SAG(09)5

Draft Report of the SAG Research Inventory Review Group

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1. Introduction

1.1 Terms of Reference

The International Atlantic Salmon Research Board's (IASRB) inventory of research relating to salmon mortality in the sea was established in 2002 and has been updated annually since then. It is an essential tool in the development of research priorities for potential funding and in better coordinating existing research efforts.

At its annual meeting in 2008, the Scientific Advisory Group (SAG) of the IASRB welcomed the valuable information presented in the inventory but agreed that consideration should be given to how this information could be better utilised. The IASRB therefore agreed to a proposal from the SAG to establish a Sub-Group comprising at least one representative from each Party, chaired by Ted Potter (EU) and with the following terms of reference:

- to review the inventory to identify areas where there may be merit in encouraging improved coordination of research and
- to highlight gaps in the research programme where new work might significantly benefit the SALSEA Programme and which might be considered for funding by the Board.

The Sub-Group was to work by correspondence and report back to the SAG in 2009.

1.2 Summary of Research Inventory – SAG(09)02

The inventory of research is maintained by the NASCO secretariat. This involves seeking updates from NASCO Parties at the beginning of each year to include new projects that have been funded or approved, to record changes to existing projects and provide progress reports, and to note projects that have been completed. The NASCO secretariat also provide an annual summary of the projects in the form of four tables:

Table 1: Approximate annual expenditure on research in relation to salmon mortality at sea by topic area and Party;

Table 2: Inventory of research relating to salmon mortality in the sea – allocation of projects by topic area;

Table 3: Expenditure on ongoing projects in the inventory of research of relevance to the SALSEA programme; (NB This table contains no financial data and so the heading could be clarified by omitting 'Expenditure on').

Table 4: Summary of ongoing and completed research projects relating to salmon mortality in the sea. (a.) Ongoing projects (b) Completed projects

This report draws heavily on these very helpful tables as a basis for highlighting gaps and opportunities for collaboration and co-ordination.

1.3 Method of working

It was greed that the Sub-Group would conduct their review on the 2009 update to the research inventory, which was made available to the Sub-Group towards the end of April. As the objectives of the review relate specifically to the SALSEA programme, the Sub-Group used the structure of the SALSEA Plan (SAL(04)05) to organise the review. Each member of the Sub-Group was asked to consider the work being undertaken in relation to a particular Workpackage Task in the Plan and assesses the extent to which the current research projects listed in the inventory appear to address the identified research needs (or new research requirements). In parallel with this, the work being undertaken under each Task was reviewed to identify areas where there may be opportunities to further improve collaboration and co-ordination. The conclusions from these reviews are reported below for each of the Workpackage Tasks in the Plan with information relating to both terms of reference being combined; the final section summarises the recommendations.

Comments:

a. The projects in the IASRB Research Inventory appear to be renumbered each year, with completed projects having no numbers. In addition, less information is provided for the completed projects. This made it more difficult to take account of completed projects in the review. It is suggested that in future a continuous numbering system should be used with the same information on the completed projects included as for the ongoing projects.
b. By electing to work on the updated inventory, the review group gave itself very little time to complete its work. If a decision is made to repeat this review process, possibly as an alternative to requesting this advice from ICES, the group would be advised to work initially on the review from the previous year and update this to take account of any new projects when the inventory is updated.

2. Work Package 1: Supporting Technologies

2.1 Workpackage 1 - Task 1: *Genetic tagging to determine stock origin* – (TP)

2.1.1 Task Objectives:

The overall objective of this task is to map regional genetic structure of Atlantic salmon and establish a standardised genetic baseline database for regional or river-specific populations.

The specific objectives are:

i. Review existing knowledge of genetic structure within the distribution area of Atlantic salmon, and establish an overall picture of population structure;

ii. Compile an inventory of available samples, both recent and historical, that could be used in a larger-scale mapping of genetic structure;
iii. Establish a cooperative programme between the principal genetic laboratories in Europe and North America to screen the major salmon stocks. This will be accomplished by selecting a suitable array of genetic markers, based upon the level of variation observed in previous studies and calibrating the scoring between participating laboratories;
iv. Based on the results from the above studies select an experimental set of populations to be sampled;
v. Review the results and determine whether sufficient precision is achieved for the purposes outlined in the core SALSEA tasks. Expand and include more areas and populations in the baseline as required;
vi. Establish a standardised database of genetic structure of baseline populations;
vii. Carry out comparative studies using conventional tags of known origin to provide support for genetic identification;
viii. Establish a "Biobank" of samples collected, and also of DNA extracts that can be made available for other purposes at later stages.

2.1.2 Assessment:

There are nine current projects (D1, E2, E11, E16, E19, E20, I4, N3, F1) and four completed projects in the inventory involving the use of genetics techniques, although not all are directly related to genetic stock identification (GSI) which is the central theme of this Task. The main areas being addressed are the development of genetic baselines of Atlantic salmon stock, the application of genetic stock identification in management and the use of genetic techniques in population studies. We are also aware of additional programmes to develop and apply genetic baselines (e.g. in USA), and to coordinate these studies (e.g. the SALMAN programme), which do not appear to be included in the inventory.

