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Proceedings Series 2004/038 | **Série des comptes rendus 2004/038**

Proceedings of a Workshop on Research into Causes of Recent Low Survival of Atlantic Salmon at Sea – Newfoundland and Labrador Perspective

Compte rendu d'un atelier concernant la recherche sur les causes du faible taux de survie récent du saumon de l'Atlantique en mer – Point de vue de Terre-Neuve-et-Labrador

February 11, 2004
St. John's, Newfoundland and Labrador

T. R. Porter

Fisheries and Oceans Canada
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P. O. Box 5667
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ISSN 1701-1272 (Printed / Imprimé)

Published and available free from:
Une publication gratuite de:

Fisheries and Oceans Canada / Pêches et Océans Canada
Canadian Science Advisory Secretariat / Secrétariat canadien de consultation scientifique
200, rue Kent Street
Ottawa, Ontario
K1A 0E6

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Printed on recycled paper.
Imprimé sur papier recyclé.

Correct citation for this publication:

DFO 2005. Proceedings of a Workshop on Research into Causes of Recent Low Survival of Atlantic Salmon at Sea – Newfoundland and Labrador Perspective; February 11, 2004. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2004/038.

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SUMMARY

In response to a recommendation in Newfoundland and Labrador Region's Salmonid Stock Assessment meeting held in November 2003 a workshop was held on February 11, 2004 with the objective of recommending a focus for research into determining factors that affect survival of salmon at sea. Participants of the workshop included research scientists, and interested stakeholders from Federal and Provincial agencies in Newfoundland and Labrador, Memorial University of Newfoundland, conservation organizations, Labrador Inuit Association, and concerned anglers.

The workshop was conducted in plenary and consisted of six presentations followed by a general discussion. Presentations provided summaries of research to-date, conclusions of previous workshops on the topic, complexities of conducting ecological research, and an overview of a recent proposal for conducting research on survival and ecology of Atlantic salmon post-smolts in the near-shore environment.

This Proceedings document provides recommendations for research direction necessary for preventing further decline in salmon abundance in Newfoundland and Labrador, and for a focussed research approach to determine factors that affect survival of Atlantic salmon at sea. A record of the presentations and ensuing discussions is also provided.

SOMMAIRE

Comme suite à une recommandation formulée lors de la réunion d'évaluation des stocks de salmonidés de la région de Terre-Neuve-et-Labrador tenue en novembre 2003, un atelier a eu lieu le 11 février 2004 en vue de recommander un objectif de recherche visant à déterminer les facteurs qui ont une incidence sur la survie du saumon en mer. Un grand nombre de personnes ont assisté à l'atelier, notamment des scientifiques et des intervenants intéressés d'organismes fédéraux et provinciaux de Terre-Neuve-et-Labrador, des représentants de l'Université Mémorial de Terre-Neuve, des organisations vouées à la conservation, la Labrador Inuit Association et des pêcheurs sportifs qui s'intéressent à la situation.

L'atelier s'est déroulé en plénière et a comporté six présentations suivies d'une discussion générale. Les présentations ont résumé la recherche menée à ce jour, les conclusions d'ateliers précédents à ce sujet et la complexité des études écologiques et ont donné un aperçu d'une proposition récente visant à réaliser une étude sur la survie et l'écologie de postsaumoneaux de l'Atlantique près du rivage.

Le présent compte rendu comporte des recommandations sur l'orientation que doit prendre la recherche afin de prévenir le déclin des stocks de saumon dans la région de Terre-Neuve-et-Labrador et sur l'adoption d'une approche de recherche ciblée visant à déterminer les facteurs qui ont une incidence sur le taux de survie du saumon de l'Atlantique en mer. Les présentations et les discussions qui en découlent sont également résumées.

INTRODUCTION

One of the outcomes of the Newfoundland and Labrador Region's Salmonid Stock Assessment meeting held in November 2003 was to hold a workshop with the objective of recommending a focus for research into determining factors that affect survival of salmon at sea (Mullins, 2003). A steering committee was formed consisting of Larry Felt, Don Ivany, Rob Perry, Shane Mahoney, Keith Watts, and Rex Porter (chair).

The objective and outputs of the workshop as defined in Mullins (2003) were revised slightly by the steering committee as follows:

Objective: "To develop a systematic and focused approach for research into causes of recent low survival of Atlantic salmon at sea."

Workshop outputs:

1. A prioritized list of specific research questions that is necessary to better define factors affecting survival of salmon at sea.
2. Define the scale of each research project
3. List benefits or outputs of each research project
4. Identify potential research partners
5. Identify sources of funds
6. Identify potential research teams.

The workshop was held on 11 February 2004. The agenda and list of participants are in Appendices I and II respectively. The invitees included were multidisciplinary in make-up, and originated from Department of Fisheries and Oceans, Inland Fish and Wildlife Division and Science Division of Department of Tourism, Recreation and Culture with the Province of Newfoundland and Labrador, Memorial University of Newfoundland, Labrador Inuit Association, Newfoundland and Labrador Wildlife Federation, Outdoor Rights and Conservation Association, Atlantic Salmon Federation, Salmonid council of Newfoundland and Labrador, and the Salmonid Association of Eastern Newfoundland.

This report provides a summary of six presentations made at the Workshop, comments made after each presentation, a synopsis of the general discussion related to the objectives of the workshop, and the overall conclusions derived. Although, all of the intended workshop outputs were not achieved, progress was made in providing direction for conducting research to better understand factors causing low survival of salmon at sea.

SUMMARY OF PRESENTATIONS

1. Variation in survival and abundance of Atlantic salmon: some examples of what we know by life-history stage & review of current research activities

Presenter: J. B. Dempson, Department of Fisheries and Oceans

Summary: A brief overview of multiple factors that can influence the survival of salmon was illustrated. This was followed by a commentary on the distribution of wild Atlantic salmon in the North Atlantic in the context of the varied environments it previously and currently exists in, coupled with the current distribution of salmonid aquaculture operations.

A breakdown was provided of the number of salmon stocks assessed in the Newfoundland and Labrador Region relative to the size of the returning adult salmon population. This showed that about 70% of the rivers assessed were characterized by runs of less than 2000 adult salmon, with 50% having runs of less than 1000 individuals. Based on data from Newfoundland stocks, it was shown that survival of first time repeat spawners was substantially more variable than egg-to-smolt (freshwater), and smolt-to-adult (marine) survival. The least variable aspect of Newfoundland salmon stocks was smolt production, although currently only four (4) stocks are monitored.

Examples from several rivers were used to illustrate that higher spawning escapements, hence greater egg deposition rates, do not necessarily produce more smolt, and that at a given egg deposition, almost the entire range of observed smolt production could occur. Egg-to-smolt (freshwater) survival was shown to vary by a factor of five in some Newfoundland rivers. This is why high variability in smolt production can occur at similar spawning escapements. There was also a suggestion of possible density-dependent effects in several rivers as evidenced by a reduction in egg-to-smolt (freshwater) survival with corresponding higher egg deposition rates (estimated numbers of eggs deposited relative to the amount of available fluvial habitat).

Data from several rivers were used to illustrate the variability in marine survival versus size of smolts emigrating from different rivers. In some cases, larger smolt yielded higher marine survival rates; in other cases no observed pattern was evident, while at one river, longer or heavier smolts resulted in a decrease in marine survival. Hence, there were no consistent patterns among rivers associated with smolt size and subsequent survival to the adult stage.

Additional examples were used to illustrate relationships between smolt abundance and subsequent return of adult salmon. Similar to the situation in freshwater with egg deposition and subsequent smolt, producing more smolt (i.e. greater numbers of smolt leaving a rivers) does not necessarily result in higher numbers of returning adult salmon in the following year. Indeed, in some rivers the entire observed range in adult returns can occur from approximately the same number of out migrating smolts. This is because marine survival is not constant, but highly variable.

