	Scientific Advisory Group of the International Atlantic Salmon Research Board ***Prioritised List of Research Needs and Topics for Consideration by the International Atlantic Salmon Research Board***	**SAG(23)08**

Prioritised List of Research Needs and Topics for Consideration by the International Atlantic Salmon Research Board

Background

During an inter-sessional meeting of the International Atlantic Salmon Research Board (the Board) held in January 2023, the Board tasked its Scientific Advisory Group (the SAG) with identifying a prioritised list of research needs based on the current state of knowledge and the Board's Inventory of Marine Research.

During the Board's 2023 Annual Meeting, CNL(23)10, the Board agreed 'Terms of Reference for the International Atlantic Salmon Research Board's Scientific Advisory Group to Identify Potential Research Priorities', ICR(23)14.

The SAG has now met, ICRIS(24)02, to address these Terms of Reference and this document contains the SAG's prioritised list of research needs and topics for consideration by the Board.

General Considerations on Climate Change

The SAG noted that the Steering Committee of the 2023 Theme-based Special Session on Climate Change, CNL(23)83, had recommended that 'NASCO recognises the climate change research that is ongoing across the Parties / jurisdictions that can inform drivers of Atlantic salmon mortality. NASCO may wish to look for opportunities to facilitate funding and increase international scientific collaboration both through the Parties / jurisdictions and the International Atlantic Salmon Research Board.'

The SAG considered that the direct effects of climate change on salmon marine survival will be difficult to assess. Increased knowledge about, for example, migration routes, growth in relation to conditions at sea and interactions between the freshwater and marine life stages of salmon may inform the assessment of the effects of climate change. The effect of climate change on salmon could, therefore, be viewed as an overriding theme that may be incorporated into all the topics that the SAG has suggested below.

Prioritised List of Research Needs / Topics

The table below provides the agreed rankings of the five research needs / topics identified by the SAG. The ranks are identified on the basis of the total score, with the individual scores from SAG members being provided for transparency. A rank of '1' indicates the highest priority. Therefore, the lower the total score, the higher the priority. Although five topics were identified, there are only three ranks because the scores were very similar for those topics ranked as '2' and those topics ranked as '3'.

Topic	Rank	Score
Studying basin-wide patterns of marine growth and survival of Atlantic salmon	1	Total: 10 *Individual Scores:1,1,1,1,1,2,3*
Migration of salmon at sea	2	Total: 17 *Individual Scores: 1,2,2,2,3,3,4*
Understanding the impact of the freshwater environment on mortality occurring at sea	2	Total: 19 *Individual Scores: 1,2,2,3,3,3,5*
Potential interactions between pink salmon and Atlantic salmon	3	Total: 29 *Individual Scores: 2,4,4,4,5,5,5*
Quantifying the mortality of Atlantic salmon caught as bycatch in pelagic and coastal fisheries	3	Total: 30 *Individual Scores: 3,4,4,4,5,5,5*

Assessments of Research Needs / Topics

Studying basin-wide patterns of marine growth and survival of Atlantic salmon

(Priority Level: 1)

Research Context

Many studies conducted in different parts of the distribution range of Atlantic salmon suggest that their marine survival is linked to growth and ocean productivity. However, some research reveals quite different patterns across regions. An Atlantic basin-wide study linking survival, growth and oceanic conditions is currently missing. It could provide insights into the drivers of Atlantic salmon marine mortality.

Approaches

Different approaches could be used, individually or combined, to address this knowledge gap. They include, but are not limited to: 1. Conducting a comprehensive literature review; 2. Gathering and analysing existing data about salmon and oceanic conditions; 3. Extracting and analysing new information from existing or novel samples (e.g. using automated scale circuli measuring tool, chemistry, stable isotopes and genetics) or studies (e.g. regarding physical marine habitat or by partitioning the marine mortality estimates into components of estuarine, near-shore and more distant mortality).

Expected Outcomes

The expected information gained by research on this topic does not have clear direct management implications. However, anticipated outcomes could be used in support of developing management options by identifying the main drivers of marine mortality and how these have changed over time. For example, if information gained through this research indicates that salmon are negatively impacted by a reduced amount of food sources, a direct management option could be to modify regulation for those fisheries reducing the availability of salmon prey in critical periods or areas. Information gained under this topic could also be used to help forecast the evolution of salmon abundance in a context of changing environment, thus helping to prioritise management actions at all stages of the salmon's life cycle and set realistic expectations for future productivity / abundance.

