IP(09)19

Protection, Restoration and Enhancement of Salmon Habitat Focus Area Report

EU-Sweden

1. Introduction

On the west coast of Sweden there are 23 rivers with Atlantic salmon populations. Several of these rivers are small, with catchments down to 30 km^2 (Table 1, Figure 1). The largest two rivers (River Göta älv and River Lagan) only have salmon in tributaries, because of canalization for navigation and hydropower development. These are the only populations that have been lost, but in most of the rivers the accessible length of the rivers has decreased due to dams.

Table 1. All rivers with salmon on the Swedish west coast, i.e. with salmon migrating to the Atlantic Ocean. For two rivers data refer to tributaries with salmon, whereas the populations in the main rivers are lost.

River name	Catchment area (km^2)	River length (km)	Average flow (m^3/s)	Only salmon in tributaries
Enningdalsälven	782	75	12,5	
Strömsån	256	30	4,5	
Örekilsälven	1340	90	22	
Bäveån	301	35	3,4	
Arödsån	30	12	0,4	
Bratteforsån	76	25	1	
Anråse å	101	18	1,1	
Göta älv	(1484)	(100)	(20)	X
Kungsbackaån	302	28	5	
Rolfsån	694	75	13,4	
Löftaån	309	30	2,3	
Viskan	2202	150	34	
Himleån	201	38	2,6	
Tvåkersån	92	22	1,3	
Törlan	72	20	1	
Ätran	3342	250	51,6	
Suseån	450	50	7,6	
Nissan	2686	200	38	
Fylleån	394	50	7	
Genevadsån	224	37	3,7	
Lagan	(227)	(46)	(4)	X
Stensån	284	47	4,7	
Rönneå	1897	100	20	
Average	773,0	65,8	11	

It is estimated that 237 ha salmon habitat is available today. The smolt production is not measured, but from electrofishing data it has been estimated to 200 000 annually, i.e. approximately 850 smolts per hectare (Fiskeriverket 1999). No recent estimate is available.

The wild salmon populations are monitored by counting ascending spawners (one river), counting sea-migrating smolts (one river) and especially through an extensive electrofishing programme. The electrofishing 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 22 of the salmon rivers are sampled, each at multiple sites. All data are reported to the Swedish Electrofishing RegiSter (SERS) at the Swedish Board of Fisheries. Along with

the population estimates, fishery catch statistics is gathered and reported to NASCO and ICES. Due to the recent spread of the parasite *Gyrodactylus salaris* (Figure 1) a monitoring programme was launched 2001.

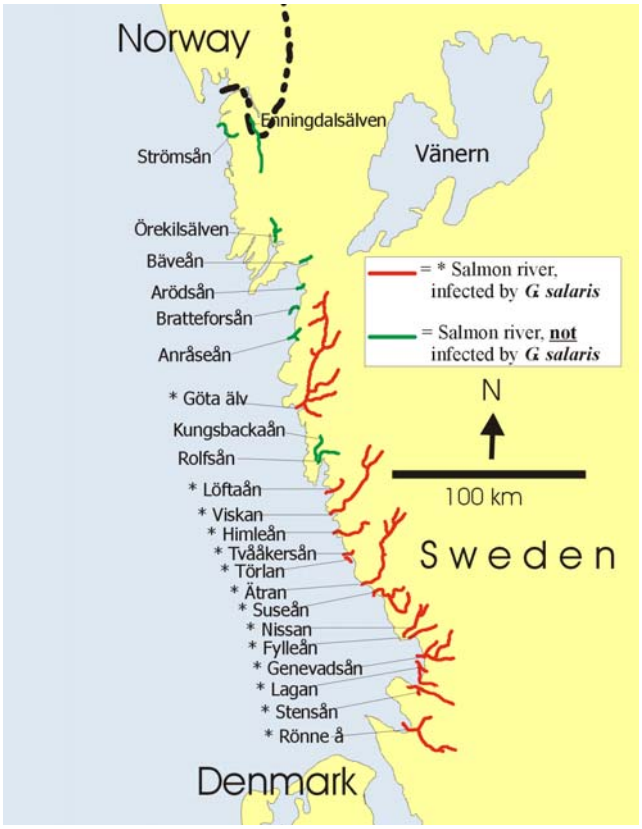

Figure 1. Map showing the position of Swedish salmon rivers on the west coast. Further, the distribution of the ectoparasite Gyrodactylus salaris is shown.

