

Approved version - June 2019

Protocol for In-season Conservation Measures for Atlantic Salmon during Environmentally Stressful Conditions in the Margaree River

(Warm Water Protocol)

Published by:
Fisheries and Oceans Canada
2920 Highway 104
Antigonish, NS B2G 2K6

Partnership:
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Margaree Salmon Association
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Atlantic Salmon Federation

This document may evolve based on the availability of new science and approved recommendations from Aboriginal organizations and stakeholders abovementioned.

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This document was last updated: May 23, 2019

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Acknowledgements

This protocol was developed with the support, collaboration and advice from Science, Conservation and Protection, and Resource Management employees at Fisheries and Oceans Canada in the Gulf region, and from representatives with the Nova Scotia Department of Fisheries and Aquaculture, the Margaree Salmon Association, the Nova Scotia Salmon Association and the Atlantic Salmon Federation.

1.0 Introduction

There is an overall concern for the status of Atlantic salmon under stressful conditions associated with exceptional climatic events. In-season management measures have been introduced to reduce the impact of recreational fishing on Atlantic salmon during periods of warm water and low water. In eastern Canada, there has been an increased frequency of closures of in river fisheries as a direct result of warm water levels (Chaput et al. 2000; Dempson et al. 2001).

The Northeast (NE) Margaree River has traditionally been considered a source of cold, clear water throughout the summer months. Recently, warm water occurrences have resulted from extended warm air temperatures and dry weather. This trend culminated in the closure of a portion of the Margaree river in the summer of 2018.

The NE Branch is mainly fed by small sheltered tributaries and springs. It is approximately 70 km in length. The upper 25 km above King Ross is a sanctuary closed to recreational fishing. The lower portion below King Ross flows 30 km to Margaree Forks, where it converges with the Southwest (SW) Margaree River to form the Main Branch. The Main Branch flows an additional 15 km to the ocean. The SW Branch is mainly fed by Lake Ainslie, the largest natural freshwater lake in Nova Scotia. Much of the lake is shallow resulting in relatively warm water temperatures in summer. The SW Branch is approximately 20 km in length. All waters of the Margaree River system excepting the sanctuary are open to public recreational salmon angling (from June 1 to October 31). The entire watershed is 1,161 km².

The process of developing a warm water protocol for in-season intervention during recreational Atlantic salmon angling activities in the Margaree River was initiated in 2018 following season closures and an agreement with stakeholders that a defined protocol to manage warm water events in the Margaree was required.

This protocol does not apply to any Aboriginal food, social and ceremonial fishery agreements for the Margaree River.

1.1 Purpose of this Protocol

The purpose of the Protocol for In-season Conservation Measures for Atlantic Salmon during Environmentally Stressful Conditions in the Margaree River (the Protocol), is to guide the timely implementation of in-season management measures to recreational angling activities in the Margaree River system.

1.2 When to use this Protocol

During the recreational Atlantic salmon angling season (June 1 to October 31), and in particular during the summer months, water temperature will be monitored daily to see if established triggers that require in-season management action to either close or reinstate angling activities to the relevant sections of the river managed by this protocol have been reached.

2.0 Science

Peer reviewed science advice was sought to determine environmental thresholds to define management strategies for Atlantic salmon under environmentally stressful conditions (warm and/or low water). Fisheries and Oceans Canada Gulf Region Science held a Science Advisory Process with the objectives of addressing questions linked to the physiology and metabolic rates of Atlantic salmon associated with level and duration of stress (warm water) and their probability of survival under such conditions.

The following document was published and is available online:

Breau, C. 2013. Knowledge of fish physiology used to set water temperature thresholds for in-season closures of Atlantic salmon (*Salmo salar*) recreational fisheries. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/163. iii + 24 p.

<https://waves.vagues.dfo-mpo.gc.ca/Library/348301.pdf>

Information in this section is directly derived from this document; for references and more detailed information, please refer to this document.

