4 Present management measures and other factors influencing salmon fishery

4.1 Description of the Present Management Measures

4.1.1 International regulatory measures

International management measures adopted by IBSFC have regulated the salmon fishery in the convention area of IBSFC until the end of 2005. However, since the IBSFC was superseded by bilateral cooperation between European Community and the Russian Federation new technical measures are developed for the Baltic salmon fishing by EU. These do not always follow strictly the recommendations made by the IBSFC but their purpose is rather to contribute to a comprehensive and consistent system of technical measures for Community waters, based on existing rules. Council Regulation (EC) No 2187/2005 laid down certain measures for the conservation of fishery resources in the waters of the Baltic Sea, the Belts and the Sound. Regulatory measures to be used in the Russian federation waters are not available.

Minimum landing size

Minimum landing size of salmon is 60 cm in Sub-divisions 22–30 and 32, and 50 cm in Sub-division 31. Additionally, there is a rule for minimum landing size for sea trout; in Subdivisions 22–25 and 29–32 (40 cm), and in Sub-divisions 26–28 (50 cm).

Summer closure

In the EC Community waters there are no longer gear based summer closures. They have been replaced by restrictions on fishing for salmon and sea trout (Article 17 of the Council Regulation (EC) No 2187/2005) and they are as follows;

1) The retention on board of salmon (*Salmo salar*) or sea trout (*Salmo trutta*) shall be prohibited;
   - a) From 1 June to 15 September in waters of Sub-divisions 22 to 31;
   - b) From 15 June to 30 September in waters of Sub-division 32.

2) The area of prohibition during the closed season shall be beyond four nautical miles measured from the baselines;

3) By way of derogation from paragraph 1, the retention on board of salmon (*Salmo salar*) or sea trout (*Salmo trutta*) caught with trapnets shall be permitted.

TAC

IBSFC implemented a TAC system for Baltic salmon fishery management for the first time in 1991. There are two separate management areas; one consists of the Baltic Main Basin and Gulf of Bothnia (Sub-divisions 22–31) and the second of Gulf of Finland (Sub-division 32). The TACs implemented for 2008 are given in Section 2.1. EC has divided salmon fishing possibilities in the Main Basin and the Gulf of Bothnia in 2009 and in the Gulf of Finland in 2009 between EC countries as follows (Council regulation (EC) N:o 1941/2006). In the Main Basin and Gulf of Bothnia (Subdivisions 22–31) the quota to be harvested by EC countries in 2009 is 15% smaller compared to year 2008. In the Gulf of Finland the EC quota is the same as in 2008. TACs have not been agreed between EC and Russian federation.

COUNTRY	ALLOCATION KEY %	QUOTA 2009
Management area: Main Basin and Gulf of Bothnia (Sub-divisions 22–31):		
Estonia	2.0660	6399
Denmark	20.3287	62 965
Finland	25.3485	78 513
Germany	2.2617	7005
Latvia	12.9300	40 048
Lithuania	1.5200	4708
Poland	6.1670	19 101
Sweden	27.4783	85 109
Russian Federation	1.9000	*)
Total	100	309 733
Management area: Gulf of Finland (Sub-division 32):		
Estonia	9.3000	1581
Finland	81.4000	13 836
Russian Federation	9.3000	*)
Total	100	15 419

***) No agreed TAC**

Driftnet ban

According to Council regulation (EC) No. 812/2004 of 26.4.2004 the use of driftnets in the fishery was banned from 1 January 2008.

4.1.2 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 throughout the 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.

Salmon with weights of less than 2.0 kg (gutted weight) can be marketed for human consumption without restrictions. Salmon with weights between 2.0 and 5.5 kg (gutted weight) can be marketed for human consumption only after trimming (deep skinning) removing the skin, the layer of fat next to the skin and certain parts of the muscle tissue (BEK Nr. 861 af. 15/09/2205 and BEK nr 1117 af 10/11/2006). From the 9th February 2009 the regulation has been changed, and from that date it has been allowed to land and sell (to countries outside the EU) all size groups of salmon.

The Danish quota was in 2008 755 511 salmon. The quota was divided into 5 time periods (from " "Bekendtgørelse om regulering af fiskeriet i 2006 og visse vilkår for fiskeriet i følgende år" (paragraf 82)):

1) 25% January–March;

2) 15% April–June;

3) 5% July–15th September;

4) 40% 16th September–15th November;

5) 15% 16th November–31st December.

However, due to the limited marketing possibilities, the distribution was not followed in 2008, and the quota was only utilised by less than 6 % in total.

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 Purtse, 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, Purtse, 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 Purtse, Selja, Valgejõgi, Jägala, Pirita and Vääna). Below of dams and waterfalls all kind fishing is prohibited at a distance of 100 m. In the River Pärnu below Sindi dam this distance is 500 m.

In **Finland** the new national regulation took place in 2008. In the Gulf of Bothnia salmon fishing was forbidden from the beginning of April to the end of following dates in four zones: Bothnian Sea 16th June, Quark 21st June, Southern Bothnian Bay 26th June and Northern Botnian Bay 1st July. Professional fisherman, however, may start fishing salmon one week before these dates by not more than 2 sealprotected trapnets/fisher). In addition during 3 weeks from the opening of fishery (dates above) not more than 5 trapnets per fisherman were allowed. After this for another 3 weeks 8 trapnets at maximum were allowed per fisherman. Non-professional fishers may start fishing salmon two weeks after the opening of the fishery by one trapnet at maximum (and only in the private water areas). In the terminal fishing area of Kemi the salmon fishing may start on 11th June. In the area outside the estuary of River Simojoki salmon fishing may start on 16th July and outside the estuary of river Tornionjoki on 6th July.

Latvia has the following national salmon fisheries regulations. In the Gulf of Riga salmon driftnet and longline fishing are not permitted. In the coastal waters salmon fishing is prohibited from 1 October to 15 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 and angling and fishing in the River Daugava.. Daily bag limit is one sea trout or salmon. All fisheries by gillnets are prohibited all year round in a 3 km zone around the River Salaca outlet from 2003. Fisheries restriction zones were enlarged around the rivers Gauja and Venta from 1 to 2 km in 2004.

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.

In rivers Daugava and Bullupe (connects rivers Lielupe and Daugava) angling and commercial fishing of salmon was allowed from 2007. However this fisheries management measure does not improve the situation in salmon fisheries because the "dioxin rule" remains valid.

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, by mesh size and by minimum landing 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. During salmon and sea trout migration, commercial fishery is under regulation in Klaipėda strait and Curonian lagoon. Fishery is prohibited the whole year round in the Klaipėda strait; from northern breakwater to the northern border of the 15th fishing bay. From September 1 till October 31, during salmon and sea trout migration, fishing with nets is prohibited in the eastern stretch of Curonian lagoon between Klaipeda and Skirvyte, in 2 km distance from the eastern shore. From September 15 till October 31 fishing is prohibited in 1 km radius from Šventoji and Rėkstyne river mouths and from southern and northern breakwaters of Klaipėda strait. License fishing is allowed from 1 January 2007 till 1 October in designated stretches of the listed rivers. The minimum size of salmon and sea trout for commercial fishery is L 60 cm.

In **Poland** the international fishery rules are extended to the coastline. Salmon fishery in the mouths of Pomeranian rivers, in the River Drweca and in the Vistula River and tributaries from the dam in Wloclawek to the mouth is forbidden from 1 October to 31 December. From dam in Wloclawek to the mouth fishing is prohibited in July–August. In the Vistula River forbidden commercial catch on Fridays, Saturdays and Sundays. In 2003 a vessel monitoring system was introduced. No changes in the fishery rules in 2006–2007.

The TAC for Poland for 2008 was set as 22 907 fish. For year 2008 a system of granting the individual salmon quota for Polish fishermen was set in accordance with Regulation of Ministry of Agriculture and Rural Development of 11.01.2008 on following principles:

- Out of the whole TAC 10% (2291 fish) was given to vessels smaller than 10 metres without dividing into individual quota.
- The remaining 90% (20 616 fish) was divided equally among vessels of length at least of 10 metres (290 salmon per vessel).

Since 2005 commercial fisheries for salmon/sea trout in rivers is based on new implemented rules. Fisheries opportunities were sold in 2005 by the state on a tender basis, where the bidder had to submit a fishing ten-year operational plan including restocking. There is difficult to get real figures on catch and effort from companies which lease water areas, because they are not obliged to report their catch nor effort.

In **Russia** the international fishery rules are extended to the coastline. In all rivers and within one nautical mile of their mouths fishing and angling for salmon is prohibited during all year, except fishing for breeding purposes for hatcheries. No changes in fishery regulations in 2001–2008.

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 could start in coastal area outside of protected areas on 11 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 Luleälven, Skellefteälven and Gideälven). In these areas salmon fishery was allowed from the start of the fishing 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 was generally forbidden. Fishery with trapnets for other was allowed in these areas from 26 June. 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 10 June, however outside the rivers Örealven, Vindelälven, Sävarån, Rickleån, Kågeälven, Piteälven and Råneälven not until 18 June. In the areas outside the rivers Ume älv, Ljungan and Kalix älv fish lacking adipose fin could be caught, even when catch of fish with adipose fin was banned.

Angling for salmon was allowed in all wild salmon rivers in the Gulf of Bothnia until the 31 August. In the rivers Öreälven, Vindelälven, Sävarån, Rickleån, Kågeälven, Piteälven and Råneälven 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 1 March to 30 September.

Since 1997 fishing regulations in the border part of river Torneälven are decided upon by the Swedish Ministry of Agriculture and the Finnish Ministry of Agriculture and Forestry. In 2005–2007 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 driftnets during two days. The regulations also provided possibilities for exemptions for licensed fishermen to use trapnets in parts of the protected area outside the river mouth.

To comply with the EU regulation 88/98 that implies that the effort in the driftnet fishery should be gradually reduced until driftnets are completely prohibited in the Baltic in 2008, the Swedish Board of fishery has reduced the number of permissions to use driftnets from 55 in 2005 to 35 in 2006. In order to be allowed to fish with in 2007 the fishers must have been active fishing in 2006.

In order to improve the situation for the poor sea trout stocks in Sub-division 31 a number of changes were implemented from July 1 2006. The minimum size for sea trout was raised from 40 to 50 cm in the sea. Furthermore a ban of fishing with nets in areas with a depth of less than 3 meters during the period 1 April–10 June and 1 October–31 December in order to decrease the bycatch of trout in other fishery. In the period 1–31 October fishery with nets with a mesh size of less than 37 mm (knot to knot) is allowed.

4.2 Evaluation of the Management Measures

4.2.1 International regulatory measures

Minimum landing size

An evaluation of the effects of the minimum landing size and minimum hook size was provided in ICES 2000. However, the changes in the regulatory measures in the EC waters (Council Regulation (EC) 2187/2005) might have changed the situation compared to the years before enforcement of this regulation. The minimum landing size in the Baltic salmon fishery is 60 cm, but the minimum landing size in Subdivision 31 has been decreased from 60 cm to 50 cm. An evaluation of this change is provided in ICES 2007. The minimum landing size is restrictive in the offshore fishery, but the size limit is of little importance in river and coastal fishery as long as smolts are protected from capture in rivers, Minimum landing size in the Baltic salmon fishery was introduced already in 1950s, when it was 55 cm. Later IBSFC changed it to 60 cm. The main reason to introduce the measure was to decrease harvest of salmon during their first summer and autumn in feeding areas (as age A.1+). It was supplemented by a rule on minimum mesh size for driftnets which gave small catches of undersized salmon. In this manner fish were instead caught some months later at a larger size or survived to migrate for spawning as A.2. fish. After their first winter at sea, a share of salmon, mainly males (grilse) migrate for spawning at a size of 50–60 cm. The majority of salmon migrating for spawning have spent two winters in sea and during spawning run they are 60–90 cm long. There is no longer a minimum hook size for long lining in EC waters.