Coincident with the decline in abundance of some Newfoundland salmon stocks, and the lack of new production resulting from increased spawning escapements in some areas (e.g. northeast, and northwest coast stocks), a number of other changes have been documented in the northwest Atlantic ecosystem. These include, but are not limited to: collapse of the northern cod stock; decline in most other ground fish populations; change in distribution of cod, capelin, Arctic cod and pandalid shrimp; delayed spawning and slower growth of capelin; diet shifts in gannets at Funk Island; diet shift in cod in NAFO Division 2J; and diet shifts in harp seals and in anadromous Arctic charr in north Labrador. Some of these changes occurred in conjunction with wide spread anomalous environmental conditions that occurred in the late 1980s and early 1990s. A discussion ensued as to whether these collective observations were consistent with a 'regime shift' in the north Atlantic.

A summary of recent or ongoing research associated with Atlantic salmon also included reference to several international or regional collaborative projects. A summary of project components or objectives were provided for the following: a) Size-selective sea survival of Atlantic salmon in eastern Canada; b) Biological and environmental determinants of run-timing of Atlantic salmon to and within rivers of eastern Canada; c) Comparative proximate body composition analyses of fluvial versus lacustrine salmon parr; d) Analysis of trends in stable isotope signatures to infer long term changes in the trophic ecology of salmon at sea; e) Temporal variation in abundance of the northernmost populations of Atlantic salmon with emphasis on the River Tana; and f) Importance of early marine feeding on growth and survival of Atlantic salmon post-smolts.

Comments (C)/ Questions (Q)/ Responses (R):

1. ***C:*** It was pointed out that the total production coming out of the mouth of the river is what is important to the overall success of the species.

2. ***Q:*** Clarification was requested regarding what is the egg deposition rate?
   R: Egg deposition rate refers to the eggs per unit of fluvial habitat and lacustrine (lake) habitat.

3. ***Q:*** How is the poaching factored into stock status once salmon leave the counting fence?
   R: It is not. We currently have no way of quantifying the number of fish killed through poaching activity. Although, it is accepted that it is an area of concern and we know that it occurs.

4. ***C:*** Generally speaking, an increase in egg deposition results in higher production of smolts, but in some cases lower survival in freshwater decreases production.

5. ***C:*** Solely producing more smolts will not necessarily result in more salmon going back into the river. Marine survival also plays a large influence in how many salmon return to the river. Theoretically, the rivers are producing enough smolts if survival at sea was increased to that observed in the 1970s. At sea survival is not consistent from year to year. It is possible that there may be a smolt run "timing" factor that influences survival.

6. ***C:*** Higher at sea survivals have occurred in the past when directed ocean fisheries were operating. Generally, smolt survival has been highly variable and generally low. This is somewhat unexpected and surprising. Perhaps, there is a large ocean fishery (e.g. non-Canadian commercial fishery, bait nets or widespread poaching) affecting the at-sea survival that is currently not acknowledged.

7. ***Q:*** Does poaching at sea replace commercial fishery.
   R: There are no data to quantify poaching at sea or in the rivers.

8. ***Q:*** Does a shift in predation cause the low survival at sea?
   R: There is some evidence that there has been a shift in predation by some predators in some years such as gannets, seals and possibly cod fish; but we have no data to be able to quantify any shift or impact on production.

9. ***Q:*** What if predation differs from time to time?
   R: Predator switching could influence the survival rate.

10. ***Q:*** Regarding the returns back to the river system, is it wild or mixture of wild and aquaculture escapees that are counted?
    R: Most rivers have only wild salmon. Some rivers such as Conne River may have wild and farmed escapees. Some, but not all, farmed salmon have been identified by external characteristics such as deformed fins; some have been identified from scale samples. Some farm escapees will go undetected. Stable isotopes can be used to determine the carbon/nitrogen signature of wild versus farmed salmon. In Newfoundland and Labrador we are not seeing a lot of farmed salmon in the rivers. Farmed salmon are normally not as fit as wild fish and this is one of the primary concerns regarding any genetic interaction that wild salmon may have with farmed salmon.

11. ***Q:*** Is there any correlation in the decrease in nitrogen signature over time in the Conne River system with regards to the aquaculture influence; i.e. related to feeding by these salmon on aquaculture food near cages?
    R: In the Gander River there was also an increase in nitrogen signature over time. Nitrogen is amplified as one goes up the food chain. This may suggest that Gander River adult salmon are feeding on organisms further up the food chain.

12. ***C:*** Isotopic analysis is only able to sample the fish that survive. Maybe fish diet should be looked at more closely.

13. ***Q:*** Assuming that survival is additive and linear what would be the result of adding more adults into the system?
    R: It would be additive.

14. ***C:*** There was a suggestion that a study be conducted to compare production and the survival rate of salmon in a river that is influenced by aquaculture, to a river that is not

influenced by aquaculture. Conne River is a prime example. Several rainbow trout can have a tremendous influence on hundreds of smolts.

15. ***C:*** A reference was made to the 1991 low temperature anomaly and the suspected low productivity this had on many river systems.

16. ***C:*** There have been a number of recorded changes in the Northwest Atlantic ecosystem that may have affected survival at sea.

17. ***C:*** Where do we go from here? Currently, DFO is only sampling half the province. An expansion to look at sea survival in Labrador should be included into the plan, since there are fewer human impacts on stocks in the north.

18. ***Q:*** Any suggestion why we have a higher survival in the north than in the south?
R: Unknown.

2. Some aspects of the ecology of Atlantic salmon (*Salmo salar* L.) in the Northwest Atlantic

Presenter: D. G. Reddin, Department of Fisheries & Oceans

In recent years, the numbers of North American multi-sea-winter and one-sea-winter salmon have been steadily declining with multi-sea-winter salmon declining at a faster rate than one-sea-winter salmon. Although the source of the mortality and its potential cause(s) remain largely unknown, sea survival rates have declined substantially even with the almost complete closure of commercial fisheries at sea. This closure should have resulted in dramatic increases in returns and survival rates, especially when the natal rivers are spatially and temporally nearby. In North America, there are regions in the southern area of the salmon range where stocks have become close to being extirpated. Due to these declines in overall abundance and near extirpation in some areas, sea research has become particularly important if the cause(s) of the at sea mortality are to be found.

Exploratory fishing in the Northwest Atlantic was begun by Fisheries and Oceans Canada in 1965. Surface gillnets of various mesh sizes were set out at dawn and fished for up to twelve hours. Live fish were tagged and released. Mortalities were sampled for biological characteristics, scales, and stomach contents. Salmon of all sea ages occurred seasonally over most of the Northwest Atlantic and were found concentrated in the Labrador Sea gyre throughout the year, at West Greenland in summer and autumn, and in the spring along the eastern slope of the Grand Banks. Salmon were distributed as far eastward as the Irminger Sea. Post-smolt salmon were first caught at sea in 1987 using gillnets of small mesh sizes not previously fished. The highest concentration of postsmolts and adult salmon occurred in the mid-Labrador Sea area. Comparison of catch rates by research vessels in the Labrador Sea and by commercial and research vessels at Greenland indicated that in most years, where there were comparable data, similar catch rates were experienced in the Labrador Sea as at Greenland. In some years, catch rates were higher in the Labrador Sea. This suggests a substantial population of salmon exists in the Labrador Sea comparable to that at West Greenland and, at least in some years, may even exceed that at Greenland because the area utilized by salmon in the Labrador Sea is much larger than at Greenland.

