The Likely Suspects Framework for Atlantic salmon: UK salmon managers views on developing decision support tools

Report based on a workshop organised by the Missing Salmon Alliance

24th June 2021

Report authors: Colin Bull and George Brown (MSA)

Workshop participants:

Jack Bloomer, Stuart Brabbs, Colin Bull, Ronald Campbell, Ian Clark, Walter Crozier, Jo Girvan, Ross Glover, Jim Henderson, Richard Holms, Peter Kerr, Roger Knight, Rasmus Lauridsen, Jonathon Louis, Craig Macintyre, Sean Robertson, Brian Shaw, Mike Smith, Jack Spees, Jamie Stewart, David Summers, Marcus Walters, Ruth Watts, Alan Wells.

THE MISSING SALMON ALLIANCE

https://missingsalmonalliance.org/

Contents

1. Executive summary

Salmon management is frequently impeded by poor access to information and evidence to support decisions. The Missing Salmon Alliance (MSA) is working to address these issues through a programme to mobilise evidence and develop a management support tool which can take locally sourced data and forecast the population growth of Atlantic salmon for a specific river, catchment or region.

In June 2021 the MSA organised a workshop via a remote hosting platform (due to ongoing Covid restrictions) with 25 attendees spanning salmon and river management organisations across the UK. This workshop provided an overview of the current management views on the availability and desirability of information resources underpinning management decisions, and an opportunity for managers to feed directly into the early development stages of a management support tool.

Key points from the workshop discussions were that:

- *"salmon management" as a term encompasses many levels from operational to policy and strategic decision making and views from upper management (e.g. government officials and advisors) may differ from those involved in more hands-on management activities.*
- *within the UK salmon rivers network there is large variation between catchments regarding the availability of knowledge sources. Where resources are more restricted a more general river habitat restoration and protection management style is being prioritised.*
- *research outputs are useful in supporting work to manipulate river and habitat conditions to protect their salmon, despite there being a lack of local information on the salmon populations themselves.*
- *whilst the intention of the tool development is to attempt to represent processes across the life cycle, the view was offered by some that it might be of most use to them if it was entirely freshwater focused as they do not believe they have the provisions or ability to influence marine conditions.*
- *marine-focused information was considered to be of interest, but not essential, to managers. Knowledge on the salmon's marine phase plays an important role in assisting management through its need for wider communication and awareness raising. It may also be very useful in supporting the adoption of more long-term sustainable approaches to salmon management*
- *it may be useful for the tool to include forecasting from the perspective of prospects for a recreational fishery season. Illustrating processes and linking actions to eventual salmon population levels could create both social and financial support for future management and conservation efforts.*
- *care would be needed in model design as well as communication to maximise the benefits of any salmon management decision support tool. It was proposed that outputs from a tool would need to be tailored to communicate with different audiences.*
- *capturing the detailed data at the right scale and level will be key to successful development of this tool and facilitate realistic and useful outputs. Having a model underlying any tool which can account for responses to extreme events (flood and drought) would be incredibly useful to river managers.*
- *there is the potential for such a tool to indicate economic values and inform decisions based on costs/ benefits analysis. The tool could be of use in the assessment of the performance of river –based strategies and actions using Key Performance Indicators (KPIs).*

2. Background and workshop objectives

Salmon management is frequently impeded by poor access to information and evidence to support decisions. These impediments can weaken decision making, restrict the opportunity to pinpoint reasons for declines, and action appropriate responses. Unless we make efforts to better understand the underlying mechanisms behind Atlantic salmon declines, we run the risk of continuing management approaches that are not best suited to the evolving ecosystem challenges, with salmon populations continuing to decline.

The Missing Salmon Alliance (MSA) is working to address these issues through the process of developing its Likely Suspects Framework programme. This involves work on the mobilisation of wide ranging physical and biological datasets, providing new resources that can help to address key scientific questions on what is driving salmon mortality, and also to provide evidence to develop a management support tool which can take locally sourced data and forecast the population growth of Atlantic salmon for a specific river, catchment or region. This salmon management focused decision support tool (referred to as the DST hereafter), is currently in early development stage, and is aiming at providing a new forecasting and simulation testing tool, in which managers can test how their actions may potentially affect Atlantic salmon populations.

As part of the DST development and scoping process a short workshop session was arranged in June 2021 by the MSA inviting river and salmon managers from across the UK to participate in guided discussion on the topic, and to capture their views regarding current information gaps and the potential for improvement in existing management tools. This workshop provided an opportunity for managers to feed directly into the early development of the DST, ensuring future development progresses in a direction that will best suit the interests of salmon managers.

The workshop commenced at 14:00, 22/06/2021 via a remote hosting platform due to ongoing Covid restrictions in the UK preventing face-to-face meetings. The group of 25 participants spanned salmon and river management organisations across the UK and was chaired by Colin Bull, the Principal Investigator for the MSA, with break-out discussion sessions moderated by Walter Crozier (MSA) and Rasmus Lauridsen (Game and Wildlife Conservation Trust). A full list of participants is provided in supplementary information.

The workshop set out with the following three objectives:

1. To provide an overview of the current views of managers on the availability and desirability of information resources that underpin decision-making at the local and regional-scales

2. To capture the feedback and guidance from salmon managers on the early-stage development of a new decision support tool

3. To provide direction and guidance from managers to integrate into the future development of a new decision support tool.

