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Proceedings of the regional peer review meeting of Environmental Thresholds to Define Management Strategies for Atlantic Salmon Fisheries under Environmentally Stressful Conditions

March 15, 2012
Moncton, New Brunswick

Chairperson: David Carins

Fisheries and Oceans Canada
Science Branch
P.O. Box 5030
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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

A regional advisory process meeting was held March 15, 2012 in Moncton (NB) to conduct a science peer review of environmental thresholds to define management strategies for Atlantic salmon fisheries under environmentally stressful conditions. The science review was conducted in response to a request from DFO Fisheries and Aquaculture Management (FAM). Participants at the science review included science staff from the DFO Gulf, Central & Arctic, Maritimes, Newfoundland and Labrador regions, personnel from DFO FAM, from universities, from aboriginal communities, and from watershed and recreational fishery organisations. All the terms of reference for the meeting were addressed. There was consensus from the review that exceeding a minimum temperature of 20ºC over two consecutive days was a reasonable threshold temperature condition to initiate management interventions of inriver Atlantic Salmon fisheries. The products of the meeting include a science advisory report and three supporting research documents.

SOMMAIRE

Une réunion dans le cadre du processus de consultation régionale a eu lieu à Moncton, au Nouveau-Brunswick, le 15 mars 2012, pour entreprendre un examen scientifique par les pairs des seuils environnementaux permettant de définir les stratégies de gestion de la pêche du saumon de l'Atlantique dans des conditions environnementales difficiles. L'examen scientifique a été réalisé en réponse à une demande de Gestion des pêches et de l'aquaculture (GPA) de Pêches et Océans Canada. Les participants à l'examen scientifique comprenaient le personnel de la région du Golfe du MPO, les régions du Centre et de l'Arctique, des Maritimes et de Terre-Neuve-et-Labrador, le personnel de GPA du MPO, d'universités, de collectivités autochtones et d'organisations de pêche récréative et des bassins versants. Tous les cadres de référence de la réunion ont été traités. Un consensus a été atteint à la suite de l'examen et il a été décidé qu'une température minimale de 20 °C pendant deux jours consécutifs était un seuil de température raisonnable pour lancer des interventions de gestion des pêches du saumon de l'Atlantique en rivière. À l'issue de la réunion, on avait produit un avis scientifique et trois documents de recherche connexes.

INTRODUCTION

The Department of Fisheries and Oceans (DFO) conducted a regional peer review meeting on March 15, 2012 in support of a request from DFO Fisheries and Aquaculture Management on the development of environmental thresholds for the management of Atlantic salmon fisheries. The terms of reference for the peer review meeting are provided in Appendix 1.

The meeting began at 9:00 AM, Thursday March 15, 2012. The chair opened the meeting by welcoming the participants and reviewing the meeting room. The chair explained the process of requesting science advice, preparation of the meeting materials, the science review, and the expected outcomes. A science advisory report, a proceedings document and several research documents are the expected products of the meeting.

The chair reviewed the rules of exchange for the meeting, reminding participants that the meeting was a science review and not a consultation. As well, everyone at the meeting had equal standing as participants as there was no observer status at the meeting. Table microphones were provided to ensure good communication during the meeting. Finally, the objective was to achieve consensus on the terms of reference for the meeting and that for the purposes of the science review, consensus was taken as an absence of opposition.

The chair then invited the participants to introduce themselves; the list of participants is provided in Appendix 2.

The draft agenda was reviewed and accepted (Appendix 3).

Three working papers were prepared to address the terms of reference. These working papers had been distributed to meeting participants by email on March 9, 2012.

- WP 1. Breau, C. The use of fish physiology to set water temperature threshold to close the recreational fishery of Atlantic salmon (*Salmo salar*) during warm water events.
- WP 2. Caissie, D., Breau, C., Hayward, J., and Cameron, P. Water temperature characteristics within the Miramichi and Restigouche rivers.
- WP 3. Breau, C., Caissie, D., and Chaput, G. Adaptive management strategies to protect salmon under environmentally stressful conditions.

