Potential Successor to SALSEA-Track

Purpose of the Paper

To provide information on two projects which may be potential successors to SALSEA-Track.

Decisions

1. A decision on a potential successor to SALSEA-Track may be required; and

2. A decision in relation to the ISMMI proposal is required, regarding the request for endorsement and matching support funding of £96k.

Background

The Terms of Reference for the International Atlantic Salmon Research Board (the Board) state that the Board will oversee, administer, and seek to advance an International Atlantic Salmon Research Programme into the causes of marine mortality of Atlantic salmon and the opportunities to counteract this mortality through the following activities:

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

- identifying research needs;

- evaluating the Inventory against research needs;

- identifying gaps in the Inventory and setting priorities for further research;

- providing a forum for co-ordination of relevant research efforts by the Contracting Parties of NASCO;

- developing administrative mechanisms to accept financial contributions to an International Atlantic Salmon Research Fund (the Fund);

- soliciting and accepting financial contributions and managing the Fund;

- establishing terms and conditions for soliciting, evaluating, approving and funding relevant research projects;

- funding approved projects and reviewing results in relation to the objectives of the Programme; and

- endorsing projects that are consistent with the objectives of the Programme, ICR(20)03.

At the 2020 Annual Meeting of the Board, it was agreed that the SALSEA-Track Programme, in its current form, should be closed. CNL(20)12. It was also agreed that:

'any successor to SALSEA-Track should have the following attributes: be problem focused with a clearly defined internationally relevant question, which is not solely developed based on the newest technology available; have clear SMART objectives; have clear timelines; have a clear budget; be at the basin-scale; and have an identified owner / co-ordinator. Additionally, it should address issues such as: data gaps / climate change / commonalities across the jurisdictions / mechanisms for supporting new technologies.'

At the 2020 Annual Meeting, the Chair said that the Board could revisit progress under this Agenda item at its meeting in 2021. The Board recognised that the process of considering a new programme can happen alongside developments of the ROAM programme (see below).

In February 2021, the Secretariat asked Board members whether they were aware of any potential successor programmes to SALSEA-Track, and if so, to provide information that would be collated into a paper for the Board meeting. In response, information on the 'Developing an International Atlantic Salmon Modelling and Management Initiative' (ISMMI) was provided. Information on the ISMMI and the ROAM Programme are given below.

Voluntary Contributions to the Board

In February 2020, Fisheries and Oceans Canada made a voluntary contribution of $75,000 CAD (£41,911) to the Board's Fund. It was stated that:

> *'the funding would be directed to the research program to tag Atlantic salmon at Greenland with popup satellite tags for the purpose of increasing our knowledge of the distribution, migration, and predation events of salmon in their second fall and winter at sea. The funding would also be directed to supporting DFO scientists and collaborators engaged in the field efforts to tag Atlantic salmon at Greenland.'*

In August 2019, the United States Department of State identified $50,000 USD (£40,150) for a voluntary contribution to the Board's Fund. The United States stated that the contribution is:

> *'to support high priority projects in line with the long-standing "International Atlantic Salmon Research Programme," namely Salmon at Sea Track (SALSEA-Track) and RAFOS Ocean Acoustic Monitoring (ROAM), both of which are cooperative international research initiatives that employ technological advances to precisely track Atlantic salmon along their migration routes. These initiatives will allow us to better understand salmon, their migration, and threats to their survival, enabling more effective management of salmon in the future.'*

Further information regarding the Board accounts can be found in ICR(21)03.

The ROAM Programme

As mentioned above, in 2020 the Board recognised that the process of considering any successor to the SALSEA-Track programme can happen alongside developments of the ROAM programme. The ROAM programme is described in the SALSEA-Track Final Report, ICR(21)04.

> *'The ASF and NOAA is also partnering with researchers from the Woods Hole Oceanographic Institute (WHOI), among others, on the development and testing of the ROAM (RAFOS Ocean Acoustic Monitoring) approach to marine tracking. ROAM is an acoustic tracking system where low frequency long ranging sound wave "pongs" are emitted from ocean moored sound sources and received by a tag equipped with a hydrophone attached to the study animal. A primary advantage of the ROAM approach is the long range of the "pongs" which could result more accurate geolocation over a wider spatial and temporal range compared to traditional light-based methods. However, it should be noted that this technology is in the early stage of development and field testing is ongoing.'*

At the Annual Meeting in June 2020, the United States member stated that there had been some delays in starting field trials. He noted that the trials were intended to piggyback on a survey of the Woods Hole Oceanographic Institution but with the pandemic, all field activities have been cancelled or delayed. He reported that as long as the original plan moved forward as the

restrictions were lifted, there was no reason why the ROAM trials would not happen, but he could provide no clear schedule as to when the trials would take place.

