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FISHERIES, STATUS AND MANAGEMENT OF ATLANTIC SALMON STOCKS IN SWEDEN: NATIONAL REPORT FOR 2013

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ABSTRACT

- Catches of Atlantic salmon was at its lowest recorded level since the early 1980ies.
- Low return of tagged fish, low average weight of grilse, lower proportion of grilse in catches and overall low Fulton condition factor of returning grilse coincided with low catches. This indicates factors in the sea as crucial to stocks.
- Prefishery abundance indicates that the stock is low, but above the national conservation limit for MSW.

- Catches of wild salmon today is only at 7% of the historical level of 1884-1899.
- 34 % of the catch was taken on the coast, where a new commercial fishing with gill nets has developed. This was a mixed stock fishery and has consequently been stopped as from 2014.
- In 2013 the total reported nominal catch of Atlantic salmon in Sweden was 14.7 tonnes (3048 individuals), which was well below the average catch for 1995-2013 (25.4 tonnes).
- As a compensation for lost production due to hydropower development on average 175,000 reared smolts are stocked annually. 65 % of the catch was estimated to be reared salmon.

- Recruitment of wild salmon is monitored with electrofishing. Recruitment (number of young salmon parr in rivers) has declined and is today (2009-2013) only 45% of the recruitment 1985-1989.
- Stock monitoring also comprises of monitoring in the index river Ätran/Högvadsån with counting of smolts and ascending spawners since the 1950s. The spawning run was below average. Recapture rate of Carlin-tagged wild smolts was low, and averaged 1.4 % for fish released in 2002-2012.
- Only nine, out of 23, rivers have not been infected with the ectoparasite *Gyrodactylus salaris*. The effects of the parasite on salmon stocks have not been proven significant at the population level, but effects on individual fish are evident.
- Liming of acidified rivers (78 % of the rivers require liming) is essential for salmon production and aquatic biodiversity.
- The low stock status requires further restrictions on the fishery and restoration of habitats and migration routes.

Contents

1. BACKGROUND

In Sweden there are 23 rivers with wild salmon on the west coast. Salmon from these stocks migrate to the Atlantic Ocean. On the south and east coast of Sweden there are additional 20 rivers with wild salmon migrating to the Baltic Sea. As the latter stocks remain in the Baltic Sea area they are called Baltic salmon, although they are the same species (*Salmo salar*) as Atlantic salmon.

Due to extensive hydropower development several salmon stocks have been lost in Sweden and instead reared salmon is released annually to compensate for the lost coastal and sea fishery. Such releases are more common in the Baltic Sea area than on the west coast. Only three rivers with Atlantic salmon have such releases of reared salmon. However, as it was the largest rivers that have been harnessed for hydropower development, the majority of salmon caught on the west coast today are of hatchery origin.

The present report of fisheries, stock status and management refers only to the Atlantic salmon stocks, i.e. the Swedish west coast. The report is part of the background data required for the stock assessment conducted by the working group WGNAS (Working group on North Atlantic Salmon) at ICES. WGNAS provides an overview of salmon catches and landings by country. The pre-fishery abundance of salmon is estimated along with returning spawners allowing international and national adaptive management. One other important task is to identify relevant data deficiencies, monitoring needs and research requirements (ICES 2012). Through ICES, advice on salmon management is given to NASCO (North Atlantic Salmon Conservation Organization).

In 2013 also a national implementation plan for the management 2013-2018 according to NASCO requirements was established.

This national report represents the joint efforts of governmental agencies (especially the County boards of Halland, Skåne and Västra Götaland, and the Swedish Agency for Marine and Water management), the Swedish University for Agricultural Sciences, and several sport fishing associations. However, the authors are solely responsible for conclusions and statements and they are not the views of the University or mentioned governmental agencies.

2. FISHERIES

2.1 Catches and traps

Commercial fishermen report their catches on a daily or monthly basis. The catches in the non-commercial fishing on the coast are not reported, while sport fishing associations in rivers give a voluntary and generally exact reporting of catches. Especially in the larger wild salmon rivers the catch statistics from sport fishing is accurate, however not always including information on the extent of catch and release (C&R) practised.

The total reported nominal salmon catch in 2013 was as low as 14.7 tonnes and 3 048 individuals (average weight 4.8 kg) (Figure 1). The catch decreased significantly from 2011-2012. The average total catch during 1995-2013 was 24.9 tonnes (±8.8 S.D.). In numbers the average the same period was 6 138 (±2 652 S.D.). The total catch in 2013 was 1 052 grilse and 1 996 MSW (number of wild and ranched salmon given in the catch in Appendix 1).,

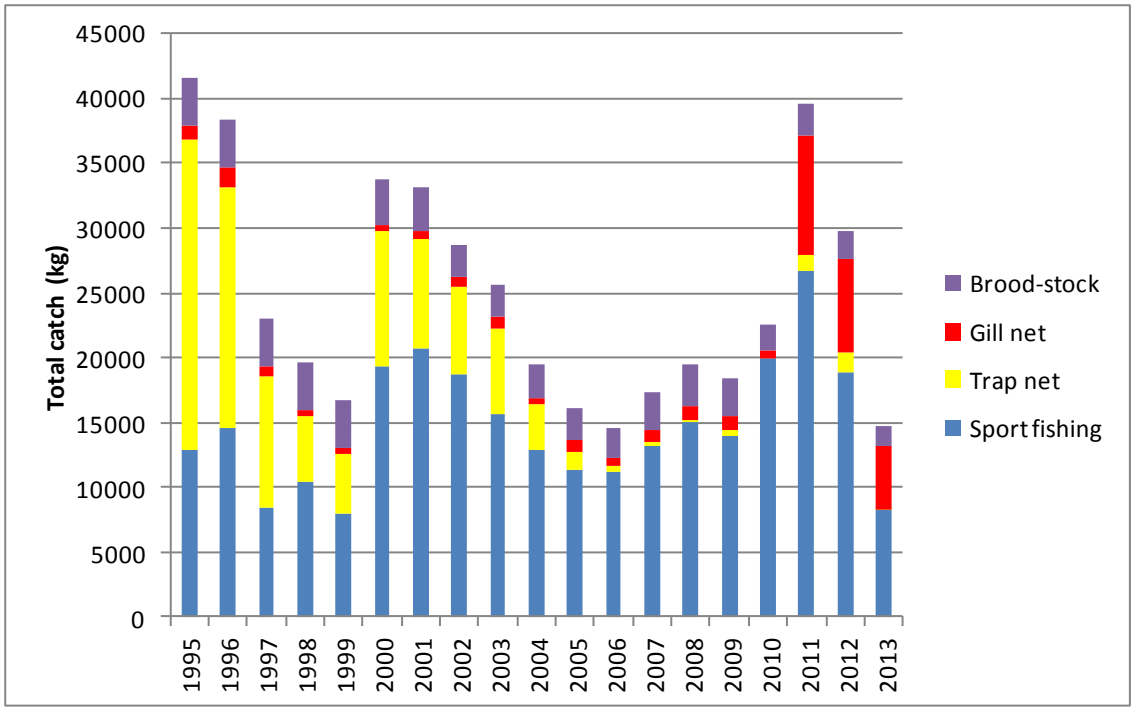


Figure 1. Total reported nominal catch of Atlantic salmon (kg) in Sweden 1995-2013 in different kind of fisheries. Trap nets and gill nets are used in coastal fisheries. Unreported catch not included.

Commercial catches of salmon with gill nets on the coast has been insignificant during 1995-2010, when salmon has only been a by-catch in gill net fisheries targeted at other species. However, from 2011 a gill net fishing directly targeted at salmon started in the southern part of the Kattegatt Sea. The catch was 5 tonnes in 2013, i.e. 34% of the total reported catch.

Several commercial fisheries for other species have been closed, e.g. fyke net fishing for eel on the Swedish west coast, large areas in the Kattegatt are protected from fishing to protect cod stocks, and there is a unilateral ban on fishing with long-lines (for salmon) in the Baltic Sea for Swedish fishermen. This lead to an increase in the commercial fishing of Atlantic salmon with gill nets on the west coast as fishermen are forced to change areas and focus species. Also non-commercial fishermen have reportedly increased the gill net fishing in southern Kattegatt. Their catches are not known. The gill net fishing in deeper waters (>3m) is forbidden as of 2014, and fishing in shallow waters is already restricted with respect to number of nets, season and mesh size.

The proportion of the total catch in weight taken on the coast (with trap nets and gill nets) declined during the period 1995-2010, but increased to 34% in 2013 (Figure 1). In 2009 only 2 % of the catch was taken on the coast (the estuarine catch is included in the coastal catch).

The number of trap nets operating on the coast has decreased from circa 60 in the 1980s to 2 in 2013 (Figure 2). The catch per trap net has successively declined, although some of the more profitable traps are still operating. However, the reported catches are so low from these traps that the quality of the data may be questioned (Figure 3).

