Report of the Scientific Advisory Group of the International Atlantic Salmon Research Board on its Evaluation of the Proposed Atlantic Salmon Marine Growth Study Outline

At its 2024 intersessional meeting, NASCO's International Atlantic Salmon Research Board (the Board) tasked its Scientific Advisory Group (SAG) with drafting a project outline that describes the requirements of a basin-wide marine growth project based on adult salmon scales (ICRIS(24)10) and agreed terms of reference (ToRs) for this work as outlined in ICRIS(24)08. The SAG reported back to the Board at the Board's 2025 Annual Meeting and, following lengthy discussion by both the Board and SAG at that meeting, it was agreed that:

- a series of online meetings would be held as a scoping workshop, led by an identified scientist, with the following objectives:
  - to agree the standardisation of obtaining images from scale samples;
  - to consider the tools to extract data from the images; and
  - to further plan the project
- a smaller group would then develop a project proposal and comparison of the potential methods and consider how the SAG's ToRs could be further answered.

Two online meetings were held during the autumn 2024, and a smaller group developed an outline for a larger project that was delivered to the SAG in January 2025 (SAG (25)01). The SAG discussed the outline by correspondence and made a few edits to the project proposal (SAG(25)02).

The outline suggests that a larger project be developed that:

1. Collect standardized images of scales from at least one population from all (or most) of the 25 stock units used by WGNAS. Samples from mixed stock fisheries should be avoided.
2. Within each stock unit the time series should ideally cover the time period from 1980s until present.
3. Only scales from maiden 1SW and 2SW salmon should be included to ensure comparable scales across stock units.
4. At least 75 1SW scales and 75 2SW scales per year should be included from each stock unit.
5. Extract growth data from all images using the same automated tool(s) to reduce differences among stock units being caused by different interpretations among scale readers.

As part of preparing the outline data availability was explored, and possible candidate data sets were identified, but further work is needed to select a complete data set.

Agreements about data availability must be sorted before inclusion of data sets in the study to secure the FAIR data principles are adhered to, and to avoid conflicts over data ownership after the project is completed.

The staff and fiscal resources needed depend on how much of the data gathering are provided as in kind, and to what extent participants already have the required equipment to prepare scales and take images of the required quality. To prepare the necessary scales (150 scales per year from 20 years) for one stock unit is estimated to be 4-6 months of work.

The project is estimated to take at least three years.

The project should be led by one dedicated leader.

The project should have a steering committee that consists of relatively few competent scientists selected for their skills, not for their party affiliation.

The outcome of the project may inform forecast models that can assist salmon management in the future.

The SAG endorses the outlined project proposal as included in the 'Proposed Atlantic Salmon Marine Growth Study Outline as Endorsed by the Scientific Advisory Group', SAG(25)02 (Annex 1).

Annex 1

SAG(25)02

Proposed Atlantic Salmon Marine Growth Study Outline as Endorsed by the Scientific Advisory Group

Prepared by: Nora Hanson, Tim Sheehan, Cindy Breau and revised by the Scientific Advisory Group

At its 2024 intersessional meeting, NASCO's International Atlantic Salmon Research Board (the Board) tasked its Scientific Advisory Group (SAG) with drafting a project outline that describes the requirements of a basin-wide marine growth project based on adult salmon scales (ICRIS(24)10) and agreed Terms of Reference (ToRs) for this work as outlined in ICRIS(24)08. The SAG reported back to the Board at the Board's 2025 Annual Meeting and, following lengthy discussion by both the Board and SAG at that meeting, it was agreed that:

- a series of online meetings would be held as a scoping workshop, led by an identified scientist, with the following objectives:
  - to agree the standardisation of obtaining images from scale samples;
  - to consider the tools to extract data from the images; and
  - to further plan the project
- a smaller group would then develop a project proposal and comparison of the potential methods and consider how the SAG's ToRs could be further answered.

This document is the smaller group's report on that work for consideration by the SAG. The smaller group proposes that the aim of the project should be to use recently developed algorithms to automatically extract circulus spacing information from Atlantic salmon scale images representing stocks from across the species' North Atlantic range in a consistent, and expedient, way. These growth data will be used to assess trends in growth across stocks as well as the past and future relationships between growth, productivity, and environmental factors, given a changing climate.

A series of two short, informal, online meetings were organised in support of developing the project outline. A 'technical' meeting was organized to discuss the technical aspects of the proposed project (e.g. sampling design, sample size determination, scale image requirements, statistical considerations). A 'data' meeting was organised to gauge interest across the jurisdictions in regards to participation in such a study, to develop a preliminary inventory of what scale image datasets may be contributed and to provide a preliminary assessment of what resource may be required by some jurisdictions to assemble the scale image datasets. A total of 26 people from 12 jurisdictions (Canada, EU (Finland, France, Ireland and Sweden), Iceland, Norway, UK (England and Wales, Northern Ireland, Scotland), and the United States) attended these meetings.

