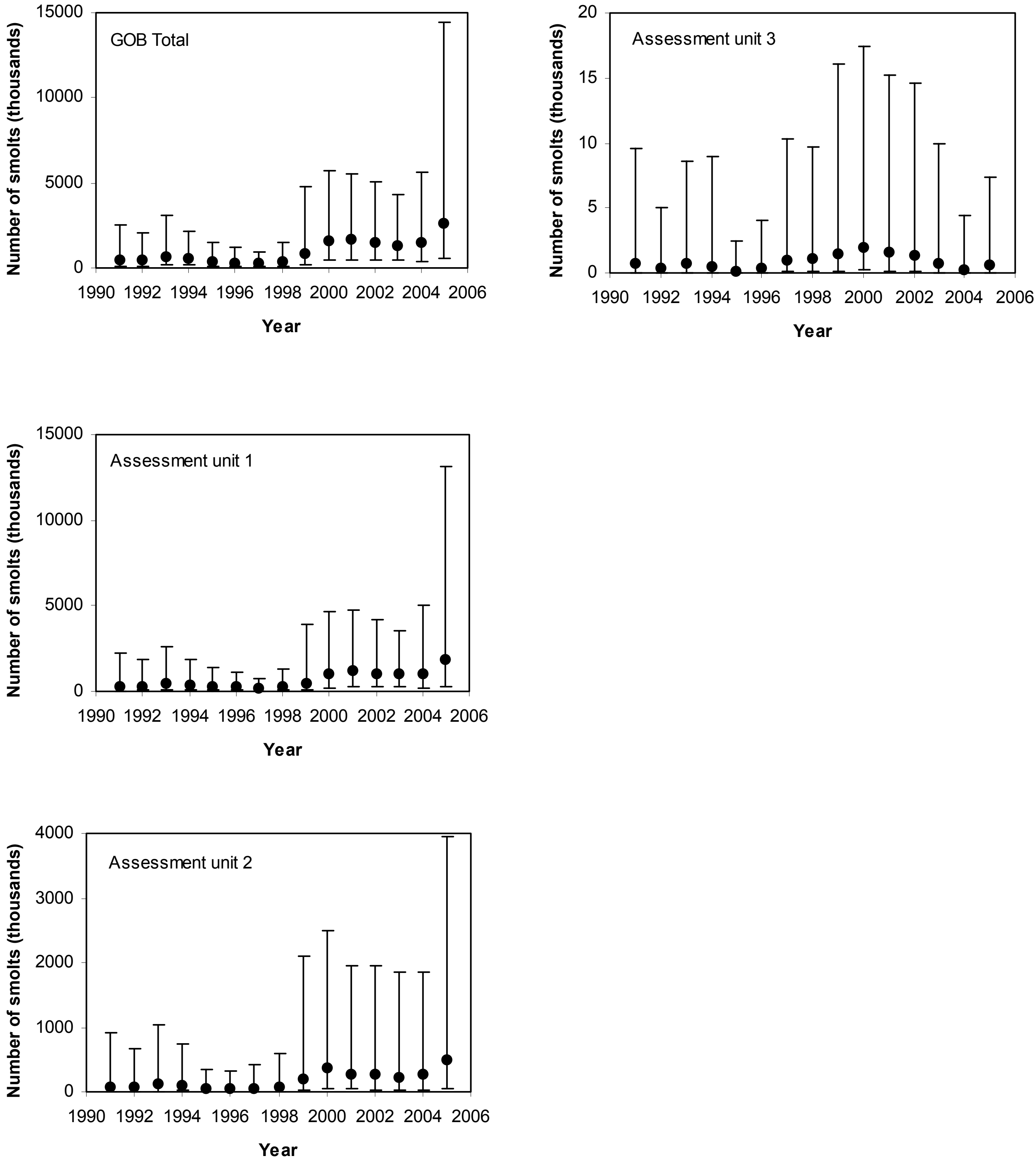
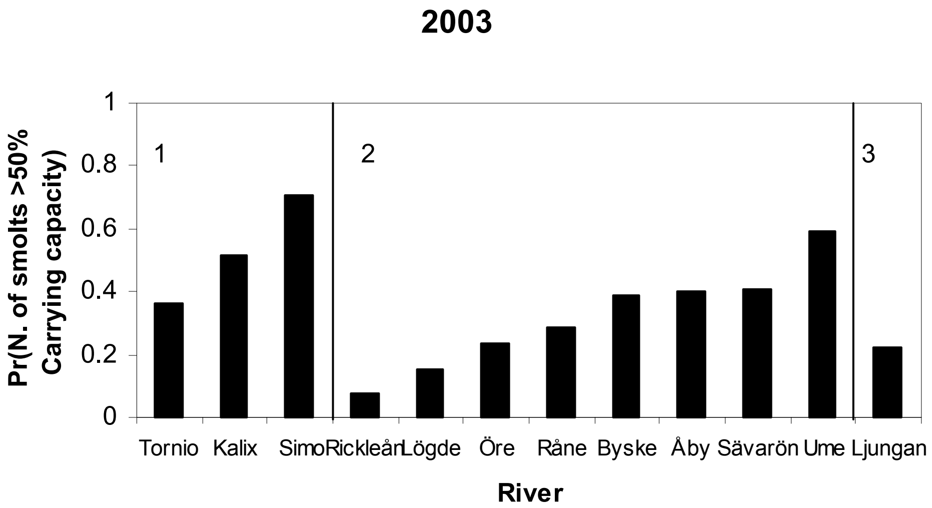


Figure 4.2.3.2. Posterior quantiles (2.5%, 50%, 97.5%) of the number of smolts produced by the Gulf of Bothnia salmon rivers belonging to assessment units 1,2 and 3, and by all assessment units together.



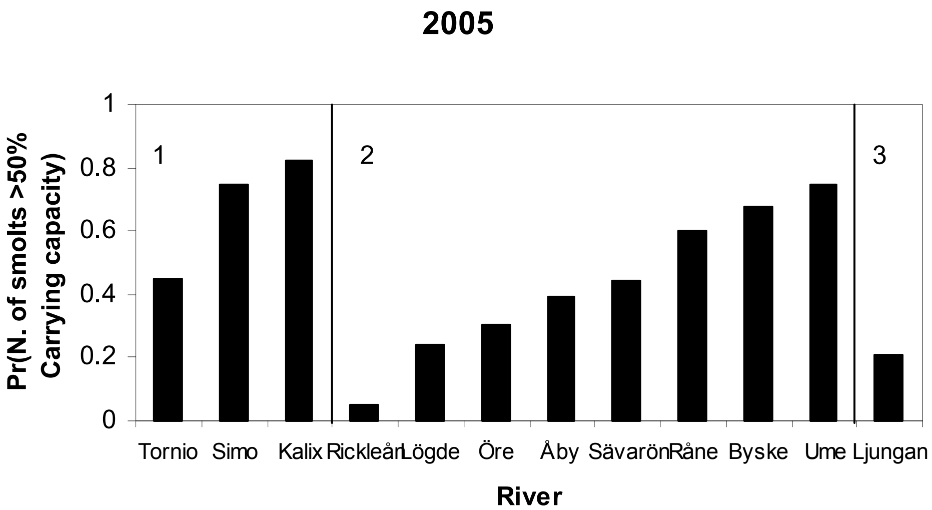


Figure 4.2.3.3. Probabilities that smolt production exceeds 50% of the carrying capacity in Gulf of Bothnia rivers in years 2003 and 2005. Probability close to 1 indicates that the 5\% level is reliably reached, value 0.5 means that it is very uncertain whether the level has been achieved, and values near 0 tell reliably that the level is not reached. Numbers on the panels indicate the assessment units (See chapter xxx).

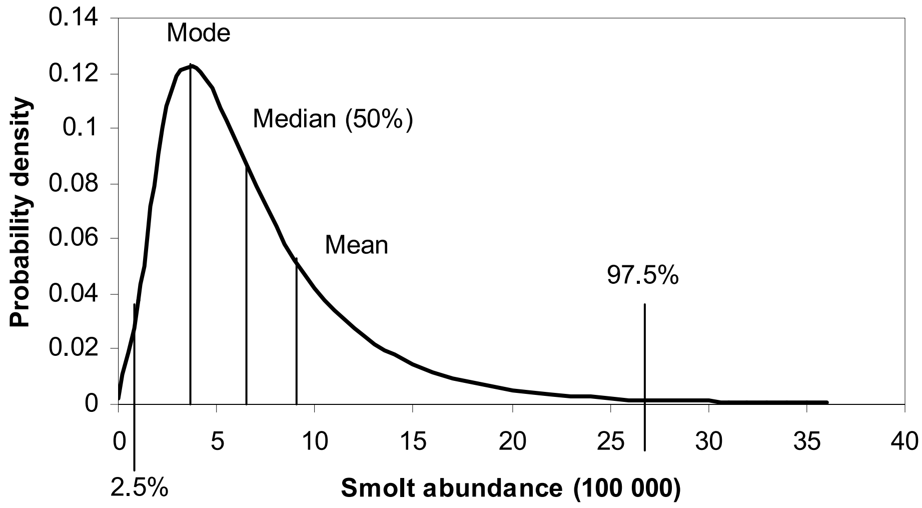


Figure 4.2.3.4 Posterior distribution of river Kalix smolt abundance in year 2004. Location of different statistics which are used to describe posterior distributions in the report are indicated by vertical lines in the figure. Most of the posterior distributions calculated by assessment models have shape similar to presented here, which means that the order of mean, median and mode is the same: the most probable value (mode) is located below the median.

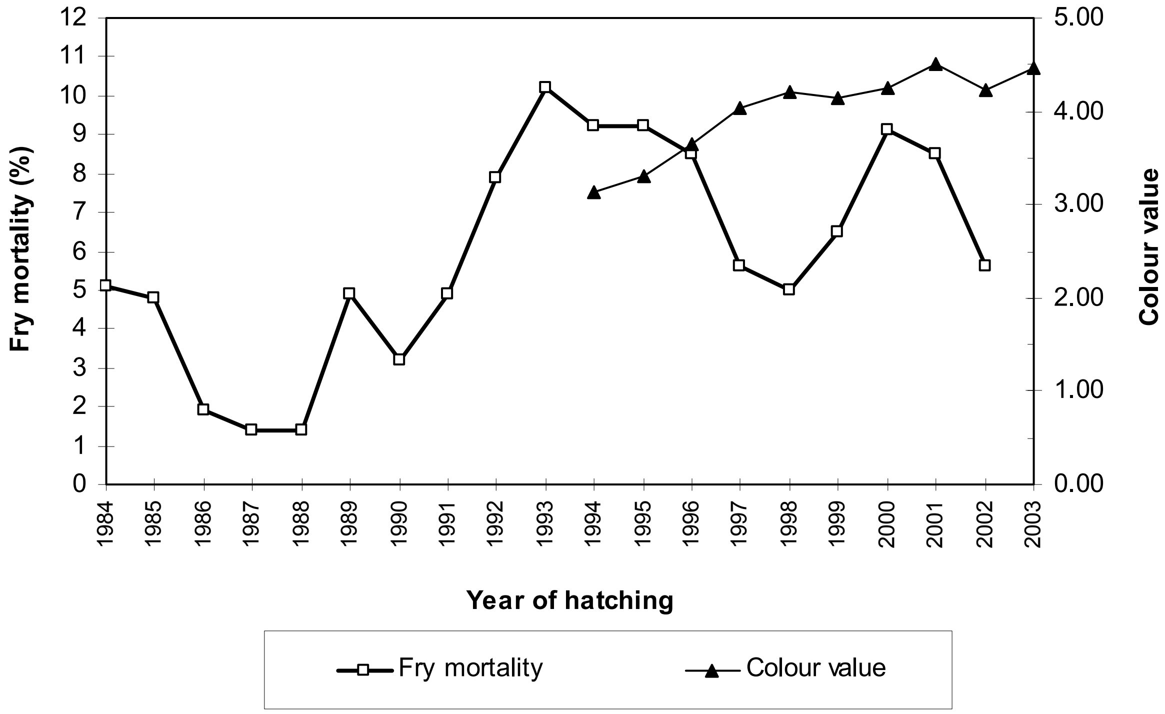


Figure 4.5.1 Relationship between fry mortality and roe color in Daugava salmon from Latvia.

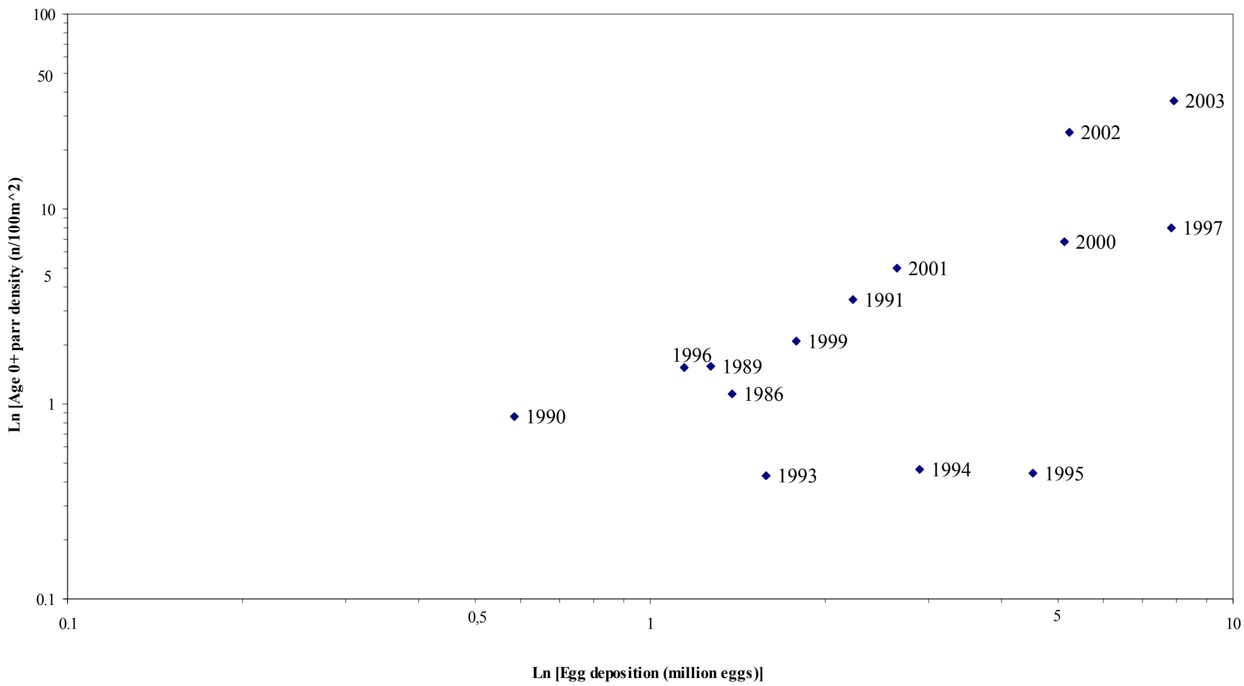
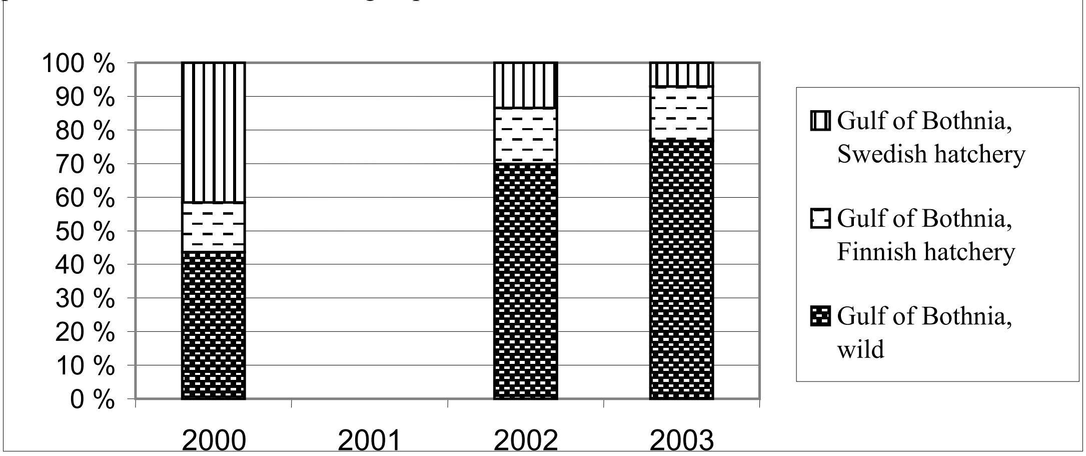


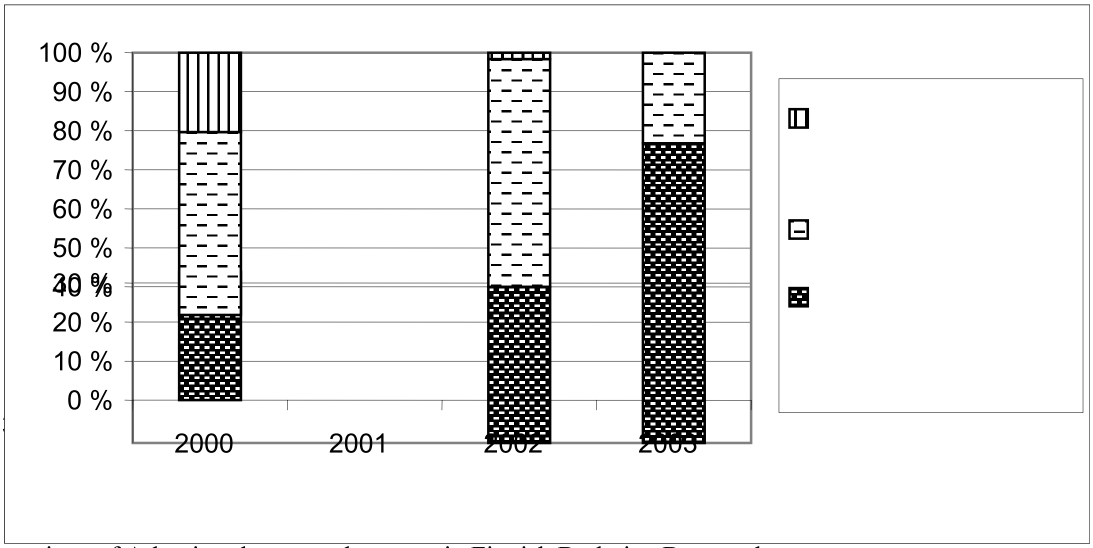
Figure 4.5.3 Densities of 0+ parr versus egg deposition in River Ume/Vindelälven in hatching years 1986 - 2003.

Figure 4.9.1 Stock group proportion estimates of Finnish Atlantic salmon catches with DNA microsatellite method.

1. Proportions of Atlantic salmon stock groups in Finnish Åland Sea catches.



2. Proportions of Atlantic salmon stock groups in Finnish Bothnian Sea catches.



3. Proportions of Atlantic salmon stock groups in Finnish Bothnian Bay catches.

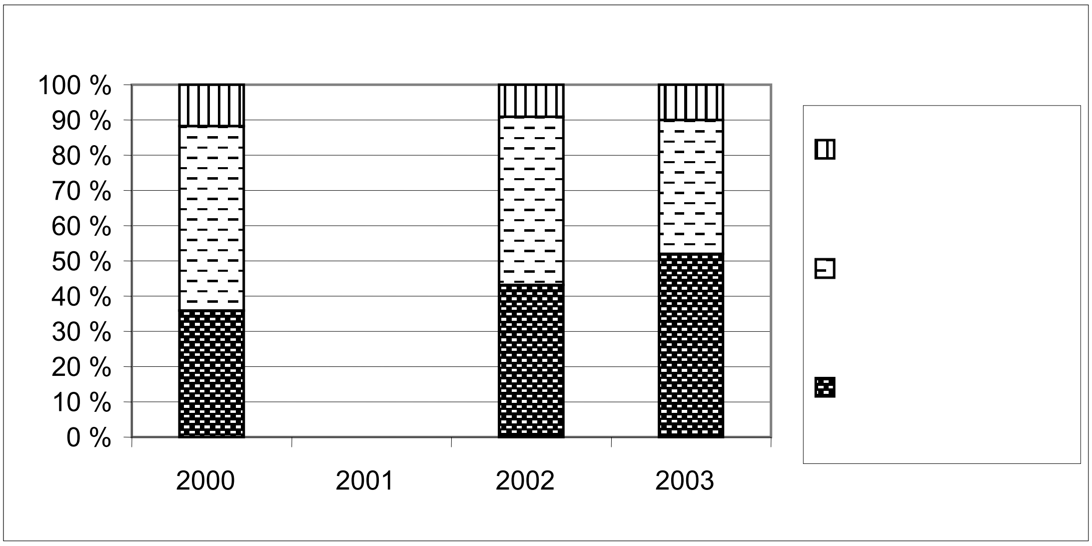
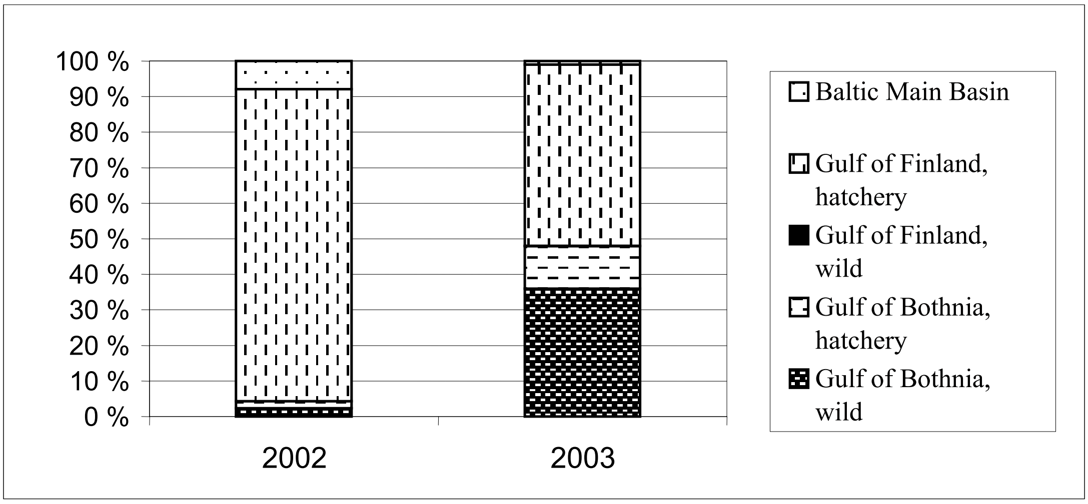
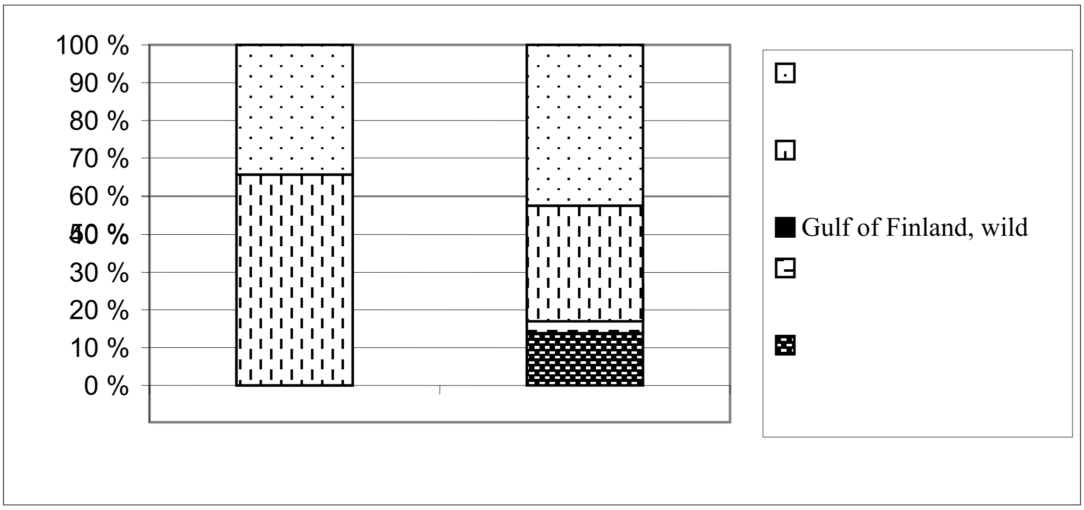


Figure 4.9.1 (Cont'd)

4. Proportions of Atlantic salmon stock groups in Finnish eastern Gulf of Finland catches.



5. Proportions of Atlantic salmon stock groups in Finnish western Gulf of Finland catches.



6. Proportions of Atlantic salmon stock groups in Finnish Main Basin catches.

5 REVIEW AND EVALUATION OF PRESENT MANAGEMENT MEASURES

5.1 Description of the Present Management Measures

5.1.1 International regulatory measures

Minimum landing size, minimum mesh size, minimum hook size, number of gears/ vessel

International management measures adopted by IBSFC regulate the salmon fishery in the convention area of IBSFC. Technical management measures are the following; minimum landing size (60 cm), minimum mesh size of driftnets (157 mm) and minimum hook size (19 mm). A maximum of 600 driftnets or 2000 long line hooks is permitted to be used per vessel fishing for salmon.

Summer closure

The following salmon fisheries regulatory measures were adopted in 1997 (Anon. 1997). Fishing with drifting or anchored floating nets is prohibited from 1 June to 15 September (both days included), except in Subdivision 32 where it is prohibited from 15 June to 30 September. Fishing with drifting lines and anchored lines is prohibited from 1 April to 15 November, except in the Gulf of Finland (Subdivision 32) where the fishing with drifting lines and anchored lines is prohibited from 1 July to 15 September. The closed area during the closed season is beyond four nautical miles measured from base-line, except in the Gulf of Finland (Subdivision 32), and the area east of longitude 22º30' E inside the Finnish fishing zone where the fishing with drifting lines and anchored lines is prohibited from 1 July to 15 September.

TAC

Since 1981 WGBAST recommended adopting a TAC to regulate the Baltic salmon fishery. In 1990, IBSFC adopted a TAC system for Baltic salmon fishery management and it was implemented for the first time in 1991. There are two separate management areas; Baltic Main Basin and Gulf of Bothnia (subdivisions 22–31) and Gulf of Finland (subdivision 32). The TACs implemented for 2003 are given in Section 3.2. The TAC for 2004 has been allocated to fishing zones in the following manner:

The Main Basin and the Gulf of Bothnia

Contracting party	Quota
Estonia	9 504
EC	346 918
Latvia	59 478
Lithuania	6 992
Poland	28 368
Russian Federation	8 740
Total	**460 000**

The EC quota in the Main Basin and the Gulf of Bothnia has been divided between countries as follows:

Country	Allocation key %	Quota
Estonia	2.0660	9504
EC		
Denmark	26.9550	93 512
Finland	33.6110	116 603
Germany	2.9990	10 404
Sweden	36.4350	126 400
Latvia	12.9300	59 478
Lithuania	1.5200	6992
Poland	6.1670	28368
Russia	1.9000	8740
Total	**100.000**	**460 000**

The Gulf of Finland

Contracting party	Quota
Estonia	3 255
EC	28 490
Russian Federation	3255
Total	**35 000**

5.1.2 National regulatory measures

In **Denmark** all salmon and sea trout streams with outlets wider than 2 m are protected by closed

areas within 500 m of the mouth during the whole year; otherwise the closure period is four months at the time of spawning run. Estuaries are usually protected by a more extended zone. Gillnetting is not permitted within 100 m of the water mark. A closed period for salmon and sea trout has been established from November to 15 January in freshwater. In the sea this only applies for sexually mature specimens. The Danish quota is in 2003 was divided in five shares. From 1 January-31 March 25%, from 1 April-30 June 15%, from l July-15 September 5%, from 16 September-15 November 40%, and from 16 November-31 December 15% could be caught.

In **Estonia** an all-year-round closed area of 1000 m radius is established at the river mouths of present or potential salmon spawning rivers Kunda, Selja, Loobu, Valgejõgi, Jägala, Pirita, Keila, and Vasalemma and at the river mouths of the sea trout spawning rivers Punapea, Õngu, and Pidula. In the case of other most important sea trout spawning rivers (Pada, Toolse, Vainupea, Mustoja, Altja, Võsu, Pudisoo, Loo, Vääna, Vihterpadu, Nõva, Riguldi, Kolga, Rannametsa, Vanajõgi, Jämaja) a closed area of 500 m is established from 15 August to 1 December. In the case of smaller sea trout spawning streams, an area of 200 m radius around the river mouths is closed from 1 September to 30 November. Apart from lamprey fishing no commercial fishery in salmon and sea trout spawning rivers is permitted. In most of these rivers also angling with natural bait is prohibited. Besides, only licensed sport fishing is permitted. A closed period for salmon and sea trout sport fishing is established in the rivers Narva, Kunda, Selja Loobu, Valgejõgi, Jägala, Pirita, Keila, Vasalemma, and Pärnu from 1 September to 30 November, in other rivers from 1 September to 31 October. Exceptions in sport fishing closure are allowed by decree of the Minister of Environment in the rivers with reared (the River Narva) or mixed salmon stock (the rivers Selja, Valgejõgi, Jägala, and Pirita). Below of dams and waterfalls all kind fishing is prohibited at a distance of 100. In the River Pärnu this distance is 500 m. No changes in the national management measures were adopted in 2003.

In **Finland** offshore and coastal salmon fishing is prohibited with all kinds of set nets, trapnets, driftnets, and longlines in Finnish territorial waters and in the Finnish fishery zone in the Main Basin and in the Gulf of Bothnia as follows:

1. from the beginning of 15 April to the end of 15 June in the area between latitudes 59º00'N and 62º30'N, excluding Gulf of Finland, and the area east of longitude 22º30'E, joining the Gulf of Finland.

2. from the beginning of 15 April to the end of 20 June in the area between latitudes 62º30'N and 64º00'N.

3. from the beginning of 1 April to the end of 25 June in the area between latitudes 64º00'N and 65º30'N.

4. from the beginning of 1 April to the end of 30 June in the area north of 65º30'N.

In addition to the restrictions described above salmon fishery is not permitted using any kind of net or trapnet from the beginning of 1 July to the end of 15 July in the sea in the special area outside the River Simojoki. Salmon fishery using all kinds of nets is likewise prohibited in the River Simojoki from the river mouth to the lake Portimonjärvi from the beginning of 1 May to the end of November. In the specially determined areas outside the dammed rivers Oulujoki, Ijoki, and Kemijoki there are no temporal restrictions for salmon fishing.

In addition it was permitted to start fishing salmon at the Åland Islands from 27 May onwards within the 4-mile coastal zone in 2002. Salmon fishery at the mouth of the River Tornionjoki was allowed to start on 3rd July. Fishing had been prohibited in the area in 1991-2001. No changes in the national management measures were adopted in 2003.

Latvia has the following national salmon fisheries regulations. In the Gulf of Riga salmon drift net and long line fishing are not permitted. In the coastal waters salmon fishing is prohibited from 1 of October to 15 of November. Salmon fishing in coastal waters has been restricted indirectly by limiting the number of gears in the fishing season. In May, October and November, only small meshed gears (mesh size below 30 mm) are permitted. In the rivers all angling and fishing for salmon and sea trout are prohibited with the exception of Licensed angling of sea trout and salmon exists in the rivers Salaca and Venta in spring time season. Daily bag limit is one sea trout or salmon. All fishery by gill nets is prohibited all year round in a 3 km zone around the River Salaca outlet from 2003.

Special terminal fishery area in the Southern part of the Gulf of Riga was established in 2002 for increasing of the hatchery reared salmon fishing near the Rivers Daugava and Lielupe outlets. Regulatory measures for fishing in this region were mitigated to increase fishing effort:

-no salmon fishing prohibition in October- November

-no fishing gear number limitation in late autumn fishing.

A possible positive effect for fisheries in the future will probably come from allowing multi-monofilament floating anchored gill nets in coastal salmon fisheries in the late autumn. Such kind of gear is cheaper and easier in operation in comparison with trap nets. A significant circumstance is that gill net sets are more safe in stormy weather. Introducing such kind of gears in the fishery are advisable due to economical reasons.

The Latvian catch quota is divided between the offshore and coastal fisheries.

In **Lithuania** the coastal fishery in the Baltic Sea is limited by quotas in numbers, by mesh size and minimal fish size. Salmon and sea trout fishery is not permitted by any gears in areas within a radius of 1 km from the river outlets into the sea. Salmon and sea trout fishery is not permitted in separate regions in the sea from 15 August to 31 October. Salmon and sea trout fishery by gillnets is prohibited from 15 of June to 15 of September, and by long line from 1 April to 15 November. In the rivers commercial and angler fishing in Curonian Lagoon and rivers is prohibited all year. Fishery is prohibited by set gillnets in an area within 3 km of the eastern coast of the Curonian Lagoon from 1 September to 31 October. Angler fishery is not permitted from boats, by bottom lines, or by spinning using live bait from 1 October to 30 November. Data on possible changes in 2000-2003 are not available.

In **Poland** the international fishery rules are extended to the coast line. Salmon fishery in the mouths of Pomeranian rivers, in the River Drava, in the River Drweca and in the Vistula River from the dam in Wloclawek to the mouth is forbidden from 1st October to 31st December. In other fresh waters salmon fishery is forbidden all year round except for fishing spawners for breeding purposes. In 2003 the Polish quota 28 368 + 14 000 salmon from exchange with Latvia was divided between cutters and boats. Each of 81 vessels longer 12 m was granted individual quota of 474 fish. The remaining part 3 956 fish was given to smaller boats (12 m and less) as a lump sum. No changes in the fishery rules in 2003. In 2003 a vessel monitoring system was introduced.

In **Russia** the IBSFC fishery rules are extended to the coast line. In all rivers and within one nautical mile of their mouth fishing and angling for salmon is prohibited during all year, except fishing for breeding purposes for hatcheries. No changes in fishery regulations in 2001-2003.

In **Sweden** south of latitude 62º55'**N,** coastal salmon fishery is allowed from the start of the fishing season. North of this latitude salmon fishery started outside of protected areas on the of 10th June. Exemptions from this early season regulation of salmon fishery was allowed to professional fishermen by the local county board in the area north of 62º55'N up to the border between the counties Västernorrland and Västerbotten.

Terminal fishing areas were introduced in 1997 in the coastal region around three rivers with reared production (River Lule älv, Skellefte älv and Gide älv). In these areas the fishery is not closed down in the early season.

In the protected areas outside the river mouths of all wild salmon rivers, usually divided into an inner and outer part, generally all salmon and sea trout fishery is forbidden. Fishery with trap nets for other species is usually allowed in the inner parts of these areas between the 25th of June and the 15th of September. In the outer parts, exemptions from this early season regulation of salmon fishery may be allowed for licensed fishermen by the local county board after the 10th of June, outside the rivers Öre alv, Vindelälven, Sävarån, Rickleån, Kåge älv, Pite älv and Råne älv not until 18th of June. In the river mouth areas outside Ume älv, Ljungan and Kalix älv fish lacking adipose fin may caught, even when catch of fish with adipose fin is banned.

Angling for salmon in the 2003 was allowed in all wild salmon rivers in the Gulf of Bothnia until the 31 th August. There was a bag limit of one salmon per fisherman and day in all rivers

Angling for salmon in the year 2003 was allowed in all wild salmon rivers in the Gulf of Bothnia until the 31th of August. In the rivers Öre älv, Vindelälven, Sävarån, Rickleån, Kåge älv, Pite älv and Råne älv the angling period was limited to the period 19 June-31 August. There was a bag limit of one salmon per fisherman and day in all rivers. . In the rivers Eman and Morrumsan, angling was allowed from the 1th of March to the 30th of September.

Since 1997 fishing regulations in the border part of river Torne älv are decided upon by the Swedish Ministry of Agriculture and the Finnish Ministry of Agriculture and Forestry. In 2003 angling was allowed in the river from 1 May to 15 August. There was a bag limit of one salmon per day. In addition there were possibilities for a limited river fishery with traditional gears during a few days. The regulations also provided possibilities for exemptions for licensed fishermen to use trap nets in parts of the protected area outside the river mouth.

The Swedish quota in year 2003 was divided into two parts. South of the latitude 59^0 30' N 63,200 salmon could be caught and north of this latitude the same number or 63,200 salmon. The quota for the Main Basin was divided into three shares. In the first period 7 January-31 March 19,400 salmon may be caught, from 1 April-31 May 26,600 salmon, and from 1 June-31 December 17,200 salmon. If the mainly coastal salmon fishery north of 59^o 30' N does not manage to catch their 50% of the catch quota until 15 September, the fish may be caught south of the latitude 59^o 30' N.

5.2 Evaluation of the Present Management Measures

5.2.1 International regulatory measures

Minimum landing size, minimum mesh size, minimum hook size

An evaluation of the effect of these measures was provided in Anon. 2000 and it is not repeated here.

TAC

The IBSFC goal is a gradually increase of the production of wild Baltic salmon to attain by 2010 at least 50% of the natural production capacity of each river with current or potential natural production of salmon. One of the main tools to reach this goal is a TAC regulation.

The Working Group recognised that since middle of the 1990s Finland and Sweden have included estimated recreational catches into landings reported to IBSFC. However, at present neither Finland nor Sweden include these when estimating the utilization of catch quotas. The Working Group has included them into catch estimates and did for the years 2000-2002 develop estimates of discard and unreporting and these were included in catch estimates in Figure 5.2.1.1. In 1991–93 there were marginal differences between landings reported to IBSFC and ICES statistics of total landings in coastal and offshore fisheries, but the difference increased in 1994-98. The utilization of the TAC has decreased in 2001-03. The discard rate has probably increased considerably in the last years as the number of salmon in gears killed by seals have increased, but this development may have changed in the last couple of years in Sweden but the total due to the development of trap nets (push up trap nets) that are less sensitive to seal interaction with fish.

Although the commercial catch has sometimes exceeded the TAC, TAC´s have overall helped to reduce catch. Until the last years TACs have been effective in restricting fishing. In the years 1999,2000, 2002 and 2003, the TAC has been partially restrictive only in some countries and regions.

The following strategies are used for implementing the TAC:

a) The TAC has been divided for the time periods of the year mainly according to fishing industry demands.

b) The TAC has been allocated for the offshore fishery for different time periods and separately for the coastal fishery.

c) The TAC has been allocated as individual quotas both for offshore and coastal fishermen.

d) The TAC has not been divided but utilised as long as a quota available.

TAC can be an effective tool to safeguard feeding fish for spawning run. In the coastal fishery for migrating spawners the TAC is not suitable as the main regulatory method, but it must be complemented or even replaced by technical measures dealing with fishing time limitations (see Section 5.2.2).

TAC to the salmon fishery has been restrictive in some countries while in other countries the allocated TAC have not been fully utilised, either because of marketing problems, regulations or, in coastal areas, due to seal problems.

In order to get a better total estimate of the landings, it would be appropriate to consider establishing additional minimum standards in the catch statistics within the Baltic Sea area. The Working Group considered that the following guidelines would improved the quality of the statistics.

a) The TAC should include catches from all components of the salmon fisheries in coastal and offshore areas, commercial as well as recreational, where these catches are retained.

b) Include both the number and weight of salmon in the statistics.

c) For a TAC in numbers the catch should be directly counted, not calculated as weight of the salmon catch converted into numbers by a conversion factor.

d) Differentiate, wherever possible, between wild fish and salmon of reared origin.

e) Weight should be given as round weight or be converted to round weight equivalent using appropriate conversion factors where fish are landed gutted.

f) Include salmon caught in non-salmon gear where retention of fish caught in this way is legal.

g) Information on fishing effort should, wherever possible, be obtained for all components of salmon fisheries.

5.2.2 National regulatory measures

National regulatory measures do among other things handle the distribution of the allocated TACs in time periods , different fisheries and in some cases even for fishing vessels. Other national measures deal with coastal and river fishery regulations.

Coastal regulations

In addition to the TAC-system, national regulatory measures have been adopted to restrict fishing mortality in coastal fisheries directed at homing salmon. In Finland and Sweden the date of opening coastal fisheries in the Gulf of Bothnia has been delayed to restrict the harvest of the early run when the share of wild salmon is the largest. These regulatory measures were strengthened beginning in 1996 to further increase escapement into the rivers. A new analysis was presented to the Working Group in 2002 on the result of the Finnish system of delayed opening. As the spawning migration covers a short time period and is progressing quickly, a change in opening date caused large differences in exploitation and supposedly had a corresponding effect on the spawning stock size. Recaptures of salmon tagged during the spawning migration in the northern Main Basin and Gulf of Bothnia support these findings. In most countries there are fishery closures near the mouths of salmon rivers. Without these closures, salmon approaching and/or entering the river will be harvested.

Survival of salmon released from trap nets in coastal fishery

At present the Swedish and Finnish coastal fishery is restricted by fishery regulations that are primarily intending to decrease the exploitation of wild salmon. In the Finnish and Swedish part of the Gulf of Bothnia, more than 80% of the salmon catch is taken by trapnets. If adipose fin clipping of reared fish is introduced, it may be possible to change the fishery regulations in many areas and retain fin clipped fish, while wild fish would be released. In Sweden, all salmon and sea trout smolt released to the Baltic from 2005 and forward will be adipose fin clipped.

In the **Finnish** coast of Gulf of Bothnia the a large scale tagging study was conducted in years 2001-2002 to examine survival of salmon which are released from trap nets. The aim of study was to evaluate whether it is possible to utilise selective coastal fishery where part of the catch would be released (e.g. wild salmon). Another objective was to compare different gears in order to find out the gear construction that would provide most uninjured fish. Also a strong net material (Dynema) was tested in fish rooms to decrease seal damaged on fish in gears. Results are presented in the WG report of 2003. (Anon. 2003)

In the **Swedish** coast of Gulf of Bothnia information on the damage on salmon in trap- and fykenets was collected during 2000-2001. More detailed information on studies is presented inthe WG report of 2003 (Anon. 2003).

A management in coastal fishery to utilise selective fishery could be realistic according to preliminary results of these studies. This management measure expects however, that the share caught salmon to be released should be somehow be detected.

5.2.3 Non-exploited salmon in rivers with reared production

Baltic salmon stocks have for a long time been highly exploited and the fishery has been adapted to a high exploitation particularly in offshore and coastal areas. In Figure 5.2.3.1, which is based on tag recoveries from Swedish taggings of reared smolts, it can be seen that the proportion of fish returning to the rivers decreased when the exploitation increased in the 1970s and 1980s. At that time 2-4% of total tag recoveries were made in rivers. In the 1990s the offshore and coastal exploitation decreased and about 10% of the recorded recoveries were once again made in rivers in similarity with the situation in the 1950s and early 60s. The proportion of total catch in Sub-div. 22-31 taken in rivers have shown a similar change and in years 1998-2000. 8.5% of total catch have on average been recorded in rivers.

Mark-recovery studies to estimate the total number of salmon spawners entering the rivers have been carried out in two Swedish rivers with reared stocks, river Luleälven, Sub-division 31, and river Dalälven, Sub-division 30, in the 1990s, 2001 and 2002 (Anon 2003).

The results were in contrast with the idea of a large non-exploited surplus in many rivers. There is indeed a surplus that may be exploited but the number of fish is only a fraction of the 500000 salmon often believed to be available for harvest. The discrepancy is probably mainly due to a significant decrease in postsmolt survival of reared fish in recent years as indicated by stock assessments (Section 6). The low number of returning reared salmon fits in with the high proportion of wild salmon in the catches in the Main Basin (Section 4.10).

5.2.4 Effects of management measures on stock development

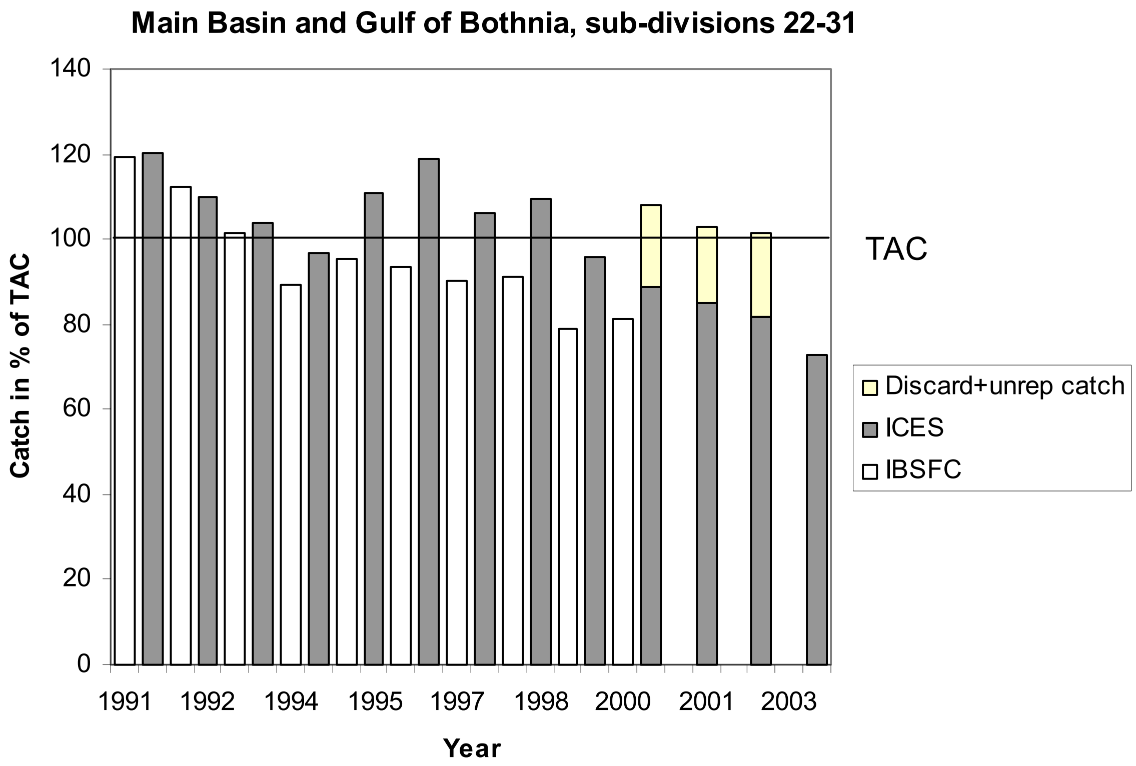
The current stock assessment provided a series of harvest rate estimates in various fisheries. As the first goal is to decrease fishing mortality, the actions should have an effect on mortality values. The stronger management actions since 1996 can be seen in the fishing mortality estimates in Section 6. Both the TAC and coastal management actions have decreased harvest rates with the outcome that more salmon has escaped to rivers for spawning. Therefore, it can be stated that management actions have had a positive effect on wild salmon stocks. Also improvement in parr densities (Fig. 4.2.1.10) support this conclusion.

Romakkaniemi et al. (2003) examined time series of salmon abundance in six rivers flowing into Gulf of Bothnia, based on the Swedish and Finnnish monitoring programmes (catch records, adult counts, electrofishing and smolt trapping). River abundance (spawners, parr and smolts) was compared with implemented large-scale and river-specific management measures and with natural factors potentially affecting abundance. It was found out that since the 1980s, the wild stocks have recovered in a synchronous cyclical pattern. The recovery occurred mainly in two jumps, first a sudden increase dating back to around 1990 and a second sharp rise in the late 1990s. The authors hypothesized that this positive development can be explained by a combination of both anthropogenic and non-anthropogenic factors operating at a large-scale and influencing survival and growth.

The offshore fishery started to decline at the time of the first increase while the reduction in the TAC together with seasonal restrictions on the coastal fishery strengthened the second increase. Improved natural conditions were suggested to have increased both survival and escapement during the first rise. Spawners producing the second rise were the offspring of the spawners of the first rise. The outbreak of the M74 mortality syndrome among alevins reduced the abundance of several year-classes that hatched during the first half of the 1990s. In most rivers, the fraction of older and female fish in the spawning run were found to had increased over the period, thereby increasing the reproductive capacity of the populations. No distinct effects of variations in river-specific management regimes were observed. Instead, the results emphasize the role of fisheries management in the open sea as well as in coastal waters and also of non-human factors in controlling overall abundance of wild salmon in northern Baltic rivers. A quantitative reconstruction of the stock history at different life stages and of the factors of interest were suggested by Romakkaniemi et al. to test this hypothesis.

Table 5.2.3.1 Summary of mark-recovery experiments with salmon spawners in the Swedish rivers Dalälven (Subdiv. 30) and Luleälven (Subdiv. 31). The experiments were carried out in year Y. Each experiment is related to the annual mean release of salmon smolts in year Y-1 to Y-3.

Year	River	Mean smolt	Spawners in river		Annual	% river exploitation	
		releases		% of smolt	river catch		
Y		(Y-1) to (Y-3)	N	release	N	Number	Weight
1993-95	Dalälven	117790	4004	3.40	1087	28.4-37.4	-
1996-98	Dalälven	164711	5592	3.40	2561	45.8-52.6	-
1996	Luleälven	575534	16502	2.87	6099	37.1	52.5
1997	Luleälven	552536	15428	2.79	7535	48.8	54.0
2001	Luleälven	530951	15780	2.97	9349	59.2	69.4
2001	Dalälven	233345	8228	3.53	3479	42.3	
2002	Dalälven	228816	8794	3.84	1758	20.0	



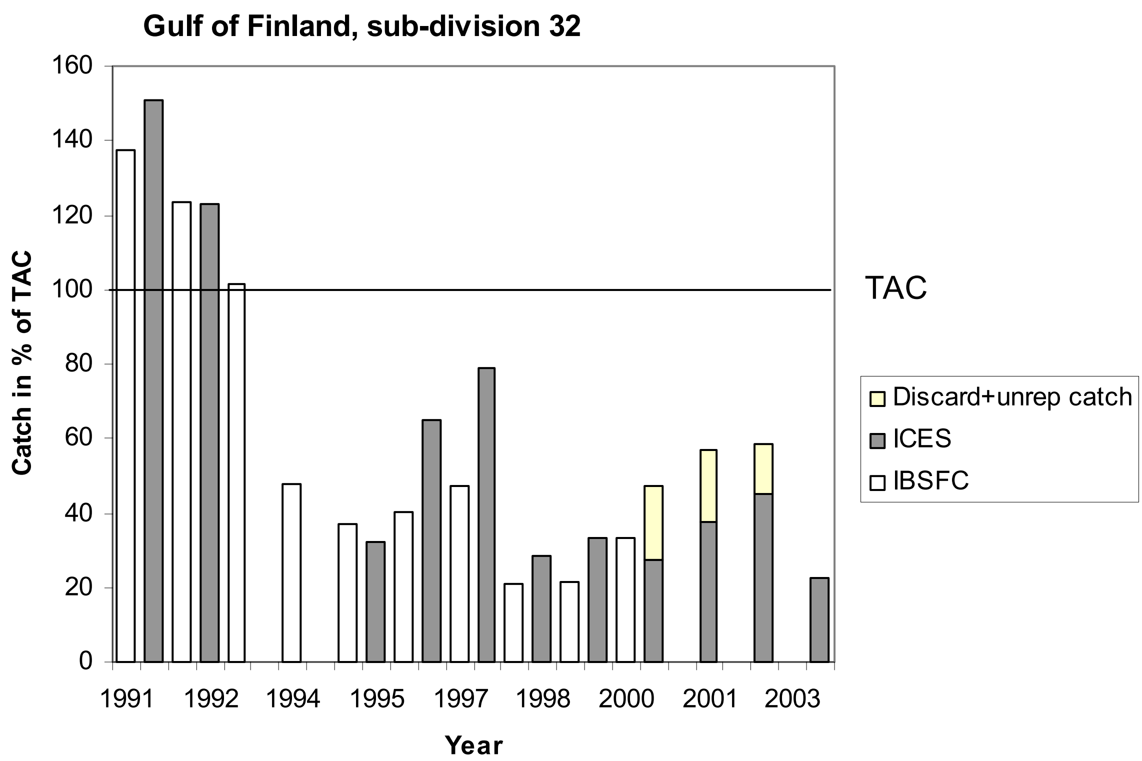


Figure 5.2.1.1 Catches of salmon in % of TAC according to IBSFC and ICES. Data on discard and unreported catch are added to ICES data in year 2000-02.