Genetic stock identification (GSI) is an integral part of the SALSEA Programme because it was selected in preference to tagging as the primary method to be used to identify the region of origin of fish sampled in marine surveys. In addition, increasing numbers of countries are developing more detailed genetic baselines for their stocks to aid in stock conservation and fishery management activities. To support this work extensive efforts have therefore been made in recent years to establish a network of groups working on salmon genetics, to agree upon sampling and analytical protocols, and to select a standard set of micro-satellite markers.

Baseline genetic datasets that have already been established for a number of countries including USA, Ireland and Canada, and this work is being extended as part of the SALSEA-MERGE project (E1) and in national programmes in Iceland (I4), UK(England and Wales) (E2) and Norway (N3). GSI is also being used to identify the continent of origin of salmon caught at West Greenland (D1), and thereby in the development of catch advice by ICES, and for samples collected in St Piere et Miquelon (F1).

Other genetic studies are being undertaken on the heritable effects of fishing (E11), the exchange of stocks between rivers (E16), the susceptibility of stocks to G.salaris (E19),

and to identify genomic regions that affect ecologically and economically important phenotypic traits (E20).

***Conclusion**:*
There is extensive work being undertaken in relation to this task and the objectives of this task appear to be well covered. It appears that there are good mechanisms in place (including through SALSEA-MERGE) to co-ordinate these studies, including ensuring all groups use the same satellite markers and comparable sampling and analytical techniques

2.2 Workpackage 1 - Task 2: *Sampling equipment evolution to increase the sampling efficiency for salmon at sea* (TS)

2.2.1 Task Objective:

The overall objective of this task is to initiate research efforts to develop smolt trawl design to minimize size selection. No detailed objectives are specified within the SALSEA Plan.

2.2.2 Assessment:

According to the Inventory, there are no ongoing efforts being directed towards this task. However, as the inventory is an "Inventory of Research Relating to Salmon Mortality in the Sea", it is possible that some relevant research activities (e.g. possible in Norway) have not been reported because they directly involved with investigating salmon mortality at sea.

There is one completed project (European Union – United Kingdom (Scotland) - Testing and development of Institute of Marine Research (IMR), Bergen, Norway, salmon trawl gear), which successfully trialed the use of an open trawl digital observer/analyzer.

The inventory list three projects being undertaken in Canada (C1), Europe (E! - SALSEA-MERGE), USA (U5) which are undertaking marine surveys using similar gear, and these are assumed to impart a size selective bias in their catches. The objective of this Task was to find ways to reduce the size selection, but work in the area has not occurred to the extent envisioned in the SALSEA Plan (SAL(04)05). Any new or ongoing efforts will likely not benefit the SALSEA Programme as we are entering the 2nd and final year of the marine surveys.

Conclusions:

a. There remains a need for further developmental work on methods to sample post-smolts and adult salmon in the open ocean that are less selective than the methods currently in use. Such work should be included in any future programme to extend marine survey and sampling programmes for salmon.
b. Efforts should also be made to determine the extent of the possible selective bias in the current sampling in order that this can be taken into account in the analysis of the results.

2.3 Workpackage 1 - Task 3: *Signals from scales* (SP)

2.3.1 Task Objectives:

The overall objective of this task is to establish standardised scale analysis techniques and identify marine growth histories and anomalies indicating common mortality factors on spatial and temporal scales.

The specific objectives are:

i. Ensure that results from scale analysis equipment in selected European and North American laboratories is comparable;
ii. Carry out scale analysis training for all participating laboratories by North American experts while ensuring that agreed-upon standardised scale examination procedures are being followed;
iii. Carry out scale analyses on selected scale sets with a view to establishing a comparable database between laboratories;
iv. Coordinate the examination of scale material available from several research agencies (or from different stocks and stock components) to identify spatial and temporal anomalies in the time series of scale growth during the marine

2.3.2 Assessment:

Three ongoing projects listed in the inventory (E7, E10, C5) are relevant to this task. These projects focus on a) scale growth patterns and b) scale microchemistry using scales from existing and new collection from Scotland, England and Wales and Canada together with scales taken from salmon sampled in the ocean. In addition, at least four of the completed studies undertaken in Canada, USA, England and Norway addressed similar topics.

There is a considerable collection of historic scale material available from most salmon-producing countries, and the results coming out of the studies suggests that analysis of scale microchemistry is likely to provide very important insights into the factors affecting salmon in the sea. However, the first requirement in analysing these scale collections and comparing results between countries is to ensure the use of standardised scale analysis procedures between laboratories. Despite the fact that work is being done in collaboration with colleagues from other organizations there is no evidence in the projects details that standardised scale analysis techniques have been established and used.

There therefore remains a need to establish standardized scale analysis procedures to ensure that results between laboratories and countries are comparable. Prof Clive Trueman (Southampton University, UK) who is managing project E7, has indicated that he is hoping to arrange workshop to bring together scientists using scale microchemistry techniques, including elemental and isotopic analysis, to agree standard analytical procedures and to improve co-ordination of these studies.