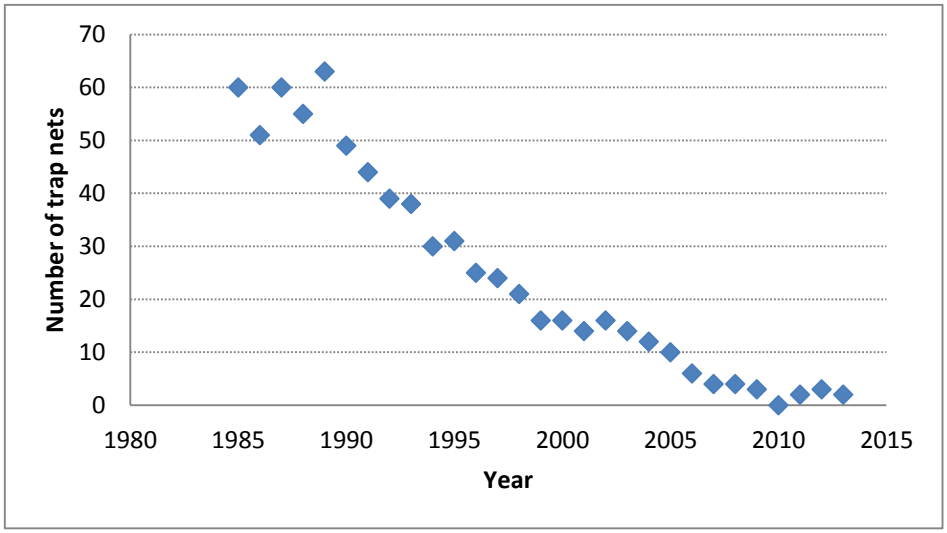


Figure 2. The number of coastal trap nets in use at the Swedish west coast in 1985-2013.

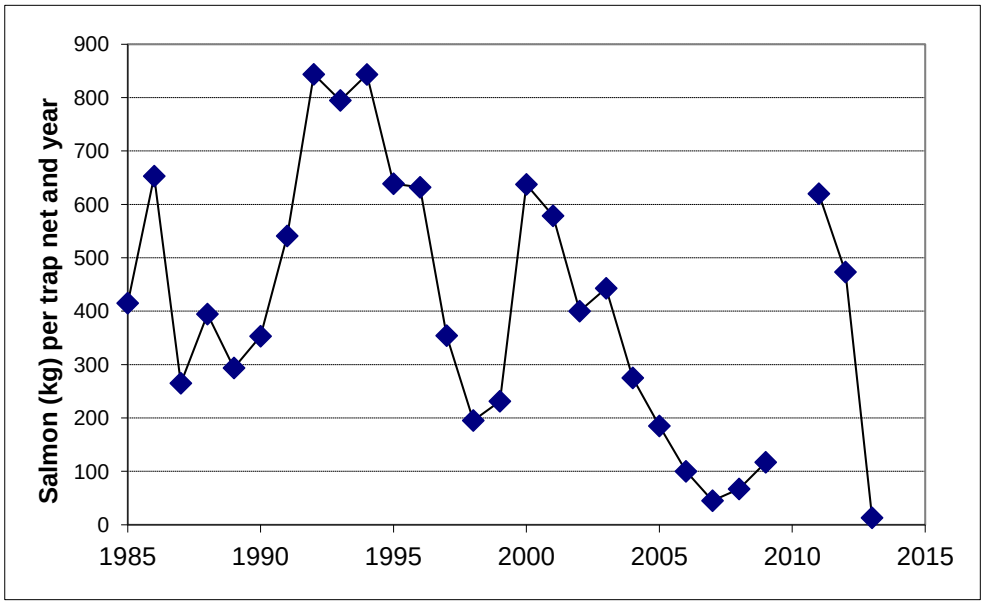


Figure 3. Reported catch (kg) of salmon per unit of effort (season; March-September) for trap nets on the Swedish west coast in 1985-2013.

Angling in rivers has gradually increased its proportion of the catch (Figure 1). The catch in the rivers (rod and line) in 2013 was approximately 8.2 tonnes, which was well below the average for the period 1995-2013 (period average; 14.7). Unfortunately no effort data is available, e.g. number of fishing permits, number of fishermen or fishing hours.

In one river, R. Rolfsån, fishing with gill nets is allowed due to immemorial usage. Only a few persons utilize this opportunity to fish in their part of the river. No catch data are available, so this fishery represents an unreported catch. The total unreported catch of Atlantic salmon in Sweden in the year 2013 was guesstimated to be 1.5 tonnes or about 10 % of the national catch. Included in this is occasional catch of salmon with rod and line on the coast as well as catch of salmon with gill nets by non-commercial fishermen.

The sport fishing catch of wild salmon has since the late 1980's been 500-3000 salmon (average 1381), with the lowest catches in 1980-82 and 2013 (Figure 4). The low catch in 2013 is not due to restrictions on fishing.

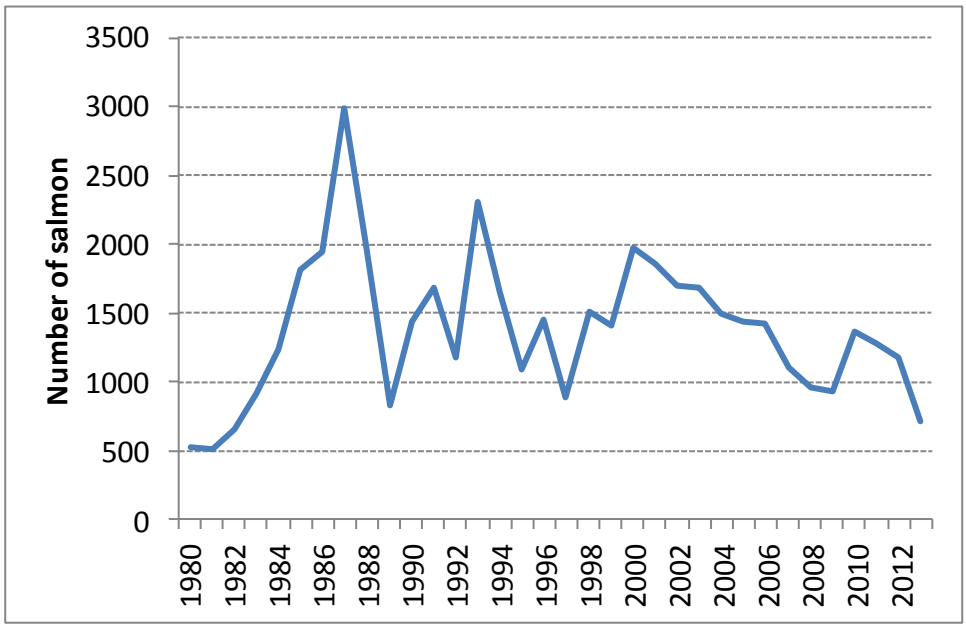


Figure 4. Reported catch in numbers of wild Atlantic salmon in sport fishing in 15 rivers without reared salmon in 1980-2013.

2.2 Catch and release

Catch and release (C&R) is generally only carried out on wild salmon (with adipose fin) when angling in rivers, whereas people fishing in rivers with reared salmon generally do not release caught fish back. C&R is voluntary and there is no total statistics of the magnitude. Although a thorough statistics is lacking, the C&R proportion evidently increases over time. In River Säveån, a tributary of River Göta älv, 27% of the salmon caught were released in 2007, which had increased to 62% in 2012 and was 67% in 2013. From what is reported the total catch in all rivers sport fishing would have increased by 9% in numbers if all caught salmon had been landed, looking only at wild salmon rivers the C&R proportion was 18%.

2.3 Releases of reared salmon

As stated above releases of reared salmon smolts are performed annually in three rivers. In 2013 159,544 reared smolts were released. Of these 66% were 1 one year old (Table 1). During the period 2000-2013 the average number of released reared salmon smolt annually has been approximately 175,000 (Figure 5). The releases in R. Lagan are considered ranching (only for fishing), while the other two rivers have enhancement stocking, i.e. some of the reared fish may return and spawn.

Table 1. Number of released reared Atlantic salmon smolts in 2013 in Sweden.

River	1 year old	2 year old	Type/Grand total	Strain
Lagan	69,598	25,668	Ranching	Lagan
Nissan	21,255	6,627	Enhancement	Lagan
Göta älv	25,970	17,426	Enhancement	Göta älv tributary Säveån
Total	109,823	49,721	159,544	

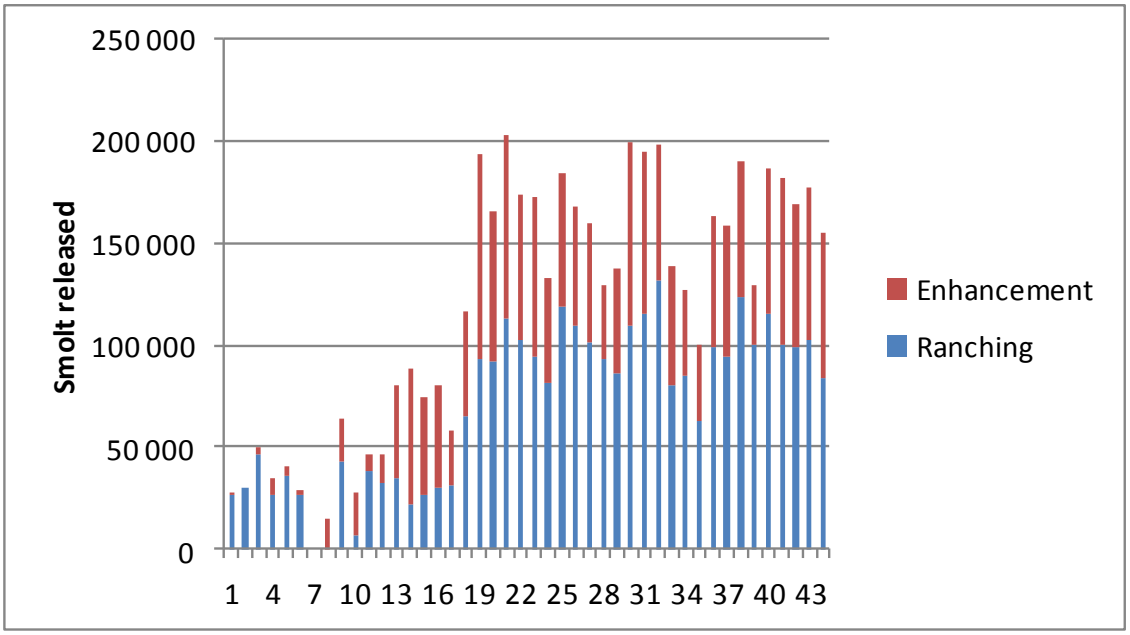


Figure 5. Number of released reared smolt (1-2 yrs old) of salmon 1970-2013 in rivers on the Swedish west coast.Ranching is practiced in R. Lagan and the remaining releases are considered enhancement stocking.