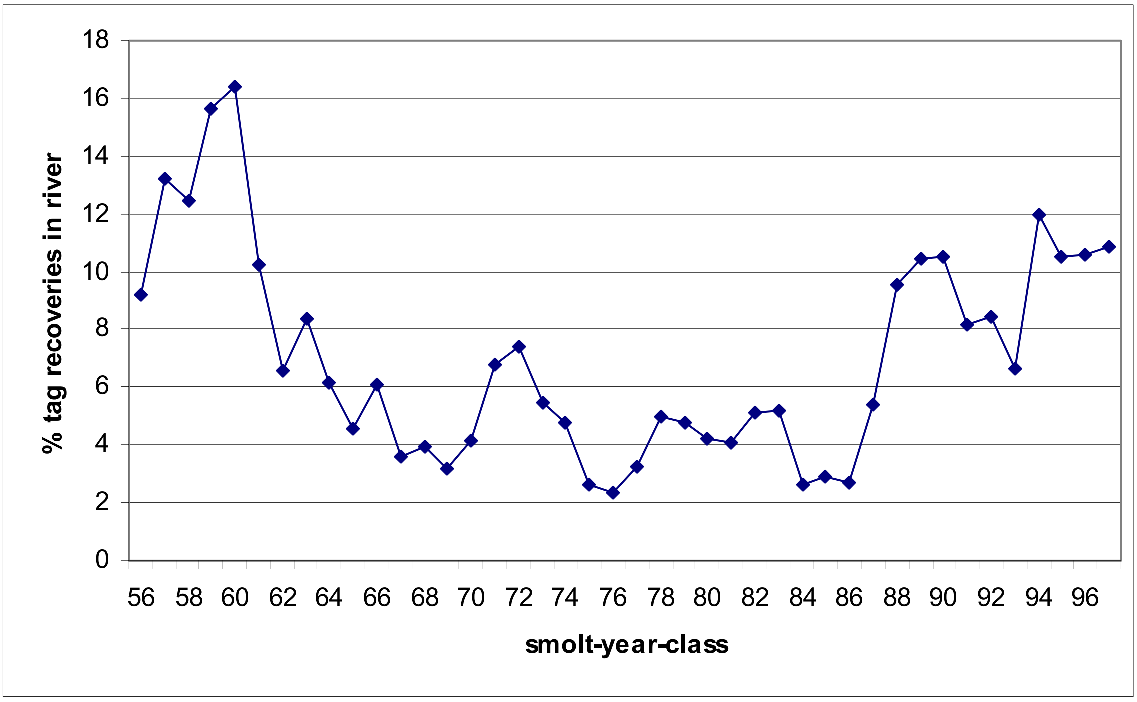


Figure 5.2.3.1 Percent of total tag recoveries in rivers from Swedish smolt releases in Gulf of Bothnia by year of release in years 1956-97.

6 REFERENCE POINTS AND ASSESSMENT OF SALMON IN MAIN BASIN AND GULF OF BOTHNIA (SUB-DIVISIONS 22-31)

6.1 Reference points for Baltic Salmon

Within the 2002 assessment, preliminary precautionary fishing mortality points F_{pa} had been calculated and applied. The descriptions of the methodology applied for the calculation of these reference points can be found in the 2002 WGBAST report. The stock-recruit parameters on which this fishing mortality rate reference points had been based, were obtained through an hierarchical meta-analysis of Atlantic salmon stock-recruit data (Michielsens and McAllister, 2004) due to the lack of stock-recruit data for Baltic salmon stocks. During the 2004 assessment, these preliminary reference points have been compared to the estimated exploitation rates for 2SW spawners but no recommendations have been based on them. Instead the objective of reaching 50% of the smolt production capacity by 2010 has been used (section 6.4.3).

In the ACFM advice of 2002, it was stated that behind the operational objective of meeting the 50% smolt production there are "*more fundamental aims, e.g. to safeguard the genetic diversity of the wild and reared stocks*". ACFM also requested that "*Managers and ICES together should consider these aspects of monitoring and development of management strategies, and include them, if considered to be relevant, in the terms of reference for future assessment working group meetings*". As there had been no discussions between the managers and ICES about the facts above and about the required management definitions, the WG in the 2003 report agreed to point out the need of more detailed and more operational definitions for the current management aims. Since there have still not been any discussions after the 2003 report, the need for redefinition of the management objectives is repeated in section 6.8.3.

6.2 Definition of assessment units within the Baltic Sea area

Within the Baltic Sea area, currently 6 different assessment units have been identified (Figure 6.2.1). The selection of rivers within an assessment unit is based on genetic and biological characteristics of the stocks contained in a unit and on management objectives. The genetic variability between stocks of an assessment unit is smaller than the genetic variability between stocks of different units. In addition, the stocks of a particular unit exhibit similar migration patterns. It can therefore be assumed that they are subjected to the same fisheries and experience the same exploitation rates. In addition to the genetic and biological considerations, the assessment units need to make sense from a management perspective.

The six assessment units in the Baltic Sea consist of:

1. Northeastern Bothnian Bay stocks, starting at Perhonjoki up till the river Kalix.
2. Western Bothnian Bay stocks, starting at Lögdeälven up to Råneälven
3. Bothnian Sea stocks, from Dalälven up to Gideälven and from Paimionjoki up till Kyrönjoki
4. Western Main Basin stocks
5. Eastern Main Basin stocks, i.e. stocks in Estonian, Latvian and Lituanian rivers
6. Gulf of Finland stocks

An overview of all the rivers covered by each assessment unit, can be found on Figure 6.2.2.

The current assessment only covers assessment areas 1 to 4. The Eastern Main Basin stocks and the Gulf of Finland stocks have different biological characteristics and different migration patterns compared to the stocks of assessment areas 1 to 4. Therefore their population dynamics would need to be expressed separately within the assessment model. These two additional assessment units will be incorporated within the model for the 2005 assessment.

6.3 Sea Life-History Model for assessing the exploition and abundance of Baltic salmon

Estimation Methodology

The same Bayesian mark-recapture methodology applied in the 2002 and 2003 assessments was also applied in the current assessment. A detailed description of this methodology can be found in annex 1. There have been several updates to the methodology in order to improve the accuracy of the results for the 2004 assessment.

During the 2002, 2003 assessments only 1 assessment area had been thoroughly covered. This had been due to the fact that tagging data for wild salmon are only available for the river Torne and the river Simo, both belonging to assessment area 1. Because of the prior assumptions in the model structure regarding the relationship between the wild and hatchery-reared salmon, the tagging data of wild salmon could only be used together with tagging data for hatchery-reared salmon from the same assessment area. The current assessment model however covers 4 different assessment units within the Baltic Sea area. Using tagging data of wild and reared salmon from assessment unit 1, the difference in post-smolt mortality and harvest rates between wild and reared salmon have been estimated. These differences in natural and fishing mortality rates have also been applied to assessment units 2 to 4 for which only tagging data for reared salmon had been available. The current assessment has excluded stocks of the Eastern Main Basin and stocks of the Gulf of Finland (assessment unit 5 and 6) since the different behaviour of these stocks would require a different model structure.

During the 2003 assessment, a first methodology, using Importance Sampling within a Visual Basic programme, had been proposed to be able to estimate absolute salmon abundances in addition to the abundance of tagged salmon. Due to limitations by version 1.3 of the WinBUGS software, it had not been possible to estimate abundances within the WinBUGS program. Using the new version 1.4 of the WinBUGS software it has been possible to estimate abundances directly in WinBUGS, thereby simplifying the assessment methodology and increasing the transparency. The population dynamics for the total abundance of salmon is expressed by the same abundance equations as the population dynamics for the abundance of tagged salmon. Both the total number of wild smolts (see annex 2) and the number of released hatchery-reared smolts are used as inputs into the model. In order to estimate salmon catches, the tag reporting rates within the catch equation for tagged salmon are replaced by the catch reporting rates. The main model outputs are the number of returning wild spawners and the number of reared spawners which are unable to spawn and which could be regarded as lost production.

The main assumptions in the current assessment model are:

1. Stocks of a particular assessment unit experience the same exploitation rates.
2. Exploitation rates between salmon stocks of assessment unit 1 to 4 mainly differ in terms of the exploitation rate by the coastal fisheries and coastal fishery exploits the salmon of assessment area 4.
3. The catchability coefficients for the different fisheries is assumed constant over the years.
4. The maturation rate (or homing rate) for wild grilse is lower than that of the hatchery-reared grilse (Kallio-Nyberg and Koljonen, 1997; Jutila et al., 2003).
5. The post-smolt mortality rate of hatchery-reared fish is higher than that of wild fish (Olla et al., 1998; Brown and Laland, 2001) and the differences in post-smolt mortality rates between wild and reared salmon for assessment areas 2 to 4 are the same as the differences between post-smolt mortality rates for wild and reared salmon of assessment area 1.
6. Post-smolt mortality rates differ from year to year (Salminen et al., 1995) in a similar way for both wild and hatchery-reared fish.
7. The instantaneous natural mortality rate for adult salmon is assumed to be the same for wild and reared salmon and constant over the years.
8. It is assumed that all adults die after spawning.
9. It is assumed that the number of salmon maulted by seals in coastal areas has increased annually by 5.5% between 1995 and 2001. Since 2003, the number of salmon maulted by seals in coastal trapnets has decreased by 20% due to improvements of the Swedish fishing gear (Finnish gear remained the same).

Data and parameter settings used within the assessment

The data and the parameter settings used in the assessment model have been reported according to guidelines provided by the ICES Working Group on Methods for Fish Stock Assessment (2004). For the current stock assessment, fishing effort data and tagging data have been used. The fishing effort figures are presented in table 3.3.1 of the working group report and the tables of released tagged salmon and recaptured tagged salmon have been reported in section 9. In comparison to previous assessments, the fishing effort data have been refined in order to obtain separate coastal fishing effort data figures for stocks of assessment unit 1 to 3.

For several of the parameters needed within the assessment methodology, data is limited (e.g. tag reporting rates) or not available (e.g. underreporting of catches). In such cases expert opinion is important. For each parameter within the assessment methodology, twelve experts have been asked to provide a most likely value and a minimum and maximum value during a meeting at Bornholm in 2003. These expert opinions were based on data obtained from previous studies done, on literature, on the experts' experience or were subjective expert estimations in case no information was available. Preliminary analyses, used for the formulation of prior probability distributions, included among others information from the broodstock fisheries, double tagging experiments (chapter 9), etc. Care has been taken to assure that the prior distributions were not based on data used within the mark-recapture model in order to avoid using the same data twice and rendering the results too informative. In general, the preliminary analyses gave often only a first indication of the model parameters but expert opinion needed to be used for example to extrapolate it to the entire Baltic Sea, or to other fisheries, etc. The use of multiple experts resulted in multiple priors for the different model parameters. Model parameters such as the reporting rates of tags are dependent on the country. As such, the probabilities distributions for each country have been weighted by the country's contribution to catches of wild and hatchery-reared salmon production and arithmetic pooling of the priors has been applied (Genest and Zidek, 1986, Spiegelhalter et al., 2004). For other priors for which each expert is assumed to have equal expertise, arithmetic pooling without weighting of the priors has been applied. A description of the different model parameters and their prior probability distribution has been provided in annex 1. Annex 1 also provides a separate table with the parameters which have been treated as known or fixed.

Results

The results from the assessment model have been reported according to guidelines provided by the ICES Working Group on Methods for Fish Stock Assessment (2004) and can be found in annex 1. Only the most important results will be reported here.

In general, the prior probability distributions for model parameters of hatchery-reared salmon have been updated considerably due to the informative tagging data for reared salmon. For wild salmon, the prior probability distributions for the homing rates and natural mortality rates, as provided by the experts, had not been updated much due to the fact that the priors had already been quite informative and the limited information available in the tagging data for wild salmon. The prior probability distributions for the catchability coefficients of wild salmon by the different fisheries had been updated to a larger extent due to the fact that the prior probability distributions had been very uninformative. This observation seems to indicate that the current results for the exploitation rates of wild salmon are influenced by the experts prior opinions about maturation rates and natural mortality rates but much less by the prior assumptions about the exploitation rates themselves.

The post-smolt mortality rates for wild and reared salmon have been allowed to differ randomly from year to year. The posterior probability distributions of the post-smolt mortality rates for wild and reared salmon, however, show a clear trend in mortality over the years (Figure 6.3.1). From 1998 onwards, the post-smolt mortality rates are on average higher than during previous years. The difference in post-smolt mortality rates between wild and hatchery-reared salmon have been kept constant while current expert opinion and results from genetic wild catch proportion estimates indicate that during resent years, the difference between post-smolt mortality for wild and hatchery-reared salmon might have increased. On average the survival during the last 5 years is half of the survival during the first five years of the time series.

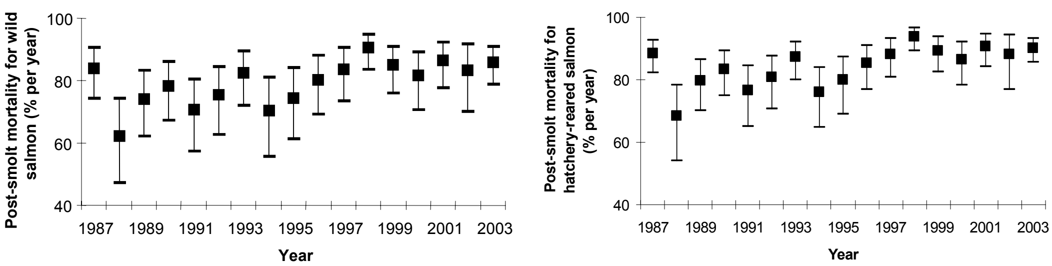


Figure 6.3.1 Annual estimates for post-smolt mortality rate (% per year) for wild and hatchery-reared salmon in the Baltic Sea area between 1987 and 2003 (medians and 95% probability intervals).

Figure 6.3.2 shows the total cumulative harvest rates for 2SW wild and hatchery-reared salmon from assessment areas 1 to 4. Posterior probability distributions for the total harvest rates for hatchery-reared salmon are higher and more informative than the posterior probability distributions for the total harvest rates for wild salmon. The total harvest rates for 2SW wild salmon of assessment units 1 to 3 are higher than the precautionary harvest rate reference point. The total harvest rate for 2SW wild salmon on average reaches the precautionary harvest rate point. This is due to the short migration route for stocks of assessment area 4, thereby avoiding the coastal fisheries. The posterior probability distributions for all the different model parameters can be found in annex 1.

Figure 6.3.3 shows the estimated abundance for wild and hatchery-reared salmon for assessment areas 1 to 4. The number of lost reared production refers to the number of reared salmon spawners that enter the river for spawning but are unable to reach the spawning grounds. Overall, the total abundance of wild spawners in each assessment area is going up until 2006 with the exception of the abundance in areas 3 (containing the river Ljungan) and 4 (containing

Mörrumsån and Emån). This indicates that although in general the abundance of wild salmon is going up, this is not necessarily the case for each individual salmon stock. Although salmon catches have declined since the early 1990's, the lost production does not show an increasing trend in lost production of hatchery-reared salmon. Instead the number of reared salmon production has declined since the end of the 90's. This is partly due to the higher post-smolt morality rates for reared salmon in recent years (Figure 6.3.1). The model also estimates the number of returning hatchery-reared salmon that are able to reproduce within the rivers. For assessment area 1, this number has increased considerably due to the large increase in the number of hatchery-reared salmon released in potential salmon rivers. These figures already indicate the model predicted spawner abundance up to the year 2006. Additional explanations about the assumptions for this forward projection of the salmon stock can be found under section 6.4 of the report.

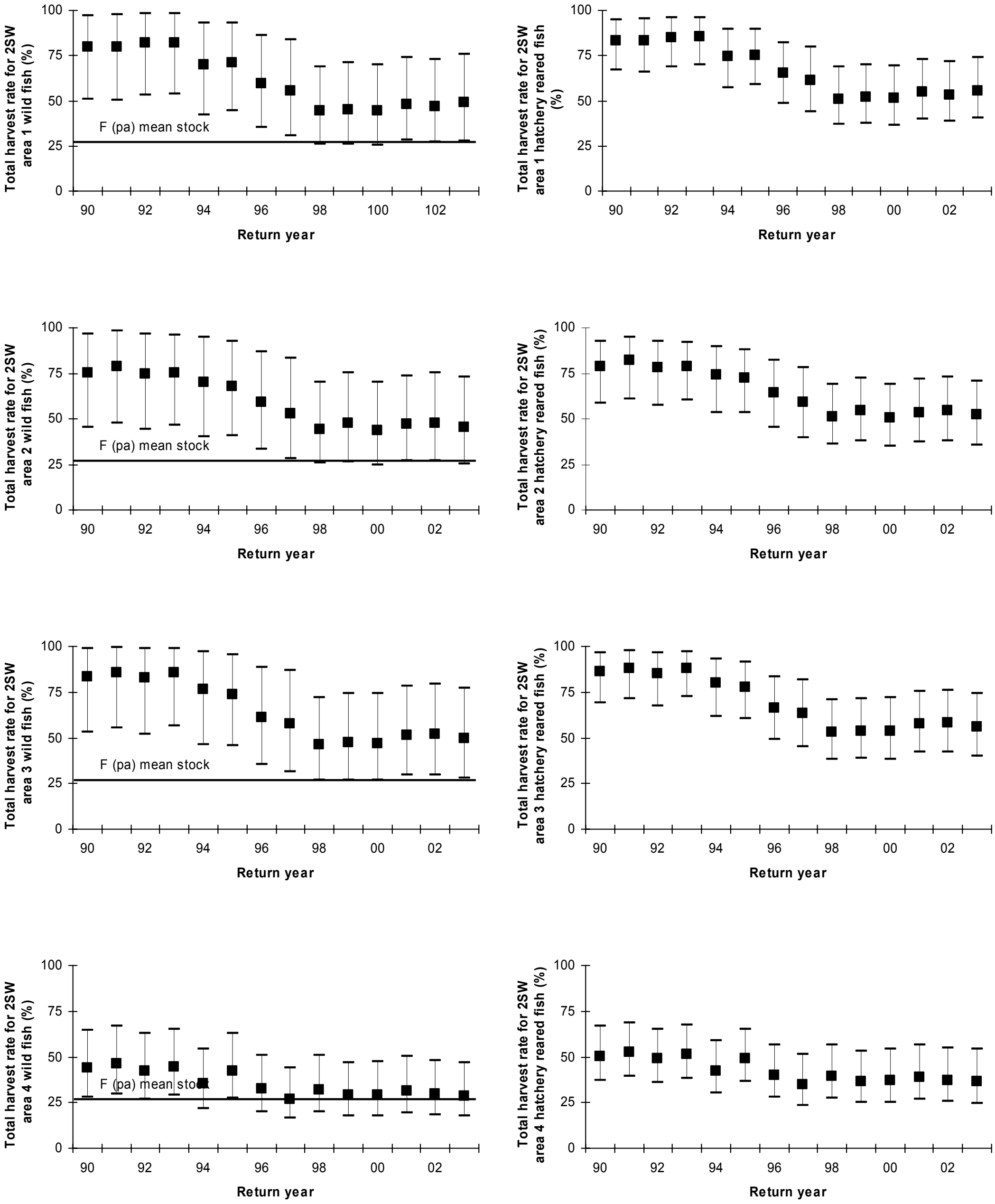


Figure 6.3.2 Median and 95% probability interval for the total cumulative harvest rate for wild and hatchery-reared 2SW salmon in assessment units 1 to 4 of the Baltic Sea area

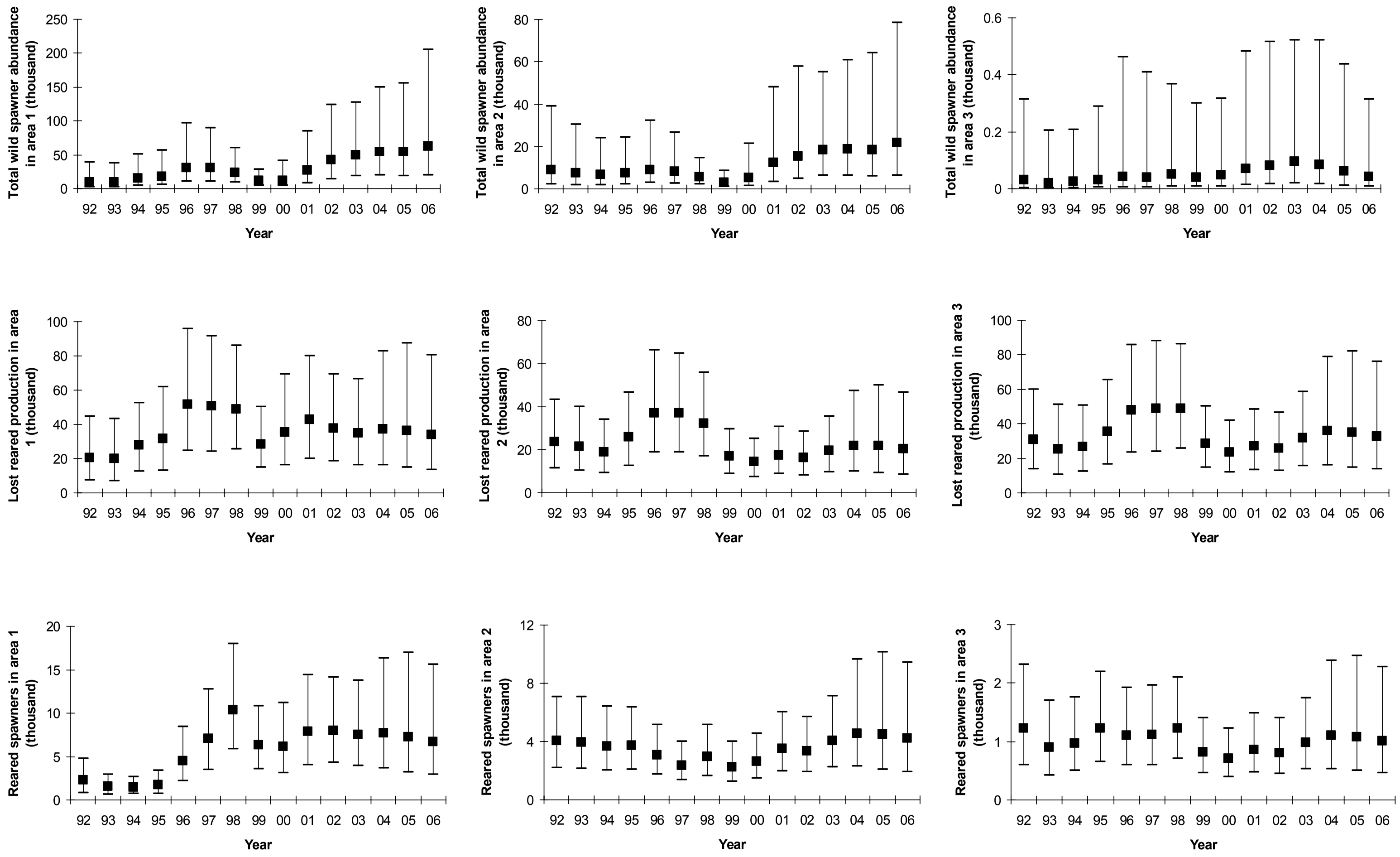


Figure 6.3.3 Estimates of wild and hatchery-reared spawner abundance for areas 1 to 3. The reared spawner abundance in dammed rivers where the salmon can not reproduce, are considered as lost production.

Diagnostics

The ICES Working Group on Methods for Fish Stock Assessment (2004) has provided important guidelines about the diagnostics used to evaluate Bayesian models. The results of the proposed diagnostics can be found in annex 1. Overall they indicate a good fit of the model to the data.

In addition to the technical diagnostic measures, the modelling results have also been compared to additional data series. Karlsson and Ragnarsson (2003) have analyzed additional tagging data for hatchery-reared salmon from the rivers Luleälven (located in assessment area 2) and Dalälven (located in assessment area 3) and calculated the percentage of retuning salmon. Therefore it is possible to compare the percentage of returning hatchery-reared salmon of assessment area 2 with the results obtained for the river Luleälven as described in the working group document by Karlsson and Ragnarsson (2003). The results for the river Dalälven can be compared to the results for hatchery-reared salmon of assessment area 3. Table 6.3.1 provides an overview of the results which indicate that the results of the assessment model correspond to additional available data regarding the % of returning hatchery-reared salmon.

Table 6.3.1 Comparison of the observed percentage of returning salmon in the river Dalälven and the river Luleälven obtained by Kalsson and Ragnarsson (2003) and the model predicted percentage of returning salmon obtained by the assessment model. The observations for the river Dalälven have been compared to the results for the stocks of assessment area 3 while the observations for the river Luleälven have been compared to the results for the stocks of assessment area 2.

Year	River	Returning salmon (%)		
		Observed	Model predicted	
		Mean	Mean	95 % PI
1993-95	Dalälven	3.40	5.12	2.70 - 8.30
1996-98	Dalälven	3.40	2.74	1.44 - 4.52
1996	Luleälven	2.87	3.94	2.02 - 6.61
1997	Luleälven	2.79	3.04	1.49 - 5.29
2001	Dalälven	3.53	2.15	1.00 - 3.90
2002	Dalälven	3.84	3.09	1.19 - 6.24

The results for wild salmon are more difficult to validate due to the lack of data about the percentage or the number of returning wild salmon in the rivers. Fish ladder data can provide an index of spawner abundance. There exist several problems related to the use of fish ladder data as a measure for the absolute number of wild spawners within a river. There may exist spawning grounds below the fish ladder, during some years there may not be enough water in the river, the salmon may not be able to find the fish ladder or the salmon may pass the fish ladder more than once. For the river Ume/Vindelälven, the proportion of spawners that find and pass the fish ladder has been estimated based on tagging experiments (Rivinoja and Leonardsson, unpublished). Table 6.3.2 indicates the observed number of spawners that pass the fish ladder, the corresponding number of spawners within the river and the model predicted spawner estimates. The results indicate that the observed number of spawners passing the fish ladder lies within the 95% probability interval for the model predicted spawner abundance, with the exception of the year 1992. For 6 years it has been possible to convert fish ladder estimates to total spawner abundance estimates based on the results from tagging experiments (Rivinoja and Leonardsson, unpublished). For the year 1999, the estimated spawner abundance falls outside the 95% probability interval for the model predicted spawner abundance. This may be among others due to the fact that the results for an entire assessment area have been compared to the results for one particular stock within the assessment area.

Table 6.3.2 Comparison of the observed number of wild salmon in the fish ladder of the river Ume/Vindelälven and the corresponding estimated number of spawners with the model predicted number of spawners for the river Ume/Vindelälven. The number of observed spawners in the fish ladder has been converted in the total number of spawners using the proportion estimates of Rivinoja and Leonardsson (unpublished).

year	Observed number	Spawner number	Model predicted Mean	Model predicted 95 % PI
1992	354	NA	4530	642 - 16830
1993	1663	NA	3679	624 - 12500
1994	1309	NA	2776	525 - 9080
1995	1164	NA	2845	583 - 9306
1996	1939	11406	3494	654 - 12050
1997	1780	6846	3031	599 - 9845
1998	1154	NA	1896	497 - 5204
1999	2208	6900	948.4	244 - 2760
2000	3367	NA	3266	464 - 13300
2001	5476	30422	9279	1485 - 32680
2002	6052	12351	11070	2087 - 37590
2003	2287	7147	10790	2676 - 31530

6.4 Stock projections

6.4.1 Effects of dioxine levels in Baltic salmon on the fishery, trading and sampling

The level of dioxine in salmon of the Baltic has been monitored by authorities in Sweden since 2000 and in Finland since 2001. The maximum level set for fish and fishery products is 4 pg WHO-PCDD/F-TEQ/g fresh weight (Council Regulation (EC) No 2375/2001). Overall levels tend to increase with size (sea age) of the salmon. In general the levels found are above the maximum EU level. The two countries have a dispensation from the EU until 2006 allowing national use of the salmon if dietary advice is given to the public. Export to other EU countries is not permitted.

During the spring of 2004, Danish authorities analysed samples from 30 salmon (5-7 kg), collected in December 2002. These salmon were all caught in ICES area 25. Analysis was done on two grouped samples for 20 (2 x 10) fish and on individual samples from 10 fish.

Dioxine level in these samples varied between 3.9 and 7.4 pg/g fresh weight. Due to these findings, the Danish authorities decided to ban commercial fishery in ICES areas 24 -32 and to put a ban on trading of salmon from this area from April 2004. Since this ban was based on analysis from a limited number of salmon, all being relatively large (5-7 kg), it was decided to do additional tests on salmon between 2 and 8 kg which will be collected during April 2004. Analyses are expected to be ready around June 2004, and after this it is expected that Danish authorities will reconsider a possible reopening of the fishery or possibly only a fishery for smaller salmon.

A large part of the catch of salmon in the Baltic area (i.e. also from other nationalities) has traditionally been sold to a company on the Danish island Bornholm. Since this is not possible after the ban, it is likely that the entire market for Baltic salmon will change, possibly influencing fishing effort. In addition to this, part of the sampling of biological information required by the European Union on length, age and weight composition of salmon landed at Bornholm by Swedish and Finish vessels has been carried out in collaboration with the trading company on Bornholm. This sampling will be discontinued with the termination of fishing and trading and the same is true for results on tagged salmon discovered at the trading company, which have been reported in detail for the last 18 months.

At the present time it is uncertain whether the dispensation given to Sweden and Finland for the national use of salmon (and other species) will be continued after 2006. Knowledge on this is essential for advice on the continuation of the release of salmon into rivers without spawning possibilities (compensatory releases), since an abrupt termination of the fishery could mean increased numbers of straying salmon into rivers with natural production. Strongly reduced release numbers, on the other hand, would endanger local populations of salmon and the law enforces mandatory compensatory releases.

6.4.2 Impact of the closure of Danish fishery and the ban on driftnet fisheries on future salmon abundances

The closure of the Danish fishery will have an effect on future salmon abundances and the impact of these measures need to be taken into account when projecting the stocks into the future. When evaluating the impact of the closure of the Danish fishery, it has been unclear if this closure would remain or if the Danish fishery would be opened again, possibly on smaller sized salmon. The closure of the Danish fishery would also mean the closure of Bornholm as a fish landing place. This would also affect other fishing fleets which have been landing salmon at Bornholm. It might not be possible to find national markets for the catch. In addition, Sweden and Finland have a dispensation until 2006 for catch and national marketing. At this time, it is unclear if the dispensation will be prolonged. Regarding the ban of driftnet fisheries, it is assumed by the working group members that the fishing fleets can quickly convert from driftnet to longline fishery and that the total catch would probably remain the same.

Because of the large amount of uncertainty about the salmon fishery and the fact that no long term projections are possible due to the lack of an updated stock-recruit function, no different scenarios regarding future management actions are taken into account when projecting the salmon population into the future. When projecting the salmon stocks into the future it is assumed that the fishing effort by the different fisheries does not change and that the post-smolt mortality rates are similar as during the last 5 years. For the 2005 assessment, longer term projections are planned under different scenarios about future management actions and different states of nature. By that time the stock-recruit function will be updated and there may be a clearer picture of the future of the Baltic salmon fishery.

6.4.3 Evaluation of the probability of reaching 50% of the smolt production capacity by 2010

The smolt abundance model (section 4.2.3) estimates the smolt abundance until 2005 for the 4 different assessment areas. Using the current assessment model, it is possible, based on these smolt abundance estimates, to estimate the total number of spawners up to 2006 for the 4 different assessment areas. It is therefore possible to examine the association between the estimated number of spawners within each assessment area with the number of estimated wild smolts produced 4 years later (e.g. the number of estimated spawners in 1991 produces the number of wild smolts as estimated for 1995). By associating the estimated number of spawners with the number of smolts, it is possible to get an idea of the possible spawner-smolt relationship within the Baltic. However, the proportion of females among grilse is only a few percentages. Using the number of MSW spawners instead of the total number of spawners would give a better indication of the reproductive capacity of the spawning population. Therefore instead of using the total estimated number of spawners, the estimated number of MSW spawners is used to obtain an indication of the Baltic salmon stock-recruit relationship for the different assessment areas. The association of MSW spawner estimates with smolt estimates is illustrated by Figure 6.4.1 for assessment area 1. On the graphs, both the medians and the 95% probability intervals are indicated. Future references about the number of spawners within the stock-projection methodology will refer to the number of MSW spawners.

Using the perceived relationship between the estimated number of MSW spawners and the estimated number of smolts 4 years later, could provide a first update of the stock-recruit function of Atlantic salmon stocks (Michielsens and McAllister, 2004) for Baltic salmon data. This method however would be rather ad hoc since in reality, several years of spawners produce the number of future smolts. An update of the stock-recruit function has therefore not been undertaken for the 2004 assessment but instead is proposed for the 2005 assessment. Neither has the stock-recruit function for Atlantic salmon stocks been used since it was deemed to uninformative and would need to be updated for Baltic salmon.

Without the use of a stock-recruit function, it is not possible to predict the number of smolts beyond the year 2005. However, based on wild smolt prediction estimates for assessment areas 1 to 4 up to 2004 it is possible to predict the total number of wild MSW spawners for the year 2006. The total number of wild spawners in 2006 will determine the number of smolts produced in 2010, which is the current reference year for the assessment of reaching 50% of the smolt production capacity. It is therefore possible to compare the predicted number of spawners with the number of spawners in earlier years and relate it to the possible number of smolts that could be produced.

Instead of associating the model predicted spawner estimates to the smolt abundance estimates, it is also possible to associate them to the probabilities of reaching 50% of the smolt production capacity. By comparing the predicted spawner abundance for 2006 with the estimated number of spawners for previous years, it is possible to make some qualitative inference about the probability of reaching 50% of the carrying capacity for the different assessment areas by 2010, even without an actual prediction of the smolt production by 2010. This is illustrated by Figures 6.4.2 and 6.4.3 for assessment areas 1 to 4 and by Figure 6.4.4 for the rivers Ume/Vindelälven and Rickleån, both belonging to assessment area 2.

Evaluation of reaching 50% of the smolt production capacity by 2010 for assessment units 1 to 4

Figures 6.4.2 and 6.4.3 associate the model predicted spawner estimates to the probability of reaching 50% of the smolt production capacity. The medians of the spawner abundances estimates have been linked within the graph to give an indication of the chronological change in the probability of the smolt production to reach 50% of the smolt production capacity. The graphs show both the medians and the 95% probability intervals for the spawner abundances. The probability of reaching 50% of the carrying capacity on the other hand, is an exact value and does not have any uncertainty. Hence the absence of probability intervals for the probability of reaching 50% of the smolt production capacity. The last probabilities indicated on the graph, are the probabilities of reaching 50% of the smolt production capacity in 2005. For example for assessment area 1, during the first years of the time series, spawner abundances were low and M74 mortality was high, hence the indication of a low spawner abundance and low probability of reaching 50% of the smolt production capacity. Later in the time series, both spawner abundances and the probability of reaching 50% of the smolt production capacity increased.

In order to make some inference about the probability of reaching 50% of the smolt production capacity by 2010, the graphs also shows the median (or 50th percentile) of the spawner abundance estimates for 2006 together with the 10th percentile. In case of assessment area 1, the median spawner abundance for 2006 is higher than the median spawner abundance of previous years. In addition, the 10th percentile of the spawner abundance estimates for 2006 is higher than several medians for the spawner abundances in previous years. For assessment area 1, this indicates that the probability of reaching 50% of the smolt production capacity by 2010 will probably be larger than the probability estimates in the past for assessment area 1. The stocks of assessment area 2 show a similar pattern as those of assessment area 1. Assessment area 3 consists of only 1 river, namely the river Ljungan. The median percentile of the estimated spawner abundance in 2006 is smaller than seen previously in the data series. This indicates that the smolt production is unlikely to exceed the higher smolt production figures of the past and that the probability of reaching 50% of the smolt production capacity by 2010 will be low. For assessment area 4, containing rivers Mörrumsan and Emån, the probability of reaching 50% of the smolt production capacity by 2010 will be high.

Evaluation of reaching 50% of the smolt production capacity by 2010 for individual salmon stocks

The previous Figures evaluated the probability of reaching 50% of the smolt production capacity by 2010 for all the stocks of the same assessment area combined. Assessment area 1 and 2, however consist of several wild salmon stocks. Even though the probability of reaching 50% of the smolt production capacity by 2010 for the entire assessment area may be high, some of the stocks of those assessment areas may have a low probability of reaching this reference point.

In section 4.2.3, the probability of reaching 50% of the smolt production capacity by 2010 had been calculated for different salmon stocks. From this analysis it became clear that the rivers of assessment area 1 are doing rather well in terms of reaching the 50% management objective. The situation is much more variable within assessment area 2. Figure 6.4.4 presents the association between the numbers of MSW spawners as estimated by the assessment model and the probability that the smolt production reaches 50% of the smolt production capacity for the river Ume/Vindeälven. The median number of spawners for 2006 is higher than the medians for the spawner abundances in earlier years. Even the 2.5th percentile of the probability distribution for the spawner abundance in 2006 is larger than the medians of certain other years. This indicates that it is highly likely that the smolt abundance in 2010 will high. In contrast, for the river Rickleån the probability of reaching 50% of the smolt production capacity has been very low in the past. Given the limited change in spawner abundance before 2005, the smolt production is unlikely to reach the 50% management goal by 2010.

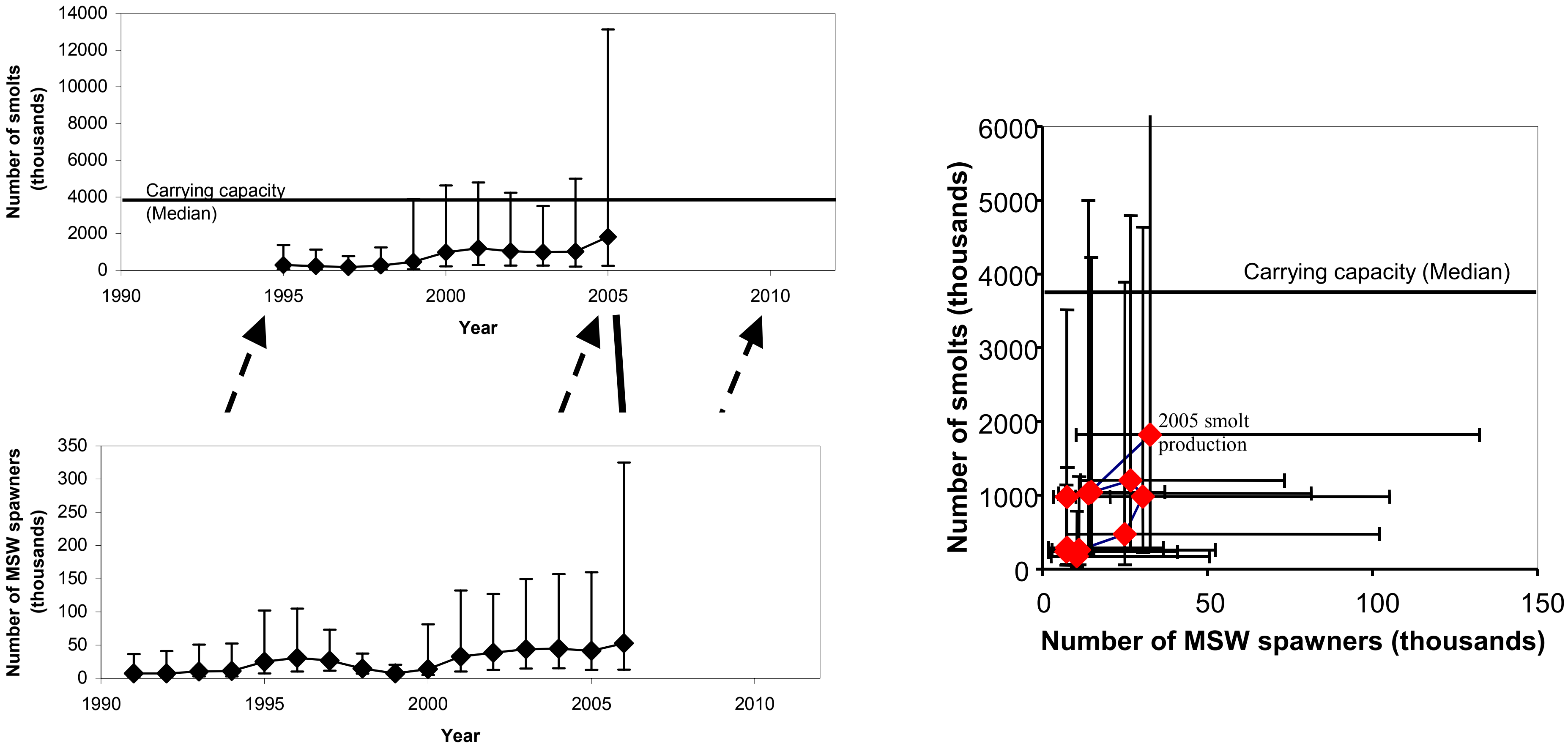
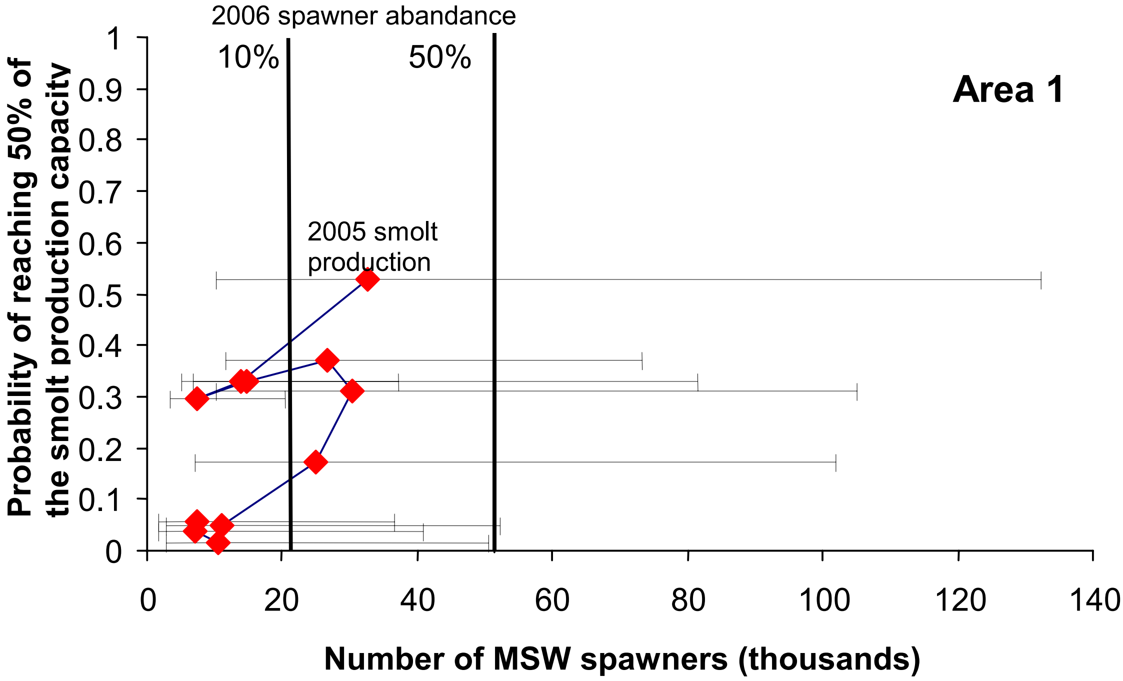


Figure 6.4.1 A diagram showing how the spawner/ smolt graph (right panel) has been constructed to illustrate the apparent positive association between the estimated number of MSW spawners in an assessment area (upper left panel) and the numbers of smolts (lower left panel) resulting from their spawning four years later (dotted arrows). The number of spawners entering the rivers in each year are predicted by the sea model (solid arrow). The number of MSW spawners in 2006 are expected to produce the smolts leaving the rivers in year 2010. The current model structure does not yet link the number of spawners to the resulting smolt numbers since no stock-recruit function has been used. In the right panel the yearly median number of spawners are linked to indicate their chronological order. The graphs show both the medians and the 95% probability intervals.



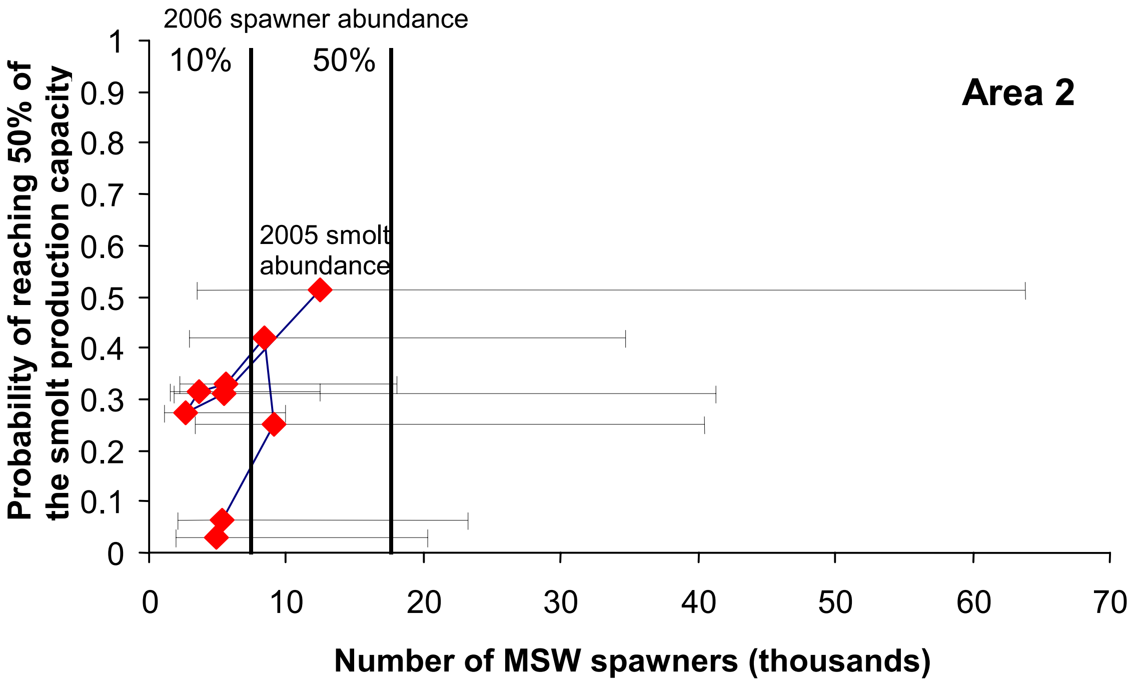


Figure 6.4.2 Association between the number of MSW spawners as estimated by the sea model and the probability of the smolt production to reach 50% of smolt production capacity as estimated by the smolt abundance model for assessment areas 1 and 2. The number of spawners in each particular year is associated with the probability of reaching 50% of the smolt production capacity four years later. The yearly median numbers of spawners are linked to indicate their chronological order. The graphs show both the medians and the 95% probability intervals for the number of MSW spawners. The vertical lines indicate the 50th percentile (or median) and the 10th percentile of the probability distribution for the spawner abundance in 2006. By comparing the predicted spawner abundance for 2006 with the estimated number of spawners for previous years, it is possible to make some qualitative inference about the probability of reaching 50% of the carrying capacity for the assessment area by 2010, even without an actual prediction of the smolt production by 2010.

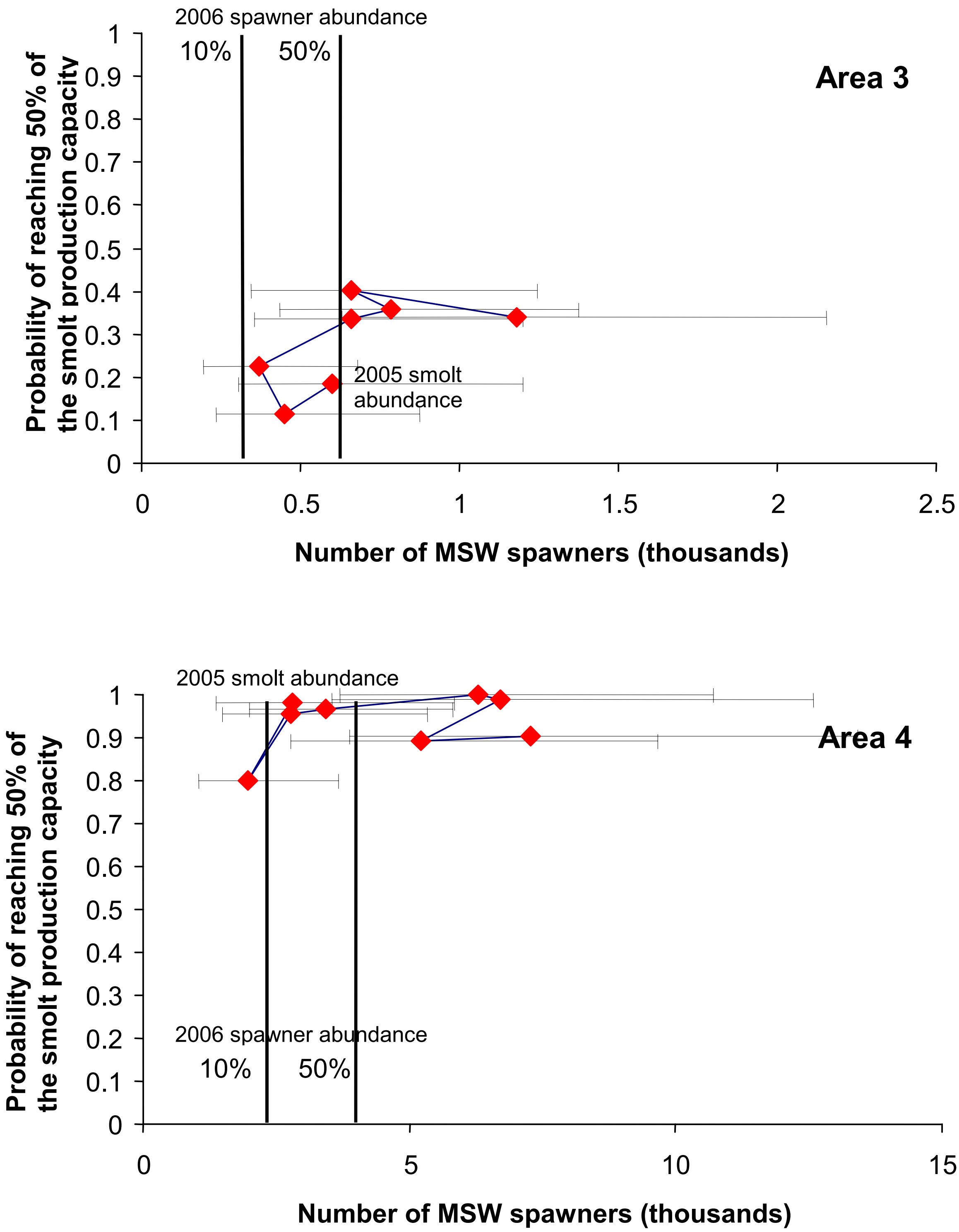
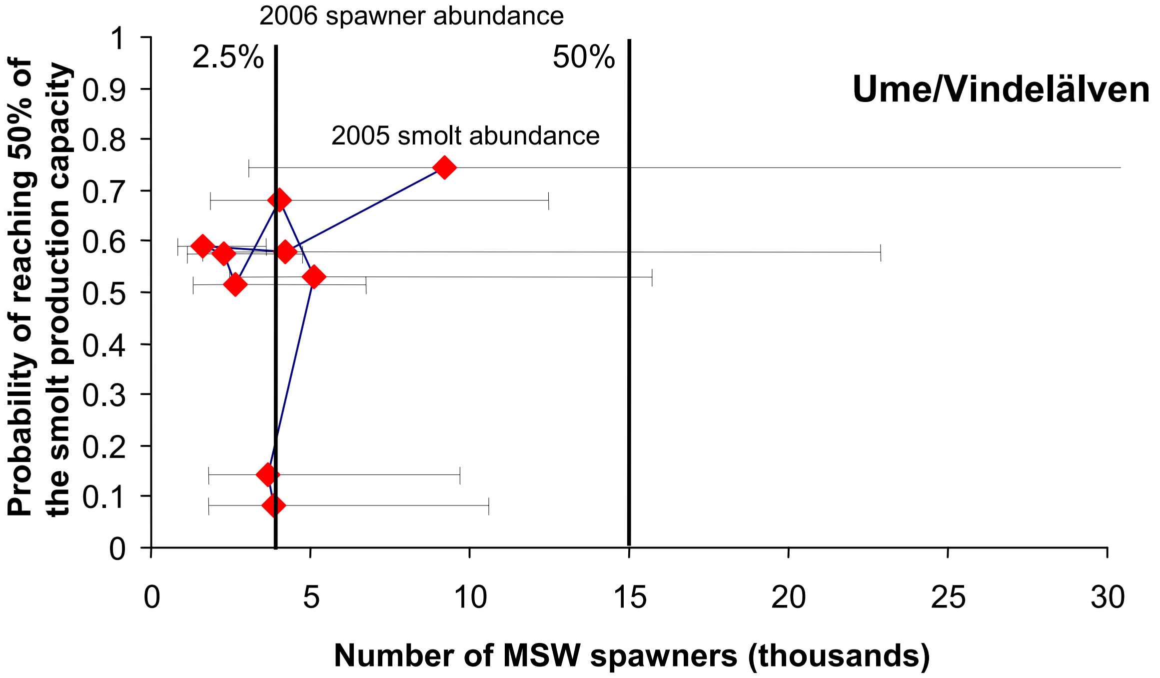


Figure 6.4.3 Association between the number of MSW spawners as estimated by the assessment model and the probability of the smolt production to reach 50% of smolt production capacity as estimated by the smolt abundance model for assessment areas 3 and 4. The number of spawners in each particular year is associated with the probability of reaching 50% of the smolt production capacity four years later. The yearly median numbers of spawners are linked to indicate their chronological order. The graphs show both the medians and the 95% probability intervals for the number of MSW spawners. The vertical lines indicate the 50th percentile (or median) and the 10th percentile of the probability distribution for the spawner abundance in 2006. By comparing the predicted spawner abundance for 2006 with the estimated number of spawners for previous years, it is possible to make some qualitative inference about the probability of reaching 50% of the carrying capacity for the assessment area by 2010, even without an actual prediction of the smolt production by 2010.