In January 2021, a further update was received from the United States member who reported that Woods Hole Oceanographic Institute (WHOI) collaborators remained keen on the project, and that some progress has been made. The pandemic has meant that marine survey time has been very limited and the field trials have not yet been conducted. There have been some advances with the tag production, and progress with tag development, with two commercial tag companies involved. The ROAM approach is also part of another study and there is increased pressure to get the field trials done in order to move to the implementation stage. In summary, the ROAM team are waiting for the marine survey side of things to progress, before seeking an opportunity to couple the ROAM field trials onto an existing survey.

A further update was provided in April 2021. Many marine surveys have been resumed but have been staffed at half capacity due to restrictions associated with the pandemic, which has limited the ability to 'piggy-back' additional work such as the ROAM field trials. However, there is a real opportunity for the field trials to be conducted in July 2021 and collaborators are trying actively to secure the necessary ship time and commitments, and to develop the field trial plan. The development of multi-frequency ROAM tags is also ongoing, which will greatly increase the versatility of the tag and allow it to efficiently operate in both freshwater and saltwater environments.

Developing an International Atlantic Salmon Modelling and Management Initiative (ISMMI)

In response to the Secretariat's request to Board members on whether they were aware of any potential successor programmes to SALSEA-Track, the NGO member provided information about 'Developing an International Atlantic Salmon Modelling and Management Initiative (ISMMI)'. The Executive Summary and Board Request sections of the submission are copied here, with full information in Annex 1.

Executive Summary

Over the past four years NASCO / the Board has actively supported the development of the Likely Suspects Framework (LSF), ICR(20)11. The NASCO / ICES advisory group (WGNAS) has supported the development of a comprehensive Life Cycle Model (LCM). The scientists involved in developing these initiatives held a series of meetings over recent months to see how best to integrate and utilise the results from these two programmes, to better inform advice and guidance to ICES and NASCO on the pressures facing salmon populations. This *ad-hoc* group concluded that a future vision for international salmon conservation and management must move beyond the provision of catch advice based on single-species demographics to an ecosystemic vision. This approach recognises the changes in the ecosystem that impact on salmon during the marine phase and tackles the urgent and fast-moving challenges facing salmon populations for the remainder of this century. Such changes are firmly embedded in global environmental change. A new management paradigm is required which no longer relies on estimates of population and catch advice alone but incorporates an ecosystem approach, linking models and prioritised research programmes to develop a suite of dynamic ecosystem indicators and integrated assessment methods.

For the ICES Atlantic salmon advice to become more closely aligned with the recognised benefits of using an ecosystems-based approach, the stock assessment methodology for salmon will require further model development and benchmarking. For example, the current iteration of the Life Cycle Model, being tested by the WGNAS in 2021, will be benchmarked in the near future. However, the LCM as it currently stands contains many assumptions around the growth

and survival of salmon at sea and there is no doubt that it would greatly benefit from the inclusion of relevant marine ecosystem data. It is now clear that for future benchmarking, what is required is a portfolio of models that include both marine environmental and marine ecosystem indicators. Such an approach, we would argue, would directly support the work of WGNAS and more closely align future benchmarking of Atlantic salmon assessments with the ICES processes for other marine species. We believe that this could be achieved by linking the LSF and the LCM-related approaches.

Board Request

The Likely Suspects Framework Workshop in November 2017 was the first scientific event held under the auspices of the International Year of the Salmon. With the endorsement of the Board / NASCO, the LSF was subsequently adopted as an IYS signature project. The subsequent, trans-basin working relationships that have developed between Atlantic salmon researchers and Pacific salmon scientists have formed the basis for a series of on-going scientific initiatives. The LSF project is currently engaged in workshops with Pacific salmon researchers, helping to develop case-use studies, with a view to implementing the LSF approach in the Pacific Basin, and with researchers in eastern Canada, through the multidisciplinary Canadian AJSRV, collaborative science project.

The current proposal reflects what is emerging from these discussions. The close parallels between the challenges in the two basins are now clear to those engaged in such co-operative programmes. What is also clear is the need to develop a suite of dynamic, ecosystem indicators, which align closely with the emerging concept of integrated ecosystem assessment. The aim of this proposal is to build on earlier co-operative successes such as SALSEA and to forge close links with those engaged in current projects such as SeaSalar, SMOLTRACK, the Greenland Tracking Programme, SAMARCH, SeaMonitor, the Moray Firth and Scottish West Coast Tracking Programmes. Many of the principals in these projects are serving on the External Advisory Board of the LSF.

In our view the Board, working through NASCO, is ideally placed to co-ordinate such an internationally focused development. The Board is basin wide in its scope and is ideally placed to encourage Parties to embrace this new paradigm and to become full partners in the programme by aligning their marine salmon programmes under the umbrella of the International Atlantic Salmon Modelling and Management Initiative.

Very significant funding, both public and private sector, has been invested in the establishment of the Likely Suspects Framework research team and in the development of the Life Cycle Model to date (circa £500k to date). These human and intellectual resources will be fully available to ISMMI.

