



STOPPING COMPENSATORY RELEASES OF SALMON IN THE BALTIC SEA

Good or bad for Baltic salmon gene pools?

REPORT FROM SYMPOSIUM AND WORKSHOP · FEBRUARY 9–10, 2012

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STOPPING COMPENSATORY RELEASES OF SALMON IN THE BALTIC SEA

Good or bad for Baltic salmon gene pools?



Report from symposium and workshop
February 9–10, 2012 · Stockholm University

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Summary and conclusions

Most of the original wild Baltic salmon populations, i.e. populations of Atlantic salmon (*Salmo salar*) in the Baltic Sea, have gone extinct, and the Baltic salmon is recognized as a high priority species of global importance by the Helsinki Commission (HELCOM 2007). To compensate for loss in natural reproduction due to hydroelectric power plants large scale releases of salmon are conducted in several rivers in the Baltic area.

Previous observations of pronounced genetic differentiation between populations inhabiting different rivers, coupled with indications that salmon hatchery stocks are genetically divergent from the wild populations they were meant to represent, have warranted conservation geneticists to warn against potential negative effects of large scale releases. In 2011 these warnings gained attention when the European Commission put forward a proposal of phasing out all compensatory releases of salmon in the Baltic area (“Proposal for a Regulation of the European Parliament and of the Council establishing a multiannual plan for the Baltic salmon stock and the fisheries exploiting that stock”; European Commission 2011).

The symposium and the workshop summarized in this report were organized to discuss, from a conservation genetic perspective, the EU proposal to halt compensatory releases. The two-day event was organized by the Department of Zoology, Stockholm University, and was initiated and funded by the Swedish Agency for Marine and Water Management and the BaltGene research program (funded by BONUS Baltic Organisations’ Network for Funding Science EEIG). Additional funding was obtained from The Sida Baltic Sea Unit and from the Nordic Council of Ministers.

The symposium and the workshop had 104 and 47 participants, respectively, representing a wide range of authorities, stakeholders, organizations, scientists, and interest groups. Eleven invited speakers presented various aspects of stocking and salmonid biology that all linked to the proposal of phasing out compensatory releases. Their presentations and the discussions are summarized in this report. When discussing issues linked to the EU proposal in relation to salmon genetic biodiversity during the workshop, participants were divided into four thematic groups: 1) Research results and issues, 2) Sport fishing, tourism, recreation, 3) Commercial fishing, salmon farms, and 4) Environment and nature protection. Agreements from each individual group are presented in this report.

Statements from the workshop

The following conclusions and recommendations were agreed upon during the workshop plenary session.

1. Releases should not be performed in wild salmon rivers with viable populations.
2. Fin clipping should be mandatory for all released fish for assessment purposes and other management considerations.
3. Conservation genetic goals and recommendations for rearing and releasing salmon must be established within three years for the Baltic Sea region. This includes handling and selection of brood stocks.
4. Monitoring programs should be launched that aims at continuously following the genetic constitution of wild and hatchery populations.
5. More research and information on the occurrence and rates of straying is urgently needed.
6. The need for conservation actions to protect and save weak salmon populations is recognized. Conservation releases can be used as one measure to support weak populations.
7. Conservation action plans on a river by river basis are urgently needed.

Background to the Baltic salmon 2012 symposium and workshop

Historically, 84 rivers flowing into the Baltic Sea have harbored Atlantic salmon populations, but currently only 10 of these maintain self sustaining wild natural populations in safe numbers (CCB 2012). Large scale releases of salmon are carried out in the Baltic region to increase productivity of separate populations and to compensate for natural reproduction that has been lost due to hydroelectric power plants that are blocking previous migratory routes.

A series of studies have confirmed that the Baltic salmon is genetically unique, and separated from salmon in the Atlantic Sea (e.g. Ståhl 1981, 1987; Verspoor et al. 1999, 2005; Nilsson et al. 2001; Koljonen et al. 2002; Johannesson & André 2006). The genetic distinctness of Baltic Sea salmon populations is maintained through low migration rates through the Danish Belts (between the Baltic Sea and the Atlantic Ocean; Klemetsen et al. 2003). Further, genetic studies conducted already in the 1980s revealed pronounced genetic differentiation between populations inhabiting different rivers within the Baltic Sea (Ståhl 1981, 1987). There were also early indications of hatchery salmon stocks being genetically divergent from the wild populations they were meant to represent (Ståhl 1983).

The results from the past few decades of salmon research have several implications for management of the Baltic salmon. In brief, current large scale releases can cause the following four types of genetic risks for native populations: *i*) loss of genetic variation, *ii*) loss of adaptations, *iii*) change of population composition, and *iv*) change of population structure (Laikre et al. 2010). These adverse genetic impacts have been recognized and documented for salmonid fishes for decades (Ryman 1981; Ryman & Utter 1987; Hindar et al. 1991; Waples 1999; Naish et al. 2008; Nielsen & Hansen 2008).

Potential risks associated with large scale releases have remained neglected by authorities and politicians for many years. However, in 2009 The European Union launched an EU Strategy for the Baltic Sea Region in 2009 (Council of the European Union 15265/1/09 REV 1; http://ec.europa.eu/regional_policy/cooperate/baltic/index_en.cfm) that partly focuses on reinforcing sustainability of fisheries. Within the framework of this work the Swedish Board of Fisheries (now the Swedish Agency for Marine and Water Management) launched a flagship project to ensure sustainable fisheries of Baltic Salmon supported by Sida and the Nordic Council of Ministers

Right: Large scale releases of salmonid species are performed worldwide. Here, releases of brown trout (*Salmo trutta*) in Stockholm Ström, Sweden.



(Swedish Board of Fisheries 2010). A workshop was held at the HELCOM headquarters in Helsinki in October 2010 and a major conclusion from that meeting was that the genetic risks of salmon stocking needs to be recognized and addressed to permit biologically sustainable management of Baltic salmon (Swedish Board of Fisheries 2010).