The stocks of salmon have been declining since the late 1980ies, as is the case for most Northeast Atlantic stocks (Friedland et al. 2009). The electrofishing monitoring in Sweden has shown a decline from an average of approx. 150 salmon parr per 100 m^2 in 1988 to 60 parr in 2008, a decline of 60% (Figure 2). This is in spite of a substantially reduced fishing in national (Karlsson 2009) and international waters (ICES report to NASCO 2009).

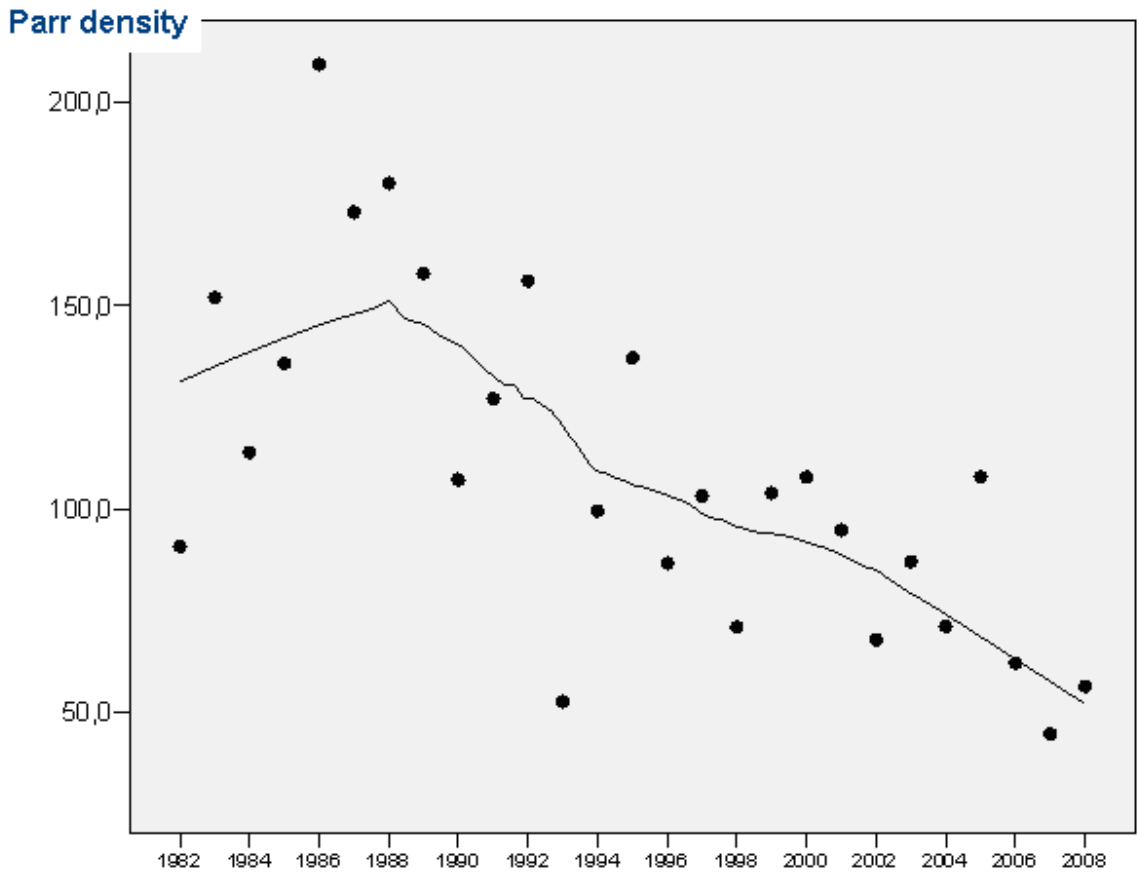

Figure 2. Average salmon parr densities of 14 selected salmon rivers on the Swedish west coast in the period 1982-2008. Data from the Swedish Electrofishing RegiSter (SERS).

2. Current status of salmon habitat

Migration obstacles

Several anthropogenic activities interact with salmon as this species is long-migrating and utilizes fast-flowing freshwater habitats. Five of the major threats to the Swedish populations in freshwaters are migration obstacles, habitat deterioration, acidification, spread of *Gyrodactylus salaris* and eutrophication. Elimination of migration obstacles and habitat restoration could increase available salmon habitat by 18% (Table 2). Much of this work has been initiated recently.

Table 2. Available salmon habitat today and potential habitat that may be available after construction of fish passes or elimination of dams. Also included is habitat that will be improved after habitat restoration.