The chances of success of such a major bid (circa £3-5m) would be considerably enhanced by the support of key inter-governmental organisations such as NASCO. The Board's endorsement and matching financial support of £96K is therefore requested for one year to allow our consortium to:

a) align existing salmon stock assessment and management models in preparation for the bid, improve engagement with salmon management at all levels and define existing key roadblocks; and

b) appoint a suitably experienced and qualified research proposal developer to build a trans-national research project funding bid (EU-Horizon or similar).

Fundamental to the work of NASCO and ICES are improvements in scientific advice to managers and the integration of advice on salmon populations across their marine phases, with

ecosystem data emanating from other relevant ICES programmes. As outlined above, we believe that a future vision for international salmon conservation and management must move beyond the provision of catch advice based on single-species demographics. It must encompass a wider eco-evolutionary vision, which recognises the speed of change in both the ocean and in our climate and which can tackle the urgent and fast-moving challenges facing salmon populations for the remainder of this century. We believe that the Board is best placed to ensure the co-ordination that is required to oversee the evolution of ISMMI and to deliver on the comprehensive, five-year, strategic plan as outlined in this proposal.

Secretariat
Edinburgh
9 April 2021

Developing an International Atlantic Salmon Modelling and Management Initiative (ISMMI)

Executive Summary

Over the past four years NASCO/the International Atlantic Salmon Research Board (the Board) has actively supported the development of the Likely Suspects Framework (LSF) (ICR(20)11). The NASCO /ICES advisory group (WGNAS) has supported the development of a comprehensive Life Cycle Model (LCM). The scientists involved in developing these initiatives held a series of meetings over recent months to see how best to integrate and utilise the results from these two programmes, to better inform advice and guidance to ICES and NASCO on the pressures facing salmon populations. The ad-hoc group concluded that a future vision for international salmon conservation and management must move beyond the provision of catch advice based on single-species demographics to an ecosystemic vision. This approach recognises the changes in the ecosystem that impact on salmon during the marine phase and tackles the urgent and fast moving challenges facing salmon populations for the remainder of this century. Such changes are firmly embedded in global environmental change. A new management paradigm is required which no longer relies on estimates of population and catch advice alone but incorporates an ecosystem approach , linking models and prioritised research programmes to develop a suite of dynamic ecosystem indicators and integrated assessment methods.

For the ICES Atlantic salmon advice to become more closely aligned with the recognised benefits of using an ecosystems-based approach, the stock assessment methodology for salmon will require further model development and benchmarking. For example, the current iteration of the Life Cycle Model, being tested by the WGNAS in 2021, will be benchmarked in the near future. However, the LCM as it currently stands contains many assumptions around the growth and survival of salmon at sea and there is no doubt that it would greatly benefit from the inclusion of relevant marine ecosystem data. It is now clear that for future benchmarking, what is required is a portfoilo of models that include both marine environmental and marine ecosystem indicators. Such an approach, we would argue, would directly support the work of WGNAS and more closely align future benchmarking of Atlantic salmon assessments with the ICES processes for other marine species. We believe that this could be achieved by linking the LSF and the LCM-related approaches.

Better Integrating Modelling and Management

Our proposal offers an opportunity to improve the biological realism of existing modelling approaches. It would allow for their integration to support the development of ecosystem and evolutionary based enhanced guidance/advice that would go beyond that presently available for Atlantic salmon. Managers at national/area/local levels would benefit from access to enhanced guidance, while the underlying advice processes would remain relevant to ICES/NASCO regulatory requirements.

Our future vision is for enhanced coordinated salmon management, aligned with the provision of a proposed new three-tiered management guidance/advice development addressing wider management needs:

- *Quantitative catch advice with regard to stock complex/national conservation limits.*
- *Management guidance (soft advice), 2-5 year outlook for stocks, including impact of ocean conditions, and evaluation of impact of management measures in a wider ecosystem context.*

- ***Scenario modelling for managers**, exploring conditions not yet experienced, such as climate change-driven extremes and impact on stock genetic diversity and resilience, including probability of extinction in climate change-sensitive areas.*

This proposed advice landscape mirrors aspects of economic forecasting, where guidance and scenario modelling tools are widely used and relayed to managers to inform policy development and decision-making.

What is ISMMI?

The ISMMI initiative would initially involve a one-year pilot study to begin in 2022. This would bring the key modelling approaches and data together under the overarching Likely Suspects conceptual framework, while concurrently building an international consortium bid, spanning the three NASCO Commission areas, for a four-year science project (2023-2026) to develop the modelling and advice frameworks. Year 5 (2026) would be an implementation year, when enhanced scientific models and new management tools would be introduced to WGNAS and NASCO.