In August 2011 the European Commission presented the “Proposal for a Regulation of the European Parliament and of the Council establishing a multiannual plan for the Baltic salmon stock and the fisheries exploiting that stock” (European Commission 2011). This proposal includes the suggestion that compensatory releases of salmon in Baltic rivers should be phased out over a seven year period. With respect to genetic biodiversity the specific objective of this initiative is to ensure that the genetic integrity and diversity of the Baltic salmon is safeguarded. In this context the Commission proposed “a phasing out of release of salmon in rivers with man made obstacles and without potential for re-establishment of self sustaining wild salmon populations in order to protect the genetic diversity of the wild stocks”.

At the request of the Swedish Agency for Marine and Water Management a population genetic research group, led by Professor Linda Laikre at Stockholm University, Sweden, compiled and synthesized information on compensatory releases of salmon in Swedish rivers and genetic variability patterns for wild salmon populations and salmon hatchery stocks in the Baltic area. The work was conducted within the framework of the ongoing research program BaltGene (Baltic Sea Genetic Biodiversity; www.tmbi.gu.se/BaltGene). Peer reviewed and “gray” literature as well as unpublished genetic data was used to analyze and identify *i*) how the loss of salmon populations has affected the overall capacity of the Baltic salmon to maintain genetic variation, *ii*) potential effects of releases on genetic variation between and within wild salmon populations, and *iii*) the amount of genetic variability of the Baltic salmon that exists exclusively in hatchery stocks.

In addition, the commission included the organization of a symposium and a workshop. The purpose of the meeting was to present the main conclusions from the above mentioned analyses and to bring together stakeholders including scientists, NGOs, authorities, managers of fisheries, hatcheries, and environment, etc. with expertise and interest in Baltic salmon. Several aspects that all linked to the EU proposal to phase out compensatory releases were presented and discussed. Summaries of presentations and discussions from the symposium/workshop are presented in this report.

The Baltic salmon 2012 symposium and workshop

Symposium program

- 09.30–10.00 Registration and coffee
- 10.00–10.10 Welcome!
Linda Laikre & Anna Palmé, Stockholm University
- 10.10–10.40 Opening session
Isabella Lövin, journalist/writer and member of the European Parliament
- 10.40–11.05 Sweden's position on the European Commission's proposal to halt compensatory releases of salmon in the Baltic Sea
Peter Funegård, Swedish Agency for Marine and Water Management
- 11.05–11.30 Coffee break
- 11.30–12.00 Large scale releases of salmon in the Baltic Sea: risks for genetic diversity of natural salmon populations (using Sweden as an example)
Linda Laikre & Anna Palmé, Stockholm University
- 12.00–12.40 Genetic consequences of stocking with hatchery strain brown trout: experiences from Denmark
Michael M. Hansen, Aarhus University
- 12.40–14.00 Lunch at Restaurant Lantis
- 14.00–14.40 Evolutionary genetics of Baltic salmon and its relevance for today's management
Marja-Liisa Koljonen, Finnish Game and Fisheries Research Institute
- 14.40–15.10 Saving naturally spawning Baltic salmon populations – this is what we need to do
Gunnar Norén, Coalition Clean Baltic

- 15.10–15.30 Coffee break
- 15.30–16.00 Releases of salmon – is it really a disaster?
Lars Hedman, Vattenfall
- 16.00–16.30 Proposed phase out of compensatory releases
– Sportfiskarna’s perspective
Glenn Douglas, Sportfiskarna (Swedish National Anglers Association)
- 16.30–16.45 Short break
- 16.45–17.00 SMOLTPRO: sustainable smolt production – an integrated approach
Rasmus Kaspersson, assistant coordinator SMOLTPRO
- 17.00–17.15 ICES’ perspective on phasing out compensatory releases and how to maintain wild salmon populations
Henrik Sparholt, ICES
- 17.15 Sum up of Day 1 – seminar closure. Introduction of workshop (Day 2)

Workshop program

The workshop provided an opportunity for in-depth discussion on some of the issues raised during the symposium on February 9. The aim was to examine possibilities to agree on recommendations to authorities including the Swedish Agency for Marine and Water Management on how to proceed with issues concerning genetic effects of compensatory releases in the Baltic.

| | |
|-------------|--|
| 09.00–09.30 | Registration and coffee |
| 09.30–10.00 | Introduction of workshop, aims for achievements during the day |
| 10.00–12.45 | Working group discussions |
| 12.45–13.45 | Lunch at Restaurant Lantis |
| 13.45–15.00 | Plenary discussion, reports from groups, and final conclusions |
| 15.00 | Closing of workshop |

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Invited speakers

Experts were invited to the symposium to give presentations relating to the EU proposal on phasing out compensatory releases of salmon in the Baltic area. Below is a brief presentation of the speakers (in alphabetic order of family name).

Glenn Douglas represents the Swedish National Anglers Association (Sportfiskarna). He is based at the office in Luleå and is the project leader for the “Wild salmon project” (*In Swedish: Vildlaxprojektet*).

Peter Funegård is a senior analyst at the International coordination unit at the Swedish Agency for Marine and Water Management. He has a wide experience of working with questions related to salmon in the Baltic Sea.

Professor Michael M. Hansen, Department of Bioscience, Aarhus University, Denmark, is an internationally leading expert in population and conservation genetics. He has devoted particular research focus on salmonid fishes, including genetic monitoring of the genetic effects of stocking. Results from Hansen’s research group are recognized by scientists worldwide and has warranted the Danish fishery management authorities to ban stocking of non-local fish from hatchery strains in Danish waters.

Lars Hedman works for Vattenfall, Sweden, and is in charge of the hatchery at the Bergeforsen salmon farm in the River Indalsälven.

Dr Rasmus Kaspersson is the assistant coordinator of SMOLTPRO (Sustainable Smolt Production – an integrated approach). The project is financed by Formas and coordinated by the University of Gothenburg.

Dr Marja-Liisa Koljonen is a senior research scientist at the Finnish Game and Fisheries Research Institute. Her main expertise lies in Baltic Sea and boreal lake fish species. She has studied the evolutionary history of the Baltic salmon and life history and population genetic related questions of several other fish species, for example brown trout, char, pikeperch, rainbow trout, and whitefish.

