SAG(13)5

Report of the Meeting of the Scientific Advisory Group of the International Atlantic Salmon Research Board

Westcourt Hotel, Drogheda, Ireland

Monday 3 June, 2013

1. Opening of the meeting

1.1 The Chairman of the Scientific Advisory Group (SAG), Mr. Tim Sheehan (US), opened the meeting and welcomed participants to Drogheda.

1.2 A list of participants is contained in Annex 1.

2. Adoption of the agenda

2.1 The SAG adopted its agenda, SAG(13)3 (Annex 2).

3. Review of the updated inventory of research

3.1 An overview of the updated inventory of research relating to salmon mortality in the sea, ICR(13)3, was presented. For 2013, 41 on-going and 70 completed projects had been included in the inventory with an annual expenditure of approximately £5.6 million (1 project is uncosted). Seven new projects have been included since the last update.

3.2 A preliminary inventory of marine research is typically completed by the end of March so it can be delivered to the ICES Working Group on North Atlantic Salmon (WGNAS) during its annual meeting. The WGNAS is requested to review the inventory and advise on any gaps, deficiencies or opportunities for increased coordination and collaboration. The SAG discussed this process and was advised that the WGNAS typically does not have the time to perform this task as its meeting is dominated by tasks to complete its terms of reference. Given this, it was suggested that the task of reviewing the inventory of marine research would be better performed by a separate group every 3 or 4 years. This sub-group should consist of current SAG members familiar with the inventory, as was the case with the sub-groups that reported in 2013 (SAG(13)02) and 2009 (SAG(09)10).

3.3 The SAG discussed the next steps for the current inventory and agreed that the jurisdictions should be given the opportunity to provide any feedback on the inventory to the Secretariat by the end of June, with a view to the inventory being made available on the Board's website by the end of July. The Parties are encouraged to provide any feedback on the current version of the inventory to the Secretariat by June 28.

3.4 At last year's meeting, the SAG discussed the need to make the inventory more visible and attractive and to increase its accessibility to researchers and other interested parties. A number of website modifications have been made to improve the profile of the inventory. The SAG further discussed other options for achieving this goal and requested that interested Parties should provide suggestions to the Secretariat to achieve this goal.

4. Review of project applications for potential funding by the Board

4.1 No proposals were received for consideration by the Board this year.

5. Developments in relation to the SALSEA Programme

(a) Report on Progress in establishing a metadatabase of salmon survey data and sample collections of relevance to mortality of salmon at sea.

5.1 In 2011, the Board had recognized that recent international initiatives under the SALSEA Programme had generated some extremely valuable databases. These include biological and genetic databases generated under the SALSEA Merge project, and time-series of data and historical tagging information compiled by ICES workshops supported by the Board. Similarly, the Board also noted the existence of some historical marine survey samples, such as those generated by the international sampling programme at West Greenland, that represent an invaluable resource dating back some 40 years or more. The Board had recognized that there is a need to ensure that these databases are securely held, maintained and agreed procedures developed to allow access to the data for future research. The need to ensure that these samples are being maintained and agreed procedures developed to allow access to them for further research was recognised.

5.2 The Board had, therefore, established a Working Group on Marine Salmon Survey Data and Sample Coordination which recommended that the most important role that the IASRB could play with regard to marine salmon survey data and sample coordination would be to establish a metadatabase of existing datasets and sample collections. In 2012, the SAG accepted a format for this metadatabase and requested that jurisdictions provide relevant information. In accordance with this request, an e-mail form, based on this format, was sent to each Party/jurisdiction on 29 October 2012. To date, returns have only been received from the US and Greenland.

5.3 The SAG recognized that there may have been some confusion regarding the purpose of the metadatabase. It was clarified that the metadatabase was not meant to be a vehicle to provide raw data to researchers and other interested parties, rather the metadatabase is meant to serve as an advertisement to researchers and other interested parties as to the availability of the valuable and unique datasets related to the marine

phase of Atlantic salmon. The SAG recognised that various Parties/jurisdictions involved in the long-term datasets have certain ownership rights to the data and the respective Parties/agencies may have, or are currently developing, data use and data sharing protocols to guide the use of agency owned data with outside collaborators. It was decided that the SAG Chairman will work with the Secretariat to develop a one page information sheet clearly explaining what the purpose of the metadatabase is and how it may contribute to increased collaboration and understanding of the marine-phase of salmon in the North Atlantic. This information sheet will accompany all future requests to the Parties for information related to candidate metadatabase datasets and will be posted with the metadatabase on the IASRB's website.

5.4 The SAG also discussed the difficulty in identifying a single person to provide information related to a dataset that results from multi-Party/jurisdiction collaboration. It was recognised that people may not have responded to the IASRB request for information if it was unclear who the proper point of contact should be for that project. To rectify this issue, a list of candidate datasets for inclusion in the metadatabase was developed and specific points of contact were identified from the attending SAG members. The Secretary will send out a second e-mail request to the Parties/jurisdictions for information related to the metadatabase. The SAG Chair will then follow-up with the various points of contact individually, to assist them in providing the requested information to the IASRB for the metadatabase.

5.5 The candidate datasets and points of contact for the datasets not previously reported on are as follows:

- SALSEA-Merge (Niall Ó Maoiléidigh)
- SALSEA North America (Tim Sheehan)
- SALSEA Greenland (Tim Sheehan)
- Faroes fishery sampling (Ted Potter)
- Faroes CWT tag recaptures (Niall Ó Maoiléidigh)
- Greenland CWT tag recaptures (Ted Potter)
- WKSTAR databases (Niall Ó Maoiléidigh)
- North American run reconstruction data used in ICES WGNAS Assessments (Gérald Chaput)
- North-East Atlantic run reconstruction data used in ICES WGNAS Assessments (Ted Potter)

5.6 The SAG Chairman will work with the individual points of contact to make sure that there is no significant overlap between the identified datasets which may cause additional confusion in the future. As an example, should the point of contact for the 'Faroes fishery sampling' project report on tag recaptures if they are also reported by the point of contact for the 'Tag recaptures for the Faroese fishery' project.

5.7 The SAG also discussed the need to make minor adjustments to a small number of fields in the current version of the metadatabase, specifically the data availability field. The SAG Chairman will work with the Secretariat to make the necessary modifications.

5.8 A preliminary metadatabase is expected to be available to the SAG for review prior to its 2014 meeting. At that time, the SAG can advise on appropriate next steps for the development and proper use of the metadatabase.

(b) Progress reports on projects funded by the IASRB

5.9 Last year, the Board agreed to fund two projects (£6,000 each) as follows:

- A proposal to undertake genetic stock of origin identification of European salmon captured at West Greenland; and
- A proposal for genetic stock identification of salmon caught in the Faroes fishery.

5.10 The funding provided by the Board allowed the projects to proceed and also led to other funds being made available from a number of Parties for the Faroes Genetic Stock Identification project.

5.11 Professor Ken Whelan gave a brief update as to the status of the Greenland genetics study. The study is primarily being conducted by University College Cork and Queens University Belfast Fish Population Genetics, Beaufort Team with additional funding from the Atlantic Salmon Trust and the Department of Culture, Arts and Leisure's Agri-food and Biosciences Institute (UK (North Ireland) and collaboration from US scientists from NOAA Fisheries Service and the US Geological Survey. The study aims to assign region/river of origin of European salmon taken in the Greenland subsistence fishery.

5.12 A total of 1,949 samples from 2002 - 2010 across a range of sampling locations were available for processing. Initial efforts were dedicated to test and optimise DNA extraction techniques. Genomic DNA extraction has been successfully carried out for all samples. Samples are currently being screened for 25 micosatellite markers, but preliminary data are available from a subset of 204 (10%) samples. Preliminary assignment results are as follows: Scotland (40%), Ireland (35%), Norway (9%), England (6%), Wales (3%), Northern Ireland (2%), France (2%), Spain (2%), and Denmark (1%). This represents a mixture of samples, drawn from a number of years and a number of different sampling locations. There is an expectation that river of origin assignments may be possible, especially for the countries with robust baselines (i.e. Scotland and Ireland). A final report is expected by August 2013.

5.13 Mr. Ted Potter gave a brief update on the status of the Faroes study. The study involves scientists from UK (Cefas and Marine Scotland Science), Norway (NINA and IMR) and Faroes (MRI) and is funded by the NASCO IASRB, and UK, Norway and Ireland. The study aims to assess the stock composition of the Faroes Salmon Fishery through genetic stock identification techniques on scales collected in the Faroes in the 1980s and 1990s.