Information interpreted from scales from salmon collected in the Labrador Sea, and the distribution of recaptures of tagged salmon indicated that salmon in the Labrador Sea originate from rivers over the entire North American range of this species. Stomach contents suggested that the salmon were feeding opportunistically on whatever was abundant in the area. Distribution of salmon as measured by catch rates and temperatures indicated that salmon were found most abundantly in water with surface temperatures between 4°C and 10°C.

Water temperature has proven to be an important variable in the ecology of salmon at sea. Experiments with data storage tags (DSTs) were conducted on Atlantic salmon kelts obtained at enumeration facilities on Western Arm Brook, Campbellton and Highlands rivers, Newfoundland in 1998. In total, data on temperature was available from eleven of the returned tags. The results indicated temperature differences between rivers and among fish within a river. Movements vertically in the water column were inferred from the daily temperature patterns and

indicated extensive diurnal movements. The DST tagged salmon spent most of their time in water from 5°C to 17 °C. Information collected by data storage tags is important for determining the marine ecology of salmon, adjusting marine climate change models for salmon and, in freshwater, water temperature protocols for opening/closing angling fisheries due to high water temperatures.

In summary, there is a lot of information available to use as background for further studies on the ecology of salmon in the sea. This information should be utilized to design experiments to test hypotheses related to why natural mortality rates are apparently so high on salmon at sea in recent years.

Comments (C)/ Questions (Q)/ Responses (R):

1. ***C:*** Some plausible hypotheses for the decline of Atlantic salmon are: predation, changes in the ocean climate, population specific survival, pollution, marine aquaculture, and fishing activities.
2. ***C:*** Sea survival has declined substantially. Salmon populations in North America declined following the overall sea survival declines. This is currently impacting on conservation. The exact cause is unknown.

3. ***Q:*** Clarification was requested regarding the "tracking" of smolt?
   R: Tracking of smolt have shown different results. Some studies have shown high survival in the estuary and near-shore while other studies suggest a high mortality.

4. ***C:*** A tagged fish may not exhibit the same behaviour as a non-tagged fish.

5. ***Q:*** How much of endocrine change occurs before smolt go into salt water?
   R: Changes do occur. There is a fair amount of literature on hormonal and other physiological changes that occur during the smolting process, which can be consulted for details.

6. ***C:*** Gadoid predation: It is important to note that the impact of predation would be dependent on the number of smolt and the number of predators present in the system. It is suspected that rock cod move inshore to feed on herring.

7. ***Q:*** Are these studies based on a single net set?
   R: Two or three sets were conducted per day near Campbellton and Gander rivers. The area where these sets occurred was full strength seawater and during the months of May and June. It was estimated that approximately 90% of the food found in the cod stomachs was herring.

8. ***C:*** Avian predators include Mergansers, belted kingfishers, double-crested cormorants, gannets (Funk Island), gulls, and murres.

9. ***Q:*** Salmon consumption by seals has been estimated by combining information on seal abundance, distribution, energy requirements and diet composition. Would fatty acids from salmon show up in seals if a fish was eaten 2 or 3 months prior to the analysis?
   R: It was explained that some fatty acids could be maintained 5-6 months in the blubber layer. Seals normally feed on one or two prey items at any given time. Signatures can be detected within 2 months; however, reference levels are required. Soft tissue from fish is usually digested within 2 hours within seal stomachs. Hard parts (carapaces, otoliths, etc) can be retained in the stomach for a lot longer period.

10. ***C:*** There is an increase in the number of seals observed in rivers. Environmental conditions, such as ice condition, influence the abundance of seals in estuaries.

11. ***C:*** Staff at salmon counting facilities also complete seal observation reports.

12. ***Q:*** Water temperatures from Data Storage Tags (DSTs) on Campbellton River kelts show that it is not uncommon for a salmon within one day to go though a rapid temperature change of 10^{o}C degrees. What we are seeing is diurnal movement. Why then be concerned with a one or two degree temperature change in the environment?
   R: It is not only the affect of temperature change on the kelts, but also on potential prey. It is known that temperature changes alter the productivity of the ocean. Salmon can feed in areas where their prey are more abundant and then move to the warmer water on the surface. The really deep dives appear to be about 50 m according to the latest data.

13. ***Q:*** During the sampling for post-smolts in gillnets in the Labrador Sea did you see any other commercial fishing occurring in the areas where the salmon were caught?
   R: It was very rare to see another boat. Salmon are generally taken near the head-ropes. i.e. the upper one meter of the three-metre deep nets.

14. ***Q:*** What is the main species in the diet of salmon?
   R: Capelin in the inshore area. In the middle of the Labrador Sea the main food source is Barracundina.

15. ***C:*** Principal crustacean prey data was collected late fall and early spring.

16. ***Q:*** In the past 30-45 years, there has been an extensive capelin fishery and the size of capelin has decreased. Are there any studies to indicate the relationship between the capelin decline and the low abundance of salmon?
   R: It has been looked at, but statistically it falls apart. Capelin are important inshore to the salmon diet, but not offshore. The proportion of capelin taken in the capelin fishery is very small in comparison to the total capelin stock. There have been well documented changes in the distribution of capelin in the North Atlantic. In addition, many other changes are taking place in the North Atlantic (documented since 1987) which complicates the analysis. Some scientists feel that the abundance of capelin in the offshore is low. The assessment indices that we currently have are for the inshore. Nonetheless, it is agreed that capelin distribution has changed, spawning has been later, and they are definitely smaller than in previous years.

17. ***Q:*** When smolts leave the river system and enter the estuary, are there capelin available in the inshore areas? If the capelin timing and distribution has changed, this may be having a negative effect on the success of the smolts. Many other marine species have changed distribution as well. Possibly salmon distribution has changed as well.
R: There are no data to document a change in the distribution of salmon.

18. ***Q:*** Is it fair to say, that Greenland's commercial catch (previously thought to be a concern) is eliminated as a problem in the reduction of the salmon population?
R: Yes. The West Greenland fishery did not harvest grilse, so there would not have been any effect on the survival of grilse stocks.

19. ***Q:*** At what part of the salmon's life at sea is the mortality occurring?
R: It's unknown.

20. ***Q:*** Does UV radiation affect prey items for salmon?
R: There have not been any studies.

21. ***C:*** There is insufficient information on the diet and growth rates of post-smolts. It may be possible that the slower growing salmon die.

22. ***C:*** Recommendations for marine research programs in the inshore areas include possible sources of mortality, tracking to determine distribution and the timing of movement from the inshore to the offshore. Research in the offshore should include sources of mortality, distribution, and migration.

3. Summary of previous workshops on factors affecting survival at sea

Presenter: D. G. Reddin, Department of Fisheries & Oceans

The results of three recent workshops on factors affecting survival at sea were presented, namely: DFO lead workshop at Sydney, Nova Scotia - February 1998 (CSAS 1998); DFO lead workshop at Halifax, Nova Scotia - June 2000 (O'Neil et al. 2000); NASCO lead workshop at Oslo, Norway – October 2000 (Anon 2001).

Sydney Workshop (1998):

The following factors were discussed as potentially influencing salmon abundance:

- Environmental Factors: *In freshwater*: temperature, discharge, influence on run timing, smolt size, physiology, etc. *In marine:* temperature, salinity, distribution, prey availability, maturation, growth, return run timing, etc.
- Predation: (cod, seals, sea birds)
- Disease / Parasites: (bacterial, viral pathogens, aquaculture impacts)
- Exploitation: marine, freshwater, by-catch, poaching, hook-and-release

The conclusion of the Sydney workshop was that no single factor could be identified as the cause of the low survival of salmon at sea. There was an indication that the ecosystem in the Northwest Atlantic may have changed, and that this ecosystem shift may be responsible for the low return rates. It is likely that the post-smolt mortality is primarily due to predation. However, it is unlikely that one species of predator accounts for the increased mortality.