Professor Linda Laikre, Department of Zoology, Stockholm University, Sweden, is a specialist in conservation genetics and has devoted her professional career to issues dealing with the genetic effects of management practices of wild and captive animal populations. Her current research interests includes the genetic effects of large scale releases, and coupling genetic monitoring of



Isabella Lövin from the European Parliament in discussion with members of the audience.

such effects to international policy. Laikre is a long standing member of the Swedish Government's Council on Biological Diversity. She was approached by the Swedish Agency for Marine and Water Management to conduct the evaluation of current knowledge on the genetic risks with large scale releases of salmon in the Baltic Sea, and she pursued this work within the framework of the ongoing research program BaltGene (Baltic Sea Genetic Biodiversity; www.tmbi.gu.se/BaltGene). She holds the main responsibility for the project reports, the symposium, and the workshop.

Isabella Lövin is a journalist and writer, and a member of the European Parliament since 2009. She is the team leader on the Fisheries Committee for the 55-strong Green Group of the Members of the European Parliament. According to the Swedish journal "MiljöAktuellt", Isabella Lövin is Sweden's third most important spokesperson for environmental issues.

Gunnar Norén initiated the formation of Coalition Clean Baltic (CCB), a network for cooperation between environmental NGOs active in the Baltic Sea catchment area. He is now the executive secretary of the organization and he is an active voice for environmental and conservation issues.

Dr Anna Palmé is a researcher at the Department of Zoology, Stockholm University, Sweden. Her research interests relate to genetic structuring of natural populations, genetic conservation, and to the effects of man's impact on biodiversity. Anna Palmé has led the work with compiling and synthesizing current knowledge on Baltic salmon genetic variation and the genetic effects of compensatory releases together with Professor Linda Laikre, and she is the leading author of the reports generated from this work. She has also led the organization of the symposium and the workshop.

Dr Henrik Sparholt has been a fisheries scientist at the International Council for the Exploration of the Sea (ICES) since 1992. He works in the Advisory Programme with coordination of basic research, monitoring of fish stocks, and information counseling.

Symposium abstracts

Presentations given during the symposium are summarized here (in the order appearing in program). Each speaker is responsible for his/her abstract.

Opening session

ISABELLA LÖVIN, EUROPEAN PARLIAMENT
NOTES FROM PRESENTATION TAKEN BY LOVISA WENNERSTRÖM

The salmon is a political fish, important in fisheries policies and in the heart of many citizens of the European Union. The future of the Baltic salmon is bleak. The number of salmon rivers in the Baltic area has decreased from around 100 to only 30. In 2011, few rivers reached 75% of their estimated potential for smolt production.

Worth discussing is if there are any wild Baltic salmon left or if all present day Baltic salmon are more or less hatchery descendants. Can we turn back the clock from the biomanipulation of our seas to resilient marine ecosystems, with preserved and esteemed ecosystem services? Do we want to eat wild salmon from naturally reproducing self-sustaining stocks, or do we want to continue trawling for sprat for "conversion to" salmon flesh? These are political issues, not scientific ones, but science is needed to underpin such political decisions.

A new multiannual plan for the Baltic salmon has been proposed from the European Commission, and the new proposal is a step in the right direction for conservation of wild salmon stocks. Inclusion of the entire life cycle of salmon – not only the marine part – is controversial among the member states within the European Union, but probably follows present legislation within the EU.

The proposal includes phasing out non conservation stocking because of the apparent risk of genetic pollution from hatchery stocks to wild populations. The risk of depletion of weak populations in mixed stock fisheries has also led to a suggestion to reduce open sea harvest within the Baltic Sea. Sweden and Finland have already taken steps towards a more coastal and river oriented salmon fishery.

At present, recreational and subsistence fisheries are not included in the plan, but Isabella Lövin believes it should be considered. Further, Lövin requests a better definition of borders between rivers and the open sea.

Sweden's position on the European Commission's proposal to halt compensatory releases of salmon in the Baltic Sea

PETER FUNEGÅRD, SWEDISH AGENCY FOR MARINE AND WATER MANAGEMENT

The presentation was a short summary of the present advice given by the Swedish Agency for Marine and Water Management to the Swedish government in October 2011 regarding the European Commission's proposal to phase out compensatory releases of reared salmon in the Baltic Sea. The advice was mainly that the agency is in general positive to reduce the amount of releases and to use other possible compensatory measurements in rivers with production of wild salmon. But the proposed phase out period of only seven years is not long enough in order to make it possible for the responsible authorities and stakeholders to be able to revise the present court decisions. The advice also includes a proposal to further investigate possible effects on the ecosystem if a large scale reduction of the present releases is implemented and more scientific based evidence regarding the possible negative genetic effects on the remaining wild salmon stocks was requested.

Large scale releases of salmon in the Baltic Sea: risks for genetic diversity of natural salmon populations (using Sweden as an example)

ANNA PALMÉ, LOVISA WENNERSTRÖM, PETER GUBAN, NILS RYMAN,
AND LINDA LAIKRE, STOCKHOLM UNIVERSITY

We have evaluated the conservation genetic risks associated with compensatory releases of Atlantic salmon in the Baltic Sea according to a commission from the Swedish Agency for Marine and Water Management. Our work has

comprised *i*) reviewing all identified scientific studies of the genetics of Baltic salmon, *ii*) reviewing all identified “gray” genetic reports on Baltic salmon in Swedish rivers, *iii*) reviewing the scientific literature with respect to genetic effects of large scale releases of salmonid fishes, *iv*) compiling, with respect to the situation in Sweden, available material on the number of fish released annually, tagging data, and genetically effective number of parents, and *v*) conducting additional analyses based on published and unpublished genetic information.