5.14 Approximately 750 scale samples collected from commercial and research catches in the fishery have been selected from each of two periods comprising the 1983/84 and 1984/85 seasons and the 1993/94 and 1994/95 seasons, respectively. Initial results have shown significant degradation of the DNA in some of the monthly samples, with substantial loss of some long alleles. While these problems may limit the number of

useable samples, analysis suggests that it will not bias the assignments. Use of a new PCR protocol, developed by Paulo Prodohl (Queens University Belfast), has greatly improved the extraction of useable DNA. Although no assignment analysis has been undertaken yet, a number of samples have been identified with alleles that are only expected to occur in North American salmon.

5.15 Mr. Gérald Chaput gave a brief update on an ongoing project that was previously funded by the IASRB. The study has evolved into a PhD project at the University of Waterloo and involves scientists from Fisheries and Oceans Canada and NOAA Fisheries Service. The study aims to use stable isotopes ratios to infer trophic structure and condition of Atlantic salmon during their life at sea.

5.16 Stable isotope samples were collected from smolts sampled at 15 index rivers in eastern Canada, from 1SW fish returning to 13 of these rivers, from 2SW fish returning to 6 of these rivers and 1SW non-maturing fish from Greenland as part of the SALSEA Greenland sampling program. Processing and analysis of all collected data are ongoing, although a manuscript entitled "Characterizing the trophic position shift in Atlantic salmon (*Salmo salar*) from freshwater to marine life-cycle phases using stable isotopes" was published in the ICES Journal of Marine Science as part of the 'Salmon Summit' symposium proceedings. Additional manuscripts detailing other aspects of the project are expected in 2013.

(c) Other activities

5.17 Mr. Dave Meerburg reported that the Atlantic Salmon Federation (ASF) has continued to assess estuarine and marine survival of tagged Atlantic salmon released in rivers of the Gulf of St. Lawrence using acoustic tags and pop-up satellite tags. There is now a detector array across the Cabot Strait (110 km northeast from Cape Breton Island) meaning that each exit from the Gulf of St. Lawrence is monitored. He also reported that work in 2013 continued the use of the wave glider as an active platform for tracking migrating tagged fish in the Gulf of St Lawrence. A wave glider was deployed in 2013 and, so far, has detected a tagged migrating kelt.

5.18 In 2012, ASF discussed the potential to install a detector array at West Greenland. This was not pursued in 2013 as planned, primarily due to the uncertainty with capturing high quality candidate fish for tagging and because of funding constraints. ASF will continue to investigate options for pursuing this work.

6. Report of the SAG Sub-Group on the Future Direction of Research on Marine Survival of Salmon

6.1 The Sub-Group met in London in December 2012. The Chairman, Mr. Ted Potter, provided a brief overview of the Sub-Group's final report, SAG(13)2 (Annex 3).

6.2 The Sub-Group considered that a priority should be to analyze the remaining samples and data arising from the SALSEA Programme and encouraged the Board to explore opportunities to support these analyses. The Sub-Group proposed that a particular focus for the Board should now be studies to partition mortality of salmon among the phases of the marine migration and it recommended that the Board should consider whether it wishes to facilitate a meeting of scientists and external partners to further

develop a collaborative international programme of research. A preliminary outline proposal was provided and the aim would be to identify where there may be particular need for international collaboration and coordination and support with fund raising.

6.3 It was noted that ICES has recommended that the IASRB support the further development of the project outlined by the SAG Sub-Group. The WGNAS report endorsed the view of the Sub-Group that analysis of outstanding samples obtained during the marine surveys under the SALSEA programme should be a priority and that a mechanism should be sought to obtain funding to support this. The WGNAS report also recommended that the IASRB support the further development of the project outlined. The WGNAS stated that 'a large international coordinated project monitoring the marine migration of many salmon stocks across the North Atlantic may provide stage-specific estimates of marine survival that would increase knowledge of marine ecology and better inform management. Stage-specific marine mortality estimates would help improve essential inputs in stock assessment models and would provide additional information for testing hypotheses on the causal mechanisms for the increase in marine mortality documented for most stocks across the North Atlantic in recent decades. These results would also be of benefit to managers trying to identify areas where action might be taken to mitigate current impacts. Detailed information on migration dynamics of salmon in nearshore waters will also aid managers involved in marine spatial planning to evaluate the impacts of alternative/renewable energy projects (e.g. wind energy, tidal energy, etc.) in marine waters'. The WGNAS also encouraged the IASRB to consider expanding the focus of this research project beyond the scope of salmon. Integrating the research needs across different species 'would increase the benefit of an effort like this and increase the likelihood of successfully competing for funding support'. The report further encourages the IASRB to consider the wide variety of resources and experiences available for an endeavor such as this as 'large-scale multinational tracking programmes are already underway in NAC. Experience gained from these efforts would increase the likelihood of success for any effort initiated in NEAC'.

6.4 The SAG Sub-Group also considered the future role of the SAG and concluded that as the SAG is the only body within NASCO that identifies research needs and addresses scientific coordination, it is the most appropriate and effective forum in which to perform this important role. The Sub-Group did not consider that the SSC, as presently constituted, is an appropriate forum in which to address the scientific work required by the Board.

6.5 It was noted that the WGNAS report endorsed this view, noting that the SAG provided an essential mechanism for scientists to collaboratively work with managers to develop scientific programmes to support the conservation, protection and enhancement of salmon stocks.

6.6 The SAG endorsed the Sub-Group's findings and encouraged the IASRB to fully consider its recommendations. The SAG recommended that the Board consider forming a new SAG Sub-Group to develop a document outlining a 'roadmap' for a large international collaborative telemetry project to ultimately provide information on migration paths and quantitative estimates of mortality during phases of the marine life-cycle of salmon.

7. Other business

7.1 There was no other business.

8. Report of the meeting

8.1 The SAG agreed a report of its meeting.

9. Date and place of the next meeting

9.1 The SAG agreed to hold its next meeting in conjunction with the Thirty-First Annual Meeting of NASCO.

9.2 In closing the meeting, the Chairman thanked the participants for their contributions to the meeting.

Annex 1

List of Participants

Gérald Chaput
Konstantin Drevetnyak
Dennis Ensing
Peder Fiske
Cathal Gallagher
Peter Hutchinson
Dave Meerburg
Michael O'Malley
Niall Ó Maoiléidigh
Ted Potter
Sergey Prusov
Elena Samoylova
Tim Sheehan (Chairman)
Ken Whelan

Annex 2

SAG(13)3

Agenda

1. Opening of the meeting
2. Adoption of the agenda
3. Review of the updated inventory of research
4. Review of project applications for potential funding by the Board
5. Developments in relation to the SALSEA Programme
   a. Report on Progress in. establishing a metadatabase of salmon survey data and sample collections of relevance to mortality of salmon at sea.
   b. Progress reports on projects funded by the IASRB
   c. Other activities
6. Report of the SAG Sub-Group on the Future Direction of Research on Marine Survival of Salmon
7. Other business
8. Report of the meeting
9. Date and place of the next meeting

Annex 3

SAG(13)2

Report of the Meeting of the Sub-Group on the Future Direction of Research on Marine Survival of Salmon

1. At its 2012 meeting, the Board agreed to reconvene the Sub-Group established by its Scientific Advisory Group (SAG) that last reported in 2009. This Sub-Group met in London during 11-13 December 2012 under the Chairmanship of Mr. Ted Potter (EU) and its report is attached, SGFR(12)10.

2. The Sub-Group reviewed the findings of recent scientific investigations and their implications for management. It noted that genetic stock identification and other advances in the field of genetics, migration modeling, tracking and studies of the diet of salmon at sea all have considerable implications for management and there have been advances in all these areas of research under the SALSEA Programme. The Sub-Group also reviewed the Board's inventory of research and identified opportunities for enhanced collaboration, gaps in the research programme and future research needs to support management. It considered that a priority should be to analyze the remaining samples and data arising from the SALSEA Programme and the Board is encouraged to explore opportunities to support these analyses. The Sub-Group has proposed that a particular focus for the Board should now be studies to partition mortality of salmon among the phases of the marine migration and it recommends that the Board considers whether it wishes to facilitate a meeting of scientists and external partners to further develop a collaborative international programme of research. A preliminary outline proposal has been provided and the aim would be to identify where there may be particular need for international collaboration and coordination and support with fund raising. The Sub-Group noted that the Board has very limited resources and recognized that if it is to continue to play a role in supporting research on salmon at sea it should consider how it can address this situation. The Sub-Group also considered the future role of the SAG and concluded that as the SAG is the only body within NASCO that identifies research needs and addresses scientific coordination it is the most appropriate and effective forum in which to perform this important role.