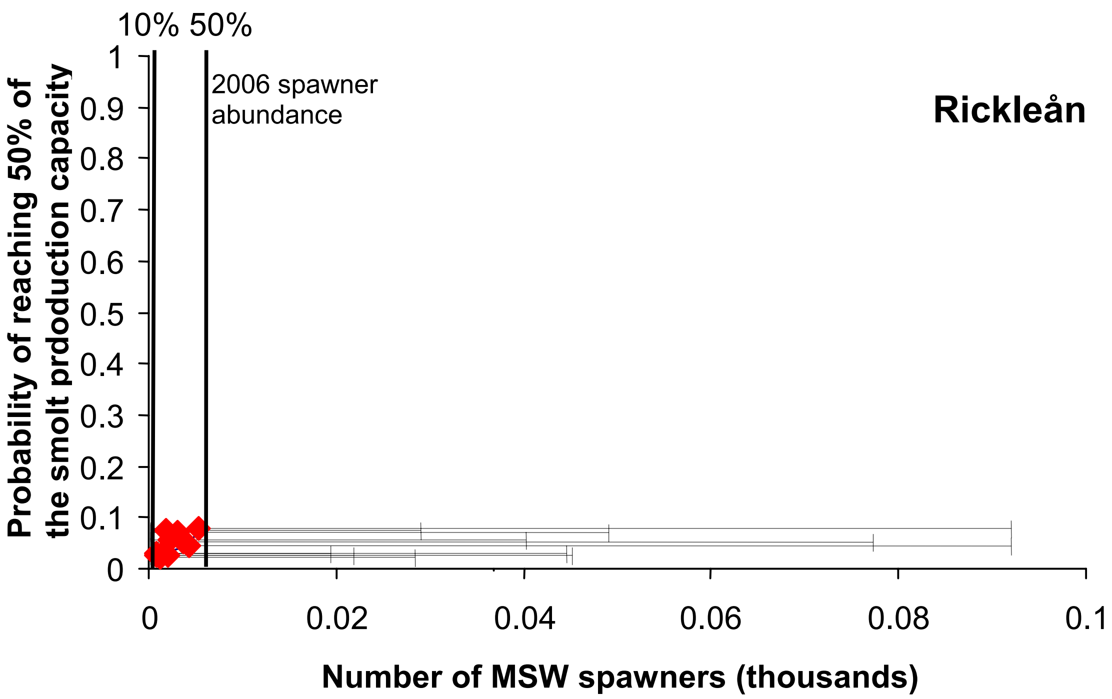


Figure 6.4.4 Association between the number of MSW spawners as estimated by the assessment model and the probability of the smolt production to reach 50% of smolt production capacity as estimated by the smolt abundance model for the river Ume/Vindelälven and the river Ricklean, both belonging to assessment area 2. The number of spawners in each particular year is associated with the probability of reaching 50% of the smolt production capacity four years later. The graphs show both the medians and the 95% probability intervals for the number of MSW spawners. The vertical lines indicate the 50th percentile (or median) and the 10th percentile of the probability distribution for the spawner abundance in 2006. By comparing the predicted spawner abundance for 2006 with the estimated number of spawners for previous years, it is possible to make some qualitative inference about the probability of reaching 50% of the carrying capacity for the assessment area by 2010, even without an actual prediction of the smolt production by 2010.

6.4.4 Conclusions from the stock assessment

The results of the assessment model indicate that the post-smolt mortality has increased during the 90's and remained at high levels since 1998 (Figure 6.3.1). The total exploitation rates on wild and reared salmon on the other hand have decreased since the mid 90's (Figure 6.3.2). Due the high post-smolt morality rates, this has not resulted in a similar increase in the number of lost production, i.e. hatchery-reared salmon that return to the rivers to spawn but are unable to reach the spawning grounds (Figure 6.3.3). For the wild salmon populations of assessment areas 1, the smolt production in the beginning of the 90's had been hampered by high M74 mortality rates (Table 4.5.1). The decrease in the exploitation of wild salmon in the mid 90's (Figure 6.3.2) resulted in an increase in wild spawners (Figure 6.3.3) and an increase in the number of smolts produced near the turn of the century (Figure 6.4.1). Once these smolts were ready to spawn, the M74 mortality had gone down, resulting in high smolt predictions, and the subsequent high spawner abundance for 2006 (Figure 6.4.1). As a whole the stocks of assessment area 1 are therefore in a comfortable position when evaluation the probability of reaching 50% of the smolt production capacity by the year 2010 (Figure 6.4.2).

Overall, the stocks of assessment area 2 have seen a similar development. The main difference between stocks of assessment area 1 and assessment area 2 is that assessment area 2 also contains some weak stocks, i.e. stocks which did not show such a clear response to changes in exploitation rates (Figure 6.4.4). In river Rickleån for example it is highly unlikely that 50% of the smolt production capacity will be reached by 2010 (Figure 6.4.4). Overall, the weaker stocks of assessment area 2 and assessment area 3 (containing only river Ljungan as a wild stock) are the most at risk of not reaching 50% of the smolt production capacity by 2010. Management actions should be taken that would relieve the fishing pressure on wild stocks of assessment areas 2 and 3.

It is highly likely that the smolt production of stocks of assessment area 4 will remain at levels higher than 50% of the smolt production capacity by 2010 (Figure 6.4.3). Although the overall exploitation rates have decreased (Figure 6.3.2), these stocks however have seen a decrease in the number of spawners and corresponding smolt numbers (Figure 6.4.3 and section 4.2.3). This can partly be explained by the increase in post-smolt morality (Figure 6.3.1).

Using the current assessment methodology, it has been for the first time possible to assess the probability of reaching 50% of the smolt production capacity. Due to limitation in the future projections of the stocks, currently it is only possible to make some qualitative inferences about the probability of reaching the target. For example, it is possible to say that the probability that the river Ume/Vindelälven reaches 50% of the smolt production capacity by 2010 is high while for the river Rickleån it will be highly unlikely (Figure 6.4.4). Once the stock-recruit function has been updated and it is possible to predict the actual smolt abundance in 2010, it will be possible to give exact figures for these probabilities.

The current assessment methodology tries to give a realistic indication of the uncertainty within the estimates for both the smolt production capacity and the smolt abundance estimates (section 4.2.3). As a result, there is considerable uncertainty in the estimates of the smolt production in comparison to the smolt production capacity. In case of very large uncertainties in the estimates of both the smolt production and the carrying capacity, the probability of reaching 50% of the carrying capacity by 2010 will be close to 50%, i.e. we are unable to say if things are improving or not. This has major consequences for the management advice. The probability of reaching 50% of the smolt production capacity by 2010 can not only be improved by trying to improve the wild salmon populations but also be improving the assessment of the population. By reducing the uncertainty in the smolt production estimates and the estimates for the carrying capacity, it is possible to give a clearer indication of whether a stock will reach 50% of the smolt production capacity by 2010 or not. The IBSFC objective states that the production of wild Baltic salmon needs to reach 50% of the smolt production capacity by 2010. This would mean that the probability to reach 50% of the smolt production capacity would need to be 100%. When evaluating the advice based on the current methodology, it should be taken into account, that 100% might be an impossible objective to reach, especially for some of the smaller stocks for which limited information is available and the uncertainty in the abundance estimates is large.

The current assessment methodology is still in the development face and there are still several pieces of information which are planned to be used to increase the accuracy of the projection estimates e.g. catch data, spawner index data from the fish ladders or the broodstock fishery, genetic stock proportion estimates, etc.

6.5 Uncertainties affecting the assessment results

6.5.1 Uncertainties regarding the data

The main information on the exploitation of wild salmon in the Baltic comes from mark-recapture data. The problem with these data is that it is geographically biased. Furthermore, only a limited number of wild salmon have been tagged. As a consequence, the number of returned tags have been scarce and the corresponding information for wild salmon at sea limited. For recent years, no Swedish tagging data have been available. This seemed to have also changed the reporting rates of Finnish tags by Swedish fishermen, thereby affecting the quality of the remaining tagging data.

Regarding fishing effort, no data have been available for the Polish offshore fisheries and the Swedish coastal fisheries by other gears (predominantly gillnet fisheries) for the entire time series. The Polish effort data have been estimated based on the CPUE of the offshore fisheries by other countries and data for the Polish salmon offshore catches. Within the Polish fishery, salmon and trout are caught jointly and a more appropriate conversion of CPUE figures to fishing efforts would be obtained when using the combined Polish salmon and trout catch figures. These figures had not been available for the entire time series but have been promised for the 2005 assessment. A similar approach has been used to estimate the fishing effort data for the Swedish coastal gillnet fishery. The Finnish CPUE in the coastal gillnet fishery has been used in combination with the catch data for the Swedish coastal gillnet fishery in order to estimate the Swedish fishing effort by coastal gillnets. In addition, the WGBAST data base contained also some missing records. The missing records of fishing efforts have been estimated based on the reported catch data for those records and the CPUE for the salmon caught during the same period by the same fishery and fishing fleet. No uncertainty has been accounted for in the calculation of missing fishing effort. The uncertainty of the fishing effort figures, as reported by the fishermen, has been estimated through expert opinions (section 3.10).

Within the assessment model, the uncertainty in the effort figures have been incorporate by using a state-space formulation of the mark-recapture model and by including errors on the fishing effort in the process error. However, in the future the uncertainty in the fishing effort data could be incorporated more explicitely within the model, based on the estimates as provided by experts.

6.5.2 Uncertainties expressed by the prior probability distributions of the model parameters

Prior probability distributions for the model parameters have been provided by 12 experts based on previous studies done, on literature, on the experts' experience or were subjective expert estimations in case no other information was available. Table of all prior probability distributions are provided in annex 1. With exception of the prior probability distributions of the catchability coefficients, the prior probability distributions for the model parameters have been given rather informative distributions. The prior probability distributions for hatchery-reared salmon are updated substantially and sensitivity analyses did not indicate that the prior probability distributions restricted the posterior probability distributions inappropriately. The prior probability distributions for wild salmon have not been updated much, thereby increasing the importance of the expert opinion. Sensitivity analyses of the maturation rates have indicated the importance of the informative priors for maturation rates for 3SW and 4SW fish. When using uninformative prior probability distributions for the maturation rates of 3SW and 4SW wild salmon, the posterior probability distributions are hardly updated and allow for maturation rates which are assumed impossible by experts.

The use of informative prior probability distributions for the population parameters have been used to update the uninformative prior probability distributions for the catchability coefficients for the different fisheries. The uninformative prior probability distributions for the catchability coefficients for wild salmon by the different fisheries have been updated substantially. It can therefore be stated that expert opinion about the population parameters in combination with mark-recapture data have been used to estimate the exploitation rates of wild salmon.

6.5.3 Uncertainties regarding the model assumptions

One of the key assumptions within the assessment methodology is that there are some similarities between wild and hatchery-reared salmon. Within the Baltic Sea area, the wild population is closely related to the hatchery-reared population since the returning wild spawners are used as broodstock in the hatcheries. Although wild and hatchery-reared fish show somewhat different life histories (Kallio-Nyberg and Koljonen, 1997; Jutila et al., 2003), certain population parameters can be regarded as similar or related. This assumption has been used extensively for the analysis of mark-recapture data. Because of the limited availability of mark-recapture data for the wild population, the necessary linkages between life history parameters for wild salmon and those for hatchery-reared salmon may however be too strong. For example, post-smolt mortality rates can vary substantially from year to year due to variable marine conditions that affect the growth rate of the fish and thereby its vulnerability (Salminen et al., 1995). Within the mark-recapture analysis the post-smolt mortality rates are allowed to differ from year to year, while at the same time allowing for a higher post-smolt mortality rate for hatchery-reared fish than for wild fish (Olla et al., 1998; Brown and Laland, 2001). However, it is assumed that the post-smolt mortality rates differ yearly in a similar way for both wild and hatchery-reared fish. This may be an oversimplification with major implications considering the large impact of the post-smolt mortality rates on the overall survival of the fish. Removing or loosening up these links between wild and hatchery-reared fish would result in an overparameterised model for wild salmon, whereby the parameter estimates reflect more the information from the priors than the information contained in the data. On the other hand, by linking the model parameters for wild and hatchery-reared salmon, the information contained in the mark-recapture data set for hatchery-reared salmon can help in the estimation of model parameters for wild salmon. This will reduce the uncertainty in the parameter estimates but it can also cause them to be biased. Given the limited amount of mark-recapture data for wild salmon, there is no point asking if it is valid to use the mark-recapture data of hatchery-reared fish to help estimate the status of the wild populations. The question is rather, if the right life-history parameters have been linked and if the assumptions, made about the similarities between the life-history parameters for wild and hatchery-reared salmon, are valid.

In addition to the assumptions about the similarities between wild and reared salmon, there are also a whole range of assumptions made to simplify the assessment model but which are known to be incorrect. The catchability coefficient for some fisheries has changed over time. The number of second time spawners are currently estimated to contribute 5% of the spawners. This has not been accounted for within the assessment model.

6.5.4 Uncertainty regarding model structure

No model uncertainty has been taken into account yet. In the future, the current model could be regarded as the base case model structure and different models, based on different sets of assumptions, could be regarded as alternative model structures. Once different model structures are set up, it is possible to calculate the goodness of fit of the different models to the data and model averaging could be applied (Hoeting et al., 1999).

6.5.5 Uncertainties regarding the software

The stock assessment model is run using WinBUGS 1.4 (Bayesian inference Using Gibbs Sampling) software (http://www.mrcbsu. cam.ac.uk/bugs) (Thomas et al., 1992). This is a freely available and user friendly software based on Markov Chain Monte Carlo (MCMC) simulation techniques used to approximate the posterior probability distributions. Models developed in WinBUGS can be described in relatively few lines compared to other programming software and/or can be presented in a graphical format. The general nature of the program and its user-friendly interface mean that for some modelling applications the algorithms can be rather slow compared to custom written algorithms.

Although user-friendly, the use of WinBUGS requires good understanding of Bayesian statistics, requiring additional training of working group members. The current working group contains five experts at Bayesian statistics of which four are also WinBUGS experts. In addition, three members have attended a WinBUGS course.

6.6 Methodological updates of the assessment

Since the 2002 assessment, there have been ongoing efforts to update and improve the stock assessment methodology for Baltic salmon. There exist several concrete plans to improve the current methodologies in the future.

6.6.1 A Bayesian data imputation approach for filling in missing effort data

For some countries no fishing effort data have been available for the entire assessment period. The effort figures have therefore been estimated based on the assumption that the CPUE for the fisheries of these countries are the same as the CPUE of other countries fishing in the same areas using the same gears. This is of concern because the assessment model relies on having an accurate time series of changes in fishing effort by gear type in order to estimate fishing mortality rates by fleet and year.

In the COMMIT and EFIMAS EC projects, which have Baltic salmon as one of the three case study species, it is intended that work will be undertaken to improve annual historic estimates of fishing effort, particularly those of Polish salmon and sea trout fishing fleets. It is proposed that Bayesian data imputation (Meng 1994; Kadane and Terrin 1997; Clarke, 2003) would be applied. This approach readily takes into account uncertainty in values for parameters in models that are applied to impute missing datapoints. It also takes into account structural information in the available data and information available about the missing cells to fill in values in the missing cells. Rather than filling in missing values by point values, probability density functions for missing values are provided instead. This way, all available information is used to impute missing values and at the same time, the uncertainty in the imputed values can be assessed and taken into account by inspecting the spread of the pdfs of the imputed values. If uncertainty is substantial (e.g., the coefficient of variation is more than 20%), then the statistical analyses that utilize effort values may treat fishing effort as a random variable with a posterior predictive distribution, rather than as a fixed value.

6.6.2 Using genetic stock proportion estimates within the assessment

In order to compensate for the limited data on wild Baltic salmon, the current assessment methodology relies on key assumptions about the similarities/differences between wild and hatchery-reared salmon stocks in order to obtain reliable estimates of the exploitation rates of the wild salmon stocks. These assumptions allow the use of the information contained in the tagging data of hatchery-reared salmon for the assessment of wild salmon stocks. In order to update the prior beliefs about these linkages, more empirical evidence is needed. Such an evidence will be obtained by comparing the proportions of smolts coming from different rivers to proportions of those fish found in the catch.

Within the Baltic Sea area, currently 6 different assessment units have been identified. By using genetic stock proportion estimates it is possible to assign catches to the wild or hatchery-reared component of the different assessment areas. For example for area 1, it is possible to estimate the total catch of wild salmon from the river Kalix, Torne and Simojoki. This information can then be used in combination with the total wild smolt production estimate of these rivers to estimate the exploitation rate at sea of this stock group, based on the assumption that stocks in the group experience similar exploitation rates due to their close geographical location and similar migration patterns. Thus, the genetic stock proportion estimates would reduce the uncertainty in the exploitation rates and abundance estimates for these wild salmon stocks. Similar methodology can also be applied to the other assessment areas. For example, data from wild salmon stocks of area 2 is currently limited to parr density estimates. These estimates have been used to produce smolt production estimates based on the relationship found in other rivers between fish densities and corresponding smolt abundances (Mäntyniemi *et al*., 2003). Apart from this river information, the only information available to estimate the exploitation rates for the wild salmon stocks at sea, are the tagging data for hatchery-reared salmon from stocks of the same assessment area. The hatchery-reared salmon of assessment area 2 has been subjected to fishing by the same fisheries as the wild salmon of assessment area 2, unlike the wild salmon of assessment area 1. The problem when using the information on hatchery-reared salmon for the estimation of the exploitation rates of area 2 are primarily the assumed differences in survival from natural and fishing mortality between wild and hatchery-reared salmon. Using separate catch proportion estimates of wild and hatchery-reared salmon, obtained from genetic stock proportion estimation, can reduce the uncertainty in the exploitation rates and abundances of these wild salmon stocks.

6.6.3 Diagnostics for model misspecification

A term of reference for the 2004 Working Group on Methods of Stock Assessment (ICES WGMG 2004) has been to investigate appropriate diagnostics that detect model mis-specification in fish stock assessment. It is acknowledged that while there are several diagnostics that have been developed and applied to detect model misspecification error in the Baltic salmon stock assessment model, further work is required. The current assessment has utilized most of the diagnostics recommended for Bayesian methods in ICES WGMG 2004. For example, several diagnostics have been applied to evaluate the goodness of fit of the model to the data. These include an evaluation of the distributions of the data predicted by the model with respect to the values of the actual data points.

While there are no indications in the computed diagnostics of any gross model misspecification (Michielsens 2003), there remain some model assumptions that could do with some further evaluation. One of these is that catchability (q) for a given fishery, e.g., offshore longline and salmon life history phase, e.g., 2SW, remains constant over time and is independent of abundance. It is proposed that work be undertaken to develop diagnostics that can indicate whether the model for fishery catchability model has been mis-specified. Another assumption that could receive some attention is the assumption that all fish die after their first spawning. This could lead to bias in estimates of harvest rates, abundance and the stock-recruit relationship. Using a simple age structured model Levontin (2003) evaluated potential biases that this assumption could cause in the predictions of steepness and abundance. She concluded that theses biases could be moderate e.g., plus or minus 5% or more, depending on the quantities and assumptions. The effects of this assumption on the estimation of harvest rates based mark-recapture data, however, has not been evaluated.

Some of this work to develop diagnostics for model misspecification and the implications of model misspecification for fisheries management procedure performance can be undertaken using the operating models in the COMMIT and EFIMAS EC projects that begin in April 2004.

6.6.4 Updating the stock-recruit function for Atlantic salmon to Baltic salmon

The current assessment model will be extended by adding a Beverton-Holt stock-recruit function in order to estimate smolt abundance estimates based on the estimated number of spawners. The Ricker stock-recruit model will not be considered since it was found to have very low probability relative to the Beverton-Holt model in a hierarchical analysis of Atlantic salmon stock-recruit data (Michielsens and McAllister 2004). A prior probability distribution for the steepness parameter of the stock-recruit function has been obtained from this hierarchical analysis while prior probability distributions for the stock-recruit function have been obtained through expert opinions about the smolt production capacity (Uusitalo 2002). The model will be fitted to the smolt production as estimated by the smolt production model. Instead of using one age group of spawners to link to the resulting smolt produced in the future, several spawner year-classes will be used and whereby the proportion contributed by each year-class is estimated by the model. The stock-recruit function will be updated for individual stocks as well as for entire assessment areas. An hierarchical model structure will be used to allow for the estimation of an updated steepness parameter for Baltic salmon which then can be used for those rivers currently excluded from the smolt abundance model. The model will allow to update both the steepness parameters as well as the smolt production capacity estimates. In addition stock-recruit data for Baltic salmon will be collected and added within the estimated methodology.

6.6.5 Development of a stock projection method

The recruitment in future years will be predicted using a Beverton-Holt stock-recruit function with updated stock-recruit parameters both for steepness and smolt production capacity. The potential impacts of various TAC's and fishing effort policies on stock rebuilding can be evaluated. Given the different management actions the probability of reaching 50% of the smolt production capacity by 2010 can be calculated. Because the spawner abundance in 2006 determines the smolt production in 2010, the impact of changes in management actions will be relatively small compared to when longer time periods are considered. Therefore an additional reference year needs to be chosen. The stock projection methodology will be applied to the different assessment areas and to individual Baltic salmon spawning population estimated to be the weakest stock. The weakest stock is defined as the population having the lowest posterior mean ratio of smolt production to smolt production capacity. Since the identification of weakest stock can change over time, the weakest stock is evaluated over a period of five consecutive years.

6.7 Methodology updates to be implemented for the 2005 assessment

Of the methodological updates mentioned in section 6.6, the following proposed refinements to the stock assessment methodologies that will be made for the 2005 stock assessment.

6.7.1 Reference point calculation

The fishing mortality rate reference points will be recalculated using the updated population dynamics model for Baltic salmon (Annex 1). This updated model will incorporate probability outputs from the assessment model, and updated probability distributions for the stock-recruit parameters.

6.7.2 WinBUGs estimation of exploitation rates and abundances

The Gulf of Finland stocks (assessment area 6) and the Eastern Main Basin stocks (assessment area 5) will be included in the assessment model. The population dynamics of these stocks is different from the other Baltic salmon stocks and will require different population dynamics equations. The inclusion of stocks of assessment areas 5 and 6 will also require the incorporation of additional tagging data: Finnish tagging data from Gulf of Finland stocks and Latvian tagging data and Polish tagging data. The results for the Eastern Main Basin stocks could potentially be validated with available Lithuanian spawner abundance estimates.

The model will be fitted to abundance index data such as fish ladder data or data from the broodstock fisheries. Expert opinions based on experiments will be used to obtain prior probability distributions to translate the abundance index data in estimates for absolute abundance. This would improve the estimation of the spawner abundance estimates to be used for the steepness estimation.

At the moment it is assumed that the harvest or exploitation rates from stocks within the same assessment unit are the same. The closer to the river, however, the more the exploitation rate could differ between stocks. When fitting the model to spawner abundance index data for one particular stock within an assessment unit, the exploitation rates for the other stocks of the same assessment area may be biased. An hierarchical model structure could be adopted which allows for the estimation of a mean exploitation rate for each stock within each assessment area but the harvest rates for individual stocks within an assessment area are allowed to deviate from this mean.

Once the stocks for all six assessment areas are modelled, the model estimated catches can be fitted to catch observations, adjusted through expert opinions for underreporting and discarding. First trial runs have already started to look at a reasonable way to include the catch data within the model while taking into account the large amount of uncertainty regarding the catch data, especially in the case of coastal catch data. The results of the assessment model, both with and without catch data, will need to be examined and compared.

Genetic stock proportion estimates allow to assign the catch to the different assessment areas. In combination with the smolt production estimates, the genetic stock proportion estimates can be regarded as genetic tagging data. The inclusion of this data within the model will help to compensate for the loss of tagging data for Sweden. Depending on the amount of information available in this data, it could also be used to estimate independent annual values for post-smolt mortality rates for wild and hatchery-reared salmon.

6.7.3 Stock projections

Two different types of stock projections will be done for the 2005 assessment. The updated stock-recruit function for Baltic salmon stocks will be used to project the stock abundance into the future beyond the 3 years as projected during this year's assessment. This will allow the evaluation of future exploitation rates using different TAC's against the harvest rate reference point, under different assumptions about future states of nature.

In this year's assessment it had been possible to evaluate the smolt production against the smolt production capacity until 2005. Using updated stock-recruit functions it will be possible to evaluate the probability of reaching the smolt production capacity by 2010 for all the different rivers under different assumptions about future TAC's and different assumptions about future states of nature, e.g. M74 levels.

In the 2005 assessment, stock projection tables will be presented indicating the probability of the smolt production reaching 50% of the smolt production capacity under different assumptions about future management measures and different states of nature. Additional stock projection tables will indicate the probability of the total exploitation rate of 2SW wild salmon exceeding the newly updated precautionary harvest rate reference point.

6.8 Suggestions for revision of advice to ICES

6.8.1 Changes in the fishery and in the stocks

During the last decades there have been major changes in the economics of salmon fisheries, in the fishing mortalities and in our understanding about stock dynamics. As in 2002, the total reported salmon catch in 2003 in the Baltic was the lowest observed since 1972, even though the number of released reared salmon is continuously high and the production of wild salmon has increased. The working group does not report price information from markets, but there is price information available in the institutes. Due to the fact that the price of commercially caught salmon has dropped, some offshore fishermen might stop fishery on higher catch levels than earlier. From 2005 and forward, the offshore fishery also faces a reduction in the driftnet fishery by 60 % in 2005 and a total ban in 2008 due to EG-regulations on the use of driftnets.

The structure of the coastal fishery with traps is different and might continue on lower stock level. This may have an important effect on the controllability of the fishery. Offshore fishery might not increase to earlier total effort levels, but this may not be the case with coastal fishery which still could have a large impact on the wild salmon stocks, especially on smaller populations. Both these fisheries might however be closed or reduced by a closure of commercial fishery and trading of salmon because of the maximum levels of dioxins set for fish and fishery products by the EU. Further analyses are needed to be able to model the impacts of these elements on the management behaviour of the system and to make the fishing effort more predictable for medium term simulations.

The positive impact of favourable conditions and management actions in some rivers were described in section 6.4.2. However, the stock dynamics is still dependent on few year-classes and lucky events. In addition to these elements, recent analyses have demonstrated that the long term objective of reaching 50 % of each river production potential is difficult to assess due to uncertainty in the smolt production and in the maximum production (section 6.4.2). For some rivers there is an indication of a positive trend in reaching this objective but other weaker rivers are unlikely to reach this objective by 2010. The reference year will also need to be revised since the spawner abundance in 2006 will determine the smolt production of 2010, currently leaving only two potential years for effective management of the fisheries to be able to reach this reference point.

6.8.2 Past and current changes in available information and information needs and their reflection on assessment possibilities

Although the total catches have decreased, the fishing mortality is still so high that an annual assessment and management system is justified. For example, the importance of the river fishery has increased as there are more economic activities based on river fishing. Also environmental restoration projects, of which several are linked to SAP rivers, require information for the prediction of the numbers of returning spawners and the probability to establish a new salmon stock within these rivers. In addition to these aspects, the long term genetic management of all stock components (both reared and wild stocks), is an issue that needs stock assessment information (individual spawning stock sizes, information about selectivity, relationships of females and males as a result of various management and fishing alternatives, establishment of new stocks into SAP rivers).

There have been several changes in the information available for Baltic salmon during the last few years. One problem is that Swedish tagging data from 1999 and forward has not been available for the assessment and therefore mostly recent Finnish data is used in the current assessment methodology. By increasing the uncertainty, this has affected the quality of the assessment. When the risk averse management rules of a Precautionary Approach are applied to the management modeling, a higher uncertainty leads to lower catch possibilities. However, there have also been positive changes in the monitoring systems as some of the genetically distinct eastern Main Basin river stocks are more effectively monitored and reported than earlier. Also some of the small Swedish stocks have been monitored more intensively during the last year. There are however no improvement in data from index rivers on count of spawners and numbers of smolt in the same rivers. This means that the stock/recruitment functions based on rivers in the Atlantic area have to be updated by other means (section 6.6.4).

The EU data collection system (see section 4.9. in WG report of 2002) requires member countries to estimate the wild salmon proportions in their catches. In Finland this is carried out both by scale readings and by genetic stock identification. The latter produces stock specific proportion estimates, which can be used to divide the wild stock into smaller components (see section 4.? and table 4.?). Although there are still some uncertainties, this genetic information can be used for the estimation of specific wild stock components, and also for the monitoring of the basic objective of keeping up the genetic variability of the salmon stocks.

The safeguarding of the wild salmon populations requires estimates about these stocks. The advantage of the current Bayesian stock identification method is (section 4.?) that it can provide probabilistic input values for the Bayesian stock assessment model (section 6.6.2), allowing for a more accurate estimation of wild salmon populations within each assessment unit.

The genetic identification becomes more uncertain when it is applied to small wild stocks within an assessment unit. This is partly because the stocks within each assessment unit are genetically close to each others (due to e.g. strayers), and partly because in any reasonable sample size, the number of salmon from small populations is easily very variable due to sampling variance. Therefore, the monitoring of these stocks must also continuously be based on river monitoring activities. This may consist of an intensified electro fishing program and of tagging of smolts or pars in wild salmon rivers, which would help the current tagging data based assessment methodology as well.

In the classical biological analysis of the stocks, the prediction of effort is actually a socio-economic task, as well as the reactions of fishermen to suggested management systems. In the case of salmon, the dependency of offshore effort on the price of salmon (which is also dependent on farmed Norwegian salmon and on farmed rainbow trout, FGFRI unpubl. analysis) is clearly a topic which needs economic analysis to be able to predict the likely catch and effort distributions between various fisheries, in addition to TAC and other management effects

6.8.3 Current management objectives and need for redefinitions

The objective of the IBSFC Salmon Action Plan is to gradually increase the natural production of wild Baltic salmon to at least 50% of the natural production capacity of each river by 2010, while retaining the catch level as high as possible. In the ACFM advice of 2002, it was stated that *" the objective of meeting the 50% smolt production be revisited in the context of the proposed* F_{PA} *reference point"*. It was also stated, that behind the operational objective mentioned above, there are *"more fundamental aims, e.g. to safeguard the genetic diversity of the wild and reared stocks"*.

ACFM also requested that; "*Managers and ICES together should consider these aspects of monitoring and development of management strategies, and include them, if considered to be relevant, in the terms of reference for future assessment working group meetings*". As there had been no discussions between the managers and ICES about the facts above and about the required management definitions, the WG in the 2003 report agreed to point out the need of more detailed and more operational definitions for the current management aims, as well as complementary elements due to the fact that current objectives probably are not in balance with an precautionary approach as discussed in the 2002 meetings of WG and ACFM.

The following criteria have been used when considering the content of new or more detailed operational objectives:

1) They should be in balance with an Precautionary Approach (new element to the objectives)
2) They should safeguard the genetic status of all Baltic stocks and take into account the total genetic variance available for the future of Baltic salmon (more exact definition of the current objective)
3) They should safeguard each wild salmon stock, also the weakest ones, with high probability (more exact definition of the current objective)
4) They should support the effective utilisation of the production capacity in wild salmon rivers and the possibility of high total catches in the future.

ACFM also stated in 2002 years advice, *"the monitoring and assessment system of the Baltic salmon should enable the evaluation of the stock status and give answers to the management questions with an adequate precision and at reasonable costs"*. This is an essential criteria, but the evaluation of this criteria is not simple.

Current assessment method provides quantitative measurement of uncertainty about the natural smolt production capacity of each river, as well as measurement of uncertainty about annual smolt production of each river in terms of probabilities. This implies that the question whether the smolt production exceeds 50% of the production capacity in a given year (past, current or future) or not can be answered only in terms of probability. However, the required level of certainty about reaching the objective (i.e. desired level of probability of exceeding 50% of the production capacity) has not been defined in the management objective. Because any measures of uncertainty has not been referred to, the current formulation of the management objective can be interpreted to mean that in year 2010 this probability should be 1 for all rivers. Probabilities near 1 would mean that the management objective has been reliably reached, probabilities near 0.5 mean that there is high uncertainty about the status of the stock compared to production capacity, and probabilities near 0 indicate reliably that the objective has not been reached. The larger the uncertainty in the annual smolt abundance prediction and the smolt production capacities, the more the probability of reaching 50% of the smolt production capacity will be close to 0.5, thereby decreasing the probability of ever reaching the objective.

6.8.4 Suggested definition of new operational objectives and the required simulation tests

When the points given above are considered in the management context, it is obvious that there is a need to systematically test the functioning of combinations of various operational management aims and the alternative assessment - management system combinations. In 2003, the WG suggested that the management evaluation approach of International Whaling Commission should be applied wherever applicable. In short, this system includes:

* an operational model (state of nature, alternative hypothesis for this by alternative model structures),
* sampling and assessment models (measurements about the state of nature, alternatives included) and
* management models (impact by man on the state of nature, includes here both fisheries control and release decisions, even though the latter ones are not able to be freely decided by managers)

The idea of these simulations is to test, how well the assessment system could describe alternative changes in the nature, and how well the management system then can react to information, and how well it can manipulate the state of nature in a desired way. This is a good system to test known or predictable changes in the nature, and to test how these changes can be dealt with within the information - management system. However, if there are unpredictable changes in the real nature, this kind of modeling exercises may give a too optimistic view about the human capability to observe and control the natural resource. In the case of salmon, M74 is a good example about such an unpredictable change. It was due to the Swedish rearing system that the problem was detected. The system requires a certain amount of produced smolts, and the required adults are taken from the rivers. As the high mortality of salmon fry appeared in the early 1990´s, salmon scientists were able to detect a phenomena which very effectively affects for example stock-recruit relationships. If no causal relationship is found to make the mortality due to M74 outbreaks more predictable, the TAC control may not be an effective tool.

It is essential to note, that the life cycle of salmon makes the system difficult to manage, and the required "insurance fees", in terms of lost catch potential and high buffer in the combination of river phase- sea stocks, may be high when estimated by the simulation models. This "fee" is likely to be dependent both on implementation error (what is the probability to achieve a desired SSB for each stock) and on the predictability of the stocks. The predictive hierarchical Bayesian prediction models (section 4.2.3.2), offer a promising tool to make probabilistic predictions of smolt abundances based on earlier years parr density observations. For example in year 2003, the smolt abundance of 2004 can be predicted by moderate uncertainty, and the smolt abundance of 2005 with higher uncertainty. This type of improvements give more time for managers to react to first signals in the wild rivers. It must be noted, that the first signal about wild stock development in the northern rivers is obtained 5 - 6 years before that year class is the most important part of the spawning stock (3 river years + 2 - 3 sea years). All sea assessment results are quite late compared to this (age group A0 in the last data year is A2 in the target year). A more timely administrative handling of the fishery would likely have an important effect on the management efficiency of Baltic salmon stocks. Simulation models can test the reliability of such a system.

The following list is an example of such management rules and elements, which could be tested in these future simulations:

1) The mean fishing mortality for mixed stock fishery must not exceed F_{PA} .

2) The fishing mortality for the weak stocks should not exceed $F_{PA,weak}$. This is a separate estimate taking into account the knowledge related to the weakest stock components.

3) If $F_{PA,weak}$ can not be reached by river specific management, the mixed fishery would be decreased to this level.

4) The probability that each population will remain above the genetically safety level (yy individuals) must be xx % over the next yy years (xx value to be defined by managers, yy values to be defined by the scientists)

5) The stocks having highest genetic value (proportion of total genetic variance) would have the highest priority when management actions are focused on different fisheries, and the uncertainty related to these stocks has the most dominating role in the risk averse decisions.

6) The production of reared salmon would be utilized in strictly restricted terminal fishing areas. These areas would be allowed to exploit no more than xx % of the total numbers of any wild population.

7) Testing of a management rule (level of TAC) based on parr densities and/or smolt production estimates

8) Testing of a management scheme where the data are from year t and TAC is for year t+1 instead of current t+2.

9) Testing of terminal fishing areas with a model simulating local migrations.

10) Testing of additional utilities obtained by tagging of wild parrs.

11) Testing of using of stock groups which are managed in the same way, and identified by genetic methods.

12) Testing of proper management units and stock assessment units, taking into account the migrations of the stocks, and the practical management possibilities.

The different combinations of assessment method, management rule and operational objectives must be tested in order to find well-justified combinations, which support the achieving of overall aims by reasonable total costs.

6.8.5 Assessment aspects based on individual stocks and on mixed stocks

The complicated management questions easily lead to complicated models. When taking into account the local and international information needs, it is obvious that two types of models are needed in the future assessment. The needed model structure for single stocks and for the overall mixed fishery may be different. The inclusion of terminal stocks, seal predation, wild salmon S/R functions etc. may not be required for all management questions. The combined use of the smolt data, tagging data, and abundance index data lead to fairly complicated model structures. Therefore, there is a need to study the possibilities to decrease the complexity of the model structure. This would help also to free more parameters, and therefore to get more justified final uncertainty estimates for the interest variables. The development of the totally probabilistic river model to include the required sea information may be an alternative way to develop predictive river - sea model combinations.

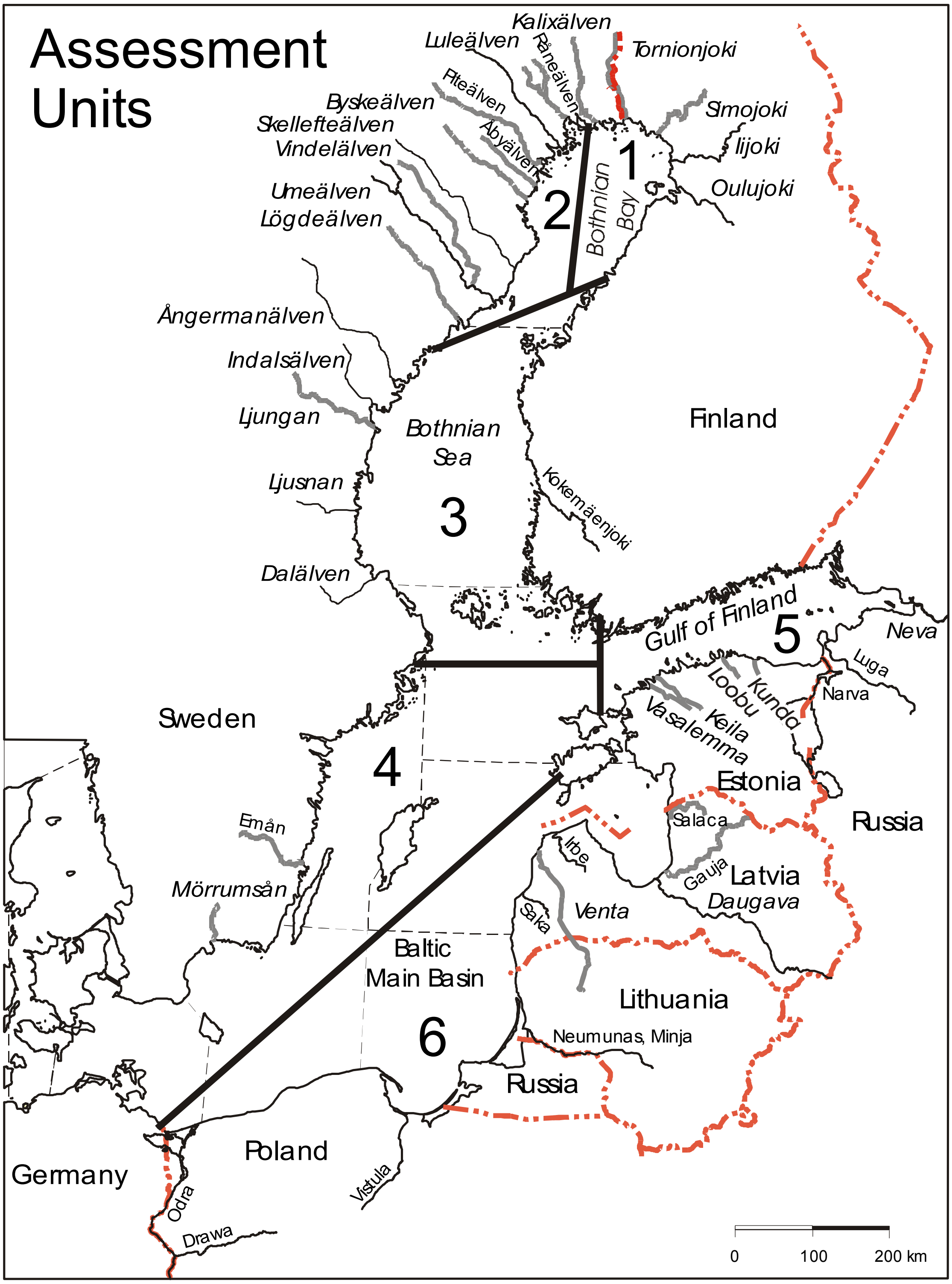
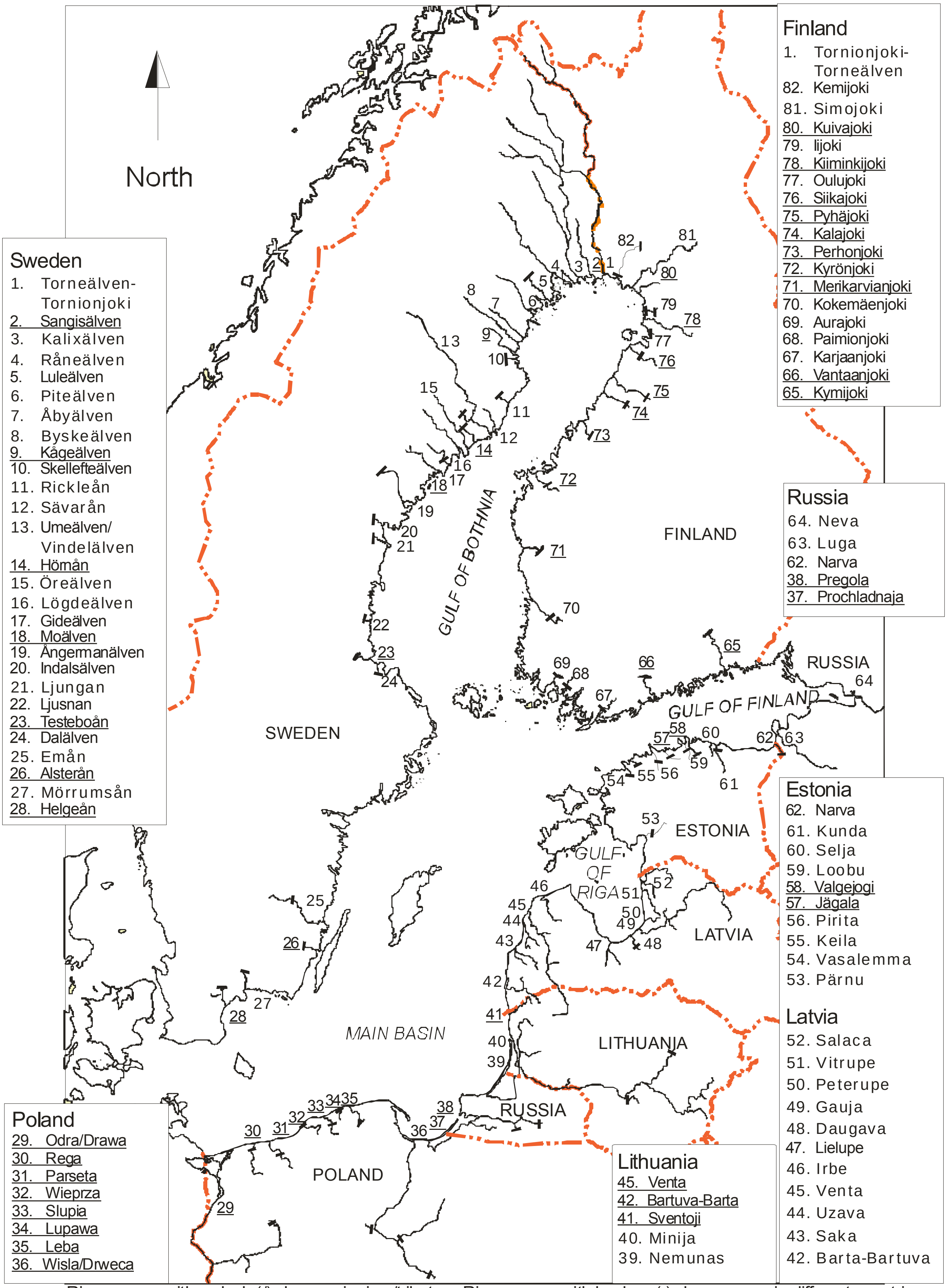


Figure 6.2.1 Grouping of salmon stocks in 6 assessment units in the Baltic Sea. The genetic variability between stocks of an assessment unit is smaller than the genetic variability between stocks of different units. In addition, the stocks of a particular unit exhibit similar migration patterns.



River names with a slash (/) show main river/tributary. River names with hyphen (-) show names in different countries.

Figure 6.2.2 Baltic salmon rivers divided into three categories (see above figure). Only lower parts of rivers with current salmon production or potential for production of wild salmon are shown. The presence of dams, which prevents access to areas, is indicated by lines across rivers. *Notation:* **river name in bold** = *river with wild smolt production*; river name underlined = *river with potential for establishment of wild salmon*; normal font = *river with releases, no natural reproduction*.

7 SALMON IN THE GULF OF FINLAND

7.1 Catch and Fisheries

The salmon landings in 2003 were 13,463 fish or 73 t (Tables 3.1.3 and 3.1.4), which is about 20% less than in 2002. Fishing effort in offshore fishery decreased and in coastal fishery increased in 2003 in Finnish coastal areas, where the main harvesting occurs. Main part (85 %) of commercial catch was taken by trap nets. Recreational catches were about 35% from the total catch in the area. However, the estimates of recreational catches contain large uncertainty. In many areas at the Finnish coast the outermost trapnet sites could not be used any more because of large damages caused by seals on salmon in gears. According to Finnish logbook records, approximately 35% of the commercial salmon catch (3821 fish) was discarded due to seal damages. Also in Estonia the harm caused by seals has increased in coastal fishery.

CPUE in the Finnish long line fishery for the 2003 was about three times lower than the average of the CPUE in the last five years and only 15% from obtained by long lining in the southern Baltic Sea (Table 3.4.1). Actually, offshore efforts are underestimated, because zero-catch-efforts are not recorded in the logbooks. This results in overestimated CPUE values in calculations. The catches have been taken in the most western part of the Gulf, where exists known, restricted feeding areas of salmon. Because of the low CPUE together with low current prices there is decreased interest in long line fishing. CPUE in trap nets in the Finnish coastal waters was 0.66 salmon which is about 30% less than in 2002 (Table 7.1.1). Fishermen operate closer to a harbour and with fewer trap nets than earlier, as it is necessary to examine the trapnets with quickened intervals to keep seal damages low.

Another factor in the dramatic catch decrease is a low initial smolt survival. Cohort analysis shows that the postsmolt survival has been very low in last five years compared to the early 1990s (Table 7.5.1). The reason for the high mortality soon after release is unknown. On seminars in Finland in December 2003 and in Estonia in February 2004 (participated Estonia, Finland, Russian Federation) changes in Gulf of Finland ecosystem particularly food web and predation (seals, cormorants) were regarded as a possible factors acting on postsmolt survival. Recent quality of artificial food used in hatcheries has been also discussed. Need of knowledge on feeding of postsmolts, impact of thermocline and halocline shifts on food organisms and food composition of seals and cormorants was stressed. No estimate of initial smolt survival in wild salmon populations is available.

The catch distribution between offshore, coastal and river catches has drastically changed. Exploitation has changed from targeting mixed stocks offshore to now focusing on local stocks in coastal areas and in rivers. By year 1987 about 80% of the total catch in the Gulf of Finland was taken offshore. In 1988 and 1989 the offshore fishery share was about 60% and in 1990–1994 offshore fishery was about 40% of the total catch. Since 1995 the offshore fishery has taken only about 20% or less of the total catch. Offshore catch in 2003 was less than 10% (Figure 7.1.1). This is due to decreased offshore catches in Finland, and increased coastal harvesting of salmon in Estonia. There is no directed salmon fishery in the Estonian coast but salmon are caught as by-catch in other coastal fisheries. In Estonia licensed sport fishing and fishing for breeding purposes are permitted in some rivers. Poaching exists in many of these rivers. In Russian rivers all salmon fishery is prohibited except fishing for breeding purposes for hatcheries.

In Finnish the commercial offshore fishery operated 17 vessels in 2003. Only 3 vessels were out in more than 20 fishing days. (Table 3.3.2). The number of vessels has halved in five last years.

Composition of the catches

Salmon originating from the Gulf of Bothnia and Baltic Sea Main Basin contribute occasionally to the catches in the Gulf of Finland (Bartel 1987, Anon.1994). In 2003 catch samples were collected from Finnish commercial fishery at the west part and the east part of the Gulf of Finland. Catch samples were aged by scale reading and stock proportions were estimated by genetic methods. Results indicated a high proportion of Gulf of Botnia stocks, in particular of the wild salmon (31%) in the catches (Table 4.2.5.1 and 4.2.5.2). No significant change in age composition from the previous year was observed.

7.2 Status of salmon populations

7.2.1 General

In Estonia salmon reproduce in 9 rivers: Kunda, Loobu, Keila, Vasalemma, Pirita Selja, Jägala, Vääna and Valgejõgi. However, production is very low in most of these rivers and therefore enhancement releases were carried. Extant wild salmon rivers in the Gulf of Finland are small and their potential production is low. In Russian Rivers Luga and Neva as well as in Finnish Rivers Kymijoki and Vantaanjoki, salmon populations are mostly based on smolt releases but also some natural reproduction occurs (Table 4.2.3.1). Salmon in the Estonian-Russian River Narva is of reared origin. General overview of smolt production and some characteristics of salmon rivers in the Gulf of Finland is given in Table 7.2.1.

7.2.2 Status of wild and mixed populations

In Estonia, five rivers supported wild salmon reproduction in 2003 (Table 7.2.2.1). One- and two-summer-old parr were found in the rivers Kunda and Valgejõgi. One-summer-old parr were found only in these rivers. Only two-summer-old parr occur in the rivers Selja, Loobu and Pirita. Some year classes of salmon in Estonian rivers were often lacking (Kangur & Wahlberg, 2001). The salmon populations from small Estonian rivers and the Neva salmon form a separate group that is distinguished genetically from the salmon populations in the Gulf of Bothnia (Anon. 1997b).

In the River Valgejõgi the restoration stockings of salmon were initiated in 1996 and in the river Jägala in 1998. The enhancement stockings were carried out in the River Selja in 1997–2003, in the River Pirita 1998–2003, and in the River Vääna 1999-2003. In these five rivers the releases will be continued in 2004–2005. The status of wild salmon populations has varied since the 1980s. The most important change in the 1990s was the occurrence of natural spawning after many years interval in the rivers Selja, Valgejõgi, and Jägala. The enhancement releases are needed for further improvement of populations in these rivers and in the rivers Pirita and Vääna.

In the River Selja salmon population was disappeared and stay absent for years. However, in 1995 there were caught salmon parr originating from natural reproduction. When comparing genetically these parr to other salmon populations it was found out that these Selja River parr resembled very much to those met in the neighbouring river Kunda. As the result of stocking activities, inbreeding between decolonizers and hatchery individuals has occurred in subsequent years (Vasemägi et al., 2001). This observation supports previously presented hypothesis that in small Estonian salmon rivers strayers from neighbouring rivers can initiate reproduction and create a new self sustaining salmon population.

Salmon used for stocking in Estonian rivers in late 90s originate from spawners caught in the Narva River brood fishery and in addition Neva strain smolts imported as eyed eggs from a Finnish hatchery have been used. In 2000-2002 brood fishes were caught from the River Narva and in sea close to the River Selja mouth.

In the Finnish rivers Kymijoki and Vantaanjoki the salmon population is based on annual smolt releases, which have been started in the early 1980s. The Neva strain has been used in these releases. In the River Vantaanjoki only occasional natural salmon reproduction occurs. The River Kymijoki is mainly used for hydroelectric production and still some area of rearing habitat exist. Ascending spawners originating mainly from hatchery-reared smolt releases spawn, and annual natural production has been estimated to be around 4000 smolts. These smolts come mostly from the rearing habitats (14 ha) below the lowest dam in one of the three main streams. Despite of the very rainy autumns most of these areas dry because of the water regulation between the power plants. There are significant areas of a better production habitat above the lowest power plants, but only a small part of the ascending salmon has access there. The river Kymijoki runs to the sea by three separate main streams and fish ladder exist only in one them. Most of the spawning salmon ascend to the streams where is no fish ladder. The success of ascending salmon to find their way to the stream supplied with the fish ladder is depending on the drainage arrangements between the three main streams. Building an additional fish ladder to the other main stream would allow an access for a much higher number of spawning salmon to access the better spawning and rearing habitats above the dams. This would magnify the natural smolt production of the river.