In summary: Our commission is of a strictly conservation genetic nature. There are several other aspects that need to be considered in relation to the European Commission proposal of halting compensatory releases of salmon in the Baltic Sea; they include ecological, socioeconomic, and fisheries related issues. Also, the specific suggestion of phasing out the compensatory releases over a seven year period must be evaluated. However, the focus of this work has been threats to biological diversity on the gene level associated with large scale releases of salmon in the Baltic region, and in this context our conclusions can be summarized as follows:

1. The Atlantic salmon in the Baltic Sea is genetically unique. It represents one of three major evolutionary units of the species. Each salmon river harbors at least one genetically distinct population.
2. The extinction of a large number of wild populations has been harmful to the Baltic salmon; the capacity for retaining genetic variability has decreased as a consequence of a reduced genetically effective population size of the global population.
3. The global and the local effective population sizes have been further depleted through decreasing size of remaining local populations.
4. From a conservation genetics perspective the compiled information suggests that the proposal of the European Commission to halt compensatory releases of salmon in the Baltic is logical and sound.
5. Large scale releases constitute a potential threat to Baltic salmon genetic diversity. This is due to the genetic risks associated with *i*) gene flow from released hatchery stocks into wild populations, and *ii*) risks of overharvest of weak, wild populations because of increased numbers of salmon in the Baltic following the releases.
6. Little research has been devoted to empirically assessing the genetic effects of compensatory releases in the Baltic Sea, but observations from large scale salmonid releases in other geographical areas include: *i*) genetic homogenization of previously diverged populations, *ii*) complete or partial replacement of native gene pools, *iii*) break down of adaptations to local conditions, and *iv*) spread of diseases and parasites reducing absolute and effective sizes of native populations.



Professor Linda Laikre, Stockholm University, introduces the genetic risks associated with large scale releases.

7. Comparisons of wild and hatchery stocks of the same river show that the genetic divergence between hatchery stocks is generally smaller than between wild ones. Further, there is a clear pattern of isolation-by-distance among wild populations, whereas no such pattern is found among hatchery stocks, suggesting that the natural genetic structure has not been maintained in hatcheries. This genetic homogenization might affect the capacity for local adaptation.
8. We have found only one monitoring study on genetic effects of compensatory releases in the Baltic Sea. In that study the scientists report a strong homogenizing effect on the genetic composition of the wild population in the River Vindelälven. This population became increasingly similar to hatchery stocks released in the neighboring area, and migration from hatchery stocks into the wild population was estimated as over 10 percent.

9. In most Swedish rivers the total number of released individuals, including smolt, fry, and eggs, exceeds the number of salmon obliged to be released according to court decisions. Crude estimates of effective population sizes (based on sex ratio only) show that Swedish salmon hatchery stocks frequently do not reach scientifically accepted levels for retaining genetic variation.
10. An unknown proportion of the current gene pool appears to be maintained exclusively through hatchery operations. Removing hatchery stocks will result in loss of genetic variation, but the extent of such loss remains unclear.
11. Strategies are urgently needed for maintenance of genetic variation that only exists in hatchery stocks, and for restoring as much as possible of the global Baltic salmon population through re-establishing spawning areas and opportunities for natural reproduction.

Based on our evaluation of the genetic risks associated with large scale compensatory releases of salmon in the Baltic we provide the following recommendations.

1. Compensatory releases of salmon in the Baltic should be phased out.
2. Releases in remaining salmon rivers that support wild, viable populations should be prohibited.
3. Conservation releases to support or re-establish weak/extinct populations can be used to protect and maintain as much as possible of the remaining Baltic salmon gene pool. The need for such releases should be evaluated on a case by case basis.
4. When releases are carried out they should always be monitored with respect to genetic effects, including those from supportive breeding because of the risk of reducing the genetically effective size of local populations.
5. The conservation genetic goal for Baltic salmon should be to create a global population that is as efficient as possible with respect to retaining genetic variation on a local and global scale.
6. A change of present fishing pressure is of key importance for the success of measures taken to improve the situation for, and the genetic status of, the Baltic salmon. It is critical that fishing pressures are modified in relation to changes in smolt production if compensatory releases are halted.
7. As many previous spawning areas and local populations as possible should be re-established.
8. The fate of individual hatchery stocks must be determined on a case by case basis. This can include *i*) using hatchery material for restoring or restocking rivers that presently do not support self sustaining populations and *ii*) keeping hatchery brood stocks or sea ranched populations as gene banks during a restricted period of time. These operations must

be coordinated and monitored, and may imply meta analysis using existing information and/or collection of new data for assessing the degree of current genetic similarity between wild and hatchery stocks.

9. A genetic advisory board should be initiated and include population and conservation geneticists from all the Baltic countries. This board should supervise and coordinate national and international efforts to restore and maintain Baltic salmon gene pools.

The reference to the full synthesis report is:

Palmé A, Wennerström L, Guban P, Ryman N, Laikre L (2012). Conservation genetic risks associated with compensatory releases of salmon in the Baltic Sea. Report, Swedish Agency for Marine and Water Management, in press.

Download from www.havochvatten.se/om-oss/publikationer.html

Genetic consequences of stocking with hatchery strain brown trout: experiences from Denmark

MICHAEL M. HANSEN, AARHUS UNIVERSITY

Millions of brown trout from commercial hatchery strains have been stocked into rivers in Denmark inhabited by indigenous brown trout populations. In 2003 these activities were discontinued, in part due to concerns about negative genetic effects. We have studied the effects and consequences of these stocking activities using analysis of microsatellite DNA markers in contemporary and historical samples, the latter represented by DNA extracted from 50–100 year old archived scale samples. In several cases we find that even heavily stocked populations are essentially not introgressed by stocked hatchery strain trout, an outcome owing to selection acting against hatchery strain trout in the wild. We have also demonstrated that at least part of the selection takes place during the marine phase of the life cycle of anadromous trout. However, some populations have nevertheless become significantly admixed, even to the point that more than half of their gene pools are now of hatchery origin. The immigration-selection balance is likely to be an important factor determining this outcome so that massive stocking into numerically small wild populations will have a particularly detrimental impact. In one case we have analyzed a system of trout populations from six neighbouring rivers prior to stocking (in the 1920s–50s) and after stocking (in the 2000s). We show that both stocking and habitat degradation has significantly altered the original genetic structure. Moreover, these two types of anthropogenic pressure probably interact, with habitat degradation leading to declining populations which in turn become more susceptible to admixture following stocking. Even in strongly admixed populations we have nevertheless been able to identify individual non-admixed trout rep-