Centering on linking the work streams of the French Institut Agro/INRAE modelling groups and the MSA LSF group, the one-year ISMMI pilot programme would address four key areas:

1. Improvement of current engagement with salmon management across scales: assisting with translation and interpretation of new model outputs, leading to better alignment with salmon management requirements, for example, via novel user-friendly Decision Support Tools (DSTs).
2. Alignment of existing salmon stock assessment and management models, realising the potential for improving biological realism in existing models.
3. Progress with data mobilisation and workflow development, providing the components for a more Integrated Ecosystem Assessment based vision for salmon that integrates existing approaches and guides future modelling work.
4. Development of a major international consortium funding bid to initiate, develop and support the evolution of ecosystem-based management for Atlantic salmon.

For example, a direct benefit of refining the biological realism of models used at WGNAS and their integration with new modelling approaches would be an improvement in PFA forecasts and enhance the NASCO framework of indicators (FWI). Such an approach would also provide wider (environmental and ecosystem) indicators of the outlook for stock survival for periods of two to five years ahead, together with potential scenario modelling of longer-term changes.

Board Request

At the 2020 NASCO Annual Meeting the Board agreed that (ICR(20)16) "a*ny successor to SALSEA-Track should be: problem focussed; with a clearly defined internationally relevant question; not solely developed based on the newest technology available; have clear SMART objectives; a clear timeline; a clear budget; be at the basin-scale, and have an identified owner/co-ordinator. Additionally, it should address issues such as: data gaps; climate change; commonalities across the jurisdictions and mechanisms for supporting new technologies".*

We believe that the ISMMI Initiative, as detailed in the full proposal below, fulfills the criteria agreed at the 2020 meeting of the Board. Delivery of the suggested strategic plan would initially involve a

one-year preparatory study to begin in 2022. This study would bring together the key modelling approaches and data sets, under the overarching Likely Suspects conceptual framework. It would concurrently build an international consortium bid for a four-year science project (2023-2026), to develop the modelling and advice frameworks, spanning the three NASCO Commission areas. Year five (2026) would be an implementation year, when enhanced scientific models and new management tools would be introduced to WGNAS and NASCO.

In our view the Board, working through NASCO, is ideally placed to co-ordinate such an internationally focused development. The Board is basin wide in its scope and is ideally placed to encourage Parties to embrace this new paradigm and to become full partners in the programme. The chances of success in launching a major research funding bid *(circa £3-5m)* would be considerably enhanced by the support of key inter-governmental organisations such as NASCO. We are therefore, seeking the endorsement of the Board for this initiative.

Very significant funding, both public and private sector, has been invested in the establishment of the Likely Suspects Framework research team and in the development of the Life Cycle Model (*circa* £500k to date). These human and intellectual resources will be fully available to ISMMI. We are also requesting matching support funding (£96k) from the Board and or parties to NASCO, for the one-year preparatory study to bring key modelling approaches and data together and to support the concurrent development of a major international research proposal, inclusive of all parties to NASCO*.*

Fundamental to the work of NASCO and ICES are improvements in scientific advice to managers and the integration of advice on salmon populations across their marine phases, with ecosystem data emanating from other relevant ICES programmes. As outlined above, we believe that a future vision for international salmon conservation and management must move beyond the provision of catch advice based on single-species demographics. It must encompass a wider eco-evolutionary vision, which recognises the speed of change in both the ocean and in our climate and which can tackle the urgent and fast moving challenges facing salmon populations for the remainder of this century. We believe that the Board is best placed to ensure the co-ordination that is required to oversee the evolution of ISMMI and to deliver on the comprehensive, 5 year, strategic plan as outlined in this proposal.

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ISMMI - Full Proposal

Developing an International Atlantic Salmon Modelling and Management Initiative (ISMMI)

Background

Over the past four years NASCO/the International Atlantic Salmon Research Board (the Board) has actively supported the development of the Likely Suspects Framework (LSF)[1] (ICR(20)11). The NASCO/ ICES advisory group (WGNAS) has supported the development of a comprehensive Life Cycle Model (LCM)[2]. The scientists involved in developing these initiatives held a series of meetings over recent months to see how best to integrate and utilise the results from these two programmes, to better inform advice and guidance to ICES and NASCO on the pressures facing salmon populations. The ad-hoc group concluded that a future vision for international salmon conservation and management must move beyond the provision of catch advice based on single-species demographics to an ecosystemic vision. This approach recognises the changes in the ecosystem that impact on salmon during the marine phase and tackles the urgent and fast moving challenges facing salmon populations for the remainder of this century. Such changes are firmly embedded in global environmental change. A new management paradigm is required which no longer relies on estimates of population and catch advice alone but incorporates an ecosystem approach and an evolutionary-based approach, linking models and prioritised research programmes. Such an approach would aim to develop a suite of dynamic ecosystem indicators, which align closely with the emerging concept of integrated ecosystem assessment (IEA). Fully supported by fisheries management efforts globally, the IEA approach provides a framework to provide management advice for fish stocks, taking account of the full array of ecosystem interactions that can influence eco-evolutionary stock dynamics.

