



Projects of Interest to the Board and its Work

Purpose

The purpose of this paper is to provide an update on projects of interest to the Board and its work, namely the SMOLTrack projects and the Likely Suspects Framework.

Decisions

No decisions are required.

Background

At the 2020 Annual Meeting of the International Atlantic Salmon Research Board (the Board), it was agreed to retain an Agenda item, focused on projects where NASCO has some ownership (such as EU-funded projects, the SALSEA-Track successor and the Likely Suspects Framework) and that if SAG and Board members knew of other relevant projects, those researchers could be invited to contribute information, [CNL\(20\)12](#). The Board asked the Secretary to provide updates on the first category of projects (i.e. where NASCO has some ownership), and, through the Board and SAG members, to seek information on new and emerging projects that would be of interest to the Board and its work.

In February, the Secretariat asked Board members to provide information on any new and emerging projects that they were aware of, that would be of interest to the Board and its work. The leaders of the SMOLTrack projects were also asked to provide an update on their work.

No details of projects that fall within the scope of the Board's activities, or that are not already listed in the Board's [Research Inventory](#), were provided.

SMOLTrack Projects

The EU has provided funding to NASCO to support the following SMOLTrack projects:

- Understanding and comparing early mortality of European salmon populations at sea (SMOLTrack I - complete);
- Comparing mortality of European salmon populations at sea using multiple -method telemetry studies (SMOLTrack II - complete);
- Quantifying smolt survival from source to sea: informing management to optimise returns (SMOLTrack III – ongoing. Update below); and
- Quantifying salmon survival from river exit to return as adult: Collecting thermal and behavioural data to refine smolt to adult survival indices (SMOLTrack IV – new. Update below).

The website for the projects is: [SMOLTRACK](#). There is also information on the [Board website](#).

The leader of the SMOLTrack Project, Professor Kim Aarestrup, DTU Aqua, has provided the following update.

The overall SMOLTrack project was initiated in January 2017, involving partners from Northern Ireland, England, Ireland, Spain and Denmark. The purpose of the project is to determine the mortality of salmon smolts / post-smolts during their migration through the lower parts of rivers, estuaries / fjords, and nearshore areas through case studies using telemetry in rivers of six areas: Denmark, Sweden, England, Ireland, Northern Ireland and Spain.

Recent marine survival estimates are amongst the lowest recorded in decades and indicate that as little as 3% of wild smolts now survive to return as adults. For decades, survival at sea has generally been accepted as the key determinant of river stock abundance. However, earlier SMOLTrack results and related initiatives have indicated that smolt mortality during the early outward migratory phase from ‘source to sea’ is much greater than previously assumed. It has thus become apparent that significant knowledge gaps remain to understand, quantify and partition the principal cumulative factors responsible for Atlantic salmon smolt survival during this critical life stage.

SMOLTrack III

Successful outward migration is likely influenced by a variety of factors such as smolt size, condition and physiological status, habitat structure, predation pressure, sea lice-induced mortality from salmon aquaculture (if present) and the effects of regional and local climatic conditions including flow and temperature regimes. The SMOLTrack III project aims to identify and evaluate the relative contribution of several of the principal factors responsible for early smolt and post-smolt mortality in order to better inform the development of fisheries management strategies that may optimise natural smolt production and consequently enhance the probability of wild adult returns.

The project will evaluate potential pressures on migrating smolts identified from several previous SMOLTrack work packages, including predator bottlenecks and thermal stressors. As migration survival is best assessed via telemetric studies, an additional central focus of this project is to validate the effect of tagging on fish behaviour, in order to better ensure the accuracy of such assessments.

To address these issues, the following work packages (WPs) were initiated:

- Work Package 1: Eval-smolt
- Work Package 2: Thermo-smolt
- Work Package 3: Hand-smolt

The following jurisdictions participate in the project:

- Denmark
- Finland (new partner)
- England
- Ireland
- Northern Ireland
- Portugal (new partner)
- Sweden
- Spain

The distribution of experienced project partners, across the wide latitudinal distribution of salmon in Europe, allows the project to investigate salmon under varying climatic ranges. Additionally, mortality of kelts migrating on the same route are being investigated in Denmark. A total of 199 adult salmon were tagged with acoustic transmitters and their subsequent migration followed via acoustic listening stations. The results were quite surprising and is being reported in a paper under preparation: ‘Returning to the house next door’.

Progress on SMOLTrack III

Most of the planned smolt tagging was carried out in 2020, despite the Covid-19 problems.

