Abundance of salmon spawners and smolt

Authors

ICES Working Group for Baltic Salmon and Sea trout (WGBAST) and Miia Mannerla (HELCOM SALAR project)

Reference to this core indicator report: [Author's name(s)], [Year]. [Title]. HELCOM Core Indicator Report. Online. [Date Viewed], [Web link].

Contents

Key message

Smolt production in the Bothnian Bay has increased in recent years as a result of stricter management measures, allowing higher number of adult spawners to ascend the rivers. However, GES is reached only in two rivers.

In the Bothnian Sea, the smolt production is low, though slightly increasing.

In the Gulf of Finland and the Baltic Proper the smolt production is low and has not shown signs of improvement. Two Estonian rivers were assessed to be in GES by expert judgment.

In Kattegat, there are three rivers reaching GES.

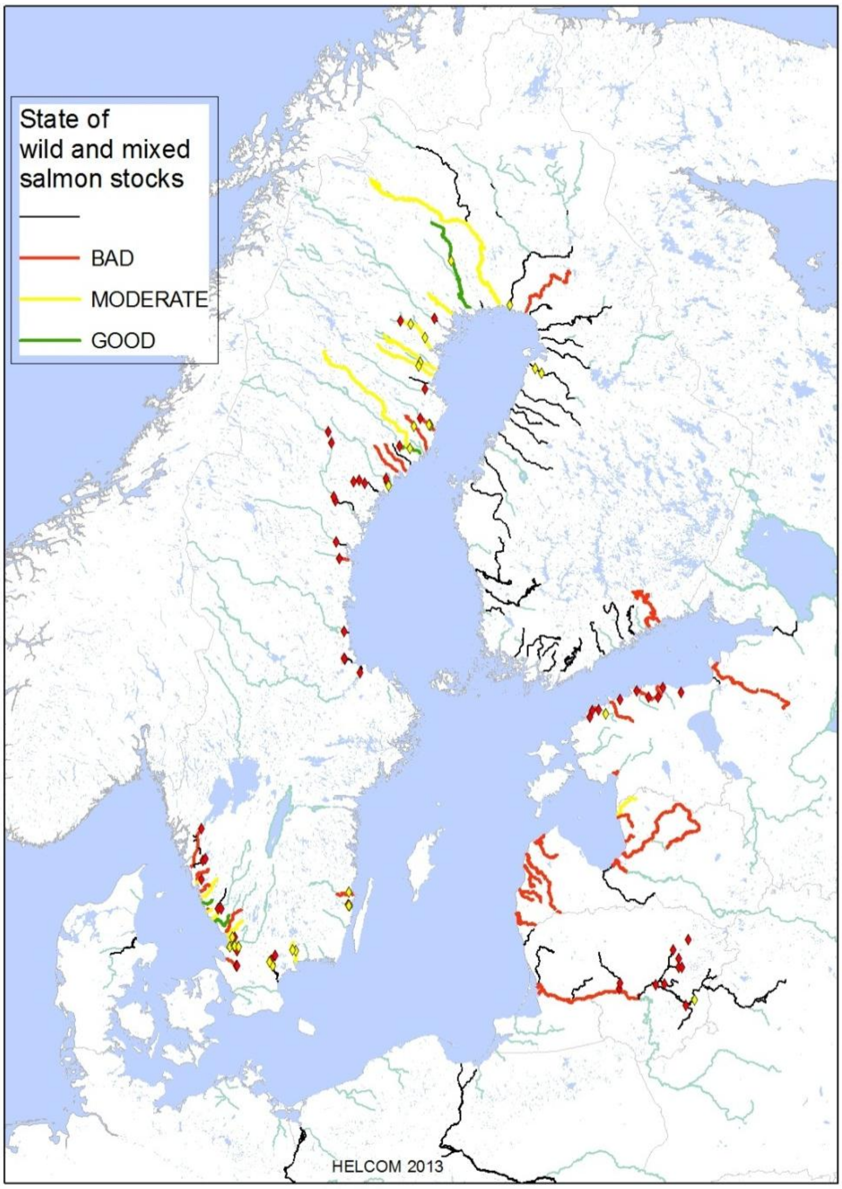


Figure 1. *Status of wild and mixed Baltic salmon stocks. Source: ICES WGBAST (ICES 2013) and HELCOM SALAR (2011). Dark blue rivers have reared salmon stocks or stocks which have not been included in this assessment. Diamond symbols represent river dams (red: non-passable, yellow: partly passable).* ***Table 2*** *lists all the Baltic rivers with salmon.*

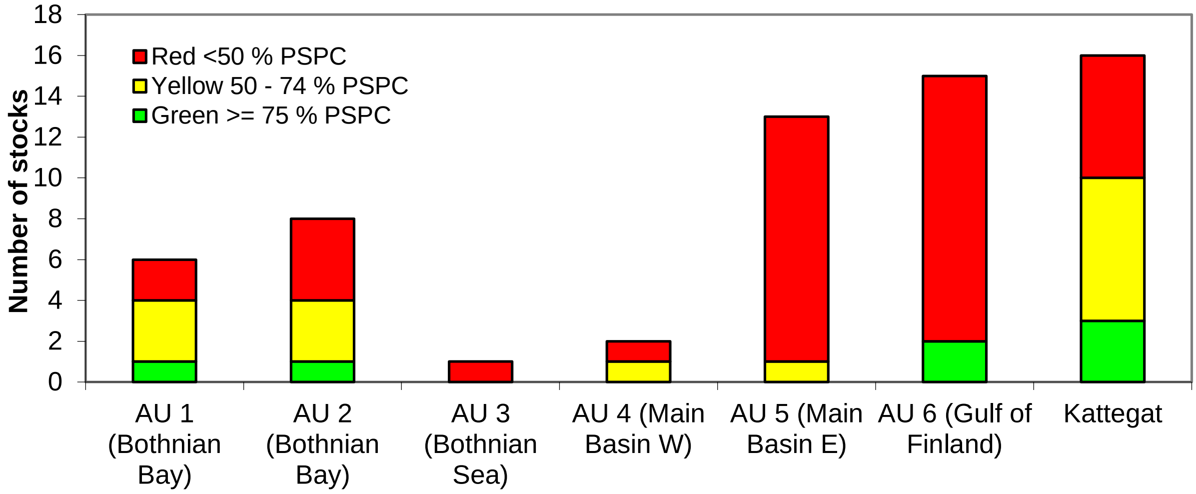


Figure 2. *Overview of the state of 40 Baltic (2009–2012) and 16 Kattegat (2007–2009) salmon river stocks based on natural smolt production. The rivers flowing to Kattegat were assessed on the basis of the HELCOM SALAR project (HELCOM 2011).*

Description of the indicator

Salmon is a long-distance migrating big predatory fish species in the Baltic Sea marine ecosystem. Salmon abundance is affected by commercial fishing at sea, barriers to reproduction areas and natural causes. When smolts enter the sea, they must have enough suitable food items along their migration paths and they must be able to avoid predation and by-catch in other fisheries in order to survive over the first critical year. The adult spawners ascend the spawning rivers after the feeding period and the number of smolts measured from the rivers reflect the abundance of the adult spawners and success of recruitment.

