Coastal Action 2018-19 Review of Fisheries Activities for the Atlantic Whitefish Recovery Project

By

Coastal Action

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Goals and Objectives

Coastal Action's Atlantic Whitefish Recovery Project (AWRP) had several goals and objectives for the 2018 field season. These goals and objectives are outlined as follows:

1. To continue to address knowledge gaps surrounding the life history of Atlantic whitefish such as migratory behaviour and selection of spawning habitat.
2. To increase Atlantic whitefish awareness within the community.
3. To continue to assess the impact on Atlantic whitefish population stability caused by smallmouth bass (SMB) and chain pickerel (CP).
4. To establish catch per unit effort (CPUE) records for SMB and CP.
5. To conduct a stomach contents survey and analysis of SMB and CP from the upper Petite Rivière lakes.
6. To operate and monitor the Hebb Lake Dam fishway and trap.
7. To operate and monitor a rotary screw trap (RST) at the base of Milipsigate Dam.
8. To assist with a boat electrofishing study of invasive species in the upper Petite Rivière lakes.
9. To work with the South Shore Wildlife Association in our invasive species removal efforts.
10. To begin detailed lake survey work focused on Milipsigate Lake.

Methodology

Study Area

All sampling took place within the Petite Rivière watershed (Figure 1) between April 17 and December 31, 2018. All data was collected from three lakes; Minamkeak, Milipsigate, and Hebb; as well as the main branch of the Petite Rivière and the upper and lower tributaries that feed into the main river.

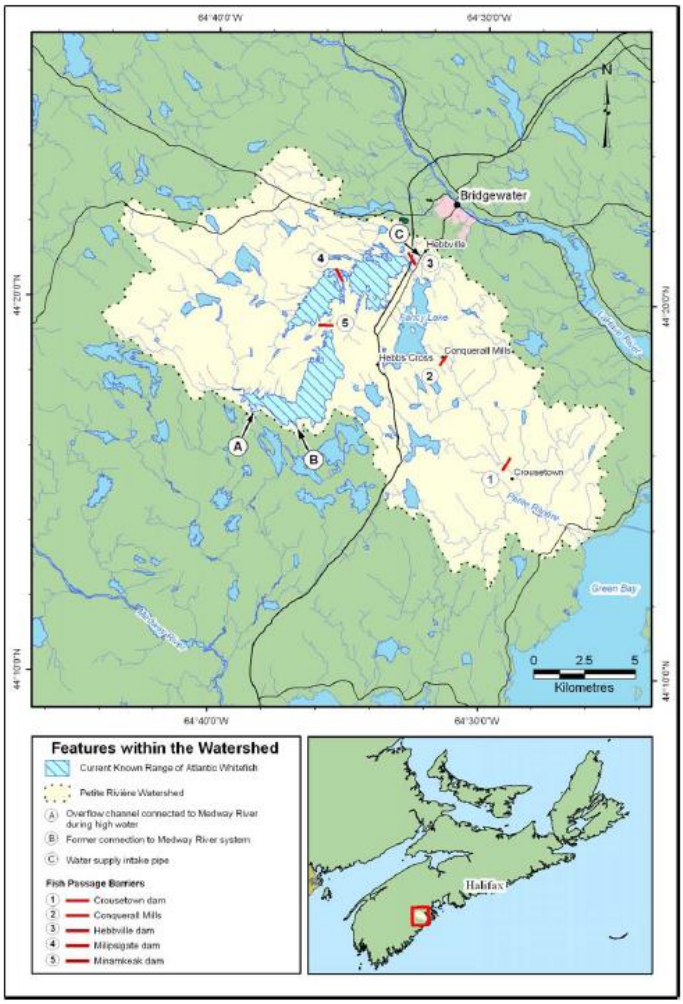


Figure 1. Map of the Petite Rivière watershed showing the three lakes (i.e., Minamkeak, Milipsigate, and Hebb), which contain the existing wild Atlantic whitefish population, as well as the dams that currently impede fish passage.

Outreach and Education

An important component of the AWRP is to provide the local community and beyond with information about the plight of the Atlantic whitefish and ongoing recovery efforts. Coastal Action staff presented to local community groups and/or had an information booth available at the following festivals and events during the 2018-19 AWRP project year:

- Presentations at several South Shore Regional School Board schools
- UK Coregonid Conservation Society Meeting – Glasgow, United Kingdom
- Rotary Club of Lunenburg
- South Shore Wildlife Association
- Friends of Nature meetings
- Privateer Days – Liverpool, Nova Scotia
- World Oceans Day

- Lunenburg Rotary Club meeting
- Mersey Tobeatic Research Institute
- Two-Eyed Seeing Gathering – Bear River, Nova Scotia

Smallmouth Bass and Chain Pickerel Biological and Catch per Unit Effort (CPUE) Study

A biological study and catch per unit effort (CPUE) survey was conducted in Hebb, Milipsigate, and Minamkeak Lakes, with special focus paid to the Milipsigate Outlet and Milipsigate Lake. All angling took place between May 1, 2018 and October 9, 2018. Using a 14 ft Princecraft aluminum boat and a four-stroke Yamaha motor, two or three anglers fished a range of habitats, concentrating on several habitat types found in the Milipsigate Outlet. These habitats included rocky drops, vegetated areas, and areas with flowing water such as the base of the Milipsigate Dam.

Figure 2. Aerial view of Milipsigate Outlet.

As part of the CPUE study, the following details were recorded:

- Total angling time at each site (minutes)
- Number of anglers
- Weather conditions
- Water temperature (°C) – Measured using a digital thermometer
- Type of lure used (i.e., Artificial worm)
- Catch data: species, fork length (cm), weight (kg)
- Stomach contents (fish, invertebrate, or empty)

- Sex of fish

The estimated CPUE value was calculated by dividing the number of angled smallmouth bass or chain pickerel by the total amount of time spent fishing in each area of the lake.

All invasive species angled during the CPUE study, as well as any captured in passive fish traps (the rotary screw traps or fishway trap), were retained and analysed for the biological component of the study. All fish were placed on ice in a cooler and were sampled within a few hours of their capture. Weight (kg), fork length (cm), sex, and stomach contents were recorded for each fish.

To determine feeding preferences, stomach contents of each fish were extracted using a filet knife and examined. The stomach contents were removed by making an incision in the fish on its ventral surface between the vent to the base of the gills to expose the internal organs. The stomach was carefully removed from the body cavity and its contents were inspected for the presence of fish or invertebrates. The mouth and throat of the fish was then inspected to visually assess whether regurgitation of stomach contents had occurred. Stomach contents were recorded as fish, invertebrate, empty, or other.

Rotary Screw Trap/ Fyke Net Study

A rotary screw trap (RST) (manufactured by EG Solutions, Inc., Corvallis, Oregon, USA) was installed directly below Milipsigate Dam. Rotary screw traps are most commonly used to capture downstream migrating salmon smolts during springtime to estimate Atlantic salmon smolt population size. The trap consists of a 5 ft diameter rotating conical drum, which is suspended between two 16 ft-long pontoons and partially submerged. Adequate depth and water flow are required to keep the drum rotating and to guide fish to a live holding box at the rear of the trap. In this case, the trap was operated with the intent to remove invasive species with consideration to the possibility of capturing Atlantic whitefish that have been known, historically, to congregate below Milipsigate Dam during May. The trap was assembled in a cove close to the site and positioned in the outflow from Milipsigate Lake. The corner of each pontoon was secured to the bank using polypropylene rope.

Figure 3. RST-BCAF deployed at Milipsigate Dam.

Coastal Action operated two RSTs during Spring 2018. RST-BCAF operated between April 17, 2018 and June 27, 2018 and from October 14, 2018 to December 21, 2018. The second RST, owned by DFO, was operated by Coastal Action between April 23, 2018 and May 31, 2018. This RST was located in Milipsigate Lake at the outflow of Minamkeak Brook. Both traps were checked by Coastal Action staff daily. Fish were removed from the holding tank of the RSTs using a dip net and placed in a bucket for sampling. All fish were identified, fork lengths were recorded (cm), and the native fish were then released. Non-native fish (smallmouth bass and chain pickerel) were measured and then sacrificed to examine stomach contents. Physical data, including water temperature (^{o}C) and weather conditions, were also recorded daily. Once all fish had been sampled and released or sacrificed, all debris was removed from the holding tank.

Figure 4. RST-DFO deployed on Minamkeak Brook.

In addition to the Rotary Screw Traps, Coastal Action also checked two fyke nets daily. These nets were located at the overflow channel between Milipsigate Lake and Hebb Lake, and downstream from Weagle Dam, respectively. The overflow channel fyke net was deployed on April 25, 2018 and remained operational until May 25, 2018. The Weagle Dam fyke net was operational between April 25, 2018 and May 17, 2018. Both fyke nets had a 30" square frame, with 6 ft wings at 45°, and a 3 ft-deep skirt, all in 1/16" knotless mesh. The body of each fyke net was 12 ft long and was attached to a holding box via a 6'' diameter opening as seen below. Zippers along each segment of the body provided access to the nets' interior and were used to clean out debris.

Figure 5. Fyke net deployed at overflow channel between Hebb Lake and Milipsigate Lake.

Figure 6. Aerial View of fyke net (overflow channel) location.

Figure 7. Fyke net downstream from Weagle Dam.

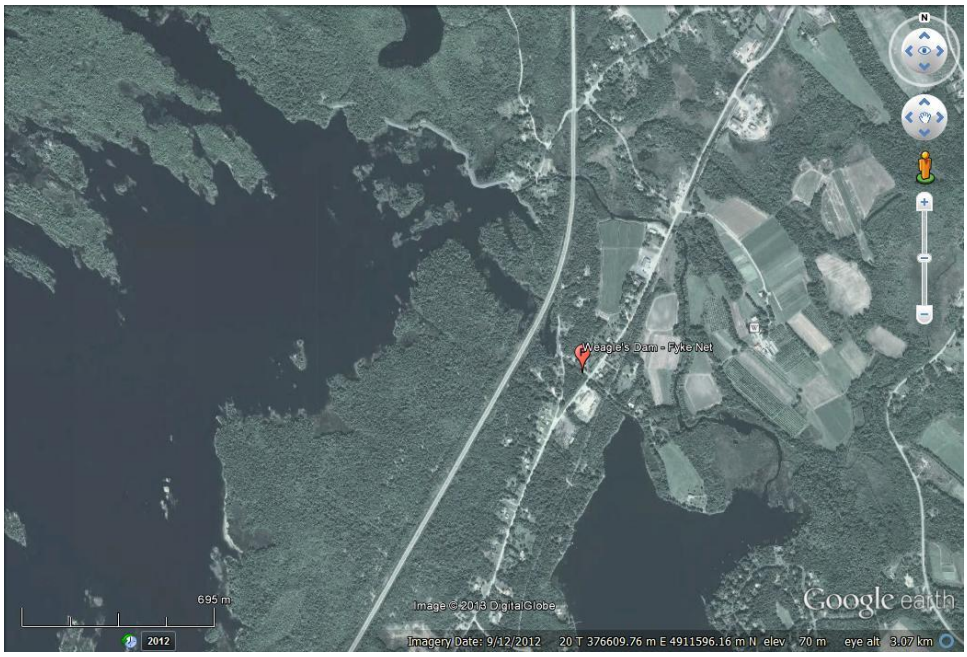


Figure 8. Aerial view of fyke net at Weagle Dam.

Spring and Fall Monitoring and Sampling Activities at the Hebb Lake Dam Fish Passage Facility

The Hebb Lake Dam Fish Passage Facility was opened by Coastal Action staff on April 30, 2018 and was operated until July 6, 2018, to allow for the upstream migration of gaspereau (*Alosa pseudoharengus)* and, from October 15, 2018 to December 19, 2018 to allow for the monitoring of Atlantic whitefish if any were to migrate upstream. A suspended 6'0" x 6'8" x 7'8" aluminum box was deployed in the fishway passage to intercept any fish that are migrating upstream into Hebb Lake. During the above time periods, the trap was monitored daily (See Figure 9).

Each day, a minimum of two staff lifted the trap using a chain pulley system. The trap was opened, and each captured fish was netted and placed in a holding tank.

In the case of the capture of an Atlantic whitefish, the fish would be held in a plexiglass aquarium to facilitate visual examinations for any signs of injury (i.e., fin clips, fin/snout erosion, tags, and general health) and to allow photos to be taken while keeping handling to a minimum. Each fish would be measured for fork length (cm), and a DNA sample (fin clip) would be taken.

All fish were sampled and released as per the protocols outlined in DFO's Hebb Lake Dam Fish Passage Facility Interim Monitoring Plan. The following species were permitted to pass upstream: white sucker (*Catostomus commersonii)*, brown bullhead (*Ameiurus nebulosus)*, gaspereau *(Alosa pseudoharengus),* brook trout (*Salvelinus fontinalis*), and American eel (*Anguilla rostrata*). Smallmouth bass (*Micropterus dolomieu*) and chain pickerel (*Esox niger)* were sacrificed for the biological study. The monitoring plan protocols ensured that any fish entering Hebb Lake would not pose a risk to Atlantic whitefish. In addition, the Hebb Lake level was recorded daily using a gauge attached to the fishway (Figure 9); and water temperature was also recorded daily.

Figure 9. Left - Fishway trap, photo courtesy of Kim Robichaud-LeBlanc (DFO). Right - Hebb Dam lake level gauge.

Smallmouth Bass Nest Survey

Determination of study site

In early June, the shoreline of Milipsigate Lake was evaluated to determine an appropriate area to conduct a smallmouth bass nest survey. A team of two used a 14 ft Princecraft aluminum fishing vessel to visually evaluate the shoreline to determine the areas in which smallmouth bass had already begun creating nests. This resulted in four discrete potential study sites. Each site was then reassessed to determine which area had the most bass nests already established and would be most accessible with the low water levels characteristic of summer on Milipsigate Lake. It was determined that the shoreline at the north end of Milipsigate Lake had the most bass nests already present and, therefore, this location would be the official study area to be continually reassessed during the study period.

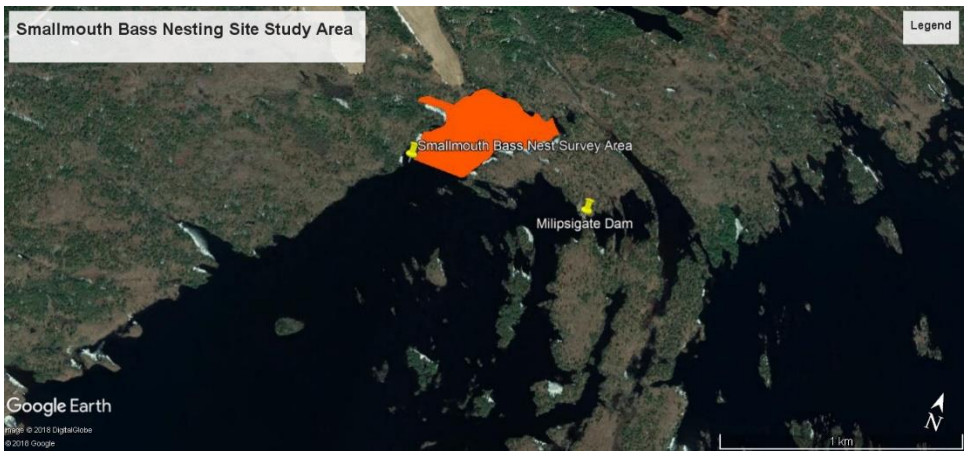


Figure 10. Satellite image showing the study area used for the smallmouth bass nest survey.

Figure 11. Rocky shoreline in Demone Cove used as the study area for the bass nest survey.

Evaluation of Bass Nests

Evaluation of bass nests took place using a 14 ft aluminum Princecraft fishing boat equipped with a 4-stroke Yamaha outboard motor. A team of two conducted a visual survey of the shoreline and recorded coordinates of bass nests using a Garmin eTrex 10 handheld GPS unit. Nests were evaluated using a Rickly Hydrological Co. AquaScope II viewer and classified according to the progression of the nests as per the following table:

Table 1. Smallmouth bass nest classes and descriptions.

NEST CLASS	DESCRIPTION
CLASS A	Newly excavated
CLASS B	Eggs present
CLASS C	Fry present but not dispersed
CLASS D	Fry dispersed
F1	Nest abandoned after being Class A
F2	Nest abandoned after being Class B
NE	No eggs visible
CF	Couldn't find nest
N	Too late to assess

Nest assessment was limited to sunny days with minimal wind to ensure ideal viewing conditions. Nests were assessed four times over the month of June and the progression of each nest was tracked. Newly excavated nests were also recorded and classified as they were found.

Zooplankton Hauls and Lake Profiling

Samples were taken monthly (July, August, and September) at the deep spot of Milipsigate Lake (44.33505, -64.60512). Firstly, a Secchi disk reading was taken followed by a profile using a ProDSS Digital Professional Series YSI sonde (model # 18A104818). Lastly, a vertical haul for zooplankton was performed using a modified CABIN kick net (mesh size 355 µm).

The YSI probe was used to collect temperature (°C), dissolved oxygen (% and mg/L), conductivity (µs/cm), TDS (mg/L), and pH readings from the surface to the substratum at 1 m intervals.

The zooplankton hauls were done using a CABIN kick net (mesh size 355 µm) that had been modified for use in this study. The wooden handle was removed, and rope was tied onto the metal ring of the net at three points and then tied together to make a line to be used for vertical hauling. Prior to performing the zooplankton hauls, the net was rinsed three times in the lake, without allowing lake water to spill over the top of the net. The sample jars (250 mL Mason jars) were then rinsed three times within the net while the net remained in the water with its ring above the surface. This was done to prevent any material from entering the sample jars that would not be excluded by the net's mesh size.