Conclusions:

a. The SAG should consider providing funds to facilitate the workshop salmon scale microchemistry being planned by Professor Clive Trueman with the aim to agree on standardized scale analysis procedures and to co-ordinate current research in this area.
b. This group could also establish of a common scale database for all countries with historic scale data that may be used in these analyses.

3.1 Workpackage 2 - Task 1: *Investigate the influence of biological characteristics of Atlantic salmon smolts on their marine mortality* (TP)

3.1.1 Task objectives:

The overall aim of this task is to identify differences in the marine survival of smolts with different characteristics, and determine the extent to which such factors could account for widespread changes in salmon stock abundance.

The specific research objectives are to:

i. Identify the key biological variables among smolts that may affect marine survival and evidence of widespread changes in these characteristics in stocks;
ii. Determine the impact of smolt characteristics on migratory behaviour;
iii. Determine the impact of smolt characteristics on marine survival and return of spawning adults;
iv. Model the impact of smolt characteristics at the population level;
v. Determine management options.

3.1.2 Assessment:

The inventory lists 13 ongoing studies (C3, E5, E8, E9, E13, E15, E18, E21, I1, N2, R1, U4) that are collecting data directly relevant to this Task, and many of these are long-term monitoring programmes. In addition a number of completed projects have provided relevant information.

There is growing evidence from these and other studies that the growth and survival of salmon in the sea may be related to various biological characteristics of smolts. Studies in this area are therefore particularly important because these are also factors which are likely to be more amenable to management intervention.

Data from many of the above programmes provide important inputs to the work of the ICES North Atlantic Salmon Working Group and the development of advice for NASCO. In addition, in response to a specific question from NASCO, ICES has established the Study Group on the Identification Of Biological Characteristics For Use As Predictors Of Salmon Abundance [SGBICEPS] which met in 2009 to: identify data sources and compile time series of data on marine mortality of salmon, salmon abundance, biological characteristics of salmon and related environmental information; consider hypotheses relating marine mortality and/or abundance trends for Atlantic salmon stocks with changes in biological characteristics of all life stages and environmental changes; and conduct preliminary analyses to explore the available datasets and test the hypotheses.

IASRB provided some financial support for the first meeting of this Study Group, which enabled two scientists working outside national laboratories to participate.

The first meeting of this Study Group highlighted the value of combining the analysis of data from a number of different monitoring programmes around the North Atlantic, but also highlighted the severe difficulties in obtaining comparable data from these programmes. This Study Group is likely to have at least two more meetings.

This is a complex and difficult area of research. It is costly to run extensive monitoring programmes and data must generally be collected over a substantial time period (e.g. more than 10 years) to provide useful results. Furthermore, co-ordination of such programmes is problematic because the various on-going programmes use a range of different techniques and collect a range of different information. However, the drivers to maintain the same approaches with the time-series tends to be stronger that the driver to use comparable approaches with other groups undertaking similar studies.

Conclusions:

a. The ICES NASWG and SGBICEPS should provide a means to continue dialogue about the co-ordination of work in this area; consideration should therefore given to covering this in the terms of the reference for future meetings;
b. IASRB should be asked to consider providing funding for the participation of two experts from outside national laboratories in the future meetings of SGBICEPS.

3.2 Workpackage 2 - Task 2 - *The impacts of physical factors in fresh water on marine mortality of Atlantic salmon* (LPH)

3.2.1 Task objectives:

The overall aim of this task is to assess the effects of physical variables on marine survival. The goal is to identify common or differing trends in freshwater physical conditions that are common throughout the geographic range, or within a geographic region, and that may modify factors such as smolt quality or migratory behaviour and reduce the ability of smolts to physiologically adapt to the marine environment.

The specific objectives are to:

i. Determine the impact of physical variables at the time of smolt emigration on survival to the open ocean (i.e. to adapt to sea water conditions and thrive and grow in marine conditions and return to natal fresh water to breed) (Sub-task 1);
ii. Determine the impact of key physical variables, such as temperature, flow, turbidity, on the run-timing of wild salmon smolts and consequent survival to the open ocean (Sub-task 2);
iii. Determine the impact of physical variables on behaviour of smolts during the transition between the freshwater and marine environments and on the abilities of smolts to survive the transition from fresh to sea water (Sub-task 3);
iv. Determine impacts of coastal transition waters on survival of returning adults into the river (Sub-task 4);

v. Model the impact of freshwater physical variables on Atlantic salmon at the population level (Sub-task 5);
vi. Determine management options for mitigating impacts (Sub-task 6).

3.2.2 Assessment:

Physical conditions experienced by Atlantic salmon smolts within fresh water may be critical to their subsequent survival in the sea. For instance, water flow and water temperature, both of which may be mediated by climate change, can modify growth, inhibit or delay smolt emigration, reduce sea water adaptation and marine survival, and influence maturation. Marine survival may also be affected by the transitional conditions, such as temperature, between fresh and saline waters.