2.1 Tolerance of Atlantic salmon during high water temperatures

Salmonids (trout, salmon, charr) have generally the lowest thermal tolerance of many fish groups. For Atlantic salmon juveniles, the incipient lethal temperature, defined as the temperature which the fish can tolerate for a long period (usually taken as seven days), is 27.8°C. The ultimate lethal temperature for juveniles, defined as the temperature which the fish cannot tolerate even for short periods of time (usually taken as 10 minutes), is in the range of 30 to 33°C. Thermal sensitivity is size-specific such that adult salmonids prefer lower temperatures and are less tolerant of high temperatures than juveniles. As such, incipient lethal temperature and ultimate lethal temperature of adult Atlantic salmon are expected to be lower than the values for juveniles and therefore the incipient lethal temperature for adult salmon is likely near 25°C.

Adult Atlantic salmon acclimated to 23°C survived for at least three days and 70% of the fish were able to recover post-exhaustive exercise when held at that acclimation temperature. However, adult Atlantic salmon only survived temperatures of 24 to 27°C for a short time period. Since the adult salmon held above 24°C were not able to recover from the effects of exhaustive exercise and anaerobic metabolism, this infers that these temperatures are above the critical temperature (T_{crit}). Since some of the adult salmon were able to recover from exhaustive exercise at 23°C, this infers that 23°C is very near

the level for T_{crit} .

Temperature-related stress in juvenile Atlantic salmon has been associated with behavioural changes such as abandonment of feeding territories and aggregations at cool-water seeps. Juvenile and adult salmon have been observed aggregating at sources of cool water when the minimum nighttime temperature remained above 20°C for two consecutive nights. Active feeding also ceased under these warm water conditions.

*Please refer to pages 2 and 3 of Breau (2013) cited above for definitions of T_{opt} and T_{crit} .

2.2 Temperature threshold

Based on laboratory studies of fish obtained in the wild, T_{crit} for 2-year old juvenile Atlantic salmon was estimated to be 24°C. T_{crit} for adult Atlantic salmon has not been measured but the aerobic capacity and thermal tolerance of adults are lower than in juveniles so T_{crit} for adult Atlantic salmon is undoubtedly lower than 24°C. In studies of the recovery rate of adult Atlantic salmon acclimated and subjected to exercise to exhaustion at 18°C, 20°C and 23°C, it was shown that most of the physiological endpoints returned to pre-exhaustion (resting) levels after four hours or more although recovery to resting levels for these endpoints took longer than 4 hours when fish were exercised to exhaustion at 20°C. In these studies, there was a delayed mortality, with 40% of the adult salmon dying when held at 20°C and 23°C. Based on the range observed in other salmonid species, a T_{crit} value of less than 24°C could be assumed.

In salmonids, the temperature range differential T_{crit} and T_{opt} was estimated to be 6 to 7°C. A proxy for T_{opt} for adult Atlantic salmon could be estimated based on the median water temperature experienced during the migration period of June and July.

The scope for activity of adult Atlantic salmon at temperatures just below 23°C is considered to be very small and anaerobic metabolism is required to sustain activities at temperatures above 23°C. Recovery is more rapid at temperatures close to T_{opt} . Daily fluctuations in temperatures can subject adult Atlantic salmon to temperature stress resulting in the accumulation of anaerobic by-products. Although potentially exposed to temperatures that exceed 23°C during the day, Atlantic salmon can recover if temperatures overnight decline to values closer to T_{opt} for even short periods of time, for example for four hours. After exercise to exhaustion, at 23°C, fish at rest can survive for days and in some instances are able to recover to resting state after exercise to exhaustion.

Threshold proposals are based on observed changes in behaviour of Atlantic salmon both in the wild and in experiments with measured physiological responses of adult salmon exposed to exercise at high water temperatures. A daily minimum water temperature rather than a maximum temperature (within the thermal tolerance limits of salmon) is proposed to be the appropriate indicator of physiological recovery and survival. T_{min} value of 20°C is proposed as the threshold temperature for assessing physiological stress in Atlantic salmon.

2.3 Water temperature characteristics in the Margaree River

Water temperature varies on temporal scales of hours, days, seasons and years. In addition, water temperature conditions can be spatially heterogeneous and associated with river size, depth, discharge and other physical features (e.g. elevation, stream exposure, slope, etc.).

There is a well-defined diel and seasonal pattern of water temperatures (minimum, mean and maximum) with peak seasonal temperatures generally occurring towards the end of July. High water temperatures are generally recorded in the months of July and August and often coincide with low water levels in summer.