For the ICES Atlantic salmon advice to become more closely aligned with the recognised benefits of using a more ecosystems-based approach in the assessment of other marine species it is envisaged that the stock assessment methodology for salmon will involve benchmarking, as appropriate. For example, the current iteration of the Life Cycle Model being tested by the WGNAS in 2021 will be bench marked by ICES in the near future. However, the LCM as it currently stands contains many assumptions around separating out the different sources of variability among the phases of the life cycle, in particular between survival during the first and second years at sea and their intricate relation with the maturation schedule. It lacks also an evolutionary perspective. There is no doubt that it would greatly benefit from the inclusion of relevant marine ecosystem data to better inform the drivers of variability and help identify tipping points during the life cycle most likely to be responsible for the decline in marine survival. These would both improve our understanding of the mechanisms and drivers of the historical trends (the hindcasting phase of the analysis) and strengthen our capacity to forecast future marine productivity and salmon abundance. This should be embedded within an eco-evolutionary approach where the intricate relationship between phenotypic plasticity and evolutionary response are considered to resolve the likely suspects of the response of individuals and populations to multiple anthropogenic pressures. It is now clear that for future benchmarking, what is required is a portfoilo of models, which include both marine environmental and marine ecosystem data. We believe that this could be achieved by linking the LSF and the LCM related approaches.

The second of three ICES/NASCO workshops (WKSalmon2 – Data Evaluation) is provisionally scheduled for 2021. The principal objective of the workshop will be to examine how best to mobilise and identify the most relevant marine ecosystem drivers; how these data can be assimilated and stored in the LSF data repository and subsequently made available to the teams refining the Life Cycle Model and other sister models. This would include the exploration of novel data on environment and ecosystem attributes across different basins and consideration of salmon energetics during the marine phase. Such an approach, we would argue, is an essential prerequisite to moving towards a novel, ecosystem based approach to future salmon management. It would directly support the work of WGNAS and more closely align future benchmarking of Atlantic salmon assessments with the ICES processes for other marine species.

At the 2020 NASCO Annual Meeting the *International Atlantic Salmon Research Board* agreed that (ICR(20)16):

2) Any successor to SALSEA-Track should have the following attributes:

- *be problem focused, with a clearly defined internationally relevant question, which is not solely developed based on the newest technology available*
- *have clear SMART objectives*
- *have clear timelines*
- *have a clear budget*
- *be at the basin-scale*
- *have an identified owner / co-ordinator.*

Additionally, it should address issues such as:

- *data gaps*
- *climate change*
- *commonalities across the jurisdictions*
- *mechanisms for supporting new technologies*

We believe that the *International Atlantic Salmon Modelling and Management Initiative (ISMMI)*, as outlined below, fulfills the criteria agreed at the 2020 meeting of the Board (Table 1). We are, therefore, seeking the endorsement of the Board for this initiative and are also requesting matching support funding of £96k from the Board and /or parties to NASCO for one year to allow for the development of a major international research proposal, inclusive of all parties to NASCO.

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[1] *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. It will enable salmon managers to adopt an adaptive management approach and to make evidence based decisions. The LSF will provide salmon managers with access to high quality information on the causes of mortality variation. A detailed understanding is required of the mechanisms driving variation in salmon stock abundance and this objective is at the very heart of the LSF process.*

[2] *The Atlantic salmon Life Cycle Model, led by researchers Institut Agro and INRAE (France), provides an integrated hierarchical Bayesian life cycle model that simultaneously estimates the abundance of post-smolts at sea, post-smolt survival rates, and proportions maturing as 1SW, for all SU (stock units) in Northern Europe, Southern Europe and North America. The model is an age- and stage-based life cycle model that considers 1SW and 2SW life history strategies and harmonises the life history dynamics among SU in North America and Europe*

Table 1 Outline and scope of Year One ISMMI proposal

ISMMI Programme area	Problems addressed	Objectives	Board matching funding requested
1.Improved engagement with salmon management across scales, assisting with translation of new model outputs better aligned to salmon management via Decision Support Tool/s	Issues with communication and integration of important research and modelling outputs into management actions Recognised issues with the poor flow between ICES/NASCO stock assessment advice and regional and local management teams / stakeholders	**Specific** To provide a User Interface (UI) Decision Support Tool **Measureable** Quantifiable use-data and metrics from engagement with UI Interface **Achievable** Phase 1 development of UI underway and technical expertise within network of proposers **Relevant** Salmon managers need better access to good management advice and forecasting tools **Time bound** A functional UI to provide decision support is deliverable within 1 year, with iterative revision and refinement necessary via continued management	£12K Time and travel for keynote participation at one workshop plus rapporteur and organisation
2.Alignment of existing salmon stock assessment and management models, realising the potential for improving biological realism in existing models	Current restricted forecasting capacity in PFA models Difficulties linking modelling to the NASCO framework of indicators (FWI). Individual models can represent important life-stage-specific survival variation differently, and include evolutionary processes	**Specific** Model evaluation and refinement to increase biological realism **Measureable** Documented revisions and evolution of modelling programmes **Achievable** Functional models exist and expertise within networks of proposers **Relevant** Recognised limitations in current modelling frameworks are addressed **Time bound** Development of specified elements within one year	£15k Contribution towards travel costs for attending 2 x 2 day workshops
3.Progress towards providing the components for a more Ecosystems Based Approach for salmon management that integrates existing and guides future modelling work	Limited use of environmental and ecosystem indicators to provide biological realism in current modelling approach Poor integration between salmon and the Integrated management approach promoted for other marine species	**Specific** Development of IEA strategy and ecosystem indicators evaluation **Measureable** Conduct comparison between outputs from current stock assessment methods and developing IEA approach **Achievable** Multiple examples of developing IEA approach and expertise within ICES networks **Relevant**	£35K Contribution towards travel costs for attending 2 x 2 day data –tech workshops Fund for partial covering WKSalmon 3 participants' costs to