The main parameter of the proposed core indicator is:

1. Smolt production in rivers (Figures 1–3),

, and the core indicator is supported by the following parameters:

2. Number of rivers with self-reproducing salmon populations (Figure 1),
3. Number of spawners in the rivers (Figure 6)
4. Post-smolt survival (relative rate) (Figure 7),
5. Fishing catches (Figure 8).

The proposed core indicator is based on the annual work of the ICES Working Group on Baltic Salmon and Sea Trout (WGBAST) and is supplemented by the results of the HELCOM SALAR project (HELCOM 2011).

Determination of good environmental status

The assessment of good environmental status (GES) is based on the smolt production in the rivers of wild salmon stocks. The potential smolt production capacity of rivers (PSPC) has been estimated and the target (so-called GES boundary) is to reach 75 % of the PSPC. There is however a need to check this target as maximum sustainable yield (MSY) of salmon requires in average a 80 % target in the rivers (see Metadata for details). In the present version of the indicator, the 75 % target of ICES has been used. As the assessment is based on probabilities to reach the target, a minimum of 70 % probability is required to reach GES.

Smolt production and PSPC are estimated for individual rivers but GES is estimated for assessment units. Thus, management measures can be made on river-level, but state of the sea is given on a broader scale.

Assessment units

The ICES WGBAST has divided the Baltic salmon river stocks to six assessment units (AU) on the basis of biological and genetic characteristics of the stocks and associated management objectives (see Figure 7 and Table 1). Stocks of a particular unit assumedly exhibit similar migration patterns and are subjected to the same fisheries, experience the same exploitation rates and are affected by management in the same way. In addition, the genetic variability between stocks of an assessment unit is smaller than the genetic variability between stocks of different units.

Salmon is highly mobile species, migrating long distances to feeding areas in the southern Baltic Proper where also the main fishing pressure takes place. Therefore the assessment units have a limited meaning in the case of salmon.

Links to anthropogenic pressures

The indicator reflects mainly the commercial and recreational fishing and ecosystem state, but also river connectivity (effect of dams) and quality of spawning habitats.

Policy relevance

The proposed core indicator of the Baltic salmon addresses the Baltic Sea Action Plan’s Biodiversity and nature conservation Segment (p. 20 of the BSAP) ecological objectives ’Thriving and balanced communities of plants and animals‘ and “Viable populations of species” (HELCOM 2007).

The proposed core indicator also addresses the following qualitative descriptors of the MSFD for determining good environmental status (Anon. 2008):

- Descriptor 1: ‘Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions‘; and
- Descriptor 3: ’Populations of commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock‘;
- Descriptor 4: ’All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity’.

and the following criteria of the Commission Decision (Anon. 2010):

- Criterion 1.1 (species distribution),
- Criterion 1.2 (population size),
- Criterion 1.3 (population condition, particularly the genetic structure)
- Criterion 1.5 (habitat extent),
- Criterion 3.1 (level of pressure of the fishing activity),
- Criterion 3.2 (reproductive capacity of the stock), and
- Criterion 4.3 (abundance/distribution of key trophic species).
- Also, the indicator has relevance to the BSAP actions of:
- ’Classification and inventorying of rivers with historic and existing migratory fish species no later than by 2012’,

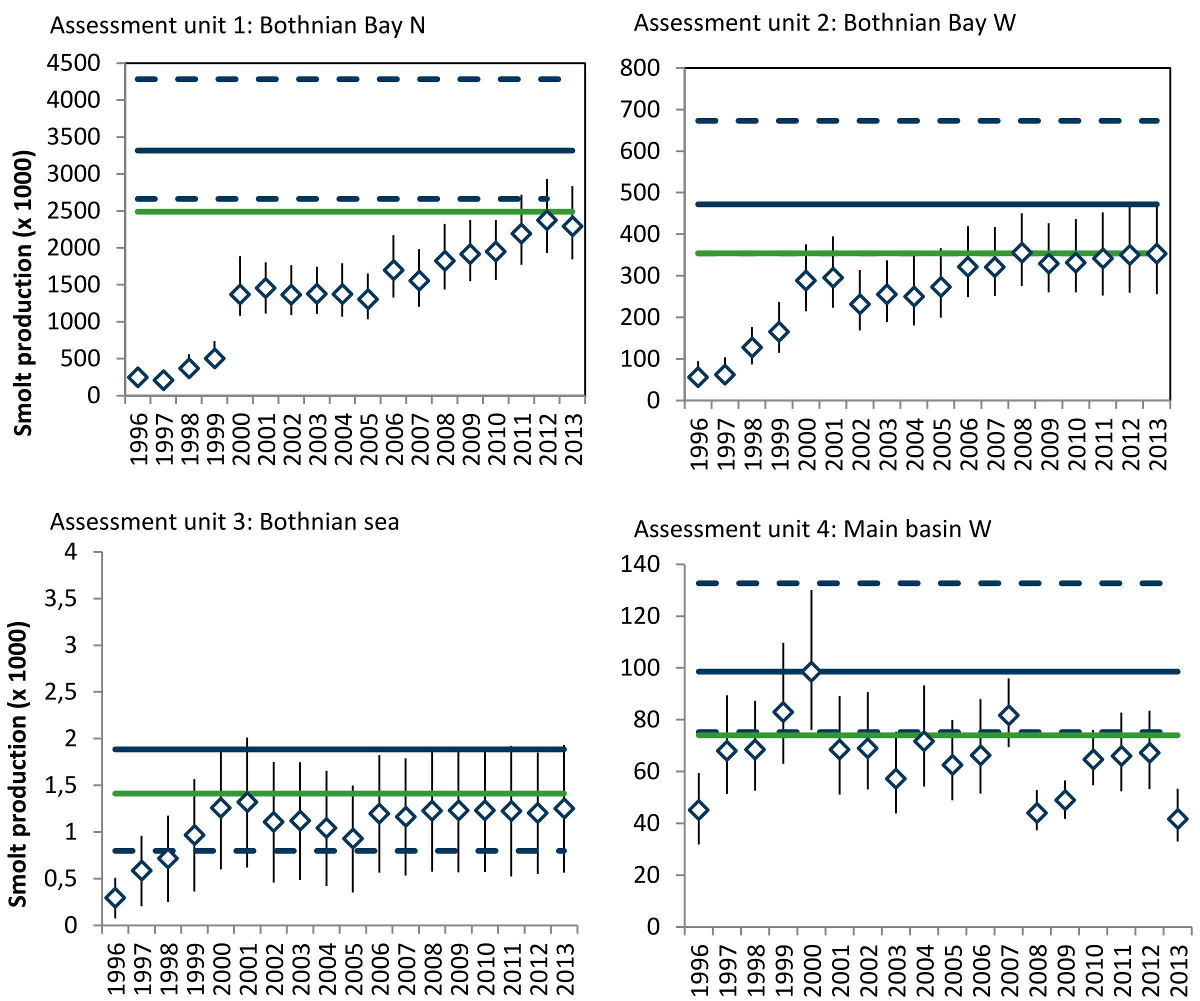
- 'Development of restoration plans (including restoration of spawning sites and migration routes) in suitable rivers to reinstate migratory fish species, by 2010', and
- 'Active conservation of at least ten endangered/threatened wild salmon river populations in the Baltic Sea region as well as the reintroduction of native Baltic Sea salmon in at least four potential salmon rivers by 2009'.