Professor Michael M. Hansen, Aarhus University, presents results from scientific monitoring of the genetic consequences of brown trout stocking in Denmark.

resenting the indigenous gene pool. These individuals are characterized by spawning late in the season (January–February) and may have been partially reproductively isolated from hatchery strain trout that tend to spawn much earlier (November). Finally, using a genome scan approach we have identified markers linked to genes that are under differential selection in hatchery and wild brown trout. This opens for a number of new possibilities for better assessing the genetic architecture underlying farmed-wild fish genetic interactions and for identifying the specific genes and traits under selection.

Evolutionary genetics of Baltic salmon and its relevance for today's management

MARJA-LIISA KOLJONEN, FINNISH GAME AND FISHERIES RESEARCH INSTITUTE

Within the Baltic Sea the anadromous populations form three clear groups, corresponding to the northern (Gulf of Bothnia), eastern (Gulf of Finland and Eastern Baltic Main Basin) and southern regions (Western Baltic Main

Basin), corresponding to the postglacial colonisation of the Baltic Sea by three phylogeographic lineages. The genetic differences among these three groups were clearly greater (G_{CB} 5.6%) than were those among population groups in the Eastern Atlantic Ocean (G_{CB} 2.2%), from Ireland to the White Sea. The isolation-by-distance model explained part of the differentiation within, but not between the lineages. According to hierarchical analysis 50% of the between stocks diversity component is resulted from differences between the three colonization lineages.

Genetic factors, such as glacial differentiation, the postglacial genetic structure of populations, gene flow levels and the probability of the existence of adaptive differences, have an effect on the formation of conservation and management units and on the long-term strategy for the sustainable use of a species. Genetically similar stock groups, phylogeographic lineages and drainage regions are recommended for use as genetic management units in addition to stock level. Hierarchical structure can be used for strategic prioritizing of conservation and management actions. Hatchery stocks are composing part of the total diversity of contemporary Baltic salmon. Gene flow from the hatchery releases has not been a problem until now. Halting of hatchery releases creates risk of losing the genetic diversity of the hatchery stocks. Their natural reproduction need to be safeguarded before halting of the releases. There are several other means to be considered for avoiding unwanted gene flow than complete halting of releases.

Saving naturally spawning Baltic salmon populations – this is what we need to do

GUNNAR NORÉN, COALITION CLEAN BALTIC (CCB)
NOTES FROM PRESENTATION TAKEN BY LOVISA WENNERSTRÖM

Salmon is an iconic fish species, of large social and economic value both present and historically. Further, it is an important indicator species for healthy waters. The situation for the Baltic salmon is today worse than it was only a few years ago. Since 2009 the number of returning spawners has decreased and a major part of the genetic lineages, especially in the Baltic Proper is under high pressure.

Releases of salmon in the Baltic area are made for several purposes, including compensatory releases for hydropower dams, non-compensatory releases in rivers/coastal zones, releases of smolt for put-and-take fisheries, supplementary releases to support threatened populations, and reintroductions of stocks in rivers where salmon has been extirpated.

According to CCB, there should be no releases at all in wild salmon rivers. Studies show that releases of hatchery salmon will lower the natural productivity of the river in the future. We also need better monitoring of straying

fish. Large-scale compensatory releases should be phased-out. Studies from Norway show negative effects of hatchery fish straying into wild populations.

Large scale releases can never support an eco-system based approach for Baltic salmon management. However, some releases can still be needed to support and safeguard weak populations close to collapse, and native stocks not having any remaining natural spawning areas. Stocking with early life stages, e.g. eggs and alevins, should be considered in such situations. The focus for rearing and releasing fish should shift from fishery compensation to compensating for the actual biological loss. 75% of Baltic salmon rivers are already lost and we need to protect what is left.

Releases of salmon – is it really a disaster?

LARS HEDMAN, BERGEFORSSEN SALMON FARM

Most of the hydropower stations in Sweden were built in the fifties. It was realized early that something had to be done for migrating fishes in Swedish rivers.

Since spawning and growth areas were destroyed in most rivers, construction of fishways was of no use. To compensate for reproduction loss smolt was released and it ended up in obligations for the hydropower companies.

Raising and releasing salmon was new and the hatcheries met a lot of problems. The largest problem was to catch enough breeders each year. In years when not enough eggs could be produced parental fish from other rivers were used. The numbers of fish produced in hatcheries came before genetic considerations. Today we have learnt more and are much more aware of genetic issues. Better buildings, technique, and feed have given us a better environment for the fish and hopefully a better salmon.

Proposed phase out of compensatory releases – Sportfiskarna's perspective

GLENN DOUGLAS, SWEDISH NATIONAL ANGLERS ASSOCIATION

One of the main reasons for the poor state of Baltic salmon stocks is environmental degradation caused by the hydro-electric industry. The Hydro electric industry should always compensate for the damage they cause. Direct restocking should only be seen as a last resort and should be phased out when compensation can be achieved by river enhancement or creation of salmon habitat that is equal to smolt production by direct restocking.

According to regulations within the proposed new multi annual plan for salmon approx. 1,7 million salmon smolt would not be released in Sweden alone if the new EU salmon management plan is adopted in current form. This is as much as the Torne river the Baltic's largest remaining wild salmon

river at 100% smolt production. To phase out smolt releases and to compensate by river restoration is a difficult process and it will take longer than seven years to recreate natural reproduction in dammed rivers.

The quality of reared smolt is an issue and must be improved with potential benefits in the form of reduced straying and greater survival of releases. The adipose fin clipping program must continue and be mandatory for all releases within the Baltic.