	Limited opportunities to refine and develop modelling and stock assessment approach	An Ecosystem-based management addresses current challenges and future requirements **Time bound** Initial IEA development will be to assemble and assess potential indicators in year 1	increase participation
4.Development of an Atlantic, basin-wide, international funding bid to develop this initiative and support the roll out of a 5-year strategic science plan for Atlantic salmon management	Limited coordination of national salmon research programmes and efficacy of resource use Requirement for a future vision for integrating international salmon management and research programmes	**Specific** The production and submission of an international funding bid **Measureable** Bid development provides identifiable research consortium and content will provide transferable resources/models **Achievable** Previous track record of proposers. Key groups and individuals are well integrated within proposers' networks assisting bid development **Relevant** International collaboration behind an agreed vision is required to address the scale of challenges facing Atlantic salmon **Time bound** Bid development and submission completed within 1 year	£34K Project bid developer, salary and travel costs contribution for 12 months involvement ~£34k
			Total £96K

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The Challenge - Integrating Modelling and Management

As outlined above our proposal offers an opportunity to improve the biological realism of existing modelling approaches and integrate them to develop ecosystem and evolutionary-based enhanced guidance/advice that would go beyond that presently available for Atlantic salmon. Through linking existing and on-going programmes of work, managers at national/area/local levels would gain benefit from access to improved guidance while the underlying processes would remain relevant to NASCO /ICES regulatory and advisory requirements.

Our future vision is for enhanced coordinated salmon management, aligned with the provision of a proposed new three-tiered management guidance/advice development addressing wider management needs:

- *Quantitative catch advice* with regard to stock complex/regional/national CLs.
- *Management guidance* (soft advice), 2-5 year outlook for stocks including ocean conditions, evaluation of impact of management measures in a wider ecosystem context.
- *Scenario modelling for managers*, exploring conditions not yet experienced, such as climate change driven extremes and impact on stock genetic diversity and resilience, including probability of extinction.

The above advice landscape mirrors some aspects of economic forecasting, where guidance and scenario modelling tools are widely used and relayed to managers, to inform policy development and decision-making.

It is widely recognised that one single over-arching stock forecasting model cannot address all requirements for integrating data on stock abundance and survival trends. Furthermore, our ability to forecast stock abundance trends for management advice purposes is highly contingent on the biological realism of the models used. Models are developed at different spatial scales and at different level of biological organisation, from individual-based models developed at the scale of populations to basin-scale models. All have pros and cons in terms of data that can be assimilated and questions that can be addressed. Developing connections among a portfolio of different models, improving biological realism in modelling approaches and exploring the potential for wider integration of ecosystem indicators to enhance the ability of ICES to provide advice on Atlantic salmon may provide a way forward. Progress may be possible via contemplating a series of models, addressing particular areas of interest but fully coupled together, rather than a single end-to-end ecosystem model.

The Likely Suspects Framework links well with the development of the work of key Life Cycle Modelling initiatives by: providing an internationally supported conceptual framework, organising key mortality questions / data resources by life-stage, spatio-temporal domains and by management drivers. Coordinated advances in both programmes form the basis of this proposal.

ISMMI: a strategic plan, under the auspices of the Board

The Board is invited to consider establishing a five-year strategic science plan as a successor to SALSEA-Track. This plan would centre on further modelling development research and data acquisition, with the primary objective of supporting a more integrated ecosystem-based approach to Atlantic salmon assessment and management: the *International Salmon Modelling and Management Initiative (ISMMI).*

Delivery of the suggested strategic plan would initially involve a one-year pilot study to begin in 2022. This study would bring together the key modelling approaches and data sets, under the overarching Likely Suspects conceptual framework. It would concurrently build an international consortium bid for a four-year science project (2023-2026), to develop the modelling and advice frameworks, spanning the three NASCO Commission areas. Year 5 (2026) would be an implementation year, when enhanced scientific models and new management tools would be introduced to WGNAS and NASCO.

The pilot study will be critical to establish the work streams for the overall five-year plan, and in particular to support the development of the Atlantic-wide consortium bid. An element of match-funding from the Board is being requested for the pilot study, as detailed in Table 1 above.