Lake depth at sample site was determined using a Humminbird Helix 9 SI unit and the net was lowered to 1 m off the bottom of the lake. The net was then hauled back up by hand at a constant speed of approximately 0.5 m/s and rinsed to ensure all net contents were flushed to the bottom of the basket.

The basket was detached from the net, and the mesh filter was removed using tweezers and then rinsed off with 95% ethanol (EtOH) into a sample jar. After emptying all basket contents into the sample jar, additional ethanol was added to ensure the preservation of the sample.

Analysis

Samples were analyzed using a compound microscope and specimens were identified to species level.

Bathymetry Survey on Milipsigate Lake

Starting in July 2018, Coastal Action staff began to map the bathymetry of Milipsigate Lake. Using a Humminbird Helix 9 SI unit provided by DFO and mounted to the Princecraft fishing boat using clamps, staff used the equipment to record the contours of the lake and the substrate bottom. This survey was carried out simultaneously while angling for invasive species for the CPUE study and fish health screening, as well as during lake profiling and zooplankton hauls.

Fish Health Screening

On September 14, 2018, Coastal Action staff and Jeremy Broome (DFO) angled on Milipsigate Lake using a 14 ft aluminum Princecraft vessel to collect 30 smallmouth bass to be sent to the Fish Health Unit in Moncton, New Brunswick to analyse tissue for potential pathogens and disease. This was necessary as Atlantic whitefish have been transferred from Milipsigate Lake and, may in future, be translocated to another lake which could infect resident fish if pathogens are present. The assumption was made that smallmouth bass would carry the same pathogens and disease as the Atlantic whitefish removed from the same lake.

Underwater Filming

Milipsigate Lake

On May 8 and 9, 2018, underwater filming was conducted in Milipsigate Lake 100 m northwest of the DFO-RST at Minamkeak Brook. This was done to check for the presence of adult Atlantic whitefish in the area. A GoPro Hero 2 camera on a telescope pole was mounted to a milk crate and a buoy on a rope was also tied onto the crate. Rocks were placed inside the crate to weigh it down, and the crate was lowered to the lake bottom using another rope. The camera was left for one hour each day, and then retrieved.

Milipsigate Dam

Post-capture of the adult Atlantic whitefish in December 2018, a GoPro Hero 2 camera mounted on a telescopic pole was used to film the area surrounding and underneath the rotary screw trap at the base of Milipsigate Dam. This was done to look for the presence of other adult Atlantic whitefish in the area.

Results

Smallmouth Bass Catch Per Unit Effort (CPUE) Study

A total of 377 smallmouth bass were angled and removed from the watershed during the CPUE study. All fish were angled using an artificial worm (Figure 12).

Figure 12. Artificial worm lure with hook.

Table 2. Number of smallmouth bass angled from seven fishing areas, the total amount of time spent angling, the estimated catch per unit effort in hours (CPUE), and other incidentally angled species.

Area	Number of bass angled	Total time spent angling (Hrs)	Estimated CPUE (# bass/hour)	Other species angled
Hebb Lake	25	5	5	Chain pickerel
Milipsigate Outlet	78	20	3.9	White perch, Chain pickerel
Milipsigate Lake	209	64	3.25	Chain pickerel
Minamkeak Lake	1	.25	4	None
Hebb Dam to Fancy Lake	50	6.25	8	Chain pickerel
Minamkeak Brook	14	.5	28	None
Total	**377**	**96**	**3.92**	

Between May 1, 2018 and October 17, 2018, approximately 96 hours were spent angling in the Petite Rivière watershed. In 2018, two areas accounted for over 87% of all angling effort, two thirds (66%) occurred on Milipsigate Lake, and 21% at the Milipsigate Outlet.

It should be noted that these numbers do not include any boat electrofishing data, the 140 smallmouth bass (SMB) removed by Jeremy Broome (DFO) from the three upper lakes during 2018, the 59 SMB removed from Wallace Lake by the South Shore Wildlife Association (SSWA), and the 30 SMB collected for the fish health screening. An additional 12 SMB were angled from Milipsigate Lake, tagged and fitted with a VEMCO transmitter, and then released back into the lake as part of a DFO study which will monitor SMB movement within the lake from October 2018 until the summer of 2019.

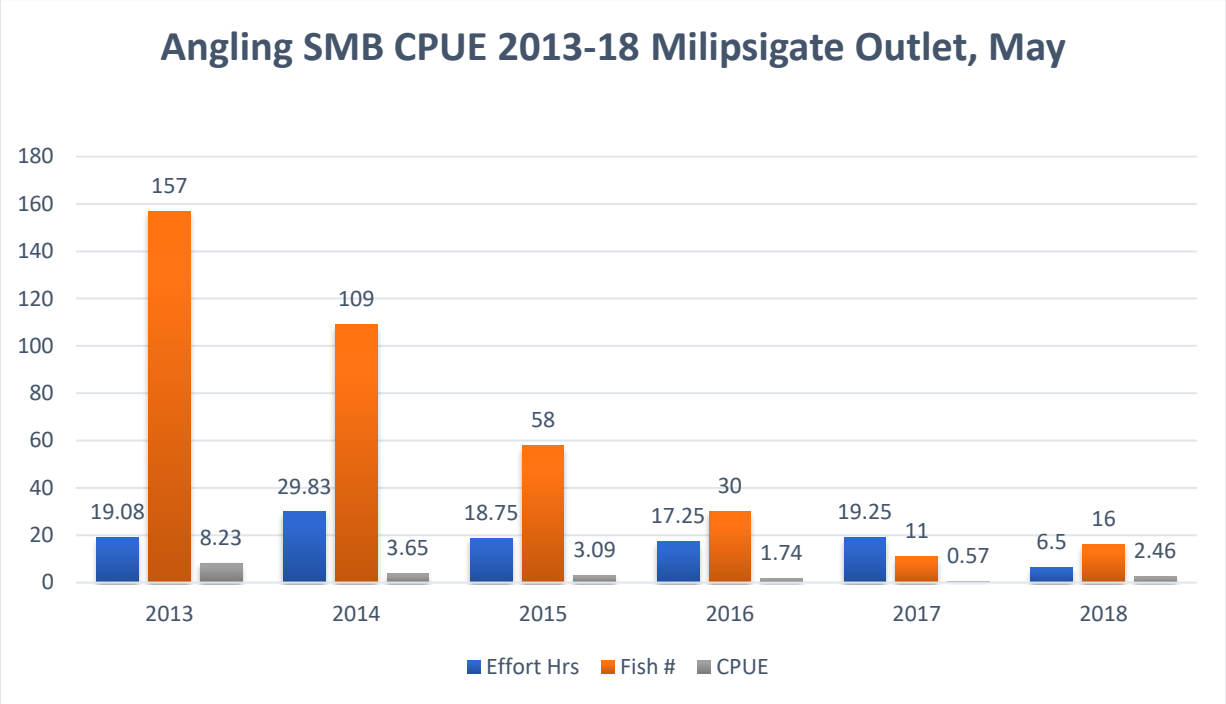


Figure 13. Number of smallmouth bass angled from Milipsigate Outlet during May of each year, total amount of time spent angling, estimated catch per unit effort (CPUE), and average length (cm).

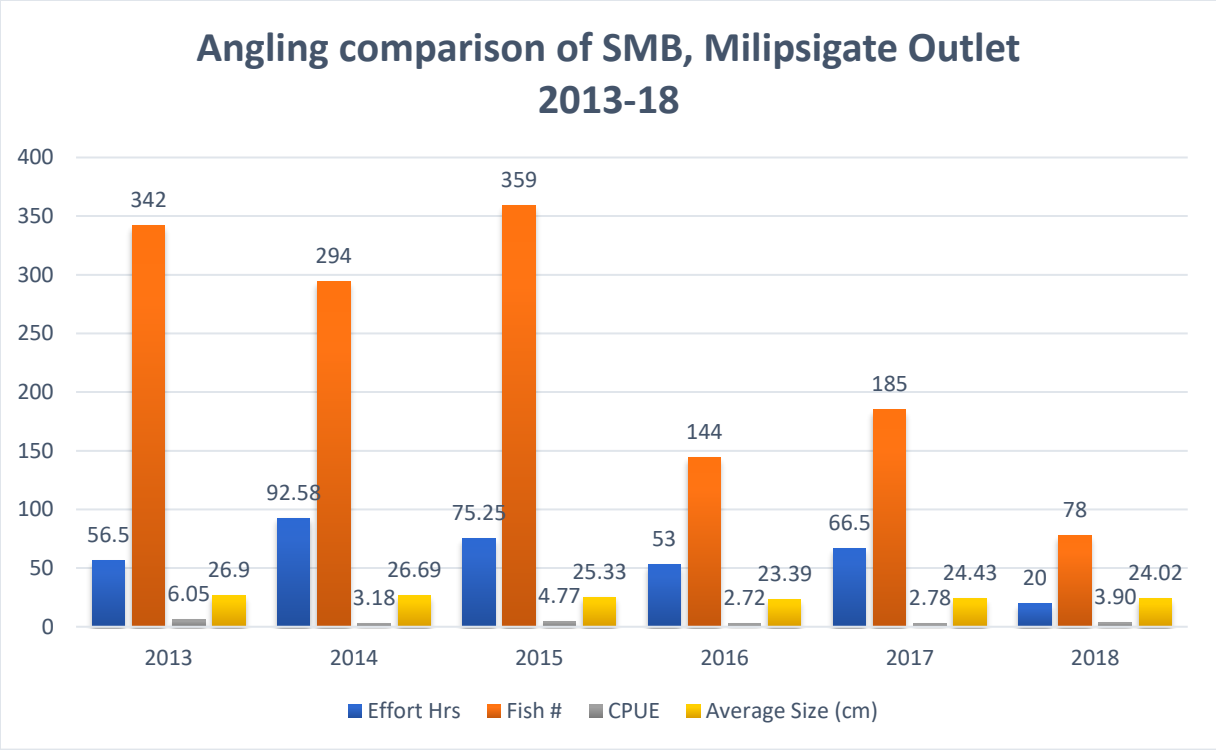


Figure 14. Number of smallmouth bass angled from Milipsigate Outlet, total amount of time spent angling, estimated catch per unit effort (CPUE), and average length (cm).

The two graphs above represent the angling effort at Milipsigate Outlet over the last five years, 2013-2018. Figure 13 indicates that the presence of SMB has dramatically decreased at this location during May of each year except for in 2018, where staff have observed an increase in the CPUE. Figure 14 also indicates a slight increase in the CPUE for 2018.

Chain Pickerel Catch Per Unit Effort (CPUE) Study

A total of 16 chain pickerel were removed by angling and analysed for CPUE comparisons with previous years. Angling effort was 96 hours and all fish were caught using the same lure as shown in Figure 12.

NB: The South Shore Wildlife Association (SSWA) removed 16 chain pickerel from Garber Lake. Finally, an additional 18 CP were angled from Milipsigate Lake, tagged and fitted with a VEMCO transmitter, and then released back into the lake as part of a DFO study which will monitor CP movements within the lake from October 2018 until the summer of 2019.

Table 3. Number of chain pickerel angled from six fishing areas, total amount of time spent angling, estimated catch per unit effort (CPUE), and other incidentally angled species.

Area	Number of CP angled	Total time spent angling (Hrs)	Estimated CPUE (# CP/hour)	Other species angled
Hebb Lake	5	5	1	SMB
Milipsigate Outlet	1	20	0.05	White perch, SMB
Milipsigate Lake	9	64	0.14	SMB
Minamkeak Lake	0	.25	0	None
Hebb Dam to Fancy Lake	1	6.25	0.16	SMB
Minamkeak Brook	0	.5	0	None
Total	**16**	**96**	**0.16**	

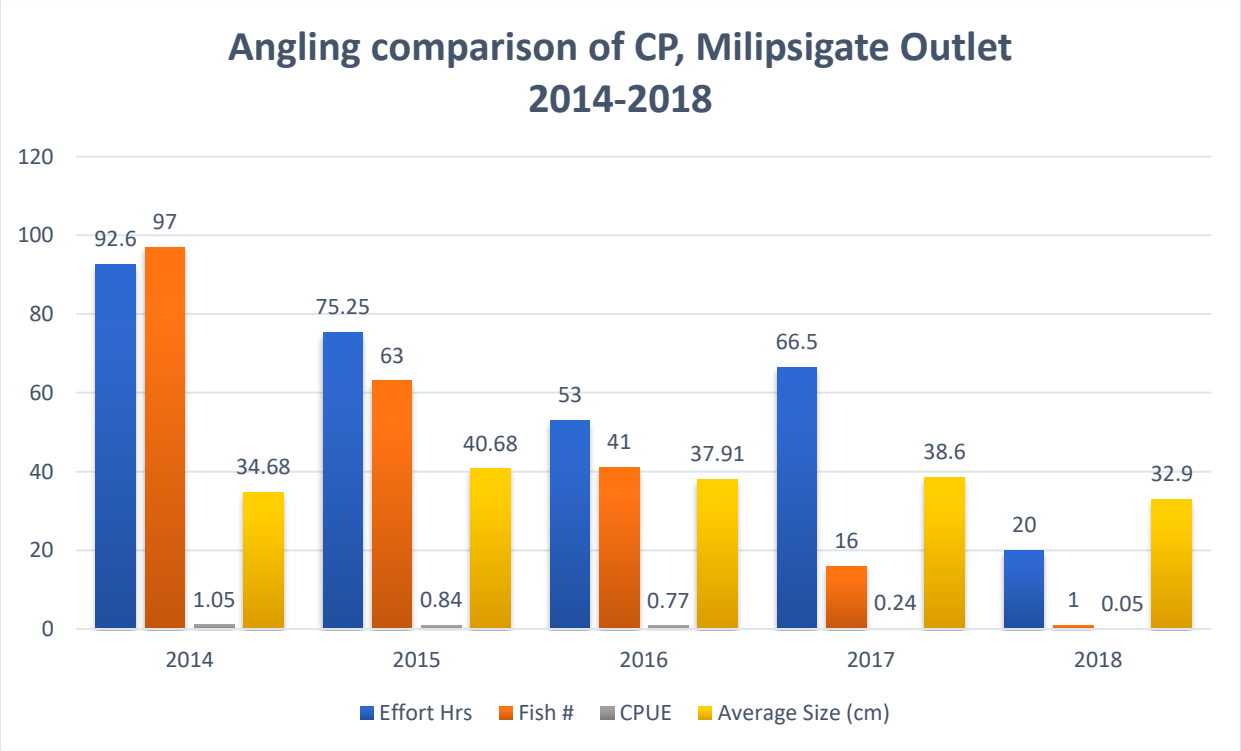


Figure 15. Number of chain pickerel angled from Milipsigate Outlet, total amount of time spent angling, estimated catch per unit effort (CPUE), and average fork length (cm).

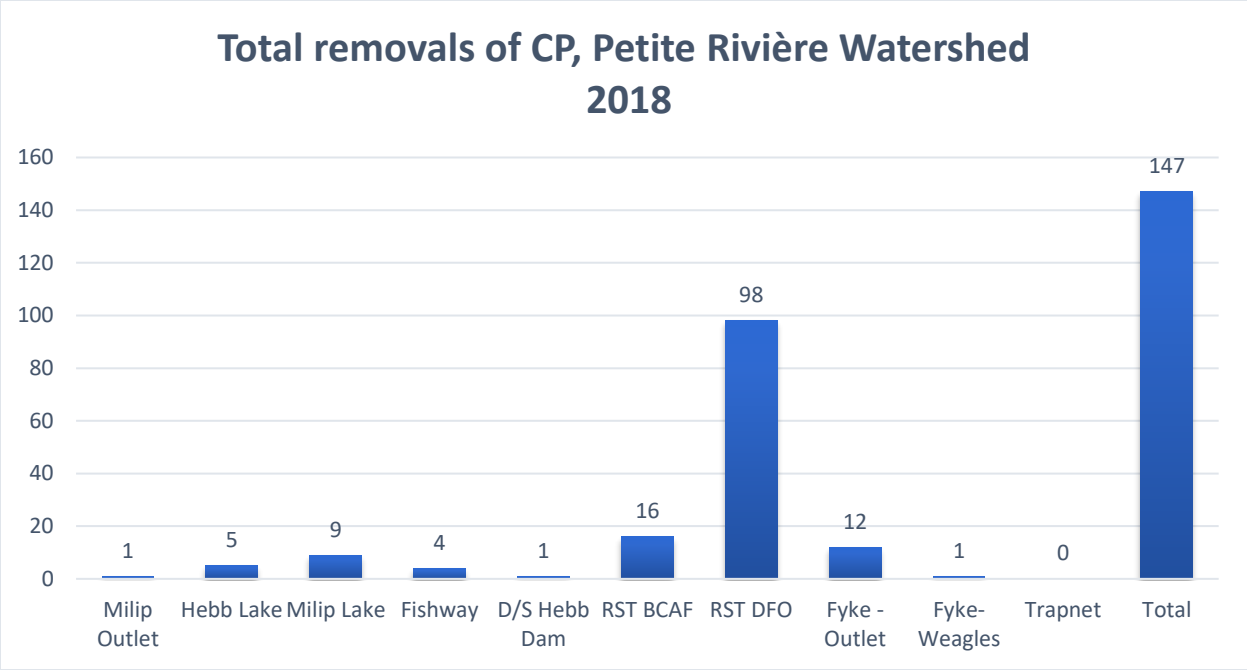


Figure 16. Chain pickerel by locations captured throughout the entire watershed by Coastal Action staff during the 2018 field season (excluding electrofishing boat).