Summer closure

The increased fishing period with long lining, especially in Sub-divisions 22–29 has had small effects on the fishery. Long lining with a high cpue is possible only during the winter months, from November/December to February or possibly March. The rule concerning a maximum number of hooks per vessel (previously 2000) has also been dropped from the EC Council regulation. This measure might contribute to an increased fishing effort by long lining. As long line fishery is very labour intense, it is not possible to increase the number of hooks so much. In addition some of the boats involved in longline fishery are small and they do not have capacity to use more than 2000 hooks.

TAC

Catch quotas have not been regulating the recent development of fishing pressure, because quotas have not been fulfilled (ICES 2008d). However, in early and mid-1990s the set quotas apparently decreased offshore fishing. This decrease together with the strict national regulations set for the Gulf of Bothnian coastal fisheries (see Section 4.2.2) was the impetus to the recovery of the northern Baltic salmon stocks (Romakkaniemi *et al.*, 2003). The decrease in harvest rates in different fisheries at that time indicates the strong effects of these management measures (Section 5).

Driftnet ban

Due to the driftnet ban, harvesting of feeding salmon has been reduced to 42 000 salmon in 2008, compared to 110 000 salmon in 2007. The driftnet ban decreased the annual harvest rate of feeding salmon to about one third (Section 5); at present effort level long lines harvest about 10% of the feeding salmon annually, while driftnets harvested annually close to 20% of the feeding salmon in the past few years (Figure 5.3.9.10.a). Formerly offshore salmon fishery was profitable particularly when it was possible to combine salmon drift net fishing with cod fishery. Due to fact that cod quotas have been very small and the period of profitable salmon long line fishing is very short, this combined salmon and cod harvesting has become less profitable or even uneconomic. This has led to wrecking of offshore vessels in several Baltic countries.

In the northern feeding areas Bothnian Sea (SD 30) and Gulf of Finland (SD32), offshore fishing with long lines would be theoretically possible with small boats and a small crew (1–2) but due to the continuous increase of the number of grey seals and their predation on hooked salmon, this kind of fishing is no longer profitable. Such fishing with small boats is still possible in the southern Baltic Proper, but the scale is much lower now than that compared to the time period before 2008.

4.2.2 National regulatory measures

ICES 2007 concluded that the delayed opening of the coastal fishery is an effective tool for saving a proportion of the spawning run from the coastal harvest. However, the run timing varies between years, which means that with multi-annually fixed opening dates, the saved proportion of spawning run is highly variable. This regulatory measure results in higher harvesting of late-migrating than early-migrating salmon ICES 2007. As older fish and females dominate in the early part of the spawning run, late opening of the fishery saves the most valuable part of the run.

4.3 Other factors influencing the salmon fishery

The incitement to fish salmon as an alternative to other species is likely to be influenced by a number of factors, such as the possibilities for selling the fish, problems with damage to the catches from seal, the market price for salmon compared to other species and possibilities to fish on other species.

In the following section a number of factors which may affect the salmon fishery are considered.

4.3.1 Dioxin

The level of dioxin in salmon of the Baltic has been monitored by authorities in Sweden since 2000 and in Finland since 2001. The maximum level of dioxin and dioxin like PCB set for the flesh from salmon will be 8 pg WHO-PCDD/F-PCBTEQ (COMMISSION REGULATION (EC) No 1881/2006). Overall levels of dioxin and related substances tend to increase with size (sea age) of the salmon, but varies also in different parts of the fish flesh with fat contents (Persson *et al.*, 2007). In general the levels found are above the maximum EU level.

In Denmark salmon above 5.5 kg (gutted weight) are not permitted to be marketed within the EU. From 9 February 2009 this size salmon may be sold to countries outside the EU. Salmon with a weight below 2 kg (gutted weight) can be marketed without restrictions, while salmon with weight between 2 and 5.5 kg can be marketed only after deep skinning and trimming. By this process the more fatty parts of the salmon are removed.

In Latvia dioxin analyses of salmon demonstrated results similar to the Danish results. Dioxin level in fish exceeds the maximum allowed level in the all salmon with a sea age of 2–3 years.

After an initial ban on marketing salmon it has after 30 November 2005 again been possible market salmon in Latvia. Salmon with ungutted (whole) weight below 4.4 kg (length limit 72 cm) can be marketed on the home market without restrictions and salmon with weight below 6 kg (ungutted) can be marketed if the ventral part of the fillet is cut off.

Sweden and Finland both have derogation from the EU until 2011 allowing national use of the salmon if dietary advice is given to the public. Export to other countries is not permitted.

While there is no information available from Germany, Polish samples of salmon were examined in 2005 and 2006. The results from these have not resulted in marketing restrictions.

For the Baltic area as such it seems to be only in Denmark and Latvia that the possibilities for marketing has been affected from dioxin levels and rules, probably influencing incitement to fish salmon also in future.

4.3.2 Size (weight) distributions of catches

The weight limits for marketable salmon strongly affects the fishing practice and possibilities in the future. It is likely that, if possible, specific marketable sizes will be targeted by the fishery.

Size limits may also affect the reported size distribution of catches. Weight distribution of sampled Polish (years 2005–2008) and Danish (years 2003–2008) are presented in Figures 4.3.2.1—4.3.2.2.

For the Danish samples the fraction of marketable salmon (weight classes below 7 kg) increased in 2006 and 2007 compared to previous years. On average 89% of the sampled salmon were below 7 kg for the years 2003–2006, while it was 99.5% in 2007 and 98% in 2008, while it on average was 85% in the Polish samples.

4.3.3 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 at several levels:

1) Direct catch loss due to damaged or escaped fish.
2) Capital losses due to damage of gear.
3) Indirect effects by seals disturbing the fishing operations.
4) Changes of fishing grounds or methods as a response to seal interaction.
5) Reduced value of catches due to scars and parasite infections.
6) Effects on fishery through competition for the salmon resource and/or altered fish behaviour.

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**, and **Russia** influence by seals on salmon fishery is still insignificant. No data are available from **Germany** or **Lithuania**, but for the first time seal damages are reported from **Poland**.

In **Estonia** the seal damage in the salmon and sea trout gillnet fishery is increasing from year to (pers. comm. of fishermen). Quantitative assessment of damage is not available as fishermen in most cases did not present claims for gear compensation.

In **Latvia**, direct catch losses of salmon by seal damages increased significantly from 2003. In the most affected area, the 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 and 60% in 2004 (525 salmon, 4.2 tonnes). Due to increasing of catch looses salmon fisheries in the autumn of 2005–2008 carried out in the lower part of the river Daugava, where seal do not enter.

In **Finland** fishermen report the share of discarded fish in numbers of salmon damaged. According to recorded data about 5626 salmon (28 t) salmon were discarded due to seal damages. Seals caused severe damages to all fisheries mainly in Subdivisions 29–32 where seal damages comprised 10% of the total commercial catch in the region. Other discards were about 785 salmon (4 t). The number of seal damaged salmon has been diminishing for 5 years. In 2007 it was 6325, 8111 salmon in 2006, 10 800 in 2005 and 12 171 salmon in 2004. Most of the damaged fish has to be discarded.

In **Sweden** the total percentage of the salmon catch in trap nets that is discarded due to damage by seals is estimated to be about 15% and this leads to an estimated discard in 2008 of 35 tonnes (25 tonnes in 2007, 35 tonnes in 2006 or 6192 salmon, 2005 49 tonnes and 9860 salmon).

The total recorded and estimated loss of salmon due to seal damages is 63 tonnes.

4.3.4 Fisheries economics

Figure 4.3.4.1 presents the monthly salmon price per kilogram paid for fishermen in Bornholm 1998–2008. During the period 1998–2004 prices were relatively stable. During the winter 2003–2004 catches of salmon were very high in the sea close to Bornholm. Later in 2004 dioxin levels in Danish samples were found to be above levels set by EU authorities, resulting in a closure of the fishery for part of the year 2004. This meant that the market situation for the salmon fishermen was very uncertain and the changes in the prices in 2004 are most likely a result of these facts.

In Denmark the price of salmon has increased gradually from 2005 through 2008, when it on average was around 5.6 €/kg. This could be due to the increase in salmon world market prices and decrease in landings. The salmon import from Norway to Denmark has levelled out since 2006, but still constitutes by far the largest share of salmon on the market (Figure 4.3.4.2), and this is also the case in Poland. Price of Norwegian salmon into Poland is presently 2.86 €/kg.

The salmon price in Finland varied between 3.3 and 7.5 €/kg in 2008, (average in 2007: 4.75 €/kg, 2006: 4.80 €/kg). In Sweden, the annual average salmon price in 2008 was 3.2 €/kg (2006: 3.29 €/kg, 2007 4.25 €/kg). In Poland the current price is around 5 €/kg. Swedish and Polish prices are subject to changes due to variable exchange rates.

4.4 Development in post-smolt survival and factors affecting it

4.4.1 Objective

The ToR for 2009 state that the Group should “evaluate (in coordination with WGNAS) the possible reasons for the low at-sea survival of salmon stocks”. Analyses of post-smolt survival rates were initiated during the WG meeting in 2008 and a chapter on this issue was included in the last year report. This year, the group has updated the data series, both regarding survival estimates and potentially important explanatory variables, and continued with analyses.

Collaboration has been initiated with WGNAS within the newly established Study Group on Biological Characteristics as Predictors of Salmon Abundance (SGBICEPS), which met in Lowestoft, England, from 3 to 5 March, 2009. The Study Group compiled time series of data on marine mortality of salmon, salmon abundance and biological characteristics of salmon using a data entry spreadsheet to ensure collection of information in a standardised format. The study group also reviewed the types of environmental information that could be made available to the group in taking forward exploratory analyses, in particular relating to the marine environment. Work to be done in the future includes incorporating additional data sets, also on environmental variables, and formulating and testing hypotheses. The Study Group will thus constitute a forum for exchange of data, ideas and methods between the WGs on the issue of salmon abundance and survival.

As the available background data for analyses differs between the Baltic Sea and the North Atlantic, both regarding data on salmon survival and abundance, and data on possible explanatory variables, only the work carried out by WGBAST during its meeting is presented in this report. Results from the SGBICEPS meeting will appear in a separate report later this spring.

4.4.2 Background

The post-smolt survival of salmon in the Baltic Sea is believed to have decreased in recent years, both for wild and hatchery produced smolt (ICES 2008). According to post-smolt survival estimates generated from the WGBAST assessment model, this decline started in the mid 1990s and has continued since then. The post-smolt survival is a key factor, together with M74, affecting the dynamics of salmon stocks in the Baltic Sea, and different assumptions about survival at-sea strongly affect stock projection analyses predicting the development of stocks in the future. Based on preliminary analyses carried out during the WG meeting in 2008, the group agreed on the following more specific hypotheses about factors affecting salmon at-sea survival, to be tested in more refined multivariate analyses.

Food availability hypothesis

Young herring are considered as important prey for young salmon, and previous studies indicate that herring abundance may be a key factor influencing salmon stock fluctuations in the sea (e.g. Kallio-Nyberg *et al.*, 2006). Therefore, increased recruitment of herring in the smolt year should lead to higher survival if herring abundance is a limiting factor. If herring recruitment directly affects survival, then by definition, at-sea survival is more or less density dependent and should be affected by smolt production in rivers and hatcheries.