Wild salmon populations in the Finnish side of the Gulf were lost by 1950s due to establishment of paper mill industry and closing the river Kymijoki by dams. The nearest available salmon strain, Neva salmon, was imported in 1970s. Status of mixed population in the river Kymijoki is based on hatchery reared smolt releases and the magnitude of natural reproduction (4000 in 2003) is small compared to the number of released smolts (293,000 in 2003). The brood stock of salmon is held in hatcheries and has been partially renewed by the ascending spawners.

In Russian rivers Luga and Neva smolt and parr have been released annually in the 1990s and later. Neva strain has been used in the river Neva. In the river Luga released smolts are based on ascending Luga and Narva river spawners as well as brood stock of mixed origin.

In the rivers Neva and Luga the salmon populations are supported by large long-term releases, but there exists also natural reproduction. In River Luga a smolt trapping survey was conducted in 2002 and 2003, and the natural smolt production was estimated to be 8000 and 7200 respectively. In the river Neva smolt production is estimated to be about 6000. This estimate, however, contains significant uncertainty.

7.2.3 Status of reared populations

The Estonian/Russian river Narva lost its native salmon stock in 1950s. A new population was established using Neva stock and strains from Latvian rivers. During 1990s all hatchery production is based on ascending spawners caught in the river. No evidence on natural smolt production exists. In 2003 the number of spawners returning to River Narva was sufficient for breeding purposes.

7.3 M74 syndrome

M74 mortality in 2004 in the Estonian hatchery Pölula was 7% (same as in 2003) of the River Narva spawners (40 females). The three females of the River Selja does not have M74. In the Estonia there is no clear evidence of the existence of the M74 syndrome in wild populations. However, abundance of salmon parr shows large variation (Table 7.2.2.1). Ascending spawners of the River Kymijoki have been caught every second or third year to add genetic material to the broodstock. M74 mortality among these brood fish has been monitored annually since 1992, when mortality was estimated to be 45%. In 2002 it was estimated to 36% (Table 4.5.1). The thiamine concentration in eggs of ascending spawners predicts quite well the M74 mortality rate in hatching fry. The mean thiamine concentration in eggs of spawners ascended the River Kymijoki in the autumn 2002 was considerably high. On this basis M74 mortalities of yolk sac fry in 2003 will be low at river Kymijoki (<10% of females). Data for M74 mortality in Russian hatcheries are not available.

7.4 Smolt Production

Natural smolt production in Estonian, Finnish, and Russian rivers in the Gulf of Finland area was estimated at 14,000 in 2003, which is about 10,000 smolt less than in the last decade in average. Hatchery-reared smolt releases including enhancement were in 2003 688,000 fish, and in 2004 the number is estimated to be about 711,000 (Table 4.6.1). The smolt production in the region has increased in the last ten years, but the catches have decreased being in the record low in the last two years. The low catches as well as the cohort analysis and the tagging results indicate a very low initial smolt survival (Table 7.5.2, Figure 9.2.1).

A share of the smolts migrates from the Gulf of Finland to the Main Basin for the feeding. According to tagging results from the Finnish releases to the river Kymijoki on an average 22 % of the fish has been caught from the Main Basin during the last 25 years and no significant change in the variation pattern has been observed during that time. Tagging results from Estonian releases, however, suggest a share of 45 % being caught from the Main Basin. At the Main Basin these fish has been exposed to about 25 % harvest rate in the last few years. The estimated harvest rate applies to the 2SW fish returning from the Main Basin to the Gulf of Finland (Figure 7.4.1).

7.5 Cohort Analysis Input Data

The catches from 1997 onwards were augmented this year for the first time by the estimated number of salmon damaged by the seals in the gears. The estimates were collected from the WGBAST Reports from year 1999 onwards and the data are presented in Table 7.5.1. The age distribution of the catches used in the analysis for years 2002 and 2003 was taken from the commercial catch samples. The age composition data for the earlier years were derived partly or totally from the tag recoveries, because there have been no good catch samples available from that time. The tagging data covered both the commercial and recreational fisheries. In years 2002 and 2003 the number of tag recaptures were low. Only the tags reported from sub-division 32 before the year 2002 has been included. To make tag recoveries comparable to each other, each tag recovery was weighted by a factor depending on releasing year and area (see e.g. Anon. 2000). The natural mortality was assumed to be 0.05 per half year. Fishing effort is very low in the offshore fishery and has also decreased significantly in coastal fishery. About 95% of the yield was caught in the coastal areas in 2003. The terminal F values were set about to the mean value of last three years (Table 7.5.2). For the youngest age-group (released 2003) the post-smolt survival was assumed to be the mean of years 2000 – 2002. There has been a decreasing trend in post-smolt survival, which justifies the use of latest values in the predictions. The analysis suggests the initial smolt survival of 2.9 % for the last four year-classes. Catch in numbers and estimates of stock size and fishing mortality for 1990–2003 are given in Table 7.5.2.

7.6 Catch Predictions for 2004 and 2005

The total catch in the Gulf of Finland in 2003 was about 25 % of the TAC of 50,000 salmon (Table 3.2.1) and is projected to be much lower than the agreed TAC also in 2004 (TAC_{2004} = 35,000 salmon). Therefore, no TAC constrains are used in projections. Catch predictions for 2004 and 2005 are given in Table 7.6.1. It was assumed that the initial smolt survival would remain low, i.e. the mean value of years 2000-2002. Mean weights and fishing mortality rates were also assumed to be the same as in 2003. *Status quo* projection gives a catch projection for 2004 and 2005 of 13,385 and 13,123 salmon respectively. These projections include the potential seal damages.

7.7 Management

At present all wild salmon populations exits in the 4 Estonian rivers and the status of these populations is weak. The potential smolt production of these rivers is small compared to the other wild salmon populations in the Baltic Sea. It is quite evident that even significantly reduced TAC could not improve the status of these populations. The Gulf of Finland offshore fishery has decreased substantially since year 1990 and catches in the coastal fishery have also decreased considerably. The catch data in 2003 shows that about 25% of the TAC were caught. The status of wild populations has remained weak (Table 4.6.1). Regional and temporal regulatory measures should be promoted in coastal and river fishery directing to these populations to improve their status. In addition the enhancement activities should be continued to avoid possible extinction of these stocks. Salmon can ascend only to a short stretch in many these rivers because of the natural or artificial migration obstacles. Salmon has never or in historical time been able to ascend above these obstacles. However, it is estimated that a total of about 30 hectare of additional rearing habitat exist above these obstacles. The Group recommends that these obstacles should be supplied with the fish passes to increase the spawning habitat area of these rivers. This would improve the potential production capacity and resilience of these populations. The Group also recommends the present fishing regulations to be thoroughly implemented. In addition extended spatial fishing restrictions, mesh size rules for gillnets and effort limitations to be implemented for the fisheries at the coast area of these rivers. All kind of fishing in these rivers should be prevented.

References

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Vasemägi, A., Gross, R., Paaver T., Kangur M., Nilsson J. and Eriksson L.-O., 2001. Identification of the origin of an Atlantic salmon population in a recently recolonized river in the Baltic Sea. Molecular Ecology (2001) 10, 2877-2882.

Table 7.1.1 Catch per unit effort in number of salmon caught per trapnet and fishing day at the Finnish coast in the Gulf of Finland, Sub-division 32.

Year	CPUE
1988	0.70
1989	1.00
1990	1.60
1991	1.50
1992	1.50
1993	1.40
1994	0.86
1995	1.15
1996	1.27
1997	1.52
1998	1.34
1999	1.30
2000	0.94
2001	0.92
2002	0.95
2003	0.66
mean1999-2003	0.96

Table 7.2.1 General overview of the salmon rivers in the Gulf of Finland.

River and category	Ascending distance km	Reproduction area ha	Potential smolt productio	Smolt production								Releases in 1999-2003
				1996	1997	1998	1999	2000	2001	2002	2003	
Vasalemma wild	4..5	1 below dam, 2 above	1500	<100	300	100	<100	0	100	100	20	0
Keila wild	1.7	3.5 below waterfall 3 above	6000	100	300	1200	300	300	1500	200	200	0
Vääna mixed	>20	4	5000	na	na	na	<100	0	0	0	20	10800
Pirita mixed	24	10 below dam, 1 above	10000	0	100	na	0	0	600	0	300	23000
Jägala mixed	1.5	0.3 below dam, 2 above	1500	0	0	0	0	0	0	0	0	11400
Valgejõgi mixed	9	1.5 below dam, 13 above	16000	0	0	0	0	0	100	100	0	26600
Loobu wild	10	6 below dam, 1 above	8000	300	600	100	0	300	300	400	40	1700
Selja mixed	>30	9	10000	3900	200	0	0	1400	200	100	0	28600
Kunda wild	2	1.5 below dam, 17 above	20000	300	1400	2100	100	1800	800	400	500	0
Narva reared	18	0	0	0	0	0	0	0	0	0	0	27000 1)
Luga mixed	353	40	80000	4000	4000	4000	4400	5000	2500	8000	7200	45600 2)
Neva mixed	74	20	20000	7000	7000	7000	8000	6500	5900	na	na	105300 2)
Kymijoki mixed	9	14 below dam, 35 above		3000	4000	4000	4000	4000	4000	4000	4000	293000 2)
Vantaanjoki reared	20	15	7000	0	0	0	0	0	0	0	0	35000 2)

1) Releases by Estonia
2) Releases in 2003

Table 7.2.2.1 Densities of wild salmon parr in electrofishing surveys at permanent stations in rivers discharging into the Gulf of Finland, Sub-division 32.

River	Year	Number of parr/100m² 0+	Number of parr/100m² 1+ and older	Number of parr in survey
Kunda				
	1992	7.4	12.9	118
	1993	0	4.5	26
	1994	2.4	0.0	7
	1995	15.4	3.1	60
	1996	22.6	13.7	98
	1997	1.2	21.5	78
	1998	13.8	0.9	68
	1999	6.4	18.1	103
	2000	20.8	7.6	75
	2001	30.3	14.7	156
	2002	13.2	4.9	55
	2003	0.7	3.6	13
Selja				
	1995	1.3	6.5	18
	1996	0.0	0.4	1
	1997	0.0	0.0	0
	1998	0.0	0.0	0
	1999	0.1	2.3	26
	2000	1.2	0.4	32
	2001	1.4	3.7	33
	2002	0.0	0.0	0
	2003	0.0	0.1	1
Loobu				
	1994	1.2	2.8	23
	1995	0.2	0.2	2
	1996	0.0	0.4	2
	1997	0.0	0.3	3
	1998	0.2	0.0	1
	1999	10.5	0.8	70
	2000	0.6	0.8	17
	2001	0.0	0.5	3
	2002	0.1	0.1	2
	2003	0.0	2.9	21
Valgejõgi				
	1998	0	0	0
	1999	2.4	0	26
	2000	0.4	1	14
	2001	4.4	1.6	58
	2002	7.1	0	3
	2003	0.2	0.8	5
Jägala				
	1998	0	0	0
	1999	0.5	0	2
	2000	0	0	0
	2001	16.2	0	38
	2002	0	0	0
	2003	0	0	0
Pirita				
	1992	1.9	0.7	11
	1993*)			
	1994	0	0	0
	1995	0	0	0
	1996	0	+	1
	1997*)			
	1998	0	0	0
	1999	6.5	0	55
	2000	0	0.9	13
	2001	1.2	0.3	18
	2002	0	0.3	10
	2003	0	2.3	38

River	Year	Number of parr/100m² 0+	Number of parr/100m² I+ and older	Number of parr in survey
Väana				
	1998	0	0.1	1
	1999	0	0	0
	2000	0.1	0	1
	2001	0	0	0
	2002	0	0.2	1
	2003	0	0	0
Keila				
	1994	1.1	1.1	12
	1995	6.9	0.3	105
	1996	11.7	1.1	115
	1997	0	5.2	47
	1998	0	1.1	10
	1999**)	95	1.3	154
	2000	3.8	6.6	52
	2001	0	2.2	21
	2002	6.3	0.7	38
	2003	0.0	0	0
Vasalemma				
	1992	3.4	2.6	23
	1993*)			
	1994	1.9	0	7
	1995	18.7	0.4	99
	1996	4.8	5	51
	1997	0	1.5	8
	1998	0	0.2	2
	1999	13.5	0	80
	2000	3.5	1.7	27
	2001	0.4	0.9	3
	2002	7.1	0.3	23
	2003	0	0	0

*) = no electrofishing
**)= Flow was extremely small and fish were concentrated on little area
\+ = minor production.

Table 7.5.1. Number of seal damaged salmon in gears in sub-division 32 in 1997-2003.
Values from year 2000 onwards are based on the log-book records. Values
before the year 2000 are estimates based on the questionaires and other indirect methods.

1997	3300
1998	3900
1999	3500
2000	3631
2001	3394
2002	3127
2003	3821

Table 7.5.2 Salmon in the Gulf of Finland. Catches, stock sizes and fishing mortalities by years and age groups.
Year is divided into half (January - June = I, July - December = II)

A) Catch estimates

	1990		1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
A0+		12791		20145		12088		11231		7081		3045		9149		5302		3395		536		874		367		524		230
A1	9523		8584		13786		19389		6336		6735		4995		11403		1777		4347		3490		1231		1308		393	
A1+		29298		51218		31699		40715		26262		12913		41529		22484		15648		14464		13459		9374		6902		4802
A2	32055		12460		16090		10880		6253		13302		14036		15485		3912		4672		5908		4630		2884		7040	
A2+		23836		20785		17166		7281		7746		13079		15190		24836		8971		9961		8670		12562		5218		3519
A3	3498		6345		2669		1712		901		1642		3026		2366		4138		693		1928		1073		1247		487	
A3+		2605		6540		3376		1255		911		290		2092		2538		397		448		3979		2099		2618		646
A4	304		0		602		161		1		2		2		260		1		210		1		1		1		1	
A4+		324		10		91		127		217		3		246		418		3		242		3		26		2		93
Total		114234		126088		97567		92751		55708		51010		90265		85093		38242		35572		38312		31363		20702		17211

B) Stock estimates

	1990		1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001		2002		2003		Mean 2000-2002
A0+		125432		95969		99563		88299		71529		111830		64582		51214		46772		46234		24420		24570		17436		11908	
A1	88441		106839		71641		82919		73039		61134		103406		52509		43544		41180		43456		22376		23013		16075		
A1+		74840		93257		54701		59964		63296		51584		93491		38827		39688		34933		37933		20084		20615		14908	
A2	74427		42615		38755		21117		17330		34596		36474		48429		15005		22491		19122		22957		9963		12878		
A2+		39534		28384		21172		9476		10387		19936		21006		30964		10458		16837		12428		17321		6664		5384	
A3	6407		14358		6727		3398		1912		2325		6208		5167		5231		1198		6301		3365		4225		1250		
A3+		2683		7469		3796		1562		940		610		2954		2607		939		464		4113		2155		2802		714	
A4	701		12		726		318		262		6		298		770		4		506		4		32		2		112		
A4+		370		11		104		145		248		3		281		478		3		277		3		30		2		106	
Total		412835		388914		297186		267197		238943		282026		328701		230964		161645		164120		147781		112891		84723		63337	
Smolt releases		497000		360000		380000		454000		495000		564000		642000		553000		622000		734000		693000		913000		736000		711000	
Initial smolt surv.		25.2%		26.7%		26.2%		19.4%		14.5%		19.8%		10.1%		9.3%		7.5%		6.3%		3.5%		2.7%		2.4%		1.7%	2.9%

693 913 736 711

C) Fishing mortality estimates
(Natural mortality, M=0,05 / half year for all age groups)

	1990		1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001		2002		2003		Mean 2000-2002
A0+		0.11		0.24		0.13		0.14		0.11		0.03		0.16		0.11		0.08		0.01		0.04		0.02		0.03		**0.02**	0.03
A1	0.12		0.09		0.22		0.27		0.09		0.12		0.05		0.25		0.04		0.11		0.09		0.06		0.06		0.03		0.07
A1+		0.51		0.83		0.90		1.19		0.55		0.30		0.61		0.90		0.52		0.55		0.45		0.65		0.42		**0.40**	0.51
A2	0.58		0.36		0.55		0.75		0.46		0.50		0.50		0.40		0.31		0.24		0.38		0.23		0.35		0.82		0.32
A2+		0.96		1.39		1.78		1.55		1.45		1.12		1.35		1.73		2.12		0.93		1.26		1.36		1.62		**1.10**	1.41
A3	0.82		0.60		0.52		0.73		0.66		1.29		0.69		0.63		1.67		0.90		0.38		0.40		0.36		0.51		0.38
A3+		5.37		2.28		2.43		1.74		5.05		0.67		1.30		6.33		0.57		4.61		4.79		6.75		3.17		**2.50**	4.90
A4	0.59		0.00		1.90		0.73		0.01		0.49		0.01		0.43		0.26		0.55		0.31		0.02		0.27		0.01		0.20
A4+		**2.20**		**2.20**		**2.20**		**2.20**		**2.20**		**2.20**		**2.20**		**2.20**		**2.20**		**2.20**		**2.20**		**2.20**		**2.20**		**2.20**	2.20
Mean	0.53	1.83	0.26	1.39	0.80	1.49	0.62	1.36	0.31	1.87	0.60	0.86	0.31	1.12	0.43	2.25	0.57	1.10	0.45	1.66	0.29	1.75	0.18	2.20	0.26	1.49	0.34	1.24	

Table 7.6.1 Salmon in the Gulf of Finland. Prediction for years 2004 and 2005.
Assumed fishing mortalities and mean weights, predicted stock sizes and catches.

Year 2004

Releases	711000
Initial smolt survival	2.9%
Recruitment	20344

Age	Weight (kg)	Fishing mortalities		Stock size		Catch in numbers		Yield (kg)	
		I	II	I	II	I	II	I	II
A0+	1.8		0.02		20344		393		707
A1	2.2	0.03		11103		271		597	
A1+	3.3		0.40		10297		3317		10945
A2	6.4	0.82		9506		5214		33372	
A2+	7.4		1.10		3974		2598		19223
A3	9.5	0.51		1705		665		6322	
A3+	9.4		2.50		974		880		8276
A4	6.8	0.01		56		0		3	
A4+	7.8		2.20		53		46		359
		total			58010	6152	7234	40294	39511

Prediction in weihtg (kg):	**79804**
Prediction in numbers	**13385**
TAC in numbers	**35000**

Year 2005

Releases	711000
Initial smolt survival	2.9%
Recruitment	20344

Age	Weight (kg)	Fishing mortalities		Stock size		Catch in numbers		Yield (kg)	
		I	II	I	II	I	II	I	II
A0+	1.8		0.02		20344		393		707
A1	2.2	0.03		18969		464		1020	
A1+	3.3		0.40		17591		5666		18699
A2	6.4	0.82		6565		3601		23049	
A2+	7.4		1.10		2745		1794		13277
A3	9.5	0.51		1258		491		4666	
A3+	9.4		2.50		719		650		6109
A4	6.8	0.01		76		1		4	
A4+	7.8		2.20		72		63		490
		total			68339	4557	8566	28739	39282

Prediction in weihtg (kg):	**68021**
Prediction in numbers	**13123**

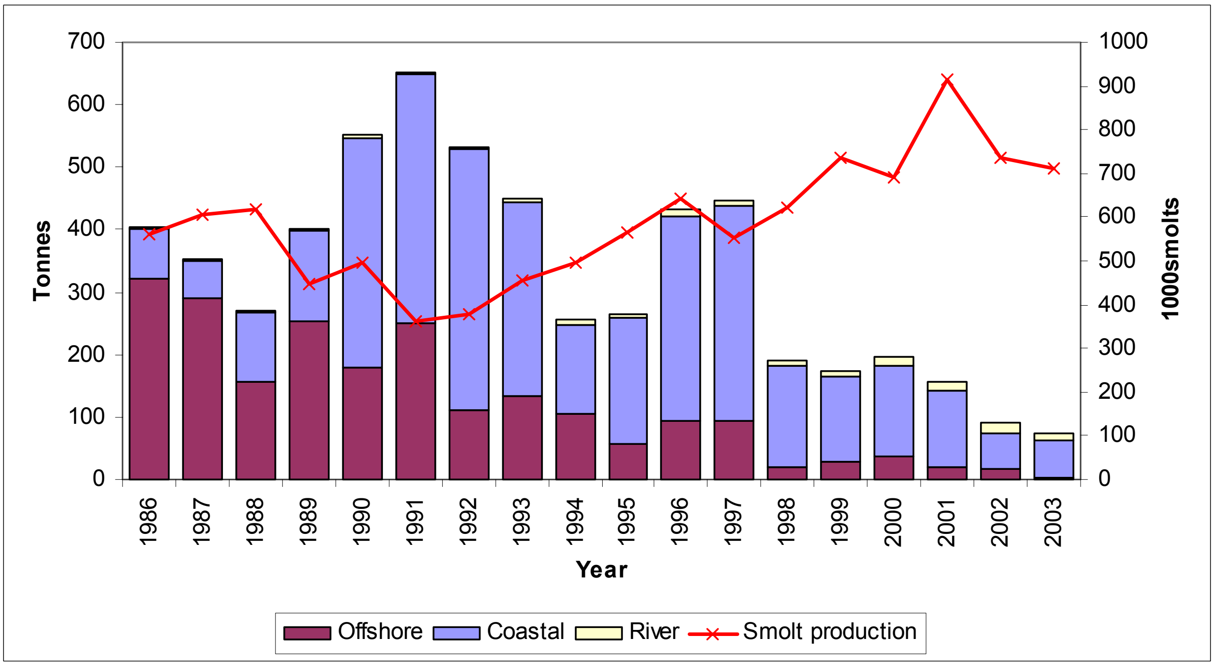

Figure 7.1.1 Salmon catches and smolt production in the Gulf of Finland in 1987-2003

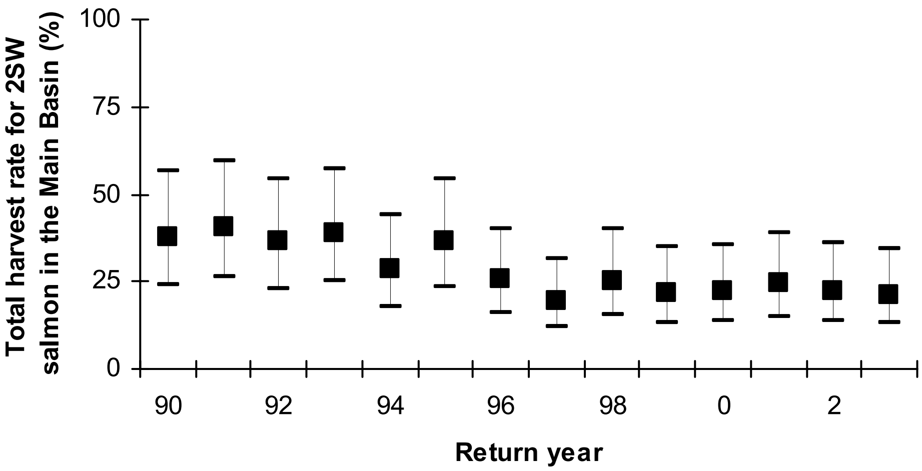

Figure 7.4.1. Median and 95% probability interval for the total cumulative harvest rate for wild and hatchery-reared 2SW salmon in the Main Basin of the Baltic Sea area

8 SEA TROUT

8.1 Nominal catches

The total sea trout catch of the Baltic Sea was 1086 tonnes in year 2003 which is 265 tonnes lower than in 2002. Catches of sea trout increased from 200 tonnes in 1979 to 1869 tonnes in 1993 and have since then, except for the years 1995-1997, been at a level of 1100-1300 tonnes. The Main Basin is still the most important area for sea trout catches. Total catches in 2003 have decreased since 2002 to 918 tons of which 85% were caught by Poland. Catches in the Gulf of Bothnia since 1996-1998 have been at the level of 200 -300 tonnes. In the Gulf of Finland after low catches in years 2000–2001 (70-80 tons), catches increased to 140 tons in 2002), but in 2003 dropped to 37 tons (Tables 8.1.1 and 8.1.2).

8.2 Status of wild and mixed sea trout populations

8.2.1 Gulf of Bothnia

Sea trout populations previously existed in numerous small rivers and brooks and in most salmon rivers. Sea trout smolt production has been assumed to be about 10–20% of salmon smolt production in most salmon rivers. At present, wild sea trout populations have been verified in 56 rivers or brooks. Some of those populations are supported by releases. Population disappearance has partly been caused by human activities such as damming, dredging, pollution and silting of these rivers. It is also obvious that many small populations have been depleted or threatened by very effective gill net fisheries during feeding and spawning migration in the sea. Carlin tagging results of the northern populations in the Gulf of Bothnia shows a large proportion and often the majority of the sea trout to be caught during the first summer in sea as by-catch in the whitefish fishery before reaching sexual maturity. In some rivers even angling of sea trout parr as local brown trout may decrease parr and smolt production considerably. Knowledge of the status of the remaining populations is poor. Most of the populations in Sub-division 31 are so small that only a few spawners enter these rivers annually.

The results of the electro fishing surveys from year 2003 indicate a precarious state for sea trout stocks on the Swedish side of the Bothnian Bay (sub-division 31) and on the Finnish side of the Gulf of Bothnia (sub-divisions 30 and 31) and Gulf of Finland (sub-division 32) (Table 8.2.1.1, 8.2.1.2 and 8.2.1.3). Apart from the river Tornionjoki the densities of 0+ parr in the remaining wild populations were either zero or close to zero. The main reason to the precarious state of wild populations is too intensive fishery, mostly as bycatch in gillnet fishing for whitefish, but also in some rivers the poor quality of rearing habitat and a restricted access to the spawning habitats.

In the Gulf of Bothnia 56 rivers and brooks are mentioned, in which wild and mixed sea trout populations exist. (Table 8.2.1.4). In the past the annual wild smolt production in Sub-divisions 30 and 31 was estimated to be of 120,000–170,000 individuals, but presently is assumed to be very much lower.

8.2.2 Gulf of Finland

The situation of sea trout populations is similar to that in the Gulf of Bothnia. There are 62 rivers discharging into the Gulf of Finland which have previously supported sea trout populations. Present status of many populations is uncertain (Table 8.2.1.4). Two more rivers with sea trout populations were recorded in 2003 in Russia.

There have been five sea trout rivers, which flow from the Finnish area into the Gulf of Finland, where natural reproduction occurs, but the diversity of the stocks has decreased, and in many cases reproduction is almost negligible. The only available information on parr densities of sea trout in the Finish rivers of the Gulf of Finland shows 6.9-9.9 individuals per 100 m^2 (Table 8.2.1.2).

Most of the natural populations were destroyed by damming of the rivers, and polluted waters. The status of a wild sea trout stock is given only to those stocks, which are breeding in rivers accessible from the sea. Despite the connection between sea and river, most of the local trout maintains natural reproduction; however, the offshore fishery takes part of the fish before they have reached maturity. The natural reproduction is about 5,000 two-years-old trout per year (Anon. 2003). Assuming the all reproduction areas in the present rivers are used, the total production capacity of all rivers could be of 100,000-150,000 two-years-old trout smolts annually.

Sea trout is the protected species in the Russian waters discharging to Gulf of Finland. Total smolt production is not available yet but recent experiments with smolt traps revealed that 2500 sea trout smolts of natural origin migrated to the sea from Luga River in 2003.

The production of wild smolts in Estonian rivers was around 60 000 smolts and in last decades is decreasing. In 2005 it will be around 10 000 smolts as in most of rivers 0+parr numbers/100 m^2 were 0 or close to 0 (Table 8.2.2). Sea trout populations exist at least in 38 rivers or brooks discharging into the Gulf of Finland. Nine brooks are very small. Five of the rivers are dammed very close to the outlet. Parr densities in Estonian rivers in 1994–2003 varied from 0 to 88 parr 0+ and from 0 to 31 parr 1+ per 100 m^2. The highest parr densities in 2003 were observed in rivers Altja, Loo and Pada, and (Table 8.2.2.). More rivers with higher smolt production are situated in the central part of the North Estonian coast. Some of the rivers have original sea trout populations, but in cases of larger rivers populations are somewhat mixed due to transplantation of fry or parr. This was carried out until the 1980's.

Out of total of 60 sea trout populations in rivers of the Gulf of Finland the status of four is classified as good, 11 is satisfactory, 24 poor and 21 not known (Table 8.2.1.4).

The wild sea trout populations in the northern Gulf of Bothnia and in the Finnish part of Gulf of Finland are in very poor condition. The main threat is a high exploitation rate in the gillnet fishery, including by-catches in the effective whitefish fishery especially in the Gulf of Bothnia. To protect the sea trout populations, regional and/or local fisheries regulations should be carried out in order to decrease the exploitation. Also enhancement activities are necessary.

8.2.3 Recommendations for management regulations for Gulf of Bothnia and Gulf of Finland

The Working Group recommends spatial fishing restrictions, minimum mesh size for gillnets and effort limitations to be implemented for the fisheries in the sea and rivers in the region. Also restoration of the rearing habitats and building of the fish ladders to expand the spawning habitat are recommended. The present situation is worse then ever before and several populations are considered to be at the risk of extinction. Therefore the Working Group recommends the national and regional agencies to take immediate actions to safeguard the remaining wild sea trout populations in the region and allow them to recover to a sustainable state in their natural environment in the rivers.

8.2.4 Main Basin

In the Baltic Main Basin, the total number of sea trout rivers supporting sea trout production is estimated to be above 500 (Table 8.2.1.4). A large majority of those rivers are small or even classified as brooks. In some of large southern rivers like the Vistula, sea trout were more numerous than salmon. Total wild smolt production in the Polish rivers is assumed to be 100,000.

In Denmark, there are in total 239 small sea trout rivers and brooks, out of them 27 was classified as good, 90 as satisfactory and 122 poor (Table 8.2.1.4).

In Estonia, sea trout occurs in at least 21 rivers and brooks discharging into the Main Basin (Table 8.2.1.4). The condition of populations is weak in most rivers. The Rivers Pidula and Õngu have dams close to the outlet. Below the dams are rearing stations taking water from reservoirs. In the River Pärnu sea trout parr did not occur in 1996–2003. In Estonian rivers, a rough estimate indicates that smolt production is about 5,000,

In Latvia, sea trout occur in 15 rivers and in a few small rivers and brooks discharging into the Gulf of Riga and Baltic Main Basin. The Salaca, Gauja and Venta rivers have the highest wild smolt production in Latvia. In 2003 wild sea trout production increased in the river Salaca up to 11 000. Sea trout populations were supported by releases of reared fry, parr and smolt mostly into the upper sections of dammed rivers. Wild sea trout parr were monitored by electrofishing surveys. The mean density of parr in the Salaca river system in 2003 was medium size and not exceeded 5 individuals/100m^2 (Table 8.2.3.1). Estimated production in all Latvian rivers is about 80,000.

In Lithuania, natural smolt production is estimated to be about 32,000 smolts. The parr density obtained from electro fishing survey in 2003 ranged from 0,9 to 22,0 individuals/100 m^2 (Table 8.2.3.3).

In Poland, the most valuable sea trout population is in the river Vistula. This population consists of two strains in terms of entering time- a winter strain and a summer strain (Bartel, 1988). In the second largest Polish river - Odra, sea trout populations spawn in some tributaries, but all these populations are very small. Sea trout also exist in 28 other rivers. In five of these, the sea trout population is considered to be large. In three other rivers commercial fishing is carried out. Annual commercial catches in the Vistula River varied from 30 to 100 tons, but the most intensive fishery occurs in the Vistula mouth. Also in the Pomeranian rivers Słupia and Wieprza a commercial fishery exists. In rivers Łeba, Parseta, Łupawa and Rega, only brood stock catches are carried out in October- November. All larger Polish rivers are stocked with one and two year old smolts. Homing from these releases is very precise in the Vistula River, more than 98%, but in the Pomeranian rivers homing is low and varied from 0.0 to 80.2% (Debowski and Bartel, 1995). All Polish sea trout are of the widely-migrating type and, according to results of tagging experiments, 30% of recoveries comes from offshore fisheries.

In Sweden there are more than 70 sea trout rivers discharging into the Main Basin (Table 8.2.1.4). All of them have natural sea trout populations, but 34 of them have small populations and each of them produces less than 1,000 smolts annually. In rivers Mörrumsån and Emån, wild smolt production was previously considerably higher, but in recent years parr densities in River Emån have been low (Table 8.2.3.2). In addition, hybrids between salmon and sea trout were found in high numbers in these rivers. It is not known if there are many populations of the widely-migrating type in southern Swedish rivers.

In the Main Basin there are 333 rivers and streams having sea trout populations. The status of sea trout populations there is classified as good in 55 rivers, satisfactory in 97, poor in 128 and not known in 53 (Table 8.2.1.4).

8.3 Reared smolt production

In Finland, about half of the releases have been made straight to the coast independent of any rivers. The other half are more or less releases to dammed rivers like in Sweden. The sea trout fishery in the Gulf of Bothnia and in the northern part of the Gulf of Finland therefore primarily exploits feeding fish or fish on their spawning run. Because of continuous releases of hatchery-reared fish, the sea trout fishery is almost independent of natural reproduction. On the other hand, at least the wild sea trout populations in Sub-division 31 are so weak that they do not support any fishery. In the other areas, the situation is better, but there also exist populations, which are near to extinction.

Some enhancement releases were carried out in sea trout rivers on the Hiiumaa Island and in rivers of Gulf of Finland in recent years. In other regions enhancement releases have stopped and it seems that this has resulted in a serious decrease in smolt production of the rivers of the Main Basin. The number of spawners is sufficient for rearing purposes on the Hiiumaa Island, where the only Estonian sea trout rearing station is situated. The production consists mostly of two-year-old smolts which are released into coastal waters.

In Swedish rivers in the Gulf of Bothnia, the number of spawners varied among rivers but in most of them the number of sea trout spawners was sufficient for brood stock purposes. Stocking with smolts since 80's was on average level of 400 000 smolts (Table 8.3.2).

In Finnish rivers spawners are scarce, but the eggs obtained from nature are sufficient to supplement hatchery spawners and to avoid the effects of inbreeding, since smolt production is totally based on reared brood stocks. Stocking with reared sea trout smolts was rather stable during the last years (Table 8.3.2). In order to enhance natural production, eggs, fry and parr are released into several rivers with natural production (Tables 8.3.1).

In the Polish rivers, enough number of spawners can be captured for rearing purposes. All these rivers are dammed and the spawning grounds are very small, requiring the sea trout population to be maintained by stocking. Yearly, about 2.5 million Vistula sea trout eggs and 5–8 million sea trout eggs are collected from Pomeranian rivers. Based on natural smolt production it is assumed that Polish sea trout populations are rather small. To increase the size of these populations, fry, parr, and smolt releases are carried out. Presently 0,6 million alevin, 0,9 million parr and about 0,9 million smolt are released (Table 8.3.1 and 8.3.2). Sea trout smolts are released into the mouth of main rivers and into a tributary of the River Vistula.

In Danish, Estonian, Latvian and most Swedish rivers, a sufficient number of spawners are available for rearing purposes. Latvian, Polish and Swedish releases of smolts are carried out in rivers and river mouths, but a majority of Finnish smolts and Estonian smolts are released straight into the sea. In the next years also releases in Denmark will take place only in the river mouths.

Enhancement releases with eggs, fry and parr carried out in 2003 will give an estimated smolt production in 2004 in the whole Baltic Sea (Sub-div 24-32) of 60,000 smolts, almost all in the Main Basin, and 100,000 smolts in 2005 of which 90% in the Main Basin (Table 8.3.1).

In 2003, 1,800,000 one, two and three year old smolts were released into the Main Basin, 1,000,000 two and three year old smolts into the Gulf of Bothnia and 400,000 one and two year old smolts into the Gulf of Finland (Table 8.3.2). Total number of reared smolts released in 2003 was 3,200,000 which is 15 % lower than in 2002.

8.4 Effectivness of stocking

The effectiveness of stocking was calculated in 1999 separately for the Main Basin, the Gulf of Bothnia and for the Gulf of Finland. For this calculation there were used catch data and data of stocking with reared sea trout smolt and natural smolt production, which have been determined on 300,000 smolts for the Main Basin, 150,000 for the Gulf of Bothnia and 130,000 for the Gulf of Finland. The estimates for Gulf of Finland were based on unreliable statistics.

Stocking with smolt in the Main Basin has since 1992 increased to the level of 2,2 million. The effectiveness of stocking of hatchery-reared and wild sea trout production in the Main Basin based on recapture data was in the period of 1996-1999 at the level of 200-350 kg/1000 smolts. The most recent Polish data for 1974-2002 based on smolt production and catches showed an effectiveness at the level of 300 – 800 kg/1000 smolts (Fig. 8.4.1). This calculation is not, as for most other releases, based only on tag return data.

Stocking of reared smolts in the Gulf of Bothnia in 1985–2003 varied from 870,000 to 1, 250,000. The effectiveness of stocking in 1986–1987 was about 100 kg/1000 smolt; for the next 5 years it reached more than 350 kg/1000 smolt, since 1990 it has decreased to the range of 135 - 239 kg/1000 smolts.

A quite different level of effectiveness was observed in the Gulf of Finland. In 1986–1987 it was more than 400 kg. In 1988–1992 effectiveness was on extremely high level, due to overestimated catches in recreational fishery. After this, the effectiveness of stocking dropped to 145 kg/1000 smolts in 1998, but in 1999 reached 362 kg/1000 smolts.

Widely-migrating sea trout, mainly from Polish and southern Swedish rivers as well as from Latvian and Estonian rivers are taken in the offshore salmon fishery. Sea trout from the Gulf of Bothnia and the Gulf of Finland are of the short migrating type and rarely migrate to the Main Basin.

As most of the Baltic Sea trout belongs to populations which remain inside relatively limited areas, mostly in the vicinity of their home river or release site, they can be managed on a national or local basis. Latvian, Estonian, Polish and southern Swedish populations of widely-migrating sea trout are to a great extent caught by fishermen from other countries.

Table 8.1.1. Nominal catches (in tonnes round fresh weight) of sea trout in the Baltic Sea by country in 1979-2003 in sub-divisions 22-32

Year	Country								Total
	Denmark[1,4]	Estonia	Finland[2]	Germany[4]	Latvia	Lithuania	Poland [9]	Sweden	
1979	3	na	89	na	na	na	105[3]	3	200
1980	3	na	173	na	na	na	74[3]	3	253
1981	6	2	310	na	5	na	66[3]	3	392
1982	17	4	326	1	13	na	111	3	475
1983	19	3	332	na	14	na	133	3	504
1984	29	2	387	na	9	na	185	3	617
1985	40	3	368	na	9	na	166	13	599
1986	18	2	349	na	8	na	140	49	566
1987	31	na	373	na	2	na	200	47	653
1988	28	3	582	na	8	na	170	112	903
1989	39	3	666	18	10	na	184	169	1,089
1990	48[3]	4	841	21	7	na	488	154	1,563
1991	48[3]	3	829	7	6	na	309	171	1,373
1992	27[3]	9	837	na	6	na	281	249	1,409
1993	59[3]	15	1250[7]	14	17	na	272	138	1,865
1994	33[8,3]	8	1,150	15[8]	18	na	222	161	1,607
1995	69[8,3]	6	502	13	13	3	262	125	993
1996	71[8,3]	16	333	6	10	2	240	166	844
1997	53[8,3]	10	297	+	7	2	280	156	805
1998	60[8,3]	8	460	4	7	na	468	145	1,158
1999	110	10	440	9	10	1	626	115	1,321
2000	58	14	332	9	14	1	812	99	1,339
2001	54	10	357	na	11	1	716	85	1,234
2002	35	16	334	12	13	2	863	76	1,351
2003[5]	40	9	188	9	6	.+	783	50	1,086

[1]Additional sea trout catches are included in the salmon statistics for Denmark until 1982 (table 3.1.2).

[2]Finnish catches include about 70 % non-commercial catches in 1979 - 1995, 50 % in 1996-1997, 75% in 2000-2001.

[3]Rainbow trout included.

[4]Sea trout are also caught in the Western Baltic in Sub-divisions 22 and 23 by Denmark, Germany and Sweden.

[5] Preliminary data.

[6]Catches reported by licensed fishermen and from 1985 also catches in trapnets used by nonlicensed fishermen.

[7]Finnish catches include about 85 % non-commercial catches in 1993.

[8]ICES Sub-div. 22 and 24.

+ Catch less than 1 tonne.

[9]Catches in 1979-1997 included sea and coastal catches

Table 8.1.2 Nominal catches (in tonnes round fresh weight) of sea trout in the Baltic Sea. S=Sea, C=Coast and R=River.

Year	Baltic Main Basin													Total	Gulf of Bothnia					Total	Gulf of Finland			Total	Grand
	Denmark[1,4]	Estonia	Finland[2]	Germany[4]	Latvia	Lithuania		Poland			Sweden[4]			Main	Finland[2]		Sweden			Gulf of	Estonia	Finland[2]		Gulf of	Total
	S + C	C	S + C	C	S + C	S	C	S[9]	S + C	R	S[6]	C[6]	R	Basin	C	R	S[6]	C[6]	R	Bothnia	C	C	R	Finland	
1979	3	na	10	na	na	na	na	na	81[3]	24	na	na	3	121	6	na	na	na	na	6	na	73	0	73	200
1980	3	na	11	na	na	na	na	na	48[3]	26	na	na	3	91	87	na	na	na	na	87	na	75	0	75	253
1981	6	na	51	na	5	na	na	na	45[3]	21	na	na	3	131	131	na	na	na	na	131	2	128	0	130	392
1982	17	na	52	1	13	na	na	na	80	31	na	na	3	197	134	na	na	na	na	134	4	140	0	144	475
1983	19	na	50	na	14	na	na	na	108	25	na	na	3	219	134	na	na	na	na	134	3	148	0	151	504
1984	29	na	66	na	9	na	na	na	155	30	na	na	5	294	110	na	na	na	na	110	2	211	0	213	617
1985	40	na	62	na	9	na	na	na	140	26	na	na	13	290	103	na	na	na	na	103	3	203	0	206	599
1986	18	na	53	na	8	na	na	na	91	49	7	9	8	243	118	na	1	24	na	143	2	178	0	180	566
1987	31	na	66	na	2	na	na	na	163	37	6	9	5	319	123	na	1	26	na	150	na	184	0	184	653
1988	28	na	99	na	8	na	na	na	137	33	7	12	7	331	196	na	na	44	42	282	3	287	0	290	903
1989	39	na	156	18	10	na	na	na	149	35	30	17	6	460	215	na	1	78	37	331	3	295	0	298	1,089
1990	48[3]	na	189	21	7	na	na	na	388	100	15	15	10	793	318	na	na	71	43	432	4	334	0	338	1,563
1991	48[3]	1	185	7	6	na	na	na	272	37	26	24	7	613	349	na	na	60	54	463	2	295	0	297	1,373
1992	27[3]	1	173	na	6	na	na	na	221	60	103	26	1	618	350	na	na	71	48	469	8	314	0	322	1,409
1993	59[3]	1	386	14	17	na	na	na	202	70	125	21	2	897	160	na	na	47	43	250	14	704[7]	0	718	1,865
1994	33[8,3]	2	384	15[8]	18	+	+	na	152	70	76	16	3	769	124	na	na	24	42	190	6	642	0	648	1,607
1995	69[8,3]	1	226	13	13	+	3	na	187	75	44	5	11	647	162	na	na	33	32	227	5	114	0	119	993
1996	71[8,3]	2	76	6	10	+	2	na	150	90	93	2	9	511	151	25	na	20	42	238	14	78	3	95	844
1997	53[8,3]	2	44	+	7	na	2	na	200	80	72	7	7	474	156	12	na	16	54	238	8	82	3	93	805
1998	60	8	103	4	7	na	na	208	184	76	88	3	6	747	192	12	0	9	39	252	6	150	3	159	1,158
1999	110[8,3]	2	84	9	10	0	1	384	126	116	51	2	3	898	248	12	0	18	41	319	8	93	3	104	1,321
2000	58	4	64	9	14	0	1	443	299	70	42	4	3	1011	197	12	0	14	36	259	10	56	3	69	1,339
2001	54	2	63	na	11	0	1	462	243	11	23	1	3	874	223	0	0	14	44	281	8	71	0	79	1,234
2002	35	5	69	12	13	0	2	539	271	53	11	1	3	1014	129	7	0	23	38	197	11	126	3	140	1,351
2003[5]	40	2	73	9	6	0	+	583	169	32	3	1	0	918	73	13	0	15	30	132	7	28	2	36	1,086

[1]Additional sea trout catches are included in the salmon statistics for Denmark until 1982 (table 3.1.2).

[2]Finnish catches include about 70 % non-commercial catches in 1979 - 1995, 50 % in 1996-1997, 75% in 2000-2001.

[3]Rainbow trout included.

[4]Sea trout are also caught in the Western Baltic in Sub-divisions 22 and 23 by Denmark, Germany and Sweden.

[5] Preliminary data.

[6]Catches reported by licensed fishermen and from 1985 also catches in trapnets used by nonlicensed fishermen.

[7]Finnish catches include about 85 % non-commercial catches in 1993.

[8]ICES Sub-div. 22 and 24.

\+ Catch less than 1 tonne.

[9]Catches in 1979-1997 included sea and coastal catches,since 1998 costal (C) and sea (S) catches are registered separately

na=Data not available

Table 8.2.1.1 Densities of sea trout parr in electrofishing surveys in Swedish rivers in the Gulf of Bothnia, Sub-div. 31, in 1978-2003.

River and year	N parr/100 m2 0+	N parr/100 m2 >0+	N sites
Ume/Vindelälven			
1981-1986	2.48	2.40	16
1989	12.53	0.70	3
1990	2.66	1.23	12
1991	3.09	0.62	6
1993	11.71	2.17	6
1994	2.55	1.71	25
1995	1.18	1.06	19
1996	8.16	1.39	21
1997	5.34	2.81	19
1998	14.97	3.84	6
1999	2.51	2.89	18
2000	2.80	2.10	12
2001	5.4	2.6	18
2002	7.6	4.5	18
2003	2.9	1.9	18
Åby älv			
1978,1986-1988	0.04	0.14	5
1990	0.11	0.19	9
1991	0.33	0.62	3
1992	0.00	0.00	1
1993	0.13	2.93	4
1994	1.51	0.63	6
1995	0.14	1.32	6
1996	0.69	1.21	6
1997	0.07	0.74	6
1999	0.16	0.44	6
2000	0.19	0.47	6
2001	0.11	0.25	4
2002	0.92	0.23	10
2003	1.3	0.4	10
Byske älv			
1986	0.14	0.26	3
1989	0.00	0.10	4
1990	0.03	0.04	6
1991	1.90	0.10	5
1992	0.00	0.15	6
1993	0.02	0.20	4
1994	0.55	0.23	12
1995	0.72	0.61	11
1996	0.90	0.34	13
1997	0.50	0.75	12
1999	0.30	0.18	15
2000	0.30	0.34	12
2002	0.92	0.23	10
2003	2.80	0.1	15
Kåge älv			
1987-1988	0.08	0.03	3
1989	0.02	0.01	3
1990	0.05	0.00	1
1991	0.01	0.03	4
1992	0.00	0.00	2
1993	0.00	0.03	5
1994	0.00	0.00	5
Rickleån			
1988	1.13	0.46	2
1989	18.15	0.36	6
1990	21.75	1.31	7
1991	10.54	2.07	7
1992	26.28	1.42	7
1993	20.49	0.86	8
1994	18.80	2.28	8
1995	16.90	2.90	8
1996	14.83	1.13	7
1997	6.04	4.29	7
1998	2.97	1.52	7
1999	5.9	0.12	7
2000	4.70	1.10	7
2002	12.40	1.25	7
2003	16.7	1.2	7

River and year	N parr/100 m2 0+	N parr/100 m2 >0+	N sites
Sävarån			
1989	0.00	0.32	4
1990	1.36	1.38	9
1991	1.56	2.23	6
1992	1.56	5.82	7
1993	4.31	2.62	7
1994	0.53	2.07	6
1995	0.46	0.75	6
1999	1.2	0.84	9
2000	1.40	1.10	9
2002	4.1	0.7	8
2003	3.4	2.5	9
Hörnån			
1988	0.00	0.00	2
1989	0.00	0.14	6
1990	5.06	0.19	6
1991	0.10	0.61	6
1992	4.68	1.50	5
1993	3.74	0.26	7
1994	0.63	1.29	5
Öre älv			
1980-1988	0.11	0.17	8
1989	0.36	0.06	14
1990	0.17	0.69	8
1991	0.60	0.21	8
1992	0.32	0.42	6
1993	0.61	0.38	13
1994	0.29	0.35	8
1995	0.12	0.17	10
1996	4.15	0.24	10
1997	0.06	0.45	10
1998	0.43	0.16	8
1999	0.48	0.55	10
2000	1.33	0.62	9
2002	1.8	0.7	10
2003	2.9	0.7	10
Lögde älv			
1980-1988	1.77	0.60	5
1989	1.68	0.15	8
1990	3.16	0.34	9
1991	1.78	0.39	9
1992	1.37	0.32	8
1993	3.54	0.31	8
1994	1.08	0.47	8
1995	1.90	0.43	8
1996	4.76	0.23	9
1997	0.69	0.66	8
1998	3.09	0.81	6
1999	1.09	0.55	8
2000	2.50	1.20	7
2002	3.09	0.81	7
2003	2.8	1.3	8

Table 8.2.1.2 Densities of sea trout parr (individuals/100 m^2) in electrofishing survey in Finnish rivers in 2003. Most of the >0+ parr were of reared origin, except in the Tornionjoki (see footnote)

River/ Tributary	No sites	Mean density of 0+ parr, first run	Estimated mean density of 0+ parr	Mean density of >0+ parr, first run	Estimated mean density of >0+ parr	Notes
Gulf of Bothnia Sub-div. 31						
Torniojoki	25		19.5		15,0*)	Stockings with parr and smolt
R. Lestijoki	8	0.1		0.5		Stockings with parr
Sub-div. 30						
R. Isojoki	11		1.4		9	Stockings with parr
Pohjajoki	5		0.3		1.1	-
Merikarvianjoki	11		0.1		2.5	Stockings with parr and smolt
Gulf of Finland Sub-div. 32						
R. Ingarskilanjoki	9		0		3.2	Stockings with parr and smolt

*) About 80 % of older parr were wild

Table 8.2.1.3 Densities of trout parr (all age groups) in rivers in the northernmost part of sub-division 31.

Year	Torne älv		Kalix älv		Råne älv	
	N parr/100 m^2	N sampling sites	N parr/100 m^2	N sampling sites	N parr/100 m^2	N sampling sites
1991	0.35	42	1.29	16		
1992	0.24	16	2.05	7		
1993	0.10	30	1.22	22	1.13	12
1994	0.29	40	2.89	29	0.23	9
1995	0.32	39	0.79	28	1.50	12
1996	0.11	39	0.39	27		
1997	0.13	41	0.55	28		
1999	0.08	41	0.15	33	0.03	12
2000	0.08	42	0.24	30	0.12	12
2001	0.14	42	0.35	14	0.1	10
2002	0.22	42	2.1	30	0.08	14
2003	0.25	42	2.2	30	0.1	14

Table 8.2.1.4. Status of monitored wild and mixed sea trout population in 2003.