Rapporteur duties were assigned to Gérald Chaput (DFO Science Gulf Region).

SUMMARY AND DISCUSSION BY TERM OF REFERENCE

TOR 1. Information on physiology / metabolic rates of Atlantic salmon and associations with level and duration of stress (warm water) and probability of survival.

This term of reference was addressed by materials in WP 1.

A number of rivers in Eastern Canada reach water temperatures in excess of 20°C, and often in combination with low water levels during the summer. During these high temperature events, salmonids have to cope or escape the high temperatures with all energy invested into survival. Any additional stress imposed on salmonids during those events will increase the probability of fish mortality. During high temperatures, metabolic byproducts accumulate in the white muscles of the fish. The metabolic byproducts have to be returned to specific levels for physiological recovery to occur. During high temperature events, cooler temperatures are required to allow

physiological recovery of fish. The probability of full recovery is reduced when the minimum daily temperature remains above 20°C.

The information was presented by Cindy Breau, DFO Science Gulf Region.

Points of discussion:

- The information presented in the working paper is complete as it relates to physiology and existing knowledge on metabolic processes related to water temperature.
- T_{crit} as defined is the maximum water temperature that can be tolerated. C_{tmax} is a surrogate for T_{crit}. It is determined by rapidly increasing the temperature and noting when a fish loses orientation / equilibrium. The response is entirely neurological. This has been done for juvenile stages and it equates to 28ºC. At this temperature, permanent cell damage ensues.
- Even at temperatures below T_{crit} and for periods of exposure which do not lead to death, cell damage does occur and it may not be repairable.
- These temperature thresholds have not been defined for adult Atlantic salmon.
- There are a large number of uncertainties for adult salmon in the natural river environment including: the role of diel cycles of temperature for recovery, how much temperature varies on a daily basis, the physical characteristics of the river which can determined the extent of diel variation in water temperatures, and the behaviour of adult salmon in the wild.
- The longer term consequences on adult salmon survival and reproduction success are not known. Stress from high water temperatures can result in cell damage. Although some of the cell damage can be repaired, this requires energy which is limited in adult salmon as they do not feed in freshwater and must survive on the energy reserves accumulated prior to entry into freshwater.
- Oxygen levels also decrease with increasing temperature. Salmonids need minimally 5 mg/l of dissolved oxygen. There is nothing to indicate that sufficient oxygen levels would not be attained in flowing waters.

TOR 2. Possible temperature benchmarks associated with probabilities of mortality (e.g. maximum daily temperature, minimum daily temperature, and combinations with discharge).

This term of reference was addressed by materials in WP 1.

- There was consensus that a minimum water temperature of 20ºC was required for recovery of Atlantic salmon and that it was a reasonable threshold temperature.

TOR 3. Possible environmental triggers associated with environmental stress on Atlantic salmon.

Information from WP 1 and WP 3 was used to address this TOR.

There is information from the literature on rates of change of cellular metabolites in adult Atlantic salmon that were exercised to exhaustion and allowed to recover. These studies indicate that many of the cellular byproducts of anaerobic metabolism can be metabolised within a few hours at temperatures of 23ºC or less. Studies on juvenile salmon indicate that behavioural changes are most likely to occur when minimum water temperatures exceed 20ºC during two consecutive days. Based on these observations, it was proposed that a 20ºC minimum

temperature that is exceeded for two consecutive days would be a trigger to initiate management action for fisheries. Although recovery rates are not defined, a period when minimum water temperatures are less than 20ºC for two consecutive days would be sufficient to allow adult salmon to recover and could be used as a re-opening trigger for management intervention.

Points of discussion:

- There is a lot of uncertainty on the metabolic recovery rates of adult salmon at various temperatures. It was assumed for the re-opening trigger that a temperature below 20ºC regardless of its duration was sufficient to allow the fish to recover. Temperatures are generally monitored on an hourly basis and if one temperature reading within a 24 hour period is below 20ºC for two consecutive days, than recovery would be considered possible. Further studies on this topic are required.
- Use of a two day window combined with the minimum temperature trigger was considered appropriate and was the consensus conclusion of the group.