2.4 Catch composition – wild or reared?

Farming of salmon is not carried out in Swedish waters. Fish that originated from reared salmon smolts, released as a part of programmes to compensate for hydropower development, made up 65% of total catch weight in the year 2013 (Table 2). The average proportion 2002-2013 has been 68%.

Table 2. Catch (tonnes) of salmon by category of origin in 2002-2013. Proportion of wild and reared catches in commercial fishing estimated.

Year	Wild	Reared	Total	Prop. (%) reared
2002	11,0	17,0	28	60,7
2003	6,0	19,0	25	76,0
2004	7,0	13,0	19	68,4
2005	7,0	8,0	15	53,3
2006	6,0	8,0	14	57,1
2007	5,0	11,0	16	68,8
2008	4,0	14,0	18	77,8
2009	4,0	13,0	17	76,5
2010	6,7	15,3	22,0	69,7
2011	10,2	28,9	39,2	73,9
2012	10,0	19,8	29,8	66,4
2013	5,1	9,6	14,7	65,4
Mean	6,8	14,7	21,5	67,8

Releases of reared salmon smolt are carried out in three rivers (section 2.3). In rivers Nissan and Göta älv the releases are considered as enhancement as the fish areboth caught in fishery and will spawn. However, in River Lagan there is no spawning areas left in the main stem, and the proportion of reared salmon that enters the tributary Smedjeån is considered

insignificant. Stocking in river Lagan is considered as ranching to compensate for lost salmon production. Previously catches has been reported with Rivers Lagan, Nissan and Göta älv taken together as ranched salmon. At the WGNAS meeting in 2014 it was decided to include only the catches in Rivers Lagan as ranhed catch.

2.5 Tagging and recapture

Data on survival and exploitation are normally available from tagging of reared salmon smolts in Rivers Lagan and Nissan. As the database is owned and run by private (hydropower) companies it is difficult to quality assure data for national and international work. The number of salmon tagged or fin-clipped in year 2013 is given in Table 3. The number of Carlin-tagged reared smolt was 4000 in 2013, which is above the average of 3000 annually 2006-2012.

Table 3. Tagged and fin-clipped Atlantic salmon in Sweden during 2012.

Origin	Carlin-tag	Adipose clip	Total
Hatchery Adult			
Hatchery Smolt	4000	159,544	159,544
Wild Adult			
Wild Smolt	500		500

In the index river (see section 6) up to 500 wild salmon smolts are Carlin-tagged each year since 1995. Data from tagging performed before 2002 are uncertain. The recapture of the smolts released in 2012 was extremely low, again indicating low sea survival of smolts 2012-2013, but some additional recaptures may occur in 2014. The average recapture rate from releases 2002-2012 was 1.35% (SD 0.64, n=11).

Applying a recapture rate of 1.35% on the estimated production of wild smolt (see section 4.2; 590 per hectare * 259 hectares) would indicate a potential annual catch of 2000 wild salmon, which is higher than what is observed (average 2003-2013 circa 1700 when unreported catches are taken account of). This may be due to differences in migration mortalities within and between rivers, as the smolt production is calculated as if no migration mortalities occur within the rivers. However, the estimated smolt production seems to be of the right order of magnitude.

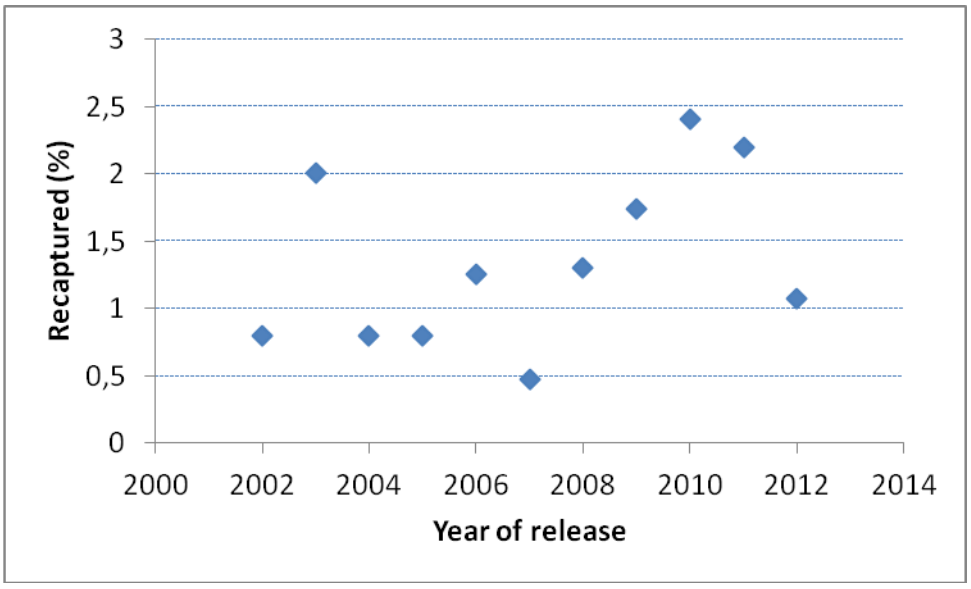


Figure 6. Recapture (%) of wild smolts with Carlin tags released 2002-2012 in the index river Ätran/Högvadsån.

2.6 Historical trend in catch

From the salmon fishing in the county of Halland catch data are available from 1884 until today. The county covers 45% of the total coastline of the Swedish west coast, with 14 of 23 salmon rivers. Today circa 80% of the Atlantic salmon catch in Sweden comes from this county, and probably the proportion was even higher at the beginning of the time series. The period from 1884-1899 the salmon catch averaged 71 tonnes, but later decreased due to hydropower development in the salmon rivers (Figure 7). The decline in catch in the years 1965-1980 has also been attributed to acidification of surface waters and increased high sea fishing. Since then survival of salmon parr has increased due to liming (Alenäs et al. 1995).

Since 2000 the catch has averaged 16.0 tonnes, which means that the catch in 2013 (11.6 tonnes) was well below normal. The present catch (2000-2013) was only 22.7% of the former (71 tonnes in 1884-1899), but to this must be added that the present catch to circa 68% consists of reared (ranching and enhancement stocking) salmon. The present catch of wild salmon therefore averages only 7% of the catch before the twentieth century.

Before the twentieth century 51% of the catch was made in rivers. Successively the catch in trap nets on the coast increased and as from 1930 to 1980 virtually no catch was registered in the rivers (Figure 7). Sport fishing was comparatively low until the 1960s. As from 1980 the catch in rivers has increased due to increased interest in sport fishing and large efforts to restore rivers through liming and other efforts, e.g. open migration routes. Since 1985 the number of trap nets used on the coast has declined (Figure 2), allowing a greater proportion of the catch to be made in the rivers.