There were a number of research recommendations, which included:

1. Ecology of salmon at sea (distribution, abundance, post-smolt ecology, effects of physical & biological environments)
2. Predation (especially on smolt and post-smolt stage at sea)
3. Salmon monitoring in freshwater (expand monitoring of smolt & adults into Labrador, Ungava, incidence of disease, parasites, aquaculture impacts)
4. Salmon life histories (movements/distribution of salmon at sea, maturation schedules, factors affecting survival, scale pattern analyses)

NASCO Workshop (2000):

NASCO organized an international workshop to develop ideas for a research program to identify and explain the causes of increased marine mortality of Atlantic salmon. The following were the research programs recommended:

1. Scale growth analyses
2. Post-smolt and adult migration and distribution
3. Thermal ecology of salmon at sea
4. Bioenergetics modeling of salmon
5. Trends in marine survival

6. Salmon by-catches in pelagic fisheries
7. Survival dynamics at the freshwater marine transition
8. Application of electronic tag technology to determine marine distribution of salmon

Sources of funding for European based projects were reviewed at the workshop. The workshop recommended establishment of a NASCO Research Fund.

NASCO, in 2001, established an International Atlantic Salmon Research Board to promote collaboration and cooperation on research into causes of marine mortality of Atlantic salmon and the opportunities to counteract this mortality. More information regarding this Board can be found on the internet at http://www.salmonatsea.com.

Halifax Workshop (2002):

This workshop built on progress made at the Sydney workshop by re-evaluating possible causes of the decline in pre-fishery abundance of North American Atlantic salmon, then focused on developing and prioritizing research project to evaluate potential factors that may have contributed the decline in salmon abundance. Sixty-two potential hypotheses were identified. Fifteen project proposals were developed and ranked, and included projects in the freshwater, the estuarine and marine environments.

The ranked research project proposals stemming from the Halifax workshop are as follows:

1a Freshwater conditioning
1b Salmon distribution – coastal field studies
2 Salmon distribution – marine field studies
3 Estimating survival with technology
4a Size dependent survival
4b Salmon distribution models
4 Temperature transitions
6a Physical characteristics of freshwater
6b Aquaculture – disease effects
7 Seal and seabird predation
8 Coastal migration routes
9 Gannets as predators
10 Marine mammal predation
11 Marine fish predation
12 Aquaculture interactions

Comments (C)/ Questions (Q)/ Responses (R):

1. ***C:*** The Countries participating in NASCO, have in total contributed about $360,000 to NASCO International Atlantic Salmon Research Board, of which Canada provided $5,000. Currently, there is no funding to address the recommendations ranked in order of priority during the Sydney and Halifax workshops.

2. ***C:*** At the time of the NASCO workshop, it was anticipated that money would be forthcoming to NASCO from member countries, stakeholder groups, and/or industry.

3. ***C:*** There is a perception that salmon is really not an important species, but rather a cultural resource. In the grand scheme of things it is difficult to obtain funding for salmon. Research proposals have to look at the big picture.

4. ***C:*** All the indications from the scale of the decline suggest that factors contributing to the decline in salmon are also affecting other fish species. It is an ecosystem problem and requires major re-focusing of scientific priorities.

5. ***C:*** With fishing mortality removed, natural mortality on stocks (e.g. cod or salmon) could be looked at. It has been over 10 years since the moratorium, and cod stocks have shown little signs of recovery. There are probably cycles, temporal and spatial scales of which we are unaware.

6. ***C:*** The pilot Conservation/Stock Recovery Strategy that at least doubled the returns in Northwest River and Harry's River should be examined more closely, with the goal of establishing similar programs in other rivers.

7. ***C:*** There should be more of a focus on historical events. Look at tragedies that have caused declines in fish stocks.

4. Challenges and complexities of developing research proposals

Presenter: M. F. O'Connell, Department of Fisheries and Oceans

Summary: The scope and multiplicity of interrelated and dynamic environmental and biological factors potentially impacting on marine survival of Atlantic salmon in the near-shore in Newfoundland, was presented as a backdrop to demonstrate the complexity of selecting pertinent variables that will produce meaningful answers within a reasonable timeframe and at a realistic cost. Within this milieu, usual considerations such as choice of representative areas to study, logistics, numbers and locations of sampling sites, sample sizes in relation to statistical power and precision, etc. all have to be examined in relation to inherent spatial and temporal inter-annual variability associated with the various interrelated components. Survival can also be affected by asynchrony in environmental conditions between the freshwater, near-shore, and high seas environments through influences on run timing, migratory behaviour, and continuity of food availability, and hence one area cannot be viewed in isolation of the others. Given all the potential sources of uncertainty and variability in the system, it is clear that token sampling of short duration will likely not accomplish much. In the midst of all this complexity however, there are certain components that readily present themselves as logical candidates for initial study and these have already been presented in a research proposal submission in the context of a "first step approach". Regardless of the models or approaches eventually employed in any research design, the dependent variable is marine survival and this is determined through enumeration of smolts and adults at counting facilities. Obviously these time series of counts are crucial and would have to be maintained in conjunction with marine research initiatives in order to achieve overall research goals.

Comments (C)/ Questions (Q)/ Responses (R):

1. ***C:*** There was a general conclusion that short-term research initiatives would not be sufficient to meaningfully demonstrate causes of low natural marine survival.

2. ***Q:*** Given the uncertainties in studying the offshore and inshore, where do you suggest spending the money?
   R: All of these factors have to be considered. A practical approach needs to be developed given expected/anticipated funding success. Different types of Qs require different scale of research.

3. ***C:*** Even if there is no new funding established the monitoring of smolts and adult salmon should continue. Information from counting facilities will provide estimates of survival at sea and in rivers

4. ***C:*** There should be a continuum of research from eggs to spawners and not a single focus on a single activity.

5. ***C:*** Unrecorded mortality is an important factor that needs to be quantified.

6. ***C:*** A rigorous experimental design to ascertain the effects and degree of poaching on Harry's and Terra Nova rivers was suggested.

7. ***C:*** Is it possible that the counting facilities are not representative of the status of the 200 rivers? There is anecdotal evidence to suggest that the stocks are higher than the counting fences indicated.

8. ***C:*** Do fisherman's impressions of salmon abundance indicate changes in population size or just better/poorer fishing?

5. Survival and ecology of Atlantic salmon post-smolts in the near-shore environment.

Presenter: C. C. Mullins, Department of Fisheries and Oceans

Summary: The percentage of Atlantic salmon smolts that survive the marine environment to return as adult salmon is highly variable and generally low compared to years when directed ocean fisheries were in place. The low survival rates of salmon in recent years are ubiquitous to Atlantic Canada. Combined with variable and declining smolt production this situation has contributed to the lack of improvement in salmon population sizes that was expected following reductions in fishing mortality since 1992.

A specific reason for the decline in marine survival is not known at this point. It has been the subject of a number of inter-regional and inter-disciplinary workshops aimed at re-analysing available data but no single or group of factors has emerged as being the primary cause. The outcome of the workshops was a synthesis of probable causes and testable hypotheses including conditions in freshwater, temperature transitions, predation, aquaculture effects, and changes in marine migration. Salmonids Section, Science Branch, DFO, Newfoundland and Labrador Region, proposed an ecosystem/multi-species approach, which is consistent with these strategic research strategies and builds on existing research and established salmon monitoring facilities.