TOR 4. Environmental (temperature, discharge/water level) characteristics (spatial and temporal) of the Miramichi and Restigouche rivers.

This term of reference was addressed by materials in WP 2. The information was presented by Daniel Caissie (DFO Science).

The seasonal cycle of water temperature variation is characterized by maximum temperatures (daily minimum, maximum and mean) attained in July and August with the highest values between mid-July to mid-August. Over a 24 hour period, the water temperature tends to reach its minimum early in the morning (8 to 9 am; T_{min}), the mean temperature in early afternoon (1 pm) whereas the maximum water temperature is generally reached in early evening (7 pm; T_{max}). Results showed a clear difference in summer water temperatures between the Miramichi River and the Restigouche River with high water temperature events more prevalent in the Miramichi River. In both river systems, the main stems generally had higher water temperatures than tributaries and the highest water temperatures were at the downstream sites. Temperatures at most sites are highly correlated, especially for sites that are in close proximity and those located in rivers of similar in size. Sites that showed the lowest correlation were small tributaries to larger river systems or sites that were far apart. The number of events where Tmin > 20°C showed higher site variability than Tmax > 23°C. High water temperature events are more prevalent from mid-July to mid-August. River discharge plays an important role in the river thermal regime as well as in overall habitat conditions. It is during summer low flows that both water levels and river temperature will have a combined effect on aquatic resources. If the 2-year low flow is used as an index of low flow conditions, then this flow is generally not reached before July 22 in the Miramichi River and not before August 27 in the Restigouche River. A multivariate analysis showed that most sites in the lower part of the Miramichi River were similar but differed from headwaters sites.

Points of discussion:

- More information should be provided in the document on the physical characteristics of the Miramichi and Restigouche rivers and how these may explain the differences in the described temperatures, Information on latitude, elevation of temperature recording sites and other site characteristics should be provided. More details are required in the figure captions as it was often not clear what information was being summarized (number of years, time of year).

- Given the differences in water temperature characteristics, consideration should be given to developing T_{crit} values for salmon specific to the rivers. Information in WP 1 suggested that for Pacific salmon, populations and species may have T_{crit} and T_{opt} values that have evolved to match the temperatures at inriver migration. A similar analysis should be done for Miramichi and Restigouche that would summarize the temperatures during the July and August migration periods in those rivers. This information should be added to the research documents and to the advisory report.
- Temperature data analysed are from recorders placed in generally shallow flowing water. No temperature loggers are placed directly in holding pools of adult salmon. Generally, water temperatures are well mixed in the water column and thermal stratification is not expected in these rivers with the exception of some very deep pools with coolwater seeps. No information is available on depth/temperature profiles in salmon holding pools.
- Analyses of spatial characteristics of temperature conditions suggest that the Miramichi River could be divided into a limited number of sectors defined by different temperature regimes. This spatial analysis was not conducted in detail.

TOR 5. Evidence that Atlantic salmon are susceptible to angling during warm water events and levels of mortalities associated with catch and release fishing.

This term of reference was addressed by materials presented in WP 1.

There is evidence based on creel survey reports from Crown Reserve waters in the Miramichi and the Restigouche River that salmon are angled on days when the mean water temperature recorded at temperature loggers in the vicinity of the fishing areas exceeds 20ºC.

Points of discussion:

- There is no information on temperatures in the pools specifically where the fish are angled or the temperatures which the fish were able to access within the pools. That being said, all the observations on salmon responses to warm water events relate to temperatures being monitored at a fixed location and not to individual fish conditions.

TOR 6. Evaluation of fishery management options for Miramichi and Restigouche rivers considering the areal extent of the intervention and the frequency and duration of management interventions.

This term of reference was addressed by materials in WP 3. The information was presented by Cindy Breau (DFO Science).