Seal predation hypothesis

If salmon smolts are under seal-predation, then the increase in number of seals along the migration path of post-smolts should coincide with lower survival. Recent studies of seal food preferences indicate that herring is the most important prey species, but that both salmon and trout occur in the diet of seals, particularly in the Gulf of Bothnia (Lundström *et al.*, 2007).

Smolt quality hypothesis

This hypothesis is relevant only for reared smolts, and states that variation in mortality in the wild could be traced back to conditions experienced in the hatchery environment. Results from field studies indicate that migration abilities of reared smolts in rivers and estuaries may be disturbed, which could make them more vulnerable to predation (Rivinoja *et al.*, 2007). Also, injuries (such as fin damages common to many reared smolts) may also affect survival negatively in the wild. Hatchery practices have continually been improved. One factor that has been changed considerably is the composition of the feed. Higher fat and energy contents, in combination with favourable river temperatures especially in autumn, have resulted in improved growth rates in hatcheries and continually larger smolts. There is a general concern that the large size of reared smolts may have negative fitness consequences in the wild environment.

4.4.3 Methods

Response variables: estimates of post-smolt survival rates

Three data sets describing salmon at-sea survival were evaluated: 1) post-smolt survival estimates (Mps) for wild salmon from the assessment model, 2) return rate to river of reared salmon from River Umeälven, and 3) tag-recapture rates of reared salmon from River Dalälven.

Mps estimates. The Mps estimates come in the form of a posterior probability distribution, which also includes the correlation between the estimates of annual mortality. The covariance of the estimates was taken into account by using the annual median as an observation.

Return rate to River Umeälven. As suggested in the Technical Minutes of last year report, this data was included as an independent data set describing at-sea survival of reared Baltic salmon. The return rate to River Umeälven was calculated in the following way. Age determined ascending reared salmon caught in the trap at Stornorrfors during the years 1998–2008 (n=452) were used to generate weight distributions for 1SW, 2SW and 3SW salmon which in turn were used to estimate the sea age of all ascending reared salmon caught in the trap between 1974 and 2008. Based on year specific information on sea-age of ascending spawners and number of released reared smolts it was possible to calculate the return rate for each smolt cohort. The trap at Stornorrfors is situated a distance upstream from the river mouth. To get an estimate of the return rate to the river mouth, which is a better index of sea survival, the return rate to the trap was corrected for variation in migration success from the river mouth to the trap. The migration success in the river has been evaluated annually between 1996 and 2005, except for 1998 and 2000, using mark-recapture experiments. According to these studies, the river migration success varies between 0.15 and 0.48. The average migration success over these years (0.29) was used for years when no information on success was available. The return rate to river was calculated based on migration success and number of counted fish at Stornorrfors.

Tag-recapture rates from River Dalälven. In some of the tagging experiments performed in River Dalälven in Sweden, all tagged fish have been examined for fin injuries. The tagging protocols have been merged with recapture protocols, to make it possible do check if smolts that have fin damages are recaptured at a rate different from healthy fish. For this data set, recaptures were divided into three different areas: recaptures in the Baltic Sea, in the river and at the hatchery which is situated 8 km from the river mouth. The data set contains more than 100 experimental release groups including 53 851 tagged fish, of which 3907 (7.3%) were recaptured.

Predictor variables

The data on potential explanatory variables characterising the Baltic Sea ecosystem and the smolt releasing hatcheries has been updated since last year meeting, and some more detailed time series have been added. The data has been collected from many different sources and it is not possible to list all variables here, except those that were judged important and were included in multivariate analyses (see below). WGBAST acknowledges the Working Group on Integrated Assessment of the Baltic Sea (WGIAB), the Baltic Fisheries Assessment Working Group (WGBFAS) and the Swedish natural history museum that kindly have agreed to let WGBAST get access to their dataseries.

Statistical procedures

From initial analyses of individual predictor variables using a loglinear regression model (carried out during this and last year WG meeting, ICES 2008), a number of variables were selected for further statistical evaluations. Predictor variables that were considered important to evaluate further include seal abundance, herring recruitment and abundance, sprat abundance, smolt production estimates (both wild and reared smolt production) and trawl effort (Table 4.4.3.1). Only factors that were assumed to have a potential direct effect on salmon survival were selected. Temperature was not included as previous studies have shown that sea surface temperature may only have an indirect effect on salmon survival through its positive effect on herring recruitment (e.g. Kallio-Nyberg *et al.*, 2006). The selected predictor variables were used to test the hypotheses that were formulated during the last year WG meeting (see above). The Mps and Ume return rate survival indices were used to test the seal predation and food abundance hypotheses following two slightly different models, whereas tag-recapture data from River Dalälven was used to test predictions from the smolt quality hypothesis.

Mps estimates. Mps estimates were extracted from the assessment model by calculating the median of the posterior distribution of the instantaneous mortality rate, and by calculating the correlation matrix of the joint posterior. Then the median values were used as observations and the correlation matrix was used as a model for correlated measurements. This is inline with the pseudo-observation approach for taking into account measurement within a sequential Bayesian analysis (Michielsens *et al.*, 2008). The mortality was assumed to vary randomly between years with an annual expected value depending on explanatory variables according to following equation:

$$E(M_y) = q\mathrm{SEAL}_y + e^{\alpha-\beta_1\mathrm{HSD30}_{y+1}-\beta_2\mathrm{HSD31}_{y+1}-\gamma_1\mathrm{HCB}_y-\gamma_2\mathrm{SCB}_y}$$

Where q is the catchability coefficient of seals and $\alpha, \beta_1, \beta_2, \gamma_1$ and γ_2 are regression coefficients. All these parameters are assumed to be positive, which means that the increase in seal abundance is assumed to increase the mortality, while the variables reflecting availability of food are assumed to decrease the mortality. The explanatory variables are described in the following table.

VARIABLE	DESCRIPTION
SEAL	Total Baltic seal counts in Swedish surveys
$\mathrm{HSD30}$	SD30 1+ herring recruitment / (SD30+SD31 smolts)
$\mathrm{HSD31}$	SD31 1+ herring recruitment / (SD31 smolts)
HCB	Herring stock biomass in central Baltic
SCB	Sprat stock biomass in central Baltic

Note that the relative recrcuitment of 0+ herring was approximated in the model by shifting the estimates of 1+ recruitment backwards by one year.

The five explanatory variables can be combined in 31 different ways. The relative credibility of these alternative models was estimated by calculating posterior probability for each of the models. Such a Bayesian Model Averaging approach weights the models based on the goodness of fit and typically induces a penalty for complexity.

For models that included the number of seals as a predictor, it was possible to calculate an estimate of the number of smolts eaten by an average seal. These can be used to assess whether the results of the model are plausible compared to independent knowledge about the diet of seals.

Return rate to River Umeälven. The assumed model structure for the return rates was highly similar to the model assumed for the estimated post smolt mortality rates. The main difference is that the offshore and coastal fishing efforts were included as predictors in each combination of explanatory variables. Furthermore, instead of using herring data from SD31, both 0+ and 1+ recruitment of SD30 were included as explanatory variables since it has been suggested that larger reared post-smolts may feed on both one year old and young of the year herring (Salminen *et al*., 2001). The mortality rates were assumed to vary randomly around the annual mean which depends on the explanatory variables:

$$\begin{aligned} Z_y &= F_y + M_y \\ F_y &= q(p\mathrm{COAST}_y + (1-p)\mathrm{OFFSH}_y) \\ M_y &= d\mathrm{SEAL}_y + e^{\alpha - \beta_1 \mathrm{H1}_y - \beta_2 \mathrm{H0}_y - \gamma_1 \mathrm{CBH}_y - \gamma_2 \mathrm{CBS}_y} \end{aligned}$$

The mortality rate was then converted to expected return rate as

$$R_y = e^{-Z_y}.$$

In order to compare the results of the modelling of the return rate to the estimated post smolt survival, the expected natural marine survival of released River Ume smolts was calculated as

$$S_y = e^{-M_y},$$

which is expected to be lower than the post-smolt survival estimated by the assessment model, because also the natural mortality during the sea migration, after the post-smolt period, is included here. However, because post-smolt survival is generally assumed to dominate the fluctuation in natural marine survival, the estimates of marine survival can be expected to vary in a way similar to the post-smolt survival.

VARIABLE	DESCRIPTION
SEAL	Total Baltic seal counts in Swedish surveys
$\mathrm{H0}_y = \mathrm{H1}_{y+1}$	SD30 0+ herring recruitment/(SD30+SD31 smolts)
$\mathrm{H1}$	SD30 1+ herring recruitment/(SD30+SD31 smolts)
CBH	Herring stock biomass in central Baltic
CBS	Sprat stock biomass in central Baltic
COAST	Mean coastal effort during the next two years after the release year, all gear combined
OFFSH	Mean offshore effort during the next two years after the release year, all gear combined

Total of 31 combinations of the predictor variables were fitted to the return rate data from 1987-2005 within the BMA framework.

Tag-recapture rates from River Dalälven. Tag-recapture data is dependent on fishing effort and the willingness of fishermen to report tags, and is therefore more problematic to use for analyses of trends in survival over time if not these problems are carefully dealt with. This dataset was therefore used only to evaluate the smolt quality hypothesis described above, more specifically the effects of smolt length and hatchery injuries on subsequent survival following release. The fish were divided into four categories: healthy (no injuries), dorsal fin injured, other fins injured, and dorsal fin and other fins injured. Release year, release date (Julian date) and length of fish at tagging were included as continuous variables. The dataset was first analysed with PROC LOGISTIC (SAS statistical software) in order to investigate the overall effect of the independent variables. Thereafter, the data was analysed with PROC GENMOD (SAS statistical software), assuming binary response of recapture, in order to calculate least-square means for the different categories.

4.4.4 Results

The work on salmon mortality in the Baltic Sea is still in an initial stage, which means that results presented here should be viewed as preliminary. It is important to highlight the fact that a correlative approach has been applied, which means that observed associations between survival estimates and biological predictors are not necessary due to causal relationships.

The independent dataset from River Umeälven on return rate of reared salmon to the river mouth was in close agreement with the Mps model estimates (Figure 4.4.4.1a). The decrease in salmon fishing effort is not taken into account in the Ume dataset. Despite that, return rate seems to have decreased during the last 8–10 years, which support the model estimates indicating a negative trend in post-smolt survival during the last decade. The natural marine survival (S_y) estimated from the River Ume return rates are lower than the post-smolt survival estimated using the stock assessment model (Figure 4.4.4.1b). The independent survival estimates show similar annual variation and the decreasing trend, which gives strong support for the conclusion that post-smolt survival has been decreasing.

Tag-recapture rates for River Dalälven reared salmon are shown in Figure 4.4.4.2. The tag-recapture rate has decreased considerably in the Baltic Sea due to the effort decrease in the salmon fishery, but recapture rates have decreased also in the river and at the hatchery. Thus, changes in exploitation and reporting rates cannot alone explain the declining recapture rates, again indicating that salmon post-smolt survival has decreased during the study period.

The predation and food availability hypotheses

Initial analyses of predictor variables indicated that survival of wild post-smolts was negatively correlated with seal abundance (Figure 4.4.4.3) and total smolt production in the Gulf of Bothnia (Figure 4.4.4.4), and positively correlated with herring recruitment in both Bothnian Bay (Figure 4.4.4.5) and Bothnian Sea. No relationships were observed between survival and total trawl effort in Bothnian Bay or pelagic trawl effort in Bothnian Sea (Figure 4.4.4.6).