River name	Habitat available (ha)	Potential habitat (ha)	Increase in per cent
Enningdalsälven	1,7	0,8	47,1
Strömsån	1,045	0,055	5,3
Örekilsälven	23	0	0,0
Bäveån	0,5	0	0,0
Arödsån	0,95	0,25	26,3
Bratteforsån	2,1	0,5	23,8
Anråse å	2,2	0	0,0
Göta älv	17,23	6,37	37,0
Kungsbackaån	4,4	0,1	2,3
Rolfsån	3,1	0,5	16,1
Löftaån	1	1,5	150,0
Viskan	16,08	9,4	58,6
Himleån	6,6	0	0,0
Tvåkersån	1,2	0,8	66,7
Törlan	0,9	0,35	38,9
Ätran	54,9	9,9	18,1
Suseån	9,5	2,8	29,5
Nissan	10,9	2	18,3
Fylleån	17,8	2	11,2
Genevadsån	13,91	0,69	5,0
Lagan	8,82	1,08	12,3
Stensån	12,44	1,06	8,5
Rönneå	27	2	7,4
Average	237,2	42,2	17,8

Habitat deterioration

Most of the smaller rivers have their lower parts in agricultural areas. Here the rivers have been channelized. Chanellization is also common in stretches downstream of hydropower plants in the larger rivers. Also for timber floating and navigation some rivers have lost good salmon habitat.

Habitats have been restored since the 1970ies, but work still remain. It is estimated that 17 of 23 rivers (74%) require habitat restoration, which will significantly affect salmon production (Table 2 and 3).

Table 3. Required habitat measures to keep and increase salmon production in the Swedish salmon rivers.

River	Altered water regulation	Elimination of migration obstacles	Habitat restoration	Increased buffer zones	Liming operations
Enningdalsälven			1	1	1
Strömsån				1	1
Örekilsälven	1	1		1	1
Bäveån	1	1			1
Arödsån		1		1	1
Bratteforsån	1			1	1
Anråse å	1	1		1	1
Göta älv	1	1	1	1	1
Kungsbackaån	1	1	1	1	1
Rolfsån	1	1	1		1
Löftaån			1	1	1
Viskan	1	1	1	1	1
Himleån			1	1	1
Tvåkersån	1	1	1		
Törlan		1	1	1	
Ätran	1	1	1		1
Suseån	1	1	1	1	1
Nissan	1		1		1
Fylleån		1	1		1
Genevadsån	1	1	1	1	1
Lagan	1		1	1	1
Stensån		1	1	1	1
Rönneå	1	1	1	1	1
	15	**16**	**17**	**17**	**21**

As several rivers have extensive land use in the form of forestry and agriculture in the catchment, the need for buffer strips (zones) is large. Swedish law does not require a buffer zone to be left, but it is encouraged as a part of the environmental consideration. Fiskeriverket (1999) estimated that buffer strips needed to be increased at 17 of the rivers, mainly in agricultural areas. In forested areas normally 5-10 m wide buffer strips are used.

Acidification

Since at least the 1960ies acidification has been an important threat against wild populations of salmon. To counteract the negative effect of acid water extensive liming operations (where fine-grained limestone is used), funded by the Swedish Environmental Protection Agency, are carried out annually in Sweden. It has been estimated that 50-75% of natural salmon smolt production on the Swedish west coast would have been lost without liming (Appelberg et al. 1989, Degerman & Schibli 1998). The acid deposition has decreased, but the recent estimate is that still two thirds of the production of smolts depends on liming activities. In fact, 21 salmon rivers require liming operations to improve the water quality (Table 3).

Eutrophication and toxic substances

Several of the rivers were almost void of salmonid production in the 1960ies. River Nissan was locally called “döda floden” (dead river) due to toxic substances from pulp mills upstream. Also in the River Viskan dieldrin, a chlorinated hydrocarbon used as an insecticide, made fish toxic in the 1960ies. Fish kills occurred in the 1970ies in River Strömsån due to pentachlorophenol (PCP) used for preserving wood. Since then the problem of toxic substances has decreased. But, toxic substances of various natures are a potential problem in 9 rivers (Table 4). No direct effect on salmon is evident.

