Chairmen's Summary

Food Production, Growth, Trophic and other Ecological Interactions

Dave Reddin and Jens Christian Holst

This session included eight papers presented orally and during an intensive poster session on Wednesday evening, four posters. During this session, much valuable information was presented ranging from food production and growth to how the natural environment in particular marine climate influence salmon abundances.

We heard about how episodic and sustained periods of thermal stress for juvenile salmon will likely result from increasing temperatures in the rearing habitats. Also, there is an expectation of greater change in transitional ocean temperatures than air temperatures in rearing areas of North America that will likely exacerbate the mismatch associated with smolt migrations. Ocean thermal conditions in key post-smolt nursery areas are expected to continue to change, making marine survival unsustainable for some segments of salmon stock complexes from both North American and Europe.

Scale analyses conducted under the SALSEA-Merge project have shown that for an Irish stock poor growth correlates with low marine survival estimates based on coded wire tag studies. There is a lack of synchronicity for some stocks while others showed synchronous growth. The period of concern for growth and perhaps mortality appeared to be in the **early months** after migration to sea.

There have been major changes in condition factor of 1SW and 2SW salmon returning to Scotland over the past 5 decades. Monitoring data from several major river systems (Tay, Spey, North Esk, Tweed) show that these changes are being driven by the marine environment and are not attributable to freshwater climate change. Condition factor explains a significant proportion of the variation in run-timing of 1SW grilse that are presently remaining at sea longer. This has management implications in terms of the vulnerability of entire 1SW cohorts to commercial netting and to angling because close seasons are inflexibly set to a specific date by statutory regulation.

There are several papers in the literature linking plankton production to Atlantic salmon and during another session we heard about the link between phytoplankton and salmon. In the Pacific, salmon production is not a simple function of plankton production in the California Current and Alaska Coastal Current systems. A bioenergetics framework which does not currently exist is required to understand the effects of ocean conditions on salmon growth in the marine environment. Relationships between salmon survival and ocean conditions can be used to forecast salmon returns and may be used to establish effective management and conservation stategies for Pacific salmon.

A relatively new technique of Stable Isotope signatures found on Atlantic salmon scales was described. Temporal fluctuations in diet conditions experienced at sea are recorded in the stable isotope composition of scales. Scales of smolts, 1SW and 2SW salmon from 15 populations from the Bay of Fundy to southern Labrador show a large amount of variation as smolts, but considerably less variation as 1SW and 2SW fish. This reduced range of variation, particularly in the carbon stable isotope signatures, reflects a significant narrowing of feeding opportunity with respect to the ecosystem salmon inhabit, although within the foodweb in which they function, salmon continue to source prey from multiple trophic levels. Isotopic analyses suggest Atlantic salmon move from generalist feeders in freshwater to specialist predators in the marine environment.

In a second presentation, stable isotopes provided a method to explore stock- and cohort- specific patterns in marine mortality. Stocks feeding in different regions are distinguished by their contrasting temporal isotope records. Fluctuations in carbon isotopes in scale archives reflect changes in phytoplankton community dynamics that can be linked to large scale oceanographic patterns such as the Sub-Polar Gyre. Salmon feeding in the Norwegian Sea are more sensitive to climate-induced changes in the phytoplankton community than those feeding further west in the Iceland Basin.

There were also two papers that provided details on the diet of salmon post-smolts through examination of stomach contents of salmon caught at sea. For the Northeast Atlantic, post-smolt diet was dominated by 0-group pelagic fish, Themisto as well as the epi-pelagic copepod, *Anomalocera pattersoni*. Thus, the post-smolt diet was more directed towards the epi-pelagic community than herring and mackerel. Also there was a decrease in stomach content from the years 2002-2003 to 2008-2009 in post-smolt diets. In the Northwest Atlantic, post-smolts were found to consume Atlantic herring and euphausiids in nearshore waters in the Gulf of Maine, while they consumed primarily hyperiid amphipods in the Labrador Sea. Diet for immature adults at West Greenland was dominated by capelin, amphipods, and squid.

This session also saw four very informative posters presented. One of these described smolt age and fine scale marine growth of Atlantic salmon postsmolts in the Northeast Atlantic. The predominant smolt age of post-smolts of wild origin at the Vøring Plateau Area in the Northeast Atlantic was two years, followed by one and three years with a few four year olds. The average rate of circuli formation in the marine zone of post-smolt scales was estimated to be 6.3 days per circulus. Both age structure and number of marine circuli in the scales suggest that the majority of the post-smolts caught belong to populations of southern European origin.

Data storage tags are being used to study the behavioural ecology at sea of Newfoundland Atlantic salmon smolts and kelts. Information recorded on the tags showed behaviour at sea to be characterized by frequent, short duration dives of up to 50 m, particularly during daylight hours. It was shown for the first time that internal and external temperatures frequently differ, with the body wall insulating internal organs from rapid changes in external temperature. This may allow salmon a metabolic advantage (e.g. swimming capacity) over their prey living at depth in cool waters. Ongoing studies include the use of geolocation tags that have been miniaturized requiring new tethering techniques for attachment to smolts. There were 215 smolts tagged in this way in the spring of 2011 and we await the returns in summer/fall 2011.

Evidence was presented for bottom-up trophic effects on return rates to a second spawning for Atlantic salmon (*Salmo salar*) from the Miramichi River, Canada. In a second poster also based on Miramichi River salmon, the changes in spawning efficiency due to the increasing presence of previously spawned salmon in the population was described. It was shown that fecundity and egg survival varied by sea age for previously spawned salmon. Managers should be taking this into account when developing management plans for the Miramichi and other rivers where similar situations exist.

Management implications

- For some Scottish stocks and possibly for those of other jurisdictions, condition factor explains a significant proportion of the variation in run-timing of 1SW grilse. Fish presently are remaining at sea longer due to poor condition. This has management implications in terms of the vulnerability of entire 1SW cohorts to commercial netting and to angling because close seasons are inflexibly set to a specific date by statutory regulation.

- Several papers show direct links of marine climate to growth and indirectly to survival. These phenologic effects can influence plankton production and then continue up the food chain to salmon. Since climate is hard to change significant management options are limited. However, it will be increasingly important to maintain as high a spawning stock as possible in order to have spawners for future generations and to rebuild stocks that have declined.

- Management needs to be flexible and adapt quickly to expected changes in survival resulting from climate variability.