	Poor	Satisfactory	Good	Not known	Total number
Gulf of Bothnia					
Sub-div 31					
Finland	1	1		1	3
Finland/Sweden		1			1
Sweden	10	2			12
Sub-div 30					
Sweden	13	9	1	16	39
Finland	1				1
Gulf of Finland					
Finland	5				5
Russia	5			14	19
Estonia	16	11	4	7	38
Main Basin					
Sweden	25	23	11	15	74
Estonia	5	4	1	11	21
Latvia	2	5	8		15
Lithuania	12	10	8	6	36
Poland	5	2	7	16	30
Danmark (Sub-div 22-25)	122	90	27		239
Russia	2			5	7
Total	**224**	**158**	**67**	**91**	**540**

Table 8.2.2. Densities of wild sea trout parr (individuals/100 m^2) in Estonian rivers of the Gulf of Finland in 1994 - 2003

	0+										1+									
River	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Pada	17	36	-	-	-	1	-	1.9	48.8	5.3	21	31	-	-	-	18	-	18.6	1.4	1.3
Kunda	2	4	14	7	16	1	15	0.9	12.2	0.3	5	6	6	21	2	11	3	4.3	1.2	1
Toolse	3	4	-	-	-	3	-	-		0	2	8	-	-	-	4	-	3.4		1.9
Selja	-	0.4	<0.1	0	0	+	23	9.3	3.4	0	-	3	2	<1	+	+	7	0.8	10	0.5
Vainupea	12	13	15	44	2	34	9	0	22.3	0	8	22	10	13	13	15	9	0	0	4.2
Mustoja	+	30	24	22	+	8	7	2.1	6.3	0.4	+	17	8	+	+	9	2	5	2	11.9
Altja	16	47	19	88	16	84	1	46.3	32.9	0.4	5	8	12	5	5	15	2	6.6	6.1	1.9
Vosu	-	36	-	-	-	52	-	-		0.2	-	8	-	-	-	19	-	-		3.3
Loobu	5	6	10	16	+	12	1	3.1	5.1	1.3	8	5	9	+	+	21	2	1.3	6	0.7
Valgejogi	-	0	2	<1	0	0.1	0	0.3		0	-	1	3	0	0	0.1	1	0.4		0.2
Pudisoo	15	11	-	-	4	-	-	4.2	5.5	1	8	11	-	2	2	-	-	5.1	2	0.5
Loo	1	32	-	-	20	-	-	-		0	6	7	-	2	2	-	-	-		11.7
Kaberla	14	26	-	-	2	-	-	21.6		0	15	10	-	4	4	-	-	2.3		1
Valkla	1	4	-	-	1	-	-	-		0	0	1	-	8	8	-	-	-		-
Jagala	-	-	-	0	0	0	0	0.4	0	0	-	-	-	0	0	0	0	0	0	0
Pirita	0	0	0	-	0	0.6	0.1	1.5	0.5	0	0	<1	<1	+	+	0.6	0.1	0.7	2.1	0.3
Vaana	-	-	-	-	4	0.2	4	25.1	6.7	0	-	-	-	-	4	5	0.2	3.9	6	3.5
Keila	0	4	7	7	+	1	1.4	2.6	1.1	0	1	0	2	+	+	1	2	0.7	1.1	1.1
Vasalemma	1	8	6	10	2	15	9	5.6	4.8	0	2	4	4	9	9	6.9	-	11.6	2.6	4
Vihterpalu	-	21	-	-	2	+	-	2.5		0	-	0	-	2	2	0.5	-	3.7		2.3
Veskijogi	-	-	-	-	-	0	-	0	11	0	-	-	-	-	-	0	9	1.1	-	2.3
Nova	-	-	-	-	0	0.5		0	9	1	-	-	-	-	0	0.5	-	0	2.1	2.2
Riguldi	-	-	-	-	-	7	-	-	-	0	-	-	-	-	-	0	-	-	-	1
Rannametsa	-	-	1.9	-	-	-	-	-	-	7.3	-	-	2.1	-	-	-	-	-	-	0.8
Haademeeste	-	-	0	-	-	-	-	-	-	0.4	-	-	0	-	-	-	-	-	-	3.1
Kadaka	-	-	6	-	-	-	-	-	-	0	-	-	9	-	-	-	-	-	-	13.4
Priivitsa	-	-	0.6	-	-	-	-	-	-	3.3	-	-	1.2	-	-	-	-	-	-	1.3
Lemme	-	-	0.4	-	-	-	-	-	-	1.8	-	-	1	-	-	-	-	-	-	1.8
Loode	-	-	0	-	-	-	-	-	-	0.5	-	-	0	-	-	-	-	-	-	4
Treimani	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	-	-	-	0
Kolga	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	-	-	-	3.4
Manniku	-	-	0.4	-	-	-	-	-	-	0*)	-	-	1.9	-	-	-	-	-	-	0*)

- \- no electrofishing survey
+ \- high water level, counting impossible
*) - river dry

Table 8.2.3.1 Densities of sea trout parr (number/100 m2) in the Latvian rivers discharging to Gulf of Riga (sub-div 28)

Year	Number of sampling sites	Main river	Tributaries		
		Salaca	Jaunupe	Svetupe	Korgene
1993	9	0	33.2	38.8	19.8
1994	10	0	*	27	20.6
1995	10	0	2	16.1	34.6
1996	10	0.4	4.3	21.3	45
1997	10	0.2	26.7	40.1	51.3
1998	11	4.7	19.6	30.5	36.8
1999	10	0	5.6	6.1	29.6
2000	10	0.7	5.7	18.6	41.8
2001	10	0.4	9.8	27.6	100.5
2002	11	0	10.2	31.1	77.7
2003	10	0	3.3	2.4	16.9

Table 8.2.3.2 Densities of sea trout parr in electrofishing surveys in the rivers Emån and Mörrumsån, Main Basin, Sub-divisions 27+25, in 1967-2003

River	Year	Number of parr/ 100 m^2		Number of sampling sites
		0 +	> 0 +	
Emån	1967	13	0.9	
	1980-85	26	2.4	
	1992	47	2.0	
	1993	42	3.1	2
	1994	2.5	0.6	2
	1995	0.2	0.6	4
	1996	0.3	0.2	4
	1997	1.9	0.4	4
	1998	6.9	0.4	2
	1999	0.9	0.0	4
	2000	1.2	0.0	4
	2001	1.4	0.0	4
	2002	1	0	4
	2003	2	0.0	7
Mean for period	1980-85	26	2.4	
	1992-94	30	1.9	
	1995-2000	1.9	0.3	
	2000-2003	1.4	0.0	
Mörrumsån	1973	24	16	
	1974	23	8	
	1975	15	1	
	1976	46	3	
	1977	6	10	
	1978	15	2	
	1979	3	6	
	1980	29	2	
	1981	18	9	
	1982	14	11	
	1983	14	1	
	1984	8	5	
	1985	13	1	
	1986	11	1	
	1989	52	0	
	1990	9	0	9
	1991	14	1	9
	1992	11	3	9
	1993	19	1	9
	1994	18	7	9
	1995	6	2	9
	1996	8	2	9
	1997	6	2	9
	1998	7	1	9
	1999	3	1	9
	2000	5	1	9
	2001	9	0	9
	2002	3	0	9
	2003	3	0	9
Mean for period	1973-89	19.4	5.1	
	1990-94	14.2	2.4	
	1995-2000	5.8	1.5	
	2000-2003	5.0	0.4	

Table 8.2.3.3 Densities of sea trout parr (number/100 m2) in electrofishing survey, in Lithuanian rivers, Main Basin (sub-div. 26) in 2003

River	Number of parr/100m^2	Number of sampling sities
Neris	7.5	20
Zeimena	2.6	11
Sventoji	0.9	10
Minija	22.0	21
Jura	4.3	14
Dubysa	7.9	10
Bartuva	1.5	19
kmena-Dar	3.6	6
Sysa	1.8	2

Table 8.3.1 Release of sea trout eggs, alevins, fry and parr into Baltic rivers in 2003.
The number of smolts is added to Table 8.3.2 as enhancement.

Region	Egg	Alevin	Fry	Parr				Smolt			
				1-s old	1-y old	2-s old	3-s old	2004	2005	2006	Total
Sub-divs. 22-29	(1)	(1)	(4)	(6)	(9)	(10)	(10)				
Denmark	0.00	0.00	374,000.00	104,800.00	107,400.00	29,550.00	0.0	17,321	17,508		34,829
Estonia	0.00	0.00	0.00	18,500.00	0.00	0.00	0.0	0	1,110		1,110
Finland	0.00	16,000.00	0.00	0.00	0.00	124,900.00	0.0	18,735	160		18,895
Latvia	0.00	0.00	0.00	103,290.00	17,000.00	0.00	0.0	2,040	6,197		8,237
Poland	0.00	590,900.00	0.00	926,700.00	0.00	0.00	0.0	0	61,511		61,511
Sweden	0.00	175,500.00	0.00	3,000.00	10,000.00	126,900.00	0.0	20,235	1,935		22,170
Lituania	0.00	0.00	80,000.00	0.00	0.00	0.00	0.0	0	2,400		2,400
Total	0.00	782,400.00	454,000.00	1,156,290.00	134,400.00	281,350.00	0	58,331	90,821	0	149,152
Sub-divs. 30-31	(2)	(3)	(5)	(7)	(8)	(8)	(10)				
Finland	0.00	0.00	51,300.00	0.00	0.00	6,500.00	0.0	0	780	1,026	1,806
Sweden	0.00	423,500.00	0.00	173,900.00	45,000.00	5,500.00	0.0	0	6,060	16,787	22,847
Total	0.00	423,500.00	51,300.00	173,900.00	45,000.00	12,000.00	0	0	6,840	17,813	24,653
Sub-div. 32	(1)	(1)	(4)	(6)	(9)	(10)	(10)				0
Estonia	0.00	0.00	0.00	16,700.00	7,000.00	0.00	0.0	840	1,002		1,842
Finland	0.00	0.00	2,700.00	0.00	0.00	0.00	0.0	0	81		81
Russia	0.00	0.00	42,700.00	0.00	0.00	0.00	0.0	0	1,281		1,281
Total	0.00	0.00	45,400.00	16,700.00	7,000.00	0.00	0	840	2,364	0	3,204
Grand total Sub-divs. 24-32	0.00	1,205,900.00	550,700.00	1,346,890.00	186,400.00	293,350.00	0	59,171	100,025	17,813	177,008

	Rate of survival to smolt	Time to smoltification		Rate of survival to smolt	Time to smoltification
(1)=	1.0%	2 years	(6)=	6.0%	2 years
(2)=	0.5%	3 years	(7)=	6.0%	3 years
(3)=	1.5%	3 years	(8)=	12.0%	2 years
(4)=	3.0%	2 years	(9)=	12.0%	1 years
(5)=	2.0%	3 years	(10)=	15.0%	1 years

Table 8.3.2 Sea trout smolt production (x1000) of reared origin to the Baltic by country and Sub-division.

Year	Sub-div.	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004[4]
DENMARK	**22**																				
	1yr																		423	350.8	
	2yr																		28		
	Enhanc.																		15		
	23																				
	1yr																		126	112.6	
	2yr																		2		
	Enhanc.																		2		
	24																				
	1yr				5	1	4	4	4	19	17	177	177	177	196	196	19	597	86	42.9	
	Enhanc.					3	2	3	3	2	2	42	432	384	395	395	29	26	1	0	
ESTONIA	29																				
	1yr	50	50	50	50	5		5													
	2yr						5	6	10	10	16	28	30	32	30	32	30	30	30		
	Enhanc.					1	1	1	4	4	1	1					2	1			
	32																				
	1yr						1													7.4	
	2yr		9	6	17													2		46.9	
	Enhanc.																	1		1.1	
FINLAND [1]	29																				
	1yr																	29	1		
	2yr	128	267	322	289	248	270	185	187	200	256	221	280	299	381	42	255	197	131	80	
	3yr																	34	24	24	
	Enhanc.								2	2		1	1	+			22	34	20	19.6	
	30																				
	1yr																	127	7	13	
	2yr	199	301	225	271	237	167	281	152	200	169	172	202	209	176	173	87	117	167	106	
	3yr																	25	26	26	
	Enhanc.					1	1		5	5				+				47	1	0.8	
	31																				
	1yr																	2	259	215	
	2yr	607	492	422	279	245	291	474	521	500	309	314	454	228	354	405	433	439	316	226	
	3yr																		2		
	Enhanc.				29	10	5		30	30		75	84	32			20		32		
	32																				
	1yr																	95	45	32	
	2yr	301	207	352	206	197	232	259	313	250	285	376	108	216	378	355	346	372	367	290	
	3yr																	18	6	16	
	Enhanc.				3	1	4		1	1		2	1	4			7	0		0.2	
LATVIA	28																				
	1yr	13	13	1	1	1	6	26	44	26	24	20	1	1	7	25	18	74	160	204.2	
	2yr		3	11	1	4	6	7	5	2					11	29	74	2	10	67.5	
	Enhanc.					1			4	11		3	10	10			7	10	3		
LITHUANIA	26																				
	1yr								0	5	5	4	4	10							
	2yr								0	0	0	3									
	Enhanc.																		2		
POLAND [3]	24																				
	1yr																				
	2yr	3	5			10													26	26.0	30
	Enhanc.					24	12	24	24	26	26	6	4	6						0	
	25																				
	1yr		55	26	49	45			21	60	22	150	90	78	76	96	92	70	30		
	2yr	299	425	349	646	587	286	104	265	360	100	254	389	511	376	291	307	406	255	259.9	240
	Enhanc.					170	165	56	119	101	119	136	150	150			84	30	58	0	
	26																				
	1yr			26	2	40	102	2	127	80	244	333	208	414	254	42	59			15.8	40
	2yr	32	135	157	211	250	212	144	111	485	423	388	432	517	625	633	538	468	484	517.6	510
	Enhanc.					37	12	15				1	5					38	33	0	
SWEDEN [2]	24																				
	1yr									22											
	2yr				4	1				34											
	Enhanc					1															
	25																				
	1yr			5	6	4	7	13	15	17	3				9	90					
	2yr	10	17	16	20	24	42	23	20	16		20		2	10	470	1				
	Enhanc.					2		1	2	2		6					36		5		
	27																				
	1yr				7	11	4	6	8	5	2		4	23	4	90	83	9	96		
	2yr	6	11	27	49	31	93	32	40	83	153	154	114	96	154	69	89	90	35	46.1	
	Enhanc.					2			1	2	1	4					17	11	12	5.3	
	29																				
	1yr													1	5	6			12		
	2yr	10	20	4	4	1	8	8	7	1	10	15	8	15	12		9	3	3		
	Enhanc.					1				6	6	+	10				17				
	30																				
	1yr						38	7	80			6	5		1						
	2yr	231	268	286	287	267	328	261	270	299	320	458	369	270	305	261	290	302	270	279.5	
	Enhanc.						21		8		16	16	10				21		18	0.9	
	31																				
	1yr			14	15																
	2yr	148	115	134	202	146	170	153	160	137	148	184	277	231	107	132	115	122	110	148.3	
	Enhanc.						14	10	21		23	18	15				21	33	16		
Russia	32																				
	1yr																			4.3	
	2yr																			0.5	
	Enhanc.																				
Total		2037	2393	2433	2621	2641	2509	2110	2584	2998	2755	3588	3064	3916	3866	3832	3128	3861	3755	3186	820

+ number of smolt less than 1000.

[1]The Finnish fish are all of the short migrating type.

[2]Of the Swedish fish, 5-10% are of the widely-migrating type.

[3] All Polish fish are of the widely-migrating type.

[4]Predicted.

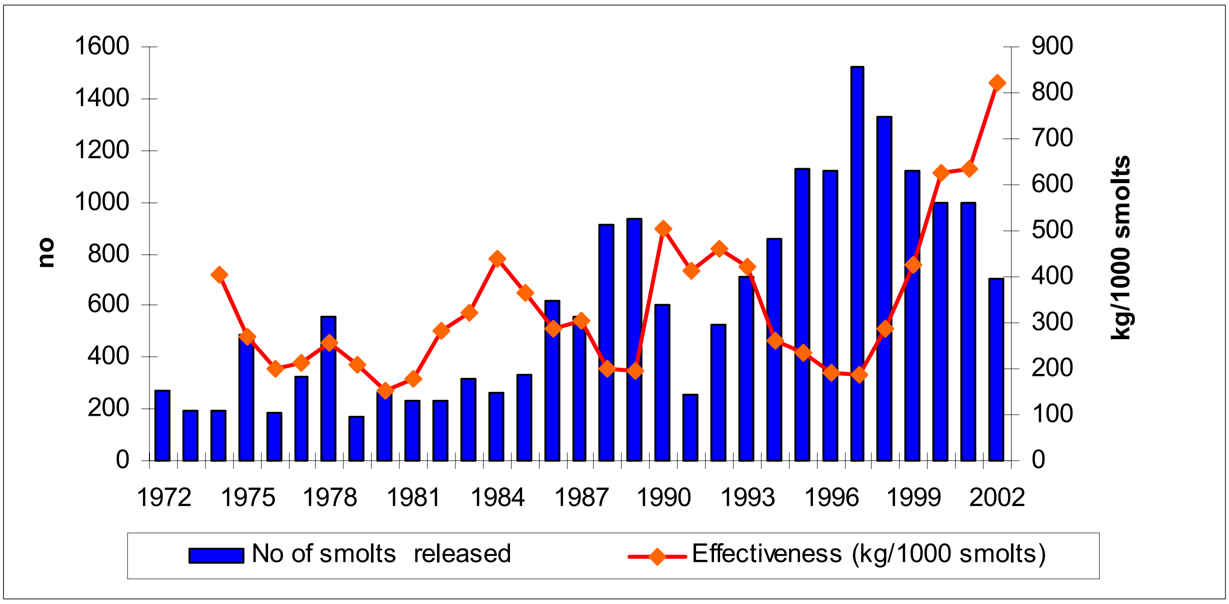

Figure 8. 4. 1. Effectivness of Polish stocking of reared sea trout smolts in 1972 - 2002

9 TAGGINGS

9.1 Tagging data in the Baltic salmon stock assessment

Extensive mark and recapture data sets exist for both wild and reared Baltic salmon. These data sets cover many different years of release and recapture and records of recapture are obtained for each of the main fisheries for Baltic salmon in the Baltic Sea and rivers. Additionally, records of annual fishing effort exist for each of the main fisheries for Baltic salmon. Mark and recapture data, providing that the recapture rates are sufficiently high (e.g., > 5%) as they have been for Baltic salmon, are among the most informative types of data available for fisheries stock assessment. Providing that estimates of *tag shedding rates*, *tag-induced mortality rates* and *tag reporting rates* for recaptured fish in each fishery are available, many different life history parameters can be estimated using mark and recapture data. Based on estimates of these variables, precise estimates of annual and total cumulative fishing mortality rates can be obtained from modelling each released cohort of tagged fish.

The mark and recapture datasets for Baltic salmon offer the possibility of highly rigorous assessments of fishing mortality rates of wild Baltic salmon. The assessment of fishing mortality rates is fundamental to ICES stock assessments since precautionary guidelines require that estimates of fishing mortality rates be compared to key fishing mortality rate reference points.

The population dynamics model (Anon 2002) simultaneously model wild and reared Baltic salmon, each as a separate fished stock. The model is fitted to mark and recapture data for reared and wild salmon for a series of release years. The model includes the capture of different life-history types of released tagged group of fish in four different fisheries: the offshore driftnet, offshore long-line, coastal and river fisheries. The model also uses estimates of the total annual fishing effort (E) for each of these fisheries to index the relative annual changes in fishing mortality rates (F) in each of these fisheries. The model estimates a catchability coefficient (q) for each of the different fisheries and other quantities estimated include the post smolt natural mortality rate, i.e., the rate of natural mortality in the first year at sea.

In the following section of this chapter (9.2) the results from some experiments conducted in and around the Baltic is referred. A more extensive summary of these results is found in Anon (2003).

9.2 Sources of error and estimation of accuracy of estimates

Possible sources of error in application of results from tagging experiments include the question of differential mortality between tagged and untagged fish and when this (possible) mortality occurs. Tag shedding (loss of tags) and whether this is related to the size of the fish. Possible difference in growth rate of tagged and untagged fish could be a problem. Reporting rate (proportion) of the tags caught in different fisheries.

A considerable mix-up of these different factors is likely and in most cases it is difficult to keep the different factors apart.

9.2.1 Tag shedding and mortality

It is vital for the tagging studies to have at least an overall estimate for tag shedding rate. Some information on salmon can be found in the data from Swedish brood stock fisheries in Gulf of Bothnia based on numbers of fish released in each year in 1987-1998 and the number of fish recovered in year 1990-1999. It is assumed that all tags in these fisheries are reported and therefore they can be used to elucidate the combined effect of tag shedding and difference in mortality between tagged and untagged. If the recovery rate in brood stock fisheries is compared with tag recoveries in rivers and river mouth areas, data on reporting rates can be calculated. It is assumed that the best dataset is available from River Dalälven, which has a meticulous control of the number of the fish caught in the brood stock fishery. There is also a very good organization of the angling in this river and the catch statistics in this river is therefore assumed to be of particularly high class. The data from this river suggests that the tag shedding/mortality remove about 30% of the number of tags.

9.2.2 Tag reporting

Tagging in Baltic salmon monitoring programs are mostly based on Carlin type of tags relying on tag recoveries being reported by the public. Therefore it is vital that fishermen find and report all tags. Some studies to estimate the reporting rate has been carried out in the Baltic Sea and their results indicate an obvious unreporting.

Backiel and Bartel (1967), working on sea trout, assumed that the increased mortality, tag loss and incomplete discovery and/or return brought about an underestimation of recaptures by ca. 15%. Dębowski and Bartel (1996), based on analysis of tagging experiments in 1961 through 1986, estimated that underestimation of stocking efficiency, which was caused by not reported tags and increased mortality of tagged smolts was up to 40%.

This level can be even higher in recent years due to catch limits and attitude of fishermen, which are afraid to return excessive number of tags because; they think, those tags can prove, to some extent, over limited catch. This is probably the case in many areas in the Baltic Sea.

In Denmark two high rewarded-tag sea trout release experiments were conducted in 1988. Increase in return rates were 10.2 % and 62.5 % respectively, depending on local awareness and possibly pattern of fishing in the area. It is, however, doubtful if these results can be used in the whole Baltic salmon fishery.

A larger Swedish dataset is available from the offshore fishery in the Main Basin. A trusted fisherman at Gotland, assumed to be reliable on the basis of earlier experiences, agreed to report all tags he found in the catches. When comparing the number of Swedish tags that he found in his catches, to the total number of Swedish tags reported, some underreporting from this man was indicated.

Observations from the offshore drift net fishery in the Main Basin in 2002, involving observers on board two salmon fishing boats suggest that slightly less than 1 % of salmon caught is tagged with Carlin tags. This number may be compared to results from other analysis, assuming equal number of recaptures of tagged salmon in all samples of salmon.

Reporting rate may vary between countries. Comparison of reporting rates from two countries fishing in the Baltic Main Basin indicates, that one country can be reporting significantly less than the other.

An experiment with different rewards for different tags (electronic Data Storage Tags – DST's) and conventional - Carlin tags, was conducted in the coastal fishery in the Gulf of Bothnia. For the DST tags it was clearly stated that a substantial reward was offered. Clear differences in recapture rates were observed, however with differences between different areas. However, it was not ascertained that the two tag types were mixed, and the results should be taken with caution. Nonetheless substantial differences in reporting were observed.

Comparing reporting rate from anglers in the Dalälven to observations in the brood stock fishery data from Dalälven suggests that the reporting rate by anglers in the river is about 80%.

In the Gulf of Finland, tag reporting rate based on total catch for a group of people known to report all recaptures, was compared to average reporting rate for all fishermen in the area. The same tag density was expected in all other fishermen's catches in the region. Discrepancies between numbers of observed and expected tags were taken as the reporting rate. The results suggested that the reporting rate varied between 40-75% (median 55%).

9.3 Present tagging and fin-clipping

9.3.1 Fin-clipping

Data on numbers of adipose fin-clipped and pelvic fin-clipped salmon and sea trout are given in Table 9.1.1. In almost all cases fin-clippings were aimed at distinguishing between reared/enhanced salmon or sea trout from the wild production. In 2003, the total number of fin-clipped salmon parr and smolt was 662 000, a decrease of 20 % since 2002. Compared to 2002, the number of fin-clipped salmon parr decreased 50% but the number of fin-clipped salmon smolt increased 35%. The total number of fin-clipped sea trout parr and smolt was 204 000, 15% higher than in 2002.

In total 210,000 fin-clipped salmon parr, 450,000 salmon smolt, 66,000 sea trout parr and 140,000 sea trout smolt were released in 2003. Most of these fin-clippings were carried out in Sub-divisions 30 and 31. Fin-clippings have been carried out in almost all of the Estonian salmon and sea trout smolt releases. In 2003 5.9% of all reared salmon smolt production to the Sub-divisions 23–31 was fin-clipped. The observed proportion of fin-clipped salmon in Latvian offshore catches dropped from the level of 6 -7% in 2000-2001 to under 3% in 2002 and 2003 (Table 9.1.2).

9.3.2 External Tagging

The number of carlin tagged reared salmon released into the Baltic in 2003 was 113,538 (Table 9.2.1). In total 1.9% of all reared salmon were tagged. In addition to carlin tagging, 8737 wild salmon smolts and smolts originating from parr releases, as well as 80 sea trout smolts, were tagged with streamer tags in 2003 in the rivers Tornionjoki/Torneälv and Simojoki. The tagging was made on catches of smolt in smolt traps.

In 2003, the total number of tagged sea trout was 58 000, the same level as in 2002. (Table 9.2.2). The recapture rate of salmon smolts shows a decreasing trend in last years in the Gulf of Bothnia, Gulf of Finland and Main Basin (Figure 9.2.1.). The Gulf of Bothnia recapture rate has mostly been at a similar level in Swedish and Finnish tagging in 1980–1999. Based on Finnish data, the recapture rate of sea trout has decreased in both Gulf of Bothnia and in Gulf of Finland (Figure 9.2.2). A similar trend is observed in Polish results from the Main Basin (Fig. 9.2.3). Tagging results indicates the long-term variation in the survival and the fluctuation seems to follow the same trend in all countries. According to tagging data the survival of the released smolts is at present lower than a long-term average. There is a need to increase tag recaptures in most of countries since increased returns will substantially improve quality of salmon assessments.

9.4 Tagging data used within the Baltic salmon stock assessment

Table 9.4.1 gives an overview of the number of tagged hatchery-reared and wild salmon released in rivers of assessment areas 1, 2 or 3. No Swedish tagging data have been available for recent years hence the large decrease in tagged salmon in areas 2 and 3. For wild salmon only salmon from area 1 have been tagged and not in every year. The number of wild tagged salmon has increased during recent years.

Tables 9.4.2 to 9.4.18 show the recaptures of tagged salmon by the different fisheries over the different years. For some records, the fishery where the tags had been recaptured, had not been recorded. The tags with missing records of the fishery where they were caught, were assigned to the different fisheries with a similar probability as the probability of catching the salmon in a particular fishery in a particular year calculated from records without missing data on the fishery. The tables show the year of release and how many years after the year of release the salmon are recaptured again. The tagging data have been used in combination with the tag reporting rates in order to estimate the population parameters of Baltic salmon as well as the exploitation rates by the different fisheries (annex 1 and chapter 6).

Table 9.1.1 Adipose and pelvic finclipped salmon and sea trout released in the Baltic Sea area in 2003.

Country	Species	Stock	Age	Number		River	Sub-division	Other fin clipping/tagging
				parr	smolt			
Estonia	salmon	Neva	1	10300	10,200	Loobu	32	500 Carlin
		Neva	1	9,500	10,000	Vaana	32	500 Carlin
		Neva	1	23,300	23,000	Narva	32	1000 Carlin
		Neva	1	10,300	10200	Selja	32	500 Carlin
		Neva	1	5200	5300	Valgejogi	32	500 Carlin
		Neva	1	22,100	22,200	Pirita	32	500 Carlin
		Neva	2	5,000	5,000	Pirita	32	500 Carlin
		Neva	2	5,000	5,000	Selja	32	500 Carlin
		Neva	2	5,000	5,000	Valgejogi	32	500 Carlin
		Neva	2	5200	5300	Jagala	32	500 Carlin
		Neva	2	2,500	2,500	Jagala	32	500 Carlin
Finland	salmon	Tornionjoki	2		4,000	Tornionjoki	31	adipose fin
		Simojoki	1	99,000		Simojoki	31	adipose fin,pelvic fin
		Simojoki	2		18,900	Simojoki	31	pelvic fin
		Kiiminkijoki	2		300	Kiiminkijoki	31	adipose fin,pelvic fin
Sweden	salmon	Ume	2		98,000	Ume	30	2000 Carlin
		Gide	2		2,316	Gide	30	1000 Carlin
		Dal	1	10,177		Dal	30	
		Dal	1	248		Dal	30	
		Dal	1		46,237	Dal	30	
		Dal	2		165,525	Dal	30	4000 Carlin
Russia	salmon	Luga	1		10,000	Luga	32	1500 Carlin
Total	**salmon**			**212,825**	**448,978**			
Estonia	sea trout	Ongu	2		23,000	Coastal	29	400 elastomer
		Selja	1	7,400		Selja	32	500 Carlin
		Selja	2		8700	Selja	32	500 Carlin
		Ongu	2		10,200	Nuutri	32	
		Pudisoo	2s	8,000		Pudisoo	32	
		Ongu	2	2,000		Nova	32	500 Carlin
		Ongu	2		1,000	Veskijogi	32	
		Ongu	2		2,000	Riguldi	32	
Sweden	sea trout	Ljungan	2		45,000	Ljungan	30	2000 Carlin
		Dalalven	2		41,762	Dalalven	30	2500 Carlin
		Ume	2		28,476	Ume	30	1000 Carlin
		Dalalven	2		1,504	Gavlean	30	
		Ljungan	2		100	Delangersan	30	500 Carlin
		Dalalven	2	4,004		Coastal	30	990 Carlin
		Dalalven	2		1,000	Coastal	30	1000 Carlin
Latvia	sea trout	Dougava	2		10,000	Dougava	30	
		Gauja	2		10,000	Gauja	28	
Total	**sea trout**			**21,404**	**182,742**			

Table 9.1.2 Releases of adipose fin clipped salmon and sea trout in the Baltic Sea and the number of adipose fin clipped salmon registered in Latvian (sub-divisions 26 and 28) offshore catches.

Year	Releases of adipose fin clipped salmon, Sub-divs. 24-31		Offshore catches Sub-divs. 26 and 28	
	Parr	Smolt	Adipose fin clipped salmon in %	Sample N
1984			0.6	1,225
1985			1.0	1,170
1986			1.2	1,488
1987	43,149	69,000	0.6	1,345
1988	200,000	169,000	1.2	1,008
1989	353,000	154,000	1.5	1,046
1990	361,000	401,000	0.8	900
1991	273,000	319,000	1.4	937
1992	653,000	356,000	5.0	1,100
1993	498,000	288,000	7.5	1,100
1994	1,165,000	272,000	1.8	930
1995	567,470	291,061	2.0	855
1996	903,584	584,828	0.8	770
1997	1,626,652	585,630	4.4	1,200
1998	842,230	254,950	5.9	469
1999	1,004,266	625,747	4.4	1100
2000	1,284,100	711,569	7.2	1200
2001	610,163	574,547	6.1	774
2002	536,800	323,870	3	995
2003		20000[1])	2.4	573

1) sea trout smolts

Table 9.2.1 Number of Carlin-tagged salmon released into the Baltic Sea in 2003.

Country	24	25	26	27	28	29	30	31	32	Total
Denmark		14000								14,000
Estonia									6,000	6,000
Finland						1,950	1,997	24,156	11,493	39,596
Sweden							20,243	15,499		35,742
Latvia										0
Poland		8,700	5,000							13,700
Russia									4,500	4,500
Total		22,700	5,000	0	0	1,950	22,240	39,655	21,993	113,538

Table 9.4.1 Number of tagged hatchery-reared and wild salmon released in assessment area 1, 2 or 3. No Swedish tagging data have been available for recent years hence the large decrease in tagged salmon in areas 2 and 3.

YEAR	Reared salmon stock in rivers without natural reproduction			Reared salmon stocked in rivers with natural reproduction			Wild salmon
	Area 1	Area 2	Area 3	Area 1	Area 2	Area 3	Area 1
1987	22809	13258	23000	6900	1987	1994	913
1988	20251	13170	31366	4112	1989	2983	771
1989	11813	13157	36851	4432	2910	0	0
1990	9825	12824	30677	6469	3995	1996	0
1991	7974	13251	36158	6987	3990	1997	1000
1992	8920	12657	33450	4081	1996	1999	574
1993	6862	12656	33825	4969	1999	1991	979
1994	7081	12964	28717	4101	1997	2000	1129
1995	6988	12971	21877	4987	2000	0	0
1996	7967	13480	22429	5991	1000	1000	0
1997	4970	13403	22788	6984	1982	1997	0
1998	6929	13448	22052	2998	1974	994	1917
1999	15816	0	3004	12861	0	0	3914
2000	6662	0	2000	8484	0	0	4811
2001	7904	0	3498	8419	0	0	5397
2002	7458	0	1000	4986	0	0	3677

Table 9.4.2 Number of tagged reared salmon released in rivers of area 1 and recaptured in the coastal trapnet fishery. The year of recapture indicates the number of years after release when the tagged salmon was recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	0	15	6	0	1	1	1	0	1	0	1	0	0	0	0	0
1	54	288	139	56	197	91	10	17	28	63	49	17	46	85	30	41
2	42	248	82	120	78	24	11	95	40	30	13	3	36	44	6	0
3	9	42	13	21	13	8	5	31	17	9	3	0	3	2	0	0
4	1	2	2	2	1	1	0	12	0	0	0	0	4	0	0	0
5	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0

Table 9.4.3 Number of tagged reared salmon released in rivers of area 2 and recaptured in the coastal trapnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	5	9	4	9	6	2	0	0	1	4	5	0	NA	NA	NA	NA
1	29	261	102	49	167	68	13	7	48	61	96	42	NA	NA	NA	NA
2	36	179	116	115	63	48	36	123	64	38	34	0	NA	NA	NA	NA
3	11	58	22	16	16	13	7	115	21	4	0	0	NA	NA	NA	NA
4	0	3	1	2	3	0	0	36	1	0	0	0	NA	NA	NA	NA
5	0	0	1	0	0	0	0	4	0	0	0	0	NA	NA	NA	NA

Table 9.4.4 Number of tagged reared salmon released in rivers of area 3 and recaptured in the coastal trapnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	11	13	12	9	29	12	5	1	1	2	0	3	0	0	0	0
1	23	238	151	93	599	261	238	69	51	25	41	26	25	0	2	6
2	57	371	183	258	218	266	109	335	52	46	8	10	22	0	2	0
3	16	139	102	43	73	65	42	268	50	4	0	2	2	0	0	0
4	0	6	2	18	5	7	0	37	0	1	1	0	0	0	0	0
5	0	1	2	2	1	0	2	3	0	0	0	0	0	0	0	0

Table 9.4.5 Number of tagged reared salmon released in rivers of area 1 and recaptured in the coastal gillnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	6	44	6	4	4	5	1	0	1	1	1	6	1	0	0	0
1	42	143	91	59	78	80	11	15	26	21	30	19	14	17	16	4
2	51	152	128	72	85	46	19	52	31	18	6	3	12	20	0	0
3	9	53	22	17	26	8	3	30	14	4	2	0	0	3	0	0
4	1	25	2	3	1	0	0	11	0	1	0	0	0	0	0	0
5	1	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0

Table 9.4.6 Number of tagged reared salmon released in rivers of area 2 and recaptured in the coastal gillnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	7	11	9	0	8	3	7	1	9	2	1	5	NA	NA	NA	NA
1	29	63	23	31	54	24	14	13	20	8	38	5	NA	NA	NA	NA
2	16	59	45	50	40	32	18	38	22	13	10	0	NA	NA	NA	NA
3	10	20	7	15	11	3	3	36	14	2	0	0	NA	NA	NA	NA
4	2	2	0	2	0	1	2	4	3	0	0	0	NA	NA	NA	NA
5	0	0	0	0	0	1	3	1	0	0	0	0	NA	NA	NA	NA

Table 9.4.7 Number of tagged reared salmon released in rivers of area 3 and recaptured in the coastal gillnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	34	46	66	43	57	36	35	18	7	12	6	7	9	0	0	0
1	47	266	139	115	237	136	110	58	42	21	36	21	12	0	0	2
2	47	263	203	198	126	85	55	146	34	34	20	2	5	2	2	0
3	22	77	43	47	26	24	10	98	9	9	0	0	0	0	0	0
4	3	5	7	1	6	1	6	16	0	0	0	0	10	0	0	0
5	1	1	2	3	0	3	7	0	0	1	0	3	0	0	0	0

Table 9.4.8 Number of tagged reared salmon recaptured in the coastal driftnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	1	2	3	1	1	0	8	0	0	0	0	0	0	0	0	0
1	0	19	7	5	53	23	26	6	2	1	2	0	3	3	0	0
2	14	73	50	41	66	93	18	1	6	0	1	0	8	0	1	0
3	7	14	17	7	17	0	4	3	1	0	1	0	0	1	0	0
4	0	3	3	0	0	3	0	3	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0

Table 9.4.9 Number of tagged reared salmon recaptured in the offshore driftnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0.5	71	127	85	68	199	175	109	20	48	37	44	17	16	18	0	0
1.5	1538	3741	1851	1401	2539	1839	1104	908	1101	789	920	127	150	99	11	34
2.5	480	698	563	433	488	352	255	852	447	259	70	5	43	7	6	0
3.5	30	192	93	65	56	79	35	185	126	14	0	0	3	9	0	0
4.5	36	34	31	9	16	23	0	84	7	0	0	0	0	0	0	0

Table 9.4.10 Number of tagged reared salmon recaptured in the offshore longline fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0.5	16	44	16	12	6	27	14	5	14	3	21	14	0	4	2	2
1.5	220	514	341	113	239	325	86	33	430	145	398	40	37	12	38	16
2.5	61	171	133	67	70	58	56	341	114	66	15	0	1	30	10	0
3.5	10	22	33	0	8	20	10	134	25	9	0	0	1	5	0	0
4.5	10	36	3	0	0	0	0	0	0	0	0	0	1	0	0	0

Table 9.4.11 Number of tagged reared salmon recaptured in the terminal river fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	38	8	14	12	29	25	13	4	13	9	2	4	0	1	1	0
1	69	359	205	174	186	148	30	13	96	93	118	78	6	3	2	4
2	28	109	95	114	82	69	60	166	96	35	50	3	4	2	1	0
3	16	51	57	30	37	43	13	107	49	16	0	0	0	0	0	0
4	0	3	1	2	1	0	2	47	3	0	0	0	0	0	0	0
5	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0

Table 9.4.12 Number of tagged reared salmon recaptured in rivers where the salmon can reproduce. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	6	0	1	11	7	16	3	12	3	15	15	2	2	0	1	0
1	2	24	6	3	12	6	1	22	4	6	14	2	4	9	1	1
2	6	25	3	3	8	2	2	20	24	6	10	0	2	3	1	0
3	6	8	2	1	2	3	3	18	5	1	0	0	1	1	0	0
4	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9.4.13 Number of tagged wild salmon released in rivers of area 1 and recaptured in the coastal trapnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
1	0	6	0	0	55	5	0	0	0	0	0	1	8	9	2	12
2	0	20	0	0	24	2	0	0	0	0	0	0	6	0	5	0
3	0	4	0	0	0	1	1	0	0	0	0	0	1	1	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9.4.14 Number of tagged wild salmon released in rivers of area 1 and recaptured in the coastal gillnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0
1	0	3	0	0	27	4	1	0	0	0	0	1	3	5	2	3
2	0	5	0	0	38	1	3	0	0	0	0	5	6	0	0	0
3	0	3	0	0	10	0	1	0	0	0	0	0	0	1	0	0
4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9.4.15 Number of tagged wild salmon recaptured in the coastal driftnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
3	0	7	0	0	8	0	0	0	0	0	0	0	0	0	0	0
4	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9.4.16 Number of tagged wild salmon recaptured in the offshore driftnet fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0.5	0	0	0	0	2	0	0	0	0	0	0	0	1	0	2	0
1.5	2	32	0	0	159	17	21	0	0	0	0	14	75	20	16	12
2.5	0	7	0	0	34	0	7	0	0	0	0	6	23	3	12	0
3.5	0	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9.4.17 Number of tagged wild salmon recaptured in the offshore longline fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
1.5	0	0	0	0	29	12	0	0	0	0	0	2	16	0	37	4
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	14	2	0
3.5	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9.4.18 Number of tagged wild salmon recaptured in the river fishery. The year of recapture indicates the number of years after release the tagged salmon have been recaptured.

Recapture	Release year															
Year	87	88	90	91	92	93	94	95	96	97	98	99	00	01	02	03
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	1	0	0	0	0	0	0	1	2	4	0	2
2	0	0	0	0	0	0	0	0	0	0	0	1	2	1	5	0
3	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

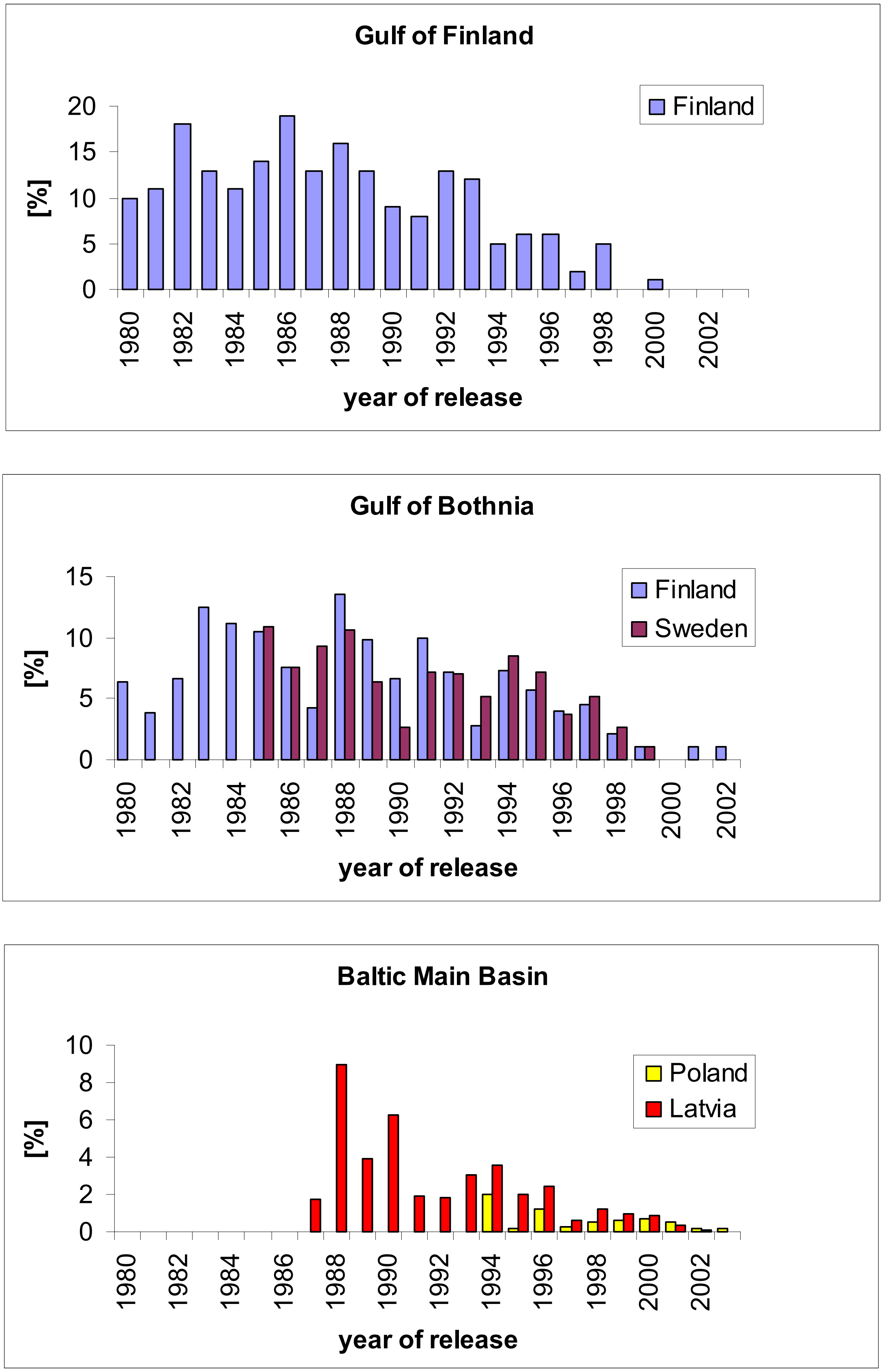

Figure 9.2.1 Recapture rate (in percent) of the tagged salmon in Gulf of Finland, Gulf of Bothnia and Baltic Main Basin in 1980 - 2003

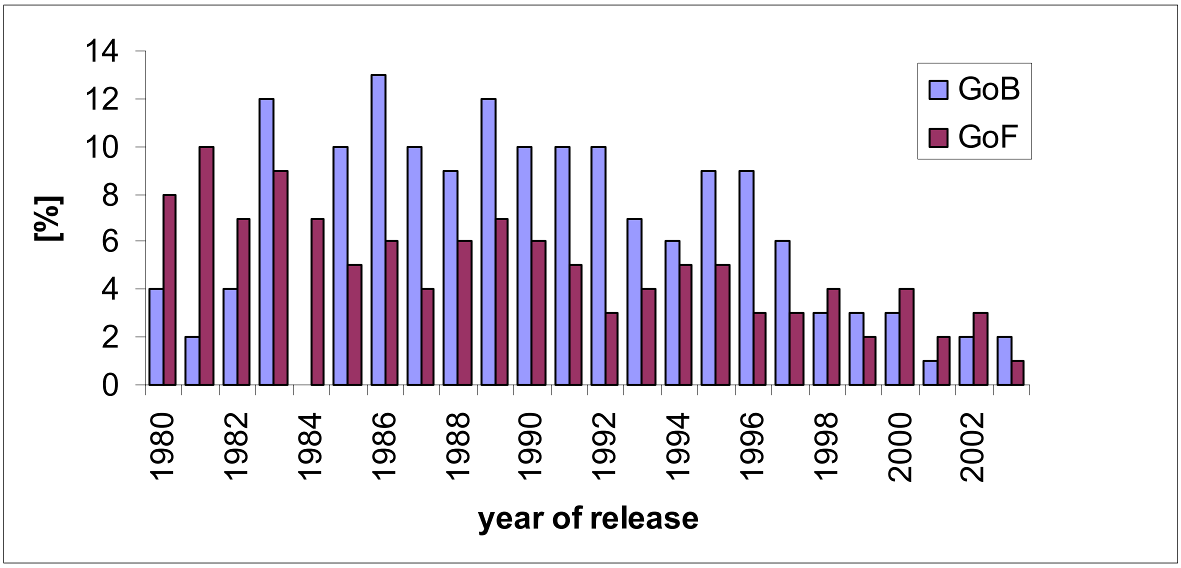

Figure 9.2.2. Recapture rate of the Finnish sea trout released in Gulf of Bothnia and Gulf of Finland in 1980-2003

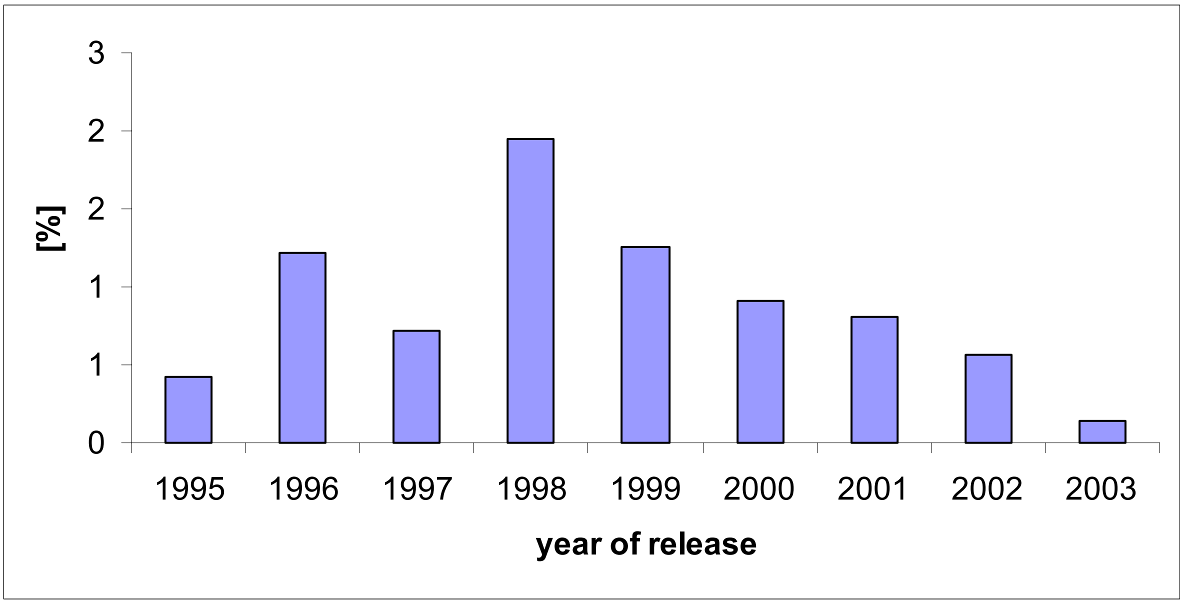

Figure 9.2.3. Recapture rate of the Polish sea trout released in Baltic Main Basin in 1995-2003

10 RECOMMENDATIONS

10.1 Recommendations

The recommendations are internal guidelines for the Group to develop and focus salmon research in the Baltic Sea. The responsibility to promote the ideas expressed in the recommendations is with the Working Group members. Some of the recommendations are repeated from the last year's report.

1. The Working Group recommends that it should meet in 2005 to address questions posed by ACFM. The Working Group should convene in Helsinki, Finland from 5th to 14th of April 2005.

2. The Working Group recommends that the genetic stock proportion analysis will be continued and be expanded in the Baltic Sea salmon fisheries. All significant mixed stock salmon fisheries should be sampled and stock proportion should be analysed if possible. To improve baseline data, sampling on wild stocks in rivers and on stocks used for releases should continue.

3. The Working Group recommends that index rivers with intense monitoring should be established in all assessment areas. In these rivers, not only parr densities but also smolt production and escapement should be measured. Data is especially needed in assessment areas where, at present, there are no data on actual smolt numbers in any river.

4. The Working Group recommends that catch and effort data should be given with information on all stock assessment areas separately, not only sub-divisions.

5. The Working Group recommends that studies of the abundance of spawners in the rivers with released salmon should be carried out.

6. The Working Group recommends that studies of the situation in the Gulf of Finland should be carried out, especially regarding major changes in the abundance of salmon post-smolt feed.

7. The Working Group recommends that applied measures regarding potential rivers should be revised in regard of the objective in the IBSFC Salmon Action Plan.

8. The Working Group recommends to collect more data on sea trout populations in different Baltic Sea areas. Information on migration and fishery exploitation is needed in particular as are data on time series of the status of wild populations.

9. The Working Group recommends further efforts to tag wild salmon, to improve tag reporting rate and to estimate the unreporting of tags. An international survey to estimate tag reporting rate in each Baltic Sea country should be carried out e.g. through co-operation with selected fishermen in each fishery. Data from Swedish taggings should be made available to the group.

10. To reduce "No data available" values in tables, all countries are urged to supply all data that has been agreed to be presented in the WG reports.

10.2 Progress on Past Recommendations

1. Studies to extend studies of the abundance of spawners in the rivers with releases should be carried out.

Progress: No progress.

2. Index rivers with intense monitoring should be established in different regions. In these rivers, not only parr densities (as required by IBSFC) but also escapement and smolt production should be measured. Standardisation of monitoring and estimates of wild smolt and parr production as well as potential production estimates should be carried out both regionally and in the entire Baltic Sea. Projects aimed at improved baseline monitoring of salmon and sea trout populations in countries in the south-eastern part of the Baltic and at estimation of potential production levels should be initiated. F of the or modelling, help with only two

Progress: In the river Simojoki (sub-div 31), a project aimed at counting ascending spawners have been initiated in 2003. In the river Sävarån (sub-div 31), there is a plan to build a combined trap for counting of both ascending spawners and migrating smolt and improving other monitoring objectives such as catch statistics, electrofishing and age analyses.

3. The Working Group needs more data on sea trout populations in different Baltic Sea countries. Information on migration, fishery exploitation, growth and the incidence of M74 in sea trout populations from different Baltic rivers is needed in particular.

Progress: Several countries have improved and extended their monitoring programmes regarding sea trout.

4. Further effort should be taken in all Baltic Sea countries to evaluate the magnitude of unreported catches of salmon and sea trout in all kind of fisheries in open sea and coastal areas as well as in rivers. In addition further actions should be taken to improve the accuracy of the estimates on discards and damages caused by seals to the salmon in gears.

Progress: No progress.

5. An international survey to estimate tag reporting rate in each Baltic Sea country should be carried out e.g. through co-operation with selected fishermen in each fishery.

Progress: No progress

6. Age compositions of the salmon catch samples should be provided by calendar years instead of fishing seasons. In addition the age composition data should be split into half year periods. Sampling should represent catches in all kind of fisheries in every country on which catch statistics are based.

Progress: No progress.

7. All countries are highly urged to supply all data that has agreed to be presented in the WG report. Intention is to get rid of No data available" values in data tables.

Progress: Some progress.

8. The present situation of many of the small eastern populations of salmon is uncertain . Efforts to should be taken to evaluate the actual status of these populations.

Progress: No progress

9. Genetical sampling should be increased in both the rivers and in the sea.

Progress: In 2003, genetical sampling has been carried out in most western Baltic rivers considered in need of improved baseline data. This will continue in 2004. Increased genetical sampling has also been carried out in the sea and coastal fishery and will continue in 2004.

10. A workshop should be held to describe and evaluate the present genetical knowledge of different salmon populations in the Baltic and its usefulness in the assessment. The Working Group recommends that this workshop takes place in connection with the next meeting of the group.

Progress: During the meeting in Tartu in 2004, The Working Group reviewed this questions with the help from geneticists working with the Baltic salmon in Russia, Estonia, Latvia, Sweden and Finland.

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2) Birzaks, J. Latvian National Report of Salmon.

3) Pelczarski, W., Bartel,R. and Dębowski, P. National report on Salmon and Sea Trout, Poland 2003.