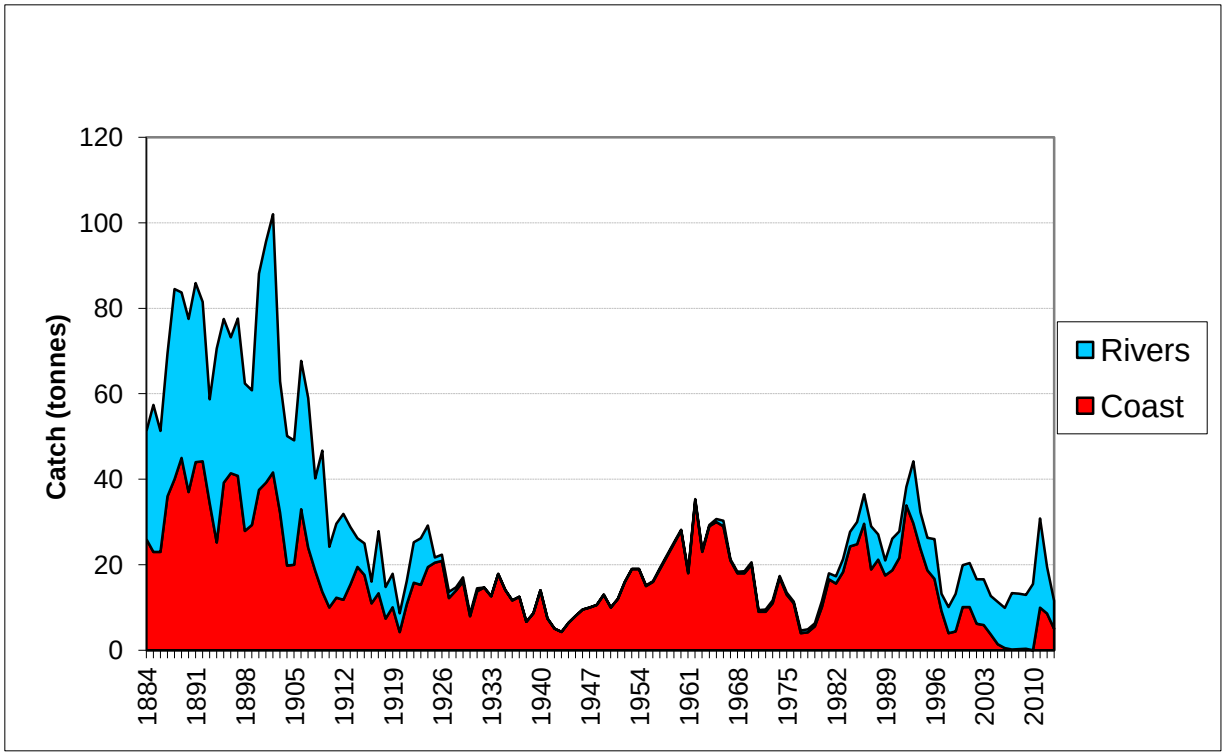


Figure 7. Total catch (tonnes) of salmon in the county of Halland 1884-2013 divided into catch in rivers and on the coast. Data: County administrative Board of Halland.

3. AGE, GROWTH AND SIZE

3.1 Smolt age and sea age

Of 2,579 analyzed spawners during 1993-2013 the average smolt age was 2.3 years. 6.6% were one year old, 64.4% two years old, 25.6% three years old and 3.5% four years old. According to back-calculated length smolts averaged 13.7 cm.

The growth of salmon in the sea can be illustrated with size after 1-5 years at sea (Figure 8a, b). Fish with a weight of less than 3.6 kg are 1 Sea Winter (1SW) fish according to scale reading.

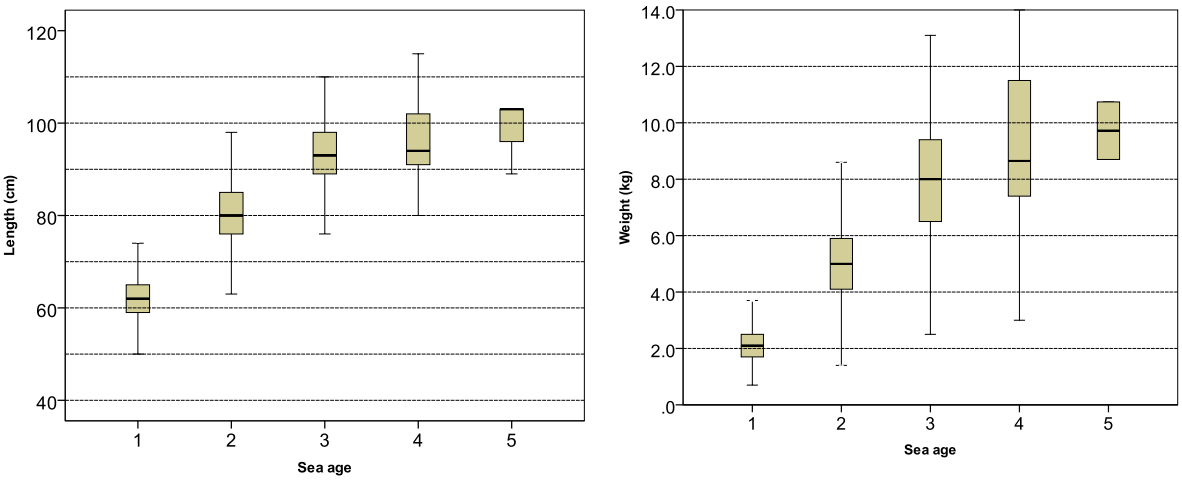


Figure 8a, b. Box-plot of median length (cm) and weight (kg) of salmon after 1- 5 years at sea according to scale reading.

The proportion of Multi Sea Winter (MSW) fish in numbers in the catch has increased significantly during 1971-2013 (Figure 9; Pearson correlation r=0.891, n=43, p<0.001), possibly indicating a successively longer time required to reach maturity and fitness. In 2013 the proportion was 65%.

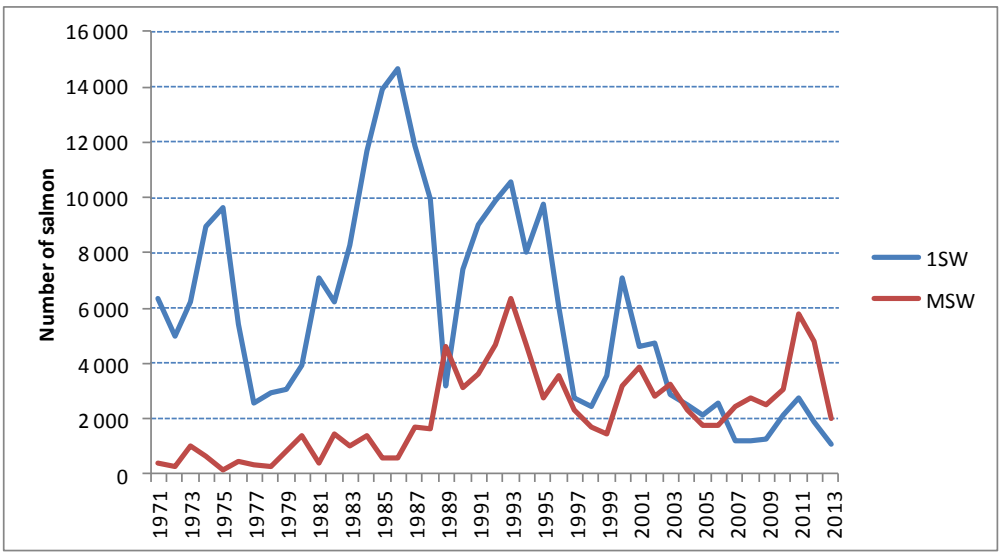


Figure 9. Number of salmon caught divided into 1 SW (grilse) and MSW salmon during 1971-2013.

3.3 Condition of returning spawners

The average weight of grilse (1 SW) in 2013 was 2.6 kg (Figure 10). The average weight was lowest in 2006 (1.9 kg). This year the condition of returning 1SW was extremely poor (see below). During the same period (2000-2013) the average weight of MSW has been 5.5 kg. The average weight of 6.0 kg in 2013 was comparatively high.

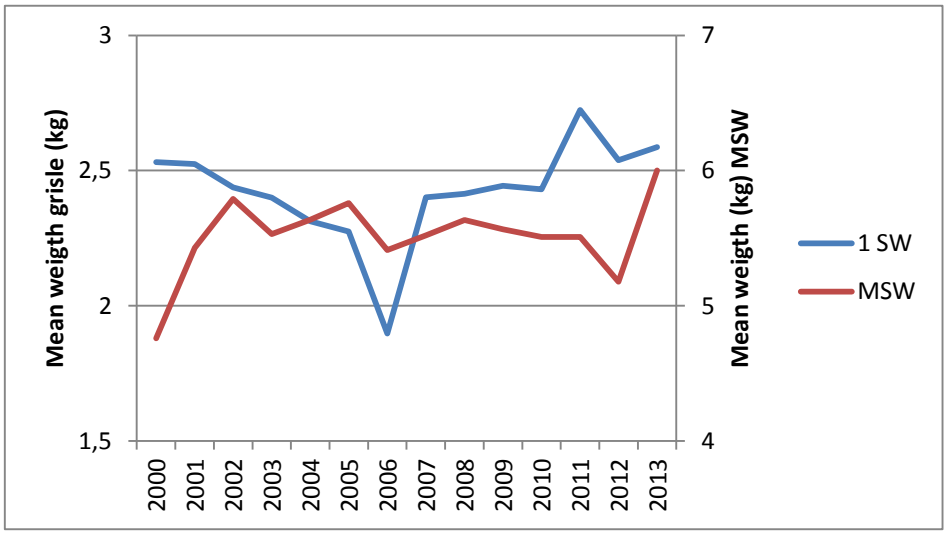


Figure 10. Average weight (kg) of 1 SW (left axis) and MSW (right axis) salmon during 2000-2013.

Using only salmon caught in sport fishing where both length (cm) and weight (kg) had been measured, the average Fulton condition factor was calculated for catches during March-September in 2001-2013. The number of salmon included for each year was circa 500-3000 (total 17,700). During 2005-2009 the condition factor of returning grilse was considerably low (Figure 11), indicating poor growth conditions in the sea. Also MSW followed this pattern. It is notable that these years when the catches were lower, the condition factor was also lower (Figure 12, 13). This may indicate that years with low condition factor the number of returning salmon is lowered. The results indicate that the total catch is to a large extent depending on variations in sea survival and growth.