According to the Water Framework Directive the ecological status of all surface waters are classified into five categories (high, god, moderate, poor and bad). The Water Framework Directive sets a target of aiming to achieve at least ‘good status’ in all waters by 2015. Good chemical status is measured as pass or fail. Although eutrophication, i.e. an increase of nutrients, is at hand in the lower part of all salmon rivers (Fiskeriverket 1999) the chemical status today is classified as good in all (Table 4). However, the ecological status is good in only 7 (32%) out of 22 classified rivers (Table 4). The cause of moderate and even poor ecological status in the lower parts of the salmon rivers is complex, but the classification is often based on benthos or fish indicating eutrophication.

Table 4. Classification of ecological status (five classes) and chemical status (two classes) in the lower part of salmon rivers in the year 2009 according to Västerhavets vattendistrikt (Water Framework Directive River Basin Directory of the Swedish West coast).

River name	Ecological status	Chemical Status	Toxic substances	
Enningdalsälven	Good	Good	No	
Strömsån	Good	Good	No	
Örekilsälven	Moderate	Good	Yes	
Bäveån	Moderate	Good	Yes	
Arödsån				Not classed
Bratteforsån	Moderate	Good	Yes	
Anråse å	Good	Good	No	
Göta älv	Moderate	Good	Yes	
Kungsbackaån	Moderate	Good	No	
Rolfsån	Good	Good	No	
Löftaån	Moderate	Good	No	
Viskan	Moderate	Good	No	
Himleån	Moderate	Good	Yes	
Tvåkersån	Moderate	Good	Yes	
Törlan	Moderate	Good	No	
Ätran	Good	Good	No	
Suseån	Moderate	Good	No	
Nissan	Good	Good	Yes	
Fylleån	Good	Good	No	
Genevadsån	Moderate	Good	No	
Lagan	Moderate	Good	No	
Stensån	Moderate	Good	Yes	
Rönneå	Poor	Good	Yes	

3. Processes for identifying priority/key habitats and required actions

Habitat restoration has a long history in Sweden, but on a larger scale it started in the 1970ies. In the first decades focus were on improving habitats for the cause of primary salmon and sea-run trout. The methods used were mainly the construction of technical fishways (fish ladders) and increasing habitat diversity by adding stones and boulders to potential salmonid habitat. Successively, the methodology and the focus have changed. Today the focus is on restoring habitats to their former status, thereby increasing salmonid production to its former level. More focus is put on restoring spawning areas, re-meandering rivers and elimination of dams. Also measures as adding large woody debris and increasing buffer zones have become more common. Fishways that are built are today often natural (by-passes) than yesterdays fish-ladders. The Swedish Board of Fisheries and the Environmental Protection Agency have produced an extensive manual for the restoration of rivers in 2008 (Fiskeriverket and Naturvårdsverket 2008).

Management of salmon habitat is now delivered at a strategic level through the Water Framework Directive (WFD). The WFD obliges all countries throughout the European Union to manage the water environment to consistently high standards. The principal environmental objectives for surface waters are to prevent any further deterioration in the classification status of aquatic ecosystems, protect them and improve the ecological condition of waters. The aim is to achieve at least good status for all waters and promote sustainable use of water as a natural resource.

Identification of key habitats and required actions has been going on since the 1980ies and was compiled by the Swedish Board of Fisheries in 1999 (Fiskeriverket 1999). The present work is carried out by the three County Administrations (the County of Västra Götaland 10 rivers, the County of Halland 12 rivers and the county of Skåne 1 river).

The basis of classification of key habitats and required actions are electrofishing monitoring, chemical monitoring (nutrients, pH, aluminium), and a standardized habitat classification. The electrofishing programme is extensive and run by the County Boards with funding from the Swedish Board of Fisheries and the Environmental Protection Agency. Evaluation of electrofishing results are done according to different methods, mainly using an index of biotic integrity (Beier et al. 2007) and evaluation if stipulated goals for parr density are met. These goals are set by the County Boards and differ between rivers. As a rule of thumb a density of 100 salmonid parr per 100 m^2 is used, but normally more precise goals are established using data from the Swedish Electrofishing RegiSter (SERS, Sers et al. 2008).

In case of weak fish populations inventories are made of potential problems. The standardized habitat classification (Halldén et al. 1997) describes the present status of the river bed, littoral zone and buffer zone. A uniform stretch of 30-1000 m of the rivers is classified and all the river length is checked by two persons walking by foot. It is possible to characterize approximately 6 km per day. Today only a few of the rivers are characterized, but the methodology is used more frequently, successively. It is aimed at describing the habitat for salmonid fish and the habitat is classified into four classes for spawning and as parr habitat.