2.4 Angling success for Atlantic salmon during warm water T°C

Results of a study on the effects of water temperature on angling catches showed that even during high water temperature events ($\geq 20^{\circ}\text{C}$), it is possible for a substantial number of salmon to be caught, even if catch per unit effort was lower (Mowbray and Locke, 1999). For Atlantic salmon, mortality rates are predicted to exceed 20% at water temperatures above 20°C (Dempson et al. 2002; Thorstad et al. 2003).

3.0 River Sections to be Managed by Protocol

1. From the East Margaree highway bridges upstream to the Cabot Trail bridge (also known as Creamery Bridge) on the Southwest Margaree River and upstream to Doyles Bridge on the Northeast Margaree River, and the Gallant River upstream from its confluence with the Margaree River to the highway bridge on the East Margaree Road.
2. From Doyle's bridge upstream to the Big Intervale Bridge on the NE Margaree River.
3. The SW Margaree upstream from the Cabot Trail Bridge (Creamery Bridge) to the Scottsville Bridge.

4.0 Monitoring parameters

During the summer salmon angling period, water temperature is monitored on a daily basis to make an informed decision when environmental conditions become stressful for Atlantic salmon. The same parameter is also monitored to indicate when environmental conditions improve.

When temperature thresholds for action as defined in this protocol are reached, the following parameters are also monitored daily: water level, air temperature, and long term

forecast. Information on fish behaviour is also sought.

4.1 Water temperature

Water temperature is the main parameter to monitor during the Atlantic salmon angling season. Water temperature will trigger the process to implement or remove in-season management measures for Atlantic salmon in the Margaree River. Secondary parameters will provide supporting evidence that angling restrictions or the removal of angling restrictions are warranted.

Every weekday morning during summer months, DFO officials will review the past 24hrs of data available from the DFO Real-time Water Temperature Monitoring Station located in the upper part of the River section 1 as defined in this protocol. This monitoring station is the only one able to provide information in real-time during the fishing season (see an example at Appendix C). Several other temperature loggers that need to be manually downloaded are installed in various locations in the river and provide annual hourly temperature data.

4.2 Water level

Water levels play a role in the warming and cooling of the water in the system depending on the air temperature, precipitation, and exposure time to day light.

Water level data is monitored during the weekdays when temperature thresholds are reached by DFO officials using Environment Canada's real time online data services. This serves as supporting information to close or reopen sections of the river.

4.3 Long term forecast

The 7 day forecast (long term) is monitored during the weekdays when temperature thresholds are reached by DFO officials using Environment Canada's online weather services. Weather for the area in North East Margaree serves as supporting information to implement or rescind angling restrictions (Appendix E).

4.4 Fish behaviour

Fish behaviour includes the monitoring of Atlantic salmon movement up the river to their spawning grounds. Under stressful environmental conditions, such as high water temperature and low water levels, Atlantic salmon will congregate to areas where conditions lower their level of stress and improve their capacity of survival. Adult salmon will be the first to seek refuge in these preferred conditions, followed by juvenile salmon, and other salmonids.

Atlantic salmon are less likely to take a fly under stressful environmental conditions, but it is a possibility and in such a case they would likely not recover from the stress as well as they would during optimum environmental conditions.

Fish behaviour is observed and monitored by partners and fishery officers and is reported when supplemental information is required to make an informed decision. DFO officials request the information from partners and fishery officers.

5.0 Management actions

The warm water protocol consists of management actions that restrict angling activities in the Margaree River based on the water temperature trigger, and supported by secondary parameters. The opposite approach applies for the removal of angling restrictions.

Prior to the implementation of any of the following management actions, consultations will occur with the partners of this protocol.

The final decision to implement any management action resides with the Department of Fisheries and Oceans.

This protocol will be reviewed annually and may be modified if necessary.

