International Atlantic Salmon Research Board

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Progress Report on The Likely Suspects Framework Project

Progress Report - The Likely Suspects Framework (LSF) Project

Background

At the 34th NASCO Annual Meeting (2017) the IASRB agreed to part-fund a workshop on the Likely Suspects Framework (LSF) concept, which had been developed by the Atlantic Salmon Trust (AST). The workshop, which further refined and developed the LSF concept, was held in Edinburgh in November 2017 and the proceedings were published in the AST Blue Book series (https://atlanticsalmontrust.org/the-atlantic-salmon-trust-publishes-important-blue-book-on-likely-suspect-framework/). In March 2018 Dr Walter Crozier attended a meeting of the ICES Working Group on North Atlantic Salmon and sought their support in principle for the LSF approach. Having received this support a full report on the project was provided to the IASRB at the 35th Annual Meeting of NASCO (2018). The meeting endorsed the LSF concept and agreed to request the Secretary to explore with ICES how best to integrate Atlantic salmon marine survival and population data with relevant ICES marine databases and to suggest that, as an initiative within the International Year of the Salmon, a number of joint workshops might be convened. This suggestion was subsequently agreed and the first of these workshops was held in June 2019 at the ICES Headquarters in Copenhagen.

The report below outlines progress with establishing the LSF team and the LSF work programme for the period 2020 to 2024.

Update on Progress to date

The Likely Suspects Framework (LSF) is the flagship project of the Missing Salmon Alliance* (MSA), and represents the development of a guiding vision for actions to help boost adult Atlantic salmon returns. For salmon managers to adopt an adaptive management approach and to make evidence based decisions, a detailed understanding is required of the mechanisms driving variation in salmon stock abundance. Providing salmon managers with access to high quality information on the causes of mortality variation is at the very heart of the LSF process.

The specific goals of the Likely Suspects Framework project are to:

1. *Facilitate the evaluation of proposed explanations about salmon population declines,*
2. *Refine our understanding of how pressures interact and contribute to variation in salmon population survival,*
3. *Provide a decision-support tool to guide future salmon management.*

There are three outline phases for the delivery of the LSF with key tasks identified and core team resources allocated (Table 1). During Phase 1 (2019-2020), the project has rapidly gained momentum, with considerable advances in each of the areas. The following sections outline a summary of progress on Phase 1 tasks.

Building the Network

The success of the LSF is reliant upon building effective partnerships, facilitating sharing of datasets, and coordinating conservation efforts. The LSF Principal Investigator (Dr. Colin Bull) started work on the project in September 2019 and focused on this task. Key international meetings attended in 2019-20 by the LSF team include:

- **NASCO/ICES-LSF salmon data working group , Copenhagen, June 2019**
- **SAMARCH International Salmon Telemetry Workshop, Southampton, November 2019**
- **International Symposium on Atlantic Salmon, Reykjavik, January 2020**
- **Salmon Ocean Ecology Meeting in Monterey, California, March 2020** (with travel support from Fishmongers , London)

As outlined above NASCO and ICES have supported a series of three LSF workshops to assist with the development of the project. The first (scoping) meeting took place at ICES headquarters in Copenhagen in June 2019 and was jointly Chaired by Gerald Chaput, Department of Fisheries and Oceans, Canada and Niall Ó'Maoiléidiigh, Marine Institute, Ireland. A full report of this meeting has been completed and will be presented to a meeting of the LSF partners and collaborators in late May 2020. The report will be published by ICES later this year.

Since that time the LSF team has focused on building international cooperation and support, and has organised a meeting in May 2020 to bring together 18 expert scientists from 8 countries to agree on prioritised actions and a delivery schedule (roadmap) for the LSF. Integrating and planning research with the international salmon research community is vital to the success of the LSF. The upcoming meeting will also make recommendations regarding Terms of Reference for two further ICES / NASCO workshops, the first of which is planned for winter 2020- 2021.