The proposed threshold temperature for in-season fishery closures was established based on fish physiology. Water temperatures below 20°C are required for fish to recover physiologically from metabolic byproducts produced as a result of anaerobic metabolism associated with high water temperatures. A minimum water temperature threshold to establish criterion for fisheries closures and openings was set at minimum water temperatures (T_{min}) over a range of successive days exceeding 20°C to initiate a fishing closure and the condition for reopening was set at a range of successive days when the minimum water temperatures (T_{min}) were less than 20°C. The number of closures and the duration of closures based on the proposed criterion were assessed using historic water temperature data from the Miramichi and the Restigouche.

Points of discussion:

- There was a consensus that the number of days at which the minimum temperature exceeded 20ºC before an intervention was triggered should not be more than two days. Similarly a reopening consideration would require that the minimum temperature be less than 20ºC for at least two days, not less.
- There is no consideration in the intervention analyses of cumulative stress from multiple events. The physiological data for such analyses are lacking.
- There was an interest from some participants for a management model that would include predictions of water temperatures and conditions based on weather forecasts from air temperatures and precipitation. The inclusion of these variables in an intervention model was intended to preclude short and potentially unnecessary closures when cooler temperatures may be imminent. Such a model would favour fisheries access over salmon stress levels. Seemingly, such an approach had been developed by the Miramichi Watershed Management Committee but this was not presented at this review meeting. The analysis of such a model would require access to weather forecasts of air temperatures and precipitation from Environment Canada rather than using the realized air temperatures and precipitation values in a forecast model of water temperatures; the latter condition is what had been used in the watershed group consideration.

TOR 7. Identification of uncertainties and other considerations for managing activities associated with environmental stress.

This term of reference was addressed in the discussions for each of the previous terms of reference. Uncertainties and knowledge gaps were included in the science advisory report.

WORKING PAPERS TO BE UPGRADED TO RESEARCH DOCUMENTS

It was recommended that the three working papers be upgraded and published as research documents, considering the discussion during the meeting.

DRAFTING AND REVIEW OF SCIENCE ADVISORY REPORT

The science advisory report was drafted after the meeting of March 15, 2012. A draft of the report was circulated to meeting participants on March 23, 2012 and after receipt of comments, the advisory report was finalized on April 20, 2012.

APPENDIX

Terms of Reference

Environmental Thresholds to Define Management Strategies for Atlantic Salmon Fisheries under Environmentally Stressful Conditions

Regional Peer Review – Gulf Region

March 15, 2012
Moncton, New Brunswick

Chairperson: David Cairns

Context

There is an overall concern for the status of Atlantic salmon under stressful conditions associated with exceptional climatic events. Inseason management measures have been introduced to reduce the impact of recreational fishing on Atlantic salmon during periods of warm water and low water levels. In eastern Canada, there has been an increased frequency of closures of inriver fisheries as a direct result of warm water and low water levels (Chaput et al. 2000; Dempson et al. 2001). Since 1962, there have been four inseason fishery closures in the Miramichi River; 1987, 1995, 1999, and 2001. The closures corresponded to the years with warm water temperatures and extremely low discharge conditions. In many other years, selected pools or locations were closed to angling due to concerns about illegal fishing activities.

The decision to intervene in season should be based on a demonstrated benefit to the resource and the intervention must be timely. There is overwhelming evidence that incidental mortality from catch and release angling increases with water temperatures above 20ºC (DFO 1998; Dempson et al. 2002). Mortality associated with any additional stress resulting from displacement of salmon from cool water seeps, burst swimming, and general unease would be expected to increase with increasing temperatures. To date, the criteria used for management intervention have been adhoc and not pre-defined which leads to delays in management response and reduced benefits to the resource.

DFO Fisheries and Aquaculture Management (FAM; Gulf Region) has requested advice on environmental thresholds for the management of Atlantic salmon fisheries. The specific questions are:

- What environmental thresholds could be used to trigger management actions to open or close Atlantic salmon fisheries?
- Given the size of the rivers (Miramichi and Restigouche), what are the options available for managing Atlantic salmon fisheries during environmentally stressful conditions?

Objectives

The objectives of the science peer review meeting are to address the questions from DFO FAM considering the following:

- Information on physiology / metabolic rates of Atlantic salmon and associations with level and duration of stress (warm water) and probability of survival.
- Possible temperature benchmarks associated with probabilities of mortality (for ex. maximum daily temperature, minimum daily temperature, and combinations with discharge).
- Possible environmental triggers associated with environmental stress on Atlantic salmon.