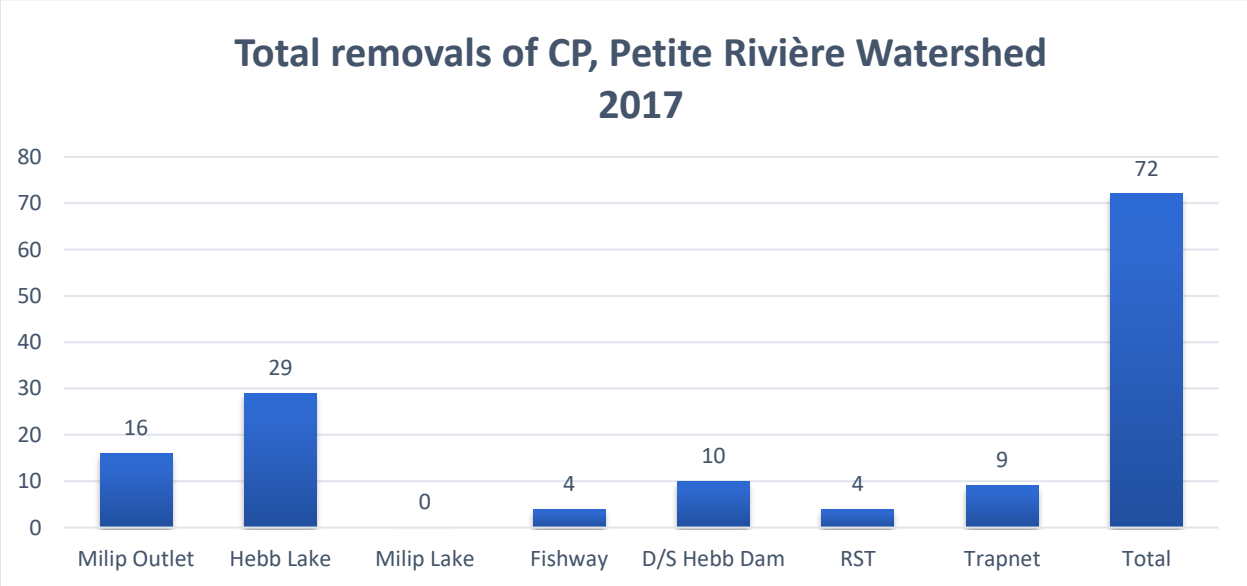


Figure 17. Chain pickerel by locations captured throughout the entire watershed by Coastal Action staff during the 2017 field season (excluding electrofishing boat).

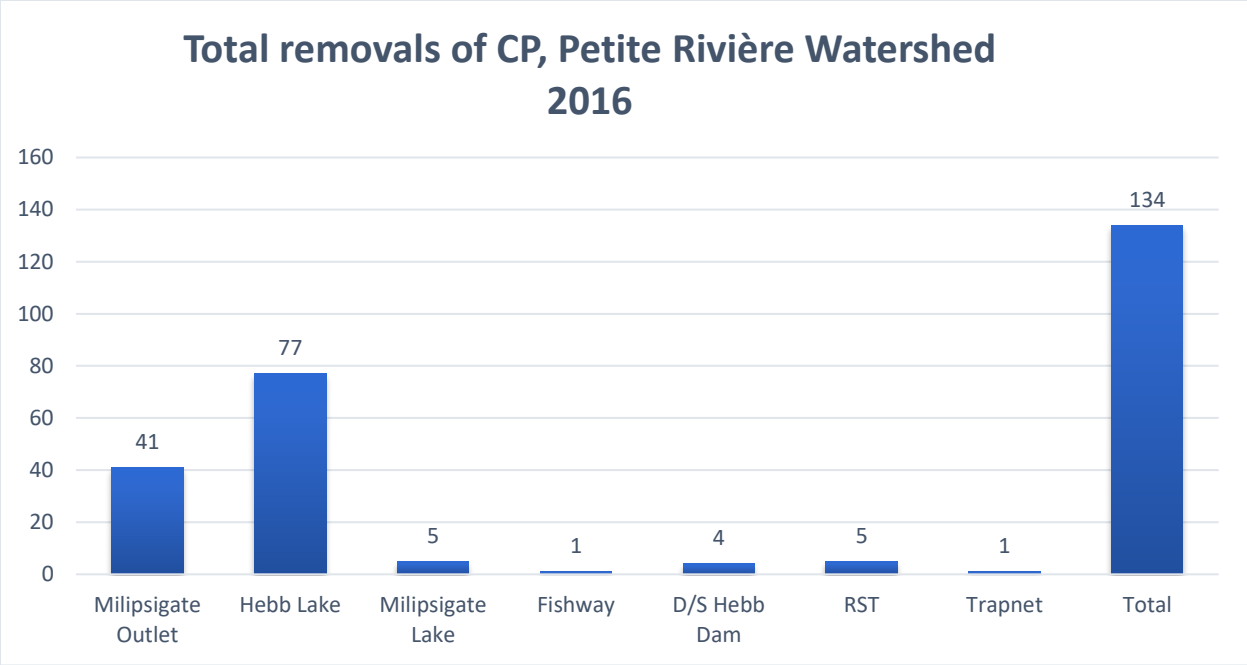


Figure 18. Location of chain pickerel captured throughout the entire watershed by Coastal Action staff during the 2016 field season (excluding electrofishing boat).

Smallmouth Bass Biological Study

A total of 421 smallmouth bass were retained for biological stomach content analysis. This total includes 377 SMB angled during the CPUE survey, 18 caught in the fishway, 9 caught in the RST-BCAF, and 17 caught in the RST-DFO.

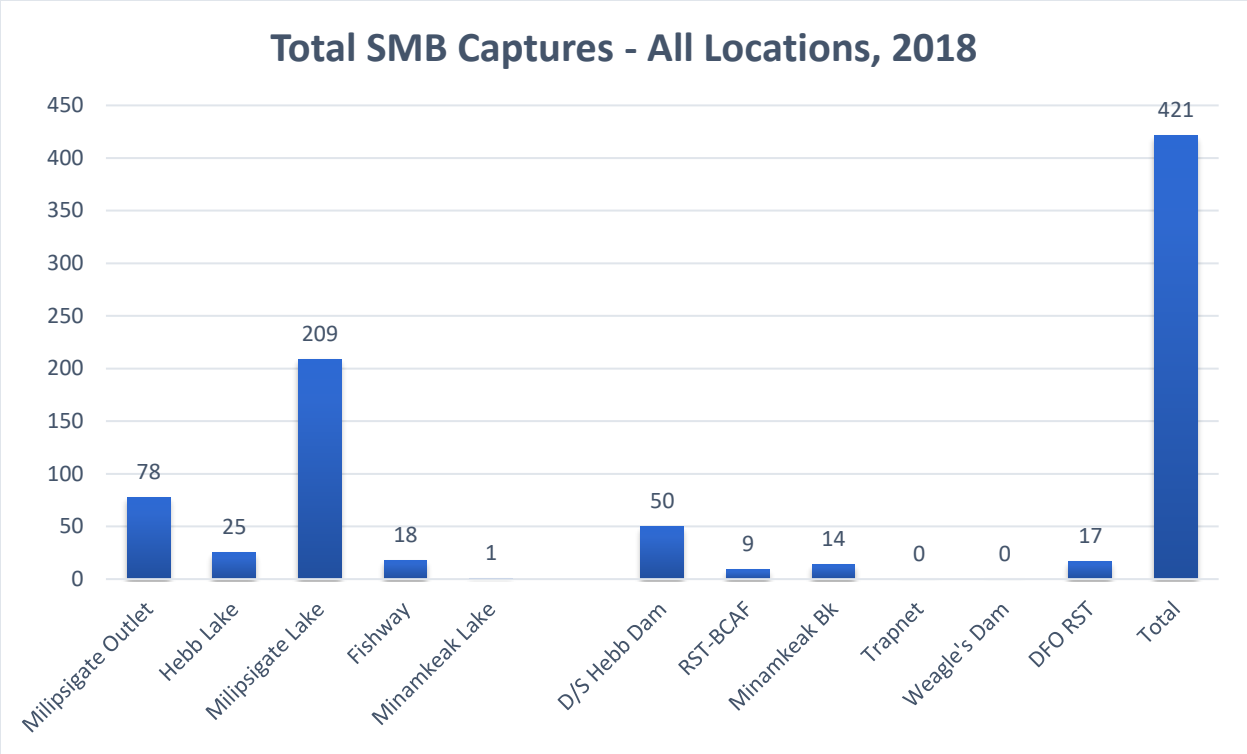


Figure 19. Total SMB biologically sampled from all collection methods in 2018.

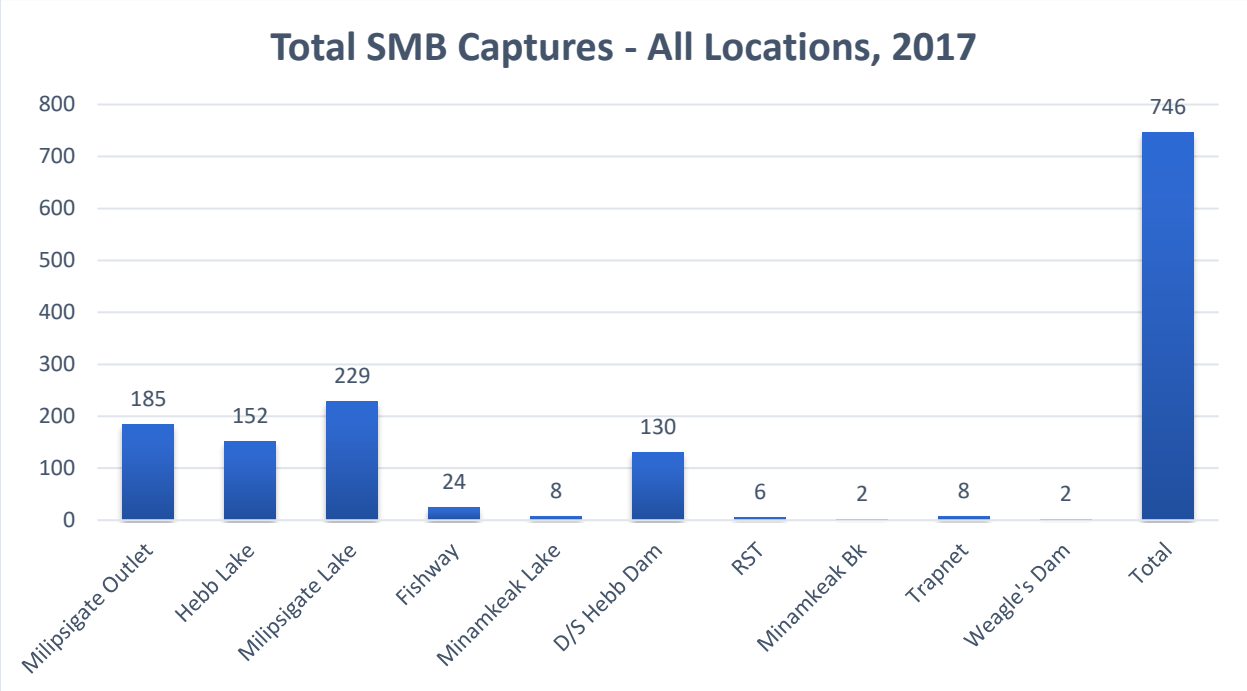


Figure 20. Total SMB biologically sampled from all collection methods in 2017.

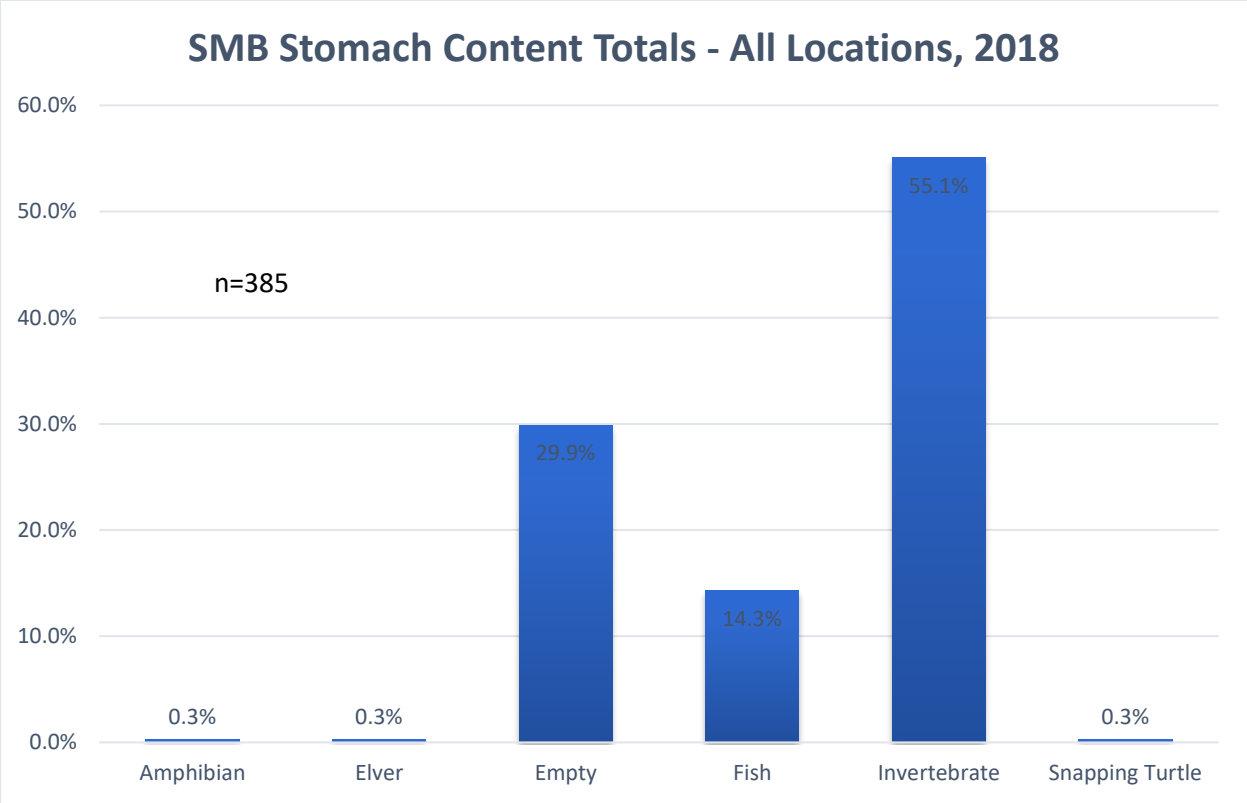


Figure 21. Stomach content analysis from 385 fish sampled from all locations in 2018.

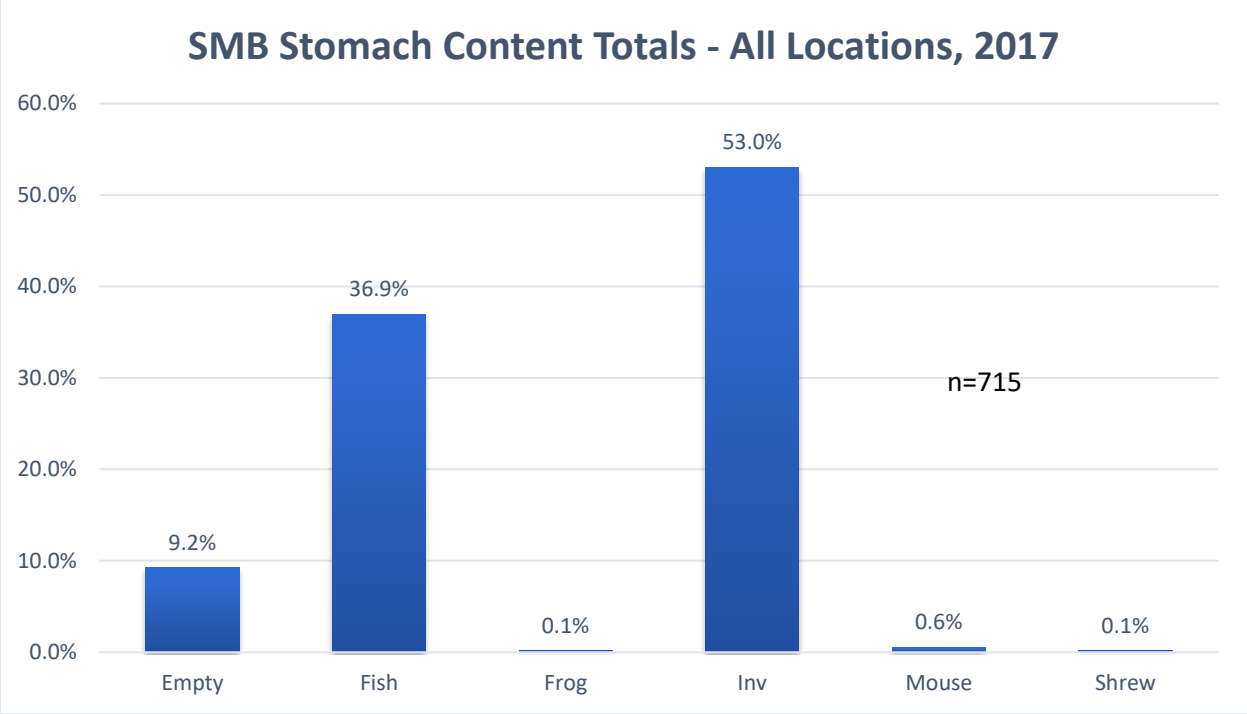


Figure 22. Stomach content analysis from 715 fish sampled from all locations in 2017.