Below, the ToRs outlined in ICRIS(24)08 are addressed in detail. The proposed spatial organization for such a project is contained in Appendix 1 and a preliminary project proposal is provided in Appendix 2. Please note that the preliminary project proposal offers a broad outline of what the project could look like and how it could be conducted. The availability of scale image datasets and any estimates of resource requirements by jurisdictions are based on incomplete information. If the project were to be adopted and implemented, the preliminary project proposal would need to be finalized and a more formal survey of participation, dataset availability and resources requirements would need to be developed.

(a) an outline of the hypothesis(es) that could be tested given available data;

A robust time series of standardized growth measurements across the North Atlantic range of Atlantic salmon would be a powerful resource for addressing a large number of research hypotheses. The final list of hypotheses to be addressed will be developed in concert with the project lead (see ToR f), but candidate hypotheses such as the following will be considered:

- Global growth signatures are less synchronous than regional growth signatures;
- Growth has a positive influence on global, regional and local (Stock Unit) postsmolt survival;
- Growth has a positive influence on global, regional and local (Stock Unit) probability of maturation at any sea age;
- Global and regional growth signatures are correlated with, and driven by, global and or regional environmental conditions (e.g. SST, primary productivity, secondary productivity);
- Critical periods during the marine migration, which may affect survival both globally and regionally, can be identified;
- Forecasts of future global and regional growth trajectories during the marine phase can be used as proxies for productivity estimates given projected future climate change.

Once the data is made publicly available (see ToR d), it is expected that the generated growth data will be available and used in a number of additional studies conducted outside of this project proposal. These studies will likely address hypotheses that have not been referenced here and are outside of the scope of the final products for this project. For example, scale growth datasets that come from monitored rivers may have additional data sources associated with the population (e.g. estimates of return rate), which may support river-specific analysis of growth that can be compared and contrasted with results from regional or global focused analysis.

(b) identification of representative scale samples from across the North Atlantic that could be included within such a study (e.g. country of origin, river of origin, sample size, years, points of contact) to provide region-specific growth patterns;

Efforts were made to outline scale dataset requirements for a North Atlantic wide investigation of Atlantic salmon growth. Topics such as spatiotemporal focus, sample size, and appropriate sample stratification schemes were investigated. A preliminary survey was conducted to gauge interest for participation among NASCO jurisdictions, to identify points of contact and to begin to inventory preliminary datasets that may be available for such a project. These topics are addressed below in the context of providing guidance for identifying representative scales samples from across the North Atlantic in support of the envisioned study.

Spatial focus: The ultimate aim of this work will be to explore drivers of, and synchrony in, salmon growth at sea among regions and how that relates to survival, productivity and abundance. Historic scale archives are in some cases linked to return rate information through dedicated trapping and monitoring facilities; however many archives are derived from commercial or recreational catch sampling without direct links to survival estimates. It is proposed that outputs from the ICES WGNAS on probability of postsmolt survival and probability of maturation at any sea-age (ICES, 2024) will help overcome this shortcoming. The lowest resolution of that data is the Stock Unit level (n = 25; see Appendix 1). As such, it is recommended that the ICES WGNAS Stock Unit be the spatial resolution that the sample datasets be organised at.

Each Stock Unit consists of one or more populations (i.e. rivers) of salmon. Scale datasets could consist of representative samples from a single population within a Stock Unit or from multiple populations within a Stock Unit.

If sufficient data are available from single populations, where for example long-term monitoring programmes also collect information on population-level return rates, these populations may be prioritised for inclusion (assuming they are considered representative of the Stock Unit). However, it may also be possible to take a smaller number of samples from multiple populations to achieve the desired number of samples (see below). What is important is that the number of samples per Stock Unit is sufficiently high and that they, in total, represent a representative sample of the fish of that Stock Unit.

To ensure that future analysis can detect patterns of synchrony in growth it will be important to ensure that scales are not derived from mixed stock samples and that all samples can be attributed to a specific Stock Unit. This Stock Unit sampling design builds upon previous scale growth related publications that have largely been conducted at the population (i.e. river) level by focusing on a broader spatial extent. This will allow for the inclusion of valuable scale growth information from populations that may have been monitored less intensely and consistently over time. However, growth extraction from river-specific datasets, when available, can also be pursued and may help assess lower spatial level patterns in subsequent analysis. This will be especially important when river-specific data (i.e. return rates) are available and can be incorporated into future analyses.