The inventory lists two projects (E3 and E4) that specifically address the objectives of this Task. In addition, some of the projects in the inventory covering biological factors of smolts on marine mortality (WP 2:1) may include effects of physical variable as well, and there may also be overlap with WP 2:2, 2:3 and perhaps 2:4.

There is obviously a large amount of information available on how physical factors in freshwater affect the life history and behaviour of salmon, and consequently marine performance such as migration, growth and mortality. Interaction between several of these factors may result in synergistic effects which in turn may increase marine mortality.

There has been no major general and complete analysis of such information. The first step should be screening of literature and development of a network of scientists who are already funded and working in this area, to promote complementary studies, avoid duplication and gain from cooperative planning and analysis of existing data. A preliminary descriptive model of factors in freshwater that affects behaviour, life history and survival and the interaction between them should be developed. The next step would be to run the model(s) by utilizing available quantitative information. When focusing on marine survival this is not an easy task, but a first result of this may be to identify the major gaps in the knowledge and their relative importance.

The network should arrange workshops to synthesize the results, the first could prepare an inventory of completed and ongoing research (literature survey) and to develop the descriptive model. Later, workshops would then be held in order to synthesise results and coordinate ongoing and future work and/or develop an integrated research programme that would address various subtasks.

Realistically the main costs should be covered by the parties, but the fund could support the participation of external scientists with special skills.

Conclusions:

a. Efforts should be made to establish a network of scientists working on topics related to the effects physical factors in fresh water on marine mortality of Atlantic salmon in order to promote complementary studies, avoid duplication and gain from cooperative planning and analysis of existing data.

b. IASRB should be asked to consider providing funding for the participation in this network of external experts with special skills.
c. A preliminary descriptive model of factors in freshwater that affects behaviour, life history and survival and the interaction between them should be developed and run utilizing available quantitative information. This should provide a mechanism to major gaps in knowledge and their relative importance.

3.3 Workpackage 2 - Task 3: *Preparing to migrate – investigate the influence of freshwater contaminants on the marine survival of Atlantic salmon* (NOM)

3.3.1 Task objectives:

The aim of this programme is to assess the effects of freshwater contaminants that are common throughout the geographic range of Atlantic salmon, on marine survival and their potential role in the widespread decline of stocks.

Specific objectives:

i. Identify freshwater contaminants that are common throughout the geographic range of Atlantic salmon and that might be expected to modify migratory behaviour and/or reduce the ability of the smolts to physiologically adapt to the marine environment (Sub-task 1);
ii. Determine the effect of environmental levels of the target contaminants on the parrsmolt transformation and the ability of smolts to survive in marine conditions (Sub-task 2);
iii. Determine the impact of the target contaminants on run-timing of wild salmon smolts and the migratory behaviour of smolts during the transition between the freshwater and marine environments;
iv. Determine the impact of target contaminants on marine survival and return of spawning adults (Sub-task 5);
v. Model the impact of freshwater contaminants at the population level;
vi. Provide management options for resolving impacts identified in these studies.

3.3.2 Assessment:

This Task is clearly undersubscribed with only one project (E3) and two completed projects (one of which was undertaken by the same team as E3) specifically aimed at understanding the role of freshwater contaminants in the early stages of salmon migration only one ongoing project addressing the objectives. The limited work in this area is unfortunate because these study have clearly indicated that exposure of smolts to some contaminants (including some widely used pesticides) can significantly reduce the survival of the fish on transition to salt water and these are areas which are clearly amenable to management intervention.

Sub-task 1: ***Identifying freshwater contaminants***
This is mainly a desk study and could be progressed relatively easily. There is probably some work ongoing in UK (England and Wales) and US.

Sub-task 2: ***Effects of contaminants on parr-smolt transformation***
This is mainly lab based – more difficult to progress – most work being undertaken in UK (England and Wales) and US.

Sub-task 3: ***Effects of contaminants on migratory behaviour and distribution***
Sub-task 4: ***Effects of contaminants on smolt behaviour and distribution***
Sub-task 5: ***Effects of contaminants on adult return rates***
All the above sub-tasks could be linked to any of the river monitoring or sampling programmes which handle smolts or other juvenile stages and which could provide sample material for telemetry or exposure to specific contaminants before release particularly if fish are being micro-tagged. The main focus is for groups of fish to be marked (e.g. PIT tagged) and exposed to environmental levels of contaminants for periods during the parr-smolt transformation. Therefore access to juveniles/smolts for PIT tagging, tracking of juveniles and survival is the common theme etc and links could be developed from some of the ongoing monitoring programmes. A large number of the projects listed in the inventory therefore have potential to provide suitable material to these sub-tasks (e.g. C4, E3, E4, E13, E8, E15, E17, E18, E21, I1, N2, N4, N6, R1, U1, U2, U3, U5)

Sub-task 6: Modelling impacts at a population level
This is mainly a desk study which would depend on some output from the laboratory experimental, field experimental and telemetry work above. This probably can't be progress too far yet.