3. Pre-workshop questionnaires

Prior to the workshop online polls were emailed to all the participants. These polls requested participants to provide their scoring on the Availability (very poor to excellent) and Desirability (Not useful to Essential) for a list of 54 information sources considered of interest to salmon management, (supplementary information). The results from the polls were discussed in the workshop in relation to current and future information requirements.

In total 16 participants filled in the poll. It should be noted that approximately 75% responses originated from Scottish rivers suggesting the responses may be skewed by the opinions and needs of northern UK salmon river management.

The 54 information sources listed were categorised as "**desirable"** to the managers if the combined votes for *very useful* and *essential* were larger than the votes for *useful, possibly useful* and *not useful.* This meant that over 50% of the managers were of the opinion that the information source was *very useful* or better.

Similarly an information source was categorised as currently "**unavailable**" to the managers if the combined votes for *poor* and *very poor/absent* were larger than the votes for *fair, good* and *excellent.* This meant that over 50% of the managers were of the opinion that the information source was *poorly* available or worse.

If an information source received a majority of its votes for being "**desirable**" and also "**unavailable**", we considered this to be an important gap in ours and the manager's knowledge. Guided by the responses (n=16) the list of information sources considered desirable but currently poorly available are presented in Table 1, categorised where possible into applicability to salmon life stage or as more general utility to salmon management.

*Table 1. Salmon management information sources that were selected from a proposed list of options (N=54: see supplementary information) and rated by the majority of respondents (N=16) as **desirable** but currently **unavailable***

Category of potential information source (N=54)	**Information source rated by respondents as desirable but currently unavailable**
Management efficacy (n=4)	Effectiveness of current management actions on sustaining populations Predictions of effectiveness of planned management actions on sustaining populations
Physical environment (n=10)	Long term simulations of climate change impacts on population viability
Juvenile rearing phase (n=8)	Freshwater predation estimates on juveniles Juvenile stock status in relation to carrying capacity Estimated egg to smolt mortality Importance of juvenile rearing conditions in relation to marine survival
Smolt migration phase (n=11)	Estimated smolt mortality during in-river migration Freshwater predation estimates on smolts Importance of smolt migration timing in relation to marine survival
Marine growth and maturation phase (n=13)	Estimated post-smolt mortality during coastal migration Estimated mortality during marine year 1 Estimated mortality during marine year 2
Mature adult return migration phase (n=8)	Estuary predation estimates on adults Freshwater predation estimates on adults Estimated adult mortality during freshwater migration

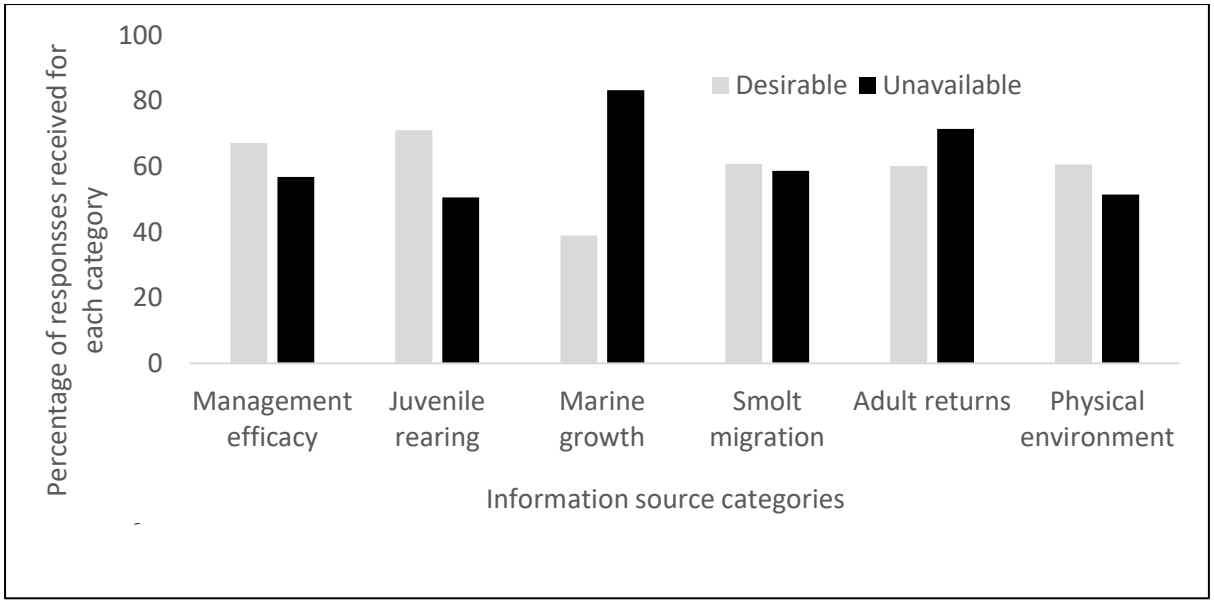

Figure 1. The distribution of responses (N=16) to the desirability and availability of 54 proposed information sources. The information sources are split into six categories (Table 1) and responses to the information sources within each category expressed as a percentage of total responses, where they are considered very useful or essential regarding usefulness for management = ***desirable*** *(Grey bars), or where availability is currently poor or very poor/absent =* ***unavailable.*** *(black bars).*

4. What informs salmon management at local and regional scales?

4.1 Introduction

A PowerPoint presentation outlining the workshop objectives and the MSA Likely Suspects Framework was introduced by the Chair at the beginning the workshop. The slideshow is provided in the supplementary information. The workshop was split into three break-out discussion groups where comments on the responses to the pre-workshop questionnaires (Table 1) and wider information needs for salmon management were considered. A synthesis and summary of the main points discussed are provided in the following sections.