The economic and recreational value of sport fishing within dammed rivers is large and outstrips the commercial fisheries value of salmon. Between 11 000–26 000 fishing days per river occur in dammed rivers.



Glenn Douglas presents the Swedish Anglers Association's perspective of the proposed phasing out of compensatory releases of Baltic salmon.

We have tools to follow the percentage of strayers in many wild rivers and currently do not see large amounts of strayers. Therefore Sportfiskarna suggest a study that evaluates:

1. Genetic effects of reared strayers to wild populations.
2. Genetic value of reared stocks.
3. The risks to weak wild populations of the removal of smolt releases but a continuation of a mixed stock fishery.
4. Economic and recreational loss to commercial and recreational fisheries.

With results from this study a long term plan should be created for the phasing out of releases with an equal strengthening of wild smolt production – not a seven year phase out.

SMOLTPRO: sustainable smolt production – an integrated approach

RASMUS KASPERSSON, SMOLTPRO, UNIVERSITY OF GOTHENBURG

Anadromous salmon and trout are important natural resources for recreation and fishing, and are a part of our cultural heritage. Human activities, however, have reduced the natural production of salmonids considerably. In an attempt to partly compensate for this there have been large releases of hatchery-produced salmon and trout for decades, yet only few have been recaptured and in recent years, the numbers have declined dramatically.

SMOLTPRO (launched in January 2010) is a four-year strategic project funded by the Swedish Research Council Formas. The main aim of SMOLTPRO is to develop ecologically and ethically sound methods for supplementary rearing of salmonids as well as to increase the socioeconomic returns of hatchery-produced salmon and trout. To achieve these goals, SMOLTPRO integrates the expertise and resources in this field of research using a multi-disciplinary approach.

Recent research have shown that modified rearing methods, such as reduced density, addition of physical structure and more nature-like feeding regimes, have positive effects on the performance of salmon and trout after release. The long-term effects of such rearing methods are, however, less well known. In SMOLTPRO, modified rearing methods will be evaluated with regard to the sea-migration of smolts, return rates of adults, and effects on the socioeconomic value. Experiments are performed in a series of full-scale hatchery systems to evaluate the generality of effects across different climate zones.

The knowledge and experience gained through SMOLTPRO will be used to develop new hatchery guidelines for sustainable smolt production, in dialogue with hatchery managers and stakeholders.

ICES' perspective on phasing out compensatory releases and how to maintain wild salmon populations

HENRIK SPARHOLT, INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA (ICES)

ICES do not have a specific view on stocking of salmon in the Baltic. ICES has however various rules, criteria and guidelines that are followed when giving scientific advice to managers. These are based mainly on various United Nations and other international agreements on how to manage fish stocks and the marine ecosystems. One of these is that fish stocks should be rebuilt to levels that can produce maximum sustainable yield. In terms of compensatory releases this might mean that these should be continued. This is because salmon in each river is a unique stock with its own unique genetics. Also in terms of keeping diversity in the ecosystem it might be argued that compensatory releases should be continued. ICES might consider this further especially if ICES' clients asked for advice on this issue.

Experience from Denmark shows, that wild salmon stocks are more robust to genetic pollution from strayers, than previous thought. Here some wild salmon stocks have survived for decades at very low stock levels in spite of heavy stocking with foreign salmon. Now that Denmark is only stocking with the wild salmon the stocks are improving at an impressive rate. Experience from Norway with farmed salmon straying to wild salmon rivers shows, that if the number of strayers are lower than 5% of the number of wild salmon at spawning time, it does probably not harm the wild stocks. Thus, the main problem with compensatory releases in the Baltic, namely that they stray to wild salmon rivers are not as problematic as previously thought.

ICES will make sure that proper sampling of genetics in salmon caught in the Baltic sea are conducted each year on a routinely basis and make sure that the data are made freely available to those with a legitimate interest in such data.

Summary of symposium discussions

Several questions were raised during the symposium presentations. The issue of phasing out large scale releases is of high importance to entire societies around the Baltic Sea, and it became clear during presentations and subsequent discussions that there are many different opinions regarding the outphasing. Below is a brief summary of the discussions.

Political decisions determine the future of the Baltic salmon

Phasing out large scale releases of salmon was a controversial question for many participants at the symposium. Several attendants emphasized that the time plan of seven years (suggested in the EU proposal) is too short for phasing out compensatory releases. However, on an EU level there appears

to be no controversy, and Isabella Lövin, member of the EU parliament, believes that it is likely that the proposal will be accepted.

In Sweden the majority of releases are regulated by court decisions, forcing power companies to compensate for lost natural reproduction due to construction of power plant stations. This legislation needs to be revised if large scale releases are phased out. It was stressed several times that phasing out large scale releases is against Swedish legislation, but it was also noted that current legislation is not a valid argument not to phase out large scale releases and that the legislation needs to be updated.

A large seal population constitutes a threat to salmon

The effects of seals and cormorants on the salmon population in the Baltic Sea were brought up several times. There is concern that seals will pose a large threat to wild Baltic salmon if all hatchery fish is removed.

The seal issue is not addressed in the EU proposal for the salmon multi-annual plan. The ambition of the European Commission is to apply an ecosystem approach to management of the Baltic Sea, but the impact of a large seal population is difficult to predict. It was stressed that we do not have enough information on the amount of salmon that is taken by seals.

Restoration of wild populations and the value of hatchery stocks

Except for compensatory purposes, releases are conducted to support weak salmon stocks. The general opinion was that such conservation stocking must be accepted, but regulations for these releases are needed.

Several participants expressed that hatchery populations are genetically valuable and should be maintained, and that efforts should be directed towards improving hatchery practices. Some salmon hatchery stocks represent populations that no longer exist in the wild. Such stocks might have a genetic value for the future. It was also suggested that “homeless stocks” from rivers that are not possible to restore should be kept in hatcheries until released in other restored rivers. However, many salmon hatchery stocks are genetically diverged from the wild populations they were meant to represent.