Conclusions:
There is potential for a number of on-going programmes to contribute to the studies of the effects of freshwater contaminants on the marine survival of salmon, and there is a therefore a need for greater co-operation.

3.4 Workpackage 2 - *Task 4: The part played by key predators (DS)*

3.4.1 Task objectives

The overall aim is to determine the contribution of predation by key predators to the marine mortality of salmon.

The specific objectives are to:
i. Determine the proportion of out-going smolts and returning adults that are removed by predation, to identify the predator(s) involved, and to determine the time, location, and circumstances of this predation;
ii. Compare current patterns and intensities of predation with the situation prior to the salmon decline.

3.4.2 Assessment:

Records of the numbers of salmon returning to monitored rivers indicate that, despite drastic reductions in directed fisheries, there has been at least a threefold reduction in marine survival rates since the early 1970s. The reductions in the numbers returning has

been accompanied by a marked decline in the proportion of older sea age fish, so much so that 3SW fish are relatively rare in many systems and 4 & 5SW fish vanishingly so. Such a change in an age distribution is a classic symptom of a sustained increase in mortality rate, a conclusion which is supported by the current relative scarcity of repeat spawners in the returning populations.

Other factors which might have contributed to the proportional reduction in the representation of older fish include, higher rates of mortality on non-maturing fish than on maturing ones, a sustained increase in maturation rates and a reduction in the representation of late-maturing populations among the returning stocks. Although all three of these explanations are credible, they do not, in my opinion, alter the main conclusion that Atlantic salmon, especially those in the southern part of the species' range, are currently suffering from a raised level of marine mortality which is sustained across all sea age classes.

Although by-catch losses to pelagic fisheries for other species undoubtedly contribute to the attrition of some salmon populations, the evidence for high marine mortality is so widespread that increased "natural" losses to predation appear to be the primary explanation despite the fact that, because of over-exploitation in human consumption fisheries, the numbers of large predatory fishes in the north Atlantic capable of catching salmon is at an all time low. However, there has been no such reduction in the numbers of surface-feeding and diving bird populations, nor in those of large marine mammals like dolphins and Atlantic grey seals, indeed, grey seal numbers are currently at record levels sustained, perhaps, by dead and dying fish discarded from fishing vessels. On this evidence, direct investigation of predation on salmon should currently be focused on estimating losses to marine mammals and birds.

Because small fishes are easier to catch than large ones, studies of predation cannot be isolated from studies of growth and of the abundance of the prey species that sustain it. In the latter instance it is important to know how much reductions in the abundance of important prey species such as sandeels and capelin are driven by fishing mortality and how much by changes in marine climate.

Conclusions:

With the above considerations in mind, the following additional studies relating to predators should be encouraged:

- Extend the study the occurrence of salmon DNA in seal scats to a wider range of haul out sites (Marine Scotland FW Laboratory and SMRU).
- Extend the application of P.I.T detection technology currently being used to study sea trout predation by seals to salmon (Marine Scotland FW Laboratory and SMRU).
- Co-ordinate the stable isotope-based study of the temperature and trophic history of salmon returning to netting stations in the north of Scotland with related work elsewhere (Scottish Oceanographic Institute, St. Andrews).
- Intensify observations on dolphin predation on salmon (SMRU).
- Initiate study of the occurrence of salmon tags and salmon DNA at *coastal* bird colonies.
- Review the current status of industrial fisheries in the north Atlantic.

– Extend the study of salmon migration pathways to the central and northern North Sea.

3.5 Work Package 2 - *Task 5: The impacts of aquaculture on mortality of salmon* (TP)

3.5.1 Task objectives

The objective of this Task as stated in the SALSEA Programme was for NASCO and ICES to hold a symposium in 2005 on 'Interactions between aquaculture and wild stocks of Atlantic salmon and other diadromous fish species: Science and Management, Challenges and Solutions'.

The objectives of the symposium were:

i. To summarise available knowledge on the interactions between aquaculture and wild stocks of Atlantic salmon and other diadromous species;
ii. to identify gaps in current understanding of interactions and develop recommendations on future research priorities;
iii. to review progress in managing interactions of aquaculture, the challenges that remain and possible solutions;
iv. to make recommendations for additional measures, including cooperative ventures between the various stakeholders, to ensure that aquaculture practices are sustainable and consistent with the Precautionary Approach.

3.5.2 Assessment:

The Symposium was held in 2005 and the proceedings written up and published. Since that time the SALSEA Plan has not been updated and it is not clear what the priorities are for future work in this area, relating to the potential effects of aquaculture on marine mortality of salmon (This is likely addressed in the report of the symposium).

Conclusion:
The SALSEA Plan needs to be reviewed and updated to spell out the need for any future work on the impact of aquaculture on the marine mortality of salmon.

4. Work Package 3 – Investigating the Distribution and Migration of Salmon at Sea

4.1 Work Package 3 - Task 1: Distribution and migration mechanisms - (JAJ)

4.1.1 Task objectives:

The overall aim of this task is to develop theoretical migration models from existing studies to facilitate surveys and provision of advice for contemporary migration and distribution theory testing.