3. The Sub-Group's report is being made available now because it believes that there may be some opportunities to further consider the approach to addressing the research gaps it has identified through informal discussions among scientists (e.g. at the ICES Working Group on North Atlantic Salmon) prior to the Annual Meeting in June. Furthermore, the Board has agreed to consider its future working methods *inter alia* in the light of the Sub-Group's report and it might be helpful to Board Members to have more time in which to consider the Sub-Group's findings. The SAG and Board will be asked to consider this report at their meeting in Ireland in June and decide on appropriate action.

Interim Secretary
Edinburgh
27 February 2013

SGFR(12)10

Report of the Meeting of the Sub-Group on the Future Direction of Research on Marine Survival of Salmon

NEAFC Headquarters, 22 Berners Street, London
11 – 13 December 2012

1. Opening of the meeting

1.1 The Chairman of the Sub-Group, Mr. Ted Potter (EU), opened the meeting and welcomed participants to London. He referred to the previous work of the Sub-Group (as reported in SAG(09)10) that had highlighted gaps in current research on marine survival of salmon, identified areas where there could be improved coordination of research and developed recommendations for changes to the inventory to improve access to the information. He referred to the good progress made in implementing the SALSEA Programme, as reported at the Salmon Summit. The International Atlantic Salmon Research Board (IASRB) and its Scientific Advisory Group (SAG) had therefore determined that this is an appropriate time to re-evaluate their roles in supporting research relevant to NASCO's objectives. Consequently, compared to its first meeting, the Sub-Group had broader Terms of Reference that included reviewing the future role of the SAG. He indicated that while the research to date had focused only on marine mortality of salmon, the Sub-Group might also wish to consider if there could be a broader role for the Board and SAG covering other aspects of research relevant to NASCO's work. He referred to the fact that the work of the IASRB and SAG had recently been welcomed by NASCO's external performance review panel and a recent EU project (TXOTX) that reviewed science to support the work of RFMOs.

1.2 The Interim Secretary added his welcome to participants and thanked Mr. Potter for chairing the meeting and the NEAFC Secretariat for hosting it. He referred to the progress made in implementing the SALSEA Programme since its development in 2004. This had been possible as a result of an extremely successful public/private fund-raising initiative and had generated enormous amounts of new information, new tools that could support management and had raised NASCO's profile.

1.3 A list of participants is contained in Annex 1.

2. Adoption of the agenda

2.1 The Sub-Group adopted its agenda, SGFR(12)6 (Annex 2).

3. Consideration of the Terms of Reference

3.1 The Sub-Group reviewed its Terms of Reference, SAG(12)3 (Annex 3) which are as follows:

- Review the outcome of recent scientific investigations and summarise the findings which have significant management implications;
- Review the Inventory of Marine Research and identify opportunities for collaboration within the suite of ongoing projects to facilitate progress with identifying the major causes of salmon mortality at sea;
- Based on the inventory and the results of recent scientific studies published in the literature, identify gaps in research efforts and knowledge which may be important for advising on salmon management actions;
- Review the larger SALSEA project and advise on a "road map" to complete other elements of the research previously identified;
- Arising from these reviews, advise on possible future role of the SAG.

3.2 The Sub-Group had been asked to take into account, *inter alia*, a number of documents as detailed in document SAG(12)3. It noted that the findings from recent research relating to mortality of salmon at sea and its implications for management had been presented and discussed at the very successful 2011 NASCO/ICES symposium 'Salmon at Sea: Scientific Advances and their Implications for Management' known as the 'Salmon Summit' (see paragraph 4.1 below) and subsequently in a range of other fora including the Atlantic Salmon Trust/NASCO meeting entitled 'Ocean Silver. The Atlantic salmon's ocean odyssey: implications for fishery managers'. Reference was also made to a draft paper entitled 'Climate and ecosystem linkages explain the widespread decline in North American Atlantic salmon populations' that has recently been submitted for publication. Further information concerning this manuscript can be obtained from the NASCO Secretariat. In addition to the documents listed in document SAG(12)3, the following documents were made available to the Sub-Group:

- Current Status of SALSEA Projects, SGFR(12)2;
- A Review of the SALSEA results, SGFR(12)4;
- Report of the SAG Research Inventory Review Group, SAG(09)10;
- Plan for Workpackage 3 of SALSEA, SAL(06)4.

3.3 The Chairman indicated that the IASRB Chairman had suggested that, in considering the future role of the SAG, it would assist the Board if the Sub-Group could consider the pros and cons of other possible arrangements to provide scientific input to the Board. In the light of the Sub-Group's recommendations on this issue, and those of the inter-sessional meeting of the Parties on a future vision for NASCO, the IASRB would then consider its own working methods.

3.4 The TORs indicate that the Sub-Group should take into account the current management priorities as indicated by the Parties. None had been provided before the meeting. A list of prioritised research needs for NASCO developed by the EU was made available to the Sub-Group, SGFR(12)5.

4. Review of the findings from recent scientific investigations and their implications for management

4.1 The Sub-Group considered a number of reports detailing the findings from recent scientific investigations as listed in Annex 3 and in paragraph 3.2 above. The

Conveners' report from the Salmon Summit had noted significant advances in the scientific understanding of the marine phase of the salmon's life-cycle. It had concluded that since management options in the ocean are limited, the principal goal of managers should be to maximize the number of healthy wild smolts that go to sea by focusing management actions on impact factors in fresh, estuarine and coastal waters. It also noted that further efforts should be made to quantify the extent of by-catch of salmon in pelagic fisheries for marine species and the opportunities for mitigation measures.

4.2 The Sub-Group noted that genetic stock identification (GSI) was an integral part of the SALSEA Programme and had been selected in preference to tagging as the most cost-effective approach for investigating the distribution of salmon stocks in the ocean. The SALSEA Merge project had included a specific objective to map regional genetic structure of Atlantic salmon and establish a standardised genetic baseline database for regional or river-specific populations. The project facilitated the development of a unique molecular assignment protocol, Genetically-based Regional Assignment of Atlantic Salmon Protocol (GRAASP). As a result of the programme, there had been significant progress in developing genetic tools to support GSI, and these tools had been tested and shown to be effective. Significant temporal and spatial heterogeneity in the distribution of the regional stock groups was found and fish of farm-origin identified, demonstrating the value and power of the tool. The results have significant implications for, and application to, management and the Sub-Group noted that they are already being used, for example, in relation to identification of the stocks contributing to the mixed-stock fisheries in Finnmark in northern Norway, North-East England and Castlemaine in Ireland.

4.3 Similarly, a new Canadian project has been initiated to develop a North American genetic baseline that is being used to identify the stocks contributing to the mixed-stock fisheries in Labrador and St Pierre and Miquelon (see paragraph 5.4).

4.4 There have also been other developments in the field of genetics that could assist management such as studies aimed at increasing understanding of the selective pressures associated with fishing, of the genetic basis of phenotypic characteristics such as age at maturity and run timing, and of the origin of escaped farmed salmon.

4.5 Information presented at the Salmon Summit had highlighted the potential adverse genetic and ecological impacts of poorly planned stocking programmes that could diminish the ability of wild salmon to adapt to a warming climate. The Sub-Group considered that there could be benefits from further discussions in NASCO on stock rebuilding programmes and in this regard noted that, in response to a request from NASCO, ICES will be advising on best practices in salmon restoration programmes. This information should assist managers in considering responses to climate change. In addition, an Atlantic Salmon Trust conference on stocking is planned for November 2013. It had also been noted at the Salmon Summit that there was a need to plan ahead for the anticipated changes associated with a changing climate and, in this regard, the Sub-Group noted that the Council of NASCO has identified this as a priority topic for a themed-based Special Session in the future.

4.6 The Sub-Group recognized that the SALSEA Programme had also led to major advances in understanding of the distribution and migration of salmon at sea through marine surveys, acoustic tracking, stable isotope analysis and migration modeling. Migration models have potential to support management as they can provide estimates of migration paths under different oceanographic conditions and this could inform decisions, for example in relation to the siting of renewable energy installations. Improved understanding of the distribution and migration of post-smolt salmon at sea obtained from both survey and modeling studies will also assist in refining estimates of by-catch of salmon in pelagic fisheries and potentially in managing fishing activities in these fisheries to safeguard salmon. The Sub-Group recognized that these models require further development but could be increasingly useful to managers in the future. Both the model developed for the North-East Atlantic and that for the Gulf of Maine had been designed to be transportable so they can be applied in other areas, and the US model is being applied to the Gulf of St Lawrence.

4.7 The Sub-Group also recognized that there have been major advances in technologies for tracking salmon at sea and that these have been applied in studies in the US and Canada that had been linked to the SALSEA Programme. Such studies can provide detailed understanding of the movements of smolts through coastal waters and the potential to obtain stage-specific estimates of survival through estuaries, nearshore waters and, increasingly, further out to sea. Such information will aid in partitioning mortality between stages of the marine phase and will be very valuable to managers when considering the potential impacts of human activities in these areas. Satellite tags and DSTs can also be used to obtain additional information on conditions experienced by salmon at sea.