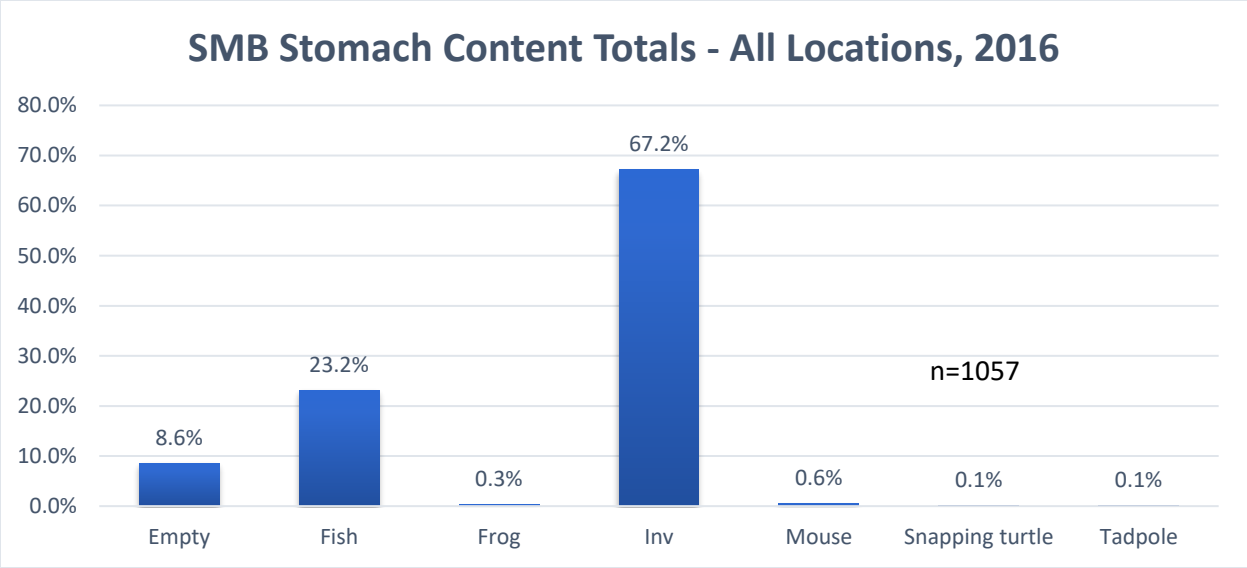


Figure 23. Stomach content analysis from 1057 fish sampled from all locations in 2016.

Table 4. Stomach content analysis SMB, May 2013-2017, from Milipsigate Outlet.

Stomach Content Analysis, Milipsigate Outlet, May 2013-2018							
Year	**# of Fish**	**% Empty**	**% Fish**	**% Invert**	**% Amphibian**	**% Reptile**	**% Eggs**
2013	181	51%	19%	51%	0%	0%	0%
2014	109	29%	31%	40%	0%	0%	0%
2015	58	7%	15%	74%	2%	0%	2%
2016	30	23%	17%	57%	0%	3%	0%
2017	11	27%	0%	73%	0%	0%	0%
2018	16	38%	0%	62%	0%	0%	0%

Table 5. All occurrences of reptiles, amphibians, and mammals found in the stomach contents of smallmouth bass (2014 - 2018).

#	Date	Location	Sex	Length (cm)	Weight (kg)	Stomach Contents
231	07 Jul 2014	Milipsigate Outlet	M	21	0.13	Redbelly Snake
44	17 May 2015	Milipsigate Outlet	F	36.7	0.64	Frog
163	22 Jun 2015	Hebb Lake	F	22.7	0.18	--
396	04 Aug 2015	Milipsigate Outlet	F	32.5	0.44	Snapping Turtle (dead)
530	13 Aug 2015	Milipsigate Outlet	F	30.6	0.45	Muskrat/ Mink (?)
9	1 May 2016	Milipsigate Outlet	M	33.8	0.64	Snapping Turtle
SSWA	21 May 2016	Wallace Lake	M	18.7	0.08	Frog
SSWA	31 May 2016	Fancy Lake	M	24.1	0.22	Snapping Turtle
136	7 Jun 2016	Hebb Lake	M	29.9	0.36	Frog
141	7 Jun 2016	Hebb Lake	M	20.9	0.16	Tadpole

147	7 Jun 2016	Hebb Lake	M	21.6	0.14	Shrew
286	30 Jun 2016	Minamkeak Lake	F	24.8	0.21	Mouse
325	30 Jun 2016	Minamkeak Lake	M	34.9	0.56	Mouse
329	4 Jul 2016	Hebb Lake	F	28.9	0.4	Mouse
331	4 Jul 2016	Hebb Lake	F	27.8	0.35	Frog
738	9 Aug 2016	Hebb Lake	M	38	0.74	Frog
894	29 Aug 2016	Minamkeak Lake	F	34	0.62	Mouse
988	20 Sept 2016	Hebb Lake	M	35.1	0.6	Mouse
595	6 Sept 2017	Hebb Lake	M	27.5	0.33	Frog
49	18 June 2017	Fishway	F	38.5		Mouse
551	1 Sept 2017	Hebb Lake	M	26.5	0.25	Shrew
688	29 Sept 2017	Milipsigate Lake	F	27	0.28	Mouse
691	29 Sept 2017	Milipsigate Lake	M	24.3	0.17	Mouse
694	29 Sept 2017	Milipsigate Lake	M	21.8	0.14	Mouse
269	29 Aug 2018	Hebb Lake	M	30.8	0.4	Salamander
30	22 May 2018	Fishway	F	33.5	0.56	Elver
342	18 Sept 2018	Milipsigate Lake	F	27.6	0.28	Snapping Turtle
DFO	8 June 2018	Minamkeak Lake	M	23.7		Frog

Figure 24. Locations of both rotary screw traps in Milipsigate Lake.

Chain Pickerel Biological Study

A total of 147 chain pickerel were removed by angling, interceptions at the fishway, fyke nets, or the RST between April 26, 2018 and October 30, 2018. This was the first year that Atlantic whitefish (AW) were found in the stomach contents of chain pickerel. A total of nine larval Atlantic whitefish were found in five different chain pickerel. These fish were found in three different areas (7 AW at the Fyke net overflow site, 1 at the RST-DFO, and 1 at the RST-BCAF). The largest chain pickerel containing a larval Atlantic

whitefish was 16.7 cm and the smallest 10.9 cm fork length. (Note: Additional chain pickerel were removed from Hebb Lake/Milipsigate Lake using the electrofishing boat.)

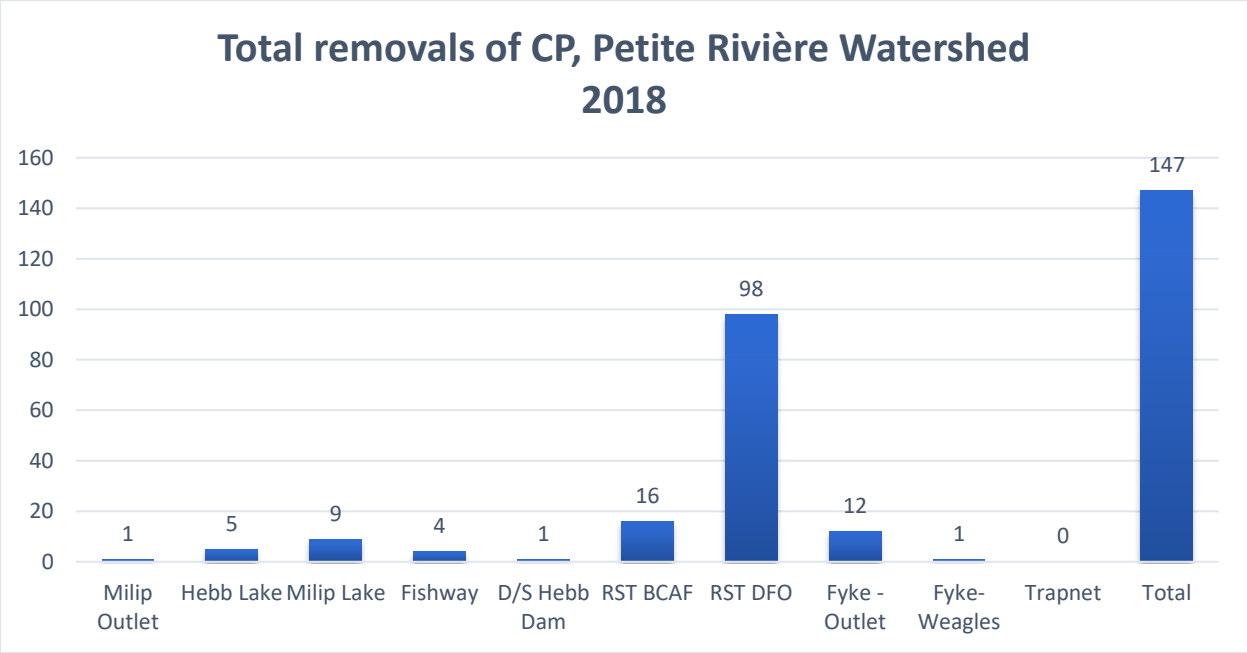


Figure 25. Number of chain pickerel removed from all locations, per month, in 2018.

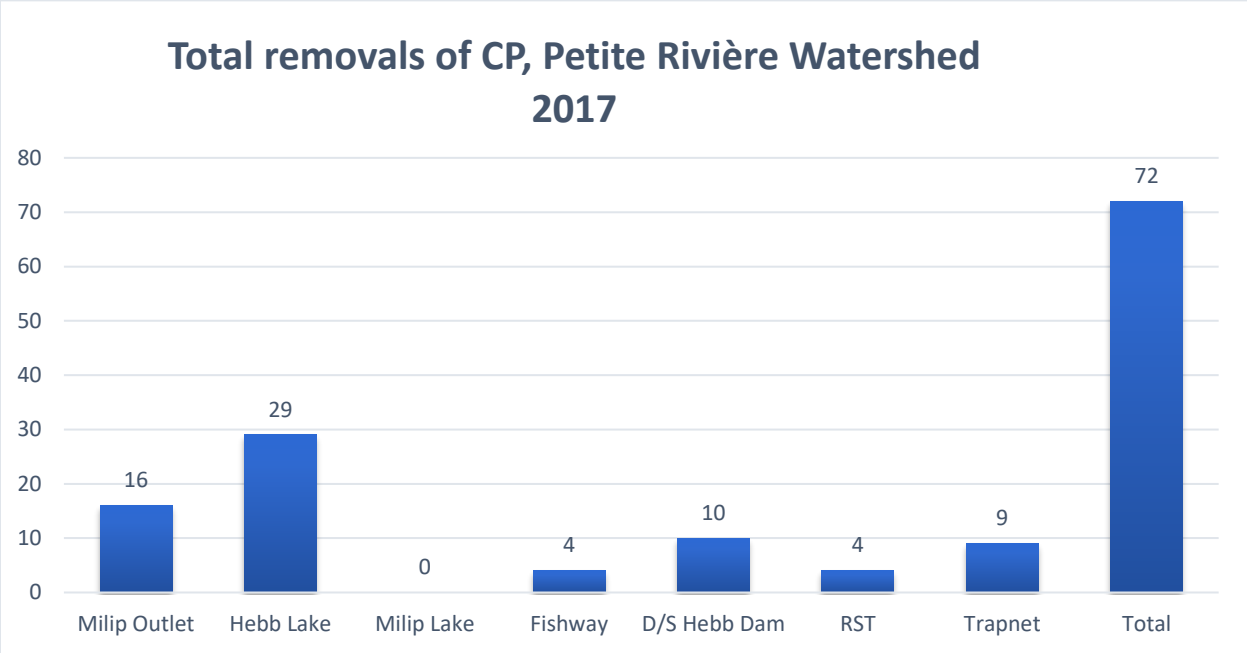


Figure 26. Number of chain pickerel removed from all locations, per month, in 2017.

Figure 27. A chain pickerel and its stomach contents; 3 YOY Atlantic whitefish.

Figure 28. Chain pickerel caught at Milipsigate Outlet with its stomach contents; two juvenile snapping turtles (alive), June 2015.

Table 6. All occurrences of reptiles, amphibians, and mammals found in the stomach contents of chain pickerel (2014 – 2018).

#	Date	Location	Sex	Length (cm)	Weight (kg)	Stomach contents
9	19 Jun 2014	Milipsigate Outlet	M	29.3	0.15	Newt
1	08 May 2015	Milipsigate Outlet	M	47.5	0.86	Frog
48	30 Jun 2015	Milipsigate Outlet	M	39.6	0.36	2 Snapping Turtles (alive)
87	17 Aug 2015	Milipsigate Outlet	M	34.7	0.23	Snapping Turtle (dead)
3	27 Apr 2016	Hebb Lake	F	41	0.48	Frog
SSWA	18 May 2016	Garber Lake	F	42	0.58	Frog
SSWA	27 May 2016	Garber Lake	M	39.4	0.42	2 Toads
70	21 Jun 2016	Hebb Lake	M	46.8	0.62	Frog

Table 7. Larval Atlantic whitefish found in the stomach contents of chain pickerel in 2018.

Larval Atlantic whitefish removed from CP, 2018				
Date	**RST-BCAF**	**RST-DFO**	**FYKE-OVERFLOW**	**TOTAL**
14 May 2018	0	0	2	2
15 May 2018	1	0	3	4
17 May 2018	0	0	2	2
22 May 2018	0	1	0	1
Total	**1**	**1**	**7**	**9**

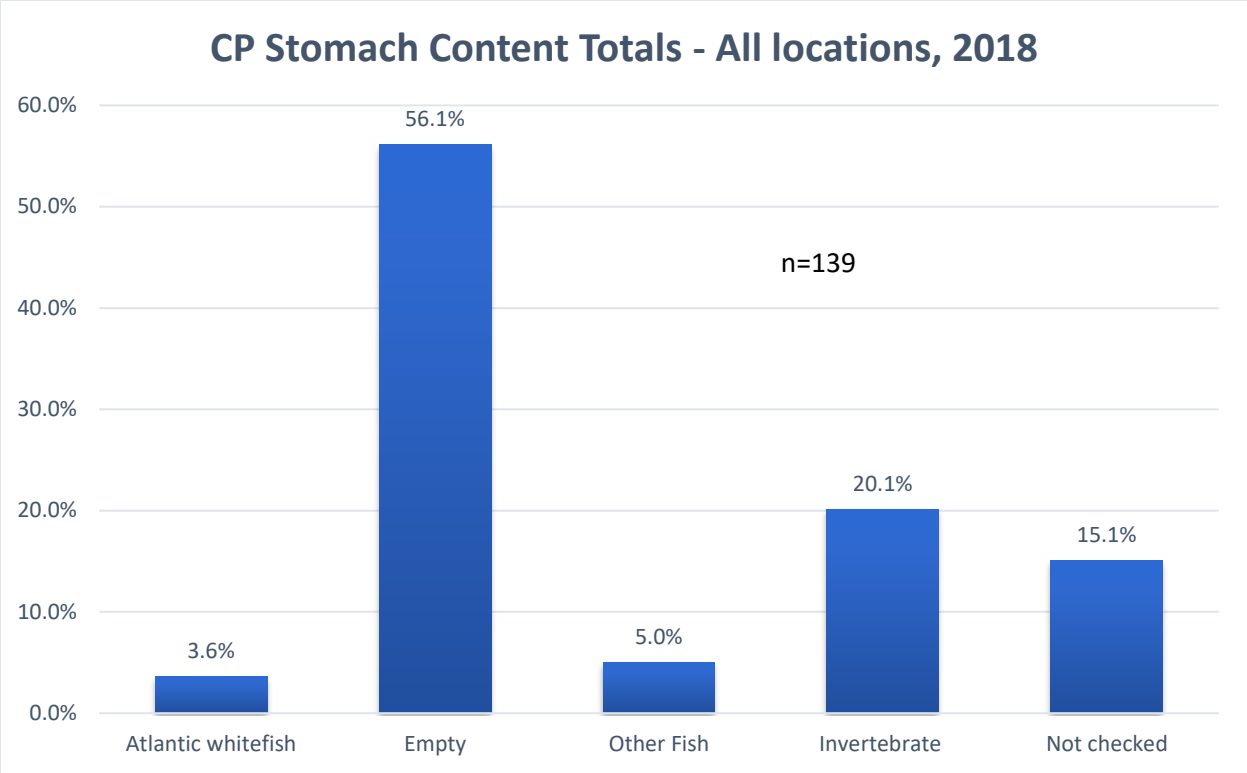


Figure 29. Stomach content analysis of chain pickerel caught at all locations in 2018.

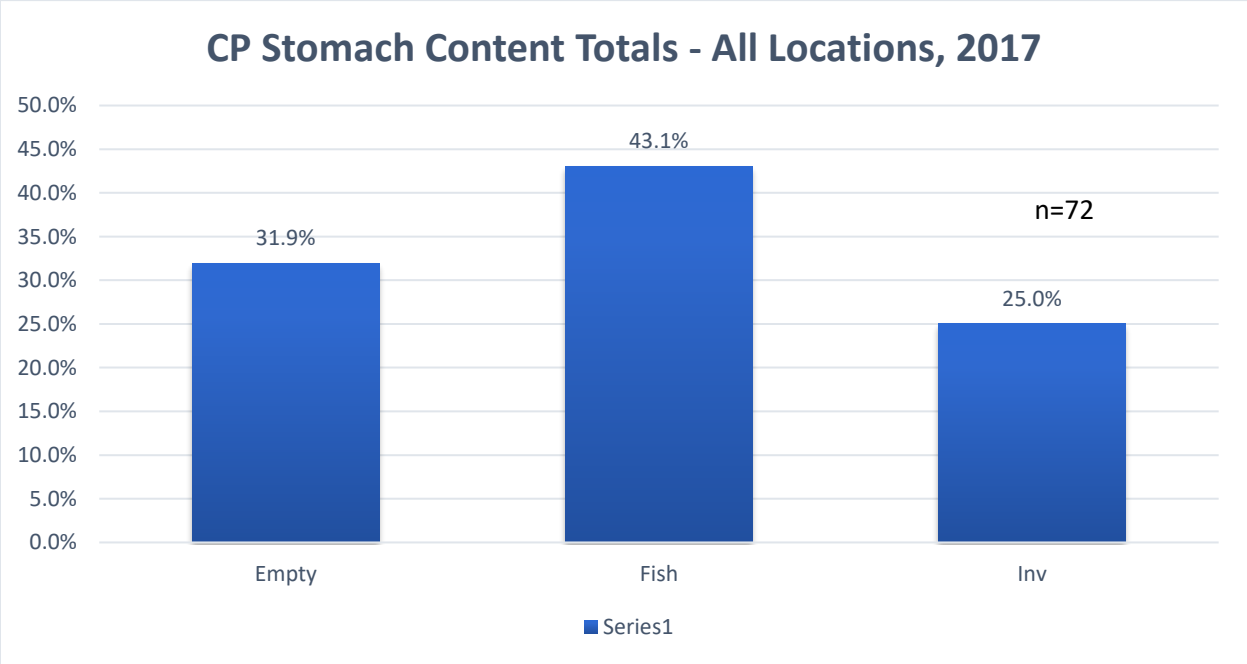


Figure 30. Stomach content analysis of chain pickerel caught at all locations in 2017.