The European Union is launching a multi-annual management plan for the Baltic Salmon, which is currently in the European Parliament. Salmon is listed as a species of community interest in the EU Habitats Directive (Annex II).

What is the status of salmon in the Baltic Sea?

Current status of the Baltic Sea salmon

Of the 56 assessed salmon river stocks only Kalixälven in the Bothnian Bay, Umeå in the Quarck, Keila and Kunda in Gulf of Finland and three stocks in Kattegat (Himleån, Suseån and Stensån) likely or very likely reached 75 % of the PSPC in 2013 (2009 for Kattegat) and can be considered to be in good environmental status (GES). As a result of the strong smolt production in two Bothnian Bay rivers, the entire assessment unit 1 is considered to be with high probability in GES (Figure 3). Similarly, the good smolt production in the river Umeå supported the Assessment Unit 2 to very likely reach GES.



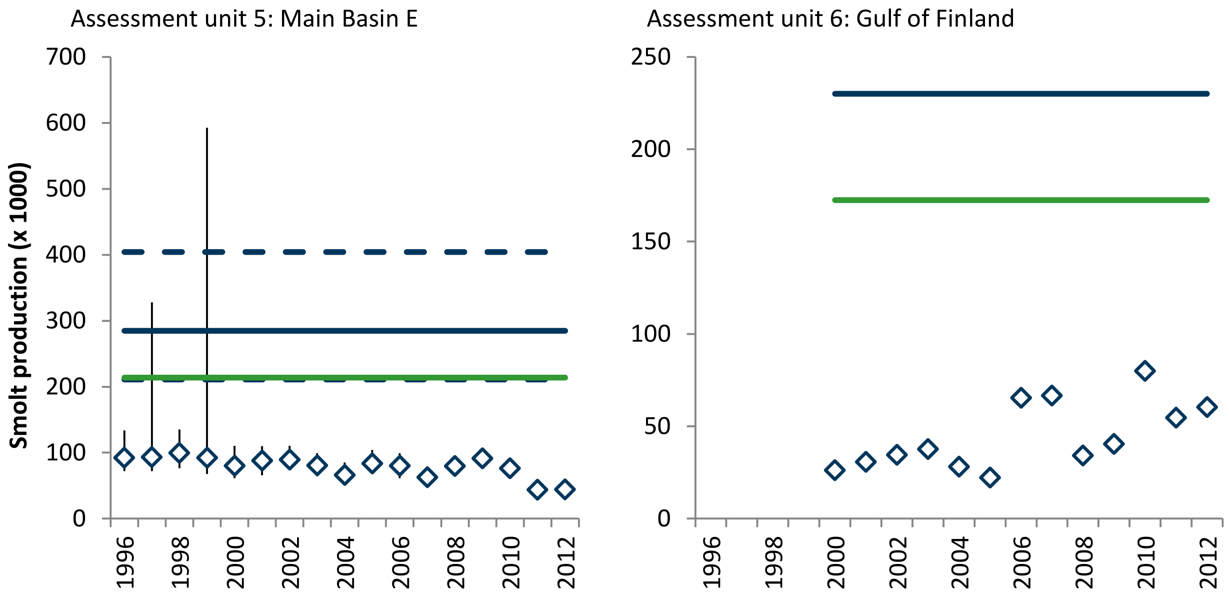


Figure 3. *Status of salmon abundance in 1996–2013, addressed by natural smolt production (median and 95 % PI), in the six assessment units. The sixth assessment unit (Gulf of Finland) was assessed without the model, based on field observations and expert judgment. The potential smolt production capacity (PSPC) is shown by the solid blue line (median) and the 95 % probability interval of PSPC is shown by the dashed lines. GES boundary (green line) is 75 % of the PSPC, presented here as the median of the probability distribution (for simplicity the 95 % PI of the 75 % target is not shown). Assessment Units 5 and 6 do not have quantitative estimates for 2013.*

There are twelve rivers, mainly from the Bothnian Bay and Kattegat, which likely or very likely reach 50 % of the PSPC in 2013. For seven rivers it is uncertain and for 13 rivers unlikely that they reached the 50 % objective in 2013. Many of the rivers with weaker status are situated in the Baltic Proper and Gulf of Finland.

The status of the smolt production of the salmon spawning stocks is highly varying. The situation in the northern Baltic rivers has improved significantly, but most of the rivers in the southern Baltic are far from reaching their potential. However, the current overall production of nearly 3 million has increased six-fold from the1996s when it was less than 500 000 smolts. The Gulf of Finland assessment unit, which is considered as a separate management unit, produced in 2012 in the Estonian, Finnish, and Russian rivers about 48 000 wild smolts (ICES 2013).

The exploitation of salmon has decreased in the Gulf of Bothnia, which at least partly explains the improved status. Also decreasing trend in M74 mortality has played a role. The number of ascending adult spawners – counted in some rivers only – shows that the increase in smolt production is a result of more abundant spawning stock (Figure 6).

In the assessment unit 2 on the Swedish side of the Bothnian Bay, the smolt production has increased only moderately and the river Ljungan in the Bothnian Sea – the only salmon river with natural reproduction in the assessment unit 3 – has low smolt production and shows only weak improvement in recent years.

The status in the southern parts of the Baltic (assessment units 4 and 5) is a different story: the production is currently less than 30 % of the potential smolt production capacity (Figure 3). The slow recovery of these stocks has been explained by overfishing, environmental problems (pollution and eutrophication) and increased predation (in the river).

Salmon stocks in the Gulf of Finland (assessment unit 6) show indications of some recovery but the status of most stocks is still poor.

There is no single reason for the poor status of many of the wild salmon stocks. In the report of the ICES WGBAST, the following factors are discussed: overfishing, eutrophication or local pollution of a river, turbine mortality, poor fish ladders, hybridization with sea trout and stochastic events (ICES 2013). The likely reasons for the state of the southern stocks (AU 4 and 5) are in the river quality and/or declined post-smolt survival.

The WGBAST report (ICES 2013) shows the temporal development of parr densities in the salmon rivers and can be used to see the patterns behind the observed smolt production results.

Salmon spawning rivers

Wild salmon populations spawned in at least 60 rivers in the middle of the 19th century, but today the majority of Baltic rivers are unsuitable for salmon due to damming, mainly for hydroelectric power production, as well as pollution. This has been partly compensated by smolts and parr releases. ICES divides the Baltic salmon rivers into four main categories: wild, mixed, reared and potential.

The salmon wild river stocks differ genetically from each other and therefore their well-being is of high importance from population genetics point of view (cf. MSFD criterion on genetic structure).

Currently there are 56 salmon rivers in the Baltic Sea. Of these, 26 rivers have wild, 12 mixed and 18 reared (completely or partly) salmon populations, respectively (HELCOM 2011, ICES 2013).