From the 31 models fitted to post-smolt survival estimates, three models stand out clearly in terms of the posterior probability (Figure 4.4.4.7). Each of these include the seal abundance and a combination of SD31 and SD30 0+ herring available per smolt. The model with seal abundance and both SD31 and SD30 as predictors has the highest degree of determination (Table 4.4.4.1). Fitting models with only seal abundance and only herring availability shows that the overall trend of post smolt survival becomes explained by the increased number of seals (Figure 4.4.4.8c), and the annual variation in survival coincides with the variation in availability of 0+ herring per smolt (Figure 4.4.4.8d).

Results from the analysis of the River Ume return rate gives similar picture, although the importance of seal abundance as a predictor is less pronounced (Figure 4.4.4.9). Using only the seal abundance again helps to capture the overall trends in the return rate and availability of herring in SD30 is an important predictor for the annual variation (Figure 4.4.4.10).

According to modelling of post-smolt survival with the assumption of seal predation, an average seal would have to consume approximately 50–100 smolts per year in order to generate the estimated increase in mortality. This uncertainty arises mainly from the uncertainty about the true size of the seal population.

The smolt quality hypothesis

There was an overall difference in recapture rate between the four categories of injuries (Table 4.4.4.2). Length at release and day and year of release also influenced recapture rate. The significant effect of year mirrors the decrease in salmon exploitation during the period, resulting in fewer tag recoveries.

There was a positive effect of smolt length on tag recapture rate. Regarding fin injuries, fish classified as having other fins injured had a recapture rate that was only 60% of the recapture rate of healthy individuals (Table 4.4.4.3). Fish with only dorsal fin injuries had, however, the same recapture rate as healthy fish, indicating that injuries on other fins than the dorsal fin have much more severe effects on survival following release in the wild.

4.4.5 Conclusions and future studies

According to our results, the herring recruitment in the Gulf of Bothnia is able to explain a large proportion of the annual variation in post-smolt survival, but is not able to explain the negative survival trend during the last decade. Including seal abundance in the models improved our ability to capture also this decline. It is important to note that because we used a correlative approach, we cannot conclude that the observed patterns are due to causal relationships.

The estimated number of salmon that an average seal has to consume per year in order to explain the estimated reduction in survival is not unrealistic. However, the available information on seal diet composition is limited, and future studies should focus on collecting such data in order to evaluate if the present seal population is actually able to regulate salmon survival downwards, which would indicate a possible causal relationship. Information about the seal diet would be particularly important from the summer time when migrating smolts are passing the densest seal populations. Regarding herring, previous studies have indicated that the recruitment of this prey species may be one of the most important factors regulating salmon abundance in the Baltic Sea, and our results support these earlier findings. The next step would be to consider a model which takes into account detailed information on salmon size, prey size distribution and predation pressure from seals during the post-smolt migration to the southern Main Basin.

Even though it is not clear whether the estimated effects of seal abundance and herring recruitment represent a true causality, the strong co-variation can potentially be utilised when predicting the post-smolt survival. Smolt production and seal abundance are both likely to change slowly, whereas the recruitment of herring is probably less predictable. However, herring recruitment has been found to be correlated with the water temperature, which in turn might be to some extent predictable. Since the number of seals and smolts are not expected to drop in the near future, the observed co-variation suggests that the post-smolt survival is expected to remain low during the next couple of years, but the annual variation is more difficult to predict.

The comparably low at-sea survival of reared salmon is likely due to many factors. Hatchery produced fish may differ from their wild conspecifics for two main reasons. First, artificial breeding and rearing of fish may result in genetic divergence of the hatchery fish away from their wild conspecifics because of altered selection regimes in the hatchery and random genetic processes during breeding (domestication effects). Second, fish are in general highly phenotypically plastic and most fitness related traits are assumed to be influenced to some extent by the rearing environment. Also, reared salmon will likely suffer from lack of experience once they are released, which may affect their ability to migrate, avoid predators and find food.

For reared salmon from River Dalälven, we observed a positive association between smolt length and tag-recapture rate. Previous studies indicate that larger smolts have higher survival probabilities in the sea (e.g. Kallio-Nyberg *et al.*, 2006) which may be due to larger smolts ability to utilise a wider spectrum of prey (e.g. Salminen *et al.*, 2001). The negative relationship predicted by the smolt quality hypothesis stems from the fact that smolts produced in the artificial hatchery environment are often much larger than wild smolts from the same area, and may therefore have passed the critical smolt-stage and lost the inclination for downstream migration. Studies using radio-tagged reared smolts have indicated disturbed migration behaviours, making them more vulnerable to predation (Rivinoja *et al.*, 2007). This suggests that the larger size of reared salmon may negatively affect survival primarily in the river environment during downstream migration. Altogether, these observations indicate that the relation between smolt size and performance is complex, and more detailed analyses that are able to evaluate effects in the river and sea environments independently are necessary to get a clear picture of how hatchery practices affect the smoltification process and survival in the wild.

As shown in this study, fin damages evidently affect the survival following release in the wild, and although fin damages is certainly not the only important factor (see above) it may partly explain the comparably low survival of many reared stocks. Clearly, the way hatcheries are managed will have impact on how reared salmon are able to cope with the wild environment.

4.5 Conclusions for the salmon fishery

The disappearance of the drift net fishery from 2008 had considerable effect on the fishery, especially on offshore fishery in Main Basin where: mainly due to ban on driftnet, total catch decreased over 200% comparing to 2007. Driftnet fishery was conducted by vessels having specialized in using driftnets in the autumn and spring and some of them long lines in the winter months. It is not expected that catches with long lines operating in fisheries only in the winter months, even with much higher effort, can fully compensate for the catches previously taken by driftnets. Consequently, coastal and river fisheries for salmon are benefiting from this reduction.

The effort in the offshore long line and coastal trapnet fisheries is expected to increase in the future (Table 4.5.1). This is due to the fact that longlines are the only possible gears in the offshore and changes in the coastal regulation are allowing for an increase in trapnet fishery. Nevertheless, increase of effort in coastal fisheries will be still influenced by several factors, e.g. increase in seal damages and changes in national regulatory measures.

In Denmark, after a ban on landing and selling salmon, a new regulation since February 2009 allows to land and sell salmon, however, to countries outside the EU only.

Due to this new regulation and the recent increase in price of salmon, the expected increase of effort in long line fisheries is estimated on 500% comparing to 2008. The effort will anyhow remain well below historical levels. The ban for marketing of Baltic salmon due to high dioxin levels is still in force in Latvia and it reduced salmon fisheries there to coastal and river catches only.

Dioxin contents in the salmon is not expected to influence fishing in Sweden, Finland, Poland, Lithuania, Estonia and Germany, because the countries either have a derogation from the EU rules until 2011, have asked for a derogation or have results from analysis of dioxin contents that permits marketing of the salmon.

Total TAC for Baltic was utilized in 38% only in 2008. Utilization of TAC in the Baltic Main Basin and the Gulf of Bothnia was at a historical low level of only 35%, however, utilizing of the TAC in the Gulf of Finland was 102%. If TAC will remain at similar level, it seems very likely that the utilizing of the TAC in Main Basin and Gulf of Bothnia in the future will be at a low level because of the above mentioned limiting factors and due to decreasing trend in post-smolt survival (see Section 5). At the same time, if regulatory measures will not change, the proportion of the catch by non-commercial fisheries will continue to increase, having in mind the fact that in 2008 these catches achieved 82% of the reported total commercial catch in numbers.

4.6 Considerations for developing management towards AU or fishery specific quotas

The working group has been asked to consider if setting TAC's by assessment units or groups thereof would better reflect the population structure and fisheries effects than the current system of TAC's, and to provide information that will allow ACOM to advise accordingly.

At present the Baltic Sea is divided into two management areas: Sub-divisions 24–31 and Sub-division 32. TAC has been set to cover sea fisheries separately in these two management units, by assuming that fisheries in the Sub-divisions 24–31 affect the stocks of AU 1–5, while fisheries in Sub-division 32 affect only AU 6 stocks. This assumption, however, does not fully hold but instead AU 1–5 salmon are also migrating in the Sub-division 32 and AU 6 salmon are migrating outside Sub-division 32 (Table 4.6.1). This is one fact that is impairing the feasibility of the current TAC system.

Another, profound weakness of the current system is that a single TAC is set to the mixed fisheries harvesting simultaneously several salmon stocks with very different status, recovery requirements and harvest possibilities. While TAC has been limiting the overall harvest pressure and consequently enabled the recovery of depleted stocks, it alone has not provided any means to adjust harvest pressure according to stock or AU specific needs (restricting further exploitation of the weakest stocks and allowing higher exploitation of recovered stocks). International regulation has been supplemented by the national regulations in order to adapt the fishing better to the management objectives. For instance, the early season closures in the coastal fishery in the Gulf of Bothnia have been an essential regulation to help recovery of AU 1–2 salmon stocks, which have the highest overall harvest pressure due to their long migration routes and which were the most depleted in the past (Romakkaniemi *et al.*, 2003). This implies that national regulations restricted fishery while the TAC did not. There is still room for improving the regional management by e.g. including to them locally adapted programs to even better take into account also weak salmon populations.

ICES 2008d recommended that all types of Baltic salmon fisheries (both sea and river) should be included under the TAC regulation, reflecting the need to control the whole exploitation of salmon in a consistent manner. However, ICES 2008b did not evaluate as such the feasibility of TAC regulation in comparison with other management tools. Neither was the question treated whether a single TAC or a system of several TAC's should be implemented.

Nominal landings have been lower than agreed TAC since 2001, and in 2008 nominal landings were 35% of the quota in Sub-divisions 24–31, but 98% of the quota in Sub-division 32 (Figure 2.1.2, Table 2.1.7). Agreed TAC has also been higher than recommended TAC in those years when a quantitative catch advice has been given by ICES. In 2008, as a consequence of driftnet ban the focus of the fishery moved to the coastal and river fisheries and only 22% of the catch was taken from offshore. Before 2008 more than 50% of the total salmon catch was taken from the offshore fishery (Table 4.6.2).

If offshore mixed stock fishery in the Main Basin will have the minor role also in the future, it would impose a possibility to move towards AU or fishery based management. The problem of AU specific management is that most of the current Baltic salmon fisheries harvest salmon coming from several AU's (Table 4.6.1). AU specific TAC's cannot be monitored and thus controlled without a laborious and very costly on-line genetic sampling of catches. Only in some extremes of the sea migration routes (e.g., Gulf of Riga, Bothnian Bay) fisheries are harvesting salmon from only one or two AU's, potentially allowing straightforward application of AU specific TAC's. Instead of AU specific TAC's, a system of fishery-based TAC's could in certain terms be a more feasible management tool than AU specific TAC's. In this alternative, fishing pressure could be adjusted according to the status and harvest possibilities of the set of stocks harvested by the fishery in concern, and the monitoring of catches would not need as much resources as the management by AU specific TAC's. However, also this alternative is bound to the reality that most Baltic salmon fisheries are mixed stock fisheries (Table 4.6.1), and thus the TAC would need to be set according to the weakest stock harvested by the fishery in concern. Both AU and fishery specific TAC's would likely lead to an allocation of catches which would strongly differ from the current allocation.

The estimation of the AU specific TAC allocation according to spawning or smolt production targets would be technically possible from the modeling point of view. Consequently the TAC would be possible to allocate by fishery. AU or fishery specific TAC allocation would, however, potentially lead to a very complex management system. Establishment of such system would evidently require long political handling by all actors (governmental and NGO stakeholders) aiming for rather detailed management guidelines. Negotiating on regional TAC's (e.g. initial allocation keys) would also potentially be a long process.