Agreeing the LSF

A fundamental requirement in this process was the construction of a high-level conceptual framework. Such a framework will primarily assist project planning and visualising how salmon are influenced by climate, prey, predators, fisheries and other human-related activities throughout the fish's life cycle. Version 1 of the diagram (Figure 1) includes key drivers for salmon management, so as to highlight how the LSF focuses on delivering the appropriate information to support adaptive management practices. It includes a number of putative salmon "domains", where the assessment of specific candidate mortality factors (e.g. predation) can form a working methodology, which can be refined in subsequent iterations. Key research questions, proposed approaches and testable scientific hypotheses will link to this diagram to provide a cohesive route to inform and prioritise collective research actions. Version 1 of the framework diagram is currently under review by the MSA Technical Steering Group.

Database design and acquiring data

Graeme Diack joined the core LSF team in January 2020, to lead on database design and development. The LSF database uses the basic structure of candidate domains and the key ecosystem interactions outlined in the conceptual framework diagram. Collection and collation of multiple environmental and biological datasets across diverse science disciplines will facilitate new analysis to reveal the processes driving salmon mortality variation. With the generous assistance of a wide range of colleagues involved in database delivery and integration of environmental datasets, from across the salmon world, the LSF data approach has evolved to incorporate data from sources that utilise many formats. Such data sources include, for example, the dynamic query of external data and locally hosted data provided by collaborators. Finding and standardising the data are both essential processes that require great care to ensure that LSF data is relevant and aligns with existing data protocols (e.g. Darwin Core, FAIR principles).

LSF resources and management – a summary of initiatives taken to build and support the LSF core team

- In January 2020 funds were allocated to invite Dr Walter Crozier to re-join the LSF initiative in a consultative capacity, as the independent chair of the Technical Steering Group of the LSF. As the architect of the original LSF concept, Dr Crozier provides unique expertise and support to the project.

- With funding agreed in the LSF core team budget, the recruitment of a two-year LSF Post-Doctoral Research Assistant will begin work in Autumn 2020. This researcher will lead on developing statistical models to determine the role which various candidate mortality factors play in key LSF domains.

- A recent application was made to the MSA Management Group to provide partial match funding for a PhD studentship, which was secured from an Academic Sponsorship Scheme (Fishmongers, London). This post will focus on modelling salmon coastal ecosystem dynamics and will complement the work of the data specialist and make use of the evolving LSF database.

- A funding proposal has also been made to MSA for support with the development of a web application to act as an LSF decision-support tool for salmon managers. Based on similar tools under development in Pacific North America, the App is fundamental in facilitating the integration of the outputs from the LSF modelling work and will provide the data in a format that can be readily utilised.

- A collaborative partnership has been initiated by the LSF team to develop a research-funding proposal to use isotopic analysis, from archived and current biological samples (otoliths and scales), to reconstruct salmon migrations patterns in the ocean.

- An MSA website is currently under development, and should be live by late-May 2020. The LSF team is currently preparing a proposal to commission a short video to illustrate the role that the LSF initiative will play in Atlantic salmon conservation.

Colin Bull
MSA Principal Investigator
May 2020

*The Missing Salmon Alliance (MSA) is an initiative supported by the Atlantic Salmon Trust, Salmon &Trout Conservation UK, Game and Wildlife Conservation Trust and the Angling Trust. It aims to reverse the devastating collapse in wild salmon populations around the UK. By combining expertise, coordinating activities and advocating effective management solutions MSA is focused on ensuring that wild Atlantic salmon populations survive and thrive in rivers, lochs and seas for the next generation.

Table 1. Outline phases for the LSF Project, showing key tasks, core team resources to deliver the goals and proposed additional resources to target specific priority areas.

Phase and timescale	**LSF Key tasks**	**MSA -LSF core team resources** ***(italics indicate proposed resources for which additional funding is required)***
Phase 1 Year 1	Build network, ecosystem framework, key questions and domains. Database design and data acquisition Publish website and communications strategy	MSA Principal Investigator Research Assistant: Database Specialist *Website designer*
Phase 2 Years 2-3	Provide first estimates for candidate mortality factors Refine estimates using ecosystem modelling, focused on knowledge gaps Design of decision-support tool	MSA Principal Investigator Research Assistant: Database Specialist Research Assistant: Data Acquisition Post-Doctoral Research Assistant: Ecosystem Modelling *Application Designer* *PhD Studentship: coastal ecosystem modelling* *Post-Doctoral Research Assistant: Reconstructing marine migration routes*
Phase 3 Years 4-5	Coordinate existing and new research to refine initial mortality estimates Deliver decision-support tool and review progress	MSA Principal Investigator Research Assistant: Database Specialist Post-Doctoral Research Assistant: Ecosystem modelling *PhD Studentship: coastal ecosystem modelling* *Post-Doctoral Research Assistant: Reconstructing marine migration routes*