Temporal focus: To relate changes in salmon growth to marine conditions, time series are required (rather than single years or short intervals), which will ideally cover years encompassing particularly 'good' and 'poor' growth outcomes as well as variable ocean conditions. Recent studies indicate that the 1990s and 2000s (e.g. Tillotson et al, 2021, Todd et al, 2021; Vollset et al, 2022; Trehin et al 2023) are particularly important periods within the North Atlantic. Further, data on probability of postsmolt survival and probability of maturation are available from 1970 to the present (ICES, 2024). Given this, scale sample times series should begin no earlier than 1970 and should cover 20-30 years. For contributed dataset sets consisting of multiple populations, the datasets do not need to be strictly overlapping. In all cases, the preference is for a continuous time series of consecutive years, but this is not an absolute requirement. Covering recent years would allow to better understand the current situation and might be particularly valuable to support the development of up-to-date management actions.

Sample size: Previous research indicates that year-to-year variation in marine growth can be high, and that differences in growth metrics are apparent among regions (e.g. Vollset et al, 2022; Trehin et al 2023). The sampling strategy for a cross-basin study should be most concerned with representation of average values at the Stock Unit level, across multiple populations and years. Whilst at least one population per Stock Unit should be sought, multiple populations per Stock Unit would be advantageous to obtaining a sample more representative of the Stock Unit. The number of samples per year and per population need not be very large to obtain this averaging effect, especially when most variation is likely to be across, rather than within years and populations. Aiming for sample sizes of at least 75 per strata (see below) is recommended. If multiple populations are combined to represent a sample dataset for a single Stock Unit, each population should contribute a minimum of 10 scale samples per strata (see below).

Strata: Within populations and years, two strata should also be considered: sea age and return date. The available data across the North Atlantic range of Atlantic salmon will be variable and nuanced (e.g. fishery sampling versus trapping facilities). It is therefore not possible to *a priori* prescribe a sampling strategy that can account for all the differences among archives.

However, a few general approaches can be suggested that could be adapted to work with the available candidate datasets. Insofar as is possible given the available data, sampling should aim to be representative of the salmon run for the selected population(s). This will provide scale samples that are representative of both early and late adult returns with the majority of samples coming from the middle of the run. It is recommended to select scale samples from one sea-winter (1SW) and two sea-winter (2SW) adult returns only. While in some Stock Units, older spawners significantly contribute to population productivity, focusing on 1SW and 2SW returns provides a more common baseline for all populations and comparisons and will help to minimize challenges with interpreting growth at the edge of a scale for older spawners as well as issues with eroded scale edges for repeat spawners.

Finally, in some areas wild populations of salmon are less available to be sampled than others. Priority should be given to wild populations within a Stock Unit where available but if hatchery fish are the only stock available, these may be included as long as this information is clearly identified within the accompanying metadata.

(c) identification of the methods to be used for data collection, including the methods for obtaining the scale samples in the required state (e.g. whole scales, scale impressions, scale images) and for extracting the growth data (e.g. standardised and co-ordinated scale processing, automated scale processing);

Fully automated (e.g. Hanson et al, 2024) and semi-automated (e.g. Chaput & Chaput, 2024) tools have been developed to extract circulus spacing data from high resolution images of salmon scales (3840 x 2748 px and 2560 x 1920 px, respectively). Automated methods have the advantage of providing high throughput and unbiased and consistent information retrieval ideally suited to application across multiple, large datasets. The systems have been designed to retrieve information from more than a single transect – not necessarily replicating exactly what a single expert reader might infer by looking at a whole scale, but incorporating 'naïve' spacing data from across the scale. Obtaining circulus spacing data from multiple transects for individual scales may provide opportunities and benefits during data analysis. The processing speed associated with automated measuring will result in significantly more individuals, and/or more scales per individual, being processed in a standardized manner given a set amount of staff resources. For example, automated circuli detection can be achieved for 100 scales within minutes while a single transect from a single scale may take a human 10-15 minutes to process.

Automated image analyses are reliant on good quality scales and images. Based on recent experience applying one automated approach (Hanson et al, 2024), it is important that scales are selected with complete centres (i.e. not regenerated scales) and without obvious damage, mucus or other visible contamination. As such, scales selected for processing may require cleaning before imaging. The available tools have been developed using relatively high resolution images (see above). Very low resolution images are not suitable for retrieval of all circuli spacings as freshwater growth is particularly obscured at low resolution. As a general guide, a human would need to be confident of identifying individual circuli on an image for it to be suitable for use within an automated or semi-automated system. If jurisdictions have images already or equipment in hand to begin imaging, it would be worthwhile checking that the image resolution is appropriate for use with automated tools.

Salmon scales often are impressed into acetate strips using a jewelry press prior to ageing; however, some institutions age samples using whole scales. There are potential advantages and disadvantages to both techniques. Preliminary data derived using the fully automated tool (Hanson et al, 2024) suggests that circulus spacing data obtained from impressed scales more closely matched that of the hand-measured spacing data than did spacing data obtained from whole scales. On that basis, using impressions is recommended if possible. However, a more formal evaluation of the potential effect of scale preparation technique is underway with results expected in 2025. The details regarding scale preparation method in support of this project should be revisited at a future date.

