Chairmen's Summary

Distribution and Migration of Salmon at Sea

Lars Petter Hansen and Peter Hutchinson

The session on Distribution and Migration of Salmon at Sea included 13 oral and 9 poster presentations, all but one paper based on research in the North Atlantic. The International Atlantic Salmon Research Board (IASRB) had agreed in 2004 that its initial research priority would be studies of the distribution and migration of salmon in relation to feeding opportunities and predation. The session allowed for presentation of recent studies on this topic, although it should be recognised that much of the data from the SALSEA Programme is still being analysed. While the salmon's marine phase was, until recently, considered as a 'black box', it is clear from the information presented in the session that there have been major advances in our understanding of the stock specific distribution and migration of salmon in the North Atlantic through a variety of research methods including analysis of historical tag recoveries, marine surveys, use of stable isotope analysis, acoustic tagging, use of 'pop-up' tags, genetic stock identification and modelling.

Acoustic tagging provides a reliable and effective method of deriving quantitative estimates of survival at points along the migration pathway. In Canada, detection arrays have extended progressively out to sea. Studies to track smolts from rivers entering the Gulf of St Lawrence out to the Strait of Belle Isle were described. Highest mortality rates for all the rivers were typically in the estuary or freshwater. These studies also indicated that there was synchronisation of migration timing among smolts from the different rivers and with kelt migration. It was suggested that predator swamping and predator confusion effects may be important survival strategies for post-smolts. It appears from these studies that the Strait of Belle Isle is a key migration route. It was indicated that acoustic tagging could form an important input to future stock assessments.

Further from shore, the SALSEA marine surveys have shown that it is possible to sample post-smolts and adult salmon at sea using either gillnets or surface trawls. The results from SALSEA North America show that post-smolts and adults have similar autumnal habitat requirements and a similar diet. Interestingly, intestinal parasite loads were substantial and may be a significant source of mortality. A full analysis of the SALSEA marine survey data should greatly enhance our understanding of salmon ecology at sea and stock-specific differences in productivity. Of course, these surveys are expensive to conduct but provide a range of valuable information on the condition of the fish and the ecosystem they inhabit. The point was made that in future, incorporation of pelagic trawling in existing fishery independent sampling programmes might provide a lower cost approach to continue this type of sampling of salmon at sea.

Modelling studies in the North-East Atlantic have shown that post-smolts swim actively with the current and appear to seek out areas where the current is strongest, with preferred temperatures in the range 9-12°C. Climate variability influences the migration paths and it was reported that the model can assist in identifying post-smolt locations along the migration pathways. These models can provide the timing of when post-smolts arrive at different locations along the migration route thereby assisting in the identification of factors that may be affecting them.

It is also clear that much can be learnt from revisiting historical tag recovery data. Information from the distant-water fisheries at Greenland and Faroes has recently been compiled and analysed providing valuable new information on the distribution and growth of salmon of different origins. This represents a valuable new source of data is to researchers. At West Greenland, North American salmon have a more northerly distribution than European origin salmon. The analysis has also provided valuable information on the origin of salmon at East Greenland and it appears that MSW fish from northern Europe may have a more easterly distribution than those from southern Europe. In the North-East Atlantic, a significant proportion of salmon caught in the late Autumn originated from southern European countries while fish from northern regions were more abundant in the winter period. Information derived from the US Carlin tagging programme was also presented. Over 1 million salmon were tagged and approximately half of the recoveries were in distant water fisheries in Canada and Greenland. A basic marine survival model based on river returns of tagged hatchery smolts from the Penobscot River has been developed that allows assessment of the effects of environmental variables on return rate.

A key element of SALSEA Merge has been the development of genetic population assignment methods. The calibration and integration of baseline microsatellite genetic data across Europe and validation of assignment methods provides a powerful tool for assignment of salmon caught at sea to region of origin. Other molecular markers, SNPs, are being developed that provide cost effective methods to provide higher definition regional or river specific assignment. The utility of these new genetic tools was described. They have already highlighted significant differences in migratory patterns among different regions. They have been used to carry out preliminary investigations of the origin of salmon taken as bycatch in the mackerel fishery around Iceland and may be used for identification of farm escapees and in assessing impacts from climate change. These genetic tools clearly have considerable potential to support management. There were informal discussions during the symposium on how data from North America can be integrated into the database and there will then be an enormously powerful tool available to scientists and to inform management.