Table 1. *The wild salmon rivers in the assessment units in the Baltic Sea.*

Assessment unit 1	Simojoki (FI), Tornionjoki/ Torneälven (FI/SW), Kalixälven (SW), Råneälven (SW).
Assessment unit 2	Piteälven (SW), Åbyälven (SW), Byskeälven (SW), Rickleån (SW), Sävarån (SW), Ume/Vindelälven (SW), Öreälven (SW), Lögdeälven (SW)
Assessment unit 3	Ljungan (SW)
Assessment unit 4	Emån (SW), Mörrumsån (SW)
Assessment unit 5	Pärnu (EE), Salaca (LV), Vitrupe (LV), Peterupe (LV), Gauja (LV), Irbe (LV), Uzava (LV), Saka (LV), Barta/Bartuva (LV/LT), Žeimena (LT)
Assessment unit 6	Kunda (EE), Keila (EE), Vasalemma (EE)

The potential rivers either have ongoing reintroduction programs or occasional reproduction. Especially those rivers that have previously held salmon stocks or rivers that have available spawning habitats are considered potential (HELCOM 2011). Apparent increase in wild reproduction has been documented in at least Kågeälven and Testeboån in Gulf of Bothnia, but most of the potential rivers show only low and irregular wild reproduction in spite of even massive stocking programmes and other rebuilding efforts (ICES 2013). More information of the management measures and their success can be read from HELCOM 2011 and ICES 2013.

In order for salmon to be able to spawn, several criteria need to be met. These include the availability of the spawning and nursery habitats; accessibility to these areas (dams or other migration hindrances may prevent this); good water and habitat quality; as well as sufficient river fisheries management practices (HELCOM 2011).

HELCOM has grouped salmon rivers according to their status into those that should be prioritized for conservation (red), those with intermediate status (yellow) and with good status (green) (Figure 5). The potential or historical salmon rivers are shown in blue in this map. The ranking was made according to the actual production in relation to the potential production (PSPC) so that the populations with the lowest ratio belong to the red list and with the highest ratio to the green list (see more about the criteria and classification in HELCOM SALAR Report, HELCOM 2011).

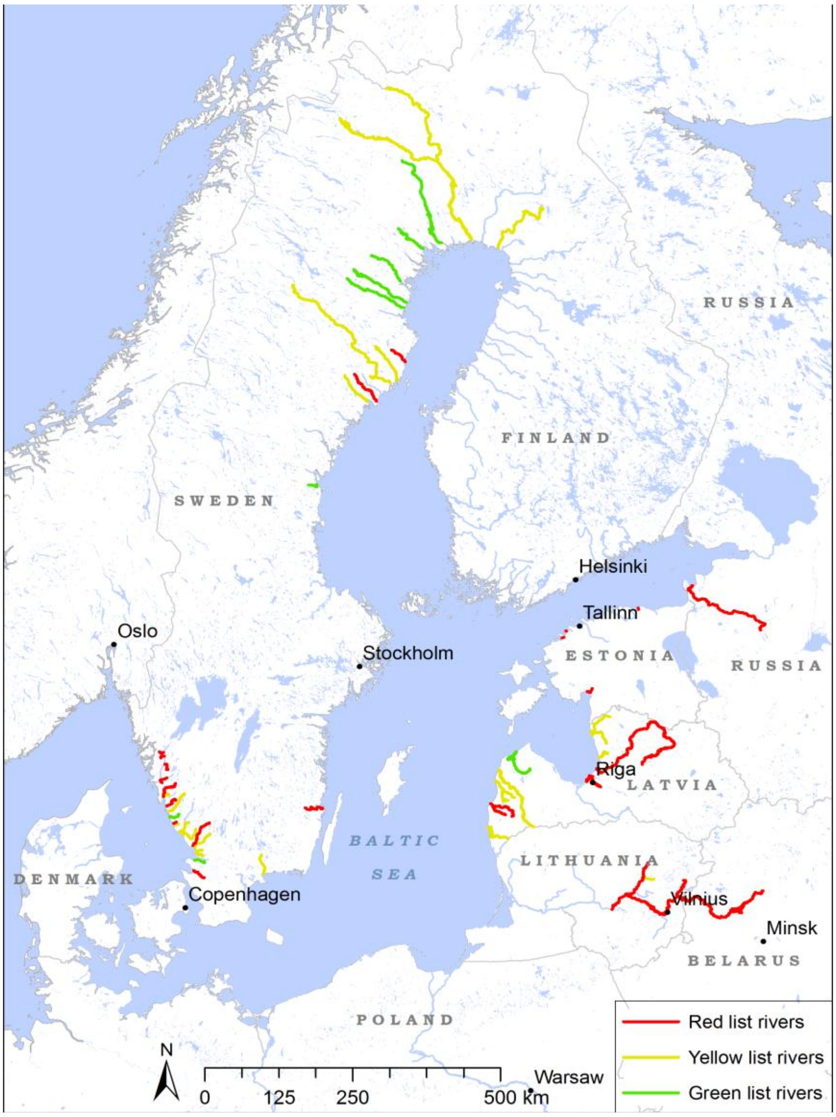


Figure 5. *HELCOM SALAR lists salmon rivers according to their status (HELCOM 2011). Blue rivers are potential or historical salmon rivers.*

Number of ascending adult spawners in the rivers of Bothnian Bay and the Quark

The number of adult spawners has been monitored in some rivers by fish counters. The numbers have increased since mid-1990s (Figure 6). Older data from mid-1970s, shows that the increase in the numbers of spawners began to increase in the 1990s and 2000s, coinciding with the management measures at sea.