4.2 Variation in the information available to salmon managers

Within the UK salmon rivers network there is high variation between catchments regarding the availability of knowledge sources. These range from areas with extensive historical and current data collection resources to those developing contemporary datasets and others where insufficient resources are available to provide sources. This variation was considered to have a geographical component with Scottish salmon rivers generally holding much more detailed salmon-specific information compared to the English and Welsh rivers. Discussion regarding developing new salmon data collection programmes (e.g. Scottish Governments National Electrofishing Project for Scotland (NEPS) highlighted a perceived divide between north and south in terms of knowledge to drive salmon management in the UK.

With reference to how the variation in salmon-specific knowledge influences management priorities actions it was considered that greater knowledge base can support the implementation of a more

structured and effective salmon fishery management regime. Where resources are more restricted and considerable knowledge gaps remain with regard to salmon populations and habitats, a more general river habitat restoration and protection management style is being prioritised.

The group also discussed the value of good quality research and access repositories of salmon-based information that indicated the effects of water quality, temperature, discharge and habitat quality in freshwater phase on sustainability of Atlantic salmon populations. It was mentioned that research outputs are useful in supporting work to manipulate river and habitat conditions to protect salmon in some systems, despite there being a lack of local information on the salmon populations themselves.

4.3 The value of freshwater and marine focused information to salmon managers

The view was expressed that river-based information was generally of higher importance to salmon managers than marine information (Figure 1). Understanding the dynamics and processes underpinning survival from egg to smolt in freshwater were identified as important knowledge sources for salmon management.

Information regarding habitat quality was considered useful for managers as links to salmon production are relatively well-researched, and possibly as this knowledge is relatively easy to obtain. Most rivers have information regarding the quality of their water and habitats as well as recordings on temperature and discharge.

Marine-focused information was considered to be of interest (Figure 1), but not essential as it was suggested that salmon managers do not believe they have the provisions or ability to influence conditions in this part of the life cycle. It was suggested that knowledge on the salmon's marine phase plays an important role in assisting management through its need for wider communication and awareness raising.

4.4 Challenges with knowledge acquisition

The groups discussed how the information sources included in the poll encompassed a range of sources and methods including simulation modelling, direct observation and combinations thereof, and that these variations needs to be considered when assessing desirability. With widely differing practical opportunities and financial implications encapsulated in the list it was noted that addressing identified knowledge gaps for some items would present far greater challenges than others. For example, obtaining consistent and applicable information on predation rates and health status is highly desirable, but satisfactorily achieving these information sources remains extremely challenging.

National incentives and programmes set up to address knowledge gaps for salmon management (such as NEPS) are of high value, but continue to face their own considerable challenges.

4.5 Management levels require multiple knowledge sources

The point was raised that "salmon management" as a term encompasses many levels from operational to policy and strategic decision making. The various levels of management may express different opinions of the desirability and availability of information and data and create a spread of responses. To ensure the most productive and successful outputs for salmon from management, it was agreed that all levels require adequate knowledge sources, and that coordination between the levels is essential to maximise efficiencies. The group commented that it would be of interest to

consider the responses from upper management (e.g. government officials and advisors) to the pre-workshop poll to illustrate these potential differences.

4.6 Utilising knowledge sources for communication

The group discussed that the value of many of the information sources listed were not specifically in guiding day-to-day management activities, but for assisting with communicating key ideas to the public and stakeholder groups. Illustrating processes and linking actions to eventual population levels could create both social and financial support for future salmon management and conservation efforts.

Information across the life cycle may also be very useful in supporting the adoption of more long-term sustainable approaches to salmon management and conservation rather than the consideration of actions that continue to be considered as "quick fixes".

4.7 Conclusions from session discussions

- Overall, the discussions in session 1 painted a useful picture of salmon managers views on their desire for, and access to, current and future knowledge sources
- There was notable variation between salmon rivers across the UK in terms of their views on accessing existing information, and their capacity to generate new and useful knowledge.
- There was a steer towards the importance of river information above marine information for general salmon management guidance. Managers prioritised information that is directly applicable to their work in the freshwater phase of the life cycle.
- It was recognised that many knowledge sources may not be essential for day-to-day management but play an important role in communicating certain aspects of salmon lifecycle and pressures to public, stakeholders and higher levels of management.

5. Integration of salmon managers' needs into the development of support tools

5.1 Introduction

The session began with a short presentation introducing the concept of the Decision Support Tool initiative for salmon which is currently under development by the MSA Likely Suspects Framework team. The slideshow is provided in the supplementary information. Following this introduction, the group was again split into the same three sub-groups, with time devoted to discussion thoughts and offer opinions regarding the tool. The following section outlines the main points raised.