The main objective of the proposal is to provide a synthesis of the relationships between factors in near-shore areas and how they may contribute to the overall mortality of Atlantic salmon post-smolts. Sub-objectives include studies of: the spatial and temporal distribution of post-smolts near-shore; environmental conditions (temperature and salinity regimes) to which post-smolts are exposed; the diet and biology (length, weight, age, growth, condition factor) of post-smolts and the availability of prey items; the influence of predation on post-smolts in estuaries and near-shore areas; the degree of synchrony between freshwater and marine environmental conditions during the transition of smolts from freshwater to the marine environment. The proposed duration of these studies is five years or one generation. The total cost to be funded has not been finalized but is expected to be approximately $150K per year.

DFO is mandated and challenged to play the lead role in investigating the causes of low marine survival and to develop effective management strategies to conserve the resource. The salmon fishing industry has had to adjust to highly restrictive management and there is considerable uncertainty for the future access to a resource at relatively low abundance. A better understanding of factors contributing to marine mortality of salmon post-smolts would result in more reliable scientific advice, added industry stability and greater security for the resource. In spite of the low marine survival, Atlantic salmon stocks in Newfoundland are relatively healthy compared to endangered and threatened stocks in the eastern USA and Bay of Fundy regions. It is important that studies such as this one be carried out <u>now</u> so that the knowledge and insights gained will benefit salmon stocks in the long term before further major declines occur.

Comments (C)/ Questions (Q)/ Responses (R):

1. ***Q:*** What is the Strategic Science Fund and who administers it?
   ***R*:** It was a DFO funded science program, open to anyone within DFO. It was a two tier process: scientific peer review and then Management. This near-shore research project was turned down because there was no inter-Regional component. It was ranked 6th among the submissions that were received. The Strategic Science Fund no longer exists.

2. ***C:*** Near-shore studies have a greater chance of success due to ability to focus where there is already ongoing research. Research near-shore is cheaper than offshore research. If we could identify that the problem is not in the near-shore, then we would have to look to the offshore.

3. ***C:*** There is a need to conduct research on ecology of post-smolts.

4. ***C:*** Consideration should be given to where there are bottlenecks in salmon life history. Smolts and returning adult salmon must all pass through a river's estuary in a short period of time, i.e. two life history bottlenecks. This is a location and a time period in which a population is particularly vulnerable. It is important to measure mortality in this area.

5. ***C:*** Studies should involve multi-species approaches (i.e. more proactive involvement in research on other species).

6. ***C:*** From a modeling perspective, studies need to include the following questions: a) what is the length of time smolts spend in estuaries; b) how many die; and c) how many predators are there.

7. ***C:*** In larger estuaries there may be opportunities to hold smolts for research.

8. ***C:*** Biological "regime shifts" involve changes in carrying capacity that result in some sources of mortality becoming very important compared to when carrying capacity was higher. If we assume there has been a "regime shift" it might help to focus research efforts.

9. ***C:*** If there has been a redistribution of biomass in the oceans in that some things benefit while others do not, this would explain differences in mortality between rivers.

10. ***C:*** DFO should contact and seek support from outside groups for future proposals.

11. ***C:*** It may also be helpful to focus more enforcement efforts in estuaries.

6. Wild salmon science.

Presenter: A. Elkins – Outdoor Rights and Conservation Association

Summary: Atlantic salmon smoltify, enter the ocean, enter predator stage, undergo growth explosion, and then sexual maturity. Research should be designed to preserve the salmon's supply of prey fish for growth. Salmon management should provide sufficient protection to preserve the salmon's life throughout this stage and through to the completion of the spawning cycle. Departmental coordination is required. One Branch cannot work without the other. Politicians have to sign on also or research is in vain.

We have run out of time and fish for more five and ten-year studies plus the delay due to the five year cycle of salmon – before results can be assessed. Assign priority to programs that give us and the salmon the biggest bang for our science and management bucks. This probably favours doing near-shore projects first.

Regarding salmon migration patterns – wild creature migrations are motivated by the need for food or a suitable environment for reproduction. Pollution and climatic considerations allow a degree of choice or gradual adaptation to change for those wild creatures that are mobile. Those are therefore secondary considerations. Science to investigate the deep-sea life styles of salmon in problem areas outside of our control cannot be justified for priority financing. Already we have shot ourselves in the foot by publicly identifying the ocean staging grounds of salmon. This information will facilitate increasing commercial poaching. The ocean is a no-man's land, let's not be poacher's best friend. Sea trout are declining in tandem with wild salmon indicating that the main problems are common to both and may be located near-shore.

In a previous workshop you gave aquaculture consideration affecting wild salmon a very low research priority. However, since aquaculture is a near shore development, which also developed in tandem with salmon decline and has attracted some controversy elsewhere, this subject should be reconsidered.

Comments:

1. ***C:*** It makes sense to Give research priority to areas that give the most immediate benefit to improving salmon stocks. Near shore research has merit.

DISCUSSION ON RESEARCH DIRECTION

There was a wide ranging discussion on research direction. Given the diversity of participants, considerable discussion took place on factors other than low mortality at sea, which are affecting salmon spawning stock size. The following points were raised during the discussion period.

- Natural survival rates of salmon (egg to smolt) in freshwater and at sea have wide fluctuations. However the available information indicates that the general low abundance of Atlantic salmon observed during the past 15 years is primarily related to low at sea survival.

- The low returns of salmon to our rivers is a very serious problem with some salmon stocks only 20% of historical production. In many rivers, stocks are not meeting their conservation requirements. There is concern that salmon returns are so low that it will be very difficult for them to increase to traditional levels. Steps have to be taken in the next 2-3 years to address this. Poaching is a major concern.

- Unrecorded fishing mortality, such as by-catch in legal commercial fisheries for other species and/or illegal fishing (poaching), was viewed as a contributing factor hampering stock recovery. No information is available to quantify the magnitude of unrecorded fishing mortality, but some participants felt that it could be 30%-50% of some stocks.

- The need for consistent research over a long-time period is essential; however, since stocks are at such a low level, action is urgently required in the short term to increase the spawning stock.

- Stakeholders felt that DFO strategy to restore the stocks should be two-pronged: 1) take immediate action to increase the spawning stocks; and 2) initiate a meaningful long-term marine research program.

- Fish counting fences have to be maintained in order to monitor changes in population sizes and marine and freshwater survival rates.

- Enforcement has to be increased; currently it is indeed inadequate.

- Additional monies are required for research, but resources should not be redirected from enforcement and fish counting fences into research.

- Several times during the workshop recommendations were made to conduct research to quantify unrecorded mortalities such as poaching, which is one variable that can be controlled and appears to be relatively high.

- There was a suggestion that quantification of poaching could be done under existing funding. If there is no new funding, researchers should work with Conservation and Protection staff to develop a couple of pilot projects similar to Harry's River and Northwest River. By-catch in bait nets is viewed to be a major problem in some areas (e.

g. Southwest and Northeast coast of Newfoundland). Research could also be conducted utilizing existing funding to quantify mortality in bait nets.

- A study should be undertaken to determine how successful fisheries management efforts have been to mitigate the affects of poaching. Does Fisheries Management Branch see a need of funding its own research on determining the effectiveness of its strategies to combat poaching and reducing bycatch?

- It may be possible on one or more rivers to develop an experimental design whereby unrecorded mortalities and the benefits of various deterrents from poaching could be examined by utilising two fish counting fences. Salmon would be counted at a counting salmon at a lower counting fence in the lower part of the river and at a fence further upstream. A method would need to be developed to determine numbers of salmon remaining between the facilities and sources of mortality (i.e. angling removals). Some type of survey of the public may also be useful in estimating illegal removals.

- One suggestion was to set up a control river, and implement a management action to reduce poaching, such as varying the level of enforcement, on other rivers.