Need for studies on straying

There were several discussions on straying and what the most accurate estimates of the number of strayers are. Information from Carlin tagging appears to be limited. One problem is the difficulty to know whether a fish found in a river would have reproduced in that particular river if it had not been caught.

An international outlook on stocking of salmonid fish

In Denmark two release systems are practiced, supportive breeding and release of hatchery reared fish (brood stock). The ranching system practiced in Sweden where salmon spend at least some part of the life cycle in the sea (sea-ranching), is somewhere in between these systems. Despite the differences between stocking systems, effects such as domestication and poor fitness of hatchery fish can be expected also in sea-ranching systems. Several participants were of the opinion that even if there has been domestication in hatcheries, hatchery individuals that are able to survive and reproduce in nature should be allowed to do so.

In parts of the USA sea-ranching of salmon, similar to the Swedish system, is practiced and effects of selection in hatchery fish have been studied. Returning spawners have been captured and pedigrees constructed. Results from these research projects show that hatchery fish have a reduced fitness already at an early age.

Conclusions and recommendations from workshop

During the one-day workshop participants discussed issues linked to the EU proposal of phasing out compensatory releases of salmon in the Baltic area, focusing on salmon genetic biodiversity. The meeting agreed on the following conclusions and recommendations:

1. Releases should not be performed in wild salmon rivers with viable populations.
2. Fin clipping should be mandatory for all released fish for assessment purposes and other management considerations.
3. Conservation genetic rules for rearing and releasing salmon in the Baltic Sea region should be established within three years. This includes handling and selection of brood stocks.
4. Monitoring programs should be launched that aim at continuously following the genetic constitution of wild and hatchery populations.
5. More research and information on the occurrence and rates of straying is urgently needed.
6. The need for conservation actions to protect and save weak salmon populations is recognized. Conservation releases can be used as one measure to support weak populations.
7. Conservation action plans on a river by river basis are urgently needed.

Working group discussions

Participants were working in the following four thematic groups during the workshop discussions (see List of participants):

1. Research results and issues,
2. Sport fishing, tourism, recreation,
3. Commercial fishing, salmon farms,
4. Environment and nature protection.

Each group discussed the proposal from the European Commission to halt compensatory releases of salmon in the Baltic from the perspective of genetic conservation in relation to the theme of the working group. Conclusions and recommendations from each of the four working groups are listed below.

Group 1: Research results and issues

1. We suggest that the conservation genetic goal for Baltic salmon is to create a global population that is as efficient as possible with respect to retaining genetic diversity on a local and global scale. This implies restoring as many as possible of the previous spawning grounds, and self sustaining river populations that are harvested at rates and using methods that do not reduce their capacity for genetic retention.
2. We stress that mixed stock fisheries pose a genetic threat to weak, genetically distinct salmon populations. Offshore fisheries should therefore be phased out. Managing the coastal zone fisheries should be improved to protect weak salmon populations.
3. We do not agree with EU proposal Article 12 point 1. We stress that releases should not be carried out in salmon rivers that maintain viable wild populations.
4. Action plans should be established within five years, focusing on restoring natural reproduction in previous and potential salmon rivers that are now heavily modified.
5. The conservation genetic value of each hatchery maintained population should be evaluated within five years, including the genetic threat that releases of such populations can pose to wild populations.
6. Conservation genetic rules for rearing and releasing salmon must be established within three years for the Baltic Sea region. This includes brood stock handling.
7. Monitoring programs should be launched that aim at continuously following the genetic constitution of wild and hatchery populations. Particular efforts should be directed towards clarifying the potential effects of straying from release operations.



Workshop participants discuss the EU proposal on phasing out compensatory releases of salmon in the Baltic Sea.

8. Fin clipping should be mandatory for all released fish for assessment purposes and other management considerations.
9. A genetic advisory board should be initiated and include population and conservation geneticists from all the Baltic countries. This board should supervise and coordinate the national and international efforts to restore Baltic salmon gene pools.

Group 2: Sport fishing, tourism, recreation

1. Fin clipping should be mandatory for all released fish in the Baltic.
2. We believe that cameras placed in fish ways could be used both to assess strayers and to gain information on natural migration.
3. We agreed that present-day scientific knowledge is poor. A comprehensive scientific evaluation, which accounts for biological, economical and sociological factors, should be conducted at each and every possible present-day salmon river. The main focus should be on rivers with weak salmon populations, where management efforts could be needed

urgently (e.g. Mörrumsån). The evaluations should involve not just salmon but also other ecologically important species.

4. The question of straying should be scientifically evaluated. Current knowledge on straying is insufficient.
5. Carlin tags should be replaced with some other tagging system that is more efficient and gives more information about the released animals for example with PIT tags or DNA technique.

Group 3: Commercial fishing, salmon farms

1. There is a lack of conclusive data regarding salmon straying in the Baltic Sea. Genetic effects of straying have not been examined in the Baltic; such effects have, however, been clearly documented in other systems.
2. Catch monitoring should include all kinds of recreational fishing in addition to the commercial fishery.
3. Adipose fin-clipping should be mandatory for all released hatchery fish.
4. If possible, there should be individual batch marking distinct for each hatchery. This could improve assessment of mixed-stock fisheries, and identify hatchery origin of straying fish.
5. Guidelines for best hatchery practice should be developed and made available to all hatchery managers. These guidelines should include all rearing processes – from selection of spawners to releasing of fish.
6. Rephrasing of Article 12.1 in the EU proposal is needed (see Conclusion 1 from the whole group/entire meeting for suggestion of rephrasing: Releases should not be performed in salmon rivers with viable wild populations.).
7. Among other things, the Baltic salmon situation is an allocation conflict. There are several objectives which are sometimes conflicting: e.g. hydro-power, fisheries, tourism, ecosystem, and genetic variation.

Group 4: Environment and nature protection

1. Management has to be considered on a river-by-river basis. This issue was brought up several times during the workshop. Whether it is decisions on stocking, reestablishment of stocks, or habitat restoration each river has to be considered separately. The possibility for stocking measures in individual rivers must in each case be evaluated in relation to the situation in nearby native rivers, and to the total stocking in the Baltic Sea and the overall risk for genetic erosion of wild native salmon stocks.
2. Article 12 in the proposal should be reformulated. There should be no stocking in wild salmon rivers.
3. We support mandatory finclipping of all released fish.