5.2 Model Scepticism

The view was expressed that the public are uneasy when it comes to modelling or simulations as their complexity can create barriers to understanding. It should be noted that this issue is not restricted to this field and, is a general difficulty experienced across many science disciplines, and in in science communication. It was noted that care would be needed in model design as well as communication to maximise the benefits of any salmon management decision support tool.

5.3 Importance of mobilising the right data

Managers agreed that for this tool to operate accurately and efficiently the most important operation will be the gathering of detailed information and parameters from the rivers themselves.

Capturing the detailed data at the right scale and level will be key to successful development of this tool and facilitate realistic and useful outputs.

Capturing strong variation between conditions in salmon rivers was recognised as important in producing valid outputs from the tool. Revisiting a theme from an earlier session it was noted that developing the tool may encounter difficulties due to the differences in data availability and quality for the rivers flowing into the North Atlantic.

A discussion on model simulations and interpretation considered the importance of recognising the sensitivity of modelling process to the ranges and distributions of data inputs, and how this can have huge effects on the outputs. It needs to be ensured that managers and owners are not misdirecting in anyway by the tool but instead informed by accurate forecasting models. The group considered it important the tool development provides constraints on inputs based on geographical regions or stock units to ensure users cannot parameterise it with values which are unrealistic and produce misleading outputs.

5.4 Including extreme conditions in the tool development

A discussion point brought up in two of the sub-groups was the role that extreme events (e.g. periods of prolonged drought and flash flooding in the freshwater phase) can influence the abundance of Atlantic salmon. It was considered likely these events would increase in their frequency in the future, and having a model underlying any tool which can account for them would be incredibly useful to river managers.

5.5 Emphasis on freshwater processes

As discussed in the previous sessions, salmon managers prioritise understanding mechanisms behind freshwater production and utilising the relevant information sources underpinning river-based management decisions.

Whilst the intention of the tool development is to attempt to represent processes across the life cycle the view was offered by some that it might be of most use to salmon managers if it was entirely freshwater focused. The group emphasised the importance of focusing on the scope, options and realism provided by representation of freshwater processes in the tool, and the importance of involving managers in building the various information inputs from their rivers to maximise realism. The base inputs need to be carefully sourced to provide locally relevant data ranges, if available. Whilst it was noted that difficulties are foreseen in the collection of information for some rivers due to variation in management capacity, providing a scaled up version of the tool with options to select from a set of larger regional parameters could help facilitate its' use where local parametrisation is challenging.

It was also proposed that developing this tool could provide an opportunity to work towards coupling the ICES life cycle modelling process (with a current emphasis on predictions for the marine phase) with more in-depth representation of freshwater processes.

Habitat quality in freshwater was discussed as an important variable to represent as a factor in any tool development. It was also considered by some to be potentially useful for the tool to include a range of habitat quality options, as habitat quality may be assessed in various ways. It should be noted that the evidence providing convincing descriptions of the positive influence of many commonly used freshwater habitat restoration activities on sustained increases in salmon production remains limited.

5.6 Emphasis on providing outputs for recreational fishery prospects

The view was expressed that for many management organisations their requirement is to prioritise activities towards maximising the number of salmon available for recreational fisheries. To reflect this perspective, and improve impact it may be useful for the tool to include forecasting from the perspective of prospects for a recreational fishery season.

5.7 Using the tool to help guide the redirection of resources

One possible advantage of the tool that was highlighted was in communicating the options for redirection of resources into areas which may need more attention. Such support may lead to improvements in financial efficiency, ensuring organisations get the most productive outputs from their investments.

The group also noted that there is the potential for such a tool to indicate economic values and inform decisions based on costs/ benefits analysis. The tool could be of use in the assessment of the performance of river –based strategies and actions using Key Performance Indicators (KPIs).

5.8 Using the tool for communication

There were mixed opinions within the groups regarding using a single tool as a way of communicating with decision makers at higher levels in forming policies and directing resources. This appeared grounded in the need to focus outputs at the appropriate level and potential misunderstanding of complex outputs in the audience. To accommodate for this, it was proposed that outputs from a tool would need to be tailored to communicate with different audiences. When directed toward a lay audience, a traffic light visual system may be beneficial, to link possible cause and effect.

Comments were also received from the group that such a tool could possibly be obstructive to management by raising more questions than providing answers.

5.9 Conclusions from session discussions

Considerable useful feedback was provided during these discussion sessions with salmon managers, and overall their reaction to the development of the management support tool was generally positive. Notwithstanding the issues raised in the discussion sessions many saw a huge potential in the tool, recognising its value to support and guide their discussions with decision makers.

- Care is required in using model simulations and in interpretation and communication of outputs to mixed audiences, with general agreement that a range of output options would be better than one.
- Appropriate parametrisation and quality control over inputs are important, but challenging. Building in options for using a predefined range of spatially-scaled options for as inputs might be beneficial.
- The tool should attempt to incorporate the capacity to account for the influence of extreme events on salmon population persistence.
- Whilst the ultimate intention of the tool development is to attempt to represent processes across the life cycle of the salmon, managers expressed the view that development of the freshwater phase modelling would initially be most relevant to their needs.
- In time the wider decision support tool development provides a useful opportunity to work towards coupling marine focused assessment models with more in-depth representation of freshwater processes.