It is worth noting that these recommendations are intended to prescribe a potential starting point for a North Atlantic-wide study, which could be built upon in the future. For example, given a standard framework for the collection and processing of images, it would be relatively straightforward to increase sample sizes for identified scale datasets, increase the temporal coverage by adding additional years, investigate the growth of additional age groups, or to investigate inter-scale variation by processing multiple scales from each individual.

(d) identification of the options for making data available publicly (e.g. FAIR data standards);

Various options exist with which to disseminate the data and information collected during this project, which may have different adherence to [FAIR (Findable, Accessible, Interoperable, Reuseable)] data principles.

1. There may be provisions within jurisdictional institutions for publishing their dataset of circulus spacings and associated metadata
    a. This option would be less desirable than publication of the full North Atlantic scale dataset within a single repository;
2. Many scientific journals require data used in the analysis to be made available via their own, or another public repository
    a. However, the dataset used for an individual manuscript may be a subset of the complete dataset;
3. The full dataset of circulus spacings and associated metadata could be made available via an open, globally-scoped data repository which may provide rapid upload, citable products, restricted access, versioning and github statistics.

Prior to initiating a project such as this, the project lead(s) should discuss options with the data providers as appropriate to decide upon a data archiving option that is agreeable to all and that maximises the future utility of the data collection effort.

(e) an estimate of the staff and fiscal resources needed by collaborating jurisdictions (including in-kind contributions) to gather the data (e.g. staff time to secure required samples and metadata, jurisdictional work team or hired contractor(s), other collaborators such as oceanographers and / or climate scientists);

In year one of the project, jurisdictions would have to gather samples and metadata, and to digitize the selected scales. Potential scale datasets would need to be identified from these datasets and individual scales would be selected. The individual scale samples would need to be retrieved and possibly either mounted or impressed (see ToR b) prior to imaging. Assuming not already digitized at an appropriate resolution, the scale samples would then need to be imaged, organized and all metadata would need to be compiled. Depending on the number of scale samples imaged, a significant amount of storage may be required given the file sizes associated with high resolution images. Lastly, project collaborators may need to transfer all image files for growth extraction, or undertake growth extraction themselves (see below). These efforts will take dedicated staff and access to specialized equipment (e.g. jewelry press, microscope, digital camera) that collaborators may or may not have access to.

An informal survey was sent to potential collaborators asking about potential datasets that could be compiled and provided to such a project and about the resources needed to undertake the work. Results from the survey should be considered preliminary as all potential collaborators may not have been included and of those included not all responded. Half of the eight respondents indicated that they would be self-sufficient and could provide the staff time and equipment required as in-kind. Of the remaining four respondents, three have the equipment to do the work but would require staff time whereas one respondent would require both equipment and staff time. These preliminary results may be reflective of the overall resource requirements of collaborating jurisdictions to get scales digitized. However, a more formal survey will need to be pursued to assess the resources that may be required to conduct such an effort.

Results from the preliminary survey suggest that staff time would be the largest resource requirement to complete data collection. It may take a dedicated staff approximately 4-6 months to compile the scale images for a single scale dataset representing a single Stock Unit, depending on the state of the archive. Preliminary estimates suggest that imaging a time series of scales representing a 20 year time period, with 75 scales per two age groups would take approximately 3 months. Before imaging however, time and energy would need to be spent investigating potential scale datasets for inclusion, selecting individual scale samples, retrieving individual scale samples from archives that may be stored on or off site and possibly engaging in a small amount of sample prep before imaging may be able to take place. This additional time could amount to upwards of 2 months.

Care should be taken when interpreting these estimates as the actual time required, as time will be dependent on many factors such as the state and level of organisation of the scale archives and associated data, if the scale needs to be processed (e.g. cleaned, mounted, impressed) prior to digitizing, as well as the work pace of the individual. The work would involve finding scale archives and associated metadata, selection of scales representing in-river migration timing, and potentially cleaning, pressing or mounting scales, and digitising them. Additional staff time would be required if jurisdictions have additional populations to contribute to the project. An estimated cost for this staff time is not provided given the variability in average salaries for staffers across the jurisdictions.

As noted above, access to specialized equipment will be required to collate the required scale images for this project, which individual jurisdictions may or may not have access to. An informal survey was conducted to identify a range of equipment options and associate prices. A number of microscope, camera and software companies were contacted and various makes and models of each required equipment were priced out to give a range of costs associated with purchasing all the required equipment. All equipment options that were cost out will meet the minimum requirements for this study (e.g. all cameras provide sufficient image resolution). Based on the information gathered, costs between £4,110 and £30,950 might be expected to purchase all of the equipment necessary to obtain the required scale images, outside of staff costs. Note that if scale impressions are required, or desired, then the necessary equipment (i.e. jewelry press and acetate slide) could be purchased for less than £400.

	min	**max**
Microscope	£3,160	£23,700
Camera	£790	£6,300
camera attachment (if needed)	£160	£160
software	free	£790
TOTALS	**£4,110**	**£30,950**

Optimally, all aspects of the data collection phase of this project would be provided as in-kind contributions by each participating party/jurisdiction/institution. There could be the possibility that identified scale samples could be collated by one jurisdiction/institution, but imaged by a cooperating jurisdiction/institution. If this project were to be initiated, the details and resource requirements associated with the data collection phase of the project will need to be finalised.