4.8 The results of the SALSEA projects had provided further evidence that salmon stocks were being affected by changing environmental conditions at sea, and it was noted that similar mechanisms appear to be affecting salmon mortality in the Northwest and North-East Atlantic, with climate change effects cascading through marine trophic levels and affecting salmon.

4.9 The Sub-Group noted that there have been considerable advances in understanding the diet of salmon at sea; additional data are being analysed from sampling at West Greenland, and some multi-species work is also ongoing. For example, at West Greenland studies have shown the importance of capelin in the salmon's diet but the size and energy content of capelin has declined in recent years. In the case of the Miramichi River, studies have provided evidence of bottom-up effects of small fish biomass in the Gulf of St Lawrence on the return rate of previous spawners. Such observations may have implications for the management of other fisheries.

5. Review of the Inventory of Marine Research; identification of opportunities for enhanced collaboration, gaps in the research programme and recommendations for future research to support management

5.1 In its 2009 report, SAG(09)10, the Sub-Group had assessed progress in relation to each of the tasks in the three work packages of the SALSEA Programme, SAL(05)4. The Sub-Group updated this analysis and its recommendations are detailed below.

Supporting Technologies

Genetic tagging to determine stock origin

5.2 When the Sub-Group last reviewed the inventory in 2009, it was felt that there was some lack of co-ordination between current genetics work on Atlantic salmon in Europe and North America. However, this had been addressed within the SALSEA-Merge project, and there is now good liaison between the various groups of geneticists who are applying GSI techniques to Atlantic salmon.

5.3 The Sub-Group considered that the utility and application of GSI techniques had been demonstrated but that there will be a need to ensure the temporal stability of the baselines in future. More detailed genetic baselines are also likely to be needed for some local management purposes. For example, in the Kolarctic salmon project to investigate the salmon stocks contributing to the coastal fishery in Finnmark, 31 microsatellite markers are being used rather than the panel of 14 markers used in the SALSEA Merge project. In this regard, it was recognized that new, cost-effective genetic tools based on SNPs are also being developed and that these may offer improved discrimination that could be applied to specific management issues. It was noted that newly developed genetic tools were capable of identifying escaped farmed salmon, and these have been used to identify the source of escapes. There are likely to be benefits from continued collaboration between geneticists as these new techniques are developed and applied.

5.4 Building on a SALSEA initiative to develop a compatible genetic database over the entire salmon distribution area, a North American project supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) has commenced. This project will combine, calibrate and integrate genetic databases for all Canadian provinces and USA Atlantic salmon populations, providing a valuable tool for identifying North American origin of salmon in fisheries.

5.5 In 2012, the Board had agreed to provide seedcorn funding to support GSI analyses of historic scales samples from salmon caught at Greenland and Faroes. These projects are now ongoing and are expected to have direct implications for the provision of advice to NASCO on the management of the fisheries in these areas.

Marine sampling equipment

5.6 The SALSEA Programme had a specific objective to initiate research efforts to develop a smolt trawl design that would minimize size selection. The Sub-Group

considered that there had been some progress on this task with the development of the live sampling box for the pelagic trawl and the implementation of standardized operating and sampling protocols. The method had been widely deployed in marine surveys in both the Northwest and North-East Atlantic as well as in other research programmes (e.g. Celtic Sea Trout Project). However, it was recognized that there is some selection in all sampling gear. Both gill nets and trawls had been used to sample salmon in the Northwest Atlantic. While the gill nets had provided samples of post-smolt and adult salmon, the trawls primarily caught post-smolt salmon. Results from SALSEA North America revealed that compared to gill nets, the surface trawl appeared to be size selective capturing the upper end of the post-smolt size range. This was contrary to expectations that the trawl would be more efficient at capturing smaller-bodied fish with slower swimming speeds than larger conspecifics. However, smaller post-smolts may have escaped through the larger upper mesh section of the surface trawl. Installing a smaller mesh liner along this section may help prevent this phenomenon. It should be noted that the surface trawl also provides an added benefit of capturing other fish species co-occurring with salmon in the pelagic ecosystem.

5.7 The Sub-Group considered that further research on sampling methods was not a high priority but noted that any known selective bias would need to be taken into account during the analysis of the data. The Sub-Group also believed that if opportunities arose, the open trawl fitted with CCTV and/or tag detectors could be used to provide additional information on post-smolt abundance. In this regard, at the Salmon Summit it had been suggested that the opportunities to incorporate salmon surveys in ongoing research surveys might be explored within jurisdictions.

Analysis of scales and other tissues

5.8 The SALSEA Programme included a specific objective to establish standardised digital scale analysis techniques and identify marine growth histories and anomalies indicating common mortality factors on spatial and temporal scales**.** The Sub-Group recognized that there had been good progress on this topic. As part of the SALSEA Merge project, a workshop had been held in Trondheim in September 2008 to train researchers from four centres in the use of the new scale reading techniques, and to ensure the use of standardized scale analysis procedures between laboratories. Additionally, two meetings of an ICES Workshop on Age Determination of Salmon (WKADS) had been held in Ireland in 2011 and 2012. These Workshops primarily focused on digital scale reading to measure age and growth, with a view to standardization. A training manual has been developed. The same techniques are increasingly being used in a wider range of research projects.

5.9 While the Sub-Group did not feel there was a need for further action to encourage collaboration it noted that there may be little awareness of these standardized procedures among researchers not directly involved in NASCO and ICES work and it was important to disseminate the findings more widely.

5.10 The Sub-Group noted that in addition to studies of age and growth, stable isotope signatures from scales (and tissue samples) could be used to investigate distribution and migration of salmon at sea, the environmental conditions experienced by salmon at sea and changes in trophic level. It was recognized that such studies are ongoing in both Europe and North America and that while there was less need for collaboration

among researchers on methodology, there was a need for some coordination to avoid duplication of effort. In this regard, the Board's inventory is a valuable tool.

Tagging technologies

5.11 The Sub-Group recognized that despite recent advances in tag development, the battery life for miniaturized tags that could be applied to smolts limits tag life to a period of about 2-3 months, although this can be extended by programming for less frequent transmissions, and advances in technology are ongoing. Larger tags, including 'pop-up' tags, with longer lifespans could be deployed on larger salmon, for example non-maturing 1SW salmon captured at West Greenland. Further development of technologies for monitoring acoustically tagged salmon at sea could include the use of wave gliders, as being developed by the Ocean Tracking Network, and consideration of the possibility of deploying receivers during biological and physical oceanographic surveys. Information derived from the SALSEA Programme could be used in developing appropriate sitings for detection arrays e.g. in the southern North-East Atlantic Commission area. There will be a need for international cooperation in agreeing on, and using, identical technologies and standard techniques, in deploying receiver arrays and in data sharing and security. There will also be a need for collaboration with companies developing new tagging and detection equipment.

Freshwater phase

5.12 The SALSEA Programme had recognized that work conducted in freshwater and the inshore zone is largely funded nationally but that there was a need for enhanced coordination of research efforts. Studies undertaken to date had highlighted the need to maximize (or optimize) the number and quality of smolts emigrating from rivers. This will, therefore, require an understanding of the factors affecting production.

Influence of biological characteristics of Atlantic salmon smolts

5.13 The overall aim of this research has been to identify differences in the marine survival of smolts with different characteristics, and to determine the extent to which such factors could account for widespread changes in salmon stock abundance. In response to a request from NASCO, ICES had established the Study Group on the Identification of Biological Characteristics for use as Predictors of Salmon Abundance (SGBICEPS). The Board had provided funding to support the participation of some non-government scientists in this group.

5.14 This Study Group had highlighted the difficulties in obtaining comparable data from the long-term monitoring studies conducted in different countries but had undertaken some interesting analyses including examination of trends in mean smolt age and in run-timing of smolts over time. The Sub-Group recognized the progress that had been made and agreed that opportunities to continue this work should be explored. The importance of long-term monitoring was stressed as it provided the basis on which to assess trends in marine survival and freshwater productivity. The Board and its SAG could provide a forum to encourage the development of this network to include a more representative selection of stocks and/or to use lower cost approaches (e.g. by only monitoring abundance) and to improve collaboration in the analysis of results.

Impacts of physical factors in fresh water

5.15 The overall aim of this research was to assess the effects of physical variables on marine survival. There are two broad goals: to identify common or differing trends in freshwater physical conditions that are common throughout the geographic range, or within a geographic region, and that may modify factors such as smolt quality or migratory behaviour and reduce the ability of smolts to physiologically adapt to the marine environment; and to improve understanding of anthropogenic factors (e.g. hydropower, abstraction) on stocks to enable improved management of these activities on specific rivers.