Rotary Screw Trap Study

RST Spring Monitoring and Sampling Activities at Milipsigate Dam/Minamkeak Brook

Two rotary screw traps (RSTs) were deployed and monitored; one at the base of Milipsigate Dam from April 17, 2018 to June 27, 2018 and the second at the outflow of Minamkeak Brook from April 23, 2018 to May 29, 2018 (see Figure 24).

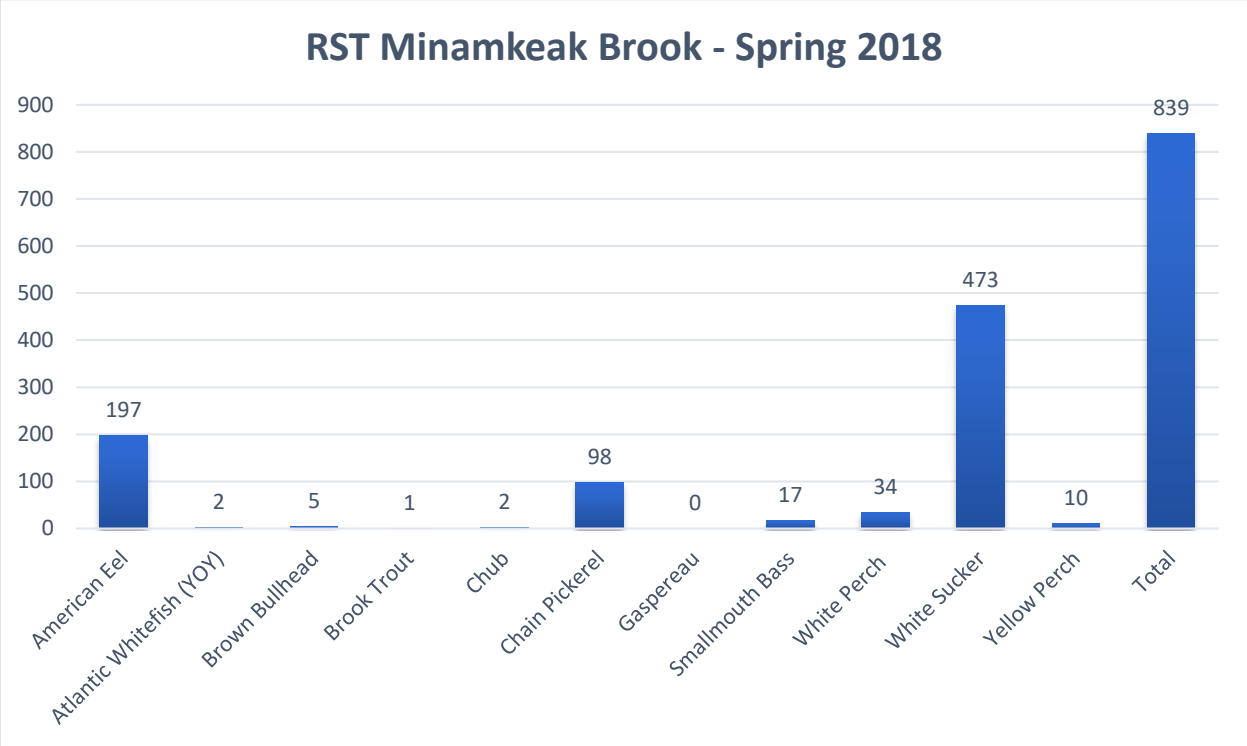


Figure 31. Total captures by the DFO-RST at Minamkeak Brook, Minamkeak Lake, Lunenburg County, Spring 2018. Data collected by Coastal Action staff between April 23 and May 29, 2018.

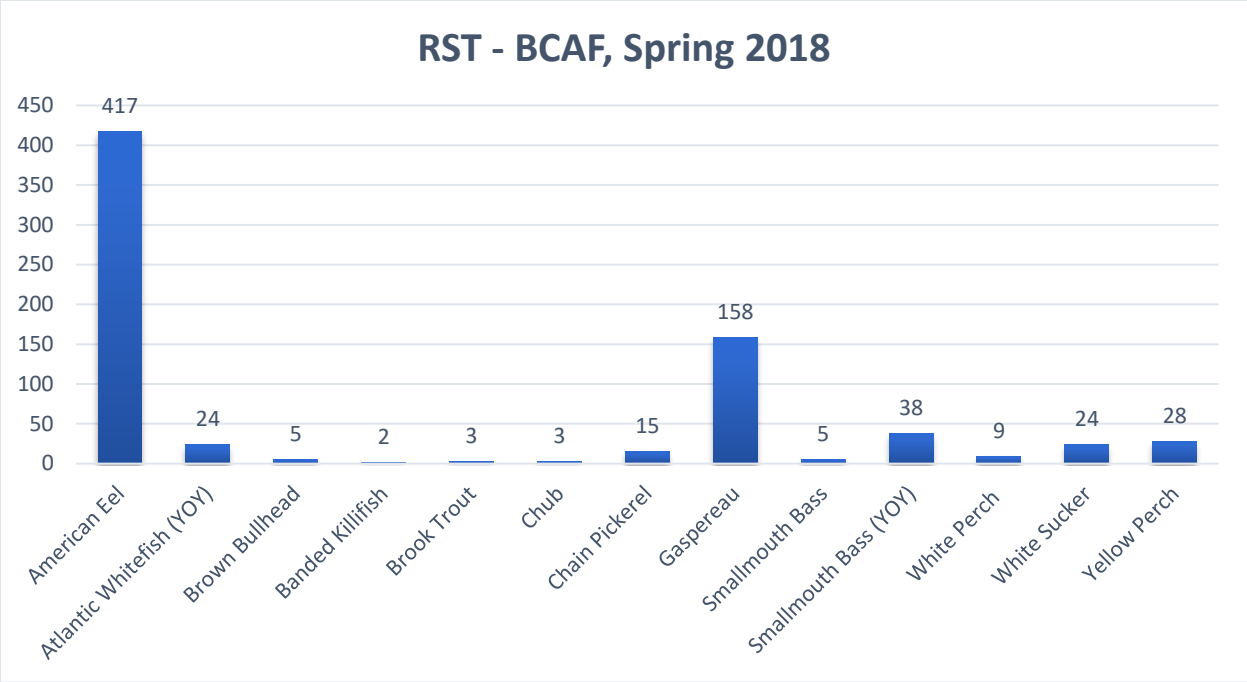


Figure 32. Total captures by species from rotary screw trap at Milipsigate Outlet, Hebb Lake, Lunenburg County. Data collected by Coastal Action staff members between April 17 and June 27, 2018.

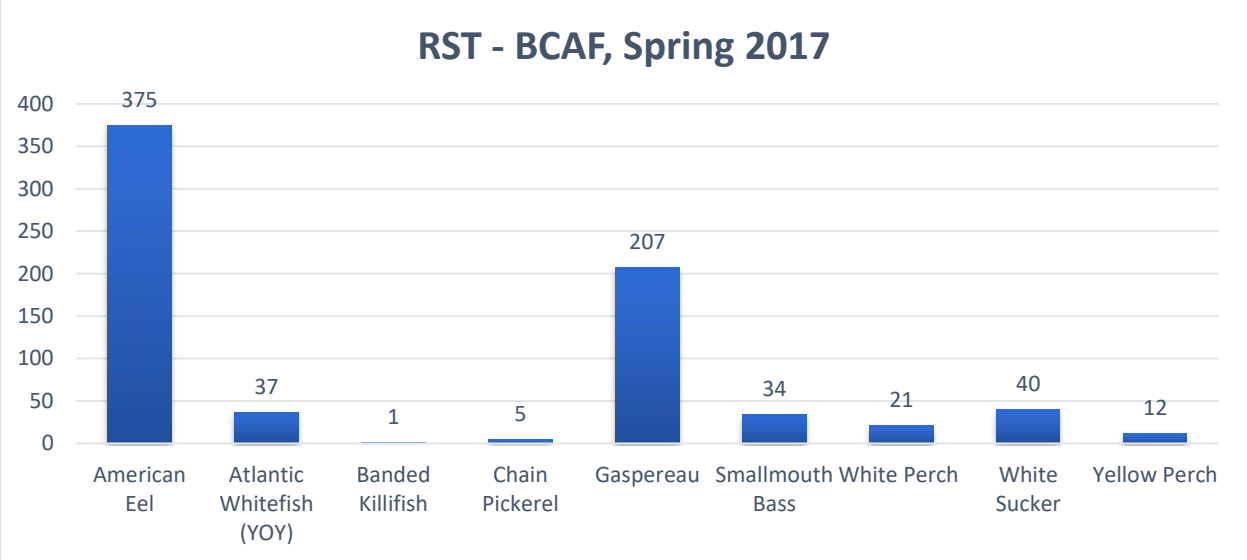


Figure 33. Total captures by species from rotary screw trap at Milipsigate Outlet, Hebb Lake, Lunenburg County. Data collected by Coastal Action staff members between April 20 and July 17, 2017.

RST Fall Monitoring and Sampling Activities at Milipsigate Dam

During the fall of 2018, a single Rotary Screw Trap was operated at the base on Milisigate Dam from October 14, 2018 to December 21, 2018. On December 7, 2018, an adult Atlantic whitefish was captured making this individual the first live adult observed since 2014.

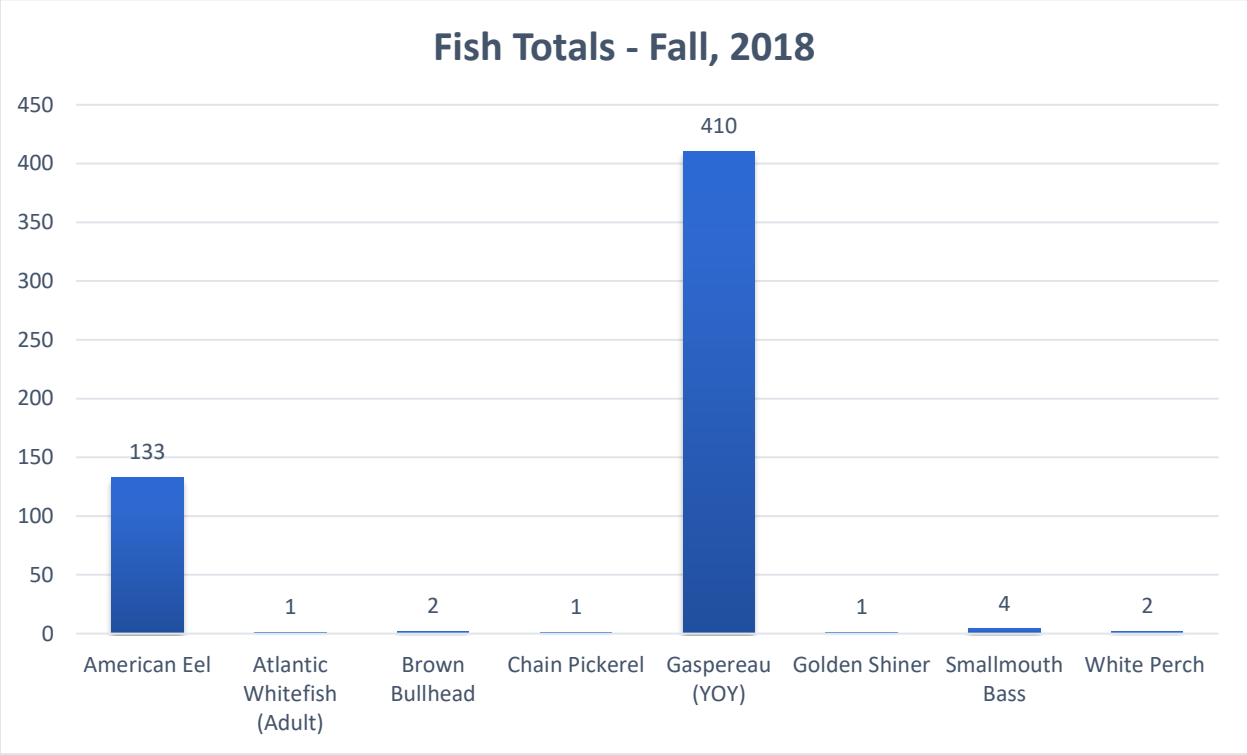


Figure 34. Total captures by species from rotary screw trap at Milipsigate Outlet, Hebb Lake, Lunenburg County. Data collected by Coastal Action staff members between October 14 and December 21, 2018.

Table 8. Total captures from RST-BCAF during Spring 2018, by month.

Species	April	May	June	Total
American Eel	63	174	180	417
Atlantic Whitefish	0	24	0	24
Brown Bullhead	0	3	2	5
Banded Killifish	0	1	1	2
Brook Trout	0	2	1	3
Lake Chub	0	1	2	3
Chain Pickerel	0	2	13	15
Gaspereau (adult)	0	72	86	158
Golden Shiner	0	0	0	0
Smallmouth Bass	0	1	4	5
White Perch	2	1	6	9
White Sucker	4	12	8	24

Yellow Perch	2	20	6	28
Total Captured	**71**	**313**	**309**	**693**

Table 9. Total captures from RST during Spring 2017, by month.

Species	April	May	June	July	Total
American Eel	76	167	118	14	375
Atlantic Whitefish	0	37	0	0	37
Banded Killifish	0	0	0	1	1
Brown Bullhead	0	0	0	0	0
Chain Pickerel	0	2	2	1	5
Gaspereau (adult)	0	110	96	1	207
Golden Shiner	0	0	0	0	0
Smallmouth Bass (adult and YOY)	0	2	3	29	34
White Perch	1	9	4	7	21
White Sucker (adult and YOY)	18	11	1	10	40
Yellow Perch	1	8	1	2	12
Total Captured	**96**	**346**	**225**	**57**	**732**

Figure 35. Larval Atlantic whitefish caught in the rotary screw trap, Milipsigate Dam, May 2016.

Table 10. Total larval Atlantic whitefish captures from 2014-2018.

Larval Atlantic Whitefish Captures, 2014-2018				
Year	**RST-BCAF**	**RST-DFO**	**FYKE-OVERFLOW**	**TOTAL**
2014	0	0	0	0
2015	4	0	0	4
2016	53	0	0	53
2017	37	0	0	37
2018	25	3	12	40
Total	**119**	**3**	**12**	**134**

Table 11. Total adult Atlantic whitefish captures from 2012-2018.

YEAR	FISHWAY	ANGLING HEBB	ANGLING MILIP OUT	E-BOAT	RST-BCAF	GILLNET MINAM	TOTAL
2012	20	1	0	0	0	0	**21**
2013	0	0	0	0	0	0	**0**
2014	0	0	1	1	0	1	**3**
2015	0	0	0	0	0	0	**0**
2016	0	0	0	0	0	0	**0**
2017	0	0	0	0	0	0	**0**
2018	0	0	0	0	1	0	**1**
Total	**20**	**1**	**1**	**1**	**1**	**1**	**24**

Spring Monitoring and Sampling Activities at Hebb Lake Dam Fish Passage Facility

The Hebb Lake Dam Fish Passage Facility monitoring trap was fished daily from May 1, 2018 to July 6, 2018. A total of 20,417 fish were intercepted, comprising seven different species. In 2013, gaspereau were permitted to access the upper watershed for the first time in over 40 years and 2018 was the largest return yet of 20,350 fish. Of the seven species caught in 2018, gaspereau, American eel, white sucker, and brook trout were allowed to continue into Hebb Lake. All invasive species were removed and sampled as part of the biological study. In previous years lamprey were captured in the trap; however, none were observed or captured in 2018.

Table 12. Total Spring capture results of fish from Hebb Dam Fish Passage Facility, Hebbville, Lunenburg County, Nova Scotia.

Species	Abundance Spring 2013	Abundance Spring 2014	Abundance Spring 2015	Abundance Spring 2016	Abundance Spring 2017	Abundance Spring 2018
American Eel	3	1	1	2	4	3
Brook Trout	1	10	2	2	1	1
Chain Pickerel	0	1	0	1	4	4
Chub Spp.	5	0	0	0	0	0
Gaspereau	2120	2924	4793	2333	11738	20350
Shad	1	0	0	0	0	1
Sea Lamprey	1	1	70	11	8	0
Smallmouth Bass	18	35	59	43	25	19
White Sucker	174	37	61	26	79	39
Total	**2323**	**3009**	**4986**	**2418**	**11 859**	**20 417**

Table 13. First and last arrivals at the Hebb Dam Fish Passage Facility – Spring 2018.