If this project were to be undertaken, there is clear scope for collaborations with oceanographers, climate scientists and or professionals from a wide variety of other disciplines (e.g. salmon biologists, statisticians, modellers). It is recommended that no additional resources be allocated for these types of collaborations. Rather, the leader of this project should be encouraged to organically build collaborations with individuals who possess the desired skill sets and to include that as appropriate in the project and acknowledge their contributions via authorship in subsequent peer reviewed published manuscripts.

(f) identification of options to facilitate the analysis and outputs, including staff resources (e.g. work team, hired contractor(s));

A basin-wide marine growth project, as outlined below, would require at least three years to complete with adequate resources. In year one, scale images would be processed to collect growth data and statistical analysis of the dataset would begin. Ideally, a dedicated person would be responsible to process images through an automated tool however, jurisdictions could decide to lead the work in their own institutions. In years two and three, a dedicated person would conduct in-depth data analyses to test pre-determined hypotheses and write at least one scientific article per year. It would be most effective if a single dedicated person were hired and led both tasks in all three years.

A fixed term appointment (e.g. contractor) could be hired to lead the project (herein project lead). It is unclear what the most advantageous option for hiring the project lead would be. It may be possible for NASCO to hire the person and they would operate under the NASCO rules (i.e. salary, benefits, overhead) or it may make sense for the person to be hired by a third party contracting or consulting firm which specialises in environmental services. There is also the possibility to hire a project lead through a participating institution. Given the variation in professional compensation across the North Atlantic, discussions would need to be undertaken to decide upon numerous details of the position such as if the position would be assigned to a single office location within one of the participating jurisdictions or if the position would be wholly remote and to settle upon a salary that would be commensurate with the project.

Ideally the project lead would have a relatively advanced skillset covering project management, international collaboration, programming and statistical modelling. The Steering Committee (see below) could help to develop a comprehensive statement of work, including a qualification list, prior to advertising for potential applicants. Although lacking a final estimate, the funding needed to support a project lead on an annual basis may range from £80,000 - £160,000 (inclusive of overhead/full economic costing).

Funding to support this position may be obtained by a number of different options such as:

1. Parties to the Board could make voluntary contributions to the International Atlantic Salmon Research Fund;
2. Parties to the Board could also seek out voluntary contribution to the International Atlantic Salmon Research Fund from other entities; or
3. Parties to the Board could collaboratively develop research funding proposals for submission to granting agencies.

Discussions on preferred options for funding this proposed research will need to be undertaken by the Board before a formal plan can be adopted.

In terms of project oversight, it is recommended that the project lead be overseen and guided by a project Steering Committee composed of a modest number of scientists with relevant expertise to ensure the project direction. Members of this Steering Committee do not have to be SAG or Board members, but instead could be scientists appointed by members of the Board. The number of Steering Committee members should be relatively small to keep it productive (e.g. ca 7) and should be organised around scientific relevance rather than by NASCO Party affiliation. The project lead would be responsible for organising and running regularly scheduled meetings with the Steering Committee to ensure adequate progression. The project lead would also be responsible for organising and running a minimum of two additional meetings with the larger group of jurisdictional collaborators to ensure that regional expertise is fully integrated into the project. Project updates could be provided by the project lead to the Board during their annual meetings. The project lead would be encouraged to engage in more frequent and less formal communications with all collaborators as appropriate.

It is unclear what level of support the NASCO Secretariat would need to provide to support an endeavour such as this. However, Secretarial support could be minimal aside from normal budget monitoring and management and possibly assistance with hiring a project lead (depending on what hiring option is pursued). The majority of effort to support the implementation of this project will be the responsibility of the project lead and the Steering Committee.

(g) an estimate of the fiscal resources needed to successfully complete the analysis and manuscript(s) (including a breakdown of the costs for the various products);

To ensure optimal progress on the project, a project lead would be hired for a period of three years. In year one, the lead would oversee data collection, build code for scale feature detection, begin data analysis, etc. In years two and three, the project lead would perform in-depth data analysis to test pre-determined hypotheses and write manuscripts.

A second, less optimal option, would be for the Steering Committee to oversee data collection and other tasks in year one with the project lead hired in year two and three. A foreseeable issue with this option is the high amount of time individuals on the Steering Committee would have to invest, which may not be feasible for many.

The fiscal costs needed to successfully complete the analysis and manuscript(s) are outlined above (see ToR f). No additional resource needs are expected beyond those already covered. A detailed breakdown of costs associated with each product is not provided as the recommendation is that the data collections aspect of this project be covered by in-kind support from the jurisdictions and that a single project lead be hired to oversee the growth extraction, analysis, manuscript preparation, etc.

