Association of Salmon Fishery Boards

NASCO - Salmon at Sea: Scientific Advances and their implications for management

L'Aquarium, La Rochelle, France, 11-13 October 2011.

The following provides a brief summary of what was an extremely interesting three day conference. This summary will focus on the presentations that were most relevant to southern populations of European Atlantic salmon.

Session 1: Introductions and Scene Setting Overviews

Following an introduction by Malcolm Windsor, Daniel Pauly gave a review of the expansion of marine fisheries over the last 60 years in the face of declining landings and fishing down the food chain. He maintained that there has been no sustainability and no maintenance of local stock – the industry is based purely on expansion. The result of this is that there has been an 80% reduction in predators (including pisciverous fish) in the North Atlantic. It was also noted that 36% of the worldwide fish catch is turned into animal feeds, of which around half is for aquaculture. Sustainable utilisation of ecosystems implies a massive reduction of effective fishing effort, the phasing out of high impact gears such as bottom trawls, the setting up of marine reserves, and the export and sharing of all these approaches to those areas and countries from which we import much of our fish supplies.

There then followed a number of talks examining the status of Atlantic salmon and trends in marine mortality, including changes in temperature. Marine return rates for Atlantic salmon are low and have declined since the mid to late 1980s. Atlantic salmon mortality at sea is very high – around 95% as opposed to 16-30% for many marine fish. Abundance has declined more severely for the multi sea-winter components and especially in the southern areas of the species range. It appears that there are broad scale factors affecting productivity and abundance, acting throughout the salmon's time at sea. Accurate stock assessment, ideally at a river-specific scale is the foundation that supports research to explore the factors that determine species abundance and population dynamics, but such assessments require long-term engagement and resources.

Studies on similar declines in the Baltic Sea indicate that the declining trend in marine survival is explained by an increased number of grey seals (which are protected in the Baltic), whereas annual variation in survival coincides with variation in recruitment of herring. However, it remains uncertain whether the observed correlations arise from direct causalities or from other mechanisms.

The physical conditions in the N. Atlantic are governed by the complex interactions in three circulation systems: the sub-polar gyre (cold, less saline waters), the sub-tropical gyre (warm, saline waters) and the thermohaline circulation (which carries water from the sub-polar gyre to the subtropical gyre at depth). During the last decades, the circulation systems have changed – the sub-polar gyre has retracted allowing warmed water to spread northwards, inducing strong warming and affecting the ecosystem at many levels. The effects of global warming of these current are not easy to predict using the current climate models.

Long-term changes in Atlantic salmon show a negative correlation with Northern Hemisphere temperature. There appears to have been a 'regime shift' in temperature after the mid-1980s (which was highlighted in a number of presentations throughout the conference) coincident with a step decline in the total nominal catch in N. Atlantic salmon. Around the same time a progressive northerly biogeographic shift (~1000km) of warm water plankton (including *Calanus finmarchicus*, a major food source for salmon) and fish in the eastern North Atlantic has occurred.

Session 2: Distribution and Migration of Salmon at Sea

This session focussed on a number of tools for assessing the distribution and migration of salmon including: historical tagging data; genetic tools; oceanographic modelling; pelagic surveys; sonic tracking; stable isotopes; by-catch in pelagic fisheries etc. One of the major outcomes of SALSEA has been the development of a genetic database across Europe. The GRAASP tool involved a unique calibration and integration of national databases across Europe, the identification of regional bio-geographical stock groups and the optimization and validation of assignment algorithms. This has resulted in a baseline of 284 rivers and more than 4000 post-smolts have been analysed and regionally assigned. A proportion of fish from surface trawls to the west of Ireland and Scotland appeared to assign to mid-south Norway. However, once a number of Norwegian fish farm strains were included in the baseline, it was clear that these fish were escaped farm fish.

The migration of Atlantic salmon post smolts in the first months at sea was modelled with a particle drift model, which also incorporated active swimming behaviour by fish. There is large inter-annual variability in surface currents which can alter migration patterns. Salinity may also be an important parameter for preference of swim direction.

The origin of Atlantic salmon in the Norwegian Sea, around the Faroes and Iceland and East and West Greenland was discussed, using a number of the techniques listed above. In Faroese waters the salmon assign mainly to rivers in Southern Norway, West-Sweden, Denmark, Scotland, England, Ireland and France. Fewer salmon from northern European populations (Northern-Norway, Finland and Russia) were found in this area. They mainly migrate to the Northern Norwegian Sea and even the Barents Sea. North American salmon were not recorded in the Faroese waters. The majority of salmon in the West-Greenland feeding areas assigned to North-America, particularly in the north of this area. In the southern part of the West-Greenland feeding area there tended to be more salmon assigned to southern European populations. In the Eastern Greenland area more salmon from Norway were recorded.

Pop-up satellite tags offer the opportunity to observe real-time behaviour of adult salmon and relate this to oceanographic patterns. Tagged kelts (smolts could not be used due to the size and weight of the tags) were released from 3 areas in Norway, Ireland, Denmark and Iceland. Fish consistently travelled with oceanic currents and gyres and used polar fronts as primary foraging habitats. These studies detected the northernmost recording of fish, the lowest temperature, the deepest dive and even detected the passage of a tag through the gut of a whale!

Stable isotopes were highlighted as an alternative means of identifying adult location at sea. The composition of isotopes of carbon and nitrogen in tissues (such as scales) is linked to the environmental conditions in feeding grounds. This showed an east/west division in feeding areas between salmon originating from the south (River Frome) and north of the UK (N.E. Drift nets) respectively, and separation in marine feeding areas between grilse and MSW returning fish.