	American Eel	Brook Trout	Shad	Gaspereau	Smallmouth Bass	White Sucker	Chain Pickerel
# of fish	3	1	1	20 350	19	39	4
First Arrival	17 Jun 2018	18 May 2018	15 June 2018	6 May 2018	15 May 2018	1 May 2018	21 June 2018
Last Arrival	28 Jun 2018	18 May 2018	15 June 2018	6 Jul 2018	6 Jul 2018	23 June 2018	22 June 2018

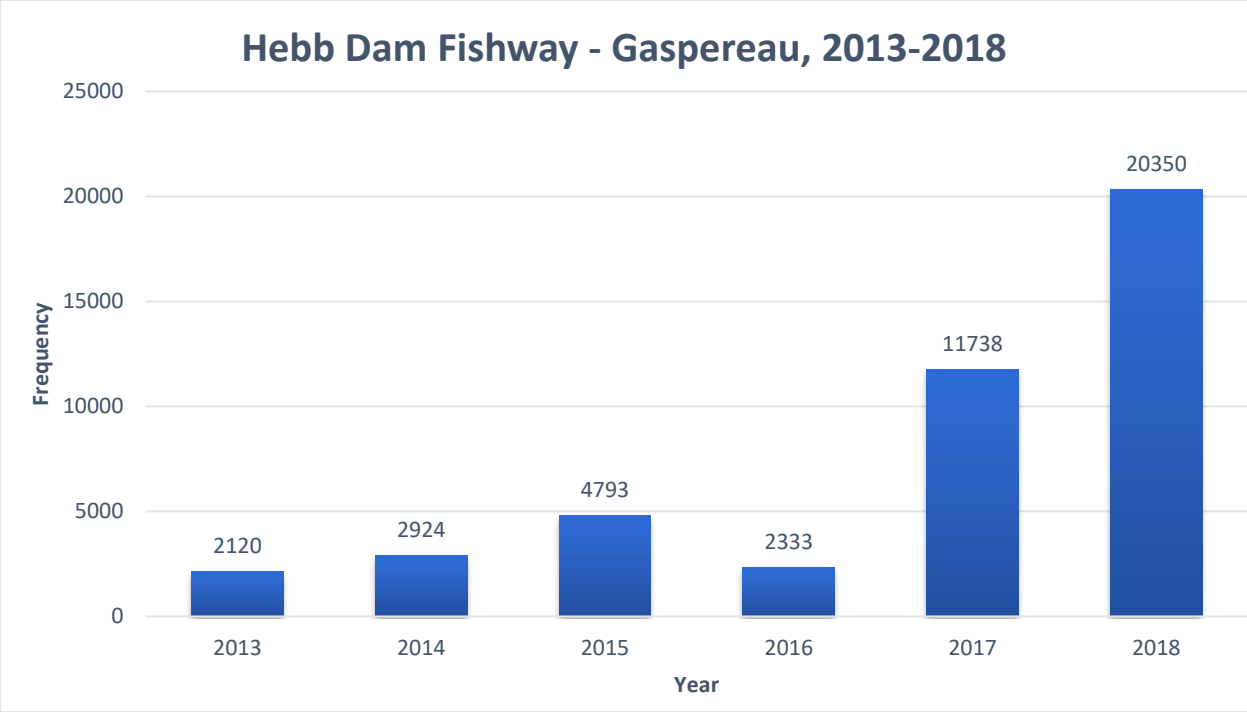


Figure 36. Gaspereau captures at Hebb Dam Fish Passage Facility, Hebbville, Lunenburg County, Nova Scotia. Data collected by Coastal Action staff (2013-2018).

Fall Monitoring and Sampling Activities at the Hebb Lake Dam Fish Passage Facility

The Hebb Lake Dam Fish Passage Facility monitoring trap was fished daily from October 15, 2018 to December 21, 2018. During the fall, Coastal Action staff captured three fish at the fishway, making this the first year since 2014 that any fish have been captured in this trap. These fish were a 26 cm brook trout caught on October 20, 2018, and two white sucker, 18.5 cm and 18.8 cm respectively, caught on November 8, 2018.

Table 14. Total Fall capture results of fish from Hebb Dam Fish Passage Facility, Hebbville, Lunenburg County, Nova Scotia. Data collected by Coastal Action staff (2012-2018).

Species	Fall						
	2012	2013	2014	2015	2016	2017	2018
American Eel	2	0	0	0	0	0	0
Atlantic Salmon	4	0	1	0	0	0	0
Atlantic Whitefish	20	0	0	0	0	0	0
Brook Trout	13	2	0	0	0	0	1
Brown Bullhead	0	1	0	0	0	0	0

Chain Pickerel	0	2	0	0	0	0	0
Smallmouth Bass	3	1	5	0	0	0	0
White Perch	2	0	0	0	0	0	0
White Sucker	36	14	20	0	0	0	2
Grand Total	**80**	**20**	**26**	**0**	**0**	**0**	**3**

Media Coverage of the Atlantic Whitefish Project in 2018

Coastal Action staff working on the Atlantic Whitefish Recovery Project were fortunate to be able to share their work with a greater audience thanks to several visits from CBC journalist Paul Withers in 2018. Articles were published on CBC's website and stories were presented on CBC Radio 1's Information Morning and CBC Nova Scotia 6 PM news. The stories covered were Coastal Action's capture of larval Atlantic whitefish in spring 2018, the discussion around moving the captured larval fish from the Coldbrook Biodiversity Facility to Dalhousie University, as well as Coastal Action's capture of a live adult whitefish in December 2018. Radio interviews on NEWS 95.7's Sheldon Macleod Show and CKBW-NEWs with Brittany Wentzell also showcased Coastal Action's work with Atlantic whitefish this season. Finally, an article about the endangered Atlantic whitefish was featured in the December 2018 edition of Rural Delivery.

Below are relevant media coverage links from 2018/19 and a link to the 2017 CBC Land and Sea Documentary:

CKBW news

1. http://ckbw.ca/news/536840008/first-adult-whitefish-found-watershed-2014

CBC News

2. Scientists race to prevent extinction
https://www.cbc.ca/news/canada/nova-scotia/atlantic-whitefish-possible-extinction-nova-scotia-1.4668237

3. Atlantic whitefish saved for the second time in 5 months
https://www.cbc.ca/news/canada/nova-scotia/endangered-atlantic-whitefish-rescued-for-second-time-in-five-months-1.4851332

4. First healthy Atlantic whitefish seen since 2014
https://www.cbc.ca/news/canada/nova-scotia/critically-endangered-atlantic-whitefish-1.4941968

5. Atlantic whitefish struggle to survive
https://www.cbc.ca/news/canada/nova-scotia/wild-atlantic-whitefish-struggle-to-survive-in-nova-scotia-1.4913433

6. The Endangered Perspective – The Whitefish Chronicles
https://www.southshorebreaker.ca/living/the-endangered-perspective-the-whitefish-chronicles-252437/

7. The Endangered Perspective – All is not lost for the Atlantic whitefish
https://www.southshorebreaker.ca/opinion/columnists/the-endangered-perspective-all-is-not-lost-for-the-atlantic-whitefish-275862/

8. IUCN- Freshwater Key Biodiversity Areas in Canada
https://portals.iucn.org/library/sites/library/files/documents/2017-054.pdf

9. Land and Sea Documentary about the Atlantic whitefish
https://www.youtube.com/watch?v=YZ_fired4E8

Smallmouth Bass Nest Survey

Nests were surveyed between June 4, 2018 and June 21, 2018. All nests assessed were determined to be Class A nests for the duration of the study period. Thirteen nests were visually assessed on the first survey day, June 4, 2018. As of the last survey date June 21, 2018, a total of 25 nests had been found in the survey area. On June 21, 2018, six of the 25 nests were found to have male smallmouth bass guarding them. These fish were removed via angling and the nests were raked. All 25 nests were raked as of June 21, 2018.

On June 21, 2018, it was noted on several occasions that there were three or four nests clustered together in a small area with only one male smallmouth bass nearby. More nests were found as the study progressed and lake water temperature increased.

Substrate for all nests was found to be pebbles and cobbles and all nests were found at a depth of approximately 0.3 m to 1.5 m.

No nests were found with eggs deposited through the duration of the study. However, smallmouth bass fry were discovered in the rotary screw trap at Milipsigate Dam downstream from the study area on June 25, 2018.

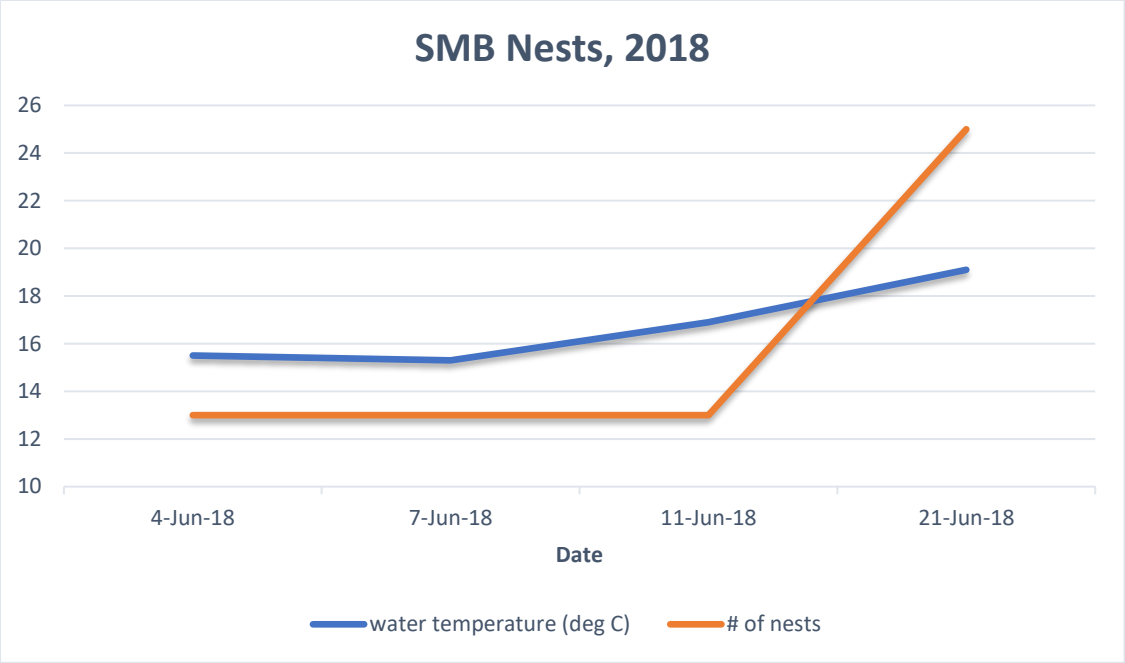


Figure 37. Total number of bass nests found and associated water temperature.

Lake Profiling and Zooplankton Hauls

Profiles taken at the deepest spot on Milipsigate Lake using a ProDSS Digital Professional Series YSI sonde were graphed to determine stratification of the lake at various points throughout the summer. The profiles indicated that conductivity remained stable across each sample date while dissolved oxygen and total dissolved solids were more variable. Stratification of the lake occurred prior to July 27, 2018, and profiling of the lake showed a thermocline beginning at 5.5 m on July 27, 2018, moving to 7 m by August 28, 2018. By the final sampling date, September 28, 2018, Milipsigate Lake was no longer stratified.

Average Secchi depth readings across the three sampling dates were 2.82 m, and the average euphotic depth was 5.64 m.

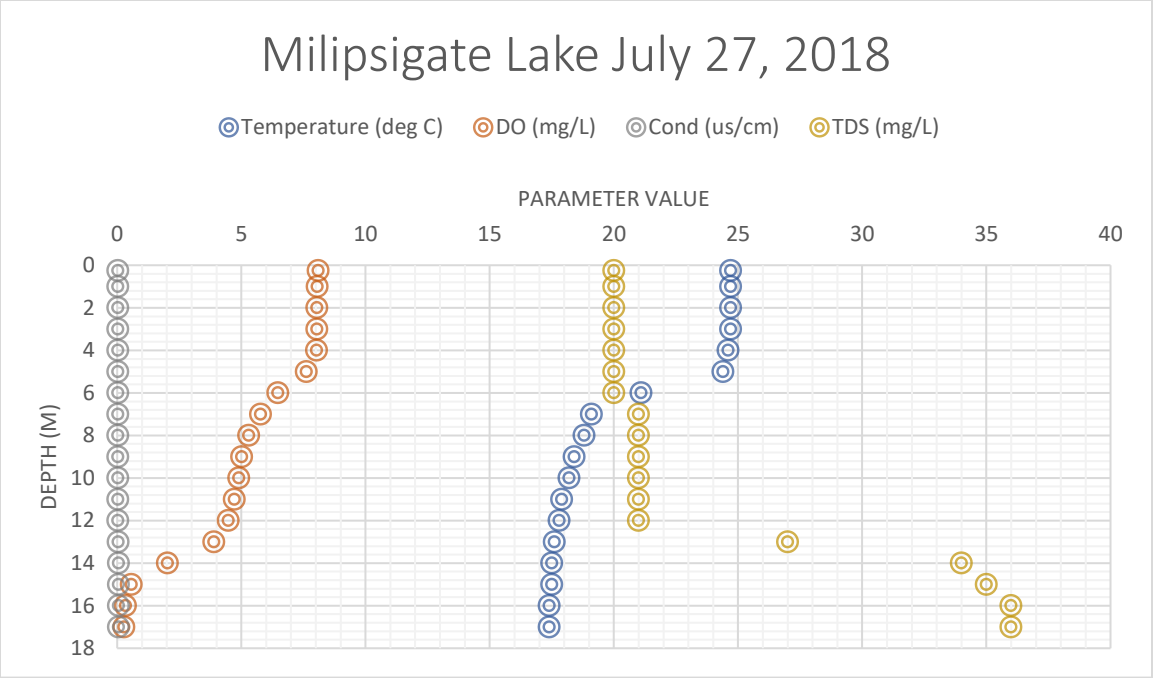


Figure 38. Lake profile from July 27, 2018 at Milipsigate Lake's central deep spot. The Secchi depth was 2.30 m.

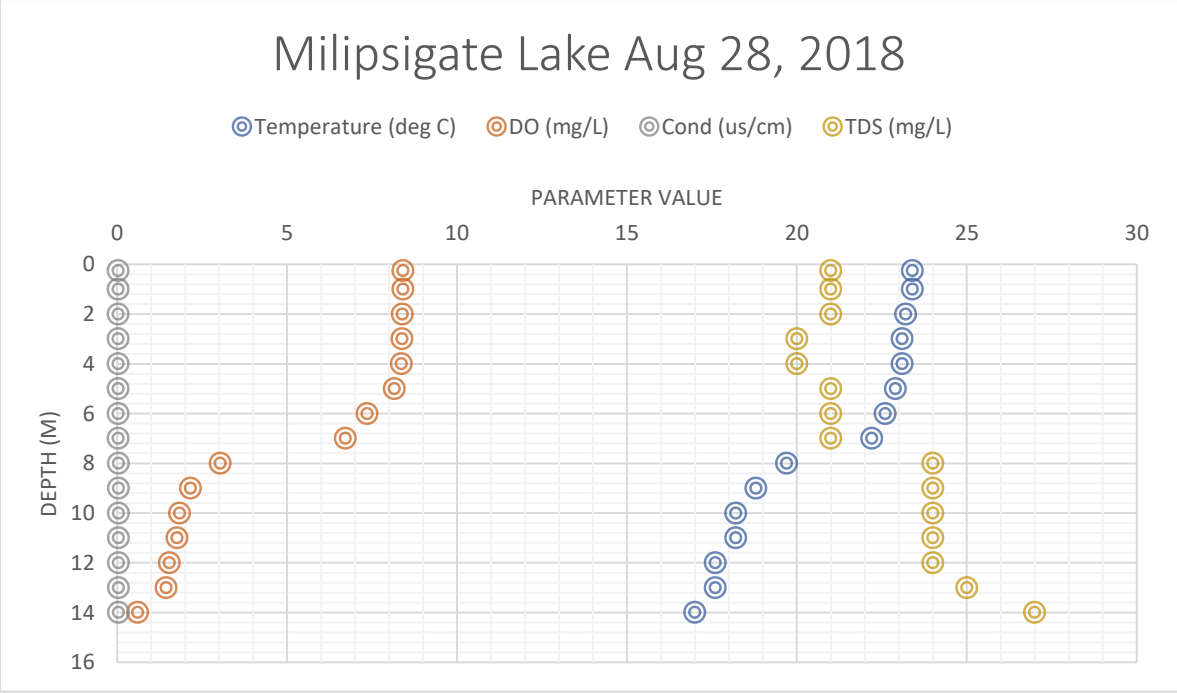


Figure 39. Lake profile from August 28, 2018 at Milipsigate Lake's central deep spot. The Secchi depth was 3.46 m.