(h) a proposed outline timetable of high-level deliverables;

This preliminary project proposal could be accomplished within 3 years:

- Year 1
    - Assembly of representative scale images from participating jurisdictions, scale image transfer and growth data extraction
- Year 2
    - Data analysis and manuscript (1) preparation and submission
- Year 3
    - Data analysis and manuscript (2) preparation and submission

At the completion of this project, a number of high level deliverables will be produced:

- Final dataset of all circulus spacing data for provided scale images archived and available for public use (see ToR d, Year 1);
- Manuscript in peer-review journal addressing a number of hypotheses noted above in ToR (a) such as describing global and regional growth signatures across the North Atlantic, the relationship between growth, postsmolt survival and maturity globally and across regions, as well as the relationship between growth and global and regional environmental conditions (Year 2);
- Manuscript in peer-review journal addressing a number of hypotheses noted above in ToR (a) such as identifying critical spatial and temporal periods that affect growth and survival

and forecasts of global and regional growth trajectories and if these growth trajectories can be used as proxies for productivity (Year 3); and

- Oral and or poster presentation(s) outlining the project and conclusions at numerous international scientific conferences and other public forum (Years 1-3)

The proposed project represents a large and ambitious project involving many different collaborators from across the North Atlantic. If successfully undertaken, the resulting final dataset will be large and contain a tremendous amount of data,which can be used to answer a number of additional scientific questions. It is possible that the project lead hired for this project will be able to produce other deliverables for this project such as additional scientific papers exploring the relationship between growth and Atlantic salmon productivity across the North Atlantic as well developing messaging of this project, including results and conclusions, for public consumption.

As noted, this project can be concluded within 3 years. However, this estimate is dependent on when the project is initiated, the efficacy of participating jurisdictions compiling scale image datasets and the efficacy of hiring a project lead as well as the length of time the analyst is hired for (i.e. 2 versus 3 years).

(i) identification of the potential management implications that may result from the outlined project.

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

The expected information gained by research on this topic does not necessarily have clear direct management implications. However, anticipated outcomes could be used to develop management options by identifying the main drivers of marine mortality, how these drivers have changed over time and what are the expected changes into the future. For example, if information gained through this research indicates that salmon are negatively impacted by a reduced amount of food sources, a direct management option could be to modify regulation for those fisheries reducing the availability of salmon prey in critical periods or areas.

Information gained could also be used to help forecast North Atlantic salmon abundance in a context of changing environment. Better forecasting of salmon productivity and abundance under a changing climate will facilitate setting realistic expectations of future productivity and abundance, which can inform and guide the development of appropriate management measures (e.g. management of fisheries, conservation limit setting). Forecasting future productivity will provide managers with the information needed to manage Atlantic salmon for resiliency given the challenges faced with expected climate change. Better understanding the links between salmon growth and survival/productivity may also provide cost effective options for monitoring Atlantic salmon populations across their range, which can be used to supplement the traditional river monitoring programs currently maintained.

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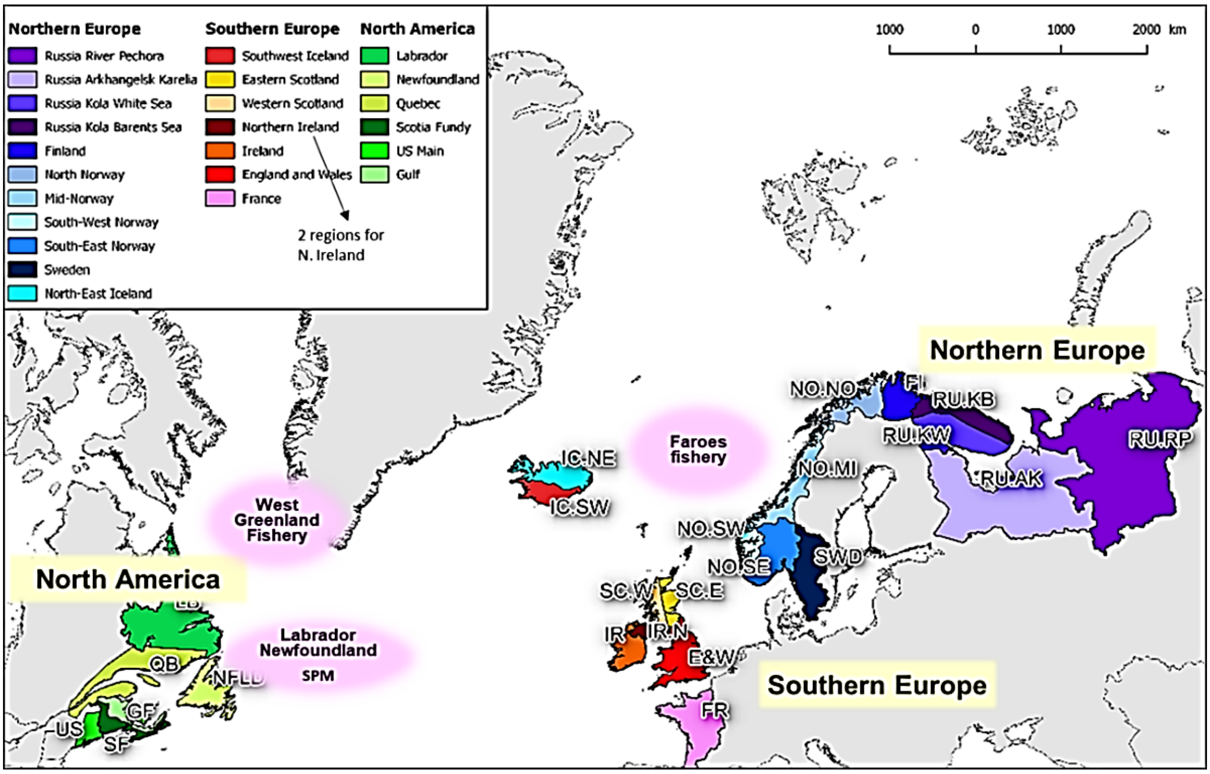
Appendix 1: Stock units