5.16 The network of monitored rivers provides an opportunity to better understand the effects of physical variables on marine survival. Low cost equipment for monitoring flows, water temperature and other physical and chemical variables is available, and installation of such equipment in monitored rivers, where such data are not currently available, would facilitate future studies.

Impacts of water quality factors in fresh water

5.17 The aim of this research was to assess the effects of freshwater contaminants from a wide range of sources, including agriculture, aquaculture and urban run-off on marine survival and their potential role in the widespread decline of stocks. The Sub-Group recognized that there had been advances in understanding of the range of contaminants that can affect the ability of smolts to adapt to sea water, but knowledge is still lacking on population level effects. It was noted that a conclusion from the Salmon Summit had been the need to maximize the output of healthy wild smolts. The Sub-Group recognized that there could be benefits from improved collaboration among groups working on this issue and stressed the importance of the network of monitored rivers in future investigations.

Marine phase

5.18 The SALSEA Programme contains four tasks concerned with the planning and implementation of marine surveys in the Northwest and North-East Atlantic.

5.19 The Sub-Group noted that in developing and implementing the SALSEA programme, the IASRB had decided to focus much of its effort on the distribution of post-smolt salmon between the time they leave coastal waters until the end of the first year at sea. These surveys have provided valuable information on the migration and distribution of salmon at sea but understanding of the factors responsible for the increased marine mortality remains limited. However, mortality is assumed to be highest early in the marine phase, and it is thought that variability in mortality in coastal waters can be high. Studies in Canada and the USA using acoustic tracking have provided very valuable stage-specific estimates of mortality from the rivers out to sea. In addition, very little research had been undertaken on mortality of salmon after they recruit to the distant water fisheries, although this is particularly important in supporting estimates of mortality of adult salmon used in assessment models.

5.20 The Sub-Group noted that in taking the work forward it would be important to consider how mortality is partitioned through the whole of the marine phase, from the

emigration of smolts leaving rivers to the return of adults into fresh water. The Sub-Group, therefore, recommends that work is considered in the following four periods:

- Transitional waters (emigration through estuaries and coastal waters);
- Post-smolts (open ocean migration to marine feeding/fishing areas);
- Post-recruits (open ocean migration from feeding/fishing areas to coastal waters);
- Return migration of adult salmon through coastal waters.

*Transitional waters (*emigration through estuaries and coastal waters)

5.21 Smolt tracking studies undertaken in the Gulf of St Lawrence and the Gulf of Maine through the Ocean Tracking Network have demonstrated the potential for large-scale international collaboration in the deployment of detection arrays extending from the coast to the shelf edge. These arrays are being used by the Atlantic Salmon Federation in its current acoustic tracking studies.

5.22 Further work in transitional waters could be undertaken using acoustic tagging both for post-smolts and returning adults and could provide valuable information to support management e.g. in relation to assessing the impacts of developments in coastal waters, although it was recognized that specific studies might be needed as part of any EIS. This work might initially focus on individual bays, such as those associated with existing monitored rivers, but then extend further out to sea. It was noted that there are initiatives to develop detection arrays at sites in the UK and Ireland. It was also noted that acoustic tagging would not be permitted in Russian coastal waters and that other approaches such as mark recapture studies may be more appropriate.

5.23 There are likely to be benefits from collaboration with researchers investigating other marine species e.g. information from tagged US origin salmon had been provided from arrays set in Newfoundland to detect cod and information on sturgeon movements had been provided by arrays set for salmon. The Sub-Group recognized that there were a number of choke points in the North-East Atlantic where arrays could be deployed along post-smolt migration routes and information obtained during SALSEA Merge, including from migration models, could also inform siting decisions. Floating detectors or powered gliders deployed from aircraft or research vessels during research surveys might also be used, and it might even be possible for powered gliders to actively follow individual tagged fish.

5.24 Marine aquaculture has been identified as one of the factors that may affect survival of salmon passing through some coastal waters, and it has been suggested the effects could potentially extend more widely. NASCO and ICES held a symposium in 2005 on 'Interactions between aquaculture and wild stocks of Atlantic salmon and other diadromous fish species: Science and management, challenges and solutions' and the proceedings had been published. In the light of the findings, 'Guidance on Best Management Practices to Address Impacts of Sea Lice and Escaped Farmed Salmon on Wild Salmon Stocks', SLG(09)5, had been developed through the NASCO/ISFA Liaison Group. Under this BMP Guidance, the international goal in relation to sea lice is that 100% of farms should have effective sea lice management such that there is no increase in sea lice loads or lice-induced mortality of wild salmonids attributable

to the farms. The international goal for containment is that 100% of farmed fish should be retained in all production facilities.

5.25 It was recognized that monitoring needs to support the international goals had been included in the BMP Guidance and that these provide approaches that could be used to assess progress towards the international goals e.g. monitoring of lice levels on farmed and wild fish, monitoring of escaped farmed salmon in rivers. Progress towards achievement of these goals should be reported to NASCO through the next round of Implementation Plans. The Sub-Group recognized that there had been new insights into the impacts of salmon farming on wild salmon stocks since the Bergen meeting, including a review prepared by ICES in response to a request from OSPAR. NASCO may, therefore, wish to consider if it would be appropriate to prepare an updated review of the potential impacts of sea lice on wild salmon stocks including recommendations for future research.

Post-smolts (open ocean migration to marine feeding/fishing areas);

5.26 The research to date under the SALSEA Merge and SALSEA North America marine surveys had focused largely on post-smolts. The opportunity had been taken to collect large numbers of samples from salmon caught at sea, but because of time constraints it had not been possible to analyse all of the data gathered. Work is underway through a PhD studentship in Ireland to analyse some of the samples (stomach contents, scales, and diseases and parasites) collected during the SALSEA Merge project. Further details of additional samples requiring further analysis from the SALSEA Merge project are provided in SGFR(12)7 (Annex 4). In the case of SALSEA North America and SALSEA West Greenland, the sampling had been conducted on limited budgets but valuable data had been obtained and some samples also remain to be analysed. Further details of the samples requiring further analysis from these projects are provided in SGFR(12)8 (Annex 5). The Sub-Group believed that further work on these data/samples should be a priority and that the need for future post-smolt sampling should be considered in the light of these analyses.

5.27 The Sub-Group noted that the metadatabase being developed by the Board is a useful initiative to increase awareness of the existence of datasets and sample collections among researchers. Data collected during the SALSEA Merge project had been collected into a single database and consideration was being given to where this could be housed. The Sub-Group noted the value of the sample collections derived from various programmes and highlighted the need for them to be safeguarded and for destructive use of samples to be carefully managed.

5.28 It was noted that Russian and Norwegian origin salmon had not been identified in samples from the SALSEA Merge surveys despite sampling occurring far to the north in the Norwegian Sea, although Finnish and Norwegian post-smolts had been caught in sampling close to the shore in mid- and northern Norway. The Sub-Group considered that migration modeling could initially be used to gain insights into the migration and distribution of these stocks at sea and that this might assist in planning any future marine surveys targeting these stocks.

5.29 The Sub-Group also recognized that information from the SALSEA Merge project had highlighted the spatial and temporal overlap of post-smolts and pelagic fisheries

for mackerel in the Norwegian Sea. ICES had previously advised that the most appropriate method of estimating by-catches of salmon post-smolts in this fishery was through observer programmes on the commercial vessels, and the Sub-Group recommends that the opportunities for further sampling be explored. In this regard, the Atlantic Salmon Trust had made a presentation to the EU's Pelagic Regional Advisory Committee, and further discussions might be encouraged in order to design and implement a sampling programme. Information on bycatch had also been obtained from land-based sampling at mackerel and herring processing plants in Iceland and Faroes and the salmon obtained had been assigned to southern European countries using GSI. The Sub-Group encourages continuation of these studies.

Post-recruits (open ocean migration from feeding/fishing areas to coastal waters);

5.30 The Sub-Group recognized that, although some work is ongoing at West Greenland, using satellite tags, little is known about the variability in mortality of salmon on their return migration from the fishery areas. The areas where bottlenecks occur are unknown, and current assessment models assume constant mortality. Improved understanding of this mortality is important as it could assist in understanding variation in returns to rivers. The Sub-Group discussed appropriate approaches to better understanding mortality during this phase and noted that marine surveys, while providing valuable information, would not provide estimates of mortality, whereas tagging could provide estimates of mortality but does not provide some of the additional information obtained during surveys. New modeling approaches are available for handling multiple recapture data but it was noted that the large-scale tagging programmes at West Greenland and Faroes had in the past resulted in relatively low numbers of tag recoveries in homewaters despite the considerably higher fishing effort at that time. The Sub-Group believed that electronic tagging techniques offer the best opportunities for improving understanding of the mortality of post-recruits and that such studies could improve the input data to the assessment models and in forecasting returns to homewaters.