From these available data, which also are published on the Internet, the status of salmonid stocks and the habitat, physical and chemical, is continuously monitored and evaluated. The required actions needed in the freshwater habitat are decided by the County Administrations,

guided by national guidelines regarding chemical constituents and fish population status. The Swedish Board of Fisheries compiles the status of stocks and habitat. Habitat restoration and the funding are compiled in a national database (Åtgärdsdatabasen). Today there is no national database of the habitat classification. These inventories are in the meanwhile stored by the individual counties. Electrofishing data are stored in the national database, Swedish Electrofishing RegiSter.

4. Activities to share and exchange information

Information exchange is predominately done using open databases, guideline documents on the Internet, seminars and workshops. In cooperation with the Sportfishing Union of Sweden seminars open to the public on the status of the Atlantic salmon are held, normally with invented speakers from other countries.

As stated previously much of the relevant data can be accessed by the public on the Internet. Data can be downloaded for free and are frequently used by the County Boards, consultants and NGO's.

The fishing rights of the salmon rivers are generally privately owned. In most rivers the fishing right owners have formed "fisheries management areas" (FMA, fiskevårdsområden) with a selected board. They are always contacted before actions are undertaken in the rivers.

As a part of the Water Framework Directive (WFD) citizens are encouraged to participate in Catchment Management Advice Groups (CMAG). CMAG are formed in all major river basins.

Habitat restoration workshops are carried out twice each year in Sweden. In the year 2007 the seminar was carried out in River Rolfsån and in the year 2008 the upper parts of River Nissan was used for field excursions. These seminars are visited by consultants, scholars and regional and local authorities. In 2009 one workshop will be held in the town of Falkenberg and River Ätran will be in focus. Thus, restoration of the salmon rivers on the Swedish west coast is encouraged and exemplified. All habitat restoration work is carried out according to the guidelines given in:

Fiskeriverket and Naturvårdsverket, 2008. Ekologisk restaurering av vattendrag. (Ecological restoration of rivers). Naturvårdsverket & Fiskeriverket, Internet, 300 p. http://www.fiskeriverket.se/service/varorochtjanster/ekologiskrestaureringavvattendrag.4.6c4377b411c8913db65800035.html (In Swedish).

5. Description of plans

National plans
Several national authorities including the Swedish Board of Fisheries, the Environment Protection Agency and the concerned County Administrations participate in the ongoing management and monitoring of rivers with wild salmon production on the Swedish west coast. In addition several local organisations and NGOs take active part in the rehabilitation and management of the rivers.

The status of the rivers with Atlantic Salmon populations has been described in detail in a report from 1999 (Fiskeriverket 1999) and a revised report will be made during 2009. Specific measurements for each salmon river have been recommended and a comprehensive national programme has been developed and has started to be implemented.

A basic criteria for local organisations to receive governmental funding for habitat protection and restoration in a river is that the estimated potential should at least be 1000 wild salmon smolts per year. Many of the smallest rivers are being biologically restored in conjunction with ongoing long term liming programmes. Voluntary work and funding from various non - governmental funds are also important parts of the work.

The Swedish Board of Fisheries has developed a national plan for Atlantic salmon for 2007-2011. It comprises three parts:

1 Management of salmon fisheries
The long term objective of the Swedish implementation plan is to reach the potential level in all 23 rivers. The medium term objective for the period 2007 – 2011 is to reach at least 75 % of the total potential production level and that at least 50 female salmons should spawn, where physically possible, in each river in order to reduce the risk for genetic erosion. This target refers to the NASCO goal of maintaining all salmon stocks above their conservation limits.

The quality of the assessment of the potential production levels in each river is improving and new information regarding the possible production in various local areas will be used to revise the present potential during 2009 (initially scheduled to 2008).

Data from the index river Ätran will be used for setting the goals during the period. As of yet goals are set from parr densities, as described earlier. As an extensive electrofishing programme is in operation, data on 22 of 23 rivers are gathered and evaluated annually.

Included in the management is a also a revision of catch statistics, and efforts to minimize fishing of wild salmon in the coastal fishery.

2 Protection and restoration of Atlantic salmon habitat
Potential production levels are linked to available habitat area suitable for salmon, which is expected to increase within the period. The goal for this part (Protection and restoration of Atlantic salmon habitat) is not fixed. As stated in section 2, table 2, a potential of 18% increase in habitat quantity is possible given that fish can reach the areas and in some cases that the permits for the hydropower plants are renegotiated.