Centering on linking the work streams of the French Institut Agro/INRAE modelling groups and the MSA LSF group, the one-year ISMMI pilot programme would address four key areas:

1. **Improvement of current engagement with salmon management across scales: assisting with translation and interpretation of new model outputs, leading to better alignment with salmon management outputs via Decision Support Tools (DSTs)**

In seeking to improve the effectiveness of salmon management advice, communication of the outputs from the increasingly complex models used in generating such advice urgently needs to be improved.

There is a need to evolve management guidance and advice in a coordinated and focused way to meet the needs of various local national and international administrations and management groups.

An important element is communicating with salmon managers and integrating their requirements into tool development. Use of terminology is important, and great care is needed in communicating modelling functions and limitations and in expectation management. If successfully addressed, this aspect could allow improvements in the flow of ICES/NASCO stock assessment advice to stakeholders, most particularly to regional and local management teams.

Inherent to the LSF concept is the use of decision support tools (DSTs), to enhance the interface between modelling outputs and managers. These tools aim to provide user-friendly, accessible graphical type outputs to show important trends, such as abundance and survival, together with prospects for ocean survival and the status of key ecosystem indicators (e.g. predators, competitors etc.). DSTs can provide a wider lifetime context to quantitative advice and allow managers to make timely decisions, while taking account of such information. Scenario ("*what-if*" prospective) is also conceivable in the design and implementation of DSTs.

Specifically we propose to:

- Host a workshop (or series of focused discussions) with managers, to seek input to guide the development of management-friendly, easily understood interfaces between model outputs and management advice / guidance.
- On that basis, develop improved interfacing between managers and modellers, specifically testing various decision support tools structures and designs.
- Concurrently, evolve the translation of model outputs beyond current parameters to encompass stock prospects (survival outlook) and scenario planning.

2. **Alignment of existing salmon stock assessment and management models, realising the potential for improving biological realism in existing models.**

This component would build on specific model components development/enhancement already underway:

Institut Agro/INRAE group and collaborators:

- Refining the LCM and exploring incorporating variability in the natural mortality rates (M) post-PFA, and the intricate relationship between survival and maturation schedule.
- Expanding biological and evolutionary realism beyond current LCM capacity to incorporate a wider range of life history options
- Improving synergies and connections between salmon modelling approaches (Individual Based Atlantic Salmon Modelling and LCM)
- Data workflow process to provide inputs to LCM

Likely Suspects Framework group:

- Prioritising a set of salmon mortality questions as testable hypotheses, linked to life stage and domain
- Building a structured data framework organising and mobilising environmental and ecological datasets, using Graph database technology

- Establishing a technical toolbox of salmon assessment resources to facilitate evaluation in future developments
- Phase 1 design of a user-interface web application of the mechanism to relay the results of the LSF programme to salmon managers: a Decision Support Tool

A direct benefit of refining the biological realism of models used at WGNAS and their integration with new modelling approaches, would be an improvement in PFA forecasts and the NASCO framework of indicators (FWI). Such an approach would also provide wider (environmental and ecosystem) indicators of the outlook for stock survival for periods of two to five years ahead, together with potential scenario modelling of future, and longer term, changes. This would guide managers on what underlying changes were impacting, or likely to impact, salmon survival and abundance, thus enhancing the utility of the FWI process.

3. **Progress towards providing the components for a more Integrated Ecosystems Assessment based vision for salmon, that integrates existing approaches and guides future modelling work**

Evolving an IEA approach for salmon management will require a high level of cooperation within ICES working groups and dedicated development time. Application of an IEA for Atlantic salmon will also require considerable development to focus it clearly on critical areas of concern and to fine tune it for use.

Drawing a distinction between hind casting and forecasting approaches within an IEA framework is important. For example, available indicators (or proxies) for past changes are not always easily integrated into methods to provide useful forecasts. However, hind casting is essential, especially in supporting an understanding of mechanistic (causal) relationships between marine indicators and salmon survival at sea. To better explain past biological and environmental conditions, hind casting models would be cooperatively focused to advance several linked areas of work:

- **New data mobilisation and workflow development to access comprehensive physical and ecological datasets**: Availability and assessment would be based initially on the inventory from WKSalmon1. The LSF data frame is currently building a suitable data resource, organised in a global data repository (using FAIR data principles) and in collaboration with colleagues working on similar challenges in North America (Atlantic and Pacific regions). Data mobilisation and sharing will facilitate new analysis (such as break-point analysis), specifically assisting linking of modelling approaches and hypotheses testing. The LCM data workflow approach, managed by Institut Agro/INRAE, shares the principles and elements of the underlying structure. We believe that an opportunity now exists to combine these data approaches.
- **New indicator development to improve assessments:** Consideration of the extent of initial datasets is required to provide variables for integration into existing or future model refinements, as potential indicators or as proxies. One focus area involves combining hydrodynamic models delivering ocean transport information with proxies for prey distribution and abundance, derived from ecological datasets (e.g. CPR series).
- **Prioritise and coordinate the work programme around addressing key mortality questions:** An MSA-LSF led initiative to prioritise salmon mortality hypotheses, which will facilitate linkage with available datasets/indicators/proxies, is underway, providing preparatory material for the upcoming 2021 ICES WKsalmon2 workshop. This will allow convergence

between relevant datasets that are likely to be informative, leading to a tightly focused data call to the wider ICES community.