5.1 Closure criteria

Parameters recorded / observed	Information collected	Management action
Water temperature at the DFO Real-time Water Temperature Monitoring Station	$T_{\min} < 20^{\circ}\text{C}$	Maintain access to the river while respecting the current management plan for the Margaree River.
Water temperature at the DFO Real-time Water Temperature Monitoring Station	$T_{\min} > 20^{\circ}\text{C}$ 2 consecutive periods of 24h	Implement a closure to angling for all species, sections 1 and 3 as defined in section 3.0.
Water levels	Water levels are decreasing	
Long term forecast (next 7 days)	High daily temp Warm nightly temp Little chance of rain	
Fish behaviour	Fish congregating in cold water refuges (i.e. Gallant River)	
Water temperature at the DFO Real-time Water Temperature Monitoring Station	$T_{\min} > 23^{\circ}\text{C}$ for 2 consecutive periods of 24 hours	Maintain closure in sections 1 and 3 and implement a closure to angling for all species on the upper sections of the NE Margaree river (section 2. as defined in section 3.0).
Water levels	Water levels are lowering	
Long term forecast (next 7 days)	High daily temp Warm nightly temp Little chance of rain	
Fish behaviour	Fish staying in cold water refuges (i.e. Gallant River), including juvenile salmon Salmon mortalities, or salmon in distress observed by C&P or partners	

5.2 Reopening criteria

Parameters recorded / observed	Information collected	Management action
Water temperature at the DFO Real-time Water Temperature Monitoring Station	$T_{\min} < 23^{\circ}\text{C}$ for two consecutive periods of 24H	Remove restrictions on the upper section of the NE Margaree River (2. as defined in section 3.0). maintain closure of sections 1. and 3.
Water levels	Stable or increasing	
Long term forecast (7 days)	Moderate or Lowering daily temp Cooler night temp Chance of rain	
Fish behaviour	No salmon mortalities or salmon in distress observed in lower sections or river	
Water temperature	$T_{\min} < 20^{\circ}\text{C}$ for 2 consecutive periods of 24H	Remove angling restrictions on the lower sections of the river (1 and 3. as defined in section 3.0).
Water levels	Stable or increasing water levels	
Long term forecast (next 7 days)	Moderate daily temp Cool nightly temp Chance of rain	
Fish behaviour	Fish moving out of cold refuges	

6.0 Communication

All variation orders will be communicated as required under the Fisheries Act by Fisheries and Oceans Canada. Management actions will also be published on the Gulf Region Recreational Fisheries web page as a Notice to Recreational Anglers under Atlantic salmon. A link to the notice is also emailed to the partners of this protocol for distribution at large.

Appendix A – Science advice (March 2012)

Science Advisory Report 2012/019

Temperature threshold to define management strategies for Atlantic salmon (*Salmo salar*) fisheries under environmentally stressful conditions