- A three-week at sea enforcement blitz was an alternative suggestion. It was noted that this would have to be done for more than one year, due to annual variability in salmon production

- The annual variability of poaching would also have to be acknowledged. In the case of Harry's River and Northwest River (Port Blandford) some of the success was attributed to the public relations campaign.

- The lack of adequate levels of enforcement has to be first documented as a problem. A suggestion is not to publicize the study, but instead, put the additional enforcement on a river and measure the effectiveness.

- It was suggested that two research strategies be developed: 1) if new monies are available; and 2) reallocation of existing budgets and/or re-evaluation of present projects and proposals.

- Several participants suggested that the focus of the research should be on understanding factors in the near-shore environment (particularly in or near estuaries) that may influence survival at sea. One suggestion was to expand the work that has been conducted in the estuary of Campbellton River. The return rate of repeat spawners appears to be higher, though highly variable, on Campbellton River compared to other monitored rivers; thus, it is a potential site for research. Research in the near-shore would be able to determine if factors in this area are making a greater contribution to the low survival than factors off–shore.

- All participants agreed that poaching is a serious issue and needs to be addressed. However, poaching is probably localized, while the decline in salmon production is ubiquitous throughout the Northwest Atlantic.

- Because so many stocks are collapsing, it is reasonable to conclude that there is some major ecological change or regime shift that is occurring. The big problem is not the poaching, but something that is occurring in the environment and is common to many stocks.

- There is evidence that other species are undergoing similar shifts in size of populations (e.g. cod). Has anyone ever tried to look at all of these, with a reference to see if there is a common denominator?

- In terms of the ecosystem, DFO is moving towards an ecosystem approach, particularly for marine species. However, there are stumbling blocks like ship time, etc. There are a number of projects currently ongoing that look at a number of species and how they have changed in the last decade. There is money out there but you have to be able to re-tool or re-direct proposals to this end.

- Perhaps, the Salmonid Sector should be more involved in the ecosystem approach. Better communication between researchers responsible for different fish species may be warranted. It is clear that we are looking at a more general marine problem and not something that is just specific to salmon.

- During the cod mortality workshop in 2000, a concept was put forth that there has been a biological regime shift in the Northwest Atlantic. The carrying capacity of the ocean differs depending on the time-period of studies. Differing domains exist. It may be that we are at a point of a very low carrying capacity of the ocean for some fish species, one of which may be Atlantic salmon. One will find in the literature that there was "a regime shift" in the 1990s in the Northwest Atlantic. The biggest change occurs in the shift of biomass. If there is a regime shift, than poaching would have a more pronounced effect then otherwise.

- Can we determine the nature of the regime shift, and can we determine how salmon are affected by such regime shifts? E.g. run-timing? What can managers do to increase the probability of success for the spawning stocks?

- Salmon survival rates (and production) would probably decrease if there was a regime shift.

- Priority should be given to northern Labrador as currently very little research is conducted in that area Labrador and no information is available on survival of salmon at sea. Labrador has long been recognized as a very pristine area to do research and because there are fewer influences on the rivers it would be a good area to do investigations. Most of the discussion has been on insular Newfoundland and while Newfoundland is important, Labrador needs to be looked as well. Poaching is also a

problem in Labrador; however, it is not believed to be as a large problem as in Newfoundland.

- There should be a smolt-adult salmon monitoring project in Labrador to determine sea survival. Currently there is no estimate of survival for Labrador stocks. The Labrador Sea area maybe able to be investigated using satellite telemetry.

- One suggested research approach was to take smolts out of the estuary and rear them in caged environments to further investigate at sea survival;

- Rearing wild smolt in marine cages was attempted for one year at Conne River. It was found that most of the mortality occurred in the first 6 weeks. Most of the smolts died due to failed feeding. Did the released adult salmon go up the river? Yes. Funding was sought to repeat this experiment; however, it was not obtained.

- It was acknowledged that the effects of Aquaculture on stocks on the South Coast cannot be discounted. This should be looked into.

- There is a need for a social component to research strategies, i.e. community participation.

- All participants agreed that the proposal presented by Mullin's was a good initial approach to conducting research to address factors in the near-shore that may be contributing to low at-sea mortality. It had a good chance of succeeding. The proposal as presented is appended to these Proceedings (Appendix III)

- Stakeholders suggested that as we go forward we should look to organizing a letter writing campaign to politicians, detailing the need for additional funding of salmon science.

CONCLUSIONS

Atlantic salmon populations in the Northwest Atlantic declined in the late 1980's and have not recovered even with closures of all commercial fisheries and restrictions placed on the recreational fisheries. Research has shown that survival rates in both freshwater and at sea have wide fluctuations; however, survival at sea during the past 15 years has been fluctuating at low levels. Participants agreed with the conclusion of previous workshops that the general low abundance of Atlantic salmon experienced in Newfoundland and Labrador in recent years was primarily related to low survival at sea. The cause of the low survival appears to be related to a major ecosystem change in the Northwest Atlantic Ocean, most probably a regime shift. Abundance of other marine fish species have also declined; and a shift in marine distribution of some species have been documented. There has also been some evidence of shifts in predation on Atlantic salmon by gannets, seals, and cod fish in some years.

A general view expressed was that some Atlantic salmon populations are continuing to decline and require immediate help to prevent further decline. Although some individual stocks may have sufficient spawning biomass many stocks are below their conservation egg deposition requirements

Participants felt that DFO's strategy to restore salmon stocks should be two-pronged: 1) take immediate action to increase spawning stocks; and 2) to initiate a meaningful long term marine research program.

There was a general view that unrecorded fishing mortality, mainly illegal fishing in rivers and near-shore, could be 30% to 50% of production. Spawning stocks can be increased by reducing this unrecorded fishing mortality. The current stock assessment methods do not include an estimate of unrecorded mortality, other than hook-and-release mortality, because there have not been adequate studies to quantify mortality caused by illegal fishing or by-catch. **High priority should be given to quantifying unrecorded mortality and, if necessary, identifying ways to reduce the mortality**. This research would give a more accurate estimate of salmon survival rates, production, and spawning stock sizes. The information could also be used by Fisheries Managers to prioritize action to reduce unrecorded mortalities as appropriate. **An evaluation of the effectiveness of fisheries management strategies to reduce illegal fishing should be carried out.**

Although poaching is a serious issue that needs to be addressed, it is not believed to be the cause of the overall decline is salmon abundance observed in the Northwest Atlantic. There have been a number of ecological changes in the Northwest Atlantic that could be contributing to the low survival of salmon at sea. It is an ecosystem problem that requires a major refocusing of research priorities to delineate contributing factors

Research should give priority to estuary and near-shore areas because these are "bottlenecks" that all out migrating post-smolts and in-migrating adult salmon must pass within a short time period. These are also areas where research has the best chance of testing hypothesis within a reasonable time frame. Research is cheaper near-shore than off-shore and can be focused in areas where sea survival rates are being measured (i.e. ongoing smolt and adult

salmon monitoring). Long-term research is required due the scarcity of background data sets, and lack of knowledge of ecology of Atlantic salmon in estuaries and near-shore.

Estuarine and near-shore research should have an ecosystem approach and include the following elements: ecology of post-smolts, estimates of mortality, identify possible sources of mortality, distribution, timing of in-shore and off-shore movements, multi-species, and estimates of predator abundance.