- The tool development could consider generating outputs that are more aligned specifically to the requirements of recreational fisheries prospects.
- The tool has the potential to be developed in such a way that it provides useful communication and planning capacity to salmon managers.

6. Workshop conclusions

The needs and opinions of a small, but generally representative, subset of UK salmon and river managers towards information and requirements were reviewed and documented in relation to current availability and desirability of a range of information sources. Considerable useful feedback was provided during the discussion sessions, and overall their reaction to the development of the management support tool was considered to be generally positive.

The short workshop was successful in making progress towards its three objectives:

1. To provide an overview of the current views of managers on the availability and desirability of information resources that underpin decision-making at local and regional-scale

2. To capture the feedback and guidance from salmon managers on the early-stage development of a new decision support tool

3. To provide direction and guidance from managers to integrate into the future development of a new decision support tool

With an overall general endorsement indicated from (an albeit small sub-set of 16) salmon managers in the UK towards the potential for the development of a focused decision support tool, there appears to be end-user support for the MSA initiative and to continue the development ensuring that

1. the ideas expressed by managers in this workshop are considered and integrated into the next phases of the tool development
2. the development of systems to adequately represent freshwater processes are highlighted and promoted in the next phase of development
3. a range of outputs to enhance the utility of the tool for communication and options assessment are integrated
4. we continue the dialogue with salmon managers and seek regular input and further guidance from these end-users (as well as others) as development proceeds.

7. Supplementary information

Table 1. The 54 potential information sources included in the pre-workshop questionnaire organised into categories. Respondents were asked to provide opinions on both the desirability and availability of the information sources.

Category	Potential information source
Management efficacy	Conservation limit (CL) Stock segregation: population genetic structure Effectiveness of current management actions on sustaining populations Predictions of effectiveness of planned management actions on sustaining populations
Physical environment	River water quality River water temperatures River flow regimes Physical river habitat quality and quantity Accessible wetted area for adults/barriers to migration Estuary water quality Estuary water temperatures Indicators of current ocean conditions for salmon Indicators of future ocean conditions for salmon long term simulations of climate change impacts on population viability
Juvenile rearing phase	Juvenile population distribution Juvenile age structure Juvenile body length and weight Juvenile health status Juvenile stock status in relation to carrying capacity Estimated egg to smolt mortality Freshwater predation estimates on juveniles Importance of juvenile rearing conditions in relation to marine survival
Smolt migration phase	Smolt population size Smolt population age structure Smolt population sex ratio Smolt migration timing Smolt body length and weight Smolt disease status Estimated smolt mortality during in-river migration Freshwater predation estimates on smolts Importance of smolt physiology in relation to marine survival Importance of smolt body length in relation to marine survival Importance of smolt migration timing in relation to marine survival

Marine rearing and maturation phase	Estimated post-smolt mortality during coastal migration Estimated mortality during marine year 1 Estimated mortality during marine year 2 Estimated adult mortality during coastal migration Marine feeding areas Marine migration routes Marine growth rates Marine predation estimates Marine competitor ecology Marine forage ecology Estimates of salmon bycatch in marine pelagic fisheries Proportion of smolts forecast to return as 1SW or MSW Forecasted marine survival prospects for salmon
Adult return phase	Adult spawning population size Adult spawning population age structure Adult spawning population sex ratios Adult body length and weight Adult disease status Estimated adult mortality during freshwater migration Estuary predation estimates on adults Freshwater predation estimates on adults

Workshop Agenda

Session 1. Scene setting. **10 mins**

a. Introduction: outline and purpose of this meeting

b. Presentation: What is the Likely Suspects Framework and what is its relevance to salmon managers?

Session 2. What informs management at local and regional scales? **40 mins**

a. Guided small focus group discussions: Needs and availability for effective salmon fishery management at the local and regional-scales

b. Brief summary of discussions from break-out session facilitators

Session 3. Managers guidance on development of effective decision support tools **45 mins**

a. Presentation: What are decision support tools for salmon management? Demonstration of a prototype

b. Guided small focus group discussions**:** Integration of salmon managers' needs into the development of new and effective support tools

c. Brief summary of discussions from break-out session facilitator

Session 4. Final thoughts and closing comments **15 mins**

List of workshop attendees

Name	Organisation / affiliation	Role in workshop
Jack Bloomer	Tyne Rivers Trust	
Stuart Brabbs	Ayrshire Rivers Trust	
George Brown	Missing Salmon Alliance	Administration / rapporteur
Colin Bull	Missing Salmon Alliance	Chair, Discussion group lead
Ronald Campbell	Tweed Foundation	
Ian Clark	Doon DSFB	
Walter Crozier	Atlantic Salmon Trust	Discussion group lead
Jo Girvan	Forth Rivers Trust	
Ross Glover	Cromarty Rivers TRust	
Jim Henderson	Nith DSFB	
Richard Holms	Tees Rivers Trust	
Peter Kerr	Northumberland Rivers Trust	
Roger Knight	Spey DSFB	
Rasmus Lauridsen	Game and Wildlife Conservation Trust	Discussion group lead
Jonathon Louis	Forth Rivers Trust	
Craig Macintyre	Esks DSFB	
Sean Robertson	Kyle of Sutherland DSFB	
Brian Shaw	Spey DSFB	
Mike Smith	Tay DSFB	
Jack Spees	Ribble Rivers Trust	
Jamie Stewart	Tweed Foundation	
David Summers	Tay DSFB	
Marcus Walters	Deveron Bogie Isla Rivers Trust	
Ruth Watts	Beauly DSFB	
Alan Wells	Fisheries Management Scotland	

Presentation slides used during the workshop

Why is the MSA flagship programme relevant to salmon managers?