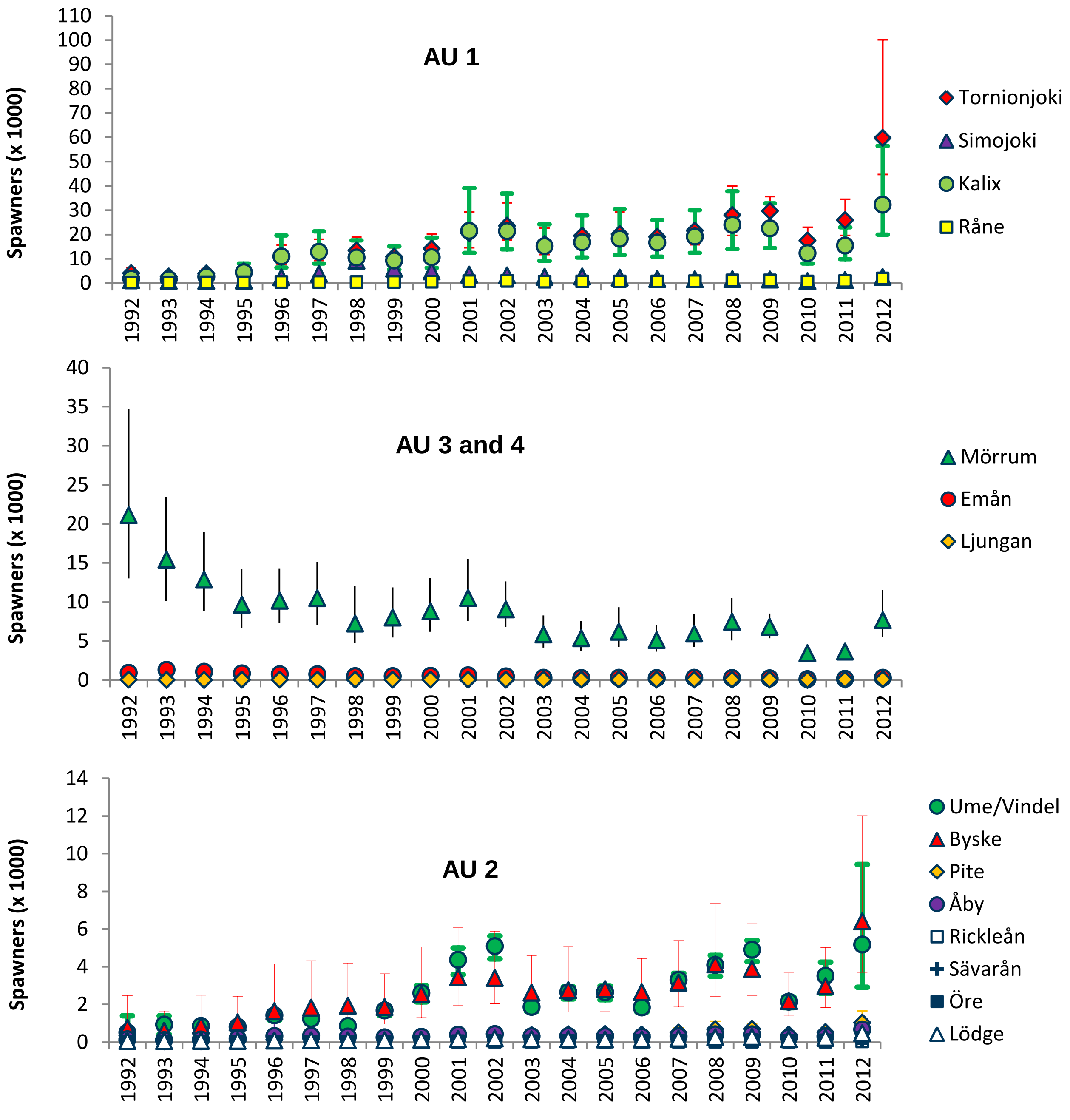


Figure 6. *Number of wild salmon (median and 95 % PI) in fish ladders in rivers in assessment units 1-4 in 1992–2012.*

Post-smolt survival

The post-smolt survival of salmon in the Baltic Sea has declined during the last 15 years and has remained at very low levels since 2005 (Figure 7). The decreased post-smolt survival has been explained by predation from the growing seal population, environmental change and increased by-catch of salmon in pelagic trawling fisheries targeted on other species in the Baltic Sea (ICES 2013, Mäntyniemi et al. 2012). The main prey of the post-smolt salmon are young herring, the abundance of which can explain part of the low survival. The post-smolt survival of the southern stocks in the assessment units 4 and 5 is not well known.

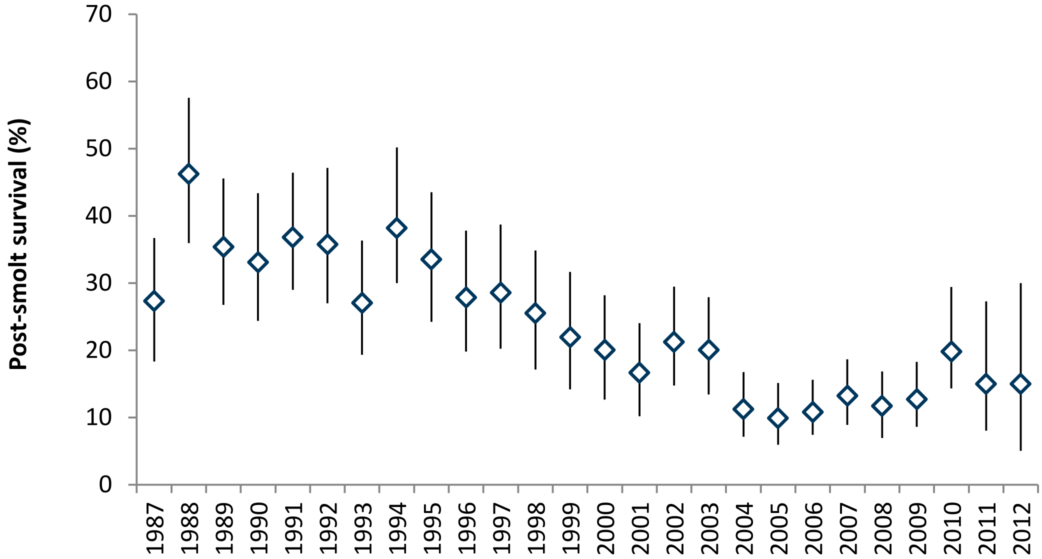


Figure 7. *Post-smolt survival (%, 95 % CI) of the wild Baltic salmon stocks (modified from ICES 2013).*

Fishing catches

Catches of salmon by commercial fishery at sea has decreased since the 1990s, but the river fishing has stayed rather stable. The driftnet ban in 2008 resulted in record low mortality in off-shore fisheries, but that was quickly compensated by the increase of long-line fishery. Also the long-line fishery is expected to decline in coming years, as a

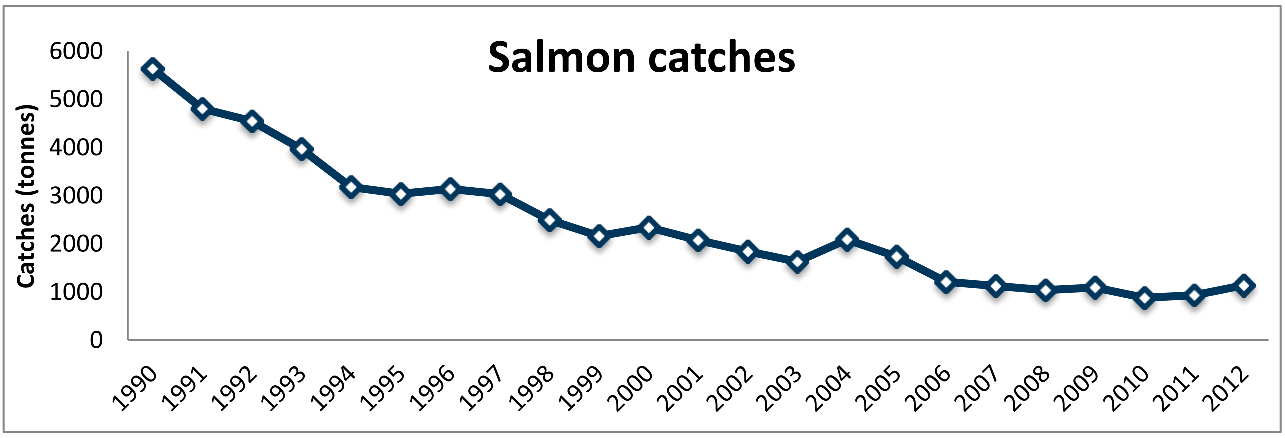


Figure 8. *Sea catches of Baltic salmon. The figure is made on the basis of ICES 2013.*

result of Sweden's decision to ban it from 2013 onwards. The coastal trapnet fishery declined from mid-1990s to mid-2000s, but has remained stable after that. Figure 8 shows the temporal development of the salmon catches.

According to ICES WGBAST report (ICES 2013), the commercial fishery exploited 49 % of TAC, but if estimated non-commercial catches, discards and unreported fishing are taken into account, the TAC was clearly exceeded. Total catch (2012) was 1139 t (whole Baltic Sea), where 65 % were landings, 11 % discards, and 29 % unreported catches. Even 33 % of the total catch is non-commercial (sea and rivers). This equals to 186 826 individuals and when discards, misreporting and non-reporting estimates are added to the figure, a total of 239 300 individuals (range of the estimate 219 500-295 500) was caught in 2012.