Summary

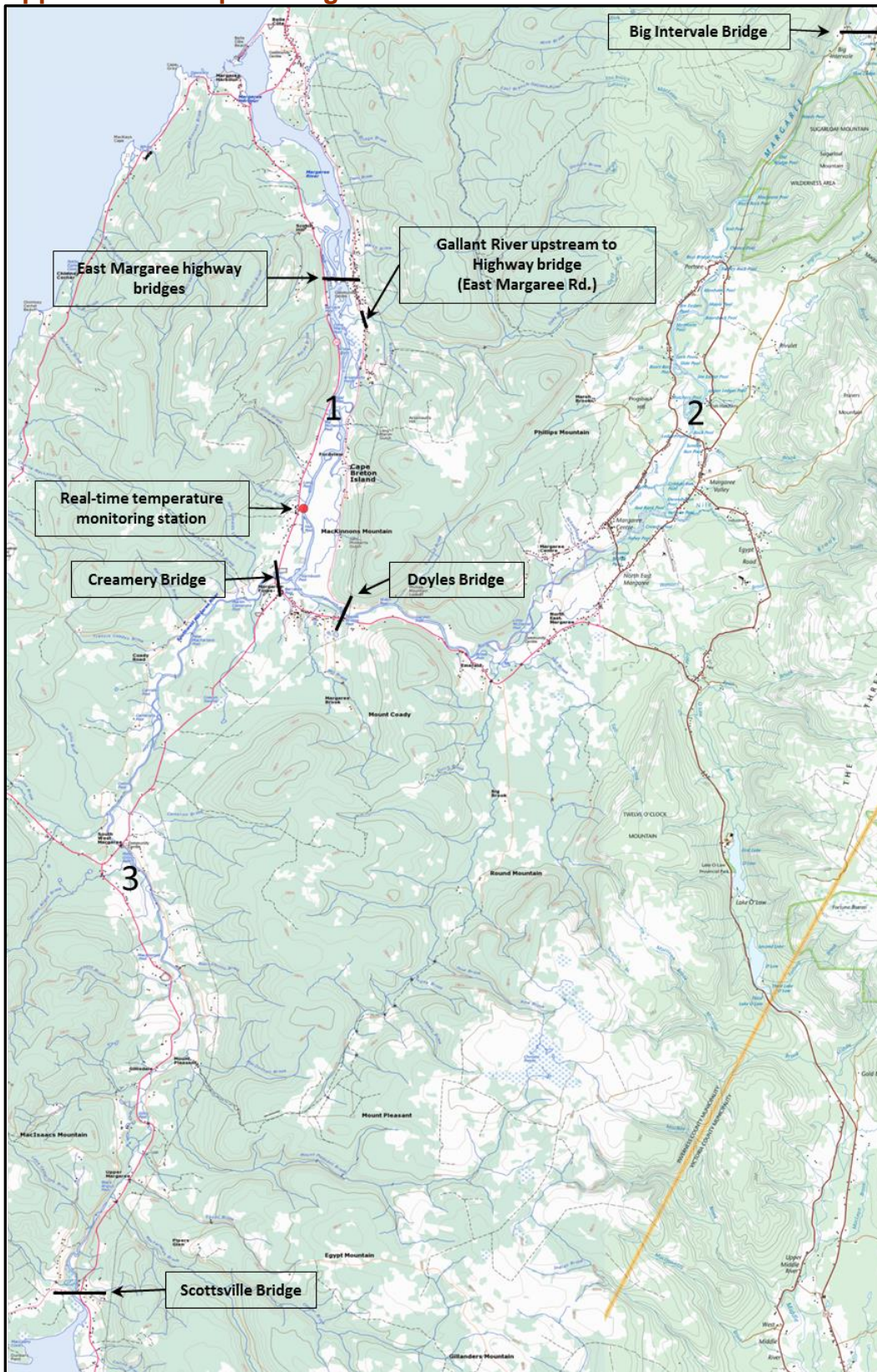
- Temperature tolerance in Atlantic salmon is size-specific with adult salmon less tolerant of high temperatures than juveniles.
- There is limited information on optimal temperatures and critical temperatures that define the aerobic scope for adult Atlantic salmon and inferences are made based on evidence from juvenile life stages of Atlantic salmon and other species.
- The temperature thresholds proposed are based on bioenergetic considerations. A daily minimum water temperature (T_{\min}) of 20°C is proposed to be most important for physiological recovery and survival of Atlantic salmon.
- The proposed closure trigger is if the minimum water temperature (T_{\min}) during each of two consecutive days equals or exceeds 20°C.
- The proposed opening trigger is if the minimum water temperature (T_{\min}) during each of two consecutive days is less than 20°C.
- Mean water temperatures show spatial structure within the Miramichi River and the Restigouche River based on main stem or tributary sites and distance from the estuary.
- The management performance of the proposed closing and opening triggers can be assessed by retrospective evaluation using criteria such as the number of closures and the duration of the closures.
- The number of salmon vulnerable to mortality from angling activities during warm water conditions is not known. In river mortalities of adult Atlantic salmon are not systematically documented in either the Miramichi or Restigouche rivers and angling statistics at a temporal scale sufficient for assessing the potential impacts of angling during warm water periods are not available.
- Other human activities can displace fish and contribute to stress on Atlantic salmon during warm water events including wading in streams, swimming in pools, boat traffic, as well as scientific activities.

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, regional peer review meeting of March 15, 2012 on the development of Environmental Thresholds to Define Management Strategies for Atlantic Salmon Fisheries under Environmentally Stressful Conditions.