A more simple application would be a system where TAC is set for the Main Basin mixed stock fishery meanwhile other fisheries would be regulated by other measures like effort regulation and closed periods. This should anyhow include also AU or even river specific management systems to ensure reaching of agreed management objectives. The systems should also contain mechanisms to prevent bad local management and guarantee the appropriate monitoring and control in rivers (in season catch control to prevent exceeding of the river specific quotas).

Table 4.4.3.1. Predictor variables evaluated in individual and multivariate analyses of post-smolt survival of Baltic salmon.

Description	Sources
Herring spawning stock biomass (SD 25-32 excluding GoR and SD 30,31)	ICES WGIAB and WGBFAS
Sprat spawning stock biomass (SD 22-32)	ICES WGIAB and WGBFAS
Herring recruitment in thousands age 1 (SD 30)	ICES WGIAB and WGBFAS
Herring recruitment in thousands age 1 (SD 31)	ICES WGIAB and WGBFAS
Pelagic trawling effort (hours), offshore in SD 30	ICES WGIAB and WGBFAS
Total trawling effort (hours), offshore in SD 31	ICES WGIAB and WGBFAS
Seal counts along the entire Swedish Baltic coast in May-June (Falsterbo-Haparanda)	Swedish Museum of Natural History
Estimated total production of wild and reared smolt in SD 30-31	ICES WGBAST
Salmon coastal and offshore fishing effort	ICES WGBAST

Table 4.4.4.1. Coefficient of determination (R^2) of the ten most likely models fitted to River Ume return rates and to estimated post smolt survival.

Response: River Ume return rate		Response: Estimated P-S survival	
Model	**R^2**	**Model**	**R^2**
H1+H0	51%	Seal+HSD30	69%
H0	47%	Seal+HSD31+HSD30	79%
Seal+H1+H0	60%	Seal+HSD31	70%
H1	42%	Seal+HSD30+HCB	67%
Seal+H0	57%	HSD30+HCB	55%
Seal+H1	52%	HSD30	38%
H0+H1+CBH	45%	Seal+HSD31+HCB	70%
Seal	49%	Seal+HSD31+HSD30+HC	77%
Seal+H1+H0+CBH	56%	Seal	48%
Seal+H0+CBH	54%	HCB	36%
Variables		**Variables**	
H1	SD30 1+ Herring / Smolts	HSD30	SD30 0+ Herring / Smolts
H0	SD30 0+ Herring / Smolts	HSD31	SD31 0+ Herring / Smolts
Seal	Seal count	Seal	Seal count
CBH	Central Baltic Herring SSB	HCB	Central Baltic Herring SSB

Table 4.4.4.2. Results from logistic regression with response variable recaptured or not.

Effect	d.f.	Wald Chi-square	level of sign.
Fish injury category	3	42.25	<0.001
Release year	1	1765	<0.001
Release day	1	40.86	<0.001
Length at tagging	1	320.45	<0.001

Table 4.4.4.3. Least-square means for the wound categories. Means denoted with the same letter are not significantly different at the 0.05 level.

Fish injury category	Estimate (mean)
Healthy (no injuries)	0.060[b]
Dorsal fin injured	0.059[b]
Other fins injured	0.036[a]
Dorsal fin and other fins injured	0.039[a]

Table 4.5.1 Effort scenarios for the main Baltic salmon fishing effort country based on experts opinions.
Factors are relative to the corresponding fishing effort in 2008.
1) indicates the most likely value

Fishery	Year	DK	PL	EE	FI	LV	SE	LT	RU	DE
Offshore DN	2009	No fishing								
	2010-2016	No fishing								
Offshore LL	2009	5	1	No fishing	1,5	No fishing	1	No fishing		
	2010-2016	4.0-9.0 5.0 1)	1.5-3.0 2.4 1)	No fishing	0.7-2.5 1.5 1)	No fishing	0.7-2 1 1)	0-2 vessels; No fishing		
Coastal TN	2009	No fishing	No fishing	1	1,2	0,8	1	No fishing		
	2010-2016	No fishing	No fishing	0.8-1,1 0.9 1)	0.7-2.0 1.2 1)	0.4-1.0 0.6 1)	0.7-1.4 0.9 1)	No fishing		

Table 4.6.1. Harvesting of salmon from different assessment units by different Baltic Sea fisheries.

Fishing area	Assessment unit					
	AU1	AU2	AU3	AU4	AU5	AU6
River fisheries	X	X	X	X	X	X
SD31 (coastal)	X	X				
SD29–30 (mainly coastal)	X	X	X			
SD32 (coastal and offshore)						X
Main Basin east, coastal					X	
Main Basin west, coastal				X		
Main Basin, off-shore	X	X	X	X	X	X

Table 4.6.2. Distribution of the Baltic salmon catch to offshore, coastal and river fisheries in 2000–2008.

COUNTRY	(All)
SPECIES	SAL
sub_div2	(All)
F_TYPE	(All)

		FISHERY		
YEAR	Data	S	C	R
2000	Sum of NUMB	213137	90811	8334
	Sum of NUMB2	68 %	29 %	3 %
2001	Sum of NUMB	265556	140756	33430
	Sum of NUMB2	60 %	32 %	8 %
2002	Sum of NUMB	237540	136608	31668
	Sum of NUMB2	59 %	34 %	8 %
2003	Sum of NUMB	235617	123641	29591
	Sum of NUMB2	61 %	32 %	8 %
2004	Sum of NUMB	250962	168573	26923
	Sum of NUMB2	56 %	38 %	6 %
2005	Sum of NUMB	175537	131484	33824
	Sum of NUMB2	52 %	39 %	10 %
2006	Sum of NUMB	123994	82324	21144
	Sum of NUMB2	55 %	36 %	9 %
2007	Sum of NUMB	111607	80190	25370
	Sum of NUMB2	51 %	37 %	12 %
2008	Sum of NUMB	41937	104020	46859
	Sum of NUMB2	22 %	54 %	24 %

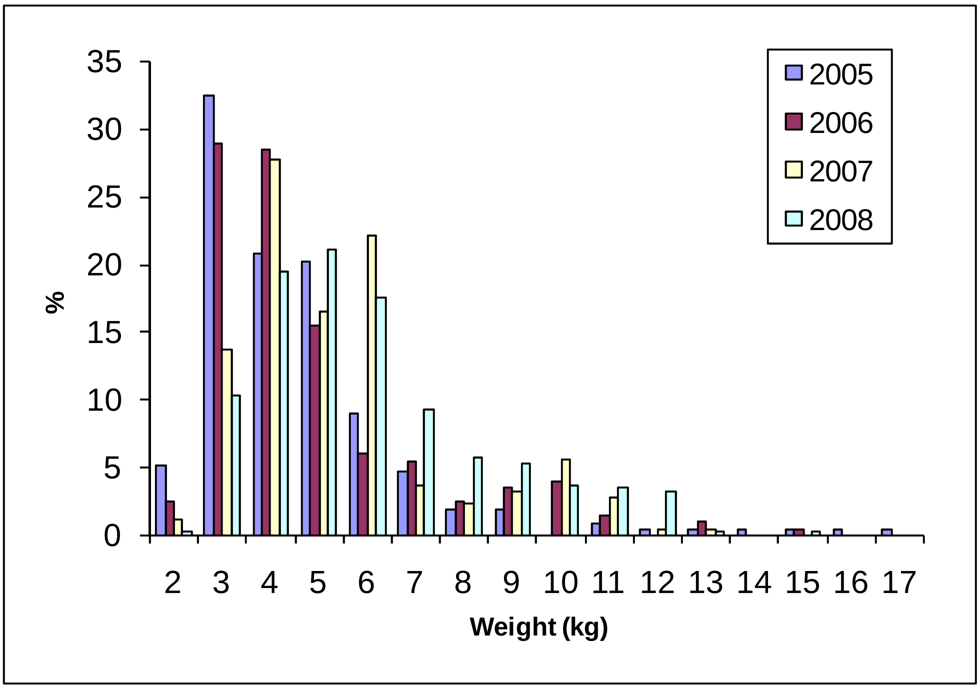


Figure 4.3.2.1. Weight distribution of sampled Polish catches of salmon 2005–2007.

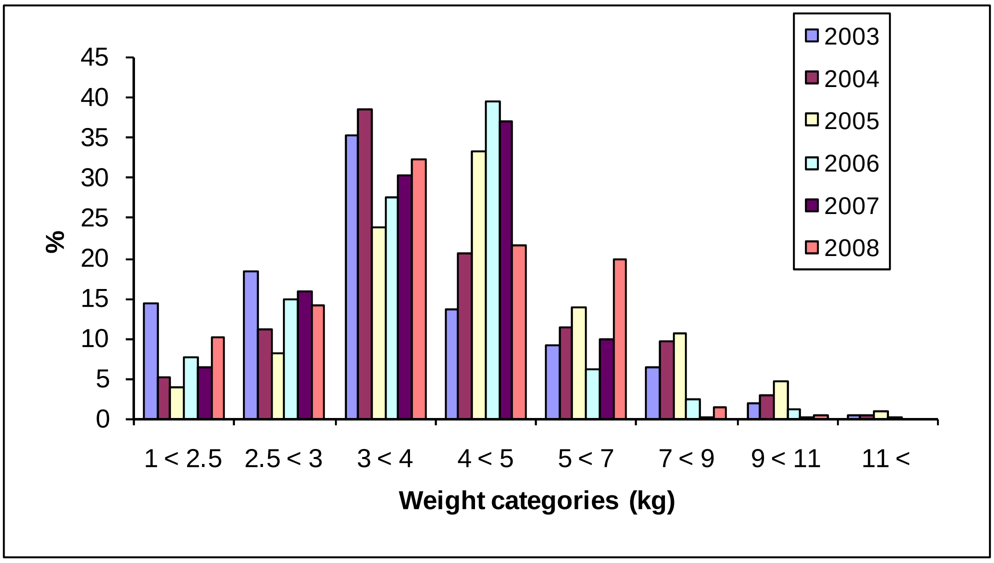


Figure 4.3.2.2. Weight distribution of sampled Danish salmon 2003–2008.

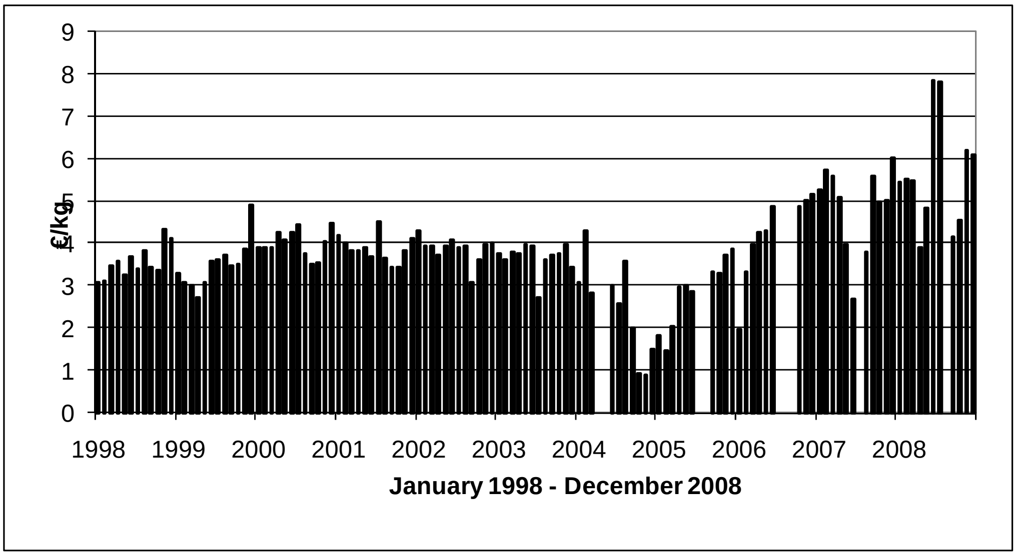


Figure 4.3.4.1. Monthly real salmon prices in Denmark. Empty spaces denotes months without landings in Denmark. Salmon prices (http://www.fd.dk) are converted to real values by using the Danish consumer price index (2000=100) (http://www.statistikbanken.dk). Value in Danish kroners have been changed using the rate 1 DKK=0.13457 EURO.