Return migration of adult salmon through coastal waters

5.31 The Sub-Group noted that recent review of telemetry results had suggested that factors resulting in delayed entry of returning adults into freshwater (e.g. during periods of low flows) may result in increased mortality. This may, therefore, be one cause of the variable mortality of adults during this phase.

5.32 The Sub-Group recognized that the battery life of tags applied to smolts would not be sufficient to last until adults returned to coastal waters even though newly developed tags can be programmed to switch on and off at certain times. There could also be a problem with retention of tags. In order to obtain information as the adults return through the outer transition zone, it would be necessary to capture fish at sea, unless there were further developments in tagging technology. It was recognized that there would need to be close coordination among NASCO Parties with regard to the technology deployed.

Key predators

5.33 Predation had also been identified as a factor within the SALSEA programme that may account for increased mortality of some salmon stocks in estuaries and throughout the marine phase. The Sub-Group recognized that there have been increases in the populations of some potential predators of salmon including marine mammals, fish-eating birds and other species of fish. In the Miramichi River, there had been an increase in the prevalence of salmon with wounds assumed to have been inflicted by predators. In some areas potential new predators had moved north linked to ocean warming e.g. silver hake.

5.34 Partitioning mortality into specific parts of the marine phase may assist in identifying the impact of predators on stocks. However, establishing predation levels is extremely challenging, particularly in the open ocean, and it was noted that a relatively small increase in the instantaneous rate of natural mortality can result in a significant reduction in overall marine survival rate. New information on the distribution of concentrations of marine mammals at sea has been obtained through remote sensing, and this could be used to look for overlaps with the distribution of salmon derived from the SALSEA Programme.

6. Development of a 'road map' to complete the research envisaged under the SALSEA Programme

6.1 Under the SALSEA Programme, the stated vision is that SALSEA offers a unique opportunity to increase understanding of: how Atlantic salmon use the ocean: where they go; how they use ocean currents and the ocean's food resources; and what factors influence migration and distribution at sea. The vision further states that SALSEA seeks to draw together intellectual and scientific resources in a concerted cooperative effort to identify the factors influencing mortality of salmon at sea and the opportunities to counteract them. The Sub-Group has highlighted the considerable advances that have been made as a result of the SALSEA Programme in understanding the distribution and migration of salmon at sea (particularly of post-smolts), how salmon use the oceans, and the implications of this new knowledge for management (see Section 4). The Sub-Group has also recommended that a priority should be to analyse the remaining samples and data arising from the three main marine components of the SALSEA Programme (SALSEA Merge, SALSEA North America and SALSEA West Greenland); details of the samples and data remaining to be analysed are provided in Annex 4 and Annex 5. The Sub-Group encourages the Board to explore opportunities to support these analyses.

6.2 The Sub-Group also reviewed the inventory of research and other sources of information relating to projects undertaken under the SALSEA Programme and has: identified opportunities for enhanced collaboration and coordination; highlighted gaps in the research programme; and made recommendations for future research to support management (see Section 5). The second component of the original SALSEA vision was to encourage a cooperative effort to identify the factors influencing mortality of salmon at sea. The findings from the SALSEA Programme to date should facilitate new research to understand when and where the mortality is occurring at sea with the objective of partitioning the mortality among transitional waters (both outbound

smolts and returning adults), the post-smolt phase and from the first winter at sea to return to transitional waters.

6.3 The Sub-Group does not believe that the development of a 'road map', allocating responsibilities, outlining timeframes and providing costings, is appropriate or feasible at this stage. The Sub-Group has recommended future research priorities, and proposes that a particular focus for the Board should be studies to partition marine mortality among the phases of the marine migration of salmon. International coordination for such a study will be particularly necessary in the North-East Atlantic because many post-smolts emigrate through the waters of multiple jurisdictions, and receiver arrays would ideally be placed at suitable 'choke points' in the migration pathway.

6.4 As was the case in developing the original SALSEA Programme in 2004, the Sub-Group recommends that the Board considers whether it wishes to facilitate a meeting of scientists and external partners (including tag manufacturers, those with experience in deploying detection arrays e.g. the Ocean Tracking Network (OTN) and those involved in tracking other marine species) to further develop a collaborative international programme of research. A preliminary outline proposal for such a programme of research on marine mortality of salmon is contained in SGFR(12)9 (Annex 6). The objective would be to develop a new research plan detailing where there may be particular need for international collaboration and coordination and support with fund raising. It is hoped that this plan would be endorsed by the Board since the Sub-Group is aware that this was extremely helpful in raising funding from external sources under the original SALSEA Programme. Those funding the original SALSEA research indicated that the development of a detailed research plan endorsed and coordinated by an inter-governmental organization made it a very attractive proposal to them.

6.5 The Sub-Group recognised that there may be some opportunities to progress the research in the short-term because detection arrays are already in place in North American waters (and others are planned in the Northwest Atlantic) and funds for tags may be available to initiate some of the work envisaged utilising monitored rivers. The OTN has also expressed interest in establishing a European programme, and the Sub-Group believes that it would be helpful to the Board in considering the next steps if opportunities to further consider the approach to addressing the research gaps it has identified could be discussed informally among scientists (e.g. at the ICES Working Group on North Atlantic Salmon) prior to NASCO's Annual Meeting in June 2013.

7. Recommendations on the future role of the Board's scientific Advisory Group

7.1 Under the its Rules of Procedure, ICR(06)10, the IASRB shall establish and administer an International Atlantic Salmon Research Programme into the causes of marine mortality of Atlantic salmon and the opportunities to counteract this mortality with the following Terms of Reference:

- maintaining an inventory of relevant research projects which are ongoing or planned and for which budgets have been confirmed;

- identifying research needs;
- evaluating the inventory against research needs;
- identifying gaps in the inventory of research and setting priorities for further research;
- providing a forum for coordination of relevant research efforts by the Contracting Parties of NASCO;
- developing administrative mechanisms to accept financial contributions to an International Atlantic Salmon Research Fund;
- soliciting and accepting financial contributions and managing the Fund;
- establishing terms and conditions for soliciting, evaluating, approving and funding relevant research projects;
- funding approved projects and reviewing results in relation to the objectives of the Programme.

7.2 In support of the financial elements of these TORs, the Board has its own Financial Rules that enable it to raise funds from the Parties and from sources outside NASCO and to carry forward unused funds into a new financial year.

7.3 In 2002, the Board established its SAG with the objectives of identifying research gaps and priorities, developing recommendations for enhanced coordination of existing research, developing calls for proposals, and developing recommendations for research and other activities that may be supported by the Board. The work detailed in the first five of the Board's ToRs is, therefore, carried out by the SAG which provides the scientific input to the Board's work.

7.4 The SAG is the only body within NASCO that identifies research needs and addresses scientific coordination, and the Sub-Group believes that the SAG is the most appropriate and effective forum in which to perform this important role. The Sub-Group noted that, under its Rules of Procedure, the Board may seek scientific advice from the Standing Scientific Committee (SSC). The Sub-Group understood that this arrangement pre-dated the change to the Rules of Procedure that enabled the Board to establish the SAG. The SSC does not include representation from all Parties or from NASCO's accredited NGOs and its main function is to develop the request to ICES for scientific advice. The Sub-Group does not consider that the SSC, as presently constituted, is an appropriate forum in which to address the scientific work required by the Board.

7.5 The Sub-Group noted that initially the composition of the SAG had followed the procedure established for the Board in which there is one nominated representative from each Party who may be assisted by advisors. The Sub-Group does not wish to restrict participation in the work of the SAG but recommends that, to facilitate communication between meetings, each Party and the NGOs should be asked to nominate a SAG member. The Sub-Group discussed whether the SAG could make proposals to the SSC on the request to ICES for scientific advice. It was agreed that any such requests should be made through the Board and the Council for referral to the SSC.

7.6 The Sub-Group noted that the Board had very limited resources and recognized that if it is to continue to play a role in supporting research on salmon at sea it should consider how it can address this situation.