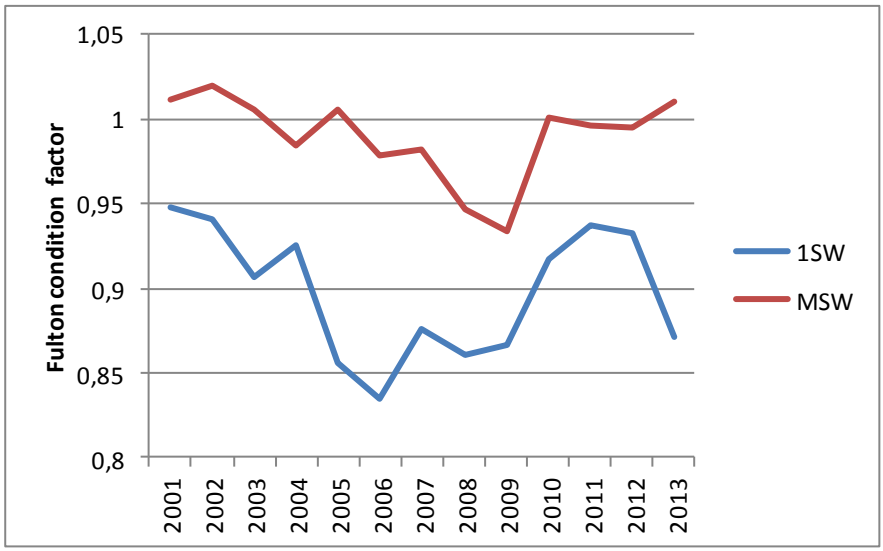


Figure 11. Average Fulton condition factor for salmon caught in sport fishing in rivers during March-September 2001-2013 (n=17,700).

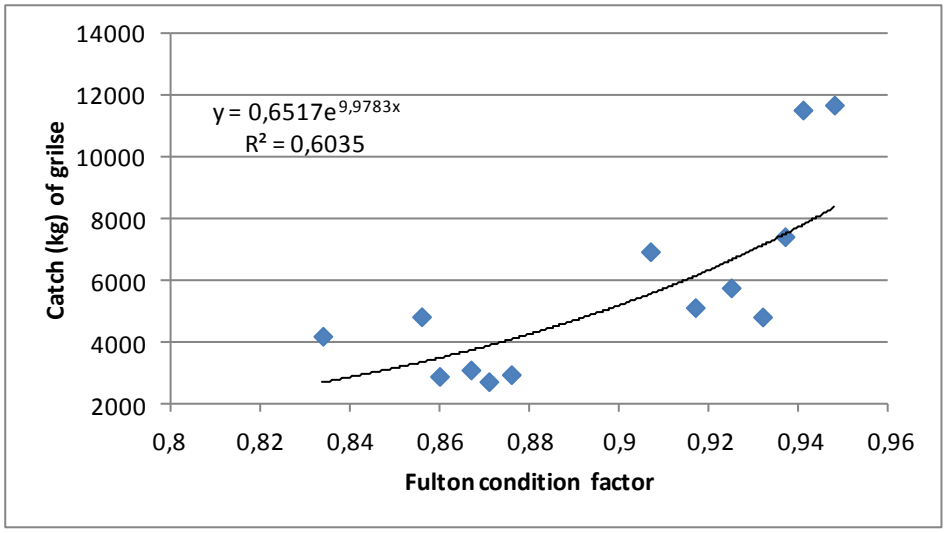


Figure 12. Total catch (tonnes) of grilse during 2001-2013 versus the average Fulton condition factor of grilse (1SW) caught in sport fishing in rivers. (The direct effect of an increase from 0.85 to 0.95 in Fulton condition factor, i.e. heavier salmon, only accounts for 13% of the increased catch.)

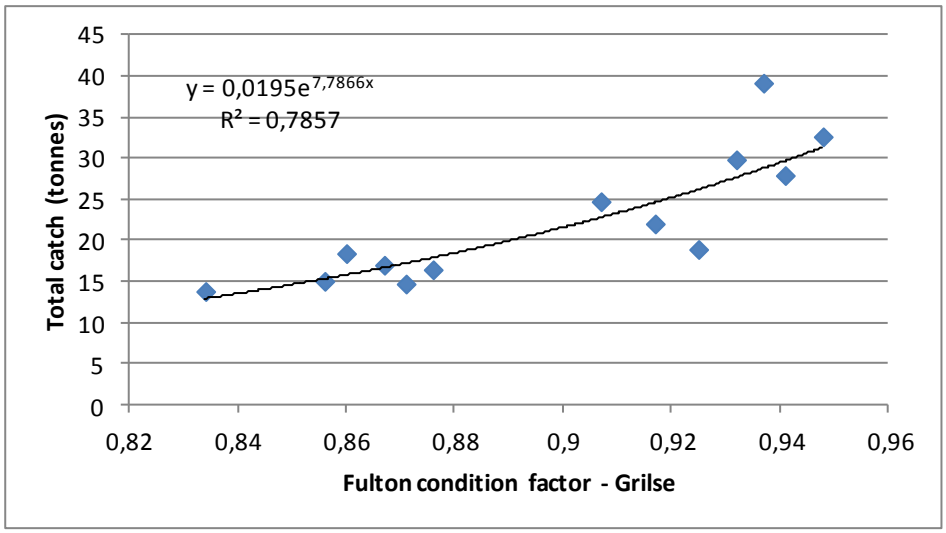


Figure 13. Total catch (tonnes) of salmon (1SW and MSW) during 2001-2013 versus the average Fulton condition factor of grilse caught in sport fishing in rivers.

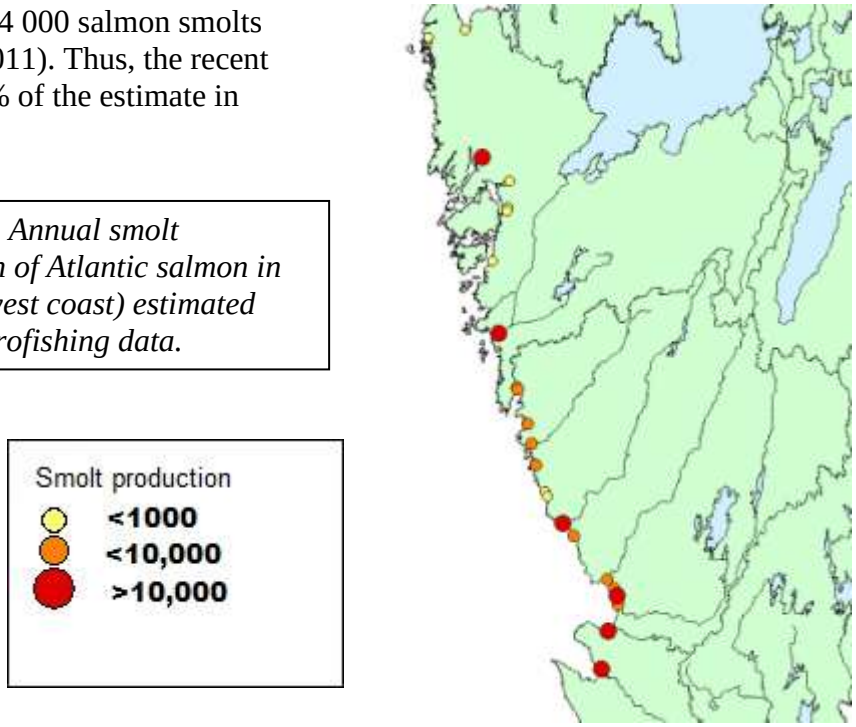
4. STATUS OF STOCKS

4.1 Salmon rivers

Atlantic salmon reproduces in 23 main rivers (259 hectares of nursery areas) on the Swedish west coast, but in River Bäveån there is presently no reproduction due to hydropower production. A few salmon are also reproducing in Rivers Kärraån and Vege å. Several of the rivers are small. The smolt production is not measured, but from electrofishing data it has been estimated in 1999 to 200 000 annually, i.e. approximately 850 smolts per hectare (Degerman et al. 1999). Only seven rivers produced more than 10 000 smolts annually, and another seven rivers produced less than 1000 smolts annually (Figure 14). A recent (2010) estimate from electrofishing results gives an average production of 590 smolts per hectare,

with a total production of 144 000 salmon smolts annually (Degerman et al. 2011). Thus, the recent production estimate was 72% of the estimate in 1999.

Figure 14. Annual smolt production of Atlantic salmon in Sweden (west coast) estimated from electrofishing data.



4.2 Parr densities in monitored rivers

Electrofishing, by wading, is carried out to quantify the populations of parr in the spawning areas, which gives a quantitative estimate of spawning success and population size. Annually 17 of the 23 salmon rivers are sampled, most at multiple sites. All data are reported to the Swedish Electrofishing RegiSter (SERS) at the Swedish University of Agricultural Sciences.

The electrofishing monitoring has shown a decline in parr densities. During 1985-1989 the average parr density was 137 Atlantic salmon parr per 100 m^2, but declined to 63 parr in 2009 -2013, a decline of 55% (Figure 15). During the period 1996 – 2013 there was no significant trend in parr abundance (Pearson correlation r=-0.012, p=0.963, n=18), whereas there was a significant decline 1985-1995 (Pearson correlation r=-0.690, p=0.019, n=11).

This lowered recruitment of salmon (parr abundance) in 1996-2013 was in spite of a substantially reduced marine fishing, and in spite of extensive and successful liming programmes, river bed restorations and establishment of new and improved fish ways.