How the indicator describes the Baltic marine environment

Relevance of the indicator for the ecosystem

Salmon is a large migratory predator in the Baltic Sea ecosystem. It is part of the Baltic Sea biodiversity, and also a species with high economic, cultural, recreational and political importance.

Salmon are anadromous fish: they breed in the Baltic rivers, and migrate to the sea to feed and grow. After their sea-feeding years they find their way back to the home river to spawn. At the sea, salmon are most often found in pelagic waters feeding on sprat shoals (Sprattus sprattus). They also feed on herring (Clupea harengus) and three-spined sticklebacks (Gasterosteus aculeatus) and may occasionally eat sandeel (Ammodytes spp.), cod (Gadus morhua) and garfish (Belone belone) (Karlsson et al. 1999).

Factors affecting smolt production

The main factor affecting the smolt production is the number of adult spawners reproducing in the rivers. Hence, the indicator has a direct linkage to the number of fish and their size (i.e. the bigger females produce more offspring). Figure 9 shows the relationship between smolt production and adult spawners.

The M74 -syndrome, a reproduction disorder found in the sea-run Baltic salmon, caused major reductions in smolt production in the northern parts of the Baltic in the 1990s (the peak) after which the mortality decreased but increased again at the turn of the century. The M74 syndrome is being monitored in many Baltic Sea rivers on a yearly basis (Keinänen et al. 2008).

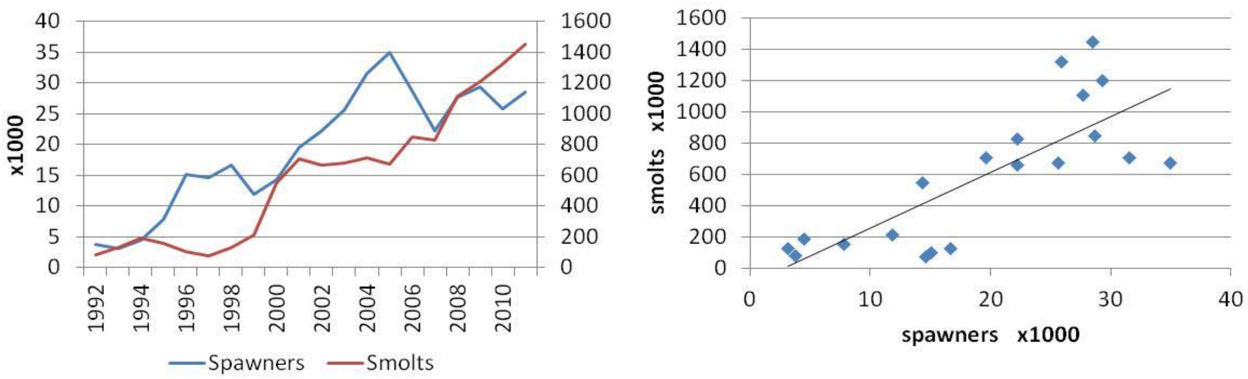


Figure 9. *Relationship between the abundance of salmon smolts and adult spawners in a time series plot (A) and in a correlation plot (B). Figure based on ICES 2012.*

The smolt production capacity of salmon in rivers is restricted by space and by behavior. There is a maximum production level which is determined by physical, chemical and biological characteristics of the environment. River specific potential smolt production capacities (PSPC) have been estimated as a reference point in order to relate how much salmon currently utilize the capacity of the spawning habitat.

The factors affecting post-smolt survival

Several physiological, behavioral and environmental factors affect salmon smolt survival (McCormick et al 1998). Some of these are predation, feeding opportunities, smolt size and habitat conditions (marine and river environment) (Mäntyniemi et al. 2012; Saloniemi et al. 2004; Salminen et al. 1995; Russell et al. 2012).

Predation may occur during the downward river migration stage by other predatory fish or by birds (Jepsen et al. 1998) or at the sea by seals (HELCOM 2012; Mäntyniemi et al. 2012). Sufficient quantity and composition of the food items (herring and sprat being the main food items of salmon) is important at the sea (Karlsson et al. 1999; Mäntyniemi et al. 2012).

A linkage between sea-surface temperatures and smolt survival has also been observed (Salminen et. al in 2008; Friedland et al. 2000). However, the factors affecting salmon smolt survival at sea are not yet fully understood and further research is needed (ICES 2012).

Responses to anthropogenic pressures

The anthropogenic impacts in the Baltic Sea area have led to the deteriorated status of salmon in this area.

Salmon is a target species for intensive offshore, coastal and river fishing.

For salmon to successfully reproduce in rivers, the following environmental criteria must be met: the sufficient quantity and quality of spawning grounds, access to those areas (barriers, such as dams, in rivers) and efficient river fisheries management.
In the rivers, the most detrimental activities to salmon have been damming, dredging and channelizing rivers for hydropower, log driving and agricultural purposes. Dams have been mainly constructed in the mid-20th century as a response to the growing demand for electricity. Also indirect impacts of human activities such as elevated nutrient and sediment loads from agriculture and forestry practices and from discharges of domestic sewage have adversely affected the ecological condition of Baltic salmon rivers.

Metadata

Data source

The data for the salmon assessment units 1–6 comes from the annual reports of ICES Working Group for Baltic Sea Salmon and Sea Trout (WG BAST). The data is based on the salmon smolt production model run by WBBAST.

The stock data from Kattegat originated from HELCOM SALAR project (HELCOM 2011).

Description of data

River surveys: parr density estimates, smolt trapping, monitoring of spawning runs and river catches;

Sea surveys: catch data, fishing effort data and catch composition estimates;

Joint river and sea surveys: tagging data (tagging in rivers, recaptures from sea and river fishery).

The table of river-monitored parameters per country in ICES (2012), page 186.