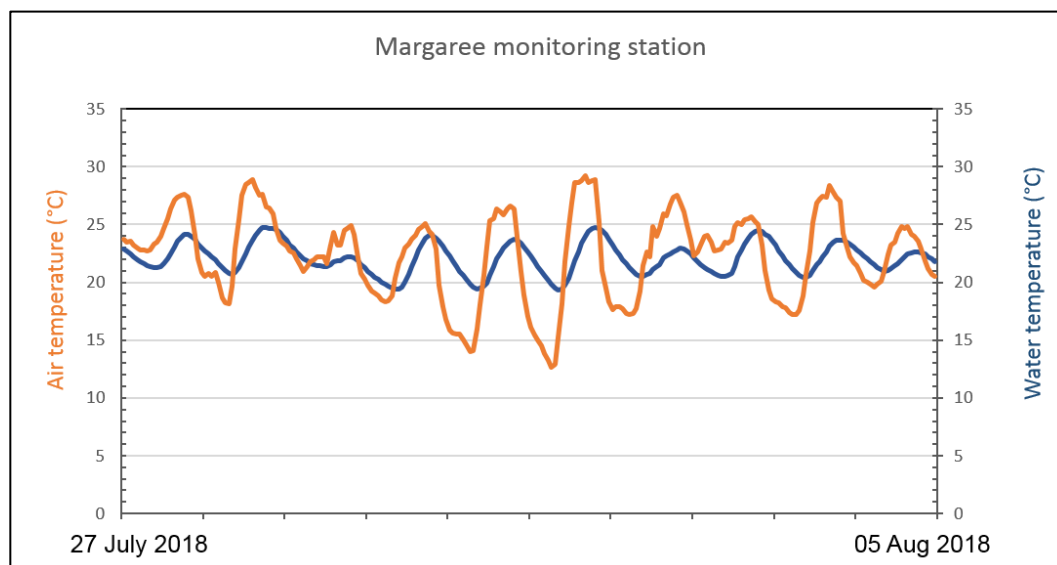
You can find the full document at the following address:

http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2012/2012_019-eng.html

Appendix B – Map of Margaree

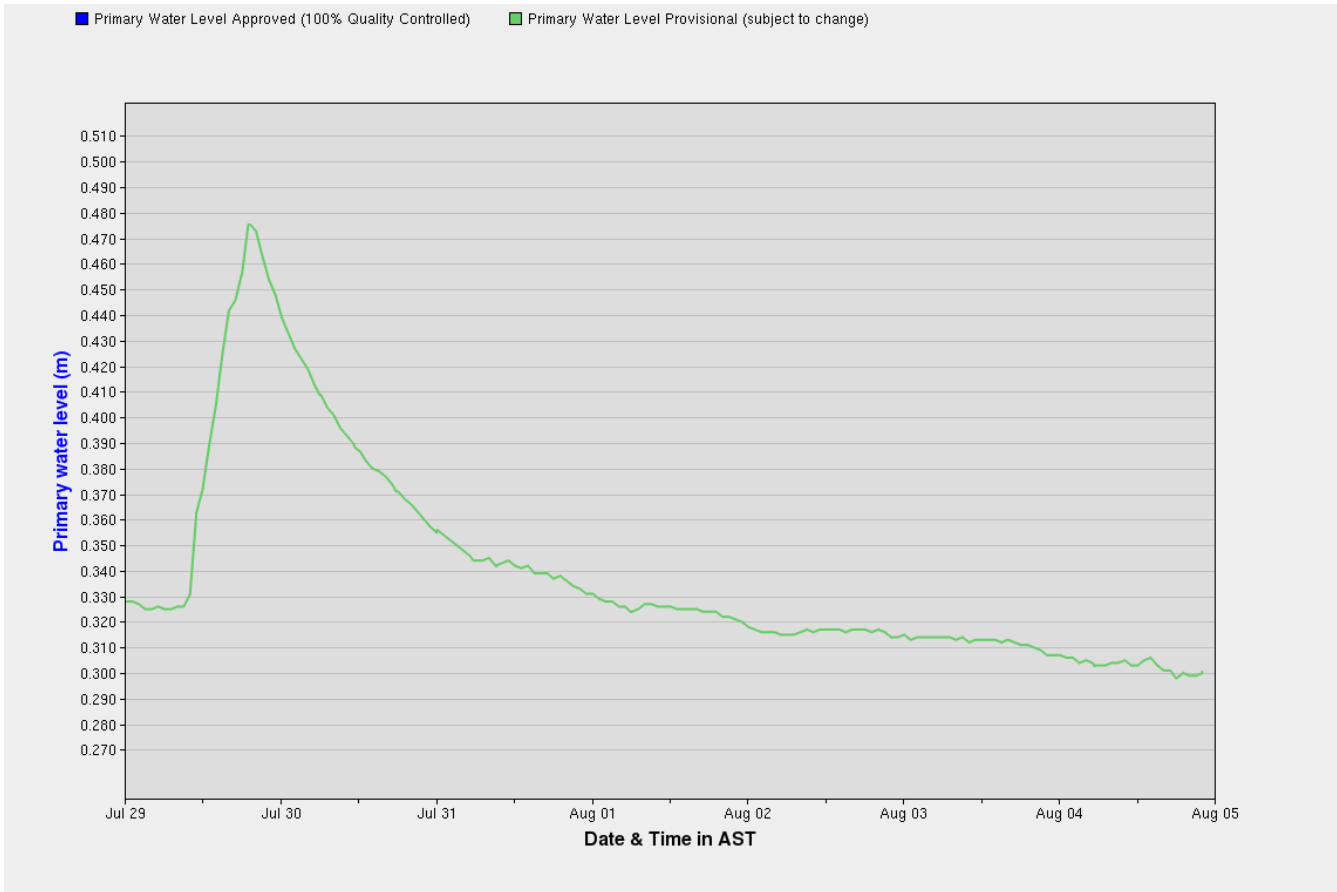


Appendix C – Water temperature graph



Example of hourly air (orange line) and water (blue line) temperature data remotely accessed from the DFO real-time monitoring station located on the main branch of the Margaree River (section 1 as defined in this protocol) for the period July 27 to August 5, 2018.

Appendix D – Water level graph
















Real-time hydrometric water level (meters) data example for July 29 to August 4 2018 period, provided by Environment and Climate Change Canada for the Northeast Margaree River at Margaree Valley (station 01FB001).

Appendix E – Environment Canada 7 day forecast for North East Margaree, NS

North East Margaree, NS

No Alerts in effect

Forecast Issued: 5:00 AM ADT Saturday 29 July 2017

Sat 29 Jul	Sun 30 Jul	Mon 31 Jul	Tue 1 Aug	Wed 2 Aug	Thu 3 Aug	Fri 4 Aug
 22°C 72°F 30% Chance of showers	 23°C 73°F Clearing	 27°C 81°F Sunny	 25°C 77°F A mix of sun and cloud	 23°C 73°F Sunny	 25°C 77°F A mix of sun and cloud	 23°C 73°F A mix of sun and cloud
Tonight	Night	Night	Night	Night	Night	
 13°C 55°F Increasing cloudiness	 13°C 55°F Clear	 16°C 61°F Clear	 14°C 57°F Clear	 15°C 59°F Clear	 15°C 59°F	

Appendix F – Roles and responsibilities

Fisheries and Oceans Canada – Fisheries and Aquaculture Management

- Monitor parameters – water temperature, water level, long term forecast, and observation of fish behaviour during C&P patrols
- Identify and provide information on possible areas of fish congregation during warm water events for protection
- Coordinate closure – inform partners when triggers have been met, gather input from partners, prepare variation order, communicate closure via email and online posting on DFO Gulf Region Recreational Fisheries web page
- Coordinate working group meetings / conference calls when necessary
- Penholder of this protocol

Margaree Salmon Association

- Provide input in the process to implement or remove closures
- Identify and provide information on possible areas of fish congregation during warm water events for protection
- Participate in working group meetings when necessary
- Communicate closures and openings to members and online

Nova Scotia Salmon Association

- Provide input in the process to implement or remove closures
- Identify and provide information on possible areas of fish congregation during warm water events for protection
- Participate in working group meetings when necessary
- Communicate closures and openings to members and online

Atlantic Salmon Federation

- Provide input in the process to implement or remove closures
- Identify and provide information on possible areas of fish congregation during warm water events for protection
- Participate in working group meetings when necessary
- Communicate closures and openings to members and online

Nova Scotia Department of Fisheries & Aquaculture

- Provide input in the process to implement or remove closures
- Identify and provide information on possible areas of fish congregation during warm water events for protection
- Participate in working group meetings when necessary
- Communicate closures and openings online