Work Package 1: Eval-smolt

Studies are initiated in Eriff, Bush and Lima. In Eriff and Bush, the aim is to look at moving fish past the identified bottlenecks. In Eriff we will be using acoustic tags and monitor survival

on fish released above and below the Tawnyard Trap. We aim to perform the bottlenecks / predation / camera study in Bush in spring 2021, as the 2020 study was abandoned due to Covid-19. Most equipment is bought, so we need mostly boots in ground. The taggings and studies in Eriff were cancelled due to Covid-19 restrictions, but will take place in 2021, if restrictions allow.

In Lima, the aim is to evaluate the timing of smolt migration and collect biometric data from migrating smolts. Caught salmon smolts will also be tagged with PIT tags to allow identification in case of recapture / detection as returning adults. Comparing this information with streamflow and temperature data collected for the study area, we will evaluate the influence of such factors on smolt migration. As the southernmost river basin in Europe with known salmon reproduction, the Lima study will provide useful information on timing of smolt migration at this extreme location that, within 'Thermo-smolt', can be compared across a latitudinal gradient of variation.

Work Package 2: Thermo-smolt

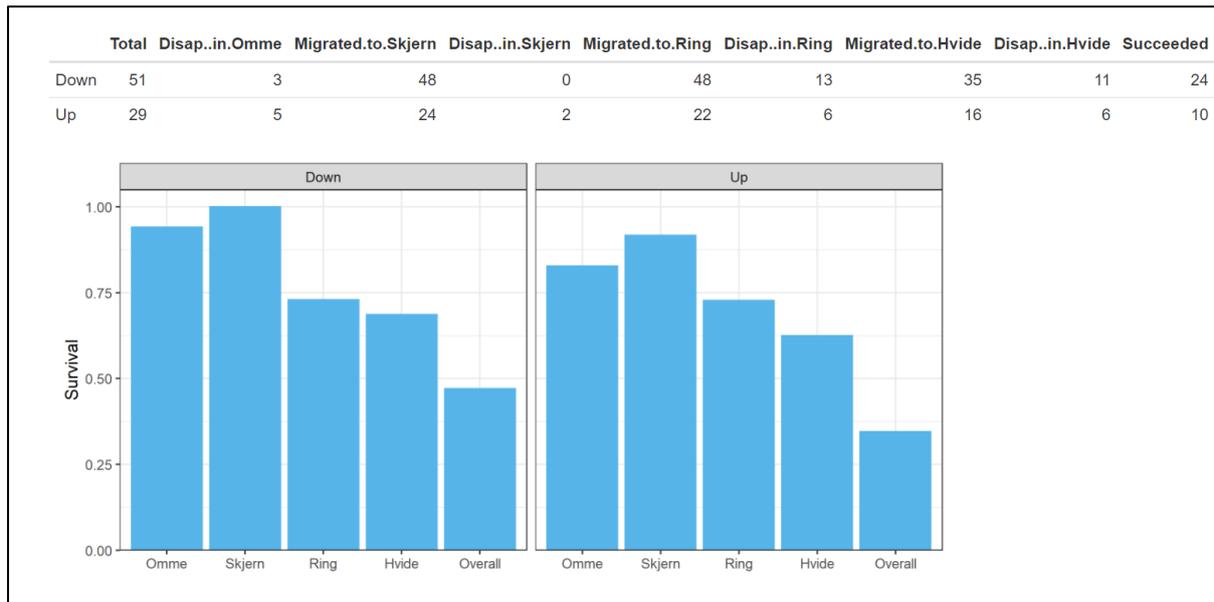
Equipment (temp-loggers) has been purchased and distributed amongst partners. In Portugal a screw trap will be set up in the Lima tributary to monitor smolt-outmigration. Inland Fisheries Ireland (IFI) with assistance from University of Gothenburg are working on a literature review on thermal and hydrological influence on smolt-run-timing. We are looking for long-term datasets on temperature and hydrology for reference. Data will come from all partners and IFI is trying to get it all included in model development and simple analyses.

Work Package 3: Hand-smolt

The SMOLTrack group identified three avenues of studies exploring potential ways of investigating effects of handling and tagging of various methods. There are no easy ways to address this, as all have shortcoming and changing variables. Some studies would best be performed with acoustic tags, while in others PIT tags may preferred.

The first Hand-smolt study in the Skjern River was carried out in spring 2020. A total of 39 salmon pre-smolts were caught by electrofishing, tagged and released in a tributary on 1 April. Two weeks later a Rotary Screw Trap was installed and 51 salmon smolts caught there were tagged. Hydrophones monitored the outmigration of tagged fish and the results show similar relative numbers from the two methods made it out of the Fjord, so no indication of the negative effect of electrofishing vs trapping / migration interruption was found.