The specific objectives are:

i. To assemble all available scientific data, both near-shore and open ocean, on post-smolt distribution, migration, growth and feeding at sea;

ii. Review current investigations using oceanographic data so as to refine/develop predictive tools for assessing marine thermal habitat preferences and possible oceanic migration paths;
iii. Test the hypothesis that distribution and stock composition are stable over time by examining time series of oceanic and home-water tag recoveries and from scale sampling programmes;
iv. Review the existing information on differences in the behaviour and survival of hatchery and reared salmon at sea.

4.1.2 Assessment:

The first step in WP3.1 will be to ensure that the best use is made of all existing survey, tracking and tagging results, available biological and oceanographic data, along with existing knowledge of salmon migrations, in order to develop hypotheses about salmon distribution and behaviour which can be tested, to improve the resolution of the proposed marine sampling tasks WP3.3.

Initially this task should be based on available biological and oceanographic data, but there do not appear to have not been any projects in the Inventory addressing this issue.

Some work has been done on salmon post-smolt migration in relation to sea-surface temperatures in the North Sea/Norwegian Sea by Norwegian scientists and west of Scotland/Norwegian Sea by Scottish scientists, aspects of this work are included in the current Salsea-Merge programme (E1 in the Inventory).

Conclusion:
Studies relating to the production and distribution of important marine organisms to physical parameters such as sea surface temperature, currents, wind speed, wave action, salinity, etc. are badly needed to facilitate and enhance a comprehensive study of the distribution and migration mechanisms for salmon in the sea.

4.2 Work Package 3 - Task 2 – A common approach –(TS)

4.2.1 Task objectives:

The overall aim of this task is to refine the plans for a large-scale marine survey programme and standardization of trawl survey techniques between the participating partners

The specific objective is:
To develop Standard Operating Procedures and plan the large-scale marine survey programme.

4.2.2 Assessment:

According to the Inventory, there are no ongoing efforts being directed towards this task. However, as the inventory is an “Inventory of Research Relating to Salmon Mortality in the Sea”, it is possible that there have been non-reported activities under this task as these

activities would not be directly investigating salmon mortality at sea. There have been previous meetings to develop the details of the SALSEA research program and specifically plan the large-scale marine survey programme.

There are five projects (C1, E1, U5, D1, F1) listed in the inventory that outline marine surveys for salmon (both trawl and land based). There have been numerous coordination efforts within and between these projects to develop standardized operating procedures with standardized data collection requirements. Project leaders have informally met at various meetings (including the 2008 NASCO Annual Meeting) and communicated via email to develop standardized protocols. However, no overarching Trawl Standardization Working Group has been developed for the entire SALSEA Program (SALSEA-Merge, SALSEA North America and SALSEA Greenland).

Work in the area has not occurred to the extent envisioned in the SALSEA Plan. Any new or ongoing efforts will likely not benefit the SALSEA Program as we are entering the 2nd and final year of the marine surveys.

***Conclusion*: (See WP1, Task 2)**

4.3 Work Package 3 - *Task 3: Salmon at sea - (GG)*

4.3.1 Task objectives:

The overall aim of this task is to carry out a comprehensive marine survey to collect samples and information required to compare migration patterns, distribution and possible factors affecting survival of reared and wild salmon post-smolts at sea

The specific task objectives are to:

i. Determine the ocean migration patterns of salmon from fresh water to return to home waters;
ii. Provide adequate samples to describe the major migration routes and distribution of Atlantic salmon at sea;
iii. Provide samples for regional stock identification using the genetic baseline studies;
iv. Collect information on sea surface temperature, salinity, current speed, direction and other oceanographic and hydrographic information;
v. Collect information on the predators and prey of salmon;
vi. Determine the distribution of salmon in relation to:
    - Sea temperature and currents;
    - Presence of prey;
    - Presence of predators;
    - Presence of competitors;
    - Ocean up-welling and productivity;

vi. Collect and analyse oceanic data (physical, chemical, biological) compared to the relative abundance of salmon (adults and post-smolts) captured in targeted trawl or sampling surveys;
vii. Collect information (scales, growth information, sex ratios, etc.) for studies on the energetics of oceanic migration;

viii. Integrate the SALSEA programme with major marine studies being undertaken by bodies such as ICES, NOAA and Fisheries and Oceans, Canada.

4.3.2 Assessment:

The inventory list 17 ongoing projects related to this Task, four marine surveys (C1, E1, I5, U5), nine acoustic tagging surveys (C2, C4, C6, E17, N4, N6, U1, U2, U3), two studies employing data storage tags (I2, I3) and one looking at trends in biological characteristics of returning salmon (E12). This part of the SALSEA Plan has been identified as being of prime important to the IASRB and is therefore central to their current research and funding efforts.

This WP is highly likely to give new and valuable information on presence/absence of post-smolts in the areas to be covered. Additional information on ocean conditions, presence of prey, presence of predators, ocean up-welling, as well as physical, chemical and biological information will be compared to relative abundance of salmon. The results can be compared to already available marine studies undertaken by ICES, NOAA and others.