Colin Bull
colin@atlanticsalmontrust.org

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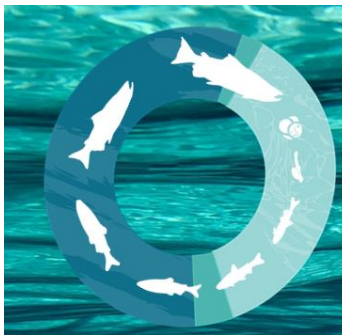

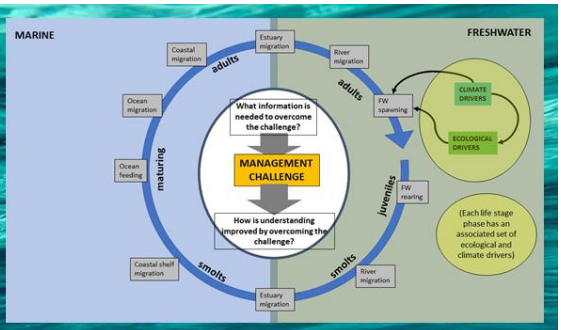

The Likely Suspects Framework approach

Building a new framework as a catalyst for seeking answers to fundamental questions regarding why marine growth , maturation rates and survival patterns fluctuate

Using this information to assist salmon conservation and management

In June 2019, the UK legislate for a net-zero target for carbon emissions by 2050.

UK Council for Science and Technology (CST) suggests a **Systems Approach** is needed:

- developing the analytical capability, flow of information, and reporting needed to inform decisions
- maximising the contribution of technology, mobilise financial systems and galvanise international collaboration
- strengthening the institutions, governance frameworks and leadership structures needed across central government to galvanise action to achieve net-zero

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Commonalities with the challenges of salmon management:

- Carbon emissions are cumulative so knock-on and carry over effects between sectors/areas must be considered.
- Many sources of carbon emissions lie outwith the UK jurisdiction hence a joined up/multilateral approach is necessary. Achieving a local objective may not materially improve the future viability of the species or guarantee achievement at national level.
- Management actions may need to combine measures. e.g. regulation coupled with advances in knowledge, actions, incentives , subsidies, spending.
- Much of the policy decision making needs to be based on the modelled outlook for future conditions (future prospects) and is necessary to plan for a range of scenarios

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Target of achieving Atlantic salmon stock sustainability and resilience

- Taking a **Systems Approach** for conserving salmon:

- developing the analytical capability, flow of information, and reporting needed to inform decisions
- maximising the contribution of technology, mobilise funding and galvanise international collaborations
- strengthening processes to galvanise action to achieve objectives

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Building a "Systems approach" towards the target of Atlantic salmon stock sustainability and resilience

Aims of the Likely Suspects Framework Programme:

- To build an framework catalyzing a process that seeks answers to fundamental questions regarding why marine survival patterns have changed
- To improve advice and guidance available to managers that allows them to consider the risks across the salmon life cycle and assess management approaches to mitigation
- To allow the impacts of proposed freshwater management actions to be considered within the context of other factors at play
- In time, to forecast prospects for cohort survival and also to simulate longer term prospects for stock recovery (or continuing declines).