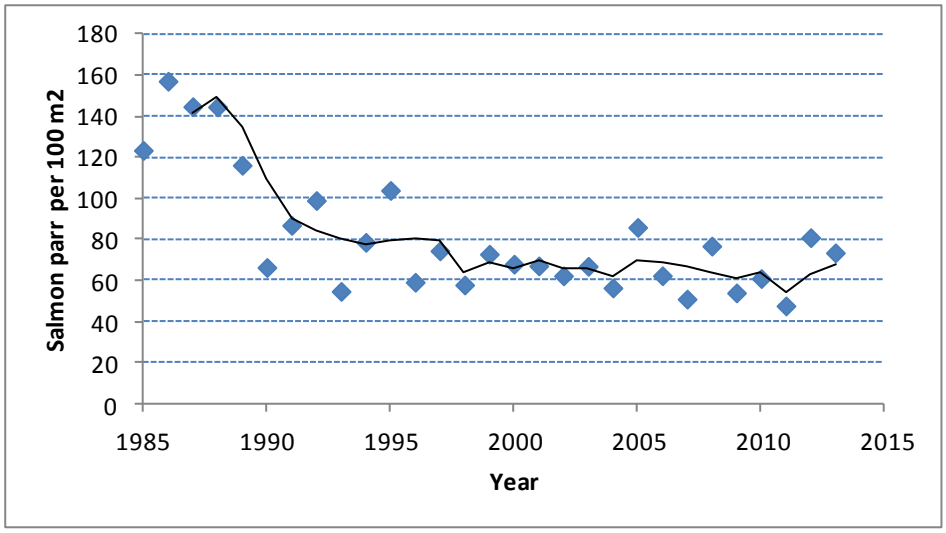


Figure 15. Average salmon parr abundance (no. per 100 m^2) of 17 selected salmon rivers (49 sites) on the Swedish west coast in the period 1985-2013. Trend line is moving averages (3 yrs). The average abundance each year was corrected for differences in sampling date and size of stream using Ancova. Data from the Swedish Electrofishing RegiSter (SERS).

On average 1985-2013 the proportion of 0+ salmon parr of the total density of salmon parr has been 77.4% (S.D. 4.4%), without any trend during the period. Suggesting that the abundance of 0+ parr one year and the abundance of >0+ parr the following year is some kind of measure of survival from 0+ to 1+; it has averaged 28.7% (S.D. 7.2%). This figure is biased as older salmon parr may move to deeper parts of the rivers, which are not possible to electrofish by wading. Expecting the problem to be of the same magnitude each year, there was no trend in this measure of survival from 1985-2013. As both the proportion of 0+ parr has remained unaltered over time, as well as the "survival" from 0+ to >0+ parr, this indicates that in-stream population regulating factors have not changed.

4.3 Prefishery abundance

Through the work within WGNAS and the EU project "Salmodel" a "run-reconstruction" model was developed for estimating the pre-fishery abundance (PFA) of salmon, based on catch data and estimates of non-reporting rates and exploitation rates (Potter et al. 2004). The output from the model has been used to provide a preliminary national Conservation limit (CL). The conservation limit is considered to be approximately the maximum sustainable yield (MSY). During the work of WGNAS 2014 the model was rerun for all datafrom 1971 to 2013 as ranched catch (River Lagan sport fishing and brood stock) was not conisered part of the wild salmon stock.

CL for individual rivers has not been established for the Swedish stocks, a work that will be undertaken in 2015-2016.

The results for the last year (2013) showed a drastic decrease in both MSW salmon and 1SW salmon (Figure 16). The number of salmon is still above the estimated CL.

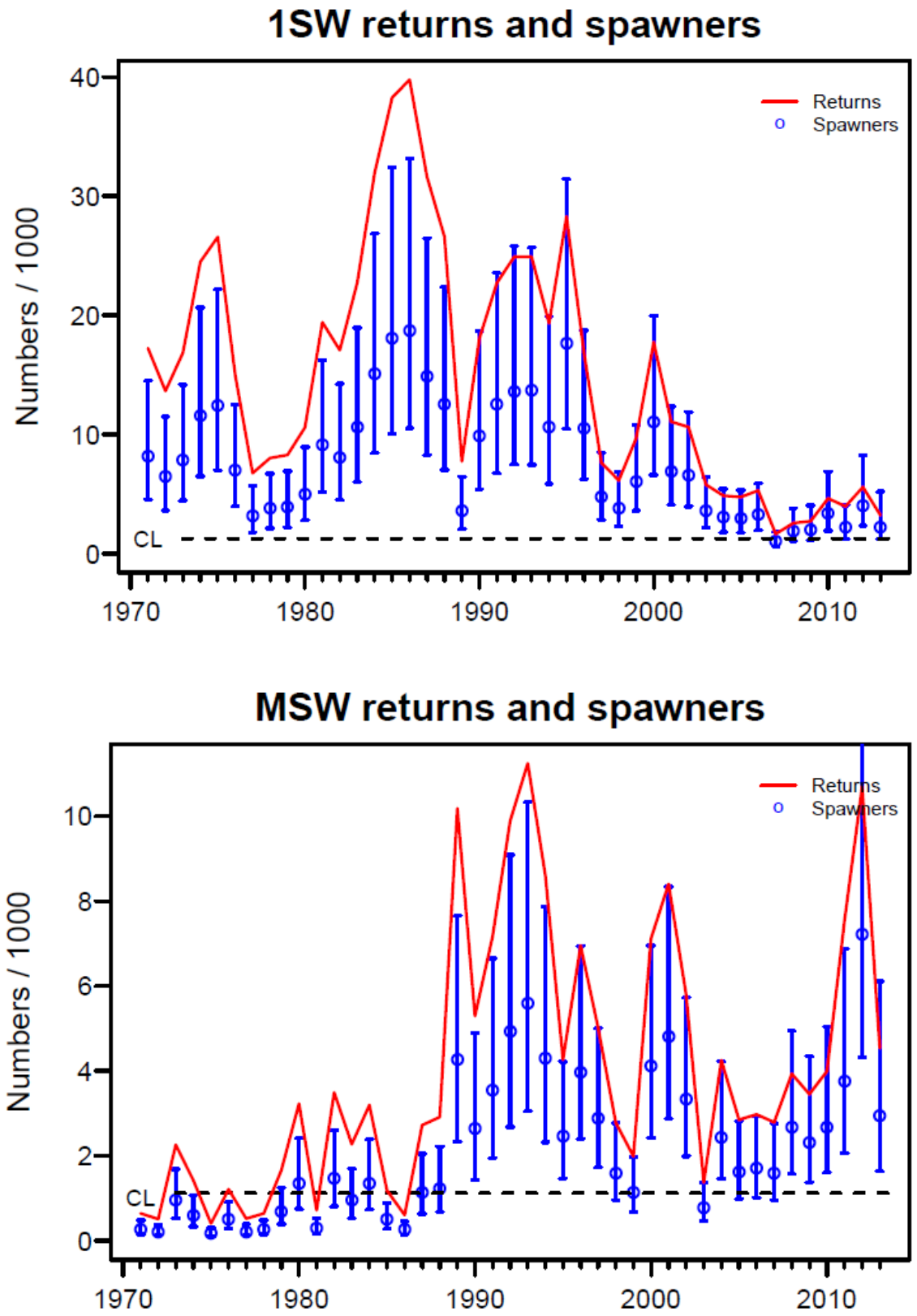


Figure 16. Resturns and spawners of 1SW (grilse, above) and MSW (below) Atlantic salmon to Swedish rivers 1971-2013. CL indicates national Conservation limit. Note the different scale on the y-axis.

The number of returning grilse was low and just above the CL. This means that the present egg deposition is heavily depending omn MSW fish. The run-reconstruction model indicates that egg depsotion in 2014 and 2014 will increase, due to the number of maturing salmon in the sea.

5. GYRODACTYLUS SALARIS

Due to the spread of the parasite *Gyrodactylus salaris* a monitoring programme was launched 2001 (Degerman et al. 2012a). At present only nine out of 23 rivers are uninfected (Figure 17). No new rivers have been infected 2006-2013. The majority of uninfected rivers are in the northern part of the Swedish west coast, i.e. in the Skagerrak Sea close to Norway. It is suggested that northern stocks may be more sensitive to *Gyrodactylus salaris* as they are isolated from southern stocks (and the Baltic) by high saline ocean waters with >30 PSU, as compared to circa 20 PSU in the southern part of the Swedish west coast. Protective measures have been undertaken to avoid spreading the parasite, e.g. ban on stocking salmonid fish in the whole catchment of not infected rivers.

The Gyro-monitoring programme was evaluated in 2011. The results showed that although individual parr with many parasites will have impaired growth and eventually die; no effects can be seen at the population level according to our large scale electrofishing surveys (Degerman et al. 2012b). Comparing the parr abundance before infection with *Gyrodactylus salaris* with after and comparing with the abundance of reference sites in uninfected rivers showed no significant differences. The trend (Pearson r) in parr abundance over time was compared with Meta-analysis between infected rivers and reference rivers. The trend did not differ.

Figure 17. Map showing the position of Swedish salmon rivers on the west coast. Further, the distribution of the ectoparasite Gyrodactylus salaris is shown with rivers in red. Green rivers are uninfected.

6. INDEX RIVER

6.1 Smolt and spawner count

There is one index river, River Ätran, where a smolt count is available from a partial smolt trap (Wolf type eel trap) in the major tributary Högvadsån (catchment area 476 km^2, average flow 11 m^3/s). The trap only catches a proportion (roughly 15%-25% depending on flow) of all descending smolts. Estimating the relation between catch efficiency and flow has proven difficult, partly due to effects of temperature but also due to effects of site of release of marked smolts. Further trials will be conducted during 2014, but it is today possible to calculate the total smolt run with sufficient accuracy.