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ANNEX 1

Bayesian state-space mark-recapture model to estimate exploitation and abundance of salmon in different assessment areas of the Baltic Sea

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Introduction

The existence of sequential fisheries during successive life history phases of a species can result in very high cumulative fishing mortality rates. Assessments of the fishing mortality rate by fishery and the cumulative fishing mortality rates are prone to bias and imprecision if only conventional fishery dependent data, such as commercial catch and catch-per-unit-effort data are relied upon (Hilborn and Walters 1992; Schnute and Hilborn 1993; Harley et al. 2001). The estimation becomes even more difficult for fishes such as salmon which have multiple life histories.

In order to address this problem, a state space mark-recapture model is proposed for Baltic salmon stock assessment. In order to accurately model the tagged fish, tag reporting rates and fishing effort figures by the fishery sector, are needed. The salmon fisheries in the Baltic Sea are divided according to location and gear type while the life cycle of the organism itself exhibits different life history phases. Depending on how many years the salmon spend in the different life phases, different life histories are distinguished. In addition, the wild salmon population in the Baltic has been enhanced with hatchery-reared salmon, which again exhibits a different life history (Karlsson and Karlström 1994; Romakkaniemi et al. 2003). Therefore a multiple sea-life history model is proposed to model both the salmon population and the salmon fisheries.

Methodology

The construction, validation and implementation of the Baltic salmon assessment model can be summarised in the following paragraphs:

(1) The population dynamics for tagged Baltic salmon is age-structured and describes the dynamics of each life history type of released tagged fish. The tagged salmon is recaptured in different fisheries e.g. the offshore driftnet, offshore long-line, coastal and river fisheries, allowing for the estimation of catchability coefficients (q) for each of the different fisheries which at the moment are assumed to remain constant over time. The fishing mortality rate (F) for each fishery in each year on each life-history type for each released cohort is the product of fishing effort (E) and the catchability coefficient ($F = q * E$). The mark-recapture model thus allows the estimation of annual fishing mortality rates in each different fishery for each sea life history type within each cohort of released tagged fish and the estimation of the total cumulative fishing mortality rate on each life history type within each cohort of released fish. Other estimated quantities include the natural mortality rates and the maturation rates or movement rates from the sea to the river.

(2) Random variability in the systems dynamics (process error) and around the observations (measurement error) are accounted for by using a state-space formulation of the model. The process error ε is introduced in the survival process and by definition lies between the following limits: $0 < \varepsilon < e^{Z}$, whereby e^{-Z} is the total (natural and fishing) mortality from one abundance level to the next. The process errors are designed as such that the abundance in the next time step is always smaller than the abundance in the previous time step ($0 < N_{t+1} = N_t e^{-Z} \varepsilon < N_t$ and $\eta = e^{-Z} \varepsilon < 1$) (Schnute and Richards 1995). Observation error is incorporated into the model through the use of the likelihood function of the data (Hilborn and Mangel 1997). In order to account for the schooling behaviour of salmon, a negative binomial likelihood function is chosen.

(3) Using Bayesian methods for mark-recapture analyses allows for the incorporation of prior knowledge. This prior information is incorporated either through the model structure or as prior probability distributions of model

parameters. The tagging data consists of wild and reared salmon. The number of tagged wild salmon is however very limited, making it more difficult to obtain reliable estimates for annual and total cumulative fishing mortality rates and for other life history parameters which area assumed different for wild salmon than for reared salmon. Prior knowledge about the biological difference or similarities between wild and hatchery-reared salmon are therefore build into the model structure by letting the model structure express the relationship between certain parameters for wild and reared salmon (e.g. the natural post-smolt mortality rate of wild salmon should be lower than that of hatchery-reared stocks). Prior knowledge is also introduced in the model through the use of informative prior probability distributions (or priors) for the different life history parameters. Prior probability distributions are obtained from previous studies done on the species or from experts. In order for the model to work correctly, these distributions need to be chosen correctly.

(4) Before discussing any results obtained through the model, the model is thoroughly tested which is done through sensitivity analyses (Clarke and Gustafson 1998), assessing the fit of the model to the data and calculating Bayesian p-values (Meng 1994; Gelman et al. 1995; Gelman et al. 1996). The model is also validated by comparing the results of the mark-recapture model with data, which have not been used within the model.

(5) By fitting the Bayesian state-space mark-recapture model to the tagging data, the prior probability distributions for each model parameter are updated. This allows among others, the estimation of the annual and total cumulative fishing mortality rate on each life history type within each cohort of released fish. The resulting posterior probability distributions (or posteriors) are subsequently compared with fishing mortality reference points.

(6) The absolute abundance of wild and reared salmon spawners can be estimated by using smolt abundance estimates (annex 2, Mäntyniemi and Romakkaniemi, 2002) in combination with the estimated model parameters. The population dynamics for the total salmon population is the same as the population dynamics for tagged salmon, with the exception of the parameters related to tagging induced mortality or tag reporting rates.

The Bayesian state-space mark-recapture analysis used in the assessment has been run using WinBUGS 1.4 (Bayesian inference Using Gibbs Sampling) software (http://www.mrc-bsu.cam.ac.uk/bugs). WinBUGS uses a Gibbs sampler to sample from the posterior distributions. For reviewing purposes, a copy of the program can be obtained from catcherine.michielsens@rktl.fi.

As with any MCMC (Markov Chain Monte Carlo) simulation, the Gibbs sampler requires an evaluation to determine if it is reasonable to believe that the samples are representative of the underlying stationary distribution i.e. if the Markov Chain has converged (Best et al. 1995: Gelman and Rubin 1992). All the modelling results described for the assessment have undergone convergence diagnostics in order to remove the 'burn-in' and to assess convergence. It is therefore assumed that the reported posterior distributions obtained through Gibbs sampling are representative for the underlying stationary distributions.

Description of data

Extensive mark and recapture data sets exist for both wild and reared Baltic salmon (section 9 of the WGBAST report). In the current mark-recapture analysis, the first and last release year considered are 1987 and 2003 and only tagging data from Finland, Sweden and Denmark are used. Currently also tagging data from Latvia and for Gulf of Finland stocks are available and these data sets are planned to be used in the 2005 assessment. Recapture records are obtained for each of the main fisheries in the Baltic Sea and rivers i.e. offshore driftnet, offshore longline, coastal driftnet, coastal trapnet, other gears used in coastal areas (predominantly gillnets) and river fisheries. Tagging data for wild salmon are only available for the river Torne and the river Simo. These two rivers are located in the north-eastern rim of the Gulf of Bothnia (assessment area 1). Tagged hatchery-reared salmon have been released over a much wider variety of rivers, both located in the north and the south.

The records of releases and recaptures of tagged salmon have been grouped according to wild and hatchery-reared salmon (section 9.4). The reared salmon in addition has been grouped according to the type of river where the tagged salmon have been released: rivers where they are able to reproduce upon returning to the river or rivers without natural reproducing salmon because of the damming of the river. Tag recaptures are also grouped according to the fishery by which they are caught. Tagged salmon caught by the coastal fishery are grouped according to the assessment unit their river of release belongs to: either assessment area 1, 2 or 3. The definitions of the assessment units are based on the genetic and biological similarities or differences between stocks. Because of the different migration patterns between stocks of different assessment units, coastal harvest rates are assumed to differ between the assessment groups. It should be noted however, that the composition of the tagged salmon population has changed over the years with no Swedish tagging data being available in recent years and the increase in tagging data from potential salmon rivers.

In addition to the mark-recapture data, the state-space sea-life history model also uses fishing effort data (section 3, Table 3.3.1). The main missing fishing effort data were the fishing effort for the Polish offshore fisheries and the fishing effort for the Swedish coastal fishery by other gears (predominantly gillnets). It has therefore been assumed that the Polish CPUE is the same as the CPUE of other countries in the offshore fisheries. The assumed Polish CPUE has been used in combination with the estimated Polish offshore catch to estimate the Polish offshore fishing effort. A similar approach has been used to estimate the Swedish coastal fishing effort by gillnets through assuming that the Finnish CPUE by the coastal gillnet fishery is the same as the Swedish CPUE for the coastal gillnet fishery.

Within the stock assessment model, the fishing effort (E) data for the different fisheries are used in combination with the estimated catchability coefficients (q) for the different fisheries in order to obtain the fishing mortality rates (F = q * E). The value for the catchability coefficients are estimated to predict a fishing mortality rate consistent with the tagging data returns and the other modelled assumptions that affect the number of recovered tags observed. The unit of fishing effort is in geardays and the unit of catchability coefficient for each fishery is in 1/(geardays * year). Thus the units for the fishing effort actually applied within the model are relatively unimportant. From a practical perspective however, the WinBUGS programs runs faster when the values for the fishing effort are not too large. For this reason the fishing efforts used in the assessment model has been expressed in terms of 100,000 geardays except for the coastal trapnet fishery which is expressed in terms of 1000 geardays.

Description of deterministic mark-recapture model

The mark-recapture analysis uses a population dynamics model that is age-structured and includes five different life history types that spend from one to five winters in the sea before returning to the river to spawn. The model simultaneously models wild and reared Baltic salmon, each as a separate fished stock. And it includes the capture of each life-history type of released tagged fish in six different fisheries: the offshore driftnet (df), offshore long-line (lf), coastal driftnet (cdf), coastal trapnet (tf), coastal gillnet (gf) and river fisheries (rf).

Within the population dynamics model it is assumed that the different fisheries occur at sequential points during the year. They are modelled as discrete points in the year by using a discrete event approximation. The offshore driftnet fishery is assumed to take place in October and offshore longline fishery in December (Figure 2). The coastal trapnet and gillnet fishery are assumed to take place during the same time. During the first year at liberty the coastal trapnet or gillnet fishery of the tagged fish takes place in August, while the coastal fishery during subsequent years is assumed to take place in June. The coastal driftnet fishery takes place one month prior to the coastal trapnet/gillnet fishery while the salmon are returning to the rivers. The fishery in the river takes place in August. In order to facilitate the sequential modelling of the different fisheries, the population dynamics model uses years that start in May and end in April.

The natural mortality is modelled as an instantaneous mortality rate. Because the fishing mortality is modelled as a set of discrete events, natural mortality rates are therefore modelled to occur separately. The tag-shedding rate is modelled to occur during driftnet fisheries and is applied as a percentage. For wild salmon, tagging mortality is applied as an instantaneous rate during the first year. For hatchery-reared salmon, tagging-induced mortality is ignored within the model, since hatchery-reared salmon are tagged up to one year before they are released. The reporting rates are modelled as percentages. Tag reporting and tag shedding rates are assumed to be the same for wild and hatchery-reared fish.

Since 1995, seal predation on salmon in the Baltic Sea area has increased. This mortality due to predation by seals has been modelled explicitly by applying a factor f_{seal} to increase the natural mortality rate M in coastal areas above the historical average because of seal predation ($M_{adjusted} = M * f_{seal}$). The percentage of salmon mauled by seals in coastal areas is assumed to have increase by 5.5% between 1995 and 2001 (WGBAST, personal communication). In addition, another parameter has been added to adjust the coastal tag reporting rate for the removal of tagged salmon from the traps or nets by seals. It is assumed that the removal of tagged salmon from the traps has decreased since 1993 by 20% due to improvements in Swedish trapnet gears.

The population dynamics of tagged fish can be described through the following equations. The abundance of released tagged fish in the river after their first 2 months at liberty (beginning of July) is given by

(1) $$N_{rf,r,1} = T_r e^{-M_{PS,r}/6}$$

whereby $N_{rf,r,a}$ is the abundance of tagged fish released in year r, that can be captured by the river fisheries (rf) during their ath year at liberty,

T_r is the abundance of fish released in year r, and

$M_{PS,r}$ is the rate of post-smolt mortality in year r. In this equation, the yearly post-smolt mortality is spread over 2 month and is therefore divided by 6 (2/12) in order to represent the post-smolt mortality rate over two months.

The number of tagged river fish caught and reported in the middle of July (third month) during their first year at liberty is given by the equation

(2) $$C_{rf,r,1} = N_{rf,r,1} H_{rf,r,1} e^{-M_{PS,r}/24} R_{rf}$$

whereby $C_{f,r,a}$ is the number of tagged fish released in year r and caught and reported by fishery f (whereby rf = river fishery, cf = coastal fishery, cdf = coastal driftnet fishery catching maturing fish, df = offshore driftnet fishery and lf = offshore longline fishery) during their ath year at liberty,

R_f is the reporting rate in fishery f,

$H_{f,r,a}$ is the harvest rate of tagged fish released in year r by fishery f during the ath year at liberty, whereby

(3) $$H_{f,r,a} = \left(1 - e^{-F_{f,r,a}}\right)$$

$F_{f,r,a}$ is the fishing mortality rate of tagged fish released in year r by fishery f during their ath year at liberty,

(4) $$F_{f,r,a} = q_{f,a} E_{f,r+a-1}$$

$q_{f,a}$ is the catchability coefficient of the tagged salmon by fishery f during their ath year at liberty, and

$E_{f,r+a-1}$ is the fishing effort in fishery f during the ath year after release year r, expressed in terms of number of geardays per year.

The abundance of coastal tagged fish in the beginning of September during their first year at liberty is given by the equation

(5) $$N_{cf,r,1} = N_{rf,r,1}\left(1 - H_{rf,r,1}\right) e^{-\left(M_{PS,r} f_{seal,r}\right)/6}$$

whereby $N_{cf,r,1}$ is the abundance of tagged fish released in year r that can be caught by the coastal fishery during their first year at liberty, and

$f_{seal,r}$ is the additional mortality factor to increase the natural mortality rate above the average rate due to seal predation in coastal areas.

The number of coastal tagged fish caught and reported in the middle of September (fifth month) during their first year at liberty is given by the equation

(6) $$C_{cf,r,1} = N_{cf,r,1} H_{cf,r,1} e^{-\left(M_{PS,r} f_{seal,r}\right)/24} R_{cf} R_{Adj,c}$$

whereby $R_{Adj,c}$ is an adjustment to the reporting rate in the coastal fishery due to the removal of tagged fish from the traps or nets by seals. In the case of the coastal fishery, the total coastal fishing mortality rate is determined by the sum of the fishing mortality rate of the coastal trapnet fishery and fishing mortality rate of the coastal gillnet fishery.

The abundance of offshore tagged fish in the beginning of October during their first year at liberty is given by the equation

(7) $$N_{df,r,1} = N_{cf,r,1}\left(1 - H_{df,r,1}\right) e^{-M_{PS,r}/12}$$

whereby $N_{df,r,1}$ is the abundance of tagged fish released in year r that can be caught by the offshore driftnet fishery during their first year at liberty.

The number of offshore tagged fish caught and reported in the middle of October (sixth month) by the offshore driftnet fishery during their first year at liberty is given by the equation

(8) $$C_{df,r,1} = N_{df,r,1} H_{df,r,1} e^{-M_{PS,r}/24} R_{df}$$

The abundance of offshore tagged fish in the beginning of December during their first year at liberty is given by the equation

(9) $$N_{lf,r,1} = N_{df,r,1} \left(1 - H_{lf,r,1}\right) e^{-M_{PS,r}/6}$$

whereby $N_{lf,r,1}$ is the abundance of tagged fish released in year r that can be caught by the offshore longline fishery during their first year at liberty.

The number of offshore tagged fish caught and reported in the middle of December (eight month) by the offshore longline fishery during their first year at liberty is given by the equation

(10) $$C_{lf,r,1} = N_{lf,r,1} H_{lf,r,1} e^{-M_{PS,r}/24} R_{lf}$$

The abundance of returning tagged fish in the beginning of May that can be caught by the coastal driftnet fishery during their second year at liberty is given by the equation

(11) $$N_{cdf,r,2} = N_{lf,r,1} \left(1 - H_{cf,r,1}\right) e^{-\left(5M_{PS,r}\right)/12} L_1$$

whereby $N_{cdf,r,2}$ is the sea abundance of maturing tagged fish released in year r, that can be caught by the coastal driftnet fishery during their second year at liberty, and

L_a is the maturation rate after a years at sea.

The number of maturing tagged fish caught and reported in the coastal driftnet fishery in May (first month) during their second year at liberty is given by the equation

(12) $$C_{cdf,r,2} = N_{cdf,r,2} H_{cdf,r,2} e^{-M_2/24} R_{df} \left(1 - S\right)$$

whereby S is the tag shedding rate in the driftnet fishery,

M_2 is the adult mortality rate, and

$H_{cdf,r,a}$ is the harvest rate of maturing tagged fish released in year r and captured by the coastal driftnet fishery during their a[th] year at liberty. It is assumed that the catchability coefficient of the coastal driftnet fishery in May of maturing fish is the same as the catchability coefficient of the offshore driftnet fishery in October. Reporting rates and tag shedding rates are equally assumed to be the same between the two fisheries.

The abundance of tagged fish in the beginning of October that can be caught by the offshore driftnet fishery during their second year at liberty is given by the equation

(13) $$N_{df,r,2} = N_{lf,r,1} \left(1 - H_{cf,r,1}\right) e^{-\left(5M_{PS,r}\right)/12} e^{-\left(5M_2\right)/12} \left(1 - L_1\right)$$

whereby $N_{df,r,2}$ is the sea abundance of tagged fish released in year r that can be caught by the offshore driftnet fishery during their second year at liberty.

The number of tagged fish caught and reported in the offshore driftnet fishery in the middle of October (sixth month) during their second year at liberty is given by the equation

(14) $$C_{df,r,2} = N_{df,r,2} H_{df,r,2} e^{-M_2/24} R_{df} (1 - S)$$

The abundance of tagged fish in the beginning of December that can be caught by the offshore longline fishery during their a[th] year at liberty (a = 2 to 5) is given by the equation

(15) $$N_{lf,r,a} = N_{df,r,a} \left(1 - H_{df,r,a}\right) e^{-M_2/6}$$

whereby $N_{lf,r,a}$ is the sea abundance of tagged fish released in year r that can be caught by the offshore longline fishery during their a[th] year at liberty.

The number of offshore tagged fish caught and reported in the longline fishery in the middle of December (eight month) during their a[th] year at liberty is given by the equation

(16) $$C_{lf,r,a} = N_{lf,r,a} H_{lf,r,a} e^{-M_2/24} R_{lf}$$

The abundance of maturing tagged fish that can be caught in the beginning of May by the coastal driftnet fishery during their a[th] year at liberty (a = 3 to 5), is given by the equation

(17) $$N_{cdf,r,a} = N_{lf,r,a-1} \left(1 - H_{lf,r,a-1}\right) e^{-(5M_2)/12} L_{a-1}$$

whereby $N_{cdf,r,a}$ is the abundance of maturing tagged fish released in year r, that can be caught by the coastal driftnet fishery in May during their a[th] year at liberty.

The number of maturing tagged fish caught and reported in the coastal driftnet fishery in the middle of May (first month) during their a[th] year at liberty is given by the equation

(18) $$C_{cdf,r,a} = N_{cdf,r,a} H_{cdf,r,a} e^{-M_2/24} R_{df} (1 - S)$$

The abundance of tagged offshore fish that can be caught in the beginning of October by the offshore driftnet fishery during their a[th] year at liberty (a = 3 to 5), is given by the equation

(19) $$N_{df,r,a} = N_{lf,r,a-1} \left(1 - H_{lf,r,a-1}\right) e^{-(5M_2)/6} \left(1 - L_{a-1}\right)$$

The number of tagged fish caught and reported in the offshore driftnet fishery in the middle of October (sixth month) during their a[th] year at liberty is given by the equation

(20) $$C_{df,r,a} = N_{df,r,a} H_{df,r,a} e^{-M_2/24} R_{df} (1 - S)$$

The abundance of coastal tagged fish in their a[th] year at liberty (a = 2 to 6) is given by the equation

(21) $$N_{cf,r,a} = N_{cdf,r,a} \left(1 - H_{cdf,r,a}\right) e^{-(M_2 f_{seal,r})/12}$$

The number of coastal tagged fish caught and reported in the middle of June (second month) during their a[th] year at liberty is given by the equation

(22) $$C_{cf,r,a} = N_{cf,r,a} H_{cf,r,a} e^{-(M_2 f_{seal,r})/24} R_{cf} R_{Adj,c}$$

The abundance of river tagged fish in their a[th] year at liberty (a = 2 to 6) is given by the equation

(23) $$N_{rf,r,a} = N_{cf,r,a} \left(1 - H_{cf,r,a}\right) e^{-M_2/6}$$

The number of tagged river fish caught and reported in the middle of August (fourth month) during their a[th] year at liberty is given by the equation

(24) $$C_{rf,r,a} = N_{rf,r,a} H_{rf,r,a} e^{-M_2/24} R_{rf}$$

The main outputs of the model are fishing mortality rates. For each year, the model estimates different fishing mortality rate values depending on the fishery (offshore driftnet, offshore longline, coastal driftnet, coastal and river fishery), depending on the age of the fish, depending on whether it is a wild or hatchery-reared fish. To present these values at this highly detailed level of disaggregation would be confusing and not necessarily very useful for management purposes. Instead the total cumulative fishing mortality rates are reported for wild and hatchery-reared fish depending on the number of years the salmon stay at sea. This total cumulative fishing mortality rate relates to the total fishing pressure a fish is subjected to during its life history. For example for 2SW fish, the fish can be caught by the river fishery immediate after release, by the coastal fishery during the first year after its release, by the driftnet and longline fishery during its first winter at sea, by the driftnet and longline fishery during its second winter at sea, by the coastal driftnet fishery and the coastal trapnet and gillnet fishery when on its way to the river and by the river fishery:

(25) $$F^{2SW}_{cum,r+2} = F^{2SW}_{rf,r,1} + F^{2SW}_{tf,r,1} + F^{2SW}_{gf,r,1} + F^{2SW}_{df,r,1} + F^{2SW}_{lf,r,1} + F^{2SW}_{df,r,2} + F^{2SW}_{lf,r,2} + F^{2SW}_{cdf,r,2} + F^{2SW}_{tf,r,2} + F^{2SW}_{gf,r,2} + F^{2SW}_{rf,r,2}$$

As such the total cumulative fishing mortality rate is not on an annual scale but over the entire life history of the salmon. The total cumulative fishing morality rates only reflect the mortality due to the fishing and do not include any natural mortality. In order to simplify the interpretation of the results, cumulative fishing mortality rates are expressed as total harvest rates. The calculation of the total cumulative fishing mortality rates correspond to the calculation of the limit and precautionary fishing mortality reference points (ICES, 2002) against which the fishing mortality rates can be compared.

Table 1: Overview of model variables of the Bayesian age-structured life-history model

Model variables	Description
T_r	River abundance of tagged smolts released in year r
$N_{f,r,a}$	Abundance of tagged fish released in year r, that can be captured by fishery f (rf = river fishery, tf = coastal trapnet fishery, gf = coastal gillnet fishery, cdf = coastal driftnet fishery, df = driftnet fishery and lf = longline fishery) in year r during their ath year at liberty
$Sp_{r,a}$	Abundance of tagged spawners in year r which have spent a years at liberty
$C_{f,r,a}$	Number of tagged salmon caught in year r by fishery f during their ath year at liberty
$H_{f,r,a}$	Harvest rate by fishery f in year r of salmon that have spend a years at liberty
$F_{f,r,a}$	Fishing mortality rate of tagged fish released in year r by fishery f during their ath year at liberty (1 / year)
$F_{cum,r+2}^{2SW}$	Total cumulative fishing mortality rate of tagged 2SW fish returning to the river for spawning 2 years after release year r

Table 2: Overview of the model parameters of the Bayesian age-structured life-history model

Model parameters	Description
L_a	Fraction of fish that home after a years at sea
$q_{f,a}$	Catchability coefficient of the tagged salmon during their ath year at liberty by fishery f, expressed in terms of 1 / (100,000 geardays * year) except for the coastal trapnet fishery: 1/ (1,000 geardays * year)
$M_{PS,r}$	Rate of instantaneous post-smolt mortality in year r (1 / year)
M_2	Rate of instantaneous natural mortality of adult fish before spawning (1 / year)
$f_{seal,r}$	Additional mortality factor to increase the natural mortality rate above the average rate due to seal predation in coastal areas
S	Tag shedding rate in driftnet fishery
R_f	Reporting rate in fishery f
$R_{Adj,c}$	Adjustment to the reporting rate in the coastal fishery due to the removal of tagged fish from the traps or nets by seals

The population dynamics for the total abundance (tagged and untagged) of salmon can be expressed by the same abundance equations as the population dynamics for the abundance tagged salmon. The total number of wild smolts are obtained through an hierarchical model of parr density and smolt abundance estimates (see annex 1, Mäntyniemi and Romakkaniemi, 2002). In addition, the total number of released hatchery-reared smolts are used as inputs into the model. For the total catch equations, the tag reporting rates for tagged salmon are replaced with the catch reporting rate. The main outputs are the number of returning wild spawners and the number of reared spawners which are unable to spawn and which could be regarded as lost production.

Description of process error term used within the assessment model

The process error is introduced in the survival process. Within the assessment model, a process error dependant on the total survival rate is proposed ($0 < N_{t+1} = N_t e^{-Z} \varepsilon < N_t$ and $\eta = e^{-Z} \varepsilon < 1$, whereby $Z = M + F$). This would account for observation error in the fishing effort data. The process error term will lie by definition between 0 and e^Z whereby e^{-Z} is the survival rate from natural and fishing mortality from one abundance level to the next.

In general, state-space models use yearly time steps when modelling a population. Because of the amount of within-year detail when modelling the multiple life histories of Baltic salmon, smaller than yearly time steps are required. Therefore, the variance of the process error has been made dependent on the size of the time step. Assuming that annual variance components are additive, the variance of the yearly process error is divided by 12 and multiplied by the number of months over which the process error is applied. The smaller the time steps the smaller the variance.

Unless suitable constraints are implemented, it may happen that the product of the survival rate and the process error is larger than 1. To prevent this, the maximum variance of the process error term is also made dependent on the total mortality rates. Within the assessment model, the yearly process error is given a symmetrical uniform distribution around 1,

(27) $$\varepsilon \sim U(\min, \max)$$

whereby the minimum and maximum process error are a function of the yearly total mortality rate. The yearly variance of this process error has a fixed distribution over time. At each point during the life history, the process error is assumed to be the same for wild and hatchery-reared salmon. In case wild and hatchery-reared salmon have different total mortality rates, the smallest resulting process error is applied to both.

Description of the Bayesian state space mark-recapture model

Prior knowledge about the salmon biology plays a key role in the specification of the model structure and the prior probability distributions. Tagging data for both wild and hatchery-reared salmon are analysed together whereby the model structure expresses the relationship between certain parameters for wild and hatchery-reared salmon. Within the mark-recapture model, the following relationships between model parameters are assumed:

1. Stocks within the Baltic Sea have been classified into six different assessment areas based on the genetics of the stocks and the biological characteristics of the stocks. Socks of a particular unit are assumed to exhibit similar migration patterns. As a result they are subjected to the same fisheries and it is assumed that they experience the same exploitation rates.
2. It is assumed that the exploitation rates between salmon stocks of assessment unit 1 to 4 mainly differ in terms of the exploitation rate by the coastal fisheries.
3. Salmon of assessment area 4 (Western Main Basin stocks) are assumed to be exploited only offshore and in the rivers without being effected by coastal fisheries due to the short migration route along the coast.
4. The maturation rate (or homing rate) for wild grilse is lower than that of hatchery-reared grilse (Kallio-Nyberg and Koljonen, 1997; Jutila *et al.*, 2003). This is implemented in the model by estimating a mean maturation rate and multiplying this mean value with a yearly maturation effect for wild or hatchery-reared salmon, allowing wild maturation rates for 1SW fish to be the same or smaller than maturation rates for hatchery-reared fish.
5. The post-smolt mortality rate of hatchery-reared fish is higher than that of wild fish (Olla *et al.*, 1998; Brown and Laland, 2001). This is implemented similarly to the maturation rates by estimating a mean post-smolt mortality rate for wild salmon and an additional mortality effects for hatchery-reared salmon.
6. Post-smolt mortality rates differ from year to year (Salminen *et al.*, 1995) in a similar way for both wild and hatchery-reared fish. This is implemented by adding a year-effect to the estimation of the post-smolt mortality rates.
7. The differences in post-smolt mortality rates between wild and reared salmon for assessment areas 2 to 4 are the same as the differences between post-smolt mortality rates for wild and reared salmon of assessment area 1.
8. The instantaneous natural mortality rate for adult salmon is assumed to be the same for wild and reared salmon and constant over the years.
9. It is assumed that the number of salmon maulted by seals in coastal areas has increased annually by 5.5% between 1995 and 2001. It is assumed that the removal of tagged salmon from the traps has decreased since 2003 by 20% due to improvements in Swedish trapnet gear.

Prior knowledge is also introduced, besides through model structure, through the use of informative prior probability distributions for the model parameters. Tables 3 and 4 give an overview of the prior probability distributions used in the analysis. The prior probability distributions of Table 3 are based on preliminary analyses by members of the ICES' Baltic Salmon and Trout Assessment Working Group (WGBAST) or on their expert opinion (WGBAST, personal communication). The information based on preliminary analyses, executed by members of the Baltic Salmon and Trout Working Group include among others historical maturation rates, information from the broodstock fisheries, double tagging experiments, etc. (section 9.3). Care has been taken to assure that the prior distributions are not based on data used within the mark-recapture model in order to avoid using the same data twice and rendering the results too informative. In general, the preliminary analyses gave often only a first indication of the model parameters but expert opinion needed to be used for example to extrapolate it to the entire Baltic Sea, or to other fisheries, etc. When eliciting expert opinions, 12 different Baltic salmon working group experts have been consulted. For each parameter, the experts have been asked to provide a most likely value and a minimum and maximum value. The use of 12 experts resulted in 12 priors for the different model parameters. The multiple priors have been pooled using arithmetic pooling (Genest and Zidek, 1986). Pooled prior probability for parameter value θ is obtained by

$$p(\theta) = \sum_k p_k(\theta) \Big/ 12 .$$

where k indicates the expert.

For some model parameters such as tag reporting rates, each expert can only give an expert opinion about the reporting rate of tags by their own fishing fleet. The prior probabilities distribution for tag return rates for each country is therefore weighted by the country's contribution to catches and arithmetic pooling of the priors is applied to obtain prior probability distributions for the reporting rates for the entire fisheries.

For some model parameters such as the catchability coefficients, selecting appropriate prior probability distributions can be difficult. Uninformative prior probability distributions for the catchability coefficients will result in bimodal distributions for the resulting harvest rates with peaks at 0 and 1. Therefore priors for the catchability coefficients are chosen in terms of the resulting harvest rates (Table 4). Priors have been chosen for the harvest rates by the different fisheries in the first year of the dataseries, i.e. 1987. Given corresponding values for the fishing effort by the different fisheries in 1987, the prior probability distributions for the catchability coefficients by the different fisheries can be calculated. In combination with the fishing efforts for the subsequent years, these prior probability distribution for the catchability coefficients then determine the prior probability distributions for the harvest rates in subsequent years. The catchability coefficients have been estimated independently for different age groups in case the gears have a different selectivity for different age-groups (Table 4).

Only two parameters in the model have not been given prior probability distributions, but are assumed to be known exactly, namely the additional natural mortality due to predation by seals, and the additional reduction in recovery rates of tags from coastal fisheries due to seal predation (Table 5). The instantaneous natural mortality has been assumed to remain constant over the years. It is however assumed that the percentage of salmon mauled by seals in coastal areas has increased annually by 5.5% between 1995 and 2001 and thereafter it has stabilised. The natural mortality rates in coastal areas and the reporting rates by coastal fisheries have been adjusted accordingly.

Table 3: Summary of model parameters, their description, the symbol used within the WinBUGS program, their prior probability distributions and the corresponding prior median, CV and 95% probability interval (PI). The distributions follow the same parameterisation as used wihtin the WinBUGS program. N denotes a normal distribution with the first term denoting the mean and the second term the precision ($1/\sigma^2$). LogN denotes a lognormal density function and the first term is the median value for the natural logrithm of the lognormal random variable. The second term represents the precision of the natural logrithm of the random variable where σ is the standard deviation of the natrual logarithm of the random variable. Beta denotes a beta distribution determined by two shape parameters. Some distributions have been truncated (e.g. I(a,b)) to indicate that prior belief that the random variable can not be smaller than a or larger than b. In case the prior probability distributions of some parameters have been based on the prior probability distributions of other parameters, the equation is provided.

Parameters	**WinBUGS symbol**	**Distribution**	**Median**	**CV**	**95% PI**
Average maturation rate for wild and reared grilse	mL1	Beta(2.3,15)I(0,0.35)	0.12	0.57	0.02 - 0.30
Hatchery reared effect on average maturation rate	ReffectL	ReffectL	1.82	2.28	1.05 - 8.05
Wild effect on average maturation rate	WeffectL	1/ ReffectL	0.55	0.41	0.12 - 0.95
Maturation rate for wild grilse	LW[1]	mL1 * WeffectL	0.06	0.85	0.00 - 0.27
Maturation rate for reared grilse	LR[1]	mL1 * ReffectL	0.24	0.40	0.07 - 0.45
Maturation rate for 2SW salmon	LW[2]/LR[2]	Beta(3.6,4.5)I(0.1,0.9)	0.44	0.36	0.16 - 0.77
Maturation rate for 3SW salmon	LW[3]/LR[3]	Beta(24,7.5)I(0.2,0.95)	0.77	0.09	0.60 - 0.89
Maturation rate for 4SW salmon	LW[4]/LR[4]	Beta(10,2)I(0.4,1)	0.85	0.12	0.60 - 0.98
Instantaneous mean wild post-smolt mortality rate	mMpsW	logN(0.23,19)I(1,3)	1.34	0.19	1.02 - 2.03
Increase in mean post-smolt mortality rate for hatchery-reared salmon compared to wild salmon	ReffectMps	Beta(0.9,1.8)I(1,2.5)	1.44	0.24	1.01 - 2.29
Instantaneous mean reared post-smolt mortality rate	mMpsR	mMpsW * ReffectMps	1.93	0.32	1.16 - 3.61
Year effect on the average instantaneous mortality rate	T	N(1,20)I(0,)	1.00	0.23	0.56 - 1.44
Yearly instantaneous wild post-smolt mortality rate	MpsW	mMpsW * T	1.32	0.30	0.69 - 2.32
Yearly instantaneous reared post-smolt mortality rate	MpsR	mMpsR * T	1.90	0.40	0.89 - 4.01
Instantaneous adult mortality rate	M	logN(-2.3, 4.3)I(0.025,0.35)	0.10	0.48	0.04 - 0.25
Tag retention rate	Tretain	Beta(20,8)I(0.5,1)	0.72	0.11	0.55 - 0.86
Tag reporting rate in the river fishery	reportrR/reportW	Beta(16,6)I(0.3,0.95)	0.73	0.13	0.53 - 0.89
Tag reporting rate in the coastal fishery	reportc	Beta(11,9)I(0.3,0.8)	0.55	0.19	0.35 - 0.75
Tag reporting rate in the driftnet fishery	reportd	Beta(8,4)I(0.2,0.95)	0.68	0.20	0.39 - 0.89
Tag reporting rate in the longline fishery	reportl	Beta(10,4)I(0.3,0.95)	0.72	0.16	0.46 - 0.91

Table 4: Summary of model parameters, their description, the symbol used within the WinBUGS program, their prior probability distributions and the corresponding prior median, CV and 95% probability interval (PI). The distributions follow the same parameterisation as used wihtin the WinBUGS program. Beta denotes a beta distribution determined by two shape parameters. The prior probability distributions for the mean catchability coefficients of the different fisheries have been derived from the prior probability distributions of the corresponding harvest rates for those fisheries in 1987 and the corresponding fishing effort in 1987 through the following equation:$q = -\log(1-H)/E$, with q being the catchability coefficient, H the harvest rate and E the fishing effort. Catchability coefficients are expressed in terms of (100,000 geardays * year)$^{-1}$with exception for the coastal trapnet fishery (1000 geardays* year)$^{-1}$

Parameters	WinBUGS symbol	Distribution	Median	CV	95% PI
River or coastal harvest rate of salmon during feeding migration in 1987	HRRR[1], HRRW[1], HRGN[1], HRTN[1]	Beta(1,20)	0.03	0.95	0.00 - 0.17
River harvest rate of grilse and MSW fish in 1987	HRRW[2], HRRW[3]	Beta(1.5,1.5)	0.50	0.50	0.06 - 0.94
River harvest rate in terminal fishing areas in 1987	HRRR[2]	Beta(1.5,1.5)	0.50	0.50	0.06 - 0.94
Coastal gillnet harvest rate of grilse and 2SW+ fish in 1987	HRGN[2], HRGN[3]	Beta(2,5)	0.26	0.57	0.04 - 0.64
Coastal trapnet harvest rate of grilse and 2SW+ fish in 1987	HRTN[2], HRTN[3]	Beta(2,5)	0.26	0.57	0.04 - 0.64
Driftnet or longline harvest rate of grilse in 1987	HRD[1]	Beta(1,20)	0.03	0.95	0.00 - 0.17
Driftnet harvest rate of 2SW, 3SW and 4SW+ salmon in 1987	HRD[2], HRD[3], HRD[4]	Beta(2,5)	0.26	0.57	0.04 - 0.64
Longline harvest rate of MSW fish in 1987	HRL[2]	Beta(2,5)	0.26	0.57	0.04 - 0.64
Catchability of salmon by the river fishery during feeding migration	qrR[1], qrW[1]	d.f. HRRR[1], HRRW[1]	0.00	1.12	0.00 - 0.02
Catchability of grilse and MSW fish by the river fishery	qrW[2], qrW[3]	d.f. HRRW[2], HRRW[3]	0.07	0.83	0.01 - 0.28
Catchability of salmon by the terminal fishery	qrR[2]	d.f. HRRR[2]	0.07	0.83	0.01 - 0.28
Catchability of salmon by the coastal gillnet fishery during feeding migration	qcgn[1]	d.f. HRGN[1]	0.01	1.11	0.00 - 0.08
Catchability of grilse and 2SW+ fish by the coastal gillnet fishery	qcgn[2], qcgn[3]	d.f. HRGN[2], HRGN[3]	0.21	0.83	0.03 - 0.87
Catchability of salmon by the coastal trapnet fishery during feeding migration	qctn[1]	d.f. HRTN[1]	0.06	1.11	0.00 - 0.36
Catchability of grilse and 2SW+ fish by the coastal trapnet fishery	qctn[2], qctn[3]	d.f. HRTN[2], HRTN[3]	0.97	0.84	0.13 - 3.97
Catchability of grilse by the drifnet fishery	qd[1]	d.f. HRD[1]	0.00	1.11	0.00 - 0.01
Catchability of 2SW, 3SW and 4SW+ salmon by the driftnet fishery	qd[2], qd[3], qd[4]	d.f. HRD[2], HRD[3], HRD[4]	0.01	0.83	0.00 - 0.05
Catchability of grilse by the longline fishery	ql[1]	d.f. HRL[1]	0.00	1.02	0.00 - 0.01
Catchability of MSW fish by the longline fishery	ql2], ql[3], ql[4]	d.f. HRL[2], HRL[3], HRL[4]	0.01	0.73	0.00 - 0.04

Table 5: Summary of fixed model parameters, their description, the symbol used within the WinBUGS program. It is assumed that the percentage of salmon maulted by seals in coastal areas has increased annually by 5.5 % between 1995 and 2001.

Parameters	Symbol	WinBUGS symbol
Adjustment to the reporting rate in the coastal fishery due to the removal of tagged fish from the traps or nets by seals.	$R_{Adj,c}$	reportcAdj
Additional mortality factor to increase the natural mortality rate above the average rate due to seal predation in coastal areas	$f_{seal,r}$	sealMort

Results

The resulting Bayesian state-space mark-recapture model can be used to estimate, among others, annual and cumulative fishing mortality rates. To assess the robustness and validity of these results several analyses have to be undertaken: a sensitivity analysis of the inference to reasonable changes in the prior distributions of crucial model parameters and in the likelihood function (Clarke and Gustafson 1998), and an assessment of the predictive power of the model by comparing posterior predictive distributions to observed data by calculating Bayesian p-values (Meng 1994; Gelman et al. 1995; Gelman et al. 1996).

The complexity of the mark-recapture model results in the use of large numbers of parameters, each with its own prior probability distribution. Tag return rates and maturation rates have been selected to be used in a sensitivity analysis in order to test the sensitivity of the results to changes in their prior probability distributions. The total fishing mortality rate is chosen as the primary output on which to test the sensitivity of the results.

A vital part of mark-recapture analyses is the determination of the tag return rates (Hilborn and Walters 1992). Therefore the prior probability distributions inputted for tag mortality rates, tag shedding rates and tag reporting rates by the different fisheries will greatly determine the results of the mark-recapture analysis. In order to test the sensitivity of the results towards changes in these prior probability distributions the model is run using different prior distributions and the resulting posterior probability distributions for the total harvest rates of 2SW reared fish of assessment area 1 are compared. Three different scenarios have been compared against the base case. First it has been assumed that the prior probability distributions of the parameters determining the tag return rates have been set too informative and therefore less informative distributions have been given (Table 6). Secondly the prior probability distributions determining the tag return rates have been given more informative distributions in order to assess the benefit of investing in studies to provide more precise estimates of parameters determining the tag return rates. And finally the parameters determining the tag return rates have been given prior probability distributions with different means, assuming the prior opinion about the tag return rates is overestimated.

Table 6: Summary of the different prior density functions (distribution, median and 95% PI) of tag return rate parameters for four scenarios: base case, uninformative priors, informative priors and lower priors

Model param.	Description	Base case prior pdf	Uninform. prior pdf	Informative prior pdf	Lower prior pdf
(1-S)	Tag retaining rate in the driftnet fisheries	B (20, 8) 0.72 (0.55-0.86)	B (5, 2) 0.72 (0.35-0.96)	B (40, 16) 0.72 (0.59-0.82)	B (10, 8) 0.55 (0.33-0.77)
R_{rf}	Tag reporting rate in river fisheries	B (16, 6) 0.73 (0.53-0.89)	B (4, 1.5) 0.73 (0.33-0.97)	B (32, 12) 0.73 (0.59-0.84)	B (8, 6) 0.58 (0.32-.81)
R_{cf}	Tag reporting rate in coastal fisheries	B (11, 9) 0.55 (0.35-0.75)	B (2.75, 2.25) 0.55 (0.15- 0.90)	B (22, 18) 0.55 (0.39-0.70)	B (5.5, 9) 0.38 (0.16-0.63)
R_{df}	Tag reporting rate in driftnet fisheries	B (8, 4) 0.68 (0.39-0.89)	B (4, 2) 0.68 (0.29- 0.94)	B (16, 8) 0.68 (0.47-0.84)	B (4, 4) 0.5 (0.18-0.82)
R_{lf}	Tag reporting rate in longline fisheries	B (10, 4) 0.72 (0.46-0.91)	B (5, 2) 0.72 (0.35- 0.96)	B (20, 8) 0.72 (0.53-0.86)	B (5, 4) 0.55 (0.24-0.84)

The resulting probability density functions for the cumulative harvest rate of 2SW reared fish returning to rivers of assessment area 1 are presented in Figure 1. The posterior probability distributions overlap widely but there still is a distinct difference between them. As could be expected, less informative prior probability distributions for tag return rates result in wider posterior probabilities for the total harvest rates (median: 61%, PI: 42-82% in 2002) compared to the base case scenario (median: 56%, PI: 40-74% in 2002). Making the prior density functions for tag return rates more informative results in a slightly more informative estimate of the exploitation rate (median: 55%, PI: 40-72% in 2002). In case the tag return rates are assumed to be lower than was the case for the base case scenario, the total harvest rate needs to be higher in order to obtain the same number of reported tagged salmon in the catch (median: 59%, PI: 41-78% in 2002). In general it can be concluded that the uncertainty about tag return rates has an impact on the estimates of the total fishing mortality rate. Additional analyses, such as double tagging studies, high reward tagging studies, etc., which reduce the uncertainty about tag return rates should be taken into consideration. However, it is even more important not to misspecify prior distributions of tag return rates compared to prior beliefs since the posteriors of fishing mortality are sensitive to the choice of prior distributions for tag return rates. All these arguments underline both the importance of including uncertainty in the values used for tag return rates and the importance of investing in studies to reduce the uncertainty about the tag return as much as possible.

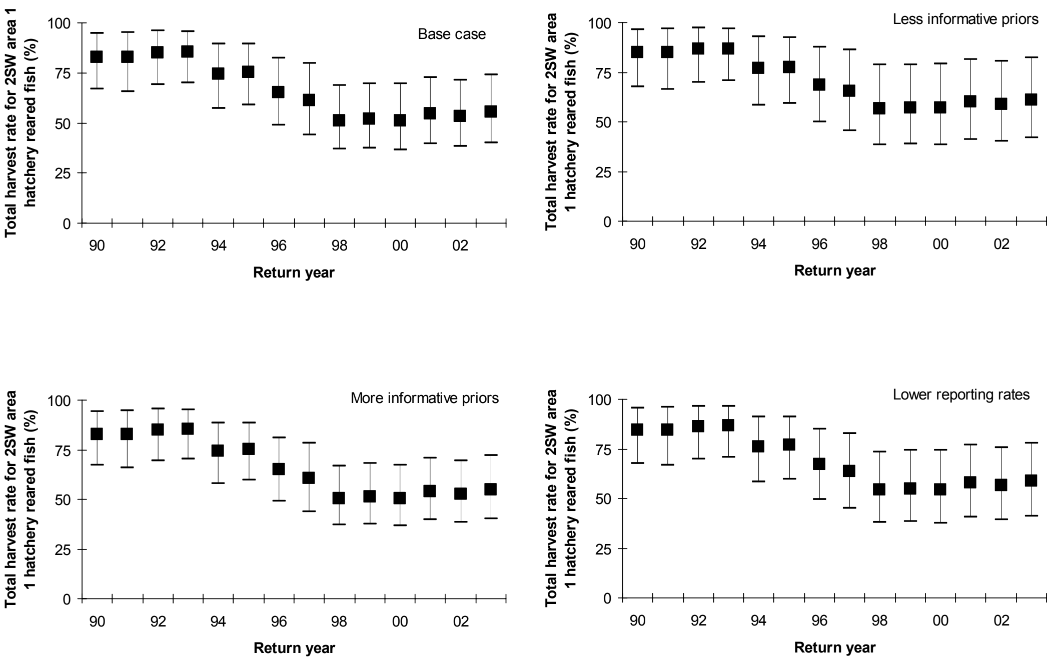

Figure 1: Sensitivity of the total harvest rate (median and 95% PI) of 2SW reared salmon of assessment area 1 under four different senarios about the tag return rates: base case scenario, less informative priors, more informative priors or lower priors for tag reporting rates compared to the base case scenario.

The second prior distributions to be evaluated for their impact on the cumulative fishing mortality rates are the priors for the homing or maturation rates. Under the base case scenario, these priors have been chosen relatively informative. Therefore a sensitivity analysis of less informative prior probability distributions is undertaken (Table 7).

Table 7: Summary of the different prior density functions (distribution, median and 95% PI) of maturation rates for two different scenarios: base case and less informative priors.

Model param.	Description	Base case prior pdf	Uninform. prior pdf
L_1	Maturation rate for grilse	B (2.3, 15) 0.12 (0.02-	B (1.15, 7.5) 0.1 (0.006-
L_2	Maturation rate for 2SW salmon	B (3.6, 4.5) 0.44 (0.16-	B (2, 2) 0.2 (0.1-0.9)
L_3	Maturation rate for 3SW salmon	B (24, 7.5) 0.77 (0.60-	B (2, 2) 0.5 (0.1- 0.9)
L_4	Maturation rate for 4SW salmon	B (10, 2) 0.85 (0.60-	B (2, 2) 0.5 (0.1- 0.9)

The resulting posterior probability distributions for the total harvest rate of 2SW reared salmon of assessment area 1 (median: 58%, PI: 42-78% in 2002) are slightly less informative then under the base case scenario (median: 56%, PI: 40-74% in 2002) (Figure 2).

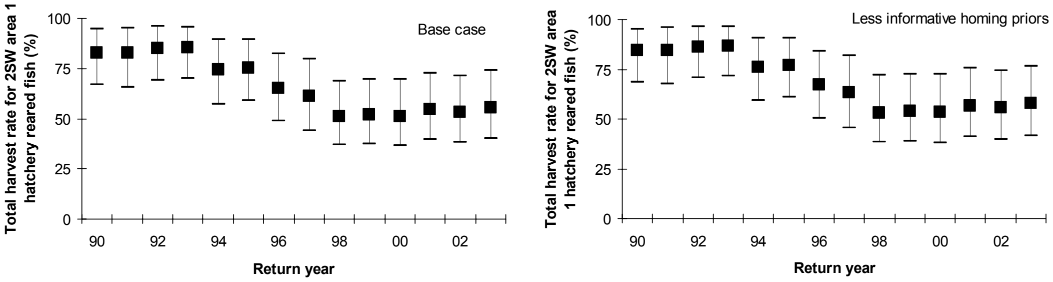

Figure 2: Sensitivity of the total harvest rate (median and 95% PI) of 2SW reared salmon of assessment area 1 under two different assumptions about the maturation rates: base case scenario or less informative priors.

More importantly however are the resulting differences in homing or maturation rates for the different age groups. The priors for the maturation rates have been chosen quite informative and by examining the posterior probability distribution when assuming uninformative prior probability distributions for the maturation rate it is possible to assess how much the results differ. When examining Table 8, it becomes clear that the posterior probability distributions for the maturation rates for reared salmon do not differ much between the two scenarios. This is due to the large number of tag releases and recoveries for hatchery-reared salmon, making the data quite informative. For wild salmon on the other hand, the differences between the posterior probability distributions for the maturation rates under the two different scenarios are distinct, especially for 3SW and 4SW salmon. This is due to the fact that there is limited information within the tagging data for wild salmon to estimate the maturation rates for 3SW and 4SW wild salmon. As a result, the maturation rates for 3SW and 4SW wild salmon primarily reflect the prior probability distribution. As a result, the informative prior probability distributions as obtained through expert opinions offer better priors for the maturation rates of 3SW and 4SW fish than the uninformative prior probability distribution as obtained without relying on expert opinions.

Table 8: Summary of the posterior probability distributions (median and 95% PI) under the base case assumptions about the maturation rates or when assuming less informative prior probability distributions for the maturation rate.

Model param.	Description	Base case maturation priors		Less inf. maturation priors	
		Median	PI	Median	PI
$L_{1,R}$	Maturation rate for reared grilse	0.2	0.16-0.26	0.19	0.15-0.25
$L_{1,W}$	Maturation rate for wild grilse	0.14	0.07-0.22	0.13	0.06-0.21
$L_{2,R}$	Maturation rate for 2SW reared salmon	0.44	0.38-0.49	0.42	0.36-0.48
$L_{2,W}$	Maturation rate for 2SW wild salmon	0.42	0.22-0.65	0.47	0.22-0.71
$L_{3,R}$	Maturation rate for 3SW reared salmon	0.63	0.56-0.7	0.6	0.51-0.67
$L_{3,W}$	Maturation rate for 3SW wild salmon	0.74	0.59-0.86	0.59	0.29-0.84
$L_{4,R}$	Maturation rate for 4SW reared salmon	0.67	0.55-0.78	0.62	0.48-0.75
$L_{4,W}$	Maturation rate for 4SW wild salmon	0.9	0.69-0.98	0.78	0.4-0.97

When comparing the observed data with the posterior predictive probability distribution, 2.3 % of the data points were located outside the 95% probability intervals of the predictive distribution. This means, that when using the model in combination with the posterior probability distributions of model parameters to simulate the mark-recapture data, that 97.7 % of the time the observed mark-recapture data will lie within the distribution of model predicted data.

About 1.9 % of the posterior predictive p-valeus were smaller than 2.5 % or larger than 97.5% and 20.5% of the posterior predictive p-values were smaller than 20% or larger than 80%. This indicates that the model may be overestimating the uncertainty in the data due to the limited amount of information in the data or the priors. When comparing the realised discrepancy with the discrepancy under the posterior predictive distribution, the resulting Bayesian p-value is 0.31.

The value of the Deviance Information Criterion (DIC) is 5983. The DIC is given by DIC = Dbar + pD whereby Dbar is the posterior mean of the deviance and pD is the effective number of parameters. Negative values for pD could indicate of conflicts between priors and the data, massive shrinkage under a bad parameterisation, etc. No negative values for the effective number of parameters have been observed.

An overview of the different diagnostics applied to assess the robustness and validity of the model is given in Table 9.