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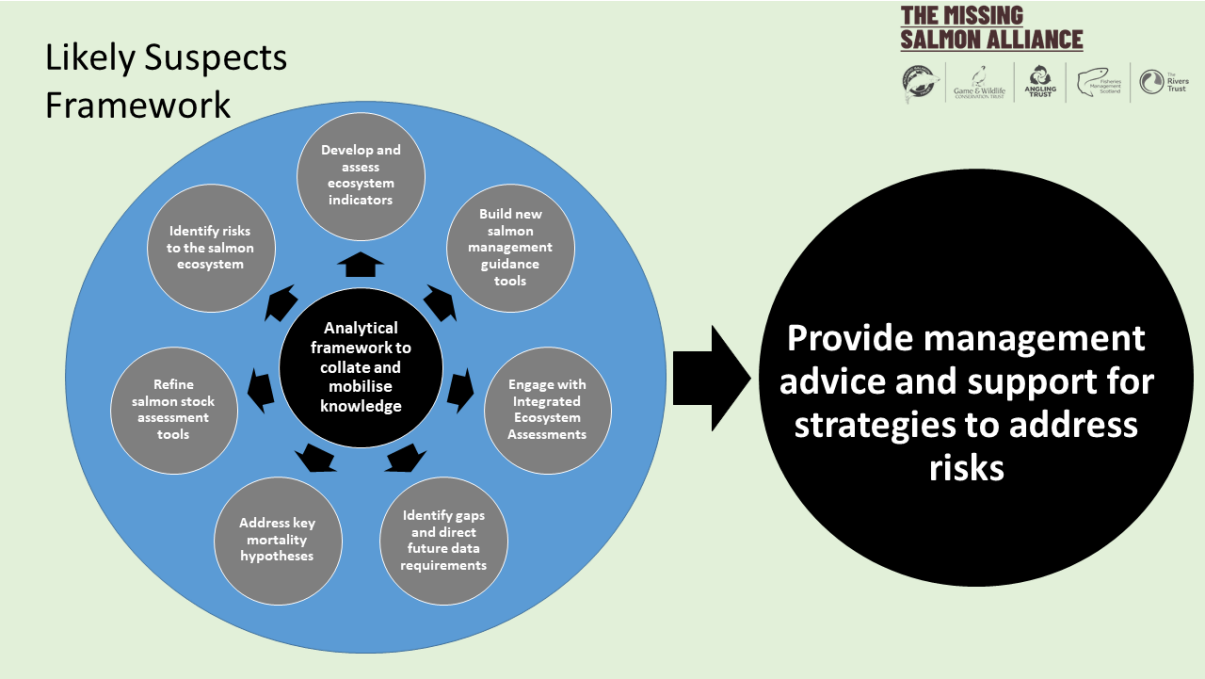
Likely Suspects Framework
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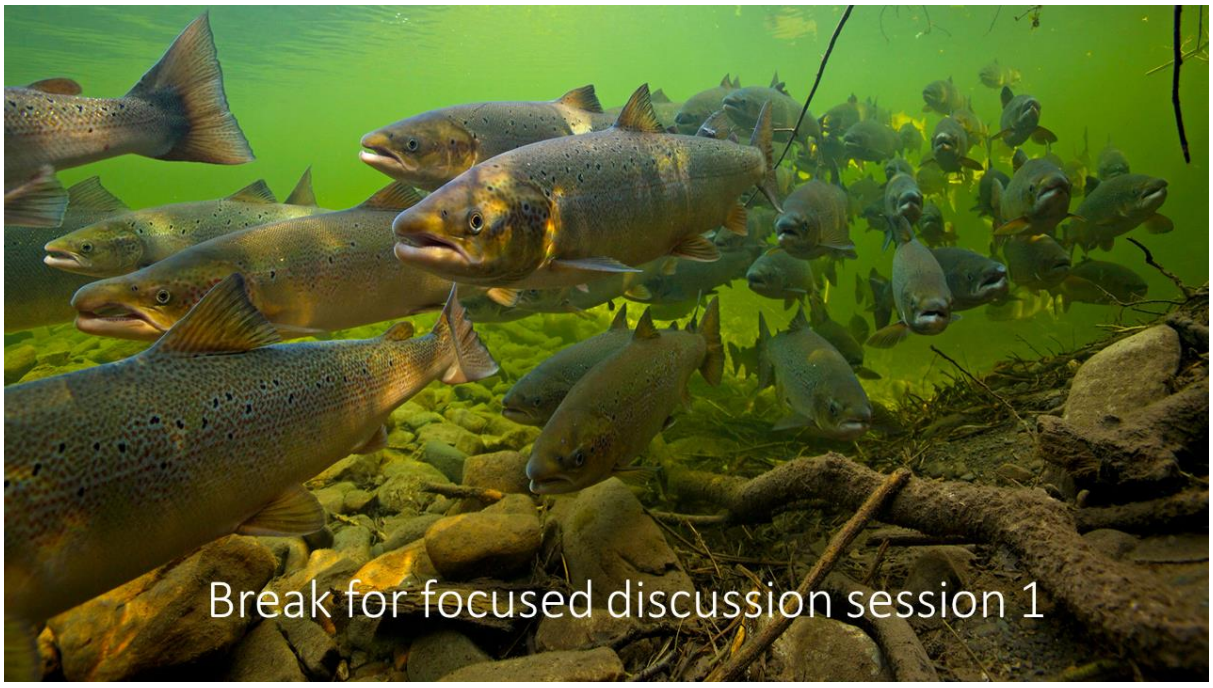
Develop and assess ecosystem indicators
Build new salmon management guidance tools
Engage with Integrated Ecosystem Assessments
Identify gaps and direct future data requirements
Address key mortality hypotheses
Refine salmon stock assessment tools
Identify risks to the salmon ecosystem
Analytical framework to collate and mobilise knowledge
Provide management advice and support for strategies to address risks


Break for focused discussion session 1

Atlantic salmon stock sustainability and resilience: providing managers with better decision-support mechanisms

- So what is needed?
- How can this be implemented ?

Challenge is to provide :

1. Improved stock assessments (ICES Working group)
2. Broadly predictive outlooks for years ahead (?)
3. Scenario-testing options : "what-if? " tools relating to management actions (?)