Using uncorrected data, i.e. the number of smolts caught in the trap, in the late 1980ies the smolt catch was considerably higher than in more recent years (Figure 18). The trap count in 2013 was 1142 smolts.

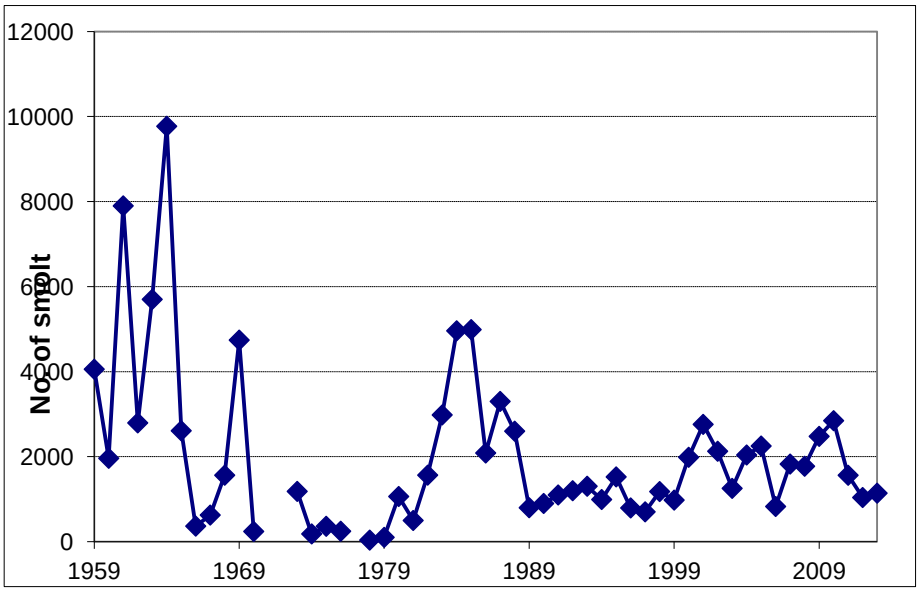


Figure 18. Salmon smolts caught in the trap at the tributary Högvadsån in the River Ätran system (index river) 1959-2013. Numbers are not adjusted for the catch efficiency of the trap (roughly 20%).

The number of ascending adults caught in the spawner trap in Högvadsån is also biased, as individuals may pass the trap in the old mill at certain water levels. During 2008 the efficiency was estimated using radio-tagged salmon, but too few fish (n=8) were used for reliable results (a 50% trap efficiency was found). Further work with this issue is of high priority and will be carried out in 2014.

The number (uncorrected for catch efficiency) of ascending spawners in 2012 was 273, below the average of 2000-2013 (337) (Figure 19). Again the results indicated low return of spawners in 2005-2009 and 2013. The number of spawners was correlated to the number of descending smolts with peaks 1985-1988 (Figure 18). The proportion of grilse in the spawning run was especially low in 1997, 1998, 2005, 2007 and 2013 (Figure 19). The low proportion (20%) of grilse in 2007 was quite extreme, which was followed by a low return of MSW fish in 2008. This indicates that smolt leaving in 2006 had especially low sea survival, as the smolt run in numbers that year did not deviate from other years. In figures 10 and 11 it

can be seen that the average weight of grilse and the Fulton condition factor in the Swedish fishery in 2005-2009 was low, again indicating bad sea conditions.

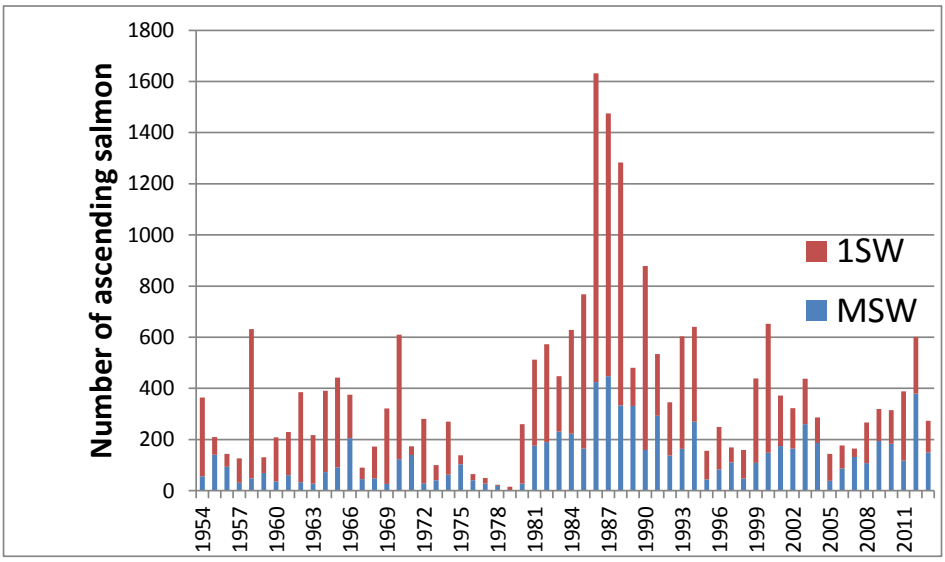


Figure 19. Ascending adult salmon (spawners) caught in the trap in the tributary Högvadsån in 1954-2013.

6.2 Reared salmon and rainbow trout

All salmon caught in the trap in Nydala are handled manually. The same person has handled the fish since the 1970s. During 1997 and 1998 several reared salmon of another strain was observed (Figure 20). It was later found that these were from stocking in southern Baltic (Pedersen et al. 2007). These years circa 5% of ascending salmon were reared. Since then the number of reared salmon, judging by their general appearance and lack of adipose fin, has been low.

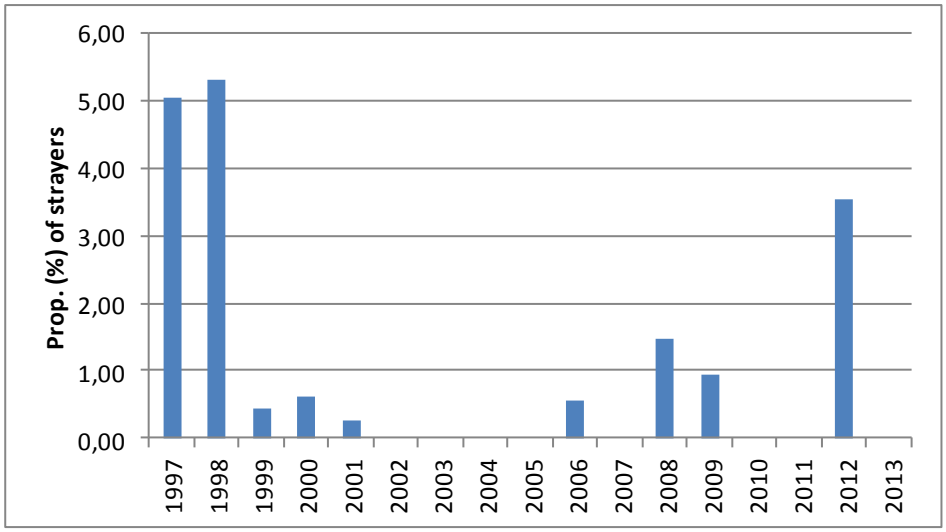


Figure 20. Proportion (%) of spawners caugth in the trap in the index river at Nydala that has been judged to be of reared origin 1997-2013.

In 2010 a sample of 90 salmon with adipose fin (all reared Swedish salmon are fin-clipped) from River Göta älv was analysed. As much as 70-75% was found to be of unknown strain (Palm et al. 2011). Evidently salmon from other areas enters the salmon rivers on the west

coast, and this migration can be of a substantial extent. It is suggested that these salmon may be from salmon farming as several fish had fin erosions.

During 1997-2013 only 7 rainbow trouts have been caught in the trap (along with 5541 salmon). This low number may be due to the lack of rainbow trout farming in the sea on the Swedish west coast.

6.3 Date of ascending

Ascending spawners arrive from late April until mid-October. There are large variations between years in median date of the arrival of salmon. On average 1SW spawners have a median arrival date of 1st of September (Julian date 244) and MSW 15th of August (Julian date 227; Figure 21). Variations between years are mainly due to water flow in the river. In 2013 the summer flow was extremely low and ascending salmon was delayed ½ month (1SW) – 1 month (MSW). This also may have affected the total run, which was low in 2013.

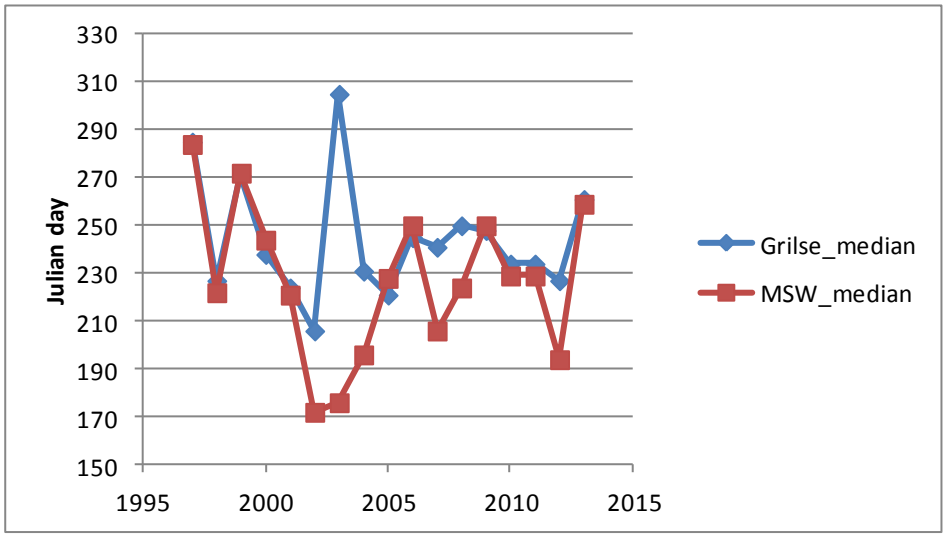


Figure 21. Median date (Julian date) for ascending spawners to the trap at Nydala, Högvadsån.