8. Any other business

8.1 There was no other business.

9. Report of the meeting

9.1 The Sub-Group agreed a report of its meeting.

10. Close of the Meeting

10.1 In closing the meeting the Chairman thanked the participants for their contributions to the meeting.

Annex 1 of SGFR(12)10

List of Participants

Canada
Gérald Chaput

European Union
Ian Davidson
Dennis Ensing
Cathal Gallagher
Niall Ó Maoiléidigh
Ted Potter (Chairman)

Russian Federation
Sergey Prusov
Elena Samoylova

USA
Tim Sheehan

NGOs
Dave Meerburg
Ken Whelan

Secretariat
Peter Hutchinson

SGFR(12)6

Meeting of Sub-Group on the Future Direction of Research on Marine Survival of Salmon

11 – 13 December 2012

Agenda

1. Opening of the meeting
2. Adoption of the agenda
3. Consideration of the Terms of Reference, SAG(12)3
4. Review of the findings from recent scientific investigations and their implications for management
5. Review of the Inventory of Marine Research
   (a) Identification of opportunities for enhanced collaboration on on-going research projects
   (b) Identification of gaps in the programme of research on salmon at sea
   (c) Development of recommendations for future research to support management
6. Development of a 'road map' to complete the research envisaged under the SALSEA Programme
7. Recommendations on the future role of the Board's Scientific Advisory Group
8. Any other business
9. Report of the Meeting
10. Close of the Meeting

SAG(12)3

Terms of Reference for the Sub-Group on the Future Direction of Research on Marine Survival of Salmon

Background

The International Atlantic Salmon Research Board (IASRB) was established by the Council of NASCO, to promote collaboration and cooperation on research into the causes of marine mortality of Atlantic salmon and the opportunities to counteract this mortality (ICR(06)05). The IASRB established a Scientific Advisory Group (SAG) to assist in identifying research gaps and priorities and to develop recommendations for enhanced coordination of existing research, calls for proposals, recommendations for research and other activities that may be supported by the Board.

The first task the IASRB undertook was to develop an inventory of existing research on marine mortality of Atlantic salmon so as to facilitate improved coordination, to identify gaps and to develop priorities; this inventory has been updated annually. The IASRB also commissioned the development of an international programme of cooperative research on salmon at sea, the SALSEA programme. This programme contains a mix of freshwater, estuarine, coastal and offshore elements, ensuring a comprehensive overview of factors which may affect the marine mortality of Atlantic salmon. However, the IASRB agreed that their initial priority should be to support the implementation of the marine survey aspect of SALSEA, because this was where there was greatest need for international collaboration and funding.

With the completion of the SALSEA-Merge, SALSEA North America and SALSEA West Greenland field programmes, it is appropriate for the IASRB and SAG to review and evaluate their roles in supporting NASCO's objective to conserve, restore, enhance and rationally manage Atlantic salmon through international cooperation taking account of the best available scientific information. A Sub-Group will therefore be established to evaluate recent scientific progress and provide guidance for how the SAG can remain an effective and productive body into the future. The recommendations provided by the Sub-Group may also provide a basis for discussions on the future of the IASRB.

Terms of Reference:

- Review the outcome of recent scientific investigations and summarise the findings which have significant management implications.
- Review the Inventory of Marine Research and identify opportunities for collaboration within the suite of ongoing projects to facilitate progress with identifying the major causes of salmon mortality at sea.
- Based on the inventory and the results of recent scientific studies published in the literature, identify gaps in research efforts and knowledge which may be important for advising on salmon management actions.**

- Review the larger SALSEA project and advise on a "road map" to complete other elements of the research previously identified.
- Arising from these reviews, advise on possible future role of the SAG

** The Sub-Group should focus its gap analysis and subsequent recommendations on applied research requirements for management. If gaps are identified, recommendations to rectify the gap should be provided and evaluated in terms of the feasibility of carrying out the specific research. Additionally, the Sub-Group should evaluate if the gap can be filled from existing programmes, from a new programme based on current technology or if new tools and advances are needed.

The Sub-Group is expected to focus on applied science related topics, but participation of managers is needed to ensure that critical management issues are addressed. Highest priority should be given to issues requiring or benefitting from international collaboration. Where management issues are identified and science needs/solutions are suggested, the Sub-Group should consider how the results are most likely to be integrated into advice and those areas that are likely to have the most immediate effects on management actions. While the Sub-Group should focus on salmon, recent changes in marine ecology, particularly in the pelagic ecosystems, caused by global climate change, should also be considered as information from other scientific disciplines can inform Atlantic salmon science and management.

The Sub-Group will require a 2-3 day working meeting to be facilitated by the NASCO Secretariat (location to be determined). Participation should be between 6-8 people, including scientists, managers and a representative from the NGO community. Representation from both North America and Europe is critical. A significant amount of preparation can be undertaken prior to this working meeting to ensure that the time spent at the meeting is productive. The Sub Group should take account, *inter alia*, of the following documents:

- Original SALSEA research programme
- EU SALSEA Merge proposal and final report
- Salmon Summit proceedings (ICES JMS)
- Salmon Summit Convenors' report
- Current status of SALSEA projects
- Inventory of Marine Research
- National initiatives
- Current management priorities indicated by Parties
- Original IASRB and SAG Rules of Procedure and ToRs
- 2012 Reports of IASRB and SAG Meetings

SGFR(12)7

Current status of samples taken for SALSEA Merge and additional samples and work to be completed from the SALSEA Merge post-smolt programme.

Fish samples

Details of external biological characteristics of all captured fish (approximately 1,700 post-smolts and 53 adults) have been recorded and entered in a SALSEA Merge database. Details include whether the fish were wild or hatchery origin, their length, weight, scale loss, presence of cataracts, presence of external parasites, presence of external tags or finclips. Sex information was noted for 1,300 plus samples. Summaries based on this material were presented in the SALSEA Merge report. There is more scope for further publication on the detail of this information.

In addition, all fish were sampled for genetic stock identification. The origin of these samples (either to river or area of origin) have been reported in the SALSEA Merge final report and in subsequent papers. Further work is being considered to refine assignments using SNPS and it is likely that further publications will arise from the original SALSEA Merge samples. Samples are held at various SALSEA partner institutions.

Scales were removed from all fish and the results of the post-smolt analyses have been presented in the SALSEA Merge report and in subsequent publications. There is scope here for further publications relating post-smolt growth and marine survival/conditions.

In addition, over 23,000 scales of Atlantic salmon from seven rivers, located in six countries have now been analysed with the new scale reading technique. Most scales are from 1970 to the present, with some limited information for one stock extending back to earlier periods. The number of circuli laid down in the marine zone of the scales in specific periods as well as the distance between the circuli were measured, and this information was summarised in the final SALSEA Merge report. Since then a MI Ireland, IMR Norway and Loughs Agency, Ireland/N.Ireland study has been initiated which will increase the number of sample rivers from which archive scale material is available and the results generated in SALSEA Merge will be extended and reinterpreted at a larger scale.

Gonads were preserved and retained for further analyses from approximately 270 post-smolts. These tissues have not been analysed as yet and would provide more insights into the developmental rate of post-smolts at different stages of the migration. Samples are stored with the agencies who collected the samples.

The presence of internal parasites was noted and in most cases enumerated for samples dissected on-board the vessels or in labs. Whole fish were retained and preserved in formalin from approximately 10% of samples taken in the Irish trawl surveys and these have been processed. A small number of samples remain frozen for processing and will be included within the MI Ireland, IMR Norway and Loughs Agency, Ireland/N.Ireland study.

Tissues samples from approximately 1,000 fish were retained for stable isotope analyses and a similar number of fish was sampled for lipid content analyses. These tissues have not been

analysed. Gills and viscera were retained either frozen or preserved in alcohol from approximately 1,200 samples. Samples taken in the Irish trawl surveys have been included in a PhD programme initiated by MI Ireland, IMR Norway and Loughs Agency, Ireland/N.Ireland as an immediate follow up to the SALSEA Merge programme.

Stomach contents were made available for approximately 750 post-smolts, while 1,400 stomachs from other pelagic species (herring and mackerel) were also available. Preliminary analyses were presented in the final SALSEA Merge report and were also presented verbally at the SALSEA symposium in La Rochelle. Data and samples are with IMR in Norway. Remaining samples from Irish trawl surveys have been included in a PhD project initiated by the MI Ireland, IMR Norway and Loughs Agency, Ireland/N.Ireland.

Oceanographic information

206 plankton tows were carried out using both horizontal tows and vertical tows. 26 specific krill trawls were also taken. These samples have not been analysed extensively to date but are with the IMR in Norway.

173 stations were sampled using Constant Temperature and Depth sensors (CTD). Information from these sensors was included within the migration model which was presented in the final SALSEA Merge report and as a subsequent publication. The model is capable of providing putative migration routes for salmon by varying oceanic parameters and is, therefore, useful for more exploratory analyses than have been carried out to date. The model is available from IMR, Norway.