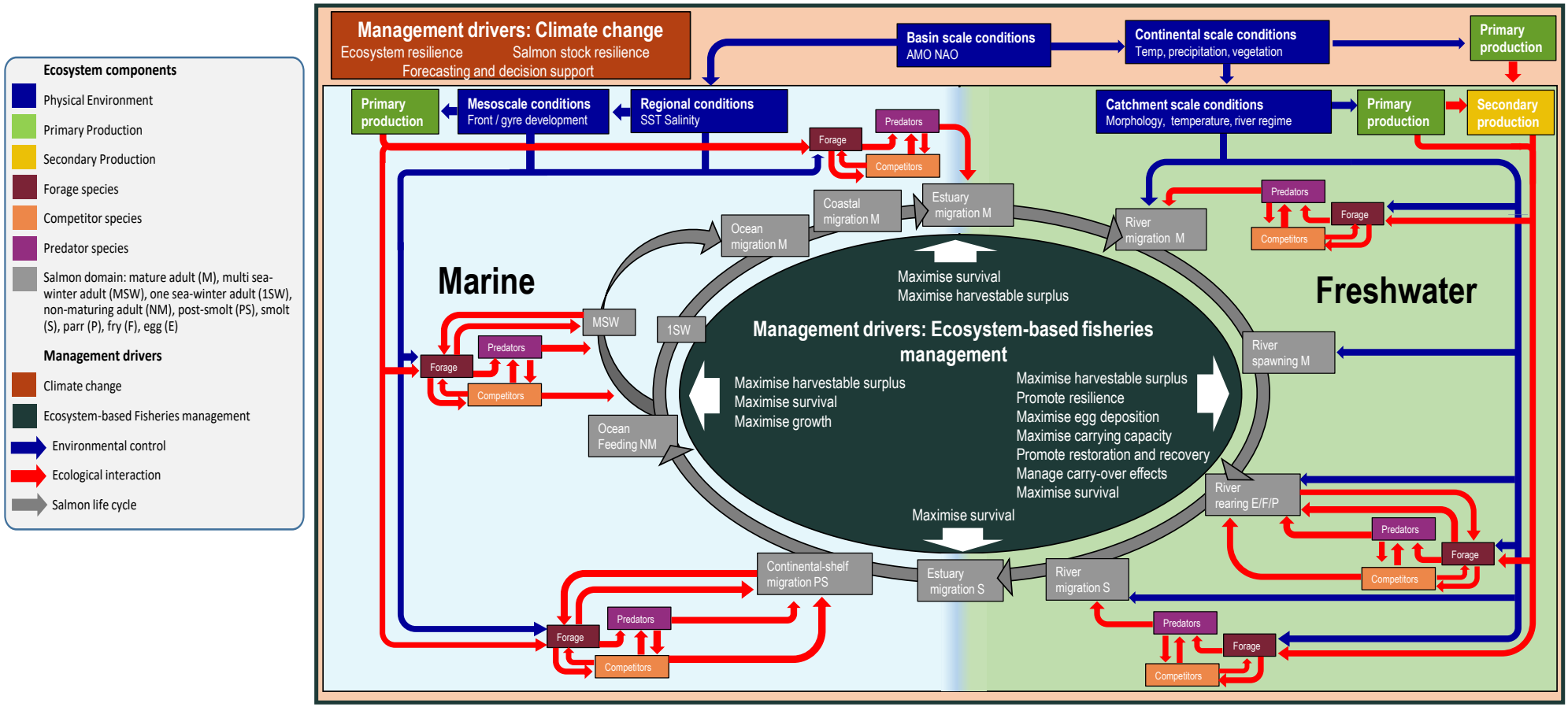

Figure 1 . Version 1 - LSF high level conceptual framework for Atlantic salmon, illustrating the direction and sources of ecosystem controls and the associated key management drivers

About figure 1:
This figure presents a high level conceptual overview of the main physical and ecological drivers and components influencing Atlantic salmon survival throughout a simplified life-cycle. It provides the background organisational structure for the Likely Suspects Framework (LSF) project goal of providing an adaptive ecosystem management system to improve the resilience of salmon populations and the dependent fisheries. Building from this conceptual framework the LSF project will proceed to assess the evidence, acquire data, and instigate research to identify, allocate and partition out candidate mortality factors. Preliminary numerical allocations of partitioned mortality will be added, and the framework refined as specific hypotheses are tested. Using an evidence-based approach to populate and expand areas of the framework will identify new and emerging risks for salmon, vulnerabilities in the management system, and suggest appropriate mitigation strategies.