The arrival of salmon at the trap in the index river is delayed as compared to the arrival of salmon in the lower parts of the river system. On average the median catch in the sport fishing on the Swedish west coast is done the 24th of August (Julian date 234), with MSW at Julian date 218 and grilse at 233.

6.4 Recruitment data

During 2000-2013 the average abundance in the index river of salmon parr 0+ was 95 (S.D. 105) and of >0+ 10.5 (S.D. 8.8) per 100 m^2 (five electrofishing sites). There was a high correlation (Pearson r=0.78) between the abundance of salmon parr in the index river and the abundance in all west coast rivers (Figure 13), indicating that the index river is representative.

A preliminary stock-recruitment curve has been established for River Högvadsån, using actual data on ascending spawners and smolts, i.e. the smolt and spawner numbers were not adjusted for catch efficiency ($Smolt=0{,}108*egg*e^{(-0{,}00000337*egg)}$). This relationship will be re-evaluated when the spawner trap efficiency is established.

In 2011-2012 the salmon habitat in the whole river was re-mapped and additional electrofishing sites were used in poor habitats in 2012 to enable an estimate of the total parr population in the system. The smolt run during 2000-2011 corresponds to a production of 590 smolts per hectare (5.9 per 100 m^2), i.e. exactly the same value as is estimated to be the average production on the Swedish west coast from electrofishing data (section 4.1). During the same period the late summer abundance of parr >0+ has been 10.5 per 100 m^2, i.e. 56% of the recorded abundance of >0+ parr in the index river will be smolt the following spring.

7. FISHERY MANAGEMENT

7.1 Present fishing regulations

The salmon fishing in the open sea is today small and regulated through NASCO. The Swedish national regulation of the Atlantic salmon fishing on the coast has remained mainly unaltered since 2004. However, in 2012 a ban on special type of gill nets (krokgarn) was implemented in the Idefjord area in cooperation with Norway. Also, from 2013 fishermen, commercial or non-commercial fishermen, may only use a maximum of six gill nets (maximum length 180 m, max. height 3 m) in shallow (<3 m) coastal waters. From 2014 there is a ban gill net fishing aimed at salmon in deeper coastal waters.

The minimum allowed size of landed salmon (and sea trout) is 45 cm in the sea and in rivers. Protected estuarine areas are established outside all salmon rivers. In these areas fishing with gill nets or other passive gear is prohibited, whereas rod-and-line fishing is allowed. In some areas where river mouths are close by one another, the protected areas have been joined forming larger units.

The salmon and trout fisheries are closed from 1st of October to 31st of March on the coast and in rivers. In rivers with large releases of reared salmon fishing may continue until 14th of October.

In shallow (<3 m depth) waters on the coast only 120 mm stretched mesh is allowed for gill nets. This is to avoid catching undersized sea trout.

Fishing rights in rivers are privately owned. Fishing for salmon or trout with gill nets is not allowed in rivers and lakes, except in River Rolfsån where a few private fishing right owners are allowed to use gill nets due to immemorial usage.

Generally, local fishing rules are applied in rivers beside the national legislation. Often these rules may be bag limits, ban on landing female salmon from 1st of August, and a maximum number of fishing licenses sold per day. In River Örekilsälven the fishing association has determined that the open season for 2014 will be 1st of May – 15th of September, i.e. 1½ months shorter than allowed according to national rules.

From 2014 there is a bag limit on rod and line fishing of two salmonids per person and day. This will have little effect on the total catch of salmon, whereas the catch of sea trout may decrease 10%.

Starting in year 2005 all reared salmon and sea trout smolts must have their adipose fin removed (fin-clipping) before release.

7.2 Mixed stock fisheries

The commercial coastal catch, 34 % of the total catch in weight in 2013, is a mixed stock fishery. As no sampling programme is established the amount of wild and reared (fin-clipped) fish has to be estimated from catches in nearby rivers. Also the proportion of MSW fish has to be estimated the same way. Which stocks are caught can't be evaluated as a screening of a genetic base-line is missing, i.e. it is not possible to separate stocks using tissue samples.

Also within the three river systems with releases of reared salmon there is mixed stock sport fishing on wild and reared salmon. It is not required by national legislation or local fishing rules that caught wild salmon is released back in these systems, although the wild stocks in tributaries of Rivers Göta älv and River Nissan have been pointed out by HELCOM as weak (HELCOM 2011).

In the large River Göta älv wild salmon was lost from the main stem in the 1920s due to hydropower development. Wild salmon remained in the lower tributaries and recent genetic studies show that they (River Säveån and River Grönån) are still genetically distinct in spite of releases of reared salmon in the main stem since 1983 (Palm et al. 2011). In the sport fishing statistics, from Lilla Edet and Trollhättan in the main stem, 25% of the catch was made up of wild fish in 2011, 36% in 2012 and 39% in 2013.

In River Nissan several small tributaries holds naturally reproducing salmon. As salmon was extinct in the river system from the 1920s the wild production today (first record in 1981) stems from releases of nearby River Lagan strain. Releases of Lagan strain continue (Table 1).

In River Lagan the original population is lost and instead reared salmon is released. However, in the tributary Smedjeån a wild salmon stock exists. In the main stem 3.8% of caught salmon was wild, i.e. not fin-clipped, according to voluntary reporting from fishermen in 2011. In 2012 this number was 1.2%. No data were available for 2013.

7.3 Seal and cormorant predation

On the Swedish west coast the population of harbour seals (*Phoca vitulina*) is estimated to be 15,000. In the brood-stock fishing at river Lagan in 2012, 3 out of 404 salmon caught (0.7%) had wounds suspected to be from seals. Complaints from sport fishermen regarding seal-inflicted injuries are rare. Danish studies reveal that predation of cormorants on smolts may have a profound effect (Jepsen et al. 2010), but this is not studied in Sweden.

7.4 Restoration & liming

As from 1978 an intense liming programme is carried out to counter-act salmon mortality. Most (18 of 23) of the rivers or tributaries to rivers are included in the liming programme. It has been estimated that circa 50% of the wild salmon smolt production would be lost without liming (Appelberg et al. 1989).

During 2013 river restoration projects were active in some rivers. A large restoration project in River Rolfsån aims at letting the Atlantic salmon again reach the upper reaches which have been inaccessible since 1909. In River Ätran one of the two lower most parallel power plants will be eliminated, leaving half of the old river bed free for passage of fish. In River Säveån a fish way was built at Hedfors, the longest by-pass in Scandinavia.

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Appendix 1.

Catch in numbers of salmon. Ranched is catch in rivers Lagan (rod and line and brood stock.)

	Total		Wild		Ranched	
Year	1SW	MSW	1SW	MSW	1SW	MSW
1971	6330	420	6220	254	110	166
1972	5005	295	4943	201	62	94
1973	6210	1025	6124	895	86	130
1974	8935	660	8870	563	65	97
1975	9620	160	9620	160	0	0
1976	5420	480	5420	480	0	0
1977	2555	360	2453	206	102	154
1978	2917	275	2903	254	14	21
1979	3080	800	2988	661	92	139
1980	3920	1400	3842	1283	78	117
1981	7095	407	7013	284	82	123
1982	6230	1460	6177	1381	53	79
1983	8290	1005	8222	903	68	102
1984	11680	1410	11584	1266	96	144
1985	13890	590	13810	470	80	120
1986	14635	570	14415	240	220	330
1987	11860	1700	11450	1084	410	616
1988	9930	1650	9604	1160	326	490
1989	3180	4610	2803	4044	377	566
1990	7430	3135	6839	2249	591	886
1991	8990	3620	8599	3033	391	587
1992	9850	4655	9550	4205	300	450
1993	10540	6370	9468	4762	1072	1608
1994	8035	4660	7347	3628	688	1032
1995	9761	2770	8933	1528	828	1242
1996	6008	3542	5318	2507	690	1035
1997	2747	2307	2415	1809	332	498
1998	2421	1702	1953	1000	468	702
1999	3573	1460	3075	712	498	748
2000	7103	3196	5660	2546	1443	650
2001	4634	3853	3504	3026	1130	827
2002	4733	2826	3374	2075	1359	751
2003	2891	3214	1833	496	1058	2718
2004	2494	2330	1537	1528	957	802
2005	2122	1770	1503	1027	619	743
2006	2585	1772	1676	1069	909	703
2007	1228	2442	521	1001	707	1441
2008	1197	2752	615	1112	582	1640
2009	1269	2495	651	979	618	1516
2010	2109	3066	1111	1139	998	1927
2011	2726	5759	1460	3100	1266	2659
2012	1900	4826	1336	3130	564	1696
2013	1052	1996	874	1431	178	565