- Environmental (temperature, discharge/water level) characteristics (spatial and temporal) of the Miramichi and Restigouche rivers.
- Evidence that Atlantic salmon are susceptible to angling during warm water events and levels of mortalities associated with catch and release fishing.
- Evaluation of fishery management options for Miramichi and Restigouche rivers considering the areal extent of the intervention and the frequency and duration of management interventions.
- Identification of uncertainties and other considerations for managing activities associated with environmental stress.

Expected publications

- CSAS Science Advisory Report
- CSAS Research Document(s)
- CSAS Proceedings

Participation

To assist in the review and the drafting of the advice, participation is expected from:

- Relevant DFO Sectors
- Watershed and angling associations
- Aboriginal peoples
- University researchers
- Invited external experts

References

Chaput, G., D. Moore, J. Hayward, J. Sheasgreen, and B. Dubee. 2000. Stock status of Atlantic salmon (Salmo salar) in the Miramichi River, 1999. Canadian Stock Assessment Secretariat. Research Document 2000/004. 85 p.

Dempson, J. B., M. F. O'Connell, and N. M. Cochrane. 2001. Potential impact of climate warming on recreational fishing opportunities for Atlantic salmon, Salmo salar L., in Newfoundland, Canada. Fisheries Management and Ecology 8: 69-82.

Dempson, J.B., G. Furey, and M. Bloom. 2002. Effects of catch and release angling on Atlantic salmon, Salmo salar L., of the Conne River, Newfoundland. Fisheries Management and Ecology 9: 139-147.

DFO. 1998. Effects of hook and release angling practices. DFO Science Stock Status Report DO-03 (1998).

Appendix 2. List of participants.

Name	Affiliation
Belanger, Pierre	DFO Fisheries and Aquaculture Management Gulf Region
Breau, Cindy	DFO Science Gulf
Cairns, David	DFO Science Gulf
Caissie, Daniel	DFO Science Gulf
Cameron, Paul	DFO Science Gulf
Carr, Jon	Atlantic Salmon Federation
Chaput, Gerald	DFO Science Gulf
Clement, Marie	DFO Science Gulf
Currie, Suzie	Mount Allison University, Sackville, NB
Curry, Allen	University of New Brunswick, Fredericton, NB
Douglas, Scott	DFO Science Gulf
Gagnon, Luc	NB Department of Natural Resources, Bathurst, NB
Giffin, Geoff	Atlantic Salmon Federation
Hambrook, Mark	Miramichi Watershed Management Committee
Hayward, John	DFO Science Gulf
Jones, Ross	DFO Science Maritimes
Kavanagh, Sana	Confederacy of Mainland Mi'kmaq, Truro, NS
LeBlanc, David	Restigouche River Watershed Management Committee
Metallic, Fred	Listiguij First Nation, Listiquij, Quebec
Randall, Bob	DFO Science Central and Arctic Region, Burlington, ON
Reid, Jenny	Miramichi Salmon Association
Sheasgreen, Joe	DFO Science Gulf
Veinott, Geoff	DFO Science Newfoundland and Labrador Region, St. John’s, NL
Ward, Devin	North Shore Micmac Council

Appendix 3. Meeting agenda.

Thursday, March 15, 2012	Time
Meeting room open, participants arrive and set-up for meeting	8:30 – 9:00 am
Opening remarks and review of agenda	9:00 – 9:15 am
WP 1. Physiology and temperature thresholds (C. Breau)	9:15 – 10:30 am
Break	10:30 – 10:45 am
WP 2. Water temperature characteristics (Caissie et al.)	10:45 am – 12:15 pm
Lunch	12:15 – 1:15 pm
WP 3. Management strategies during warm water events (Breau et al.)	1:15 – 3:00 pm
Health Break	3:00 – 3:15 pm
Conclusions and summary points – review of draft advisory report	3:15 – 5:00 pm