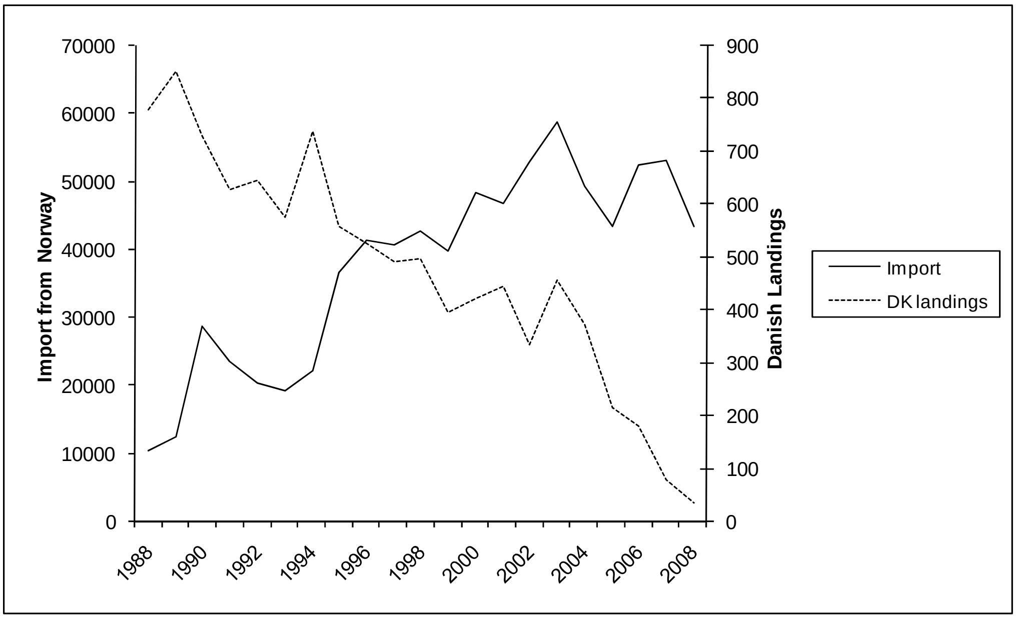
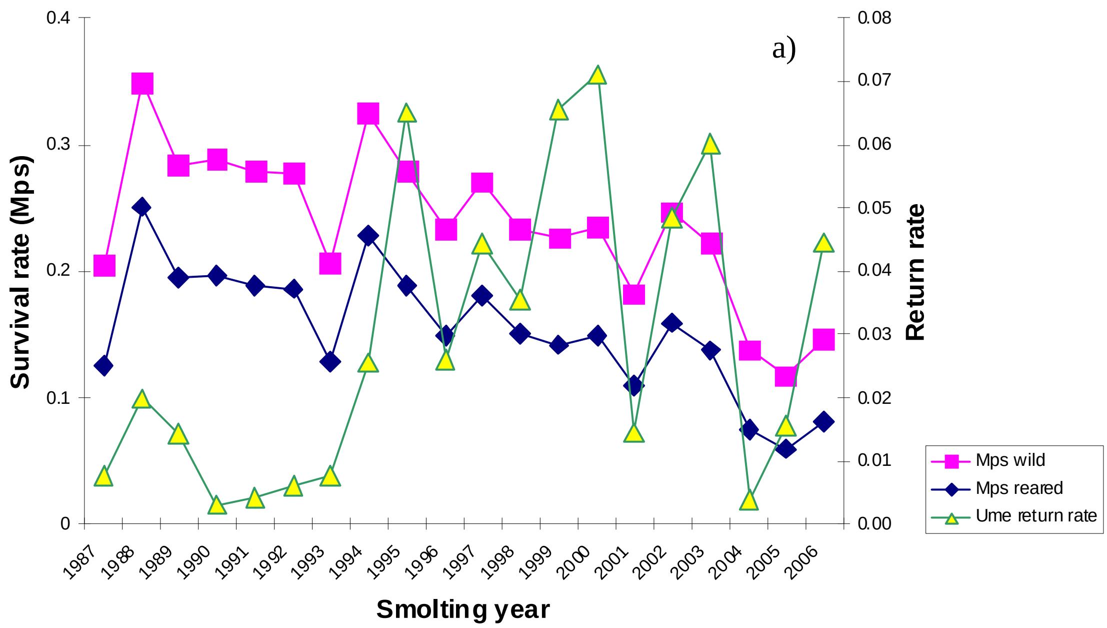


Figure 4.3.4.2. Danish landings of salmon and import to Denmark of farmed salmon from Norway during the period 1988–2007. Source: Statbank Denmark, http://www.statistikbanken.dk.



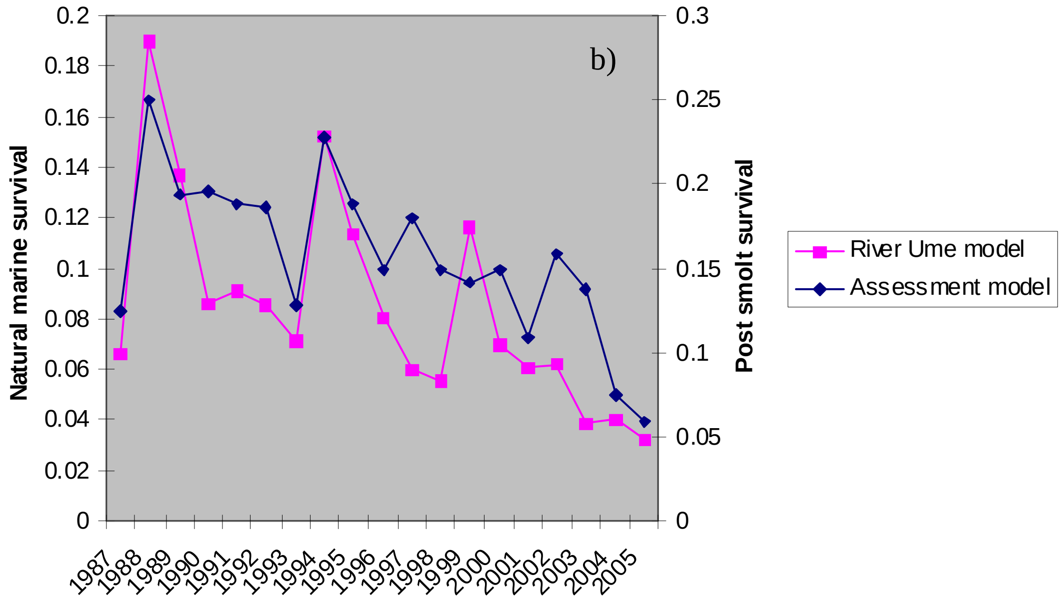


Figure 4.4.4.1. Development in a) post-smolt survival of wild and reared salmon estimated by the assessment model and return rate of reared salmon to River Umeälven, and b) post-smolt survival of reared salmon estimated by the assessment model and estimated natural marine survival of reared salmon from River Umeälven.

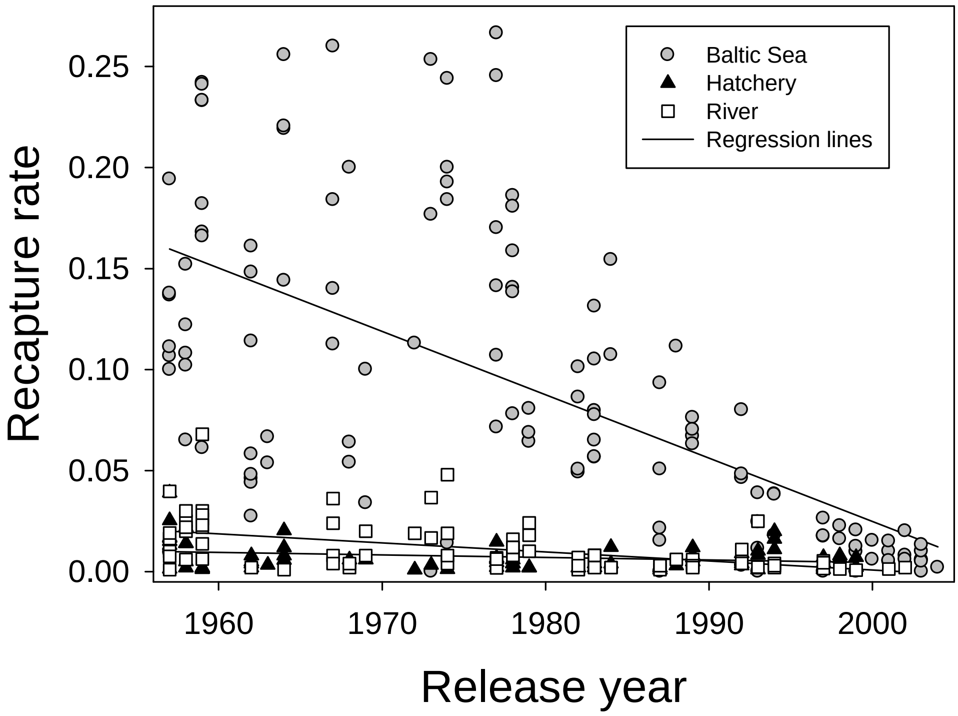


Figure 4.4.4.2. Recapture rates of reared salmon from River Dalälven in the Baltic Sea, River Dalälven and the hatchery. Changes in recapture rates: Baltic Sea ($F=82.86$, $r^2=0.40$, $p<0.001$), River ($F=27.04$, $r^2=0.25$, $p<0.001$), Hatchery ($F=4.89$, $r^2=0.07$, $p<0.031$).