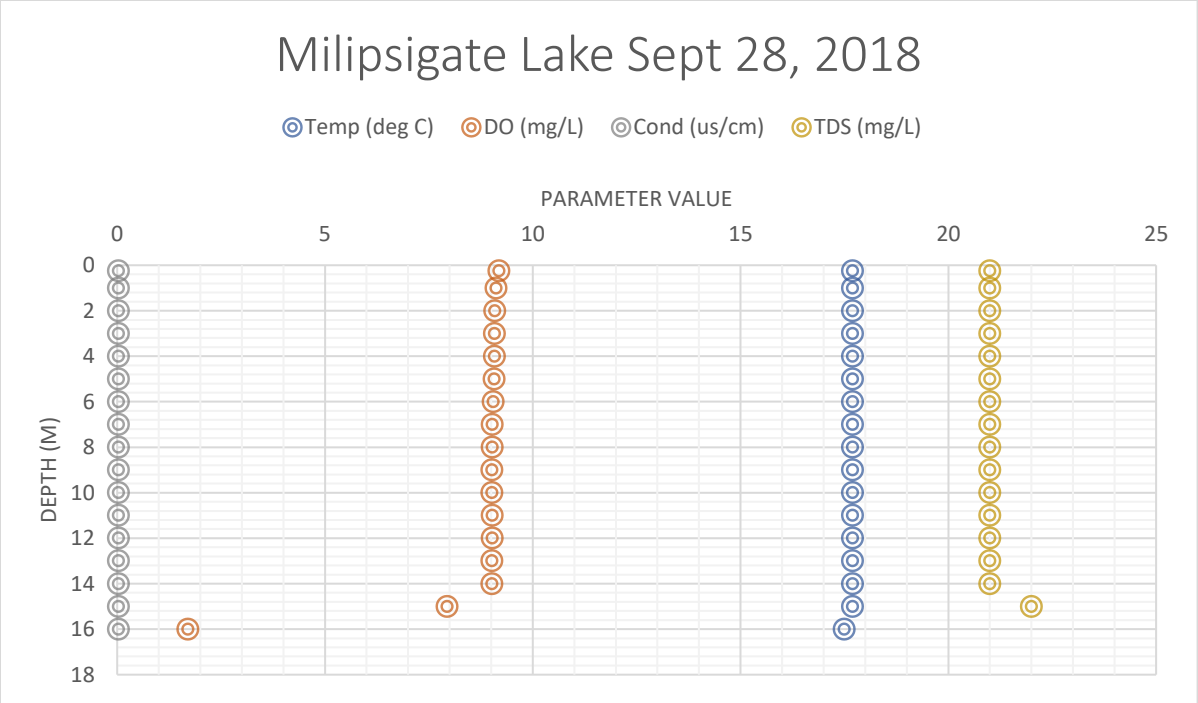


Figure 40. Lake profile from September 28, 2018 at Milipsigate Lake's central deep spot showing the lake is no longer stratified. The Secchi depth was 2.70 m.

Zooplankton Species Identification

Samples were obtained from three different locations in Milipsigate Lake (central deep spot, Demone Cove, upstream of Milipsigate Dam) over four months (July, August, September, and October). Analysis of the samples revealed uniform species composition across all sites. Species identified included *Daphnia catawba, Diaphanosoma brachyurum, Leptodora kindti, Epischura nordenskioldi, Polyphemus pediculus, Daphnia ambigua, Eubosmina longispina, Sida crystallina,* and *Heterocope septentrionalis.* Unidentified female calanoid copepods were also present in the samples. See Appendix 1 for images of specimens. While this study was not quantitative, it was noted that *Daphnia catawba* was most abundant across all samples relative to any other species identified in the samples.

Bathymetry Survey on Milipsigate Lake

Approximately 75% of Milipsigate Lake was surveyed. This data has been submitted to DFO in order to create a map of the contours and substrate of the lake.

Underwater Filming

No Atlantic whitefish adults were captured on video in Milipsigate Lake or at Milipsigate Dam in 2018.

Discussion

Outreach and Education

On April 12, 2018, Coastal Action was invited to the annual meeting of the UK Coregonid Conservation Society. The meeting was held at the Scottish National Heritage Building in Clydebank, Scotland. The meeting was a great opportunity to share the Atlantic whitefish story on an international level.

Figure 41. Meeting of the UK Coregonid Conservation Society, Clydebank, Scotland. Bottom row L-R: Melanie Fletcher (Natural England), Dave Ottewell (Natural England), Dr. Colin Adam (University of Glasgow), Dr. Colin Bean (Scottish Natural Heritage); Middle Row: Dr. Andy Gowans (Environment Agency), Andrew Breen (Coastal Action), Kevin Gallagher (Northern Ireland Fisheries Management); Top Row: Alex Lyle, Dr Ian Winfield (C.E.H).

During the year, Atlantic whitefish presentations were delivered at various schools within Lunenburg county, the Rotary Club of Lunenburg, as well as the South Shore Wildlife Association (SSWA) Annual General Meeting. Over the last four years, members of the SSWA have assisted Coastal Action each year with various field work projects.

Coastal Action hopes that in 2019 this community involvement continues, and the organization is able to develop new partnerships with other ENGOs for the recovery of the Atlantic whitefish.

Kespukwitk Two-eyed Seeing Gathering

On October 18 and 19, 2018, Coastal Action attended the Kespukwitk Two-Eyed Seeing Gathering in Bear River First Nation, Nova Scotia. This conference was hosted by the Mersey Tobeatic Research Institute (MTRI) and Bear River First Nation to discuss environmental issues in southwest Nova Scotia and highlight relevant work by organizations within the region. At the poster session during the conference, Coastal Action presented our work on the Spring 2018 capture of 28 larval Atlantic whitefish.

Smallmouth Bass and Chain Pickerel Catch Per Unit Effort (CPUE) Study

Smallmouth Bass

In the month of May from 2013-2017, a downward trend in CPUE was present in Milipsigate Outlet. However, in May 2018, the CPUE was higher than the May 2016 value in this area. Fewer hours of angling were conducted in this area than previous years (6.5 hrs) as compared to the 2013-2017 (mean hrs angled = 20.83 hrs) making this year's data less robust. It is possible that if more angling hours were completed in this area, the downward trend of CPUE would have continued. Smallmouth bass presence in this area in May of each year has dramatically decreased since angling for invasive control began in 2013.

For all months in 2013-2018, a downward trend of total number of fish caught in this area is present, while CPUE also presents a downward trend except for 2018. However, fewer hours were spent angling in this area in 2018, making this year's data less robust than previous years. Despite this, the overall trend indicates that angling is an impactful method of control for smallmouth bass.

Chain Pickerel

The removal of chain pickerel at Milipsigate Outlet started in 2014. As compared to 2014, in 2018, fewer chain pickerel were removed from this area and CPUE has decreased. This indicates that fewer chain pickerel are inhabiting this area year after year. This is most likely due to a combination of various efforts by Coastal Action and partners including boat electrofishing, removal of invasive species at the Hebb Dam fishway, and both the Rotary Screw Trap and the floating trap net deployed at Milipsigate Dam.

Smallmouth Bass and Chain Pickerel Biological Study

Smallmouth Bass

Of the fish retained and analyzed for stomach contents at Milipsigate Outlet, 0% contained fish in their stomach contents, which remained the same as compared to fish caught at Milipsigate Outlet in 2017. More fish were found empty than in previous years of the study as well, except for fish sampled in 2013. Percent invertebrates consumed has remained relatively constant, whereas, percent of fish captured with empty stomachs has increased compared to all years since 2014. There are possibly two explanations for these findings; firstly, the abundance of small native fish has decreased due to previous predation and secondly, due to ongoing efforts to reduce the population of invasive species, the average size of the SMB and CP has been reduced, therefore the remaining smaller fish are not able to prey upon the remaining native fish.

Chain Pickerel

During 2018, Coastal Action made some significant discoveries in the chain pickerel biological study. During May, for the first time, project staff found nine larval Atlantic whitefish in the stomach contents of chain pickerel. This was observed at three locations; both RST locations and at the fyke net location between Hebb and Millipsigate Lake. Although not a surprise, these were the first documented cases.

Rotary Screw Trap/Fyke Net Study

This was the fifth year that Coastal Action deployed a Rotary Screw Trap at the base of Milipsigate Dam. The purpose this year was to capture larval Atlantic whitefish and then transport them to the Coldbrook Biodiversity Facility in Coldbrook, NS. To assist with the capture of the larval fish, a second Rotary Screw Trap was deployed at the outflow of Minamkeak Brook into Milipsigate Lake and two fyke nets were deployed at Weagle Dam and the overflow channel between Milipsigate Lake and Hebb Lake. Larval Atlantic whitefish were caught at three of these sites, only the Weagle Dam fyke net did not capture larval whitefish. It can be assumed that the fish caught at these independent sites are not siblings. They are currently being held at Dalhousie University's Aquatron Laboratory with the intention to be used in the future as broodstock for a captive breeding program. The offspring can then be used to reintroduce anadromy and to facilitate range expansion.

Spring/Fall Monitoring and Sampling Activities at the Hebb Lake Dam Fish Passage Facility

Spring

This year, the spring migration of gaspereau upstream through the fishway was the largest on record since the fishway's opening in 2013. The total of 20,350 gaspereau was nearly a 100% increase on the previous record of 11,737 from the spring of 2017. Due to this large number of fish using the fishway, it is now necessary to make a decision regarding the management of this fishway prior to the spring of 2019 regarding the enumeration of gaspereau. Options include limiting the number of gaspereau permitted to migrate upstream to the upper lakes, installing an electronic counting device, or ceasing to count the gaspereau individually during the busiest part of the spring run. It should also be noted that no lamprey were intercepted during this year's spring monitoring of the fishway.

Fall

As in previous years, the fall monitoring at the Hebb Dam Fishway was disappointing as only three fish were captured; one brook trout and two white sucker. However, without some form of streamside incubation facility, captive breeding program, or a strategy to promote the re-introduction of anadromy for this species then the chance of an adult Atlantic whitefish being captured at the fishway is close to zero. No adult Atlantic whitefish have been captured at the fishway since 2012, and it is now thought that these fish were the remainder of the captive bred fish released in 2008.

Smallmouth Bass Nest Monitoring and Removal

The number of nests found in the area increased as the water temperature increased through the month of June. Male smallmouth bass were excavating more nests as the month progressed. There were several

instances of nests being excavated very close together, which can possibly be attributed to one smallmouth bass excavating several nests in a small area and guarding all the nests together.

It is unlikely that the smallmouth bass fry discovered in the rotary screw trap at Milipsigate Dam are from the study area investigated and are more likely from another part of the lake closer to the dam. However, the presence of smallmouth bass fry indicates that despite destroying all the nests in the study area, smallmouth bass are still successfully reproducing, and a much larger team would be required to eradicate all nests in the lake and stop reproduction.

Survey Challenges

It was apparent from initial surveys of the lake that it would be impossible for a team of two to assess the entire shoreline of Milipsigate Lake for bass nests. Smallmouth bass spawning season is short, the shoreline is long, and survey days are highly dependent on weather. To effectively complete this survey, it was necessary for it to be a sunny, clear day with virtually no wind on the lake. Any wave action on the surface of the water dramatically decreased visibility through the water, making it impossible to view the nests. Furthermore, water levels also steadily decreased on Milipsigate Lake through the month of June, increasing the difficulty of maneuvering the boat through the shallow rocky areas of the nearshore region where all the nests were located. Poor weather combined with low water meant that it was not possible to check each nest on each survey date. Additionally, even if the weather was ideal and visibility through the water was high in the relatively shallow water of the cove, it is possible that bass were creating nests in slightly deeper water in the mouth of a cove which could not be seen or destroyed even if observed.

Use of Nest Monitoring as a Control Tool

To use this method as a control tool, the entire lake would need to be surveyed in a very short window of time. A much larger team than two people is required. This method only allows the monitoring and destruction of nests that can be observed from a boat. Some nests may exist in shallower areas that are not boat accessible, or deeper areas where the bottom cannot be seen from the surface. This survey method is also time-sensitive and weather-dependent, making it challenging to complete effectively regardless of the number of people.

Suggestions for Future Control Methods

During Summer 2019, it is recommended that the same survey area be visited to determine if fewer nests are observed compared to 2018. As smallmouth bass likely make their nests in the same place each year, it should be investigated whether our removal of nests from this area had any longer-term impact. On the final survey day, angling occurred in the study area and males guarding nests were removed, so if more nests are present in the next year, it can be reasonably assumed that smallmouth bass males who were not present in the cove the previous year have newly-invaded the area for nest building.

Lake Profiling and Zooplankton Hauls

The relative abundance of *Daphnia catawba* possibly indicates the importance of this zooplankton species as a food source for planktivorous fish. Feeding habits of larval Atlantic whitefish are poorly understood; however, it is likely that the larval fish are feeding on zooplankton, and possibly *Daphnia catawba* based on their abundance in this lake. This information may be relevant in finding a suitable habitat for translocation of Atlantic whitefish.

Recommendations

Recommendations for 2019

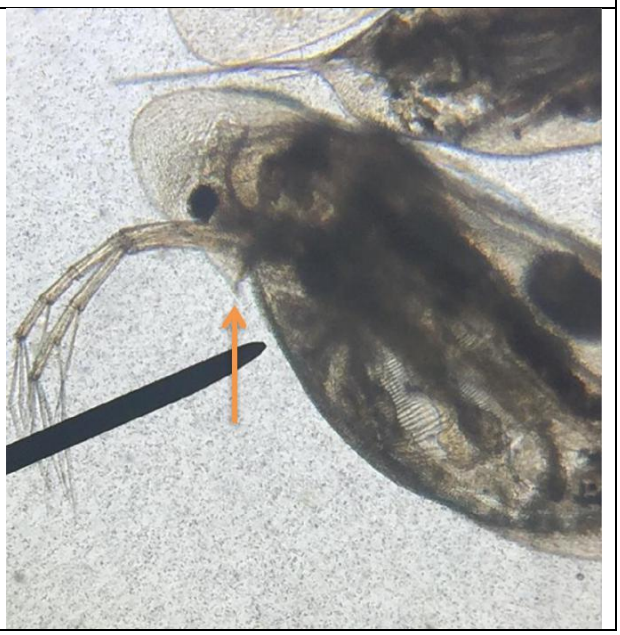
1. Deploy and operate Rotary Screw Traps at the base of Milipsigate Dam and Minamkeak Brook.
2. Deploy and operate fyke nets at Wallace Lake outlet stream and Milipsigate to Hebb Lake overflow channel.
3. Re-establish a captive breeding program and increase efforts concerning range expansion.
4. Continue with control methods targeting invasive species.
5. Continue the outreach and educational activities at local schools and community events.
6. Re-establish a committed group of volunteers to assist with fieldwork on the Atlantic Whitefish Recovery Project.
7. Continue with lake surveys to determine suitable areas for Atlantic whitefish range expansion opportunities (Newfoundland and Labrador).

Appendix 1: Zooplankton Identification Photos

Specimen 1

- This specimen resembles the Cladocera order
- Body and legs covered with a bivalve carapace, legs not segmented or prehensile
- This specimen resembles the Daphniidae, Ilyocryptidae, Macrothricidae, Moinidae families

- Antennules small and are not prominent, belongs to the Daphniidae family
- This specimen resembles the Daphnia genus



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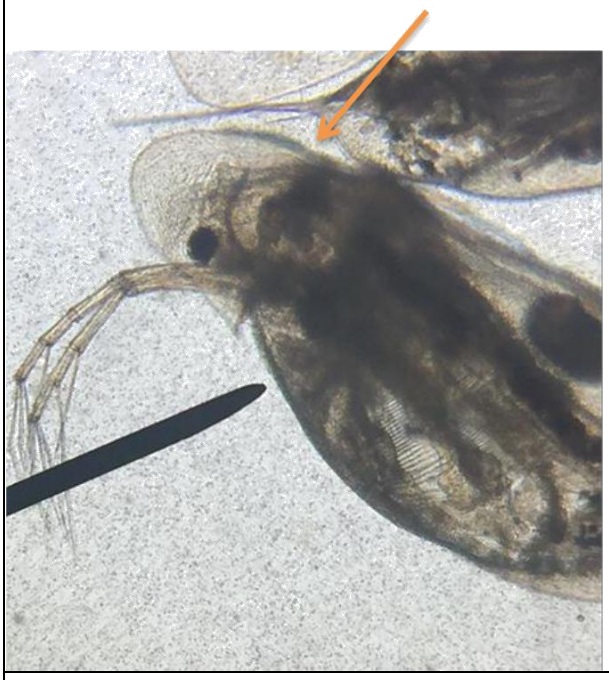
<td>  </td>
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- Cervical sinus absent

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- No visible extension of carapace