Table 9: Overview of the different diagnostics applied to assess the robustness and validity of the model and the convergence of the MCMC simulation

Diagnostic	Reference	Results
Convergence diagnostics	Gelman and Rubin (1992), Best et al. (1995)	Burn-in has been removed and the number of necessary iterations taken after convergence have been evaluated so that reported posterior distributions are representative for the underlying stationary distributions.
Sensitivity analysis	Clarke and Gustafson (1998)	A sensitivity analysis of maturation rates indicated that the effect of the priors for the maturation rates of reared salmon on the posteriors is limited. However, the informative, expert determined priors for the maturation rates for 3SW and 4SW wild salmon are determining the posterior probability distributions for the maturation rates for 3SW and 4SW wild salmon due to a lack of information in the tagging data. A sensitivity analysis of the reporting rates indicated the importance of these parameters.
Posterior predictive distributions	Gelman et al. (1995)	About 2.3 % of the observed data points were located outside the 95% probability intervals of the posterior predictive distribution. This indicates that the observed data could be obtained when using the model to simulate data by using posterior distributions of model parameters
Bayesian posterior predictive p-values for each data point. The posterior predictive p-value is defined as the probability that the replicated data is more extreme than the observed.	Meng (1994), Gelman et al. (1995, 1996)	About 1.9 % of the posterior predictive p-values were smaller than 2.5% or larger than 97.5% and 20.5% of the posterior predictive p-values were smaller than 20% or larger than 80%. This indicates that the uncertainty in the data may be overpredicted due to limited data and uncertain prior probability distributions.
Bayesian p-value by comparing the realised Chi-square discrepancy with the Chi-square discrepancy under the posterior predictive distribution	Gelman et al. (1995), Brooks at al. (2000, 2002)	A Bayesian p-value of 0.31 was obtained when comparing the realised discrepancy with the discrepancy under the posterior predictive distribution.
Deviance Information Criterion (DIC)	Spiegelhalter et al. (2002)	The value for the DIC is 5983. There are no negative values obtained for the pD (effective number of parameters) so there is no indication of conflicts between priors and the data, massive shrinkage under a bad parameterisation, etc.
Comparison of the model predicted proportion of reared spawners to observed proportions of reared spawners in rivers Luleälven and Dalälven This data was not used to estimate the model parameters	Karlsson and Ragnarsson (2003)	The observed proportion of returning reared salmon all lie within the 95% probability interval of the model predicted proportions of returning reared salmon returning. The model prediction is based on the estimated number of released reared salmon in rivers Luleälven and Dalälven and the model parameters as estimated for reared salmon of assessment area 2 (in case of Luleälven) and assessment area 3 (in case of Dalälven).
Comparison of the model predicted number of wild spawners to observed numbers of reared spawners in river Ume/Vindelälven This data was not used to estimate the model parameters	ICES (2003)	The observed number of spawners passing the fishladder in Ume/Vindelälven lie within the 95% PI for the model predicted spawner abundance with the exception of year 1992. For 6 years it has been possible to convert fish ladder observations to total spawner estimates. Five out of six spawner estimates fall inside the 95% PI.

Estimated model parameters under base case scenario

The model has been run using the base case scenario. The results for the maturation rates of wild and reared salmon indicate a significant update of the prior distributions for the maturation rates of reared salmon (Figure 3), indicating that the information available in the tagging data for reared salmon is larger than the information available in the tagging data for wild salmon. Although the posterior distribution for the maturation rates of 3SW and 4SW reared salmon seem to have been dominated by the prior probability distributions, the results of the sensitivity analysis indicate that even with uninformative prior probability distributions for the maturation rates for reared salmon, the same results would have been obtained. The choice for informative prior distributions for the maturation rates is important for wild salmon since there is little information available in the tagging data about the maturation rate of wild MSW salmon. An informative prior distribution based on expert opinions has been preferred in order to be able to utilise the biological understanding of the experts for the estimation of the maturation rates of MSW wild salmon.

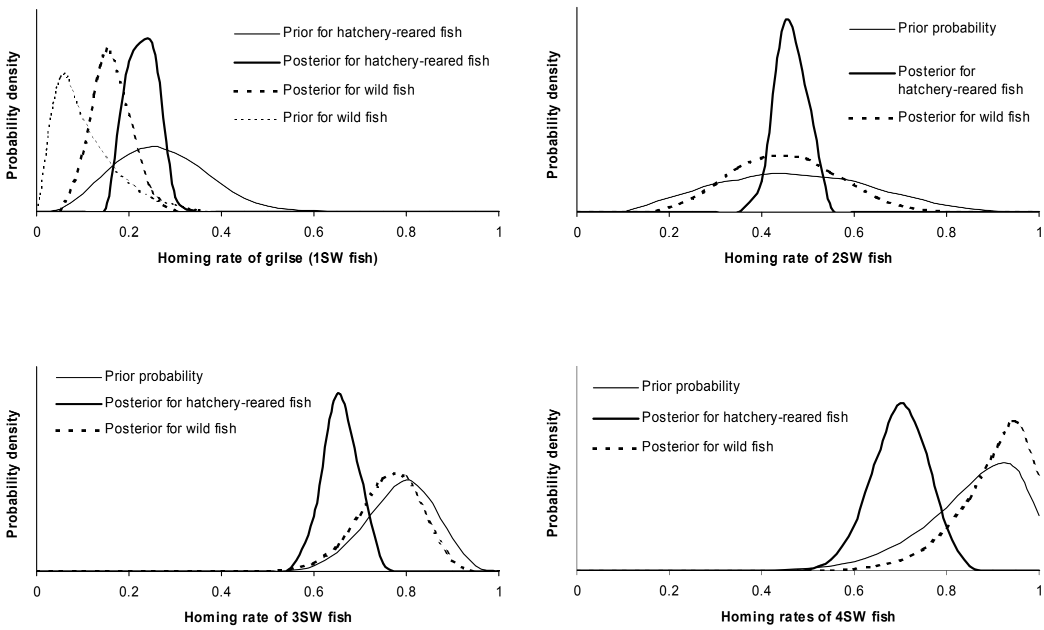

Figure 3: Prior and posterior probability distributions of the maturation rates for wild and hatchery-reared salmon retuning after 1 to 4 winters at sea.

Figure 4 shows the results for the average adult natural mortality rate and the average post-smolt mortaltiy rate. The posterior adult mortality rate is on average higher than the adult morality rate as assumed by the prior probability distribution of the experts. Also the difference between the average post-smolt mortality rate for wild and reared salmon is on average smaller than assumed by the prior expert opinion. Figure 5 shows the annual posterior estimates for the post-smolt mortality rate of wild and reared salmon. There is a general trend in the results indicating that post-smolt mortality rates have been higher in recent years. The reasons behind this shift in post-smolt mortality rate levels is unclear.

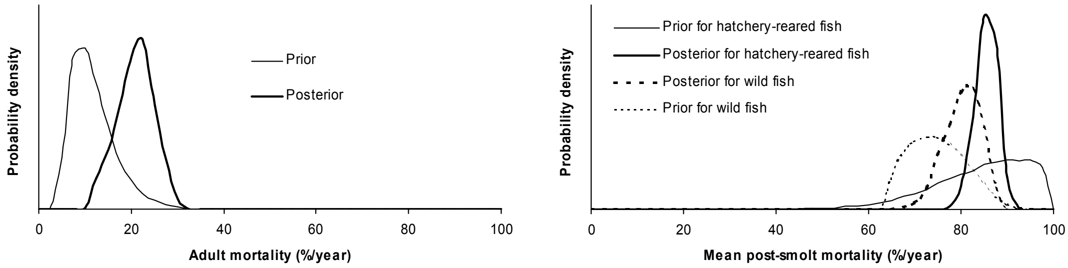

Figure 4: Prior and posterior probability distributions for average natural mortality rates for adults and wild and hatchery-reared post-smolts in the Baltic Sea area (expressed in terms of the % mortality per year).

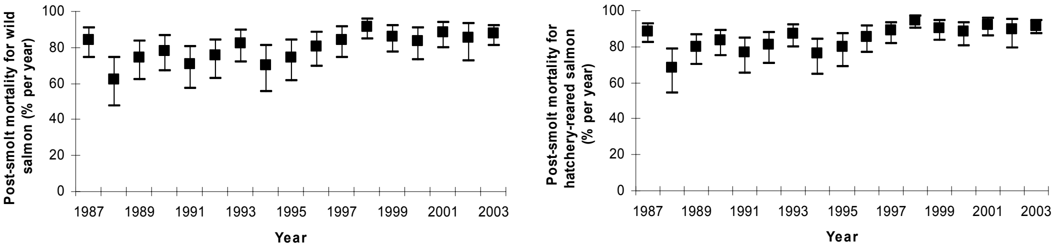

Figure 5: Annual estimates for post-smolt mortality rate (% per year) for wild and hatchery-reared salmon in the Baltic Sea area between 1987 and 2003 (medians and 95% probability intervals).

The main outputs of the model are the total harvest rates for 4 assessment units for the different age groups (Figures 6, 7, 8 and 9). In general, the uncertainty in the harvest rates estimates for wild salmon is larger than for reared salmon. This is partly due to the larger uncertainty about the model parameters for wild salmon originating from the limited number of tagging data for wild salmon. The harvest rates for the stocks of assessment area 1, 2 and 3 are higher than the harvest rates for the stocks of assessment area 4 due to the fact that stocks of assessment area 4 are only effected by offshore fisheries and river fisheries but not by coastal fisheries. In general the total harvest rates of stocks of assessment area 2 are slightly lower than the harvest rates of stocks of assessment area 1 which might be attributed partly due to the difference in migration route. The harvest rates increase as the salmon stay longer at sea.

The total harvest rates of 2SW wild salmon have been compared to the preliminary precautionary reference point. For assessment areas 1, 2 and 3 the total harvest rate of 2SW wild salmon is higher than the precautionary reference point for 2SW salmon. For 2SW wild salmon of assessment area 4, on average the precautionary reference point has been reached.

The model also produces estimates for the abundance of wild and hatchery-reared salmon for assessment area 1 to 4 (see figure 6.3.3 in section 6.3 of the report). The lost reared production refers to the number of reared salmon spawners that enter the river for spawning but are unable to reach the spawning grounds. Overall, the total abundance of wild spawners in each assessment area is going up until 2006 with the exception of the abundance in areas 3 (containing the river Ljungan) and 4 (containing Mörrumsån and Emån). This indicates that although in general the abundance of wild salmon is going up, this is not necessarily the case for each individual salmon stock. Although salmon catches have declined since the early 1990's, the lost production does not show an increasing trend in lost production of hatchery-reared salmon. Instead the number of reared salmon production has declined since the end of the 90's. This is partly due to the higher post-smolt mortality rates for reared salmon in recent years. The model also estimates the number of returning hatchery-reared salmon that are able to reproduce within the river. For assessment area 1, this number has increased considerably due to the large increase in the number of hatchery-reared salmon released in potential salmon rivers.

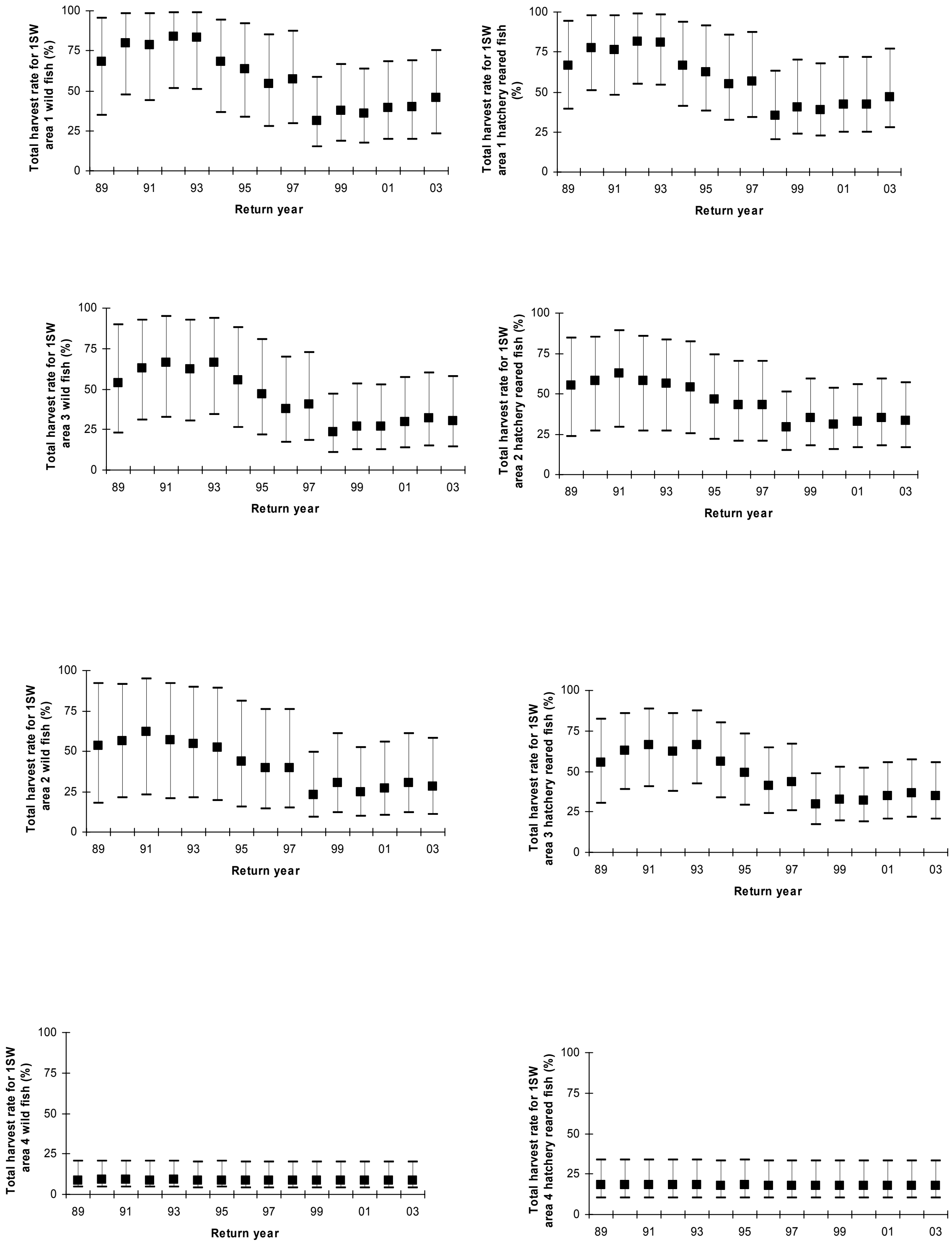

Figure 6: Median and 95% probability interval for the total cumulative harvest rate for **wild and hatchery-reared 1SW salmon** in assessment units 1 to 4 of the Baltic Sea area

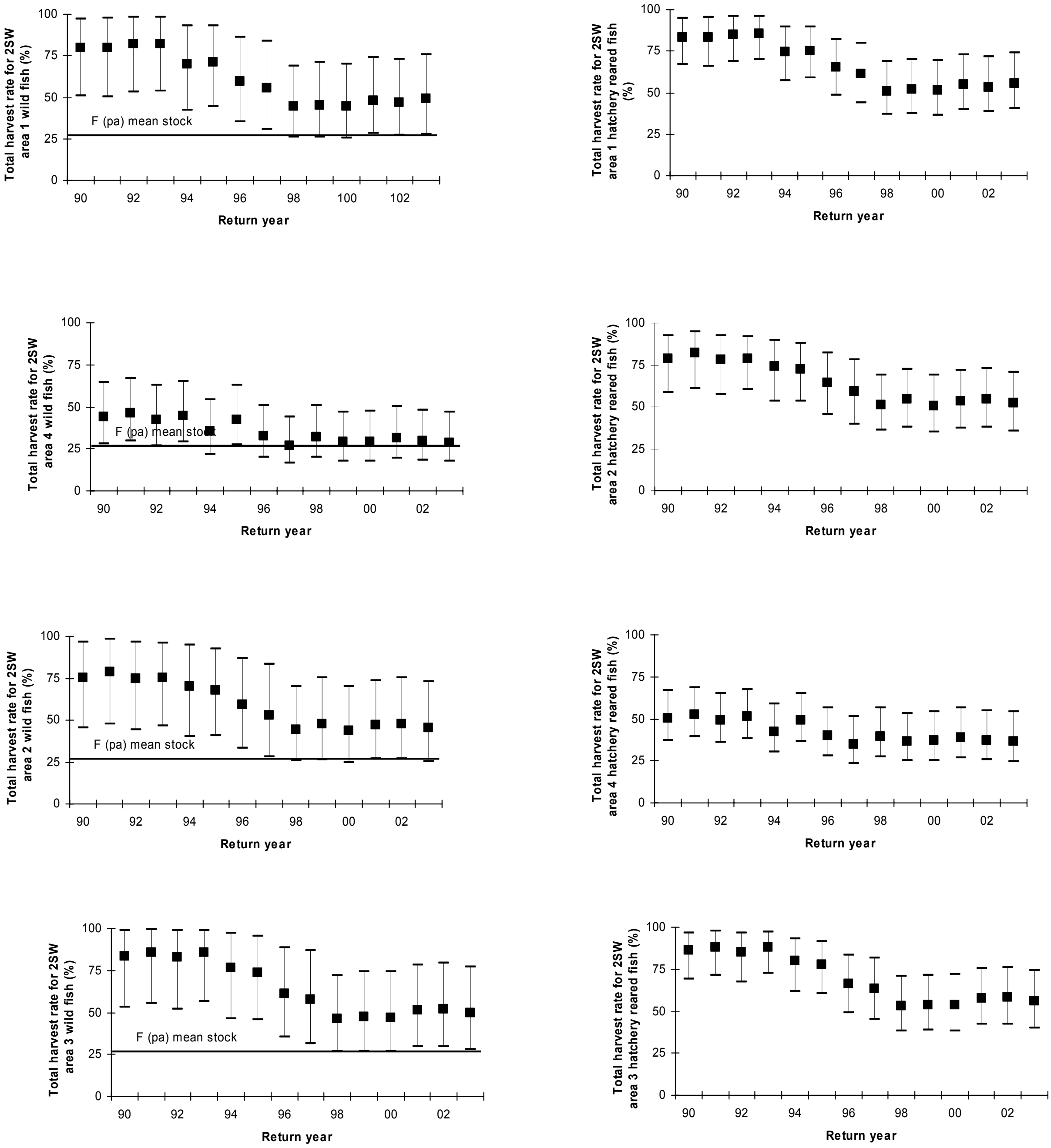

Figure 7: Median and 95% probability interval for the total cumulative harvest rate for **wild and hatchery-reared 2SW** salmon in assessment units 1 to 4 of the Baltic Sea area

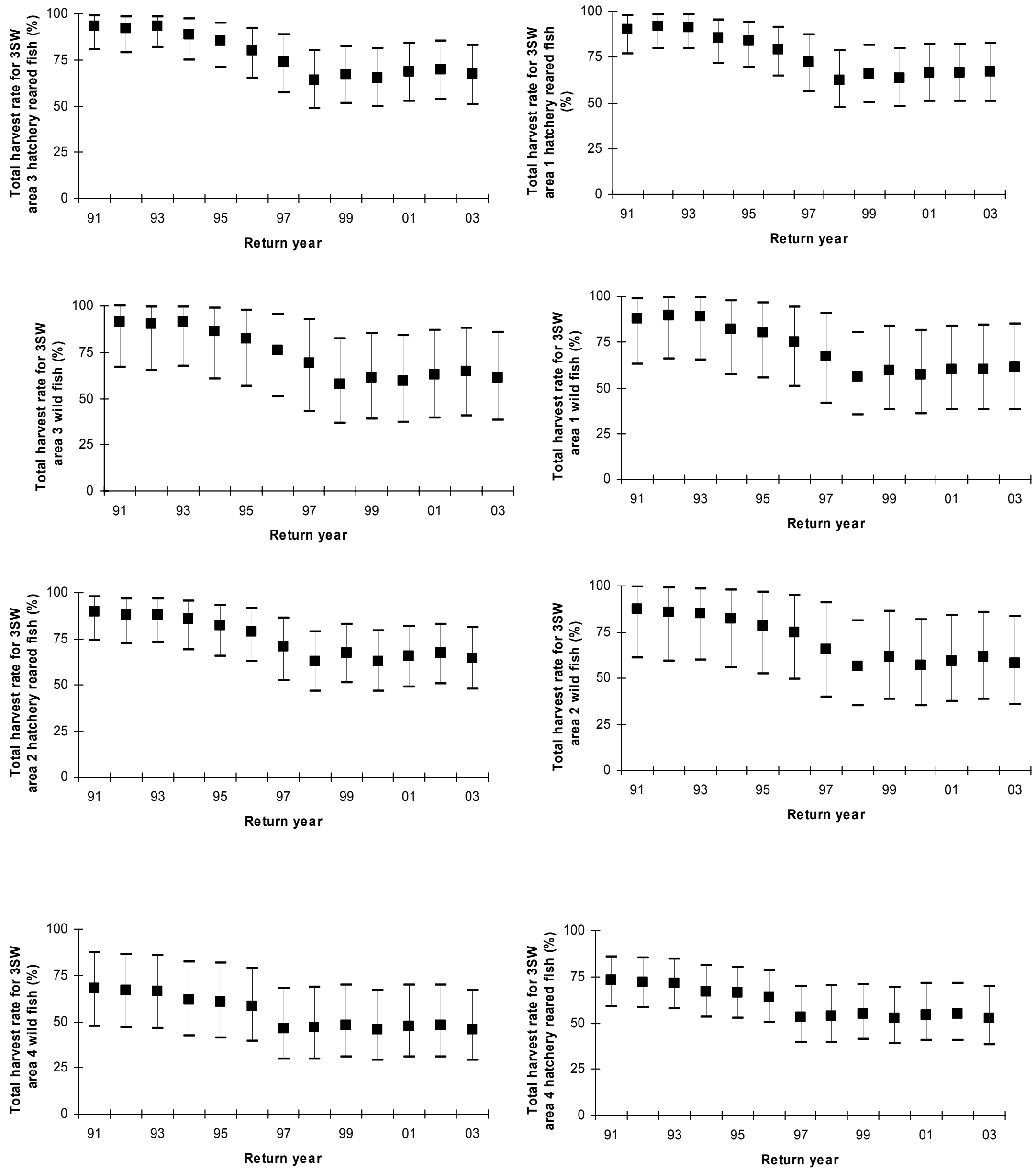

Figure 8: Median and 95% probability interval for the total cumulative harvest rate for **wild and hatchery-reared 3SW salmon** in assessment units 1 to 4 of the Baltic Sea area

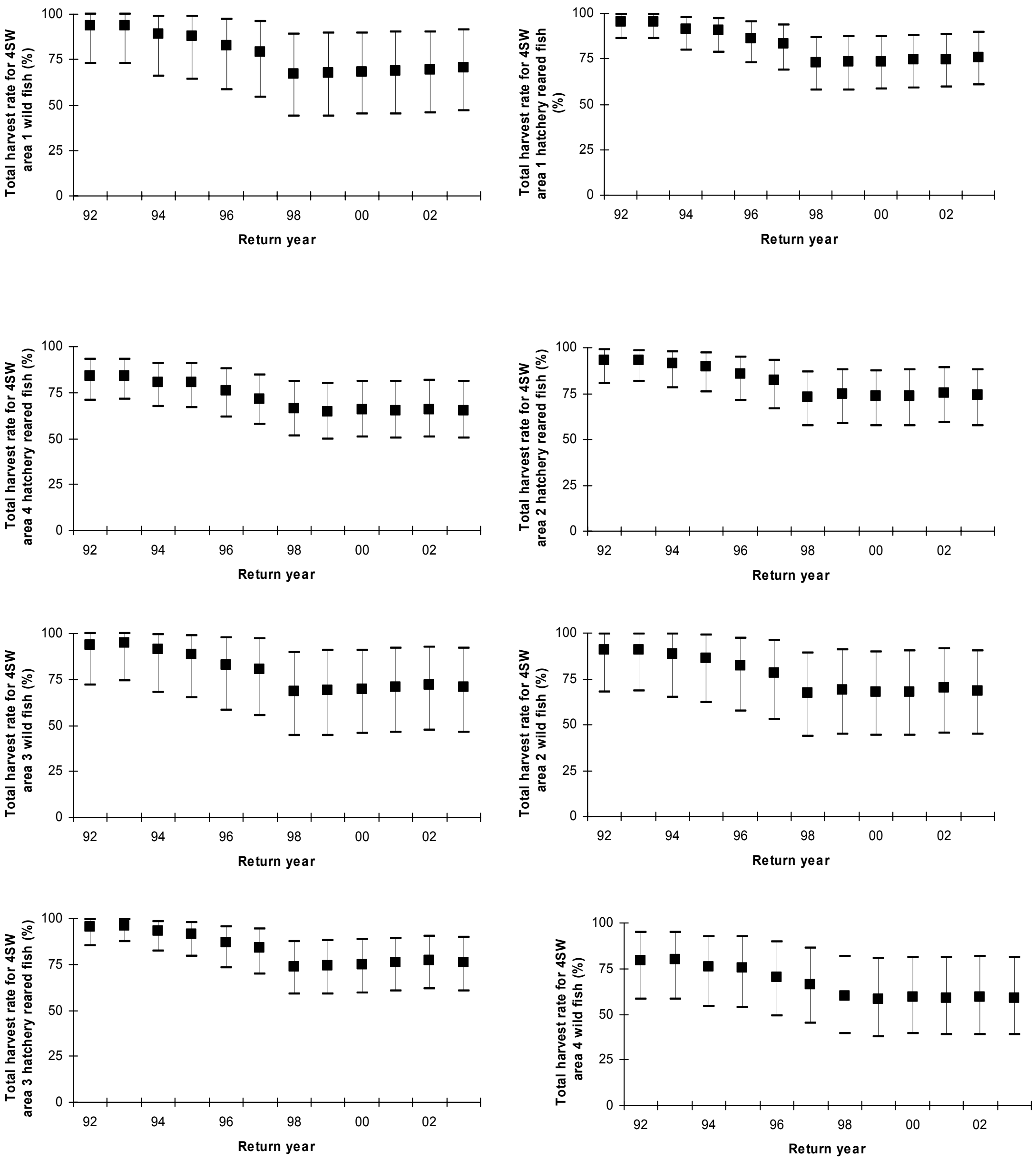

Figure 9: Median and 95% probability interval for the total cumulative harvest rate for **wild and hatchery-reared 4SW salmon** in assessment units 1 to 4 of the Baltic Sea area

Table 10: Summary of model parameters, their description, the symbol used within the WinBUGS program, their posterior probability distributions expressed in terms of median, CV and 95% probability interval (PI)

Parameters	WinBUGS symbol	Median	CV	95% PI
Maturation rate for wild grilse	LW[1]	0.13	0.28	0.06 - 0.21
Maturation rate for reared grilse	LR[1]	0.20	0.13	0.15 - 0.25
Maturation rate for 2SW wild salmon	LW[2]	0.41	0.28	0.21 - 0.63
Maturation rate for 2SW reared salmon	LR[2]	0.43	0.06	0.37 - 0.49
Maturation rate for 3SW wild salmon	LW[3]	0.74	0.09	0.60 - 0.85
Maturation rate for 3SW reared salmon	LR[3]	0.62	0.06	0.56 - 0.69
Maturation rate for 4SW wild salmon	LW[3]	0.89	0.09	0.67 - 0.98
Maturation rate for 4SW reared salmon	LR[3]	0.67	0.09	0.56 - 0.77
Instantaneous mean wild post-smolt mortality rate per year	mMpsW	1.62	0.10	1.27 - 1.90
Increase in mean post-smolt mortality rate per year for hatchery-reared salmon compared to wild salmon	ReffectMps	1.17	0.09	1.02 - 1.42
Instantaneous mean reared post-smolt mortality rate per year	mMpsR	1.88	0.08	1.58 - 2.16
Yearly instantaneous wild post-smolt mortality rate per year	MpsW	1.62	0.26	0.83 - 2.48
Yearly instantaneous reared post-smolt mortality rate per year	MpsR	1.88	0.25	0.99 - 2.90
Instantaneous adult mortality rate per year	M	0.10	0.48	0.04 - 0.25
Tag retention rate	Tretain	0.88	0.09	0.62 - 0.88
Tag reporting rate in the river fishery	reportW	0.71	0.14	0.50 - 0.87
Tag reporting rate in the terminal river fishery	reportrR	0.66	0.16	0.44 - 0.84
Tag reporting rate in the coastal fishery	reportc	0.52	0.16	0.37 - 0.69
Tag reporting rate in the driftnet fishery	reportd	0.78	0.11	0.60 - 0.92
Tag reporting rate in the longline fishery	reportl	0.65	0.20	0.38 - 0.88

Table 11: Summary of catchability coefficients for wild salmon, the symbol used within the WinBUGS program and the posterior probability distributions expressed in terms of median, CV and 95% probability interval (PI).

Parameters	WinBUGS symbol	Median	CV	95% PI
Catchability coefficients of wild salmon in river fishery (100,000 geardays *year)$^{-1}$				
Catchability of salmon by the river fishery during feeding migration	qrW[1]	0.00011	0.30	0.00006 - 0.00020
Catchability of grilse by the river fishery	qrW[2]	0.009	0.47	0.004 - 0.022
Catchability of MSW fish by the river fishery	qrW[3]	0.01	0.36	0.005 - 0.020
Catchability coefficients of wild salmon in coastal gillnet fishery (100,000 geardays *year)$^{-1}$				
Catchability of salmon by the coastal gillnet fishery during feeding migration	qcgn[1]	0.00047	0.69	0.00007 - 0.0015
Catchability of grilse by the coastal gillnet fishery	qcgn[2]	0.066	0.86	0.009 - 0.280
Catchability of 2SW+ fish by the coastal gillnet fishery	qcgn[3]	0.047	0.84	0.007 - 0.196
Catchability coefficients of wild salmon in coastal trapnet fishery (1000 geardays *year)$^{-1}$				
Catchability of salmon by the coastal trapnet fishery during feeding migration	qctn[1]	0.00005	0.58	0.00002 - 0.00015
Catchability of grilse by the coastal trapnet fishery	qctn[2]	0.015	0.43	0.006 - 0.032
Catchability of 2SW+ fish by the coastal trapnet fishery	qctn[3]	0.009	0.47	0.004 - 0.022
Catchability coefficients of wild salmon in offshore driftnet fishery (100,000 geardays *year)$^{-1}$				
Catchability of grilse by the drifnet fishery	qd[1]	0.0002	0.43	0.00009 - 0.00047
Catchability of 2SW salmon by the driftnet fishery	qd[2]	0.018	0.26	0.011 - 0.030
Catchability of 3SW salmon by the driftnet fishery	qd[3]	0.020	0.30	0.012 - 0.037
Catchability of 4SW+ salmon by the driftnet fishery	qd[4]	0.018	0.38	0.009 - 0.064
Catchability coefficients of wild salmon in offshore longline fishery (100,000 geardays *year)$^{-1}$				
Catchability of grilse by the longline fishery	ql[1]	0.00008	0.36	0.00004 - 0.00017
Catchability of MSW fish by the longline fishery	ql2]	0.006	0.31	0.0034 - 0.011

Table 12: Summary of catchability coefficients for reared salmon, the symbol used within the WinBUGS program and the posterior probability distributions expressed in terms of median, CV and 95% probability interval (PI).

Parameters	WinBUGS symbol	Median	CV	95% PI
Catchability coefficients of reared salmon in river fishery (100,000 geardays *year)$^{-1}$				
Catchability of salmon by the river fishery during feeding migration	qrR[1]	0.00007	0.32	0.00004-0.00013
Catchability of salmon by the terminal river fishery	qrR[2]	0.020	0.38	0.011-0.41
Catchability coefficients of reared salmon in coastal gillnet fishery (100,000 geardays *year)$^{-1}$				
Catchability of salmon by the coastal gillnet fishery during feeding migration	qcgn[1]	0.00045	0.48	0.00007-0.0009
Catchability of grilse by the coastal gillnet fishery	qcgn[2]	0.059	0.80	0.009-0.223
Catchability of 2SW+ fish by the coastal gillnet fishery	qcgn[3]	0.042	0.65	0.007-0.126
Catchability coefficients of reared salmon in coastal trapnet fishery (1000 geardays *year)$^{-1}$				
Catchability of salmon by the coastal trapnet fishery during feeding migration	qctn[1]	0.00004	0.33	0.00002-0.00007
Catchability of grilse by the coastal trapnet fishery	qctn[2]	0.012	0.44	0.006-0.029
Catchability of 2SW+ fish by the coastal trapnet fishery	qctn[3]	0.010	0.23	0.006-0.015
Catchability coefficients of reared salmon in offshore driftnet fishery (100,000 geardays *year)$^{-1}$				
Catchability of grilse by the drifnet fishery	qd[1]	0.00025	0.16	0.00019-0.00035
Catchability of 2SW salmon by the driftnet fishery	qd[2]	0.018	0.13	0.014-0.024
Catchability of 3SW salmon by the driftnet fishery	qd[3]	0.021	0.14	0.016-0.028
Catchability of 4SW+ salmon by the driftnet fishery	qd[4]	0.018	0.18	0.014-0.029
Catchability coefficients of reared salmon in offshore longline fishery (100,000 geardays *year)$^{-1}$				
Catchability of grilse by the longline fishery	ql[1]	0.00008	0.30	0.00005-0.00015
Catchability of MSW fish by the longline fishery	ql2]	0.0066	0.27	0.0042-0.0115

Validation of the mark-recapture results with other data

In addition to other statistical diagnostics, the results of the model have also been validated by comparing the results of the model to additional data series, such as the percentage of returning hatchery-reared salmon in the rivers Luleälven and Dalälven as obtained by Karlsson and Ragnarsson (2003) from mark-recapture experiments in these rivers and the number of returning wild salmon in the fish ladder of the river Ume/Vindelälven.

Validation of the results for hatchery-reared salmon

When comparing the % of returning salmon for the rivers Dalälven and Luleälven with the proportion of returning salmon as estimated for reared salmon of assessment area 3 and 2 respectively, the observed numbers fall within the model predicted 95% probability interval (Table 13). This indicates that the model seems to be able to predict a data set not used for parameter estimation. This indicates that the model can capture dependencies between different types of data.

Table 13: Comparison of the observed percentage of returning salmon in the river Dalälven and the river Luleälven obtained by Kalsson and Rgnarsson (2003) and the model predicted percentage of returning salmon obtained by the assessment model. The observations for the river Dalälven have been compared to the results for the rivers of assessment area 3 while the observations for the river Luleälven have been compared to the results for the rivers of assessment area 2.

year	River	Returning salmon (%)		
		Observed	Model predicted	
		Mean	Mean	95 % PI
1993-95	Dalälven	3.40	5.12	2.70 - 8.30
1996-98	Dalälven	3.40	2.74	1.44 - 4.52
1996	Luleälven	2.87	3.94	2.02 - 6.61
1997	Luleälven	2.79	3.04	1.49 - 5.29
2001	Dalälven	3.53	2.15	1.00 - 3.90
2002	Dalälven	3.84	3.09	1.19 - 6.24

Validation of the results for wild salmon

The results for wild salmon are more difficult to validate due to the lack of data about the percentage or the number of returning wild salmon in the rivers. Fish ladder data can provide an index of spawner abundance. There exist several problems related to the use of fish ladder data as a measure for the absolute number of wild spawners within a river. There may exist spawning grounds below the fish ladder, during some years there may not be enough water in the river, the salmon may not be able to find the fish ladder or the salmon may pass the fish ladder more than once. For the river Ume/Vindelälven, the proportion of spawners that find and pass the fish ladder has been estimated based on tagging experiments (Rivinoja and Leonardsson, unpublished). Table 14 indicates the observed number of spawners that pass the fish ladder, the corresponding number of spawners within the river and the model predicted spawner estimates. The results indicate that the observed number of spawners passing the fish ladder lies within the 95% probability interval of the posterior predictive distribution for spawner abundance, with the exception of for the year 1992. For 6 years it has been possible to convert fish ladder estimates to total spawner abundance estimates based on the results from tagging experiments (Rivinoja and Leonardsson, unpublished). For the year 1999, the estimated spawner abundance falls outside the 95% probability interval for the model predicted spawner abundance. This may be among others due to the fact that the results for an entire assessment area have been compared to the results for one particular stock within the assessment area.

Table 14: Comparison of the observed number of wild salmon in the fish ladder of the river Ume/Vindelälven and the corresponding estimated number of spawners with the model predicted number of spawners for the river Ume/Vindelälven. The number of observed spawners in the fish ladder has been converted in the total number of spawners using the proportion estimates of Rivinoja and Leonardsson (unpublished).

year	Observed number	Spawner number	Model predicted	
			Mean	95 % PI
1992	354		4530	642 - 16830
1993	1663		3679	624 - 12500
1994	1309		2776	525 - 9080
1995	1164		2845	583 - 9306
1996	1939	11406	3494	654 - 12050
1997	1780	6846	3031	599 - 9845
1998	1154		1896	497 - 5204
1999	2208	6900	948.4	244 - 2760
2000	3367		3266	464 - 13300
2001	5476	30422	9279	1485 - 32680
2002	6052	12351	11070	2087 - 37590
2003	2287	7147	10790	2676 - 31530

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Predicting salmon smolt abundance using a simple hierarchical Bayesian model

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Abstract

A hierarchical Bayes model was developed to describe the relationship between relative densities of salmon parr and absolute abundance of salmon smolts. The core of the model is a latent dynamic regression model which connects relative densities of parr to smolt abundances. Information about parameter values between different rivers is transferred through hyperparameters which are common to all rivers. Needed model inputs are prior distributions of model parameters and independent estimates of relative parr density and smolt abundance in a form of statistics of posterior distributions calculated separately from electrofishing and smolt trapping data.

1 Introduction

Up to date, the smolt production of Baltic salmon rivers has been predicted using a set of different regression models. Slopes of these regression models have

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been obtained by fitting a linear regression line to point estimates of relative parr abundance and smolt abundance (ICES 2002). Predictions have been generalized to all rivers by using point estimates of parr production area as scaling factors and river-specific predictions have been expressed as point estimates. This procedure ignores uncertainty arising from measurement error, uncertainty about parameter values, uncertainty associated with between-river variation of model parameters and uncertainty about the model structure.

Bayesian statistics provides a rigorous way to take into account these kinds of uncertainties. Bayesian statistics operates using probabilities as measures of uncertainty. Thus, uncertainty about parameters of regression equations and about smolt and parr abundances is expressed in terms of probability distributions. In addition, hierarchical Bayesian modeling is a powerful tool for transferring information between exchangeable units, such as rivers (Prévost et al. 2001; ICES 2002), electrofishing sampling sites (Wyatt 2002) or migration days (Mäntyniemi and Romakkaniemi 2002).

In this paper we present a Bayesian method which also utilises the idea of using linear regression models to predict upcoming smolt and parr abundances based on previous parr densities. However, this method takes into account sampling errors of measurements, as well as uncertainty about parameter values. Variation of model parameters between rivers is also taken into account by using a hierarchical model structure. The model also utilises expert opinions about some of the parameters.

2 Model inputs

2.1 Measurements of smolt abundance

The smolt abundance $S_{y,r}$ of river r in year y must be expressed in a form of a probability distribution, unless the absolute number of smolts is directly observed. The probability distribution can be based on an opinion of an expert, or it can be based on the information contained in smolt trapping data. For example, methods proposed by Mäntyniemi and Romakkaniemi (2002) can be used separately for deriving posterior distribution of the run size from mark-recpture data. If expert judgement is used, it is essential that the expert opinion is independent of the information about the previous parr densities.

For the sake of simplicity, the probability distribution which describes the uncertainty about $S_{y,r}$ based on mark-reacpture data or expert opinion should be

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summarized by mean $I_{S,y,r}$ and coefficient of variation $C_{I_S,y,r}$. These statistics are used as model inputs.

2.2 Measurements of relative parr density

Point estimates $I_{P,y,r,a}$ of the total number of age a parr found from the electrofishing sampling sites of river r in year y are used as measurements of relative density $P_{y,r,a}$ of age a parr ($a = 0+, 1+, \geq 2+$). The number $n_{y,r}$ of sampling sites is also needed for assessing associated measurement errors.

2.3 Information about the size of the production area

Information about parr production area A_r of each river is also needed. Uncertainty about A_r should be expressed in a form of probability distribution. For computational convenience, probability distribution of A_r should be approximated by a suitable parametric density function. Information about the parr production area can be derived from expert knowledge as suggested by Uusitalo et al. (2003).

3 Model structure

3.1 Latent population dynamics model

The population dynamics model is a parametric probability model which describes the connections between relative parr densities and consecutive numbers of migrating smolts in terms of relative survival rates and parr production area of a river.

3.1.1 Model for one river

Because only one river is under consideration in this section, index r is dropped out for notational convenience.

It is assumed that the expected number ES_y of smolts in year y depends on the relative density of age $\geq$1+ parr in previous year and on the smolt carrying capacity of the river as given by equation

$$E(S_y) = A\beta_3(p_1 P_{y-1,2} + p_2 P_{y-1,1}), \tag{1}$$

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where β_3 is a scaling factor greater than 0. A log-normal prior distribution is assigned to β_3. The parr production area is used as a scaling factor in order to make β_3 parameters comparable across rivers. Parameters p_1 and p_2 are unknown weights ($p_1+p_2=1$) which describe the relative contributions of relative densities of age 1+ and age $\geq$ 2+ parr. Conditional on the expected number of smolts $E(S_y)$ and variation parameter γ_s, the number of smolts migrating out from the river in year y is assumed to follow a log-normal distribution with mean $E(S_y)$ and variance $\gamma_s ES_y$. (We use unconventional parameterization of the log-normal distribution for notational convenience, see appendix A for details.)

$$S_y \mid E(S_y), \gamma_3 \sim LN(E(S_y), \gamma_3 E(S_y)) \tag{2}$$

Here γ_3 represents the natural variation of the population size. This includes the variation arising from the "coin tossing" type of randomnes in fish survival as well as the between-years variation in the survival probability.

The expected relative density $E(P_{y,2})$ of age $\geq$2+ parr is assumed to depend on the weighted average of the relative density of age 1+ parr in three previous years

$$E(P_{y,2}) = \beta_2(q_1 P_{y-1,1} + q_2 P_{y-2,1} + q_3 P_{y-3,1}). \tag{3}$$

This is based on the assumption that most of the parr at age 2+ or older actually belong to age groups 2+, 3+ and 4+. Weights q_1, q_2 and q_3 are treated as unknown, and therefore they are assigned a dirichlet prior distribution. Conditional on the expectation $E(P_{y,2})$ and variance $\gamma_2 E(P_{y,2})$ the relative density of age $\geq$2+ parr is assumed to follow a log-normal distribution

$$P_{y,2} \mid E(P_{y,2}), \gamma_2 \sim LN(E(P_{y,2}), \gamma_2 E(P_{y,2})). \tag{4}$$

The relationship between the expected relative density $E(P_{y,1})$ of age 1+ parr and the relative density $P_{y-1,0}$ of age 0+ parr in the previous year is also described by a linear function

$$E(P_{y,1}) = \beta_1 P_{y-1,0}, \tag{5}$$

where β_1 is the slope of the regression line. Given the expectation $E(P_{y,1})$ and variance $\gamma_1 E(P_{y,1})$, the relative density $P_{y,1}$ of age 1+ parr is assumed to follow a

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log-normal distribution

$$P_{y,1} \mid E(P_{y,1}), \gamma_1 \sim LN(E(P_{y,1}), \gamma_1 E(P_{y,1})). \qquad (6)$$

For each year y, the relative density $P_{y,0}$ of age 0+ parr must be assigned a prior distribution, which may, for example, be based on the information about the number of spawners in the river in year $y-1$. In the absence of any useful information, a vague prior distribution proportional to $1/P_{y,0}$ on a reasonably wide range of values can be used.

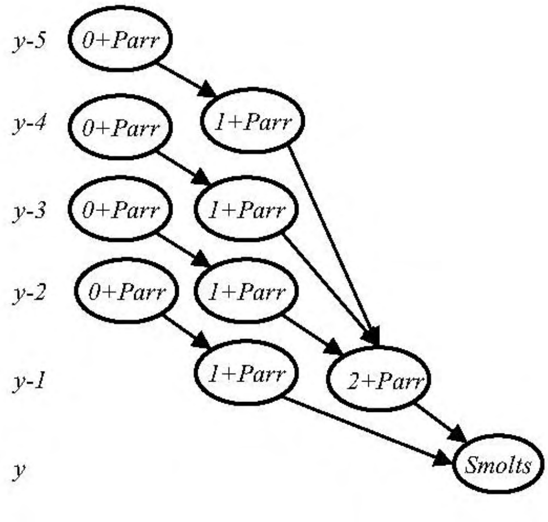

Figure 1: A schematic diagram illustrating the assumed dependencies when assessing the smolt abundance of year y

3.2 Models for measurements

3.2.1 Relative parr density

Often a set of electrofishing sampling sites does not represent well the distribution of habitat types of the river. Thus, the mean density of sampling sites can not be regarded as an observation of the true parr density. Instead, the observed parr

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Table 1: List of symbols used in the model specification for one river

	Indices
y	year
a	age
	Data
$I_{S,y}$	the posterior mean of the smolt abundance from separate analysis
$C_{S,y}$	the posterior CV of the smolt abundance from separate analysis
$I_{P,y,a}$	the point estimate for the total number of parr at age a found from all electrofishing sites
n_y	the number of electrofishing sampling sites
	Parameters
S_y	the number of smolts
γ_3	the ratio of the variance and mean of the log-normal distribution describing the natural variation of the abundance of smolts around the mean
$E(S_y)$	the expected number of smolts
A	the parr production area
β_3	the scaling factor between the expected number of smolts and previous parr density
p_1, p_2	weights which determine the extent to which the densities of age 1+ and age >1+ parr contribute to the expected number of smolts
$P_{y,a}$	the relative density of parr at age a
γ_2	similar to γ_3, but for the relative density of age $> 1+$ parr
$E(P_{y,a})$	the expected density of age a parr
β_2	scaling factor between the expected relative density of age $> 1+$ parr and previous densities of age 1+ parr
q_1, q_2, q_3	weights which determine the extent to which the densities of age 1+ parr in three previous years contribute to the expected density of age $> 1+$ parr
γ_1	similar to γ_2, but for the relative density of age 1+ parr
β_1	the scaling factor between the expected relative density of age $1+$ parr and previous density of age 0+ parr

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density can be regarded as an indication of relative parr density $P_{y,a}$ which may be proportional to the real parr density. It is assumed that the expected parr density $d_{i,y}$ in each sampling site $i = 1, \ldots, n_y$ varies according to a distribution with mean $P_{y,a}$ and coefficient on of variation δ, meaning that the spatial distribution of parr is assumed to be clustered. The expected number of parr in each sampling site is then given by $d_{i,y}s$, where s is the surface area of a sampling site. The number of parr in a sampling site is assumed to follow a Poisson distribution with mean $d_{i,y}s$. These assumptions imply, that conditional on $P_{y,a}, \delta, s$ and n_y, the total number of age a parr found from all sampling sites ($I_{P,y,a}$) follows a negative binomial distribution:

$$I_{P,y,a} \mid P_{y,a}, \delta, s, n_y \sim NB(n_y s P_{y,a}, \delta s) \qquad (7)$$

The mean of this distribution is given by $n_y s P_{y,a}$, and the variance is $n_y s P_{y,a} + \delta n_y s^2 P_{y,a}$. The CV is then $\sqrt{1+\delta s}/\sqrt{n_y s P_{y,a}}$, which means that the higher amount of electrofishing sites results in more precise measurements as, can be expected. The point probability function of the negative binomial distribution can be found in the appendix A.

3.2.2 Abundance of smolts

Smolt trapping may produce complex data, which leads to complex models. Connecting such measurement models to this population model may lead to difficult computational problems. However, smolt trapping models can be used separately, and results of these analysis can be easily incorporated into this model. By pretending that the posterior mean $I_{S,y}$ is an "observed" measurement of smolt abundance obtained through a measurement process, which has an error CV of $C_{S,y}$, the information in the posterior distribution can be brought into this model

$$I_{S,y} \mid S_y, C_{S,y} \sim LN(S_y, (C_{S,y} S_y)^2). \qquad (8)$$

For this approximation to work properly, it is necessary that the shape of the posterior distribution obtained from the separate data analysis or from expert opinion is roughly log-normal.

3.2.3 Hierarchical extension to multiple rivers

The idea of hierarchical modeling is to think that river specific parameters are random draws from a probability distribution which describes the between-river

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variation of the parameter. For example, each river r which has some data about the relative density of 0+ parr and relative density of 1+ parr will provide some information about the river-specific slope parameter $\beta_{1,r}$. Using data from multiple rivers also provides information about the between-river mean and variation of this parameter. This information can be used when making inference about parameter $\beta_{1,r}$ in a river which does not have information about this parameter. Following this idea,the following river specific parameters are assumed to be random draws from a distribution which describes their variation between rivers:

$$
\begin{aligned}
\beta_{1,r} \mid \mu_{\beta_1}, C_\beta &\sim LN(\mu_{\beta_1}, (C_\beta \mu_{\beta_1})^2) \\
\beta_{2,r} \mid \mu_{\beta_2}, C_\beta &\sim LN(\mu_{\beta_2}, (C_\beta \mu_{\beta_2})^2) \\
\beta_{3,r} \mid \mu_{\beta_3}, C_\beta &\sim LN(\mu_{\beta_3}, (C_\beta \mu_{\beta_3})^2) \\
\delta_r \mid \mu_\delta, C_\delta &\sim LN(\mu_\delta, (C_\delta \mu_\delta)^2) \\
(q_{1,r}, q_{2,r}, q_{3,r}) \mid \alpha_{q,1}, \alpha_{q,2}, \alpha_{q,3} &\sim Dirichlet(\alpha_{q,1}, \alpha_{q,2}, \alpha_{q,3}) \\
(p_{1,r}, p_{2,r}) \mid \alpha_{p,1}, \alpha_{p,2} &\sim Dirichlet(\alpha_{p,1}, \alpha_{p,2})
\end{aligned} \tag{9}
$$

Parameter μ represents the overall mean and C represents the coefficient of between-river variation of river-specific parameters. Parameters α of the dirichlet distribution control the between-river mean and variance of weight parameters.

3.2.4 Model output

Results obtained from the model are posterior distributions of model parameters including for example smolt and parr abundances. These distributions include information contained in the prior distributions and information contained in the observations. Posteriors can be presented by suitable statistics which describe the location and variation of the distribution, such as mean, median, mode, standard deviation and probability intervals. All aspects of the distribution are contained in its density function, which can also be plotted. It is also possible to calculate the probability that for example the smolt abundance is greater than some fixed value. Furthermore, the probability that the smolt abundance in a given year is higher or lower than some other random variable. An important application of this property can be to calculate the probability that the smolt production is larger than 50% of the production capacity of the river, which can be used as a measure of the weakness of a population.

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4 Example: predicting smolt output from salmon rivers in the Gulf of Bothnia

4.1 Data

Electrofishing results from 12 salmon rivers of Gulf of Bothnia are available. This data together with probabilistic estimates of smolt production of rivers Simojoki and Tornionjoki were used. For some of the rivers, there is no data about the abundance of age $\geq 2+$ parr. Instead, there is data ($I_{P,y,\geq 1+}$) about the abundance of age $\geq 1+$ parr. These observations are assumed to follow a log-normal distribution conditional on mean $P_{y,1} + P_{y,2}$ and variance $(C_{P,y,a}(P_{y,1} + P_{y,2}))^2$.

For river Tornionjoki, previous point estimates of smolt production for years 1987-1998 were used as posterior modes, and CV of 0.4 was assumed for those years. For years 1999-2003 the mean and CV were obtained from a separate analysis conducted using the approach described by Mäntyniemi and Romakkaniemi (2002). The smolt production measurements for river Simojoki were obtained by using the old point estimates as prior modes and by assuming a CV of 0.4. Smolt production data has been scaled down by dividing each observation by 1000 for numerical convenience. For the same reason, equation (1) has been scaled down

$$E(S_y) = A\beta_3(p_1 P_{y-1,2} + p_2 P_{y-1,1})/100. \qquad (10)$$

4.2 Prior distributions

This section describes the prior distributions assigned to model parameters. Because the parr densities can be assessed only in relative scale, it is difficult to express informative prior knowledge about model parameters which do not have clear biological meaning. Prior distributions for river specific scaling factors $\beta_{1,r}, \beta_{2,r}, \beta_{3,r}$ are defined by assigning prior distributions to parameters $\mu_{\beta_1}, \mu_{\beta_2}, \mu_{\beta_3}$ and C_β which characterize the between river mean and variation of the parameters.

Preliminary model runs indicated that the river-specific scaling parameters $\beta_{1,r}$ might be positively associated with the river specific parr production areas A_r. In order to account for this kind of association, a regression model

$$\log(\mu_{\beta_{1,r}}) = \nu_1 + \nu_2 \log(A_r) \qquad (11)$$

was assumed. Prior distributions assigned to all model parameters can be found from the table (2).

Table 2: Prior distributions for model parameters.