Details of Stock complexes, Countries and Stock units (SU) used within the ICES WGNAS Life Cycle Model (ICES, 2024) and proposed for the spatial organization and coverage for this project.

Stock complex	Country	Stock unit
North America (NAC)	Canada	Labrador
North America (NAC)	Canada	Newfoundland
North America (NAC)	Canada	Quebec
North America (NAC)	Canada	Gulf of St Lawrence
North America (NAC)	Canada	Scotia-Fundy
North America (NAC)	USA	USA
Northern Northeast Atlantic (N NEAC)	Finland & Norway	River Tana/Teno
Northern Northeast Atlantic (N NEAC)	Iceland	Northeast
Northern Northeast Atlantic (N NEAC)	Norway	Southeast
Northern Northeast Atlantic (N NEAC)	Norway	Southwest
Northern Northeast Atlantic (N NEAC)	Norway	Mid
Northern Northeast Atlantic (N NEAC)	Norway	North
Northern Northeast Atlantic (N NEAC)	Russia	Archangelsk
Northern Northeast Atlantic (N NEAC)	Russia	Kola / White Sea
Northern Northeast Atlantic (N NEAC)	Russia	Kola / Barents Sea
Northern Northeast Atlantic (N NEAC)	Russia	Pechora River
Northern Northeast Atlantic (N NEAC)	Sweden	Sweden
Southern Northeast Atlantic (S NEAC)	France	France
Southern Northeast Atlantic (S NEAC)	Ireland	Ireland
Southern Northeast Atlantic (S NEAC)	Iceland	Southwest
Southern Northeast Atlantic (S NEAC)	U.K. (England & Wales)	U.K. (England & Wales)
Southern Northeast Atlantic (S NEAC)	U.K. (Northern Ireland)	River Foyle (Loughs Agency)
Southern Northeast Atlantic (S NEAC)	U.K. (Northern Ireland)	DAERA areas
Southern Northeast Atlantic (S NEAC)	U.K. (Scotland)	East
Southern Northeast Atlantic (S NEAC)	U.K. (Scotland)	West


Northern Europe
Russia River Pechora
Russia Arkhangelsk Karelia
Russia Kola White Sea
Russia Kola Barents Sea
Finland
North Norway
Mid-Norway
South-West Norway
South-East Norway
Sweden
North-East Iceland
Southern Europe
Southwest Iceland
Eastern Scotland
Western Scotland
Northern Ireland
Ireland
England and Wales
France
2 regions for
N. Ireland
North America
Labrador
Newfoundland
Quebec
Scotia Fundy
US Main
Gulf
1000 0 1000 2000 km
Northern Europe
NO.NO
FI
RU.KB
RU.KW
RU.RP
NO.MI
RU.AK
Faroes
fishery
IC.NE
IC.SW
West
Greenland
Fishery
NO.SW
NO.SE
SWD
North America
SC.W
SC.E
IR
IR.N
E&W
Labrador
Newfoundland
SPM
QB
NFLD
GF
US
SF
FR
Southern Europe

Appendix 2: Preliminary project proposal

Project title: North Atlantic wide investigation of Atlantic salmon scale growth

Project Summary: The proposed project will use automated tools to extract growth measurement data from a large number of archived Atlantic salmon scales from across the species' North Atlantic range. The use of an automated tool will allow for the extraction of growth data from a large number of individuals organized at the ICES WGNAS Stock Unit level in a standardised manner, which has not been feasible prior. Participating jurisdictions will provide scale image datasets and a project lead will be hired to oversee all aspects of the project including growth data extraction, data analysis and summation. These data will be used to support the development of peer reviewed manuscripts, public relations material and oral or poster presentations describing global and regional growth signatures across the North Atlantic, the relationship between growth, postsmolt survival, maturity and environmental conditions in the past and into the future given climate change. Resulting products are expected to aid in the development of better forecast models of salmon productivity and abundance across the species range and to provide information needed to facilitate the management of Atlantic salmon for resiliency given the challenges faced with expected climate change.