4. Stocking should preferably be made with as early life stages as possible, especially when done for restocking purposes. Research and information is needed on the potential of stocking with e.g., fertilized eggs.
5. Improve the knowledge of hybridization with brown trout. Improve the knowledge of fishermen and others to identify the species.
6. Phase out offshore fisheries.
7. A prerequisite for carrying out management programs should be that appropriate funding is available.
8. We believe that there is an increased need of knowing the geographical distribution and migration routes of wild and reared salmon respectively, to investigate if different management is needed in different parts of the Baltic Sea.
9. There is a knowledge gap on the frequency of strayers, both wild and hatchery reared, and the effects of straying.
10. More information on mixed fisheries is needed. Good genetic data is required for this.
11. Reasons for the decreased post-smolt survival rates must be investigated.
12. There should be more follow-up on the effects of domestication of hatchery reared fish.

Other issues raised during and after the workshop

Here we summarize some additional issues raised during the group discussions as well as comments sent to us after the workshop.

In Group 2 (Sport fishing, tourism, and recreation) the following statements were made in addition to the group agreements listed above:

- If there is continued release of salmon there should be guidelines set for the raising and release that should be followed by the hatcheries.
- Not just the river conditions should be monitored when releasing salmon but also the Baltic Sea environmental conditions. Unfavorable conditions in the Baltic could cause lower migration back to the rivers because of lower food levels.
- Previous salmon spawning grounds should be restored, but such restoration should interfere as little as possible with other species' needs.
- If there is a complete stop of salmon releases there could be a need for a ban on commercial fishing until stocks have recovered enough to put up with the high fishing pressure.
- There could be new fishing quotas for exposed rivers where net fishing is banned and catch and kill is only permitted to local residents.

From members of Group 3 (Commercial fishing and salmon farms) the following comments have been sent to us after the workshop:

Lars Hedman, Bergeforsen salmon farm, Vattenfall:

Even if we did not discuss it, I want to add that Carlin tagging is not a good way to tag fish. It should be replaced by some other method, for example DNA tagging, pit tags, etc. Carlin tagging is a method that gives no answer and is a problem for animal welfare. We must ask ourselves: why do we tag and what do we want to know? I am not against guidelines for hatchery practice; I think that is a very good idea. But the guidelines had to be realistic. 500 parents is no problem for the big rivers but some small rivers will never reach that number.

Janis Birzaks, Insitute of Food Safety, Animal Health and Environment (BIOR), Latvia:

Guidelines for best hatchery practice should provide all rearing process, from selection of spawners till release of fish. Improvements of hatchery salmon parr and smolt processing will be:

- Use of sufficient number of spawners;
- Use of home river or nearest salmon river spawners;
- Hatcheries broodstocks are under the question, spawners from the wild are better – use of spawners spend their life (or part of life) in the wild;
- Rearing process should repeat as possible natural T and light regimes;
- No coastal and sea releases should be conducted. Hatchery reared salmon smolt releases should move in the rivers as far a way from the sea as possible.

From members of Group 4 (Environment and nature protection) the following statements have been sent to us after the workshop:

Sverker Lovén, Fishery advisory officer, City of Stockholm

The plan is not required, that is fine as it is today. Both reared and wild salmon have unique genes. Each individual has unique combinations of genes. Every living creature today shows that they are good enough, though genetically speaking, they have lived with unbroken flame of life in 1 billion years.

It is important to save individuals from fishing by rules, but all fishing must be counted, particularly the gray seals fishing of probably about 100,000 salmon per year, as much as the Swedish salmon fishing.

Strayers are natural, nature's way of testing new gene combinations. In reared salmon gene pool can be improved by a small part alien wildlife breeding material is supplied and by more parents.

Fin clipping is a blunt instrument. People often can not see the difference between clipped and non-clipped salmon. Cutting costs a lot, it can harm the fish, it does not describe where the fish comes from, and it makes stocked fish less attractive to fishermen. Better labeling/tagging models must be developed.

Stanislovas Jonusas, European Commission:

I have a general remark to make on the Agreements. I cannot adhere to the statements provided in the summary, especially those ones which are related to the Commission's proposed salmon management plan, e.g. Articles 12, 13 and etc. The Commission services conducted very extensive impact assessment of the proposed plan and it consulted a big number of stakeholders before the draft salmon plan was being prepared. Therefore, all the content of the plan has a reason and is based on scientific information provided by ICES and STECF. Since the meeting was more of a scientific and not management nature, I did not intervene much. Therefore, I would prefer that somewhere in the document it was indicated that not all participants were of the same opinion. If you refer to the agreement on something, maybe you could include that the majority of the members of the group agreed. That would imply that the minority was in disagreement.

Dan Blomkvist, County administrative board of Norrbotten:

The group came to no consensus regarding the issue of phasing out large scale releases. Several participants in the group felt that they could not support phasing out large scale releases at this stage. Concerns were raised that phasing out compensatory releases actually could prove to be harmful for weak stocks if the current fishing pattern in the Baltic Sea is maintained. It should be a long term goal not to sustain populations by means of stocking, but the decision of whether or not to stop releases should be taken on a river by river basis.

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The Baltic Salmon 2012 symposium and workshop was organized to discuss the conservation genetic pros and cons of the European Commission proposal to halt compensatory releases of salmon in the Baltic Sea. The meetings brought together a wide range of scientists, managers, politicians, and interest groups.

Agreements were reached and the message passed on from this meeting includes that releases should not be performed in wild salmon rivers with viable populations, that conservation genetic goals and recommendations for rearing and releasing salmon must be established within three years, that monitoring programs should be launched that aim at continuously following the genetic constitution of wild and hatchery populations, fin clipping should be mandatory for all released fish, and that conservation action plans on a river by river basis are urgently needed.