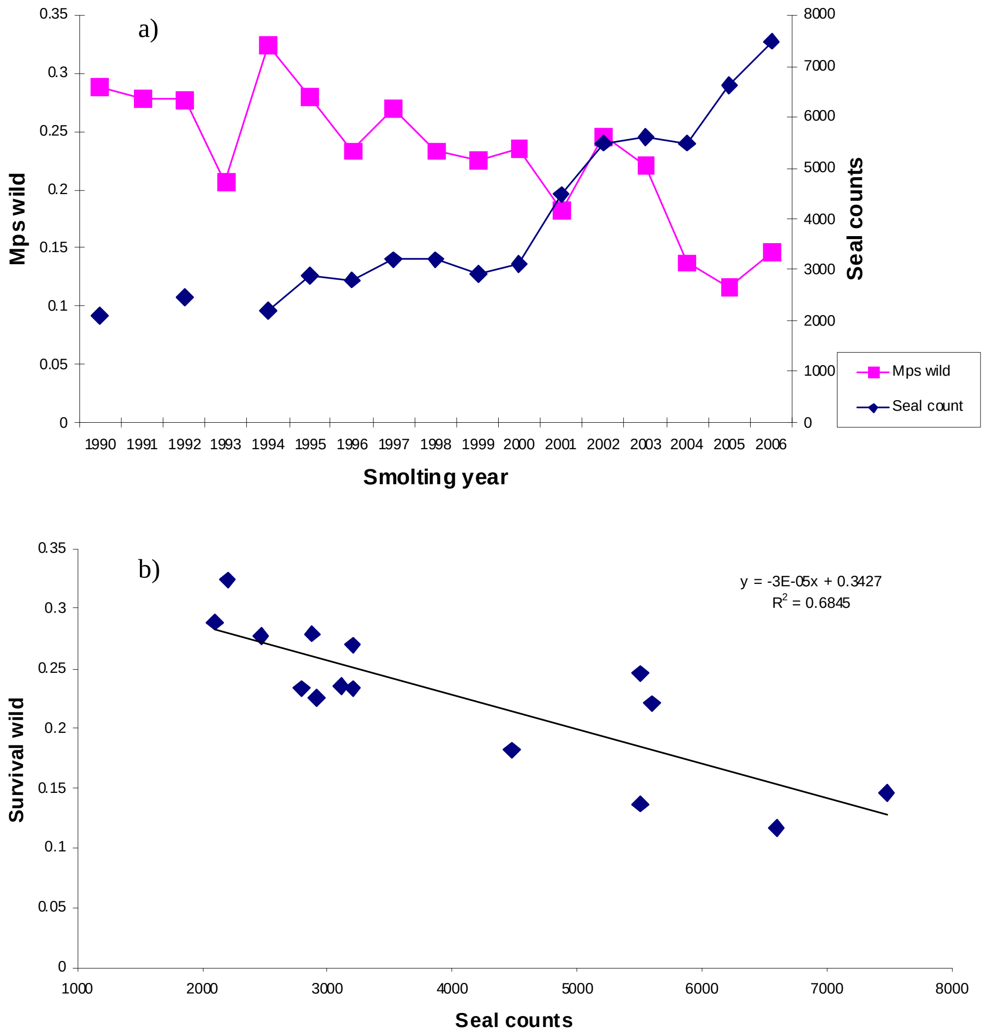


Figure 4.4.4.3. a) Development in survival of wild post-smolts and seal abundance along the Swedish coast, and b) indications of a negative correlation between these variables.

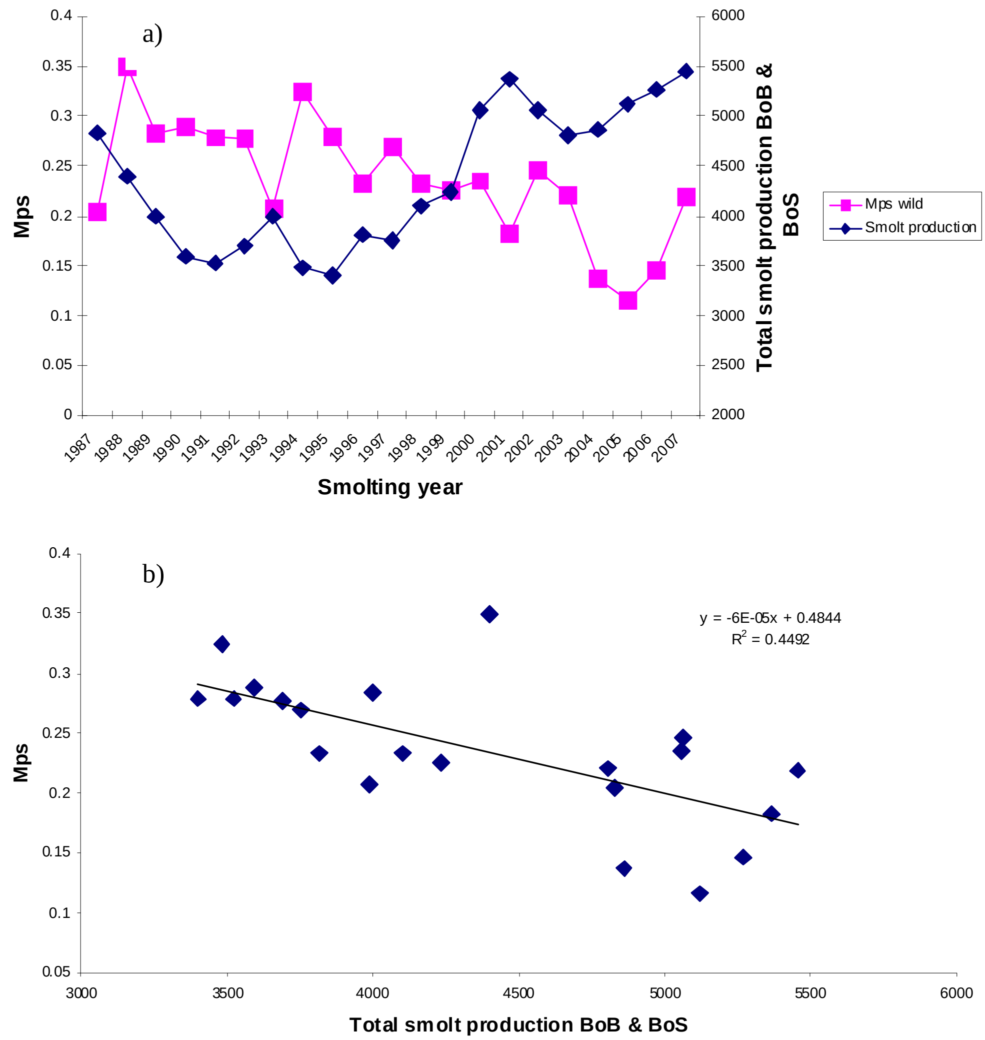
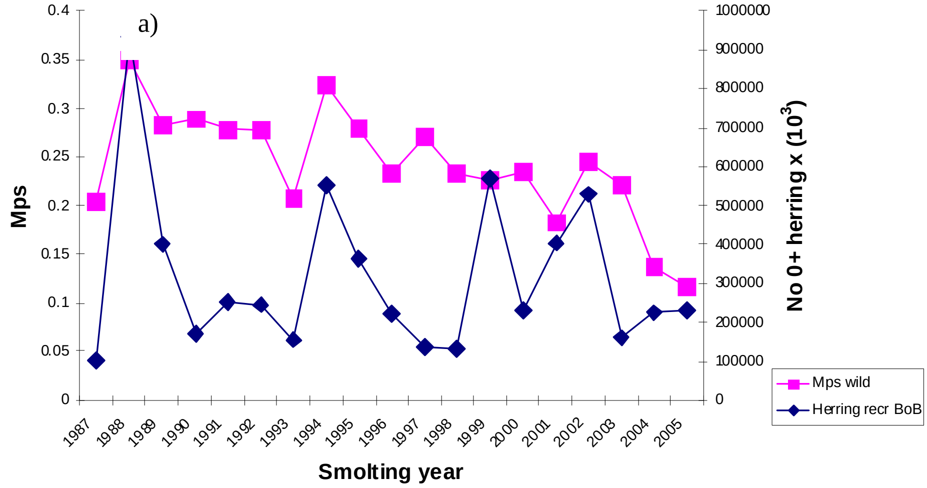


Figure 4.4.4.4. a) Development in survival of wild post-smolts and the production of wild and reared smolts in Bothnian Sea and Bothnian Bay, and b) indications of a negative correlation between these variables.



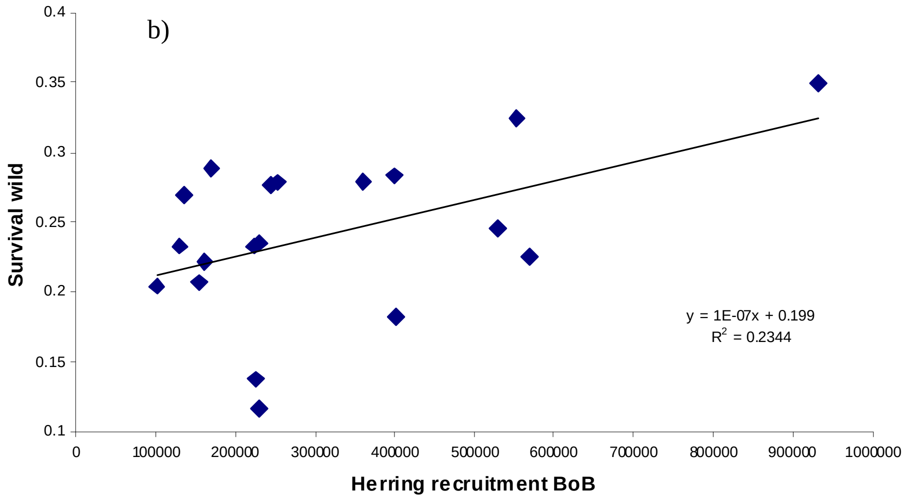
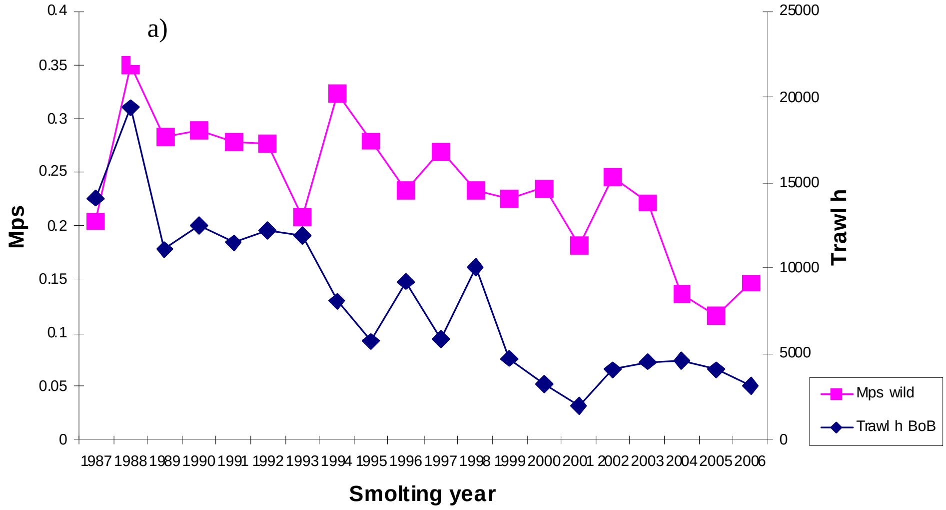


Figure 4.4.4.5. a) Development in survival of wild post-smolts and recruitment of herring in the Bothnian Bay, and b) indications of a positive correlation between these variables.



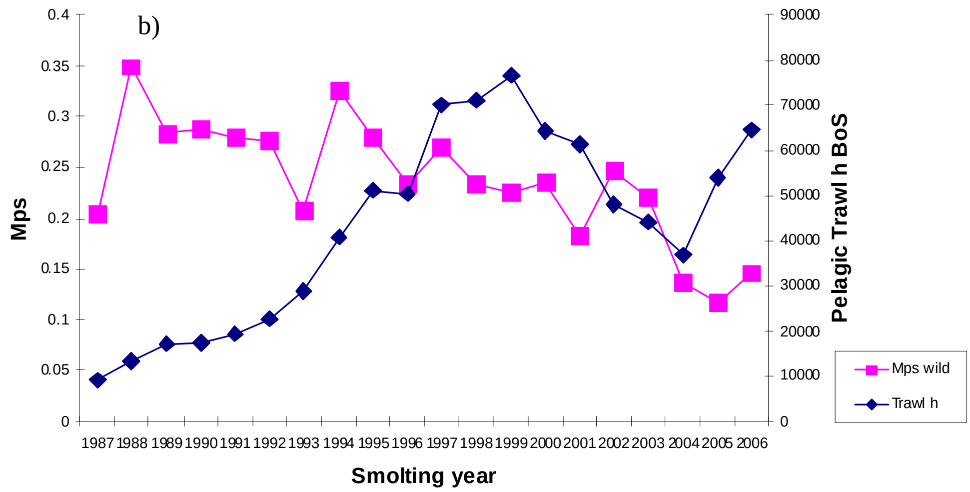


Figure 4.4.4.6. Development in survival of wild post-smolts and a) total trawling effort in Bothnian Bay, and b) pelagic trawling effort in Bothnian Sea.