Assessment units

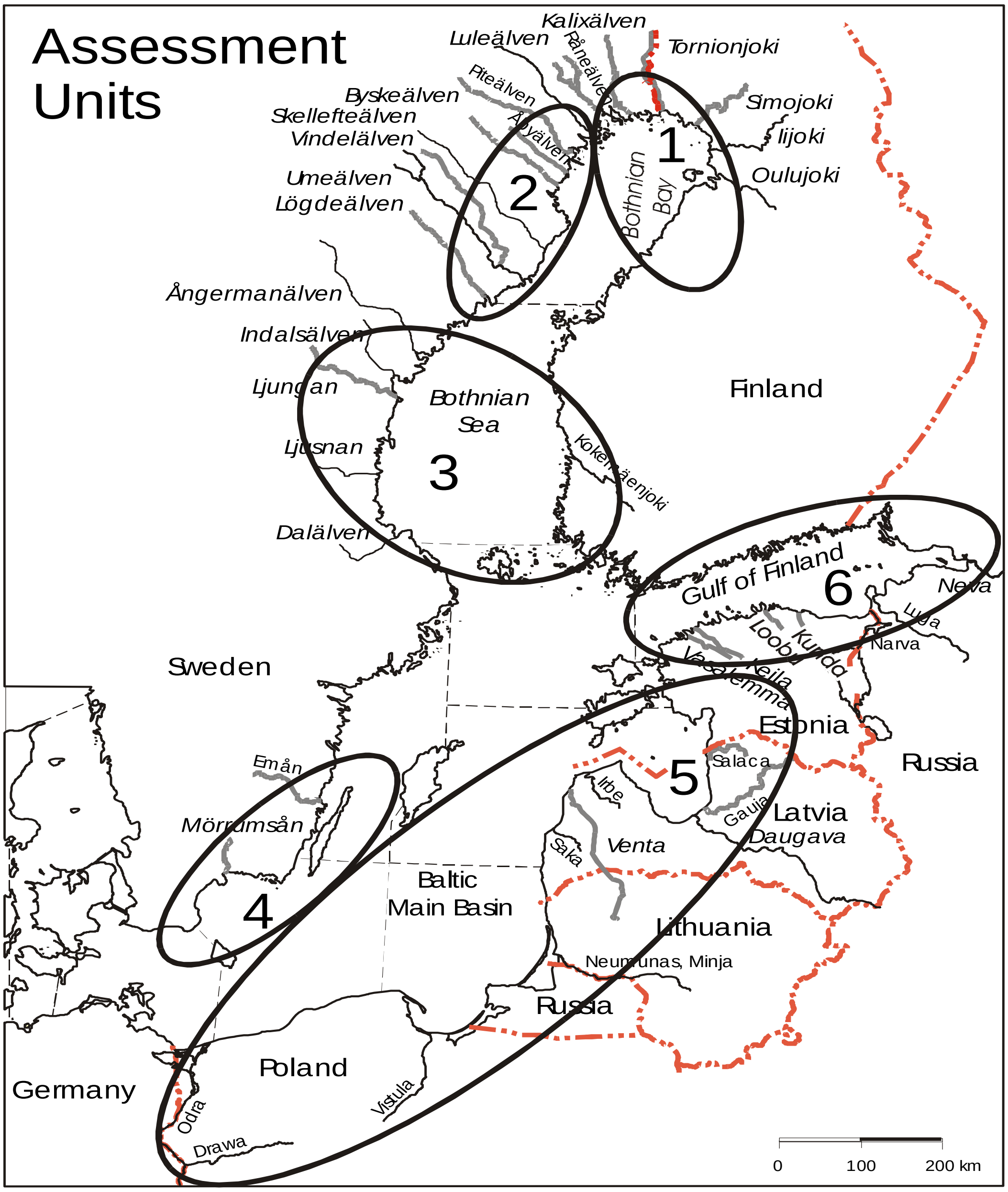


Figure 10. *ICES assessment units of Baltic salmon.*

Table 2. Salmon rivers of the Baltic Sea.

River	ICES area	Category	Country
Assessment unit 1: North-eastern Bothnian Bay			
Tornionjoki;Torneälven	31	WILD	FI/SE
Kalixälven	31	WILD	SE
Råneälven	31	WILD	SE
Simojoki	31	WILD	FI
Kemijoki	31	REARED	FI
Iijoki	31	REARED	FI
Oulujoki	31	REARED	FI

Assessment Unit 2: North-western Bothnian Bay			
Piteälven	31	WILD	SE
Åbyälven	31	WILD	SE
Byskeälven	31	WILD	SE
Rickleån	31	WILD	SE
Sävarån	31	WILD	SE
Ume/Vindelälven	31	WILD	SE
Öreälven	31	WILD	SE
Lögdeälven	31	WILD	SE
Luleälven	31	REARED	SE
Skellefteälven	31	REARED	SE
Assessment Unit 3: Bothnian Sea			
Ljungan	30	WILD	SE
Gideälven	30	REARED	SE
Ångermanälven	30	REARED	SE
Indalsälven	30	REARED	SE
Dalälven	30	REARED	SE
Ljunsnan	30	REARED	SE
Kokemäenjoki	30	REARED	FI
Aurajoki	29	REARED	FI
Paimionjoki	29	REARED	FI
Assessment Unit 4: Western Main Basin			
Emån	27	WILD	SE
Mörrumsån	25	WILD	SE
Assessment Unit 5: Eastern Main Basin			
Pärnu	28	WILD	EE
Salaca	28	WILD	LV
Vitrupe	28	WILD	LV
Peterupe	28	WILD	LV
Irbe	28	WILD	LV
Uzava	28	WILD	LV
Saka	28	WILD	LV
Barta	28	WILD	LV/LT
Gauja	28	MIXED	LV
Daugava	28	MIXED	LV
Venta	28	MIXED	LV
Nemunas	26	MIXED	LT
Minija	26	REARED	LT
Lielupe	28	REARED	LV
Slupia	26	REARED (1	PL
Assessment Unit 6: Gulf of Finland			
Kunda	32	WILD	EE
Keila	32	WILD	EE
Vasalemma	32	WILD	EE
Purtse	32	MIXED	EE
Selja	32	MIXED	EE
Loobu	32	MIXED	EE
Valgejõgi	32	MIXED	EE
Jägala	32	MIXED	EE
Pirita	32	MIXED	EE
Vääna	32	MIXED	EE
Luga	32	MIXED	RU
Neva	32	MIXED	RU
Kymijoki	32	MIXED	FI
Karjaanjoki	32	REARED	FI
Narva	32	REARED	RU/EE

Kattegat			
Göta älv	22		SE
Kungsbackaån	22		SE
Rolfsån	22		SE
Löftaån	22		SE
Viskan	22		SE
Himleån	22		SE
Tvååkersån	22		SE
Törlan	22		SE
Ätran	22		SE
Suseån	22		SE
Nissan	22		SE
Fylleån	22		SE
Genevadsån	22		SE
Lagan	22		SE
Stensån	22		SE
Rönneå	22		SE

1) Natural production found (Bernaœ R, Dębowski P, Bartel S, et al. (2010) Occurrence of juvenile salmon, Salmo salar L., from natural spawning in the Słupia River (northern Poland). Archives of Polish Fisheries. Volume 17, Issue 4, Pages 317–321).

Geographic coverage

26 rivers with wild salmon stock, 14 rivers with mixed salmon stocks (only natural production included) and 16 stocks of Kattegat. See Table 2.

Relevance of assessment in the Baltic Sea

Baltic salmon is a highly migratory species migrating across the entire basin to feed in the southern sub-basins. Salmon is thus a part of the Baltic food web and also a respected target species for fisheries in all the Baltic Sea countries. This indicator follows the state of salmon stocks in the reproductive season but describes the Baltic Sea wide state of the salmon.

Recommendation for monitoring

The distribution of salmon rivers is at the moment biased to northern and eastern parts of the Baltic Sea. Table 2 lists all the salmon rivers (wild, mixed and reared stocks) and also notes the respective country. Only Denmark and Germany do not have natural production of salmon in the Baltic Sea. Restoration programmes of current and historical salmon rivers are among the actions of the Baltic Sea Action Plan and have been started in some countries. This may change the need to start monitoring in new rivers in future.

Temporal coverage

Time series of parr densities start in some rivers in 1970s, but usually in 1990s. All of the salmon rivers have time series of at least 10 years.

Methodology and frequency of data collection

Annual electrofishing of parr.

Annual automatic fish counters for adult spawners.

Annual trapping and tagging of smolts.

See ICES 2013 for details.

Methodology and data analyses

Smolt production estimates are generated by a few different methods in the rivers. In the rivers in the Bothnian Bay, smolt abundance has been monitored and its relationship with parr densities has been analyzed by linear regression analysis. This has been used as a basis for some other rivers where only parr densities have been monitored. In Piteälven the smolt production has been modeled on the basis of the number of eggs in females, whereas in Emån and Mörrumsån the survival rate of parr to smolts has been used to estimate the smolt production. In the rivers in the assessment units 5 and 6, parr densities in association with the size of the reproduction areas, survival from parr to smolt stage, etc. form the basis for the smolt production estimates.