Components in the figure
Central to the conceptual framework are two groupings of salmon management drivers representing the need to understand impacts of climate change on the salmon and wider ecosystem, and a multiple-species ecosystem-based approach to determine strategies, stock assessment and forecasting. In order to address the management drivers, targeted strategies will be added to a more detailed model or models and linked to domains or life-stages, with a further tier of associated management actions focused on maintaining and enhancing salmon stocks.
For climate change, three main management drivers applicable to the generalised life-stages (freshwater, estuarine and ocean grouping) are included. For the Ecosystem-based management drivers, several will likely apply at multiple points in the salmon life-cycle but their delivery mechanisms will vary depending upon domain and life-stage. The management drivers include restoring wild salmon stocks and protecting the wider ecosystem, whilst highlighting the importance of promoting resilience in a changing world. Managing “carry-over effects” is a key driver that links freshwater and marine phases of the life-cycle, and acknowledges that conditions experienced by salmon in one domain can be fundamentally important in determining the survival chances in subsequent domains. For example, variation in freshwater rearing conditions may result in smolts migrating out in sub-optimal condition that subsequently leads to higher rates of marine mortality when faced with challenges.
This conceptual framework will be the central component for the LSF project, establishing the basis to build an understanding of the drivers of salmon mortality, and provide the evidence-base upon which to build adaptive management strategies.

Progression and development through the life cycle includes time spent in various freshwater habitats (within the green box) and migration through transitional estuarine habitats (merged colours) to coastal and open ocean habitats (within the blue box). The main times and places occupied by salmon during the course of their life-cycle are indicated as ecosystem domains (grey boxes) with some (i.e. estuary and river domains) utilised by several life stages, for different activities (i.e. feeding, migration). The figure does not aim to represent the length of residency or possible temporal overlaps between life-stages in these domains.

Salmon growth and survival, as the fish transitions between domains, is dependent upon the individual meeting its nutritional and other physiological requirements, whilst avoiding detrimental stochastic events, and evading predators. Whether these conditions are met and an individual survives, will be controlled largely by physical (environmental) and ecological (trophic) factors interacting across various scales and acting both directly and indirectly on salmon. These factors may, in combination, determine the survival outcome at a particular place and time. They may contribute to an outcome at a later life stage by influencing feeding opportunities, energetics or physiological status at an earlier stage, leaving fish less capable of transitioning.

A hierarchy of environmental controls that act across varying scales determine the availability of primary production and base energy inputs for both the freshwater and marine ecosystems that support salmon. These controlling conditions are represented in the model by blue boxes and the base energy inputs in green and gold. Shifts in basin scale conditions variously affect elements of the salmon's physical, nutritional and ecological needs, and responses can differ as changes in controlling conditions cascade down amongst the various domains.

Fundamental ecological processes impacting salmon growth and survival are depicted as interactions amongst forage, competitors and predators. These are represented in the framework as six "clusters" of interlinked boxes, illustrating coupling and responsiveness to variations in environmental conditions at various key points in the salmon life-cycle. The species composition, abundance, and dynamics within each box in a cluster are not represented, and these will vary amongst clusters, and locations. Certain co-existing species may have positive and negative ecological interactions with salmon depending upon their life stage and size, in relation to salmon occupying any given domain. For example emerging trout fry may be an important seasonal forage for salmon parr in an upland stream, but then adult trout may prey on salmon smolts as they migrate downriver. Similarly, herring fry may provide an important component of post-smolt salmon diets during their first few months at sea, but older herring may also be competing for prey and may attract marine predators that also opportunistically consume salmon. Such complexities in trophic interactions cannot be adequately represented in this framework, but will be examined as the Likely Suspects Framework project develops.