The research proposal previously submitted by the Salmonids Section (and presented at this workshop) but not funded, is still appropriate. The proposal needs to be updated with new information and modified to more explicitly include other fish species (more ecosystem focus). The research needs to be multi-disciplinary due to the complexity of conducting ecological research. It is important to conduct some of the research in Labrador to better understand survival/mortality in an environment that has fewer anthropogenic impacts. The limited information available indicates that northern stocks have a higher marine survival than southern stocks. Comparative research could assist in better defining the more important factors affecting survival at sea. It is important to maintain salmon and smolt monitoring facilities, for these are the only measure of changes in survival of salmon both in freshwater and at sea. Previous research has already indicated that in-river survival rates from egg to smolt stage are highly variable.

Participants viewed **research in the off-shore areas to be important**, since information is not available on mortality of salmon this area. However, it is unlikely that off-shore research will be successful in quantifying factors contributing to mortality in this area without a very large and expensive program. However, research should be undertaken if opportunities exist to improve our knowledge of the population dynamics of salmon off-shore with priority given to determining sources of mortality, distribution, and migration.

Aquaculture cannot be ruled out as a contributing factor in the declines of salmon on the south coast of Newfoundland; but it is probably not the cause of the overall decline in Northwest Atlantic salmon abundance. However it was noted that in a number of cases, areas where salmon stocks are doing the worst (e.g. Maine, Bay of Fundy, Conne River, parts of Norway, etc.) are all areas where salmonid aquaculture was initiated and escalated in the past several decades.

There should be a more pro-active approach to partnering (piggy backing) with other ecosystem programs that have been initiated primarily to address other marine species. Also, opportunities to collaborate in research associated with Marine Protected Areas should be investigated.

RESEARCH RECOMMENDATIONS TO DETERMINE THE CAUSES OF RECENT LOW SURVIVAL OF SALMON AT SEA

1) Quantify unrecorded mortality and, if necessary, identify ways to reduce the mortality, and evaluate the effectiveness of fisheries management strategies to reduce illegal fishing.

2) Implement a long-term multi-species research program on the ecology and population dynamics of salmon in estuaries and near-shore. The proposal already developed by the Salmonids Section, DFO, Newfoundland and Labrador Region is an appropriate starting point. The research is multi-disciplinary requiring collaboration among various researchers.

3) Research on sources of mortality, distribution and migration of salmon in off-shore areas should be pursued on an opportunistic basis.

4) Research on the impact of aquaculture operations on local Atlantic salmon stocks should be undertaken.

5) Continuation of smolt and adult salmon monitoring facilities is an essential component of the above research recommendations.

ACKNOWLEDGEMENTS

Thanks are extended to all participants of the workshop, particularly to non-DFO participants for giving up their own time to attend and contribute. Special thanks are extended to those who made presentations, to Dale Richards who assisted with the preparations for the workshop and did a superb job of taking notes, and to Derek Osborne for assisting with the editing and publishing of these Proceedings.

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APPENDIX I: Agenda for workshop on research into causes of recent low survival of Atlantic salmon at sea.

Date:	**February 11, 2004 Time: 08:00 – 16:30**
Location:	E. B. Dunne Boardroom, Northwest Atlantic Fisheries Center
Objective:	"To develop a systematic and focused approach for research into causes of recent low survival of Atlantic salmon at sea."
08:00 – 08:15	Introductions and organization of workshop
08:15 – 09:15	Summary of research to-date – *(B. Dempson)*
09:15 – 09:30	Break
09:30 – 10:30	Summary of research to-date – *(D. Reddin)*
10:30 – 10:45	Break
10:45 – 11:15	Summary of previous workshops on factors affecting survival at sea *(B. Dempson, D. Reddin)*
11:15 - 11:45	Challenges and complexities of developing research proposals (*M. O'Connell)*
11:45 – 12:30	Lunch
12:30 – 13:15	Review research proposals previously developed by DFO *(C. Mullins & C. Bourgeois)*
13:15 – 14:45	Discussion on research direction and Qs that should be addressed
14:45 – 15:00	Break
15:00 – 16:30	Prioritize research and complete tables
16:30	Workshop adjourned

APPENDIX II: List of participants at the workshop 11 February 2004.

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APPENDIX III: Presentation by C. Mullins on a research proposal submitted by the Salmonids Section to the Science Strategy Research in December 2001.

Near- shore ecology and survival of Atlantic salmon post-smolts

Science Strategic Research Fund Project

Proposal Submitted
December 2001

The problem

- **Reductions in fishing mortality since 1992 resulted in improvements in spawning stock biomass but after two generations many stocks have not shown any net improvement in population size (O'Connell et al., 2004).**

- **Analysis of information available from DFO monitoring facilities it is evident that the lack of improvements since 1992 was due to a decline in marine survival of smolts compared to the 1980's (CSAS, 2001; O'Connell et al., 2000).**

- **The low survival rates of salmon in recent years are ubiquitous to Atlantic Canada**

Causes / solution?

A **specific reason for the decline in marine survival is not known at this point. It has been the subject of a number of inter-regional and inter-disciplinary workshops aimed at re-analysing available data but no single or group of factors has emerged as being the primary cause.**

1. **Sydney, NS January, 1998 (Dempson et al., 1998; CSAS 1998, (D0-02))**
2. **Halifax, NS, June 2000 (O'Neil et al., 2000)**
3. **NASCO Workshop on Marine Survival**

Background

- **There is evidence to suggest that latitudinal differences in marine survival of salmon may be related to factors in freshwater such as smolt size and condition factor (Dempson, et al., 1994). Such factors can explain small differences between rivers but are unlikely to explain the major change in marine survival observed for a large number of rivers in recent years.**

- **Such major change is more likely related to larger-scale factors (Dempson et al., 1998) including timing of seawater entry in relation to temperature, food and predators (McCormick et al., 1998; Hansen and Quinn, 1998; Moore et al., 1995; Hansen and Jonsson, 1989; Cross and Piggins, 1982**).

Background

- **Marine climatic conditions in the Northwest Atlantic have been warming in recent years. In 2000, surface and integrated water-column temperatures at Station 27, the Flemish Cap, Hamilton Bank as well as in the three large bays on the Northeast coast of Newfoundland were up to 3 OC higher than long-term means (Colbourne, 2001).**

- **Changes in water temperature can affect salinity regimes and water current patterns can result in changes in distribution of marine organisms.**

- **The migration of Atlantic salmon in the oceans is believed to be closely associated with high seas marine surface temperature (Reddin and Shearer, 1987) but with a few exceptions (Moore et al., 1995), there is little information on food and feeding or migratory behaviour of salmon in near-shore areas.**

- **Predation by seals, cod and birds in the estuary have been documented in recent years (Downton et al., 2001; Mullins and Caines, 2000; Montevecchi, et al., 2000) and there is speculation that it has increased.**

Objectives

Overall:

- **synthesis of relationships between factors in near-shore areas and survival of Atlantic salmon post-smolts.**

- **Sub-objectives:**
- **describe the spatial and temporal distribution of Atlantic salmon post-smolts in the near-shore area (6-E, 11-M)**
- **describe the environmental conditions (temperature and salinity regimes) to which Atlantic salmon post-smolts are exposed in the near-shore area (4-E)**
- **describe the diet and biology (length, weight, age, growth, condition factor) of post-smolts and the spatial and temporal distribution of prey items (5-E)**
- **determine the effects of predators on survival of Atlantic salmon post-smolts in the estuary and near-shore areas (6-E, 7-E, and 8-E)**
- **examine the degree of synchrony between freshwater and marine environmental conditions during the transition of smolts from freshwater to the marine environment (4-E)**

Note: objectives consistent with "Workshop on Research Strategies into the Causes of Declining Atlantic salmon Returns to North American Rivers" in June 2000 (O'Neil et al., 2000):

Part A: spatial and temporal distribution

Hypothesis: variation in estuarine survival is an important component of total marine survival.