In 2010, a new mackerel fishery opened in Icelandic and Faroese waters and following the documented by-catch of salmon, genetic analyses were undertaken at the request of the Icelandic government to determine whether these fish were of Icelandic origin. These fish were found to be of southern European and Norwegian origin and, despite uncertainty as to the extent of these by-catches, the numbers may be significant. It is likely that the numbers that were found during this research were under-estimates of the real numbers. It was also noted that non-catch mortalities (e.g. due to scale loss in passing through nets) could not currently be quantified.

Session 3: Food Production, Growth, Trophic and Other Ecological Interactions

There would appear to be, in addition to differences in genetics and migration behaviour, differing mechanisms as to how climate variation controls post-smolt survival. European Atlantic salmon recruitment appears to be governed by factors that affect the growth of post-smolts during their first summer at sea, including warmer sea surface temperatures and shifting prey abundances. In contrast, North American Atlantic salmon recruitment appears to be governed by variation in predation pressure during the first months at sea. There may be a mismatch between the cues that stimulate smolt migration and ocean conditions that may exacerbate the marine survival problem.

Grilse returning to Scottish coastal waters have shown recent and marked declines in growth condition, with identical time-series patterns of response for the Spey, North Esk, Tay and Tweed dating back to the 1960s. This effect is attributable to the marine environment and is not a response to systemic changes in freshwater catchments. Long-term variations in adult salmon size, growth condition and lipid energy reserves will have major impacts on fecundity and egg quality of successfully spawning females.

Stomach content analyses of post smolts collected by surface trawling in the Northeast Atlantic were conducted and analysed in relation to environmental data, geographical location and various biological features. The diet was dominated by 0-group fish (fish in their year of birth) and amphipods. 0-group fish dominated particularly in the continental shelf regions whereas amphipods dominated in offshore and Arctic regions. Post smolt growth peaked during years when 0-group fish dominated the diet.

Session 4: Implications for Salmon Management

In many rivers, juvenile salmon are growing faster and smolts are migrating to sea at a younger age and smaller sizes. This is particularly apparent for rivers in the southern part of the north east Atlantic. This may have the effect of damping the impact of increased marine mortality, assuming that higher in-river survival prior to smelting is not outweighed by increased mortality of the smaller smolts at sea. Smolt run timing is occurring earlier with increasing concerns that this might result in a mismatch with optimum marine conditions – the 'environmental window' for smolts. A range of contaminants and other factors in freshwater (such as herbicides, pH etc.) have been shown to have marked effects on smolt quality, with implications for subsequent life stages, and ultimately adult returns.

It is essential that conservation measures taken to address climate mediated declines are appropriate. The release of captive bred animals to augment wild populations were highlighted as having the potential to disrupt the capacity of natural populations to adapt to higher freshwater temperatures associated with climate variability. Rather than imposing an additional genetic load on wild populations by introducing captive bred animals into natural environments, conservation efforts should focus on optimising conditions for adaptation to occur by reducing exploitation and protecting critical habitats. Other tools in the 'manager's toolbox' which were highlighted include preserving and restoring river habitat, temperature shading by riparian woodland, minimising and eliminating fish passage constraints, eliminating habitat fragmentation, and managing land use activities.

Marine ecosystem productivity indicators have been used along the US west coast to forecast annual returns of Pacific salmon. 16 indicators of ocean conditions and ecosystem productivity that relate to early marine survival of juvenile salmon and subsequent adult escapement were developed. These indicators are based on physical factors, and biological indicators that index the quality of food within the food chain and catches of juvenile salmon during trawl surveys. The indicators are subsequently displayed in a traffic light system, where red represents poor ocean conditions and green represents good ocean conditions. These early predictions allow managers to make early decisions to improve harvest management.

In some cases, changes in the pattern of growth and mortality of Atlantic salmon are due to factors within our control and can be alleviated by management action. There are some options for 'ecosystem management' with regard to managing predators and prey species. In other circumstances, such as climate change modifications, there may not only be little that can be done to reverse the pressures but the severity of the impacts may also be expected to increase in the future. As a result, maintaining current management approaches, which generally involve trying to restore historic stock structures, may no longer be appropriate. Managers will also need to determine whether it is likely to be practical (or even possible) to maintain favourable environments for salmon in specific areas in the face of major climatic changes.

Session 5: What Does it all Mean for Salmon Conservation, Management and Future Research?

The focus of the work of SALSEA has been the migration routes and feeding areas of Salmon in the open ocean. There is a clear need to improve our knowledge of the near shore migration patterns of Atlantic salmon and the inshore habitats of sea trout. A clear message from this conference is that many of the factors affecting marine survival, such as changes in oceanic currents, increasing sea surface temperature and the associated availability of prey species are largely outwith human control. However, we must understand these processes in order to forecast and respond to changes in the marine environment. In the light of this challenging global environment, managers must ensure the maximum number of healthy wild salmon go to sea from their rivers. Keeping salmon populations abundant therefore involves managing those factors which are in the gift of mangers, and Governments, to address, with a particular focus on the freshwater, estuarine and coastal waters. These include the improvement of degraded freshwater habitat, removal of barriers to migration, reductions in exploitation, ensuring marine renewables are deployed in a sensitive and well-informed manner and addressing the negative effects of salmon farming.

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