Tagging of sub-adult salmon in the far north has been prepared and 20 Floating DST-tags were purchased, but the expedition and the logistics involved was a larger and more expensive enterprise than expected, so some of the activities here have been transferred to the SMOLTrack IV project.



Box 1. Results from Hand-Smolt experiment in the Skjern River in 2020. The two groups are fish electrofished and tagged before smolt migration period (Up) and smolts trapped in Rotary screw trap during migration (Down).

SMOLTrack Outputs

Some of the recent SMOLTrack results are still being processed, but the following papers are being prepared or have been published:

- results from the Danish kelt study; in prep: “Moving next door: Repeat spawning Atlantic salmon from River Skjern return to a neighbouring river instead”.
- smolt overall paper: "The Atlantic salmon smolts that never reached the sea. Lessons learnt from a pan-European project." – in review, submitted to ICES Journal of Marine Sciences.
- Flávio, H., Caballero, P., Jepsen, N. and Aarestrup, K. 2021. Atlantic salmon living on the edge: Smolt behaviour and survival during seaward migration in River Minho. *Ecology of Freshwater Fish*, 30, 61-72.

SMOLTrack IV

The overarching aims of the SMOLTrack IV project are to investigate thermal preferences and feeding and migration behaviours of smolt and / or immature salmon in the marine environment, using novel deployments of current and advanced telemetry, to contribute to improved understanding of factors influencing marine survival of salmon. Increasing temperatures have been highlighted as potentially a key factor in the decline of salmon populations both at local and oceanic scale. Climate change has been flagged as a major threat to the long-term survival of the species. Yet measured data on the thermal environment experienced by migrants, initially in fresh water, and subsequently in transitional and marine / oceanic waters are limited. Establishing the temperature regime which facilitates successful smolt to adult return will contribute to determining thermal preferences in each of these habitats thereby contributing fundamental ecological data to understanding marine survival. By focusing on the smolt stage to adult river return, and the immature salmon to river return, these studies will address key data deficits namely (a) temperature preferences of salmon across its outward and return migrations and (b) detailed tracking and temperature data for immature fish as they return to natal rivers.

As such, the project work packages are designed to better describe and understand:

1. The temperature experience of post-smolt migrating towards and returning from their ocean feeding grounds (Work Package 1).
2. The movement and thermal pathways of immature salmon at the feeding grounds and when returning to their natal rivers (Work Package 2).

Both Work Package 1 and Work Package 2 aim to provide a scientific basis for describing and understanding Atlantic salmon behaviour at sea. The results will act as a stepping-stone to more advanced understanding of the movement and survival at sea, as well as aid in building hypotheses underlying survival sea.

Likely Suspects Framework

(submitted by Colin Bull, Principal Investigator Missing Salmon Alliance)

Background

At its 16th Annual Meeting (2017) the Board 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](#).

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 Board 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 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.

In 2020 a report was delivered to the Board outlining progress in establishing the LSF team and the LSF work programme for the period 2020 to 2024 (Table 1). The current report provides an update of progress over the past 12 months against this outlined work programme.

*[*The Missing Salmon Alliance (MSA) is an initiative supported by the Atlantic Salmon Trust, Game & Wildlife Conservation Trust, Fisheries Management Scotland, The Rivers 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

Phase and timescale	LSF Key tasks
Phase 1 Year 1	Build network, ecosystem framework, key questions and domains. Database design and data acquisition Publish website and communications strategy
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
Phase 3 Years 4-5	Co-ordinate existing and new research to refine initial mortality estimates Deliver decision-support tool and review progress

Building the Core Team

It is recognised that the successful delivery of the LSF programme will rely heavily upon collaboration and co-operation amongst a great many organizations and individuals. Spearheading the initiative is the LSF core team (funded by the Missing Salmon Alliance, MSA). This core team now consists of three staff: the Principal Investigator (Colin Bull) and Database specialist (Graeme Diack) were joined by a Technical Research Assistant (George Brown) in November 2020.

In 2021 funding from the MSA has been agreed for an Ecological Modeller to join the LSF core team and lead the development and refinement of modelling initially focused on salmon mortality and variation in marine prey fields.

The [Technical Steering Group](#) for the LSF has been expanded in 2020 to include 12 invited experts from nine countries, representing a range of organizations and background experience. This expert group has already been involved in a process of prioritising mortality hypotheses for the LSF.