Migration of salmon at sea

(Priority Level: 2)

Research Context

A primary research need and data requirement for understanding the drivers of Atlantic salmon marine mortality is their location in the marine environment in time and space. Historically we have had a rudimentary understanding of the marine migration of the species across its range, but we do not have the specificity to properly identify, investigate and / or rank potential mortality stressors. In recent decades, advances have further elucidated the details of Atlantic salmon marine migration through small and large tagging, telemetry, survey and modelling studies. However, these advances have been focused primarily on the early post-smolt and kelt phases and less information is available about the critical late post-smolt phase and the returning adult phase, when individuals re-enter coastal waters and may be susceptible to numerous anthropogenic stressors. In addition, not all populations have been studied, nor have year-to-year variations been thoroughly investigated, and the wide knowledge base necessary to model the marine migration of all salmon populations is, therefore, missing.

A critical research need that the Board may consider directing resources towards is to continue to map Atlantic salmon marine migration in time and space across the entire North Atlantic. Progress on this research need could be made via a small number of individual research studies or via large-scale, well-co-ordinated, studies covering the entirety of the species range.

Approaches

Progress could be made by employing a wide variety of approaches such as tagging, telemetry, DNA of historical samples, eDNA, modelling based on start- and endpoints and chemical analyses of archival otoliths and scales. These approaches could be used within individual studies or in concert. In addition, results from these studies, and all previous studies, should be combined to inform future modelling efforts to maximise the information gained from each effort.

Expected Outcomes

The potential implications from such an effort are wide and varied. Having a better understanding of where salmon are in the marine environment in time and space could be used to aid in the planning of marine developments such as new offshore wind or aquaculture facilities. In addition, having a better understanding of the marine migration of Atlantic salmon could also help explain observed patterns of growth and inform the question of potential bycatch of Atlantic salmon in pelagic fisheries occurring within the east and west North Atlantic. Further, until a better understanding of where salmon are in the North Atlantic in time and space and where and when salmon are thought to be disappearing, the question about what can be done about it cannot be answered. Having this fundamental information is a critical need to better inform the discussion of potential management options. Having this detailed information may also offer the possibility of eliminating the likelihood of other hypothesised stressors being relevant, which will, therefore, allow future researchers and managers to focus their effort on the remaining stressors. Finally, a detailed understanding of current marine migration is an essential requirement to understanding how migration may change with a changing climate and therefore what old stressors may remain relevant and what new stressors may become relevant in the future.

Understanding the impact of the freshwater environment on mortality occurring at sea

(Priority Level: 2)

Research Context

The core question of this research topic is: 'to what extent do freshwater characteristics such as temperature, pH and pollution affect smolt quality (e.g. physiology, size and run timing) in a manner that influences marine survival?'

Noting that we choose, for simplicity of writing here, to refer to the quality of the smolts, but we recognise that this quality can be influenced by a range of intrinsic (parental contributions) and extrinsic (environmental) factors acting on the egg to smolt stages. But that said, we require an understanding of what determines the quality of smolts in ways that affect their probability of survival during the marine phase.

Examples of such freshwater influences include those determining smolt size, which may affect patterns of marine growth of salmon and hence may influence their mortality rates. Thus, an understanding of how the freshwater environment influences smolt size (and perhaps growth patterns) is required, to aid in fully understanding factors that influence growth (and hence size-related mortality) in the marine environment. Linking to other proposed research topics, for example, 'Studying basin-wide patterns of marine growth and survival of Atlantic salmon', should consider including freshwater influences on growth patterns. Similarly, does growth in fresh water influence sea-age profile, i.e. whether smolts become 1SW or MSW returning adults, and associated migration of salmon at sea? Better characterising the influence of the freshwater environment may be useful for more accurately partitioning mortality between freshwater influences and factors occurring directly in the marine environment. Furthermore, one must not ignore the overriding past, present and future influences of climate-related changes in the freshwater environment that will influence smolt size, smolt age and other 'quality' aspects through a range of mechanisms.

Approaches

The core challenges of characterising 'smolt quality', and the intrinsic and extrinsic factors that influence this quality, mean that this research topic can be addressed using a wide range of field- and lab-based research methods, and existing and new data collection.

It is envisaged that comparisons between studies throughout the oceanic basin area will build the broad, general relationships and understandings, providing the added value as compared to site- or stock-specific studies.

Expected Outcomes

Although this topic may not at first appear directly related to salmon in the marine environment, it is relevant to the scope of the prioritisation exercise where the freshwater influences can help explain the fate of salmon at sea. It also has the advantage that some pressures acting in fresh water can potentially be mitigated by direct interventions in the freshwater phase (e.g. habitat restoration, etc.) that could provide benefits for marine survival. For example, reducing river temperatures through the direct management of abstraction and flows could mitigate the potential impacts of climate change.

However, as much of the research and management in the freshwater environment can be implemented at local and national scales, and the relative importance of some freshwater factors will vary from place to place (ranging from absent to the primary influence), there is a challenge to identify and focus on the element(s) where research sponsored by the Board can provide 'added value' to the research and management communities.