Environmental conditions experienced at sea are recorded in the stable isotope composition of scales and stocks migrating to different areas may be distinguished by their contrasting temporal isotope records. Investigations indicated that salmon from the north of the UK feed in the Norwegian Sea, while those from the south of the UK feed further west around the Iceland basin. There was little evidence from the isotope record that salmon successfully returned to the south of the UK from West Greenland. This tool may be a supplement to other methods of studying the distribution and migration of salmon at sea.

Tracking of adult salmon using 'pop-up' satellite tags was also described. These studies have shown that polar fronts are often primary foraging habitats, tagged salmon tend to travel with the main ocean currents, and that they may utilize deeper water than previously known, although why they dive to such depths remains unclear (feeding, predator avoidance?). These new technologies can assist in tracking salmon in the ocean in conjunction with other indirect methods.

Acoustic tagging of kelts has shown that survival through the estuary was high but increased further out to sea. Consecutive spawning salmon spent around 55 days at sea while alternate spawners spent around 400 days at sea.

During 2004 and 2005, concerns were expressed about possible bycatch of salmon in fisheries for other pelagic species, particularly mackerel. Widely differing estimates were developed by ICES at that time based on research vessel and commercial catches of post-smolts and mackerel. These ranged from a handful of post-smolts to several million (a significant proportion of NEAC PFA). New information derived from SALSEA Merge helps to clarify the temporal and spatial overlap of post-smolts and pelagic fisheries. Since the ICES estimates were developed new fisheries for mackerel have commenced around Iceland and Faroes. Screening of catches have provided minimum estimates of the bycatch per 1,000 tonnes of mackerel and herring of 4.8 and 7 salmon at Iceland and 1.5 salmon per 1,000 tonnes of mackerel at Faroes. The quantification of bycatch remains challenging, not least because it was reported that much information comes from unofficial sources, and surveys at processing plants for fish for human consumption and screening of the catches on board commercial fishing vessels were recommended together with experiments using commercial fishing gear. Non-catch fishing mortality of salmon in these fisheries has not been assessed. It was suggested that lowering of the head rope in the mackerel gear may be a possible approach to minimising bycatch. In the North Pacific bycatch limits are set in relation to the pollock fishery and are monitored by the industry.

Associations between time series of catches and various environmental and climatic factors both in freshwater and oceanic phases have been investigated. Rivers in close proximity showed similar trends but differences were identified in the relationship between the Atlantic Multi-decadal Oscillation (AMO) and catches on, for example, the East and West coasts of Scotland.

Three presentations in the session examined relationships between environmental variables and marine survival of salmon. A coupled ocean circulation and bioenergetics modelling approach was described that allows investigation of migration routes and growth condition of post-smolts through the Gulf of Maine. This model allows identification of potential marine mortality bottlenecks, identification of areas for field research and a tool for testing hypotheses relating to impacts of predators impacts and climate change scenarios. A second presentation from the US focused on whether oceanographic changes in the Northwest Atlantic can explain the region-wide decline in Atlantic salmon populations in the 1990s. Relationships between salmon and zooplankton were examined and strong negative correlations in trends between salmon and plankton were found although few correlations in

inter-annual variability were found. Future work will investigate factors that may explain the inter-annual patterns and will investigate when salmon may be most susceptible to oceanographic conditions.

A dramatic example of fluctuations in Pacific salmon abundance was provided from the Fraser River. The sockeye salmon fishery had been closed for three years due to low returns with the 2009 returns the lowest since quantitative monitoring began in 1948. However, in 2010 the returns were the highest in 97 years (~25 million salmon). This extreme variability in returns was attributed to a combination of variable spawner abundance and variable oceanic conditions that appear to have been more marked in recent years. The need to determine life stage-specific mortality rates was noted. These findings highlight the importance of maintaining freshwater production so that the salmon can benefit from any improvement in ocean conditions.

In summary, there have been major improvements in understanding of the distribution and migration of salmon at sea in recent years. The session highlighted a range of valuable new tools that are available to scientists and managers including newly established databases of information, new approaches to identifying salmon to region or river of origin, new modelling methods and new tags. It is clear that scientific challenges remain not least the quantification of bycatch which is important given the deployment of larger and more effective pelagic gear. A full analysis of the data derived from the SALSEA Programme should further improve understanding of salmon migration and distribution at sea. While a further programme of dedicated salmon surveys may not be feasible in the current economic climate, incorporating salmon trawls into on-going pelagic monitoring programmes could be explored as a way to further advance understanding in this area.