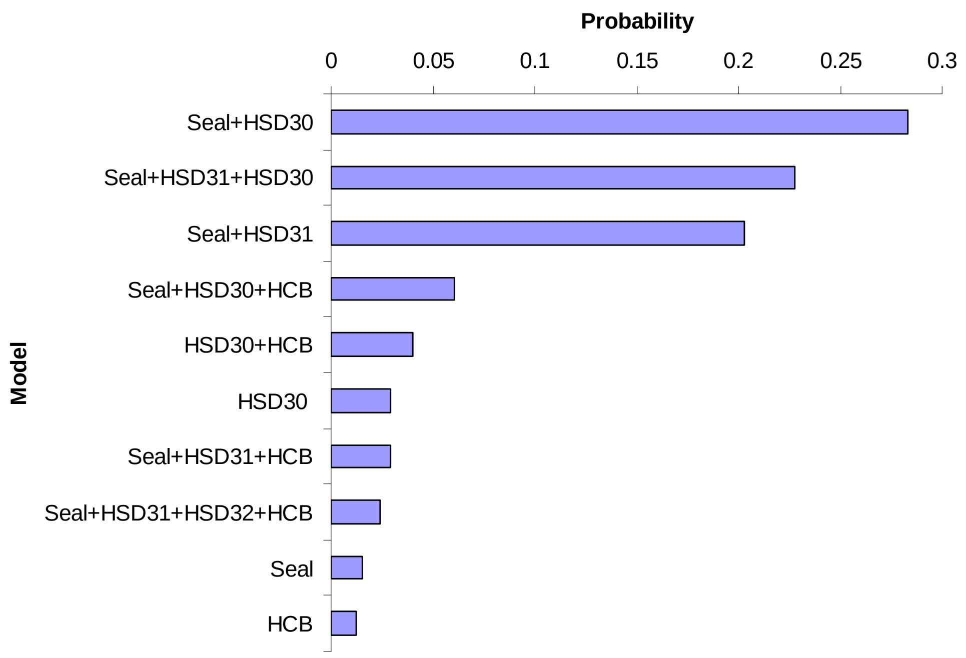


Figure 4.4.4.7. Posterior probabilities of the 10 most likely predictor variable combinations to explain the variation in the survival of wild post-smolts.

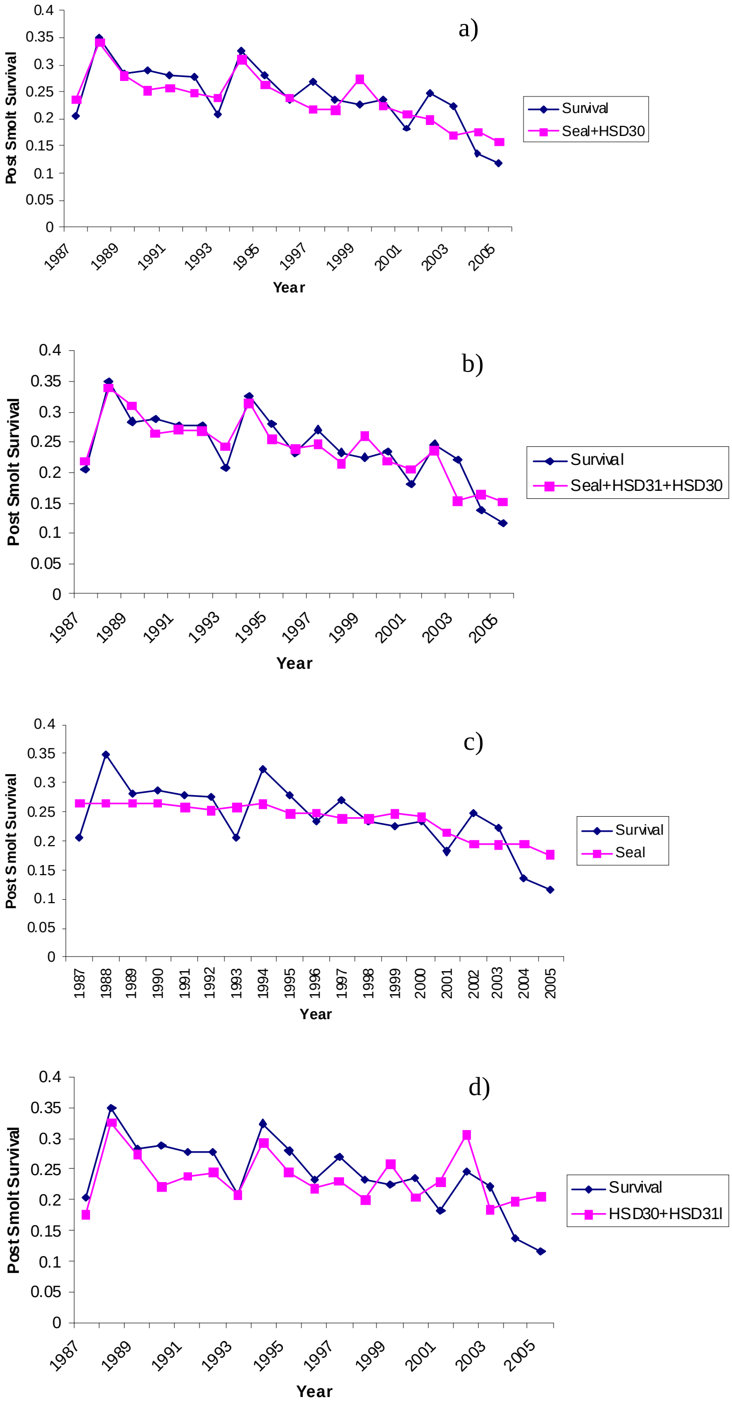


Figure 4.4.4.8. Ability of different variable combinations to explain the variation in the estimated survival of wild post-smolts. The combinations are a) seal abundance and number of herring recruits per produced smolt in SD 30, b) seal abundance and number of herring recruits per produced smolt in SD 30 and 31, c) only seal abundance, and d) only number of herring recruits per produced smolt in SD 30 and 31.

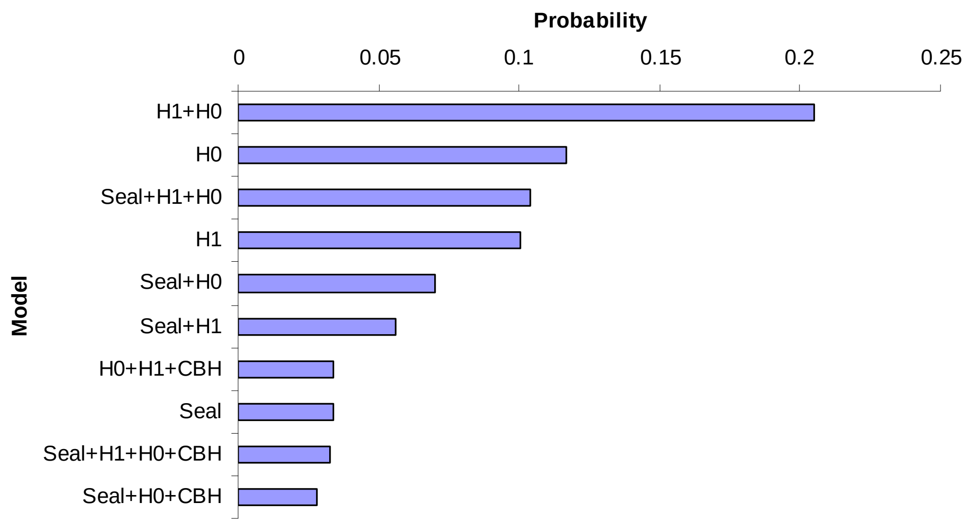


Figure 4.4.4.9. Posterior probabilities of the 10 most likely predictor variable combinations to explain the variation in the return rate of reared salmon from River Umeälven.

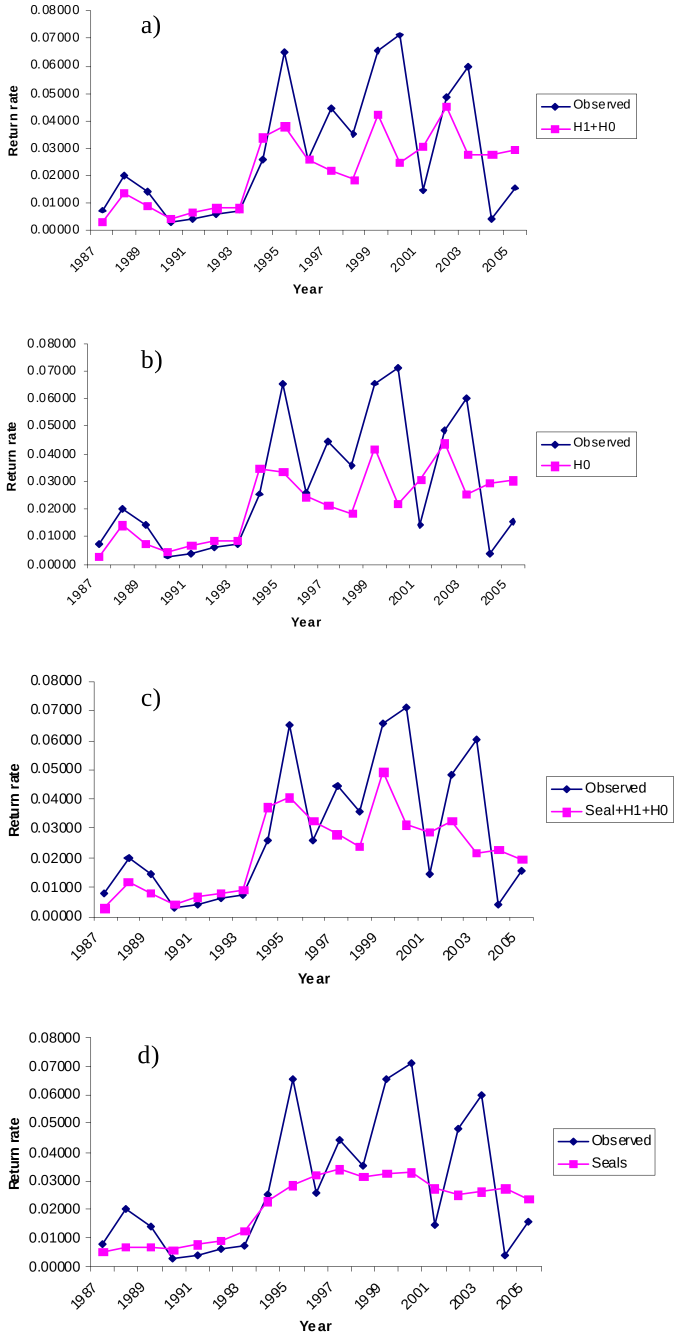


Figure 4.4.4.10. Ability of different variable combinations to explain the variation in the return rate of reared salmon from River Umeälven. The combinations are a) number of herring recruits per produced smolt in SD 30 and 31, b) number of herring recruits per produced smolt in SD 30, c) seal abundance and number of herring recruits per produced smolt in SD 30 and 31, d) only seal abundance.