The quality of present salmon habitat will be further enhanced during the period and the set goal for liming activities are to achieve a pH of at least 6,3, which will protect salmon reproduction. The pH-goal is evaluated annually.

There is a need to conserve habitats and species that are directly dependant upon water. Many of the salmon rivers are today included in the Natura2000 network of protected areas. Several are also protected as nature reserves according to Swedish legislation. The estuary of River Kungsbackaån and River Rolfsån is a large nature reserve with strict limitations on fishing and exploitation.

3 Management of aquaculture, introductions and transfers and transgenics

Stocking measures and aquaculture activities are under strict control of competent authorities in order to minimise possible effects on wild stocks and risks for spreading of diseases. All stocking and aquaculture activities require a permit from the Count Administrative Boards and new aquaculture establishments in salmon rivers are banned according to regulations issued by the Swedish Board of Fisheries.

Regional plans

Regional goals for each salmon river are set by the County Administrative Boards, especially regarding chemical status (nutrients, pH, aluminium). In all rivers a habitat restoration plan is established. These plans are revised every fifth year (next time 2011). The plans in detail describe each action and the required funding.

As an example the habitat restoration plan for River Rolfsån 2007-2011 can be presented (http://www.lansstyrelsen.se/vastragotaland/projektwebbar/rolfsan/). During the period seven fish passages are planned. This would make all of the former salmon habitat available. It has been closed off by dams since 1911. Habitat restoration is also planned at one river stretch downstream a hydropower plant. Further, increased minimum flow at two hydropower plants are planned. This will be achieved by simply buying water.

6. Overview of ongoing activities

Fish passages
During 2008 fish passages were established in River Genevadsån (at Vessingeån) and two are being built at River Rolfsån (at Apelnäs and Bosgården; finished during 2009).

During the period 2006-2009 several more fish passages are planned in River Rolfsån, River Göta älv (in the tributary River Säveån at Hedefors, estimated cost 1.2 million Euro) and an old fishway is being restored in River Örekilsälven (at Torp).

During 2007 the last migration obstacle was eliminated in River Himleån. The whole river, with tributaries, is today accessible for salmon and sea-run brown trout.

In 2010 it is planned to eliminate one hydropower plant in River Ätran. Salmon can today pass the plant using a fishway (Denil-type) since 1945, but elimination of the plant will further enhance the spawning run and also the smolt migration. The estimated cost is 1.8 million Euro.

Habitat restoration
Habitat restoration was performed in River Göta älv, at River Säveån Jonsered, in 2007. It is estimated that this area will produce an extra 300 salmon smolts annually.

Restoration has been undertaken in River Himleån in 2007-2008. Also in 2009 a part of the river will be re-meandered.

In River Enningdalsälven habitat restoration of Långevallsälven is planned to 2010.

Several other habitat restoration operations will be carried out, e.g. in tributaries to River Viskan (at the stream Musån) and River Lagan (in River Smedjeån).

Increased water from hydropower plants
The water flow downstream of the hydropower plant at Aspen, River Säveån, was increased from initially 0,5 m^3/s after water court decision to 2,4 m^3/s in 2008. This is estimated to produce an extra 560 salmon smolts annually.

Elimination of private fishing with a trap
In River Fylleån a private salmon trap has been operating. In 2008 the County Board bought the fishing rights and the fishing has ceased. Private fishing with traps today only exists in River Rolfsån.

Liming
Liming operations will be continued in all rivers.

Monitoring
Monitoring of parr populations are undertaken annually in 22 of the rivers. Generally this is carried out by the County Administrative Boards. Data are each year compiled and evaluated at a national level.

Index river

In the Index River Ätran, with the tributary River Högvadsån, work has continued to establish the catch efficiency of the smolt trap. The efficiency varies with water flow. Another year with high spring flow is required for a final evaluation.

In the river tagging of migrating wild salmon smolts has been carried out annually (Karlsson 2009). An extensive electrofishing programme is also carried out. Earlier ascending spawners were checked at two sites (Herting and Högvadsån), but since the dam at Herting will be eliminated, monitoring of spawners will continue only in Högvadsån.

The river habitat has not yet been classified according to Swedish habitat classification standards.

Gyrodatctylus monitoring

The monitoring of occurrence and infestation of Gyrodactylus salaries continues. Field experiments comparing growth and survival of infected and un-infected salmon parr have been carried out. The results indicate a significant effect on growth and condition factor of Gyrodactulus on parr.

7. References

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