Variable name	Density function	Range
ν_1, ν_2	$N(0, 316)$	$-\infty, \infty$
C_δ	$\propto 1/C_\delta$	0.01,10
μ_δ	$LN(1, 100)$	0,∞
$\mu_{\beta_2}, \mu_{\beta_3}$	$Unif(0, 100)$	0,100
$\gamma_1, \gamma_2, \gamma_3$	$Unif(0.01, 10)$	0.01,10
C_β	$Unif(0.01, 10)$	0.01,10
$\alpha_{p,1}, \alpha_{p,2}$	$Gamma(5, 2)$	0,∞
$\alpha_{q,1}, \alpha_{q,2}, \alpha_{q,3}$	$Gamma(1, 3)$	0,∞
$P_{y,0}$	$LN(10, 1000)$	0,∞

4.3 Results

4.3.1 MCMC-simulation

WinBUGS software package (Spiegelhalter et al. 2003) was used to obtain samples from the posterior distributions of model parameters. Two MCMC chains from different starting points were run for 8800 iterations. According to convergence diagnostics, both chains had reached the same distribution before 4000 iterations, which was decided based on Gelman-Rubin convergence diagnostics and on visual insoection of chains and their running quantiles. Consequently, first 4000 iterations were discarded, and remaining 4800 iterations from both chains were used for calculating the results. Monte Carlo errors of the posterior distributions of smolt abundance were generally less than 2% compared to the estimated standard deviation of the distribution.

4.3.2 Model checking

Model's ability to predict missing data was examined by calculating a Bayesian p-value for each observation (Gelman et al. 1996). Each year's smolt abundance observations $I_{S,y}$ were predicted by using the parr and smolt abundance observations from previous and upcoming years from all rivers. For continuous distributions, the set of p-values should roughly look like a sample from a uniform distribution if the model predictions and observations fit well together (Gelman et al. 1996). This was verified for the smolt abundance estimates of rivers Simojoki and Tornionjoki, because they are the only rivers with smolt abundance observations. Plots of ordered Bayesian p-values together with the cumulative distribution

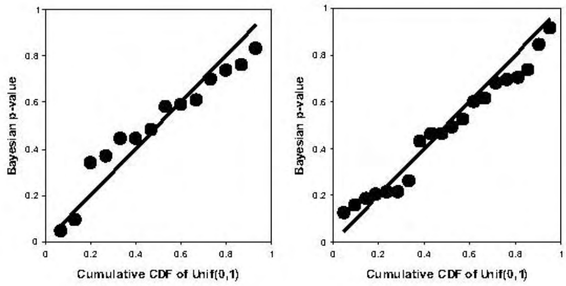

Figure 2: Ordered Bayesian p-values (dots) against corresponding values of the cumulative distribution function of $Unif(0,1)$ distribution calculated for smolt abundance observations $I_{S,y,r}$ of the River Tornionjoki (left) and of the River Simojoki (right). Straight line indicates the expected values in a case when data is generated from the model.

function of a standard uniform distribution (Fig. 2) showed that the model fits well for the data from both rivers. It was not possible to evaluate model's performance in predicting correct smolt abundances, as total smolt counts are not available from any of the rivers.

4.3.3 Posterior distributions of model parameters

Estimates of parameters $\beta_{3,r}$, which describes the linear relationship between the expected number of smolts and the relative parr density in the previous year, are different in rivers which have data about that parameter (Fig.3). For the rest of the rivers, the parameter estimates are equal and have mean close to that of the average of the two. Because the between-rivers variation of this parameter has been assumed to be equal to the between river variation of parameters $\beta_{1,r}$ and $\beta_{2,r}$ which vary considerably between rivers, the uncertainty about the parameter values is much higher in other rivers than in rivers Simojoki and Tornionjoki.

The CVs of the posterior distributions of the smolt abundance are considerably higher in other rivers than in rivers Simojoki and Tornionjoki, and there are

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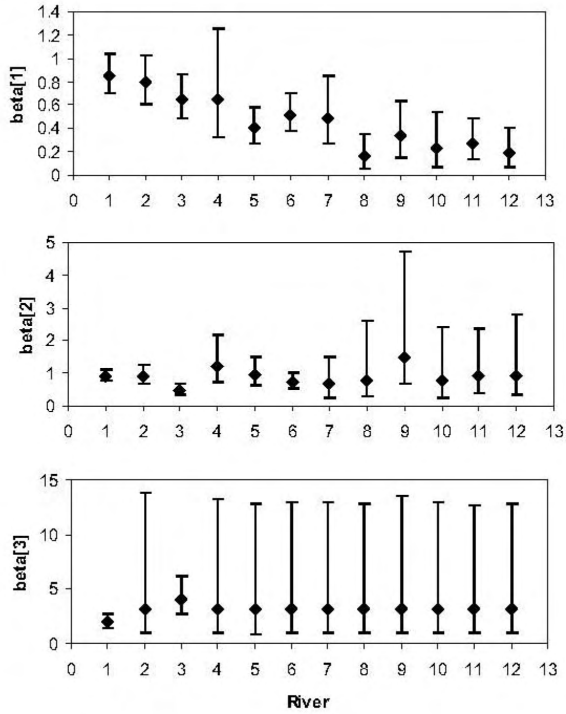

Figure 3: Posterior quantiles (2.5%,50% and 97.5%) of river-specific scaling factors between relative densities of age 0+ parr and age 1+ parr ($\beta_{1,r}$), between relative density of age 1+ parr ($\beta_{2,r}$) and age $\geq$ 2+ parr, and between relative density of age >1+ parr and the expected number of smolts ($\beta_{3,r}$). The numbers of rivers can be translated to river names as follows: 1)Tornio 2)Kalix 3)Simo 4)Råne 5)Aby 6)Byske 7)Ume 8)Rickle 9)Svar 10)Öre 11)Lögde 12)Ljungan.

also differences between these other rivers (Fig. 4). Differences between rivers are probably caused by differences in the uncertainty about the parr production

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area and differences in the uncertainty about the previous relative parr densities. In most of the rivers, there seems to have been a clear increase in the smolt abundance between years 1998-2001, and after that the trend seems to be somewhat decreasing, but for 2005 the abundance is expected to increase again. For example, rivers Tornionjoki and Kalix seem to have a similar kind of development and predictions of smolt production in recent and upcoming years, but there is a clear difference in the associated uncertainty (Fig. 5).

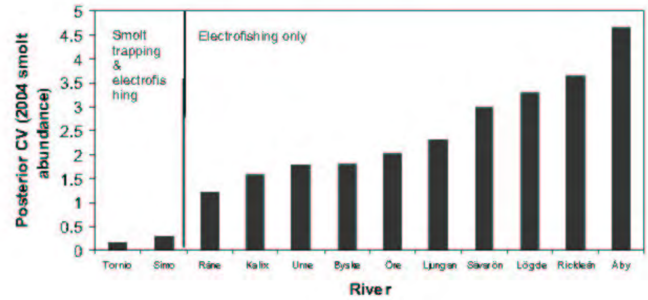

Figure 4: Uncertainty about smolt abundance of Gulf of Bothnia rivers in year 2004 in terms of coefficient of variation (CV) of the posterior distribution.

In many small rivers, the posterior distributions reflect high uncertainty about the smolt production. Typically the posterior distributions are strongly skewed, which means that although most probable values of smolt production are low, there is still considerably high probability that the smolt production is actually quite high.

As can be expected, the total smolt production from all 12 salmon rivers follows rather closely the development of the smolt production of the river Tornionjoki, which has the largest parr production area (Fig. 6). Despite the fact that there is quite high uncertainty about the production of many individual rivers, the total production is dominated by the two largest rivers, Tornio and Kalix, for which the uncertainty about the production is not very high, and thus the uncertainty about the total production is not as high as it is in some individual small rivers.

In order to evaluate the annual production of each stock in respect to potential smolt production of the river, the probability (P_{80}) that the production exceeds

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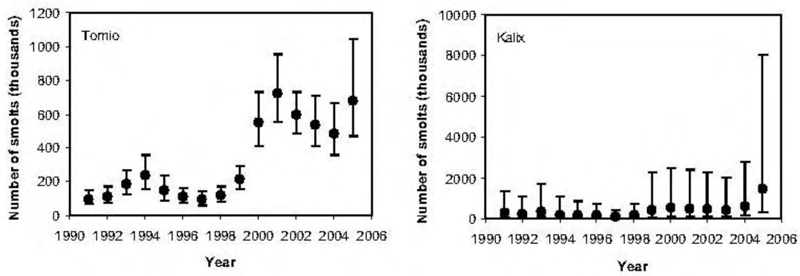

Figure 5: Posterior medians and 95% probability intervals for the smolt abundance in rivers Tornionjoki and Kalix in years 1991-2005.

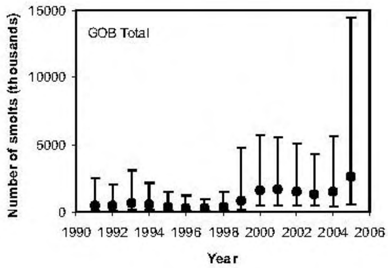

Figure 6: Posterior medians and 95% probability intervals for the smolt abundance in Gulf of Bothnia rivers in years 1991-2005.

50% of the production capacity was calculated for each year and for each stock. Prior distributions reflecting the views of domain experts about the smolt carrying capacity as derived by Uusitalo et al. (2003) were used in calculations. In order to act as if the 50% of the potential production was exceeded, P_{50} should be close to one.

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According to results, in year 2003 the overall level of P_{50} is lower than in year 2005 (Fig. 7). Because the potential smolt production is assumed remain stable in time, the difference is due to predicted increase in smolt production. There are also big differences between rivers, especially in the assessment unit 2, where strongest stocks are more likely to be above than below the 50% target, and the weakest rivers are certainly below.

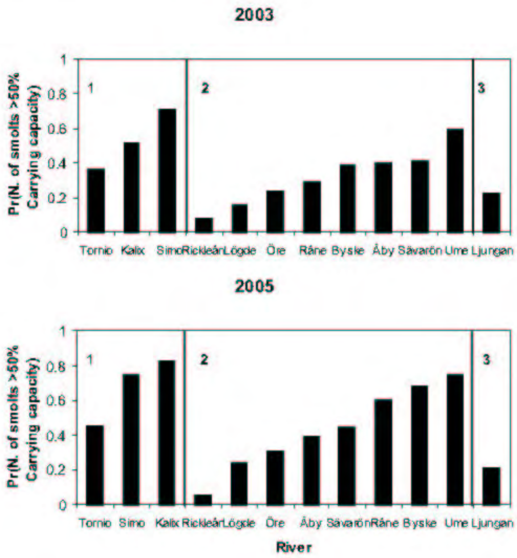

Figure 7: Probabilities that smolt production exceeds 50% of the carrying capacity in Gulf of Bothnia rivers in years 2003 and 2005. Probability close to 1 indicates that the 50% level is reliably reached, value 0.5 means that it is very uncertain whether the level has been achieved, and values near 0 tell reliably that the level is not reached. Numbers on the panels in the figures indicate the assessment area.

5 Discussion

The latent population dynamics model is fairly simple and utilises commonly used distributions such as the log-normal distribution. The choice to use the log-normal distribution for describing the natural random variation is well justified here, because smolt and parr abundances can have also larger values than in the previous state of the cohort, and because negative values are not allowed. However, for the same reasons, gamma distributions could have been used as well.

The variance of the log-normal distribution (i.e. the natural variation of abundance around the mean) was assumed to be proportional to the mean. This kind of structure was chose because it has some analogy to a situation in which a more rigorous population dynamics model might be used: if measurements about true parr abundance could be made, it would be reasonable to use binomial model between life stages. In binomial distribution, the variance is proportional to the mean, when the probability of success is constant.

The expectation of the log-normal distribution was assumed to be a linear function of the relative abundance in the previous life stage. In other words, it is assumed that the survival is not density dependent, which obviously can not be true in all cases. However, if the smolt production is low compared to the carrying capacity, the linear model may lead to reasonable inferences. On the other hand, it is difficult to know whether the smolt production is low compared to the carrying capacity or not, because there may be high uncertainty about both the carrying capacity (Uusitalo et al. 2003) and the smolt production. In the philosophical sence, it may be somewhat contradictory to use a linear model and admit that there exists a carrying capacity.

It is important to keep in mind, that posterior distributions of relative parr densities and smolt abundances tend to shrink towards their linear relationship, because of the hierarchical nature of the model. The amount of shrinkage is positively associated to the amount of measurement error. Because of the hierarchical modeling between rivers, river-specific parameter estimates are also expected to shrink towards their common mean. For a river with informative data, the parameter estimate will not be much influenced by the information obtained from the other rivers, but if there is little or no information about the river-specific parameter, then the information from the other rivers will dominate the inference: the mean of the posterior distribution will be very close to the overall mean, and the variation of the posterior distribution will be high. In our example, there is information about parameter $\beta_{3,r}$ only from two (Tornio and Simo) out of 12 rivers. These two rivers have slightly different parameter estimates, and remaining ten

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rivers have posterior distributions which have mean roughly equal to the mean of the two estimates and much higher variance (Fig. 3).

The basis of the hierarchical modeling was to assume that river-specific parameters are conditionally independent given the parameters which describe the variation between rivers. This means also, that we should not be able to order the river specific parameters before seeing the data. If there is information which would make the ordering possible, then this information should be taken into account in the model structure, and then the hierarchical modeling would be more appropriate again. In this sense, the analysis in our example could be improved, because there actually is river-specific information about the mortality of smolts during their migration (Uusitalo et al. 2003) which is not used in the presented analysis.

The model devides the variation in the data to two components: the natural variation of the abundance, and the random variation of the measurements (measurement error). If the measurement error is underestimated, the natural variation is overestimated and predictive distributions of future abundance have too large variance, and vice versa. However, under- or overestimation can not be detected by any means other than comparing model predictions to true smolt abundances. When true abundances are not available, which usually is the case, the predictive ability of the model can not be validated by any data. The ability to predict observable data can still be verified. This was done in small scale, and results indicated reasonably good fit to the observations. The credibility of the model can be also assessed by evaluating the quality of the models which connect the unobservable abundances and relative densities to observable quantities such as electrofishing data. These may be highly complex models which take into account, for example, the spatial correlation of the parr density and unequal capture probability of individuals and schooling behaviour and run timing dynamics of smolts. Such models can be used separately, and their results can be used in the model presented here by approximating the shape of the obtained posterior distributions by using a log-normal or some other flexible distribution.

In our example the smolt trapping information was based on a mixture of previous point estimates, expert opinion and on rigorous mark-recapture modeling (last years in R. Tornionjoki time series). Further work should include reanalysis of the mark-recapture data sets of both rivers by the method used for R. Tornionjoki data during the last years.

The measurement model used in this work for the electrofishing data is based on the assumption that there is no spatial correlation in the parr density between the sampling sites, and that the density varies around the mean density with un-

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known CV. It is also assumed that there is no uncertainty about the total number of parr at sampling sites. At the current stage, the sensitivity of inference to these quite strong assumptions has not been evaluated. One possibility to improve the estimation in this respect would also be to reanalyze the historical data by using the method proposed by Wyatt (2002) and Wyatt (2003), and transfer the posterior distributions from these analysis by using the log-normal approximation.

Obvious future developments of the population dynamics model are the inclusion of the density dependence in survival. Alternative distributional and function reformulations can be studied and incorporated by using Bayesian model averaging techniques. Atttempts to improve the model to such a direction that the parameters would have more clear biological meaning should also be made. This would help in using biological expertise in formulating the prior distributions. The behaviour of the model can also be studied by using simulated data generated by a detailed life-history model.

The possibility to compare the smolt production estimates and carrying capacity estimates by calculating the probability (P_{50}) that the smolt production exceeds 50% of the carrying capacity provides a practical way to measure whether such an management goal will be or has been reached. When this probability is around 0.5, it is highly uncertain whether the goal has been reached or not. Probabilities near 0 and 1 indicate higher degree of certainty. There are four interrelated factors which determine the probability: 1) true smolt abundance 2) true carrying capacity 3) uncertainty about the true smolt abundance 4) uncertainty about the true carrying capacity. The probability P_{50} can thus be affected by increasing the smolt production and/or reducing uncertainty about smolt production and/or carrying capacity.

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A Parameterisation of the log-normal distribution

By expression $x \mid \mu, \sigma^2 \sim LN(\mu, \sigma^2)$ we mean that conditional on mean μ and variance σ^2, x follows a log-normal distribution. This corresponds to a probability density function

$$\begin{aligned} p(x \mid M, S) &= \frac{1}{\sqrt{2\pi S^2}x} e^{(-\log(x)-M)^2/(2S^2)}, \\ M &= \log(\mu) - \log(\sigma^2/\mu^2 + 1)/2, \\ S^2 &= \log(\sigma^2/\mu^2 + 1), \end{aligned}$$

where M is the mean and S^2 is the variance of $\log(x)$.

B Parameterisation of the negative binomial distribution

By expression $x \mid \mu, k \sim NB(\mu, k)$ we mean that conditional on mean μ and dispersion parameter k, x follows a negative binomial distribution. This corresponds to a point probability function

$$p(x \mid \mu, k) = \begin{pmatrix} x + \frac{\mu}{k} - 1 \\ \frac{\mu}{k} - 1 \end{pmatrix} \left(\frac{1}{1+k}\right)^{\frac{\mu}{k}} \left(\frac{k}{1+k}\right)^{x}, \tag{12}$$

where μ is the mean and $\mu + k\mu$ is the variance of x.

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Predicting salmon smolt abundance using a simple hierarchical Bayesian model

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Elja Arjas§

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Abstract

A hierarchical Bayes model was developed to describe the relationship between relative densities of salmon parr and absolute abundance of salmon smolts. The core of the model is a latent dynamic regression model which connects relative densities of parr to smolt abundances. Information about parameter values between different rivers is transferred through hyperparameters which are common to all rivers. Needed model inputs are prior distributions of model parameters and independent estimates of relative parr density and smolt abundance in a form of statistics of posterior distributions calculated separately from electrofishing and smolt trapping data.

1 Introduction

Up to date, the smolt production of Baltic salmon rivers has been predicted using a set of different regression models. Slopes of these regression models have

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been obtained by fitting a linear regression line to point estimates of relative parr abundance and smolt abundance (ICES 2002). Predictions have been generalized to all rivers by using point estimates of parr production area as scaling factors and river-specific predictions have been expressed as point estimates. This procedure ignores uncertainty arising from measurement error, uncertainty about parameter values, uncertainty associated with between-river variation of model parameters and uncertainty about the model structure.

Bayesian statistics provides a rigorous way to take into account these kinds of uncertainties. Bayesian statistics operates using probabilities as measures of uncertainty. Thus, uncertainty about parameters of regression equations and about smolt and parr abundances is expressed in terms of probability distributions. In addition, hierarchical Bayesian modeling is a powerful tool for transferring information between exchangeable units, such as rivers (Prévost et al. 2001; ICES 2002), electrofishing sampling sites (Wyatt 2002) or migration days (Mäntyniemi and Romakkaniemi 2002).

In this paper we present a Bayesian method which also utilises the idea of using linear regression models to predict upcoming smolt and parr abundances based on previous parr densities. However, this method takes into account sampling errors of measurements, as well as uncertainty about parameter values. Variation of model parameters between rivers is also taken into account by using a hierarchical model structure. The model also utilises expert opinions about some of the parameters.

2 Model inputs

2.1 Measurements of smolt abundance

The smolt abundance $S_{y,r}$ of river r in year y must be expressed in a form of a probability distribution, unless the absolute number of smolts is directly observed. The probability distribution can be based on an opinion of an expert, or it can be based on the information contained in smolt trapping data. For example, methods proposed by Mäntyniemi and Romakkaniemi (2002) can be used separately for deriving posterior distribution of the run size from mark-recpture data. If expert judgement is used, it is essential that the expert opinion is independent of the information about the previous parr densities.

For the sake of simplicity, the probability distribution which describes the uncertainty about $S_{y,r}$ based on mark-reacpture data or expert opinion should be summarized by mean $I_{S,y,r}$ and coefficient of variation $C_{I_S,y,r}$. These statistics are used as model inputs.

2.2 Measurements of relative parr density

Point estimates $I_{P,y,r,a}$ of the total number of age a parr found from the electrofishing sampling sites of river r in year y are used as measurements of relative density $P_{y,r,a}$ of age a parr ($a = 0+, 1+, \geq 2+$). The number $n_{y,r}$ of sampling sites is also needed for assessing associated measurement errors.

2.3 Information about the size of the production area

Information about parr production area A_r of each river is also needed. Uncertainty about A_r should be expressed in a form of probability distribution. For computational convenience, probability distribution of A_r should be approximated by a suitable parametric density function. Information about the parr production area can be derived from expert knowledge as suggested by Uusitalo et al. (2003).

3 Model structure

3.1 Latent population dynamics model

The population dynamics model is a parametric probability model which describes the connections between relative parr densities and consecutive numbers of migrating smolts in terms of relative survival rates and parr production area of a river.

3.1.1 Model for one river

Because only one river is under consideration in this section, index r is dropped out for notational convenience.

It is assumed that the expected number ES_y of smolts in year y depends on the relative density of age $\geq$1+ parr in previous year and on the smolt carrying capacity of the river as given by equation

$$E(S_y) = A\beta_3(p_1 P_{y-1,2} + p_2 P_{y-1,1}), \tag{1}$$

where β_3 is a scaling factor greater than 0. A log-normal prior distribution is assigned to β_3. The parr production area is used as a scaling factor in order to make β_3 parameters comparable across rivers. Parameters p_1 and p_2 are unknown weights ($p_1+p_2 = 1$) which describe the relative contributions of relative densities of age 1+ and age $\geq$ 2+ parr. Conditional on the expected number of smolts $E(S_y)$ and variation parameter γ_s, the number of smolts migrating out from the river in year y is assumed to follow a log-normal distribution with mean $E(S_y)$ and variance $\gamma_s ES_y$. (We use unconventional parameterization of the log-normal distribution for notational convenience, see appendix A for details.)

$$S_y \mid E(S_y), \gamma_3 \sim LN(E(S_y), \gamma_3 E(S_y)) \tag{2}$$

Here γ_3 represents the natural variation of the population size. This includes the variation arising from the ”coin tossing” type of randomnes in fish survival as well as the between-years variation in the survival probability.

The expected relative density $E(P_{y,2})$ of age $\geq$2+ parr is assumed to depend on the weighted average of the relative density of age 1+ parr in three previous years

$$E(P_{y,2}) = \beta_2(q_1 P_{y-1,1} + q_2 P_{y-2,1} + q_3 P_{y-3,1}). \tag{3}$$

This is based on the assumption that most of the parr at age 2+ or older actually belong to age groups 2+, 3+ and 4+. Weights q_1, q_2 and q_3 are treated as unknown, and therefore they are assigned a dirichlet prior distribution. Conditional on the expectation $E(P_{y,2})$ and variance $\gamma_2 E(P_{y,2})$ the relative density of age $\geq$2+ parr is assumed to follow a log-normal distribution

$$P_{y,2} \mid E(P_{y,2}), \gamma_2 \sim LN(E(P_{y,2}), \gamma_2 E(P_{y,2})). \tag{4}$$

The relationship between the expected relative density $E(P_{y,1})$ of age 1+ parr and the relative density $P_{y-1,0}$ of age 0+ parr in the previous year is also described by a linear function

$$E(P_{y,1}) = \beta_1 P_{y-1,0}, \tag{5}$$

where β_1 is the slope of the regression line. Given the expectation $E(P_{y,1})$ and variance $\gamma_1 E(P_{y,1})$, the relative density $P_{y,1}$ of age 1+ parr is assumed to follow a log-normal distribution

$$P_{y,1} \mid E(P_{y,1}), \gamma_1 \sim LN(E(P_{y,1}), \gamma_1 E(P_{y,1})). \tag{6}$$

For each year y, the relative density $P_{y,0}$ of age 0+ parr must be assigned a prior distribution, which may, for example, be based on the information about the number of spawners in the river in year $y-1$. In the absence of any useful information, a vague prior distribution proportional to $1/P_{y,0}$ on a reasonably wide range of values can be used.

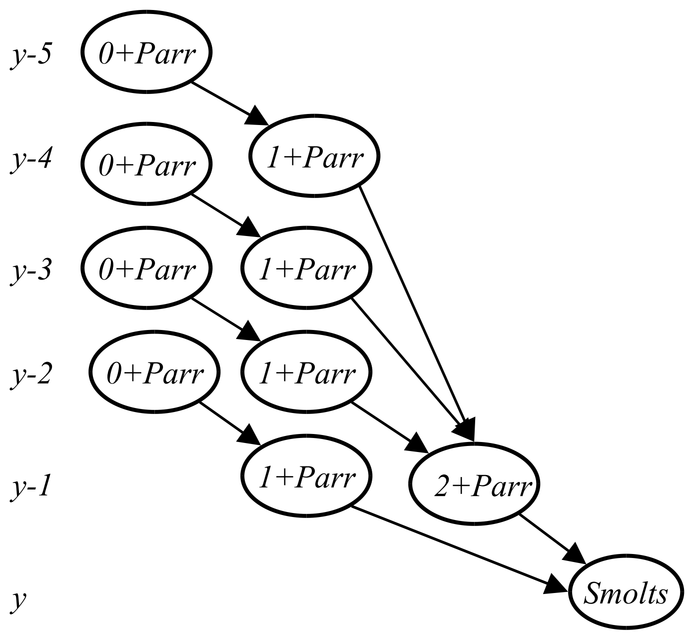

Figure 1: A schematic diagram illustrating the assumed dependencies when assessing the smolt abundance of year y

3.2 Models for measurements

3.2.1 Relative parr density

Often a set of electrofishing sampling sites does not represent well the distribution of habitat types of the river. Thus, the mean density of sampling sites can not be regarded as an observation of the true parr density. Instead, the observed parr

Table 1: List of symbols used in the model specification for one river

	Indices
y	year
a	age
	Data
$I_{S,y}$	the posterior mean of the smolt abundance from separate analysis
$C_{S,y}$	the posterior CV of the smolt abundance from separate analysis
$I_{P,y,a}$	the point estimate for the total number of parr at age a found from all electrofishing sites
n_y	the number of electrofishing sampling sites
	Parameters
S_y	the number of smolts
γ_3	the ratio of the variance and mean of the log-normal distribution describing the natural variation of the abundance of smolts around the mean
$E(S_y)$	the expected number of smolts
A	the parr production area
β_3	the scaling factor between the expected number of smolts and previous parr density
p_1, p_2	weights which determine the extent to which the densities of age 1+ and age >1+ parr contribute to the expected number of smolts
$P_{y,a}$	the relative density of parr at age a
γ_2	similar to γ_3, but for the relative density of age $> 1+$ parr
$E(P_{y,a})$	the expected density of age a parr
β_2	scaling factor between the expected relative density of age $> 1+$ parr and previous densities of age 1+ parr
q_1, q_2, q_3	weights which determine the extent to which the densities of age 1+ parr in three previous years contribute to the expected density of age $> 1+$ parr
γ_1	similar to γ_2, but for the relative density of age 1+ parr
β_1	the scaling factor between the expected relative density of age $1+$ parr and previous density of age 0+ parr

density can be regarded as an indication of relative parr density $P_{y,a}$ which may be proportional to the real parr density. It is assumed that the expected parr density $d_{i,y}$ in each sampling site $i = 1, \dots, n_y$ varies according to a distribution with mean $P_{y,a}$ and coefficient on of variation δ, meaning that the spatial distribution of parr is assumed to be clustered. The expected number of parr in each sampling site is then given by $d_{i,y}s$, where s is the surface area of a sampling site. The number of parr in a sampling site is assumed to follow a Poisson distribution with mean $d_{i,y}s$. These assumptions imply, that conditional on $P_{y,a}, \delta, s$ and n_y, the total number of age a parr found from all sampling sites ($I_{P,y,a}$) follows a negative binomial distribution:

$$I_{P,y,a} \mid P_{y,a}, \delta, s, n_y \sim NB(n_y s P_{y,a}, \delta s) \tag{7}$$

The mean of this distribution is given by $n_y s P_{y,a}$, and the variance is $n_y s P_{y,a} + \delta n_y s^2 P_{y,a}$. The CV is then $\sqrt{1+\delta s}/\sqrt{n_y s P_{y,a}}$, which means that the higher amount of electrofishing sites results in more precise measurements as, can be expected. The point probability function of the negative binomial distribution can be found in the appendix A.

3.2.2 Abundance of smolts

Smolt trapping may produce complex data, which leads to complex models. Connecting such measurement models to this population model may lead to difficult computational problems. However, smolt trapping models can be used separately, and results of these analysis can be easily incorporated into this model. By pretending that the posterior mean $I_{S,y}$ is an ”observed” measurement of smolt abundance obtained through a measurement process, which has an error CV of $C_{S,y}$, the information in the posterior distribution can be brought into this model

$$I_{S,y} \mid S_y, C_{S,y} \sim LN(S_y, (C_{S,y} S_y)^2). \tag{8}$$

For this approximation to work properly, it is necessary that the shape of the posterior distribution obtained from the separate data analysis or from expert opinion is roughly log-normal.

3.2.3 Hierarchical extension to multiple rivers

The idea of hierarchical modeling is to think that river specific parameters are random draws from a probability distribution which describes the between-river variation of the parameter. For example, each river r which has some data about the relative density of 0+ parr and relative density of 1+ parr will provide some information about the river-specific slope parameter $\beta_{1,r}$. Using data from multiple rivers also provides information about the between-river mean and variation of this parameter. This information can be used when making inference about parameter $\beta_{1,r}$ in a river which does not have information about this parameter. Following this idea,the following river specific parameters are assumed to be random draws from a distribution which describes their variation between rivers:

$$
\begin{aligned}
\beta_{1,r} \mid \mu_{\beta_1}, C_\beta &\sim LN(\mu_{\beta_1}, (C_\beta \mu_{\beta_1})^2) \\
\beta_{2,r} \mid \mu_{\beta_2}, C_\beta &\sim LN(\mu_{\beta_2}, (C_\beta \mu_{\beta_2})^2) \\
\beta_{3,r} \mid \mu_{\beta_3}, C_\beta &\sim LN(\mu_{\beta_3}, (C_\beta \mu_{\beta_3})^2) \\
\delta_r \mid \mu_\delta, C_\delta &\sim LN(\mu_\delta, (C_\delta \mu_\delta)^2) \\
(q_{1,r}, q_{2,r}, q_{3,r}) \mid \alpha_{q,1}, \alpha_{q,2}, \alpha_{q,3} &\sim Dirichlet(\alpha_{q,1}, \alpha_{q,2}, \alpha_{q,3}) \\
(p_{1,r}, p_{2,r}) \mid \alpha_{p,1}, \alpha_{p,2} &\sim Dirichlet(\alpha_{p,1}, \alpha_{p,2})
\end{aligned} \tag{9}
$$

Parameter μ represents the overall mean and C represents the coefficient of between-river variation of river-specific parameters. Parameters α of the dirichlet distribution control the between-river mean and variance of weight parameters.

3.2.4 Model output

Results obtained from the model are posterior distributions of model parameters including for example smolt and parr abundances. These distributions include information contained in the prior distributions and information contained in the observations. Posteriors can be presented by suitable statistics which describe the location and variation of the distribution, such as mean, median, mode, standard deviation and probability intervals. All aspects of the distribution are contained in its density function, which can also be plotted. It is also possible to calculate the probability that for example the smolt abundance is greater than some fixed value. Furthermore, the probability that the smolt abundance in a given year is higher or lower than some other random variable. An important application of this property can be to calculate the probability that the smolt production is larger than 50% of the production capacity of the river, which can be used as a measure of the weakness of a population.

4 Example: predicting smolt output from salmon rivers in the Gulf of Bothnia

4.1 Data

Electrofishing results from 12 salmon rivers of Gulf of Bothnia are available. This data together with probabilistic estimates of smolt production of rivers Simojoki and Tornionjoki were used. For some of the rivers, there is no data about the abundance of age $\geq 2+$ parr. Instead, there is data ($I_{P,y,\geq 1+}$) about the abundance of age $\geq 1+$ parr. These observations are assumed to follow a log-normal distribution conditional on mean $P_{y,1} + P_{y,2}$ and variance $(C_{P,y,a}(P_{y,1} + P_{y,2}))^2$.

For river Tornionjoki, previous point estimates of smolt production for years 1987-1998 were used as posterior modes, and CV of 0.4 was assumed for those years. For years 1999-2003 the mean and CV were obtained from a separate analysis conducted using the approach described by Mäntyniemi and Romakkaniemi (2002). The smolt production measurements for river Simojoki were obtained by using the old point estimates as prior modes and by assuming a CV of 0.4. Smolt production data has been scaled down by dividing each observation by 1000 for numerical convenience. For the same reason, equation (1) has been scaled down

$$E(S_y) = A\beta_3(p_1 P_{y-1,2} + p_2 P_{y-1,1})/100. \tag{10}$$

4.2 Prior distributions

This section describes the prior distributions assigned to model parameters. Because the parr densities can be assessed only in relative scale, it is difficult to express informative prior knowledge about model parameters which do not have clear biological meaning. Prior distributions for river specific scaling factors $\beta_{1,r}, \beta_{2,r}, \beta_{3,r}$ are defined by assigning prior distributions to parameters $\mu_{\beta_1}, \mu_{\beta_2}, \mu_{\beta_3}$ and C_β which characterize the between river mean and variation of the parameters.

Preliminary model runs indicated that the river-specific scaling parameters $\beta_{1,r}$ might be positively associated with the river specific parr production areas A_r. In order to account for this kind of association, a regression model

$$\log(\mu_{\beta_{1,r}}) = \nu_1 + \nu_2 \log(A_r) \tag{11}$$

was assumed. Prior distributions assigned to all model parameters can be found from the table (2).

Table 2: Prior distributions for model parameters.

Variable name	Density function	Range
ν_1, ν_2	$N(0, 316)$	$-\infty, \infty$
C_δ	$\propto 1/C_\delta$	0.01,10
μ_δ	$LN(1, 100)$	0,∞
$\mu_{\beta_2}, \mu_{\beta_3}$	$Unif(0, 100)$	0,100
$\gamma_1, \gamma_2, \gamma_3$	$Unif(0.01, 10)$	0.01,10
C_β	$Unif(0.01, 10)$	0.01,10
$\alpha_{p,1}, \alpha_{p,2}$	$Gamma(5, 2)$	0,∞
$\alpha_{q,1}, \alpha_{q,2}, \alpha_{q,3}$	$Gamma(1, 3)$	0,∞
$P_{y,0}$	$LN(10, 1000)$	0,∞

4.3 Results

4.3.1 MCMC-simulation

WinBUGS software package (Spiegelhalter et al. 2003) was used to obtain samples from the posterior distributions of model parameters. Two MCMC chains from different starting points were run for 8800 iterations. According to convergence diagnostics, both chains had reached the same distribution before 4000 iterations, which was decided based on Gelman-Rubin convergence diagnostics and on visual insoection of chains and their running quantiles. Consequently, first 4000 iterations were discarded, and remaining 4800 iterations from both chains were used for calculating the results. Monte Carlo errors of the posterior distributions of smolt abundance were generally less than 2% compared to the estimated standard deviation of the distribution.

4.3.2 Model checking

Model's ability to predict missing data was examined by calculating a Bayesian p-value for each observation (Gelman et al. 1996). Each year's smolt abundance observations $I_{S,y}$ were predicted by using the parr and smolt abundance observations from previous and upcoming years from all rivers. For continuous distributions, the set of p-values should roughly look like a sample from a uniform distribution if the model predictions and observations fit well together (Gelman et al. 1996). This was verified for the smolt abundance estimates of rivers Simojoki and Tornionjoki, because they are the only rivers with smolt abundance observations. Plots of ordered Bayesian p-values together with the cumulative distribution

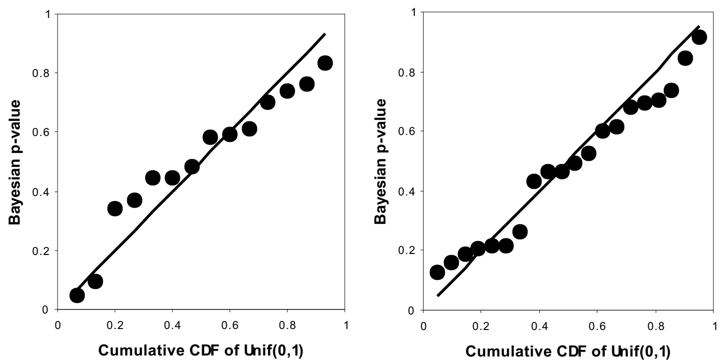

Figure 2: Ordered Bayesian p-values (dots) against corresponding values of the cumulative distribution function of $Unif(0,1)$ distribution calculated for smolt abundance observations $I_{S,y,r}$ of the River Tornionjoki (left) and of the River Simojoki (right). Straight line indicates the expected values in a case when data is generated from the model.

function of a standard uniform distribution (Fig. 2) showed that the model fits well for the data from both rivers. It was not possible to evaluate model's performance in predicting correct smolt abundances, as total smolt counts are not available from any of the rivers.

4.3.3 Posterior distributions of model parameters

Estimates of parameters $\beta_{3,r}$, which describes the linear relationship between the expected number of smolts and the relative parr density in the previous year, are different in rivers which have data about that parameter (Fig.3). For the rest of the rivers, the parameter estimates are equal and have mean close to that of the average of the two. Because the between-rivers variation of this parameter has been assumed to be equal to the between river variation of parameters $\beta_{1,r}$ and $\beta_{2,r}$ which vary considerably between rivers, the uncertainty about the parameter values is much higher in other rivers than in rivers Simojoki and Tornionjoki.

The CVs of the posterior distributions of the smolt abundance are considerably higher in other rivers than in rivers Simojoki and Tornionjoki, and there are

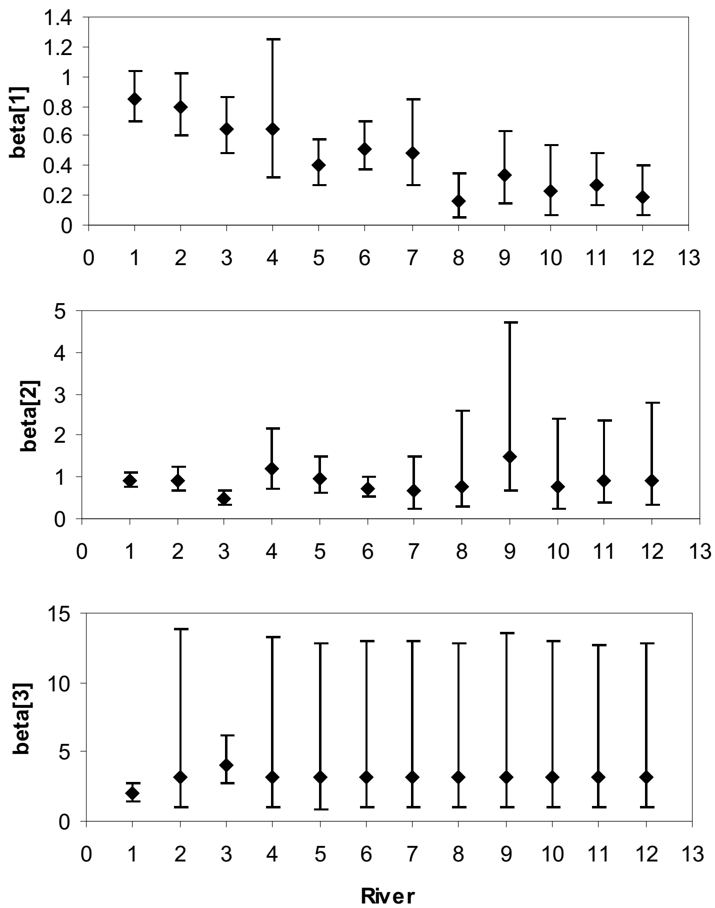

Figure 3: Posterior quantiles (2.5%,50% and 97.5%) of river-specific scaling factors between relative densities of age 0+ parr and age 1+ parr ($\beta_{1,r}$), between relative density of age 1+ parr ($\beta_{2,r}$) and age $\geq$ 2+ parr, and between relative density of age >1+ parr and the expected number of smolts ($\beta_{3,r}$). The numbers of rivers can be translated to river names as follows: 1)Tornio 2)Kalix 3)Simo 4)Råne 5)Aby 6)Byske 7)Ume 8)Rickle 9)Svar 10)Öre 11)Lögde 12)Ljungan.

also differences between these other rivers (Fig. 4). Differences between rivers are probably caused by differences in the uncertainty about the parr production area and differences in the uncertainty about the previous relative parr densities. In most of the rivers, there seems to have been a clear increase in the smolt abundance between years 1998-2001, and after that the trend seems to be somewhat decreasing, but for 2005 the abundance is expected to increase again. For example, rivers Tornionjoki and Kalix seem to have a similar kind of development and predictions of smolt production in recent and upcoming years, but there is a clear difference in the associated uncertainty (Fig. 5).

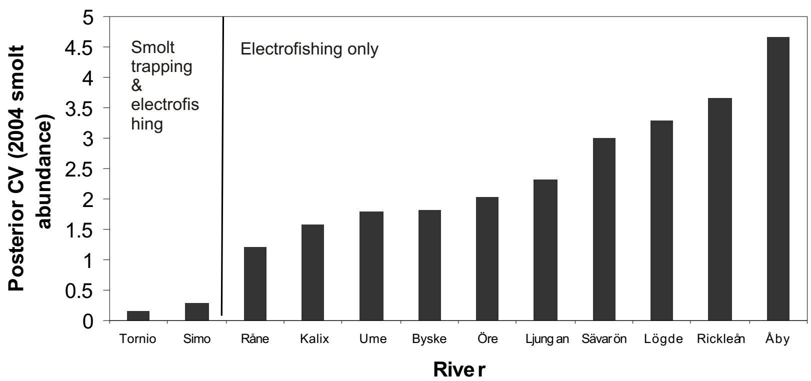

Figure 4: Uncertainty about smolt abundance of Gulf of Bothnia rivers in year 2004 in terms of coefficient of variation (CV) of the posterior distribution.

In many small rivers, the posterior distributions reflect high uncertainty about the smolt production. Typically the posterior distributions are strongly skewed, which means that although most probable values of smolt production are low, there is still considerably high probability that the smolt production is actually quite high.

As can be expected, the total smolt production from all 12 salmon rivers follows rather closely the development of the smolt production of the river Tornionjoki, which has the largest parr production area (Fig. 6). Despite the fact that there is quite high uncertainty about the production of many individual rivers, the total production is dominated by the two largest rivers, Tornio and Kalix, for which the uncertainty about the production is not very high, and thus the uncertainty about the total production is not as high as it is in some individual small rivers.

In order to evaluate the annual production of each stock in respect to potential smolt production of the river, the probability (P_{50}) that the production exceeds

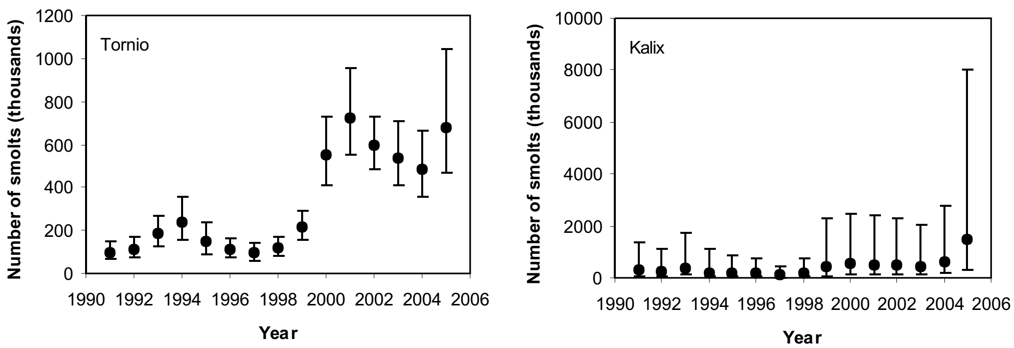

Figure 5: Posterior medians and 95% probability intervals for the smolt abundance in rivers Tornionjoki and Kalix in years 1991-2005.

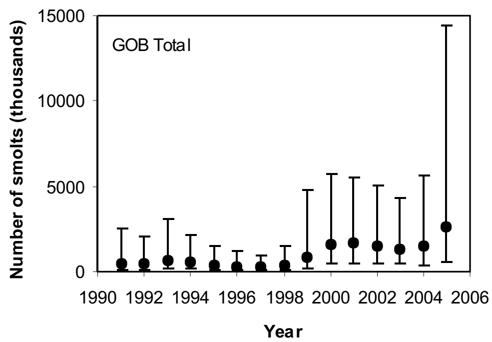

Figure 6: Posterior medians and 95% probability intervals for the smolt abundance in Gulf of Bothnia rivers in years 1991-2005.

50% of the production capacity was calculated for each year and for each stock. Prior distributions reflecting the views of domain experts about the smolt carrying capacity as derived by Uusitalo et al. (2003) were used in calculations. In order to act as if the 50% of the potential production was exceeded, P_{50} should be close to one.

According to results, in year 2003 the overall level of P_{50} is lower than in year 2005 (Fig. 7). Because the potential smolt production is assumed remain stable in time, the difference is due to predicted increase in smolt production. There are also big differences between rivers, especially in the assessment unit 2, where strongest stocks are more likely to be above than below the 50% target, and the weakest rivers are certainly below.

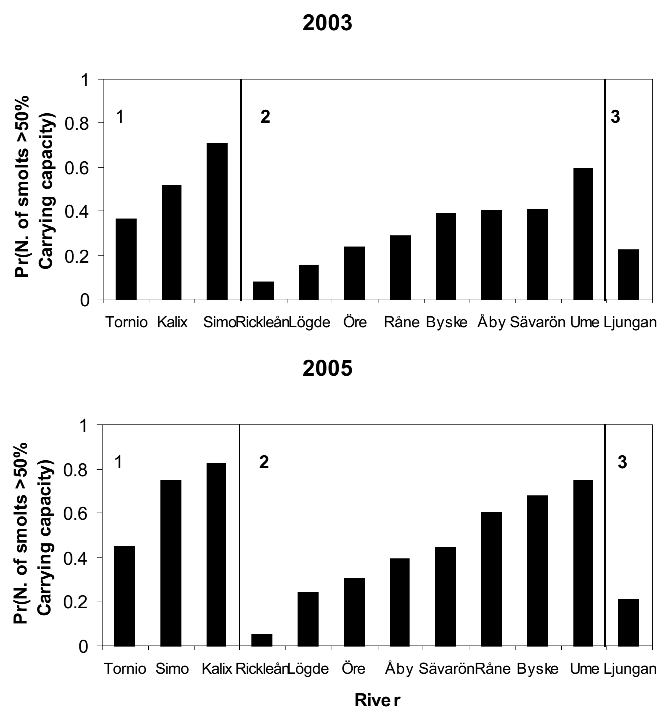

Figure 7: Probabilities that smolt production exceeds 50% of the carrying capacity in Gulf of Bothnia rivers in years 2003 and 2005. Probability close to 1 indicates that the 50% level is reliably reached, value 0.5 means that it is very uncertain whether the level has been achieved, and values near 0 tell reliably that the level is not reached. Numbers on the panels in the figures indicate the assessment area.

5 Discussion

The latent population dynamics model is fairly simple and utilises commonly used distributions such as the log-normal distribution. The choice to use the log-normal distribution for describing the natural random variation is well justified here, because smolt and parr abundances can have also larger values than in the previous state of the cohort, and because negative values are not allowed. However, for the same reasons, gamma distributions could have been used as well.

The variance of the log-normal distribution (i.e. the natural variation of abundance around the mean) was assumed to be proportional to the mean. This kind of structure was chose because it has some analogy to a situation in which a more rigorous population dynamics model might be used: if measurements about true parr abundance could be made, it would be reasonable to use binomial model between life stages. In binomial distribution, the variance is proportional to the mean, when the probability of success is constant.

The expectation of the log-normal distribution was assumed to be a linear function of the relative abundance in the previous life stage. In other words, it is assumed that the survival is not density dependent, which obviously can not be true in all cases. However, if the smolt production is low compared to the carrying capacity, the linear model may lead to reasonable inferences. On the other hand, it is difficult to know whether the smolt production is low compared to the carrying capacity or not, because there may be high uncertainty about both the carrying capacity (Uusitalo et al. 2003) and the smolt production. In the philosophical sence, it may be somewhat contradictory to use a linear model and admit that there exists a carrying capacity.

It is important to keep in mind, that posterior distributions of relative parr densities and smolt abundances tend to shrink towards their linear relationship, because of the hierarchical nature of the model. The amount of shrinkage is positively associated to the amount of measurement error. Because of the hierarchical modeling between rivers, river-specific parameter estimates are also expected to shrink towards their common mean. For a river with informative data, the parameter estimate will not be much influenced by the information obtained from the other rivers, but if there is little or no information about the river-specific parameter, then the information from the other rivers will dominate the inference: the mean of the posterior distribution will be very close to the overall mean, and the variation of the posterior distribution will be high. In our example, there is information about parameter $\beta_{3,r}$ only from two (Tornio and Simo) out of 12 rivers. These two rivers have slightly different parameter estimates, and remaining ten rivers have posterior distributions which have mean roughly equal to the mean of the two estimates and much higher variance (Fig. 3).

The basis of the hierarchical modeling was to assume that river-specific parameters are conditionally independent given the parameters which describe the variation between rivers. This means also, that we should not be able to order the river specific parameters before seeing the data. If there is information which would make the ordering possible, then this information should be taken into account in the model structure, and then the hierarchical modeling would be more appropriate again. In this sense, the analysis in our example could be improved, because there actually is river-specific information about the mortality of smolts during their migration (Uusitalo et al. 2003) which is not used in the presented analysis.

The model devides the variation in the data to two components: the natural variation of the abundance, and the random variation of the measurements (measurement error). If the measurement error is underestimated, the natural variation is overestimated and predictive distributions of future abundance have too large variance, and vice versa. However, under- or overestimation can not be detected by any means other than comparing model predictions to true smolt abundances. When true abundances are not available, which usually is the case, the predictive ability of the model can not be validated by any data. The ability to predict observable data can still be verified. This was done in small scale, and results indicated reasonably good fit to the observations. The credibility of the model can be also assessed by evaluating the quality of the models which connect the unobservable abundances and relative densities to observable quantities such as electrofishing data. These may be highly complex models which take into account, for example, the spatial correlation of the parr density and unequal capture probability of individuals and schooling behaviour and run timing dynamics of smolts. Such models can be used separately, and their results can be used in the model presented here by approximating the shape of the obtained posterior distributions by using a log-normal or some other flexible distribution.

In our example the smolt trapping information was based on a mixture of previous point estimates, expert opinion and on rigorous mark-recapture modeling (last years in R. Tornionjoki time series). Further work should include reanalysis of the mark-recapture data sets of both rivers by the method used for R. Tornionjoki data during the last years.

The measurement model used in this work for the electrofishing data is based on the assumption that there is no spatial correlation in the parr density between the sampling sites, and that the density varies around the mean density with unknown CV. It is also assumed that there is no uncertainty about the total number of parr at sampling sites. At the current stage, the sensitivity of inference to these quite strong assumptions has not been evaluated. One possibility to improve the estimation in this respect would also be to reanalyze the historical data by using the method proposed by Wyatt (2002) and Wyatt (2003), and transfer the posterior distributions from these analysis by using the log-normal approximation.

Obvious future developments of the population dynamics model are the inclusion of the density dependence in survival. Alternative distributional and function reformulations can be studied and incorporated by using Bayesian model averaging techniques. Atttempts to improve the model to such a direction that the parameters would have more clear biological meaning should also be made. This would help in using biological expertise in formulating the prior distributions. The behaviour of the model can also be studied by using simulated data generated by a detailed life-history model.

The possibility to compare the smolt production estimates and carrying capacity estimates by calculating the probability (P_{50}) that the smolt production exceeds 50% of the carrying capacity provides a practical way to measure whether such an management goal will be or has been reached. When this probability is around 0.5, it is highly uncertain whether the goal has been reached or not. Probabilities near 0 and 1 indicate higher degree of certainty. There are four interrelated factors which determine the probability: 1) true smolt abundance 2) true carrying capacity 3) uncertainty about the true smolt abundance 4) uncertainty about the true carrying capacity. The probability P_{50} can thus be affected by increasing the smolt production and/or reducing uncertainty about smolt production and/or carrying capacity.

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A Parameterisation of the log-normal distribution

By expression $x \mid \mu, \sigma^2 \sim LN(\mu, \sigma^2)$ we mean that conditional on mean μ and variance σ^2, x follows a log-normal distribution. This corresponds to a probability density function

$$\begin{aligned} p(x \mid M, S) &= \frac{1}{\sqrt{2\pi S^2}x} e^{(-\log(x)-M)^2/(2S^2)}, \\ M &= \log(\mu) - \log(\sigma^2/\mu^2+1)/2, \\ S^2 &= \log(\sigma^2/\mu^2+1), \end{aligned}$$

where M is the mean and S^2 is the variance of $\log(x)$.

B Parameterisation of the negative binomial distribution

By expression $x \mid \mu, k \sim NB(\mu, k)$ we mean that conditional on mean μ and dispersion parameter k, x follows a negative binomial distribution. This corresponds to a point probability function

$$p(x \mid \mu, k) = \binom{x + \frac{\mu}{k} - 1}{\frac{\mu}{k} - 1} \left(\frac{1}{1+k}\right)^{\frac{\mu}{k}} \left(\frac{k}{1+k}\right)^{x}, \tag{12}$$

where μ is the mean and $\mu + k\mu$ is the variance of x.