Building the network

The success of the LSF is reliant upon maintaining effective partnerships, and building new ones to facilitate data mobilisation and co-ordinating conservation efforts. To assist with building a network and communicating the aims of the programme, the MSA website detailing the LSF project went live in 2020: <https://missingsalmonalliance.org/likely-suspects-framework>

During the past 12 months face-to-face meetings have been curtailed due to Covid, however, the LSF team has remained active and engaged in online events. Relevant meetings and workshops attended by the LSF team during this time include:

- GeoBon Open Science Conference, July 2020;
- IFM Atlantic Salmon Conservation Conference, November, 2020;
- IYS Salmonscape International workshop series, December 2020;
- NASCO / ICES Salmodel workshop, January 2021;

- PNAMP Emerging Technologies Information Sessions, February 2021; and
- Canadian ASJRV science meeting, March 2021.

Building International Co-operation and Support

Integrating and planning research with the international salmon research community is vital to the success of the LSF. In May 2020 the LSF team hosted an international workshop to set out an agreed and peer reviewed roadmap for the delivery of the LSF programme. Attended by 18 expert scientists from eight countries the workshop agreed a set of prioritised actions and an outline delivery schedule. The workshop report and outputs are in the process of being written up as a position paper for submission to a peer-review journal.

The LSF team has been engaged with NASCO and ICES in planning the second in the series of NASCO / ICES workshops to be held in 2021, that will assist with the development of the LSF project. This event (WKSalm2) will focus on aligning and mobilising data with priority mortality hypotheses. The LSF team has been working inter-sessionally on preparatory information and developing resources to assist the workshop participants.

In autumn 2020 the team led an exercise to prioritise a set of salmon mortality questions as testable hypotheses to inform the LSF and as a preparatory resource for WKSalm2, with involvement from members of the ICES-WGNAS and the LSF Technical Steering Group. The resulting report setting out 11 mortality hypotheses, associated sub-hypotheses and extensive background supporting information is currently being finalised.

The LSF team PI was invited by the IYS to join the planning and delivery team for their Salmonscapes Workshop Series, focusing on data assessment methods and developing case studies for the LSF concept, in the Pacific region. The PI has also been involved in the planning and development of a DFO-funded ASJRV project looking to mobilise Atlantic salmon data from freshwater sources in Canadian and US rivers, to test linkages between freshwater and marine mortality.

A short, animated film outlining the key principles and processes behind developing the Likely Suspects Framework for Atlantic salmon is nearly complete and will be viewable on the MSA website in April 2021.

Database Design and Providing Support for Managers

Work on the technical delivery of a functional LSF database resource has been ongoing, with the collation of multiple data resources identified as being of value in testing salmon mortality hypotheses. To provide a repository for salmon-related meta-data, the LSF now has a presence established on the Knowledge Network for Biodiversity (KNB) data portal <https://knb.ecoinformatics.org/>. The LSF data resources are being organized using Graph database technology as a flexible indexing tool between ideas and datasets, providing a structured framework to allow data queries.

In tandem with the data resources developments, we are establishing an LSF technical toolbox of salmon and ecosystem modelling and assessment resources (source code, descriptors) to facilitate future development of hypotheses-testing scenarios.

During 2020 the LSF team have continued to forge strong international links with data scientists in relation to data mobilisation and technologies. We lead regular discussion groups with data science colleagues from Canada and USA, promoting knowledge transfer and compatibility in the development of salmon-related database programmes.

Phase 1 design (user-interface web application) of the mechanism to relay the results of the LSF programme to salmon managers (a Decision Support Tool) is on schedule for delivery in

March 2021. Phase 2 will then begin linking this front-end with existing and developing salmon life-cycle models and data sources, trialling with a small number of case-study rivers to test the system and illustrating the value of the Framework to salmon managers.

Catalysing New Research to Support LSF Delivery

The core team continues to engage, through building collaborations and partnerships, with external research organisations to develop and carry out programmes that assist LSF delivery. In 2020 links developed with mathematicians and oceanographers at the University of Strathclyde have led to a fully funded PhD studentship starting in 2021. Backed by UK funders (NERC, Fishmongers Company, MSA and MSS) this research programme will focus on applying an energetics approach to explaining Atlantic salmon survival during the critical early marine phase. An associated six-month data-focused post-doctoral position at University of Strathclyde (funded by Fishmongers Company) will carry out analysis on existing ocean simulation models and plankton datasets in preparation for the PhD programme.

The LSF team is in the early stages of developing a pilot study (led by Anna Sturrock at the University of Essex, UK) comparing chemical signals in salmon eye lens and otolith tissues. This study may provide information on migration routes and variation in salmon rearing conditions, to highlight areas for the LSF to focus on in the future. Tissue samples from over 100 wild salmon carcasses were collected in 2020 and in 2021. This research will continue and expand over the coming year, with the research consortium developing an external funding bid.

Secretariat
Edinburgh
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