Bayesian model was used to estimate the Potential Smolt Production Capacity (PSPC). According to ICES WGBAST report (ICES 2013), the model consists of ten variables, five of which describe or reflect the external factors, physical and biological, to which salmon reproduction is exposed in the reproduction rivers (chance of successful spawning, habitat quality of parr area, smoltification age, mortality during migration, and size of production areas). Three variables (parr density capacity, pre-smolt density capacity, and smolt production capacity) describe the juvenile salmon stocks' response to the external factors. The remaining variables, expert and river, are auxiliary variables that enable handling of all the estimates in the same model. See details in Uusitalo et al. 2005 and ICES 2013.

Determination of GES boundary

Estimation of smolt production status is complicated. The measurements are generally computed by comparing the actual smolt production to the potential smolt production capacity (PSPC). The complication arises from that both of these parameters are highly uncertain (Uusitalo et al. 2005).

Reaching at least 75 % of the PSPC in rivers has been suggested by ICES if the plan is to recover salmon populations to the maximum sustainable yield (MSY) level (ICES 2008, 2012). The ICES workshop on Baltic Salmon Management PLan Request (WKBALSAL, ICES 2008), however showed that reaching MSY may require revising the 75 % target level in most rivers to over 80 %. HELCOM has aimed to use the 80 % PSPC target for the BSAP assessments (HELCOM 2007, HELCOM 2011). In this version of the core indicator report, the 75 % target has been used until ICES WGBAST has revisited the target.

The natural production capacity in the Baltic is highly variable and the estimates for PSPC include uncertainty which has been incorporated into the models. Therefore the estimated smolt production as well as the PSPC (and the 75 % target) have been presented as medians and 95 % probability intervals (PI) of the value distribution.

Strengths and weaknesses of data

Strengths

The indicator covers all rivers with wild salmon stocks. Several parameters at sea or in rivers support the smolt production indicator. The parr density parameter – monitored by electrofishing – is made in all rivers and gives a basis for many modeled parameters.

Weaknesses

The smolt production is modeled based on different methods in different rivers and the applicability of the model parameters estimated in the northern rivers may not be directly transferable to the southern rivers. The same applies to estimates on post-smolt survival and number of ascending adult spawners.

References

Anon. (2008): Directive 2008/56/EC of the European Parliament and the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Official Journal of the European Union, L 164/19, 25.06.2008.

Anon. (2010): Commission decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (2010/477/EU). OJ L 232/14, 2.9.2010.

Friedland, K.D., Hansen, L.P., Dunkley D.A., MacLean J. (2000). Linkage between ocean climate, post-smolt growth, and survival of Atlantic salmon (*Salmo salar* L.) in the North Sea area. ICES Journal of Marine Science, 57: 419–429. ICES Journal of Marine Science, 57: 419–429. Available online at: http://icesjms.oxfordjournals.org/content/57/2/419.full.pdf+html.

HELCOM (2007): Baltic Sea Action Plan. Available at: http://www.helcom.fi/BSAP/en_GB/intro/.

HELCOM (2011). Salmon and Sea Trout Populations and Rivers in the Baltic Sea - HELCOM assessment of salmon (*Salmo salar*) and sea trout (*Salmo trutta*) populations and habitats in rivers flowing to the Baltic Sea. Balt. Sea Environ. Proc. No. 126A.

HELCOM (2012). Development of a set of core indicators: Interim report of the HELCOM CORESET project. PART B. pp. 167-169.

ICES (2008). Report of the Workshop on Baltic Salmon Management Plan Request (WKBALSAL), 13–16 May 2008, ICES, Copenhagen, Denmark. ICES CM 2008/ACOM:55. 61 pp.

ICES (2012). Report of the Baltic Salmon and Trout Assessment Working Group (WGBAST), 15–23 March 2012, Uppsala, Sweden. ICES 2012/ACOM: 08. 347 pp. Available at: http://www.ices.dk/reports/ACOM/2012/WGBAST/wgbast_final_2012.pdf.

ICES (2013) Report of the Baltic Salmon and Trout Assessment Working Group (WGBAST), 3–12 March 2012, Tallinn, Estonia. ICES CM 2013/ACOM:08 332 pp.

Jepsen, N., Aarestrup, K., Økland, F., Rasmussen, G. (1998). Survival of radiotagged Atlantic salmon (*Salmo salar* L.) – and trout (*Salmo trutta* L.) smolts passing a reservoir during seaward migration. Hydrobiologia 371-372 (0): 347-353.

Karlsson, L., Ikonen, E., Mitans, A., Hansson, S (1999) The diet of salmon (*Salmo salar*) in the Baltic Sea and connections with the M74 Syndrome. Ambio 28 (1): 37-42.

Keinänen, M., Uddström, A., Mikkonen, J., Rytilahti, J., Juntunen, E.-P., Nikonen, S. & Vuorinen, P. J. (2008). Itämeren lohen M74-oireyhtymä: Suomen jokien seurantatulokset kevääseen 2007 saakka. *Riista ja kalatalous – Selvityksiä* 4/2008. 21 p. http://www.rktl.fi/www/uploads/pdf/uudet%20julkaisut/selvityksia_4_2008.pdf.

McCormick, S., Hansen, L., Quinn, T., Saunders R. (1998). Movement, migration, and smolting of Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. 22 (Suppl. 1): 77-92.

Mäntyniemi, S., Romakkaniemi, A., Dannewitz, J., Palm, S., Pakarinen, T., Pulkkinen, H., Gårdmark, A., and Karlsson, O. (2012). Both predation and feeding opportunities may explain changes in survival of Baltic salmon post-smolts. – ICES Journal of Marine Science.

Romakkaniemi, A., Karlsson, L., Jutila, E., Carlsson, U., and Pakarinen, T. (2003). Development of wild Atlantic salmon stocks in the rivers of the northern Baltic Sea in response to management measures. ICES Journal of Marine Science, 60: 329-342.

Russell, I., Aprahamian, M., Barry, J., Fiske, P., Ibbotson, A., Kennedy, R., Maclean, J., Moore, A., Otero, J., Potter T., Todd, C. (2012). The influence of the freshwater environment and the biological characteristics of Atlantic salmon smolts on their subsequent marine survival. ICES Journal of Marine Science.

Salminen, M., Kuikka, S., Erkamo, E. (1995). Annual variability in survival of sea-ranched Baltic salmon, *Salmo salar* L: significance of smolt size and marine conditions. Fisheries Management and Ecology 2 (3): 171-184.

Saloniemi, I., Jokikokko, E., Kallio-Nyberg, I., Jutila, E., Pasanen, P. (2004). Survival of reared and wild Atlantic salmon smolts: size matters more in bad years. ICES Journal of Marine Science, 61: 782-787.

Uusitalo, L., Kuikka, S. and Romakkaniemi, A. (2005). Estimation of Atlantic salmon smolt carrying capacity of rivers using expert knowledge. ICES Journal of Marine Science, 62: 708-722.

View data

The data is presented in ICES working group 'Baltic Sea Salmon and Sea Trout' report 2013.