Biological samples like genetic mapping and origin of fish, growth rate, scale pattern, isotopes, etc will also provide new information on salmon in the sea. In threes areas there is a need to ensure that the results obtained by different groups are comparable, and it would be desirable to develop co-ordinated programmes to provide good coverage of the North Atlantic.

Information on environmental factors from fish that have survived the marine phase can be looked at as a “gap” in the already listed SALSEA projects. Although post-smolts are caught in the sea it will not be clear if they are those that will survive or the actual importance of those areas. WE will not know whether the surviving fish are coming from the “hotspot” areas covered by research ships cruises.

Information sampled by data storage tags (DST), like temperature, depth, salinity, location (GPS) etc. could to some extent fill this gap by giving additional information on at least some environmental factors sampled by DST recorders carried by the surviving fish. Areas known to have high sea survival of Atlantic salmon should be prioritized or other areas known to be important or of special value for the salmon distribution and/or existence. This could also be used in areas that are not covered by the SALSEA sampling program.

The use of DST should be encouraged for use on:

- Hatchery smolts. DST tags for tagging hatchery smolts are already available and in use. Although it is not known to what extent they reflect the lifecycle of wild salmon.
- Wild smolts. DST tags for wild smolts are under development. For example wild smolts from River Ellidaar, S-W Iceland will be tagged internally with dummy DST tags with PIT inside in spring 2009.
- Kelts. At least few types of DST suitable for tagging kelts are available and in use. In some areas they are giving valuable information on the ocean habitat preferred by

kelts. This part of the salmon population is of high importance in many areas and needs more attention.
- Fish farm escapees – fish released intentionally. Large adult salmon from fish farms could be tagged with "pop-up" DST tags already in use for tagging Tuna. These tags could give information on the environment in areas used by both the fish recovered as well as from fish that do not survive. This will also have the potential for comparison of the fish that dies and fish that survive.

The advantages of using DST are:
- They do not require expensive marine vessels for collection of samples and measurements of environmental factors.
- They collect information from individuals closing the marine phase of the lifecycle.

Disadvantages are:
- The tagged fish needs to be recovered as well as the tags.
- Expensive, while the development costs are paid.
- High number of tags not recovered (depends on survival rate).
- Limited number of parameter recorded as well as limited number of records.

Conclusions:
a. The use of tagging technologies, particularly archival tags, should be encouraged as a cost effect method to complement and enhance the results from marine surveys.
b. Efforts should be made to co-ordinate studies of the condition and lipid content of 1SW & 2SW salmon returning to netting stations in northern and eastern Scotland (Marine Scotland FW Laboratory and Scottish Oceanographic Institute, St. Andrews) with related work elsewhere to provide comparable results from different parts of the North Atlantic.

4.4 Workpackage 3 - Task 4: Distribution and migration –(TP)

4.4.1 Task objectives

The overall aim of this task is to analyse and collate data from the marine surveys, report on the distribution of salmon at sea, report on the biological and physical oceanographic factors which influence migration and distribution of Atlantic salmon and report on natural and man-made mortality factors which may significantly affect survival of salmon at sea

The specific task objectives relating to different sets of results are:
Genetic assessment of stock composition:
- Evaluate the stock composition of the samples at differing geographic scales and assess deviations from expected proportions.

Man-made effects
- Evaluate ICES SGBYSAL report in relation to new data collected during trawl surveys;
- Evaluate the effects of directed fishing mortality;
- Assess the level of ocean contaminants in areas where post-smolts are located.

Predators

- Provide an assessment of predation from historical data and records;
- Compare the distribution of salmon and their predators.

Productivity

- Assess the effect of varying ocean productivity on survival of salmon;
- Combine existing time series of survival and growth of salmon with productivity studies, plankton surveys, weather satellite surveys, etc.

Food availability

- Examine whether the survival of salmon is dependent on the distribution and relative abundance of prey types (fish, crustaceans, squid);
- Investigate the distribution and abundance of prey types in relation to salmon survival.

Growth effects

- Investigate the relationship between survival and growth rate with new data and samples from the research surveys (Work Package 2).

Water temperature

- Investigate the relationship between survival and water temperature from existing long time-series and new data on SST, fixed stations and transects, DST data from the research surveys (Work Package 2).

Competition

- Examine the relationship between survival and competition with other pelagic fish species (herring, mackerel, blue whiting, lumpfish) taking into consideration: competition for food, competition for space, schooling effects.

Combined synergistic effects

- Consider overall natural mortality as a result of combined synergistic effects.

4.4.2 Assessment

The objectives in this Task are obviously picked up in many of the research projects in the inventory, particularly those such as SALSEA-Merge (E1) which involve large integrated programmes. There would be value in developing models which begin to bring some of these information streams together with the aim of exploring more fully the data coming out of these programmes and identifying more clearly the most important gaps in our understanding of the factors that may be having the greatest impact on marine survival.

Conclusion:

There is a need to initiate the development of an integrated model covering the whole pre-smolt and smolt phase with main focus on survival.