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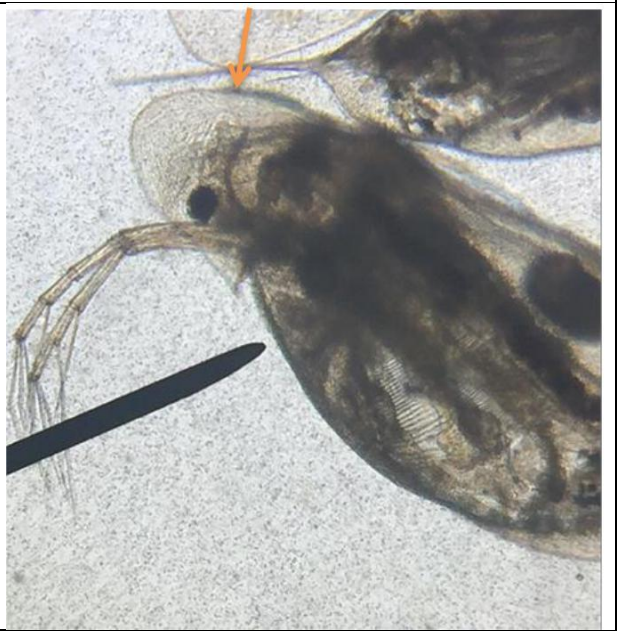
<td>  </td>
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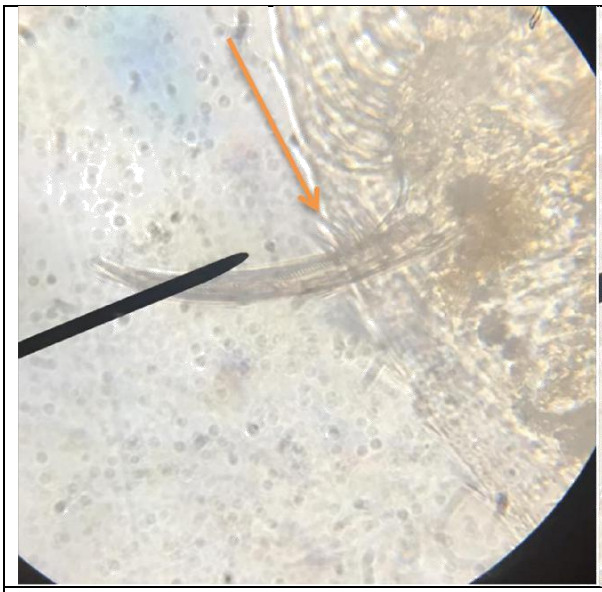
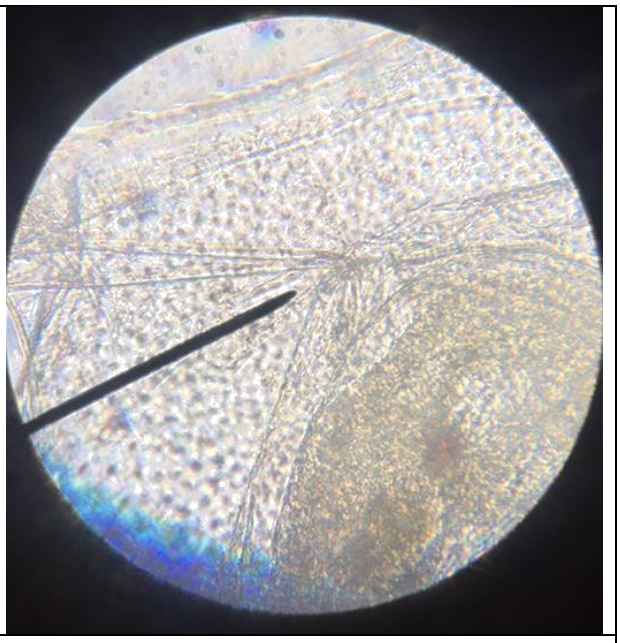
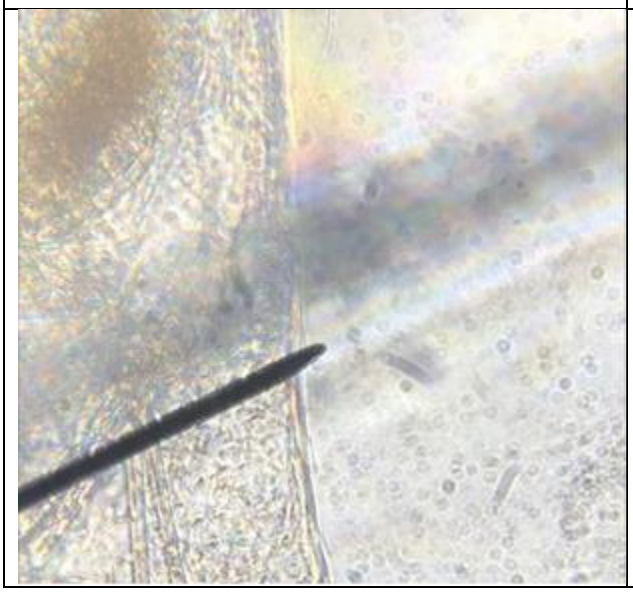


- Teeth of middle pecten very stout, at least three times the length of distal pecten teeth; generally, four to six middle pecten teeth

- Optic vesicle does not touch margin of head

• 2nd and 3rd abdominal processes weakly pubescent or lacking pubescence	
	• Dorsal spinules further apart, interspinule distance greater than 1.5 (usually 2-3) times the spinule length (difficult to see in picture) • Specimen is identified as ***Daphnia catawba***

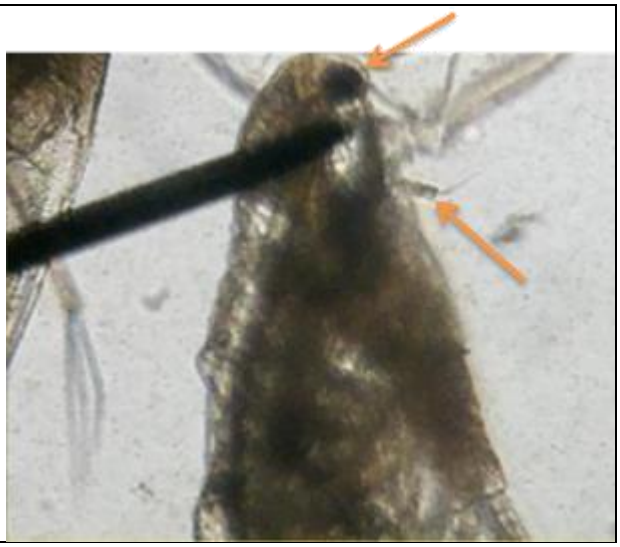
Specimen 2

- This specimen resembles the Cladocera order
- Body and legs covered with a bivalve carapace, legs not segmented or prehensile
- This specimen resembles the Holopedidae and Sididae families

- Branched antennae

- First segment of dorsal ramus of antenna without lateral expansion

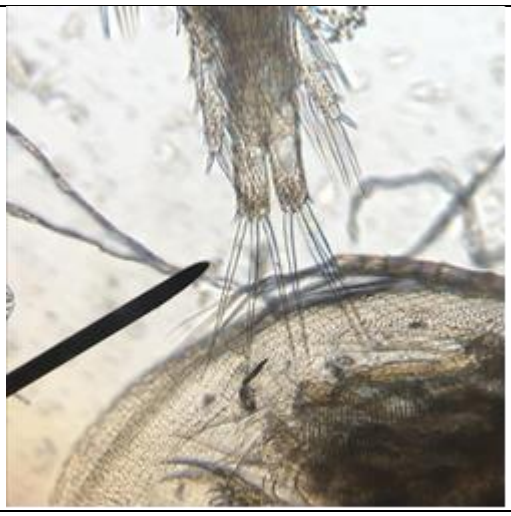
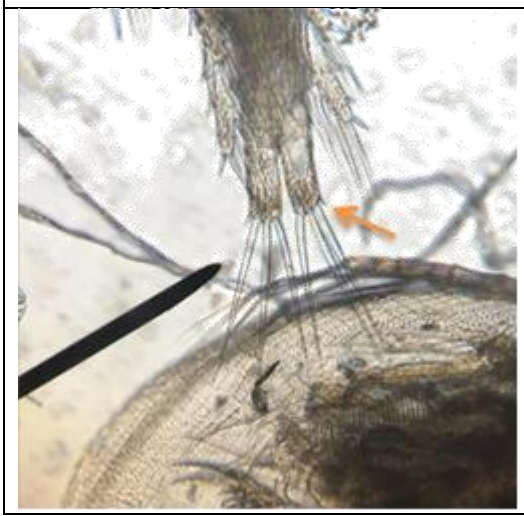
- Post abdominal claw with three spines; dorsal ramus of antenna with two segments

• Reflexed antennae not reaching past end of head; eye large and near edge of head • Specimen is identified as ***Diaphanosoma brachyurum***	

Specimen 3

	• This specimen resembles the Cladocera order • Body and legs not covered with a carapace; Legs prehensile and segmented • Body long with six pairs of legs up to 17 mm long • Species is identified as ***Leptodora kindti***

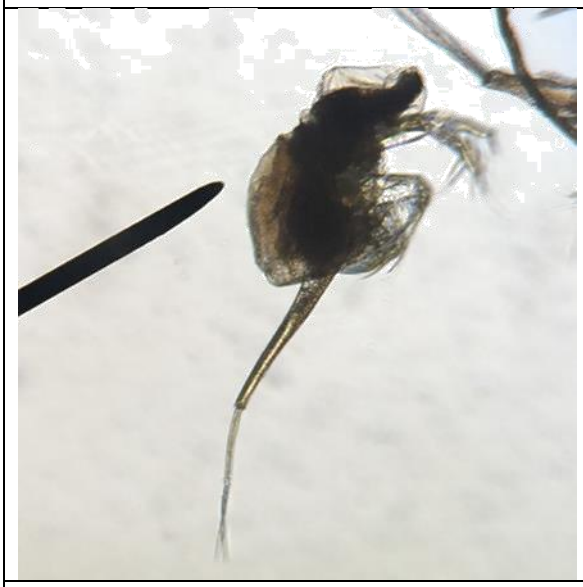
Specimen 4

	• This specimen resembles the Copepoda order • First antennae (ant) long relative to body, first antennae short relative to body, with 23 to 25 segments
• Has three stout caudal setae on each caudal ramus; last abdominal segments may curve off to one side (not a good indicator alone)	
	• Caudal ramus of both sexes with shorter or spiniform outer seta which is shorter than the ramus

• Female abdomen straight • Species is identified as ***Epischura nordenskiøldi***	

Specimen 5

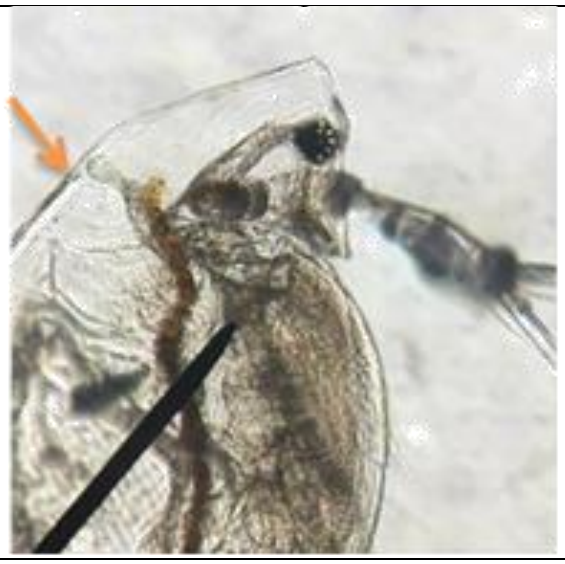
	• This specimen resembles the Cladocera order

• Body and legs not covered with a carapace, legs not segmented or prehensile; legs prehensile and segmented	
	• Body short with four pairs of stout legs, very large bulging eye
• Lacks long barbed tail spine, pedicle (slender "tail") less than length of body • Specimen is identified as ***Polyphemus pediculus***	

Specimen 6

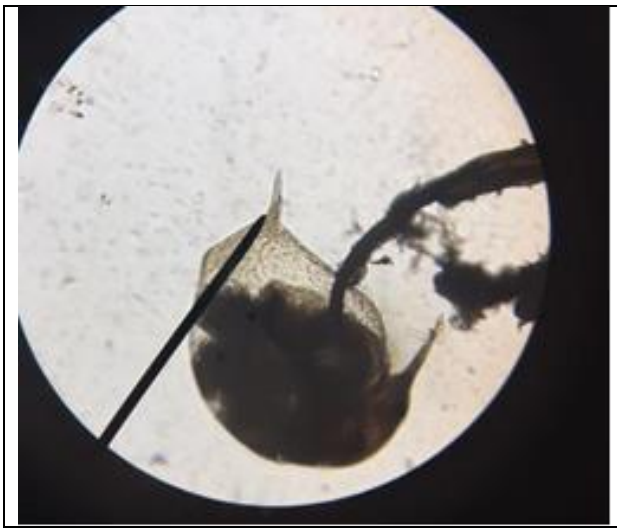
- This specimen resembles the Cladocera order
- Body and legs covered with a bivalve carapace; legs not segmented or prehensile
- This specimen resembles the Daphniidae, Ilyocryptidae, Macrothricidae, Moinidae families

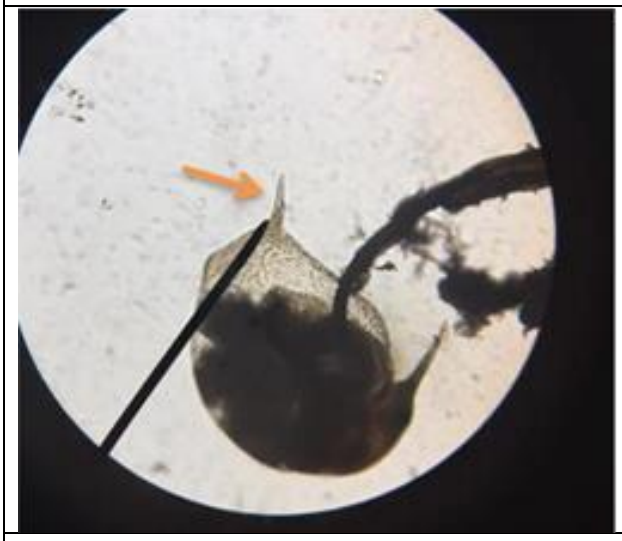
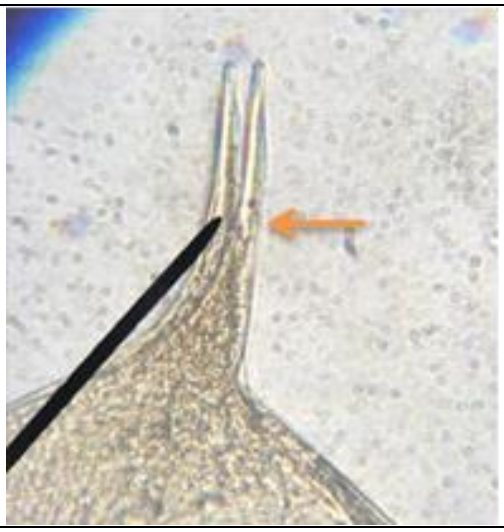
- Antennules small and are not prominent (Daphniidae family)
- Daphnia genus

	• Cervical sinus absent • No visible extension of carapace • Teeth of proximal, middle and distal pecten are small and approximately the same size
• Hair at bottom of second segment, extends past top of ramus	

	• Head small relative to body with or without helmet, small rostrum, body length generally less than 1 mm • Specimen is identified as ***Daphnia ambigua***

Specimen 7

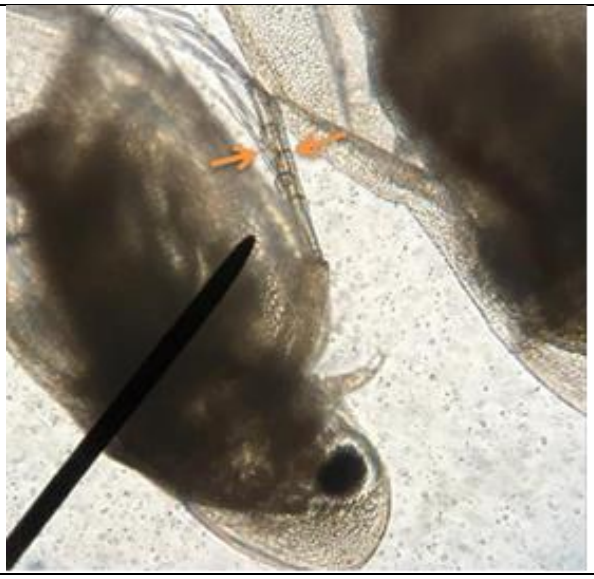
	• This specimen resembles the Cladocera order • Body and legs covered with a bivalve carapace; legs not segmented or prehensile • Bosminidae family

• Antennules separately attached to head and are approximately parallel to each other • Post abdominal claw with proximal pecten only; sensory bristle near tip of rostrum	
	• Mucro present
• Mucro with small notches on the ventral side • Specimen is identified as ***Eubosmina longispina***	

Specimen 8

- This specimen resembles the Cladocera order
- Body and legs covered with a bivalve carapace, legs not segmented or prehensile
- This specimen resembles the Holopedidae and Sididae families

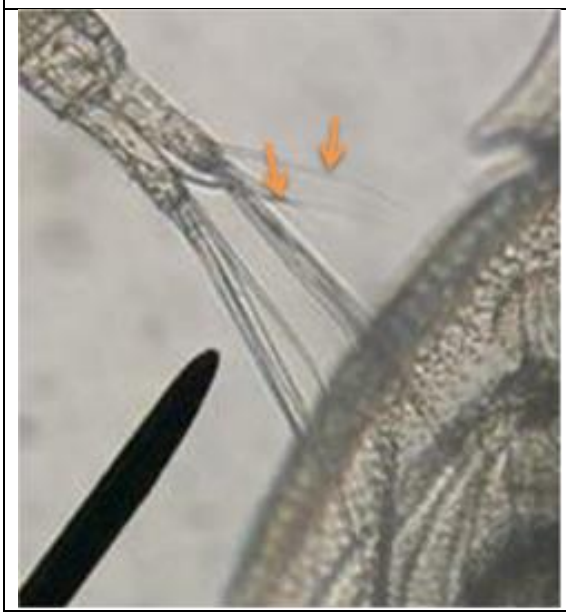
- Branched antennae (ant)
- First segment of dorsal ramus of antenna without lateral expansion
- Post abdominal claw with four spines; dorsal ramus of antenna with three segments
- The specimen is identified as ***Sida crystallina***



Specimen 9

- This specimen resembles the Copepoda order
- First antennae long relative to body, with 23 to 25 segments

- Has three stout caudal setae on each caudal ramus; last abdominal segments may curve off to one side (not a good indicator alone)



- Caudal ramus of both sexes with slender outer seta which is approximately equal in length to the ramus
- Specimen is identified as ***Heterocope septentrionalis***

Specimen 10

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- This specimen resembles the Copepoda order
- First antennae long relative to body, with 23 to 25 segments

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- Has five thin caudal setae on each caudal ramus; never has a bend in the last abdominal segments
- Length of caudal ramus three times its width
- Five setae of similar length

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	• Female calanoid copepod (egg sack present) • Species is identified as Calanoid copepod female • A male is needed for further identification

Specimen 11

	• Copepod molt

Unidentified Specimens