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1. Quantitative and qualitative advice

- Advice is provided to (mainly) enable management decisions on catch limits, where there is an exploitable surplus in the first place.
- The process (Run Reconstruction and Bayesian Life Cycle modelling) provides estimates of stock status that can be downscaled and used to assess against regional / local conservation targets (e.g. egg deposition)
- Recognised areas where better biological realism could be achieved.
- Poor coordination with marine species modelling (integrated ecosystem assessments)

ICES CIEM

NASCO

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2. Management guidance

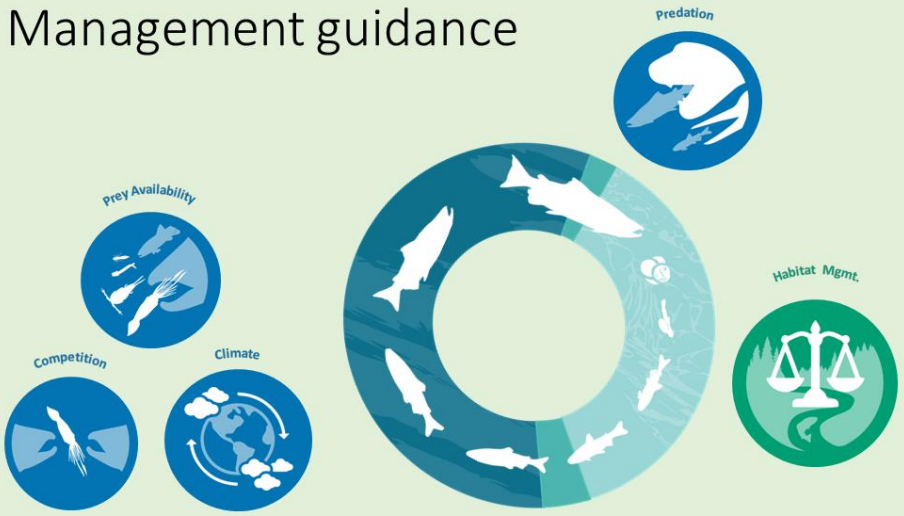

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TABLE 2. Indicators presently used to forecast salmon returns to the Columbia River and to coastal rivers of Washington and Oregon. The values of each indicator from Table 1 are ranked from high to low and color-coded based on their impact on salmon. Lower numbers (1–5) indicate better ocean ecosystem conditions, or "green lights" for salmon growth and survival. Higher numbers (12–16) indicate poor ("red light") conditions.

Ecosystem Indicators	Year															
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PDO (°C anomaly; Dec–Mar)	15	6	3	11	7	16	10	14	12	9	5	1	13	4	2	8
PDO (°C anomaly; May–Sep)	10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8
ONI (°C anomaly; Jan–Jun)	16	2	1	5	12	13	11	14	7	10	3	9	15	4	5	7
46050 SST (°C; May–Sep)	14	8	3	4	1	7	16	13	5	15	2	9	6	10	11	12
Upper 20 m T (°C; Nov–Mar)	16	10	7	9	5	13	14	11	12	4	1	8	15	3	2	6
Upper 20 m T (°C; May–Sep)	13	10	12	4	1	3	16	15	7	8	2	5	11	9	6	14
Deep temperature (°C; May–Sep)	16	6	8	4	1	9	12	14	10	5	2	7	13	11	3	15
Deep salinity (May–Sep)	16	3	7	4	5	13	14	8	6	1	2	11	15	10	9	12
Copepod richness anomaly (no. species; May–Sep)	16	3	1	7	6	12	11	15	13	10	8	9	14	4	5	2
N. copepod biomass anomaly (mg m^{-3}; May–Sep)	15	12	7	8	5	14	13	16	9	11	4	10	6	1	2	3
S. copepod biomass anomaly (mg m^{-3}; May–Sep)	16	3	5	4	2	11	13	15	12	10	1	8	14	9	7	6
Biological transition (day of year)	16	11	7	3	8	12	10	15	14	4	1	2	13	5	9	6
Ichthyoplankton (mg 1,000 m^{-3}; Jan–Mar)	16	8	2	4	6	15	14	10	13	12	1	9	3	11	7	5
Chinook salmon juvenile catches (no. km^{-1}; Jun)	15	4	5	13	9	11	14	16	10	8	1	6	7	12	3	2
Coho salmon juvenile catches (no. km^{-1}; Sep)	11	2	1	4	3	6	12	14	8	9	7	15	13	5	10	NA
Mean of ranks	14.7	6.1	5.0	5.9	5.5	11.3	12.9	13.7	10.0	8.6	2.8	7.9	11.0	6.7	5.5	7.6
Rank of the mean rank	16	6	2	5	3	13	14	15	11	10	1	9	12	7	3	8

Peterson, W.T., Fisher, J.L., Peterson, J.O., Morgan, C.A., Burke, B.J. and Fresh, K.L., 2014. Applied fisheries oceanography: Ecosystem indicators of ocean conditions inform fisheries management in the California Current. *Oceanography*, 27(4), pp.80-89.

Ocean indicators as guidance on stock prospects

Broadly predictive outlook for years ahead

Potential for some actions ?

THE MISSING SALMON ALLIANCE

Salmon management planning and activities may benefit from better knowledge on some "big picture" things:

- What are the prospects for recovery of more favorable marine survival conditions, or indeed a worsening trend, leading in time to loss of adaptive capacity and genetic and phenotypic diversity of wild stocks, and ultimately potential extinction events?

- What impact management actions in the freshwater phase actually can have on prospects for improving marine survival of out-migrating smolts, and to what practical extent can these actions mitigate losses at sea?

THE MISSING SALMON ALLIANCE

The LSF Decision Support Tool interface

- Phase 1 demonstration : for feedback and illustration
- Phase 2 : build links to existing models and assess options to integrate new variables (from dataframe)
- Phase 3 : Model refinement and capacity building to provide regionally aligned forecasting and scenario-testing tool

https://shiny.missingsalmonalliance.org/salmonDST/

THE MISSING SALMON ALLIANCE