Similar to the growth and migratory patterns topics, the 'added value' element of research supported by the Board may start with a basin-scale review of our understanding of smolt quality and freshwater influences. Such a review should contribute to explaining the observed changes in marine mortality, and predicting what will happen in the future for Atlantic salmon populations. In particular, can a common thread across the basin that contributes to our understanding of changes in marine mortality patterns over time be identified? Such knowledge might not lead to direct management actions but would certainly provide indirect support to overall management approaches.

Potential interactions between pink salmon and Atlantic salmon

(Priority Level: 3)

Research Context

At its Annual Meeting in 2022, NASCO made a statement (CNL(22)47) calling for mitigation efforts for pink salmon and encouraging research efforts on the topic in the Convention area. Based on this statement, the Terms of Reference for the NASCO Working Group on Pink Salmon (CNL(23)69) further call for consideration of both research and data needs and possible management measures to better understand the effects of pink salmon on Atlantic salmon.

Very little is known about the potential interactions between pink salmon and native Atlantic anadromous salmonids, or possible direct and / or indirect impacts on Atlantic salmon populations. Such interactions may take place at different life stages, including the marine feeding migration.

Survival of Atlantic salmon at sea is believed to be density-independent because the density of Atlantic salmon at sea is low. Pink salmon are known to affect the marine ecosystem and growth, abundance, distribution, phenology and survival of a variety of other organisms in the Pacific Ocean. Data from the Pacific suggest reduced growth and survival of other salmonids in years when pink salmon are abundant. The abundance of pink salmon in the North Atlantic is very low in comparison with its abundance in the Pacific. However, in the north-eastern part of the distribution of Atlantic salmon (northern Norway and Russia), pink salmon likely outnumber Atlantic salmon in the sea every second year; odd-year spawning pink salmon are currently abundant whereas even-year spawners are scarce in the same areas.

Approaches

First, it is important to understand the scale and nature of the possible interactions. Are pink salmon a problem for native species, and, if yes, under which circumstances, at which scale, on which temporal and spatial extent? Second, what kind of policy and management decisions should be taken, how much effort, cost and risk on native species should be tolerated when mitigating the potential negative effects of pink salmon?

Potential interactions could, for example, be investigated by diet analysis estimating overlap between pink salmon and Atlantic salmon, by modelling of migration routes of pink salmon smolts and Atlantic salmon smolts from rivers to estimate overlap in distribution, studying return migration and its timing and by comparing scale growth and relative abundances in the sea of both species. Such comparisons could make use of the year-to-year variation and investigate whether the variables differ between odd and even years.

Expected Outcomes

Improved understanding and scientific data on the impacts of pink salmon would be readily applicable to the development of management options. If invasive pink salmon not only impact native salmonids in spawning rivers, but also in the ocean, this will have even broader management implications. For example, evidence of competition for resources between the species, and density-dependent impacts on Atlantic salmon in the ocean, could call for even more efforts to reduce pink salmon spawning than those planned and implemented so far. In contrast, fewer intraspecific impacts than suggested in some predictions and risk assessments would probably call for reconsideration of feasible management measures in different jurisdictions.

Quantifying the mortality of Atlantic salmon caught as bycatch in pelagic and coastal fisheries

(Priority Level: 3)

Research Context

The potential for post-smolt Atlantic salmon bycatch in the large-scale small-pelagic fisheries of the North-East Atlantic (as well as in coastal fisheries) has been of concern for years, but investigations have been hampered by the lack of detailed fishery catch and post-smolt distribution data. Advances have been made detailing post-smolt distribution in the North-East Atlantic and, given the renewed focus on the potential bycatch issue, progress has been made towards identifying the fishery data required to enable an understanding of the magnitude of the problem. Although this research topic is a North-East Atlantic issue, it has the potential to affect populations from a large portion of the species' range and does provide the potential for management actions to be developed if the bycatch of salmon was determined to be significant. This issue was highlighted in the ICES Advice for 2023, where the lack of progress on previous recommendations on this subject was noted and a list of data deficiencies and research needs provided.

Approaches

To enable a determination of the scale of post-smolt Atlantic salmon bycatch, progress could be made on two main fronts. Firstly, a quantitative analysis of the risk of exposure and bycatch risk to salmon stocks could be carried out through developing an improved understanding of post-smolt and adult salmon migration routes in time and space, together with knowledge of gear- and fisheries-specific fishing effort data (in both smaller-scale inshore and larger-scale offshore fisheries). At the same time, since bycatch data collection is difficult to access directly at present, research is required to complete the development of eDNA data collection methods from scientific and commercial pelagic trawls to improve detection of salmon bycatch, including to quantify levels of uncertainty.

Expected Outcomes

If the magnitude of the bycatch of salmon at sea is determined to be large in some fisheries, there is potential for direct management actions through modification to these to minimise bycatch (such as targeted closed areas in both time and space). It must be recognised, however, that requests for adjustments to fishing patterns will be challenging and the evidence base for salmon bycatch will, therefore, need to be clear.