4. **Development of an international funding bid to initiate, develop and support the evolution of ecosystems-based management for Atlantic salmon.**

A central component of the proposed ISMMI programme will be the building of an international consortium-funding bid for a four-year Atlantic-wide science project, to fully develop the modelling and advice frameworks outlined above. This comprehensive bid for external funding (*circa* £3 - £5 million) could be targeted towards the new Horizon Europe Programme (or similar) with strong linkages to similar and complimentary funding opportunities in North America.

We envisage that by drawing together a wide range of collaborators in a cohesive and comprehensive bid for external funding, the 4-year proposal could include the four work packages below. Bid development could take advantage of the timing of the third in the series of NASCO / ICES workshops (WKSalmon3, provisionally planned for 2022) as a checkpoint to direct, review and evaluate the content of the proposal.

- **Model development:** Model integration within the LSF top-level conceptual framework, (portfolio of models), including enhancing biological realism of candidate modelling approaches. This would support ICES benchmarking and WGNAS annual advice to NASCO.
- **Accessing and mobilising the data:** Hypotheses-led mobilisation of the data components to provide an ecosystem-based vision for future salmon stock assessment and management. Such an approach would inform and enhance future modelling work.
- **Management guidance and advice:** Directing model and data developments to provide enhanced management guidance and advice in an accessible format via DSTs.
- **Communications:** Rolling out the implementation of the project outcomes, via deliverables targeting the needs of ICES/NSASCO, and communicating with the wider management community, at local, national and Atlantic Basin scales.

Board Request

The Likely Suspects Framework Workshop in November 2017 was the first scientific event held under the auspices of the International Year of the Salmon. With the endorsement of the Board/NASCO, the LSF was subsequently adopted as an IYS signature project. The subsequent, trans-basin working relationships that have developed between Atlantic salmon researchers and Pacific salmon scientists have formed the basis for a series of on-going scientific initiatives. The LSF project is currently engaged in workshops with Pacific salmon researchers, helping to develop case-use studies, with a view to implementing the LSF approach in the Pacific Basin, and with researchers in eastern Canada, through the multidisciplinary Canadian AJSRV, collaborative science project.

The current proposal reflects what is emerging from these discussions. The close parallels between the challenges in the two basins are now clear to those engaged in such co-operative programmes. What is also clear is the need to develop a suite of dynamic, ecosystem indicators, which align closely with the emerging concept of integrated ecosystem assessment. The aim of this proposal is to build on earlier co-operative successes such as SALSEA and to forge close links with those engaged in current projects such as SeaSalar, SMOLTRACK, the Greenland Tracking Programme, SAMARCH, SeaMonitor,

the Moray Firth and Scottish West Coast Tracking Programmes. Many of the principals in these projects are serving on the External Advisory Board of the LSF.

In our view the Board, working through NASCO, is ideally placed to co-ordinate such an internationally focused development. The Board is basin wide in its scope and is ideally placed to encourage Parties to embrace this new paradigm and to become full partners in the programme by aligning their marine salmon programmes under the umbrella of *the International Atlantic Salmon Modelling and Management Initiative.*

Very significant funding, both public and private sector, has been invested in the establishment of the Likely Suspects Framework research team and in the development of the Life Cycle Model to date (*circa* £500k to date). These human and intellectual resources will be fully available to ISMMI.

The chances of success of such a major bid *(circa £3-5m)* would be considerably enhanced by the support of key inter-governmental organisations such as NASCO. The Board's endorsement and matching financial support of £96k is therefore requested for one year to allow our consortium to a.) align existing salmon stock assessment and management models in preparation for the bid, improve engagement with salmon management at all levels and define existing key roadblocks and b.) appoint a suitably-experienced and qualified research proposal developer to build a trans-national research project funding bid (EU-Horizon or similar).

Fundamental to the work of NASCO and ICES are improvements in scientific advice to managers and the integration of advice on salmon populations across their marine phases, with ecosystem data emanating from other relevant ICES programmes. As outlined above, we believe that a future vision for international salmon conservation and management must move beyond the provision of catch advice based on single-species demographics. It must encompass a wider eco-evolutionary vision, which recognises the speed of change in both the ocean and in our climate and which can tackle the urgent and fast moving challenges facing salmon populations for the remainder of this century. We believe that the Board is best placed to ensure the co-ordination that is required to oversee the evolution of ISMMI and to deliver on the comprehensive, 5 year, strategic plan as outlined in this proposal.

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