Principle Goal: The principle goal of this project is to investigate patterns of Atlantic salmon marine growth across the North Atlantic. This will be achieved by collecting growth data across the North Atlantic range over multiple years.

The following recommendations are intended to guide scale sampling:

- Growth indices will be derived as an average over the Stock Unit (n = 25 as defined by ICES WGNAS [ICES 2024]);
- At least one scale dataset consisting of 75 samples per age group (1SW and 2SW adult returns only) per year (min year = 1970 and max year equal present, ideally covering 1990s and 2000s and spanning at least 20-30 years) for each Stock Unit;
- Scale datasets could consist of one of the following:
    - a representative time series from a single population, or
    - a representative time series sampled from multiple populations with each population contributing at least 10 scales per age group and year;
- Samples from mixed stock fisheries should be excluded;
- Priority should be given to sampling wild fish over hatchery fish.

The following recommendations are intended to guide growth increment data extraction and dissemination:

- Use a fully automated tool to extract growth increment (circuli spacing) data from scale images in a consistent way;
- Image at least one scale per fish, taken from the standard region (Shearer, 1992). Scales should be clean, have intact centres and no visible erosion. Ideally the image is of a single scale (at least a single focus), and the scales are oriented in a consistent manner (e.g. with the longest axis vertical). Embedding essential metadata (location, date, age, size) within the image properties is recommended, if possible, to avoid the risk of information loss.

- Assuming no evidence is provided to the contrary, either whole or impressed scales may be imaged, with a preference for impressions. The most important consideration is that clear, high quality, images are obtained to maximise information retrieval.
- The project lead should work with project partners to determine the most appropriate venue for making data publicly available in as FAIR (Findable, Accessible, Interoperable, Reuseable) a manner as possible within an appropriate timescale (i.e. before the end of project lead contract).

Milestones and timetable

Year 1

- Jurisdictions
  - compile scale image dataset(s)
- Project lead
  - growth data extraction using automated tool
  - scope growth data analysis methods and develop code base for processing and analyzing extracted scale growth measurement data
  - organize and run project oversight, jurisdiction and Board meetings
- Project Steering Committee

○ selection of members and participation in regular oversight meetings

Year 2

- Project lead
  - data analysis and summation
  - writing of manuscript(s) and communications (e.g. conference and public presentations)
  - on-going project management including organizing and running various project meetings
- Project Steering Committee
  - participation in regular oversight meetings

Year 3

- Project lead
  - data analysis and summation
  - writing of manuscript(s) and communications (e.g. conference and public presentations)
  - on-going project management including organizing and running various project meetings
- Project Steering Committee
  - participation in regular oversight meetings

Cost Summary:

Further discussions by the Board are needed as a number of different decisions need to be made before a cost summary can be estimated, such as:

Will compiling the scale image datasets be in-kind contributions by all of the participating parties/ jurisdictions, some of them or none of them?

How many parties/jurisdictions will need resources to support staff costs?

How many parties/jurisdictions will need resources to purchase scale imaging equipment?

Will parties/jurisdictions be able to collaborate and share resources?

If additional resources are needed, what are the cost estimates per participating jurisdiction?

Will the Board provide the needed resources to all, some or none of the jurisdiction's needing them?

Will the project lead be hired for 2 years or 3 years, recognizing that hiring a project lead for 2 years will place a significant burden on the Steering Committee to oversee the first year of the project?

Will the project lead be hired by NASCO or some 3rd party entity?

Where will the project lead be required to work (e.g. NASCO headquarters, a participating institution or fully remote)?

What is an appropriate compensation for the project lead, especially depending where they are located?

Will the project lead be expected to travel to any participating jurisdiction institutions, NASCO headquarters, and or Board annual meetings?

Although not directly related to costs of the project, an additional question that needs to be decided upon is related to the source of funding to support this project. Specifically:

1. How will funding be secured to support this project - suggested options are:
   a. Parties to the Board could make voluntary contributions to the International Atlantic Salmon Research Fund;
   b. Parties to the Board could also seek out voluntary contribution to the International Atlantic Salmon Research Fund from other entities; or
   c. Parties to the Board could collaboratively develop research funding proposals for submission to granting agencies.

We recommended that the Board considers using the April intersessional meeting as an opportunity to discuss and understand what is being proposed and to have initial discussions on the questions noted above. Hopefully discussions during the intersessional meeting will allow Parties to be in a position to make decisions on these questions during their June 2025 annual meeting.