Background: Atlantic salmon smolts undergo major physiological changes (Hoar 1976; Wedemeyer et al. 1980) as they enter the ocean, a time when environmental conditions are highly variable. Residency time in near-shore areas is largely unknown.

Study Area:Exploits River and Bay of Exploits (50x1.5km)

Methods:

- **Exploits River Mark smolts using:**
  - **Year 1) streamer tags (3000)**
  - **Year 2) mark additional smolts using acoustic transmitters**
- **Bay of Exploits:**
  - **recapture using gillnets, live traps and seines**
  - **Tag and release any untagged**
  - **Collect stomach samples from mortalities**
  - **Track acoustic tags with mobile hydrophone and two arrays of acoustic relay buoys – one in the inner and one in the outer estuary/bay**
  - **Growth rate?**
- **Determine time of entry into the estuary, residency time and survival rate**

Part B: environmental conditions

Hypothesis: Differences in near-shore environmental condition could affect food availability and migration patterns and post-smolt survival

Background: Smolt migration (Hesthagen and Garnas 1986) and survival are known to vary geographically. Changing environmental conditions affecting smolt run timing and distribution of predators and prey at sea most often identified as major influences on marine survival.

Study area(s): Western Arm Brook, Exploits River, Campbellton River, Conne River, estuaries and coastal areas

Methods:

- Marine environmental monitoring stations will be set up throughout the period of smolt run (May to August)
- preliminary list of the marine environmental data to be collected:
  - Surface water temperature and salinity
  - Bottom temperature and salinity
  - CTD probes will be used to record temperature and salinity throughout the water column
  - Bathymetry (estuary)
  - Ice cover (ice in and out dates as well as

Part C: diet, relative condition and food availability

Hypothesis: productivity and food availability for post-smolts in near-shore areas has been depressed causing salmon to suffer lower marine survival.

Background: Smolt migration is believed to be optimized for specific geographic locations in that it is synchronised with maximum food availability (Hvidsten et al. 1995). Prey availability and preference are unknown.

Study Area: Bay of Exploits, St. Barbe Bay

Methods:

- Collect post-smolts for biological sampling
  - Lt., wt., sex, condition, disease, parasites
  - stomach contents from gillnets, live traps and seines (see Part A).
- Conduct integrated vertical and horizontal plankton and benthic sampling.

Part D: predation

Hypothesis: predation on post-smolts by marine fish, mammals and birds in near-shore areas has increased resulting in reduced survival of salmon.

Background: There is growing concern that predators are responsible for declining salmon returns. Seal sightings in particular are increasing in rivers and estuaries where post-smolt and adult salmon concentrated. Predation on post-smolts is known to occur in estuaries but the extent is unknown.

Study area(s): vicinity of Western Arm Brook and Campbellton River (smolt and adult monitoring)

Methods:

- frequency of occurrence of seals and sea birds
- videotape potential or actual seal foraging behaviour
- lethal sampling (seal diets, age determination, body condition and reproductive status)
  - Prey identified on the basis of otoliths and other hard body parts as well as soft tissue (when present)
  - Prey size and weight reconstructed through standardised regression techniques (Hammill and Stenson, 2000)
- possibly estimate seal feeding rates (groups of foraging seals can be identified for later sampling after a known residency period).
- Stomach contents of birds obtained from rookeries by non-lethal sampling.
- stomach contents of cod identified by gill netting throughout the smolt run.

Part E: synchrony between freshwater and estuary temperatures during smolt transition

Hypothesis: Smolt survival is negatively associated with the magnitude of temperature difference between freshwater and the estuarine environment at the time of emigration.

Background: Emigration needs to be synchronised with marine environmental conditions to optimise survival (Cross and Piggins 1982; Hansen and Jonsson 1989; Moore et al. 1995)

Study area: Exploits River and possibly others (Western Arm Brook, Campbellton River and Conne River) where time series exist on smolt descent and freshwater environmental conditions

Methods:

- Lab study of temperature transition and stress on smolt physiology
- Retrospective analysis of available historical and new (Part B) environmental data in relation to survival

Rationale

Social and Economic

- DFO mandated and challenged to play lead role to investigate causes of the decline in marine survival and to develop effective management strategies to conserve the resource and prevent further closures of economically and socially important fisheries.

Fisheries Management and Conservation

- management changes implemented in 1992 still in effect plus additional measures to continue to provide access to a resource at relatively low abundance.
- Annual variation in marine survival causes uncertainty for long-term management strategies.
- in-season and annual changes necessary to maintain viable spawning populations.
- considerable uncertainty in an industry that already had to adjust to highly restrictive management
- In some cases, continued exploitation at low natural survival rates could result in increased risk to the resource itself.

Scientific advice

- better understanding of factors that affect marine survival would result in more reliable scientific advice, added industry stability, greater security for the resource.

- In spite of the low marine survival, Atlantic salmon stocks in Newfoundland relatively healthy in comparison to endangered and threatened stocks in the eastern US and Bay of Fundy regions. It is important that studies such as this one be carried out now so that the knowledge and insights gained will benefit salmon stocks in the long term before further major declines occur.

Potential Key Players

- Science, Oceans and Environment Branch, DFO, NL
- Memorial University of Newfoundland, St. John's, NF
- Science Division, Province of Newfoundland and Labrador
- Parks Canada
- DFO, Gulf
- Faunes et Parcs Quebec, Quebec City, Qc,
- Norwegian Institute for Nature Research (NINA Co-ordinating Institution), Tromso, Norway.
- Abitibi Price
- Conservation Groups

Approach benefits

- Ecosystem/multi-species approach
- physical/biological modeling
- Incorporates understanding of ocean processes and climate change
- Multi-disciplinary
- Cost-effective
- Can be broken down into smaller components
- Involve graduate students
- Builds on ongoing research
- Uses established facilities
- Multi-year (3)
- Comparative studies
- Utilizes historical databases
- Will generates new time series
- database of near-shore environmental information and biological information on salmon post-smolts will be the first in Canada
- addresses issues related to climate change and marine environmental quality in near-shore areas.
- Results have implications for other Regions

Funding (years 2002/03 through 2004/05 as applicable):

		2002/03	2003/04	2004/05	Total
SSF 2000 Required	SAL ($K)	40	40	40	120
	O&M($K)	130	75	75	280
	CAP ($K)	10	10	-	20
	Shiptime ($K)	-	-	-	-
	Total ($K)	180	125	115	420
Regional A-Base Invested	SAL ($K)	210	210	210	630
	O&M($K)	25	25	25	75
	CAP ($K)	85	85	85	255
	Shiptime ($K)	-	-	-	-
	Total ($K) (in-Kind)	320	320	320	960
Funding provided by partners	SAL ($K) (In-kind)	25	25	25	75
	O&M($K)	40	40	40	120
	CAP ($K)	-	-	-	-
	Shiptime ($K)	-	-	-	-
	Total ($K)	65	65	65	195
Total cost of project	SAL ($K)	275	275	275	825
	O&M($K)	195	140	140	475
	CAP ($K)	95	95	85	275
	Shiptime ($K)	-	-	-	-
	Total ($K)	565	510	500	1575

Note 1: Regional A-Base investment is as follows for the four study sites: 1) Salaries for professional biological ($110K/yr) and technical ($100K/yr) support and supervision of the project; 2) Capital equipment includes 4 boats and motors and enough gillnets and fyke traps for each site; and 3) O&M includes 4 DFO vehicles, one at each site (~$6K ea/yr).

Note 2: In-kind Salary dollars are a conservative estimate of professional contributions provided by M.U.N. and other non-DFO partners; O&M dollars are field support provided by the non-profit organisations through funding received from HRDC (equivalent to two student workers at each of the four study sites).