5. Summary of comments and conclusions:

This section summarizes the comments and conclusions from the report; the numbering indicates the section number of the comment in the report:

1.(a) The projects in the IASRB Research Inventory appear to be renumbered each year, with completed projects having no numbers, and less information is provided for the completed projects. It is suggested that in future a continuous numbering system should be used with the same information on the completed projects included as for the ongoing projects.

1.(b) If a decision is made to repeat this review process, possibly as an alternative to requesting this advice from ICES, the group would be advised to work initially on the review from the previous year and update this to take account of any new projects when the inventory is updated.

2.1.2 There is extensive work being undertaken in relation to genetic stock identification and the objectives of WP1.1 appear to be well covered. It appears that there are good mechanisms in place (including through SALSEA-MERGE) to co-ordinate these studies, including ensuring all groups use the same satellite markers and comparable sampling and analytical techniques

2.2.2(a) There remains a need for further developmental work on methods to sample post-smolts and adult salmon in the open ocean that are less selective than the methods currently in use. Such work should be included in any future programme to extend marine survey and sampling programmes for salmon.

2.2.2(b) Efforts should also be made to determine the extent of the possible selective bias in the current marine sampling methods in order that this can be taken into account in the analysis of the results.

2.3.2(a) The SAG should consider providing funds to facilitate the workshop on salmon scale microchemistry being planned by Professor Clive Trueman with the aim to agree on standardized scale analysis procedures and to co-ordinate current research in this area.

2.3.2(b) This group could also establish of a common scale database for all countries with historic scale data that may be used in these analyses.

3.1.2(a) The ICES NASWG and SGBICEPS should provide a means to continue dialogue about the co-ordination of work on the influence of biological characteristics of smolts on their marine survival; consideration should therefore given to covering this in the terms of the reference for future meetings;

3.1.2(b) IASRB should be asked to consider providing funding for the participation of two experts from outside national laboratories in the future meetings of SGBICEPS.

3.2.2(a) Efforts should be made to establish a network of scientists working on topics related to the effects physical factors in fresh water on marine mortality of Atlantic salmon in order

to promote complementary studies, avoid duplication and gain from cooperative planning and analysis of existing data.

3.2.2(b) IASRB should be asked to consider providing funding for the participation in this network of external experts with special skills.

3.2.2(c) A preliminary descriptive model of factors in freshwater that affects behaviour, life history and survival and the interaction between them should be developed and run utilizing available quantitative information. This should be used to identify major gaps in knowledge and their relative importance.

3.3.2 There is potential for a number of on-going programmes to contribute to the studies of the effects of freshwater contaminants on the marine survival of salmon, and there is a therefore a need for greater co-operation.

3.4.2 The following additional studies relating to predators should be encouraged:

- Extend the study the occurrence of salmon DNA in seal scats to a wider range of haul out sites (Marine Scotland FW Laboratory and SMRU).
- Extend the application of P.I.T detection technology currently being used to study sea trout predation by seals to salmon (Marine Scotland FW Laboratory and SMRU).
- Co-ordinate the stable isotope-based study of the temperature and trophic history of salmon returning to netting stations in the north of Scotland with related work elsewhere (Scottish Oceanographic Institute, St. Andrews).
- Intensify observations on dolphin predation on salmon (SMRU).
- Initiate study of the occurrence of salmon tags and salmon DNA at *coastal* bird colonies.
- Review the current status of industrial fisheries in the north Atlantic.
- Extend the study of salmon migration pathways to the central and northern North Sea.

3.5.2 The SALSEA Plan needs to be reviewed and updated to spell out the need for any future work on the impact of aquaculture on the marine mortality of salmon.

4.1.2 Studies relating to the production and distribution of important marine organisms to physical parameters such as sea surface temperature, currents, wind speed, wave action, salinity, etc. are badly needed to facilitate and enhance a comprehensive study of the distribution and migration mechanisms for salmon in the sea.

4.3.2(a) The use of tagging technologies, particularly archival tags, should be encouraged as a cost effect method to complement and enhance the results from marine surveys.

4.3.2(b) Efforts should be made to co-ordinate studies of the condition and lipid content of 1SW & 2SW salmon returning to netting stations in northern and eastern Scotland (Marine Scotland FW Laboratory and Scottish Oceanographic Institute, St. Andrews) with related work elsewhere to provide comparable results from different parts of the North Atlantic.

4.4.2 There is a need to initiate the development of an integrated model covering the whole pre-smolt and smolt phase with main focus on survival.

Annex 1: Members of the Review Group

Gerald Chaput	Canada
Gudni Gudbergsson	Iceland
Lars Hansen	Norway
Jan Arge Jacobsen	Denmark (in respect of Faroes and Greenland)
Niall O'Maoileidigh	European Union
Ted Potter (Chair)	European Union
Sergei Prusov	Russian Federation
Elena Samoylova	Russian Federation
Tim Sheehan	USA
Dick Shelton	AST
Fred Whoriskey	ASF
Peter Hutchinson	NASCO Secretariat