Chlorophyll samples were retained from 120 stations and 97 samples were retained for nutrients at sea. These samples require analysis

A range of oceanographic parameters was recorded from on-board ship monitors including salinity, temperature, depth etc. Most of the data have been included within the oceanographic model. However, there is scope for more in depth analyses of oceanic factors affecting the migrations of salmon post smolts.

For additional information regarding the status or results from any of the SALSEA Merge samples or data, please feel free to contact Dr Niall Ó Maoiléidigh, Marine Institute, Ireland (omaoile@marine.ie).

A table detailing the samples taken during each survey is available from Dr Ó Maoiléidigh or from the NASCO Secretariat.

SGFR(12)8

Current inventory and status of samples taken for SALSEA North America and SALSEA Greenland

SALSEA North America

SALSEA North America consisted of research survey cruises conducted in the Labrador Sea during the summer/autumn of 2008 and 2009 in support of the SALSEA research program. A total of 47 stations were surveyed in 2008 with a surface trawl and 21 stations were surveyed in 2009 (14 surface trawls and 7 surface gillnet sets). A total of 107 salmon were captured and biological data and samples are available from 85 fish.

Data collected include fish origin, biological characteristics, sex, scale loss, information on external parasites, presence of external tags or finclips and a variety of biological samples to support further investigations into the health of salmon captured. Sheehan *et al*. 2012 provided a comprehensive summary of the surveys and catch results including oceanographic conditions and bycatch at each station sampled. However, there is scope for further investigation on the samples and data collected as many samples remain unprocessed.

Biological characteristics data are available for all fish sampled. Data are available on conductivity, temperature and depth profiles collected at select stations surveyed and bycatch data at each station surveyed. A small number of sea lice samples were preserved and are being processed to support various genetics studies.

All fish were of North American origin, however finer than continent of origin determinations were not conducted. Scales were collected for ageing although more detailed analysis of growth via image analysis processing has not been conducted to date.

Ovary samples were collected and have been processed although detailed analysis has not been conducted. Various tissue samples were collected and have been preserved in a frozen state for disease screening, although these samples have not been processed yet. Stomach samples were collected and results have been presented (Sheehan *et al*. 2012). A gross summary of the macroparasite intestinal samples have also been presented although further more detailed analyses could be conducted on those samples.

Various tissue samples were collected for stable isotope based investigations and these samples are currently being processed. In addition, dorsal muscle samples for lipid analysis, otolith samples and frozen whole carcasses are also available to support various research interests.

For additional information regarding the status or results from any of the SALSEA North America samples or data, please feel free to contact the Program Coordinator, Timothy Sheehan, NOAA Fisheries Service (Tim.Sheehan@noaa.gov).

A table detailing the samples is available from the Program Coordinator or the NASCO Secretariat.

SALSEA Greenland

SALSEA Greenland was developed to conduct broader and more detailed sampling of fish harvested from the waters off West Greenland in support of the SALSEA research program. Fresh whole fish were purchased directly from individual fishers and detailed sampling resulted in a large number of samples being collected from each fish. The samples and data are in various stages of processing. Some results have been reported in peer reviewed publications (Dixon *et al*. 2012), some preliminary results have been reported in various ICES WGNAS reports (ICES, 2010; ICES, 2011; ICES, 2012) whereas many of the samples have yet to be processed, analyzed and reported.

Data collected includes fish origin, biological characteristics, sex, information on external parasites, presence of external tags or finclips are available. All fish have been assigned to be either North American or European origin, however finer than continent of origin determinations have not been conducted yet. Scales were collected for ageing although more detailed analysis of growth via image analysis processing is ongoing.

Ovary samples were collected (2009 only) and have been processed although detailed analysis has not been conducted. Various tissue samples were collected and have been preserved in a frozen state for disease screening. Stomach samples were collected and are currently being processed and preliminary results have been reported by ICES (2010). Macroparasite intestinal samples were collected although there is scope for further investigation on the samples.

Various tissue samples were collected for stable isotope based investigations and these samples are currently being processed. In addition, dorsal muscle samples for lipid analysis, otolith samples and frozen whole carcasses are available to support various research investigation.

For additional information regarding the status or results from any of the SALSEA Greenland samples or data, please feel free to contact the Program Coordinator, Timothy Sheehan, NOAA Fisheries Service (Tim.Sheehan@noaa.gov).

A table detailing the samples is available from the Program Coordinator or the NASCO Secretariat.

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Preliminary outline proposal for collaborative international programme of research on marine mortality of salmon

Objective: To identify the presence, timing and location of survival bottlenecks of salmon for different stages of the marine phase and to obtain estimates of stage-specific mortality rates of salmon at sea.

Strategy:

The objective will be addressed by building on the existing infrastructure and historical data sets from index rivers in NAC and NEAC areas, from knowledge gained from SALSEA activities on timing and migration corridors of post-smolts in southern NEAC, from advances in acoustic tracking technologies (Whoriskey, 2011; Lacroix, 2012), and benefiting from academic, industry and government partnerships.

Methods:

- Acoustic technologies (as deployed on some NAC rivers in the Gulf of St. Lawrence and US) are proposed to be applied to a select set of index rivers in the NEAC and NAC areas, with estuarine/bay detection arrays at each index river and targeted at-sea arrays (drifting surface receivers) established at identified choke points along the nearshore migration paths of post-smolts.

- Detection of acoustically tagged post-smolts could extend into the nearshore and offshore areas by incorporating into existing national marine surveys the deployment of monitoring receivers during station sampling for biological / physical oceanography monitoring.

- Further development of technologies for monitoring acoustically tagged salmon at sea could consider the use of wave gliders as presently being developed by OTN (Ocean Tracking Network (http://oceantrackingnetwork.org/, Dalhousie University, Canada) as well as potential opportunities for developing receiver capacity on broad-scale oceanographic projects such as the ARGOS programme. (http://www.argo.ucsd.edu/index.html).

- Similar technologies and year-round detection arrays deployed at Cabot Strait in the Gulf of St. Lawrence, with parallel bay and estuary detection arrays in index rivers in the Gulf of St. Lawrence, OTN Line at Halifax and US arrays could be used to estimate mortality during the second winter at sea of non-maturing 1SW salmon captured, tagged and released from West Greenland.

- Estimates of detection and survival probabilities would be obtained using variations of Cormack-Jolly-Seber (CJS) models (Gimenez *et al*., 2007, Royle, 2008).

Benefits of proposed research activity

- Design tagging and inshore monitoring activities using existing national index rivers programs in NAC and NEAC areas.
- Use demonstrated acoustic technologies and experimental techniques developed prior to and during SALSEA allowing marking and tracking of smolts at sea.
- Design marine detection arrays / grids taking into account new knowledge from SALSEA on migration and distribution of post-smolts in the southern NEAC area and for Gulf of St. Lawrence and US rivers in NAC area.
- Opportunistically use national marine research vessel campaigns deployed for various monitoring and research activities at sea to monitor for acoustically tagged post-smolts.
- Partner international research programmes for other species (OTN), and industry (suppliers) supporting the development and use of acoustic technologies.

Risks and limitations of research activity

- Despite recent advances in tag development, battery capacity for minituarized tags to be deployed in smolts limit the tag life to 2 – 3 months transmission time (although tags can be programmed for delayed transmission and advancements in technologies are ongoing) (larger tags with lifespans of several years could be deployed on non-maturing 1SW salmon from West Greenland).
- Cost of expendable individual tags ($300 - $400 Cdn per tag) and accompanying sample size requirements (100 tags per index river per year).
- Relatively large-bodied smolts (>= 14 cm fork length) are required.
- Tags must be proximate (less than 1 km) to receivers for detection.
- Detection efforts (cumulatively days) during the varied marine research vessel surveys may be insufficient to detect a statistically efficient number of the surviving acoustically tagged salmon post-smolts in the large expanses of the Norwegion Sea / Irminger Sea.
- Such programmes have not been attempted in the open ocean areas not associated with land borders.

Need for international collaborations

- Tagging and release of smolts from a suite of index rivers in NEAC and NAC requires agreeing on and using identical technologies and standard techniques which would require from international coordination among national agencies and partners.

- Use of national research vessel surveys from multiple countries requires central coordination to deploy receiver units and monitoring and to coordinate data sharing and security.

- Sharing costs of expendable items (tags) among national agencies for the index rivers.

Resource requirements

Existing

- OTN, Atlantic Salmon Federation and NOAA Fisheries Service directed activities in NAC.

- Index rivers infrastructure for monitoring river-specific salmon populations and for capturing smolts for tagging.

- National marine vessel research programs directed at other components of the marine ecosystem.

New resources

- Funds to purchase acoustic tags (multi-year) and receiver units (single year) for index river programs.

- Vessel time to deploy and retrieve drifting receiver arrays at previously identified choke points.

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