LaHave River Invasive Species Project

2019 Final Report

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Coastal Action

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Acknowledgements

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Introduction

Coastal Action

Coastal Action is a non-profit community-based NGO that addresses environmental concerns in Lunenburg County, Nova Scotia. The goal of the organization is to restore, conserve, and enhance the environment through research, education, and action. Petite Riviere, LaHave, Gold, Mushamush, and East River are all watersheds that are located within the organization's boundary of operations. Communities that are located within these boundaries include Lunenburg, Bridgewater, Chester, and MaHone Bay, as well as other smaller communities.

Over the past 25 years, Coastal Action has successfully completed various environmental projects in Lunenburg County including species at risk, watershed sampling/monitoring, habitat restoration, and environmental education.

Problem

Atlantic Salmon (*Salmo salar*) are threatened throughout most of their Canadian range by non-native fish species. Many factors are influencing population declines in both freshwater and marine habitats. In Nova Scotia, two aquatic invasive species threaten the survival Atlantic Salmon during their freshwater migration as smolt through direct predation: smallmouth bass (*Micropterus dolomieu*) and chain pickerel (*Esox niger*).

Invasive Species

Smallmouth Bass (Micropterus dolomieu)

Smallmouth bass are a freshwater sunfish native to Great Lakes/Saint Lawrence River region of Canada. They have been observed using both lacustrine and riverine habitat type during multiple life stages. The ability to survive in a variety of habitats within a watershed allows smallmouth bass to access a large portion of a that watershed. This also allows smallmouth bass to spread quickly through new watersheds when introduced. The first authorized introduction of smallmouth bass in Nova Scotia occurred in 1942 in Yarmouth County. Smallmouth bass currently occupy 180+ lakes in Nova Scotia due to countless authorized and un-authorized introductions since the 1940's (Leblanc, 2010). Once established, smallmouth bass alter ecosystems through direct predation and habitat competition.

Chain Pickerel (*Esox niger*)

Chain pickerel are a freshwater fish in the pike family native to lakes in Eastern North America ranging from southern Maine, South to Florida, and West to Texas. Authorized introductions occurred in three locations in southern Nova Scotia in 1945 (Mitchel et al. 2011). Due to their high catchability and desired fight when caught, they have been illegally introduced into 95+ lakes in Nova Scotia since their initial introductions in the mid 1900's (Mitchell et al. 2011). Chain pickerel prefer lacustrine habitat with dense vegetation. They use this vegetation for spawning and hunting purposes. They are considered burst predators, waiting for prey to enter burst distance until they strike. The preference of lacustrine habitat slows, but does not stop, their spread through watersheds. Chain pickerel can drastically alter ecosystems when introduced. Their prolonged presence can result in the total loss of small bodied fish species and a truncating of fish body size distribution towards large fish (Mitchell et al. 2011).

Goals and Objectives

The 2019 field season goals and objectives comprised the second portion of a two-year research project. They address the problem of predation on Atlantic salmon (*Salmo salar*) smolt by two freshwater invasive fish species, smallmouth bass and chain pickerel. The 2019 field season focused on tagging the two invasive species as part of an ongoing mark and recapture study, as well as obtaining a comprehensive diet structure through live stomach content removal. A gastric lavage technique was applied to the two non-native fish species for the entire season to form the diet structure. Each fish had the stomach contents weighed and separated for further analysis. The contents will be identified to the lowest taxonomic level possible. Indicators of success for the 2019 field season were as follows:

1. Number of smallmouth bass and chain pickerel tagged
2. Number of stomach contents extracted
3. Number of recaptured smallmouth bass and chain pickerel
4. Efficiency of gastric lavage technique

Methods

Smallmouth Bass and Chain Pickerel Extraction

The most cost effective and time efficient method for extraction of smallmouth bass and chain pickerel for analysis and tagging was scientific angling. This method was used throughout the 2019 field season for all sampling. Scientific angling was also chosen for its ability to exclude most native species from sampling based on the type of bait used. Two chain pickerel fishing tournaments assisted in the extraction of tagged fish, as well as the extraction of stomach contents. A 14-ft Princecraft aluminum boat was the main sampling station and primary mode of transportation during the extraction of smallmouth bass and chain pickerel. A wide variety of baits were used, targeting the non-native predators. This was an attempt to mimic what the fish were feeding on at the time of sample determined by periodic non-lethal stomach content samples from the non-native species and from observations during sampling. Angling took place between May 11, 2019 and August 23, 2019.

Tagging

Once a fish was angled, it was placed in an aerated live well on the boat. Upon capture, each fish was anaesthetized using a 40 mg/L clove oil mixture. A temperature was taken of the solution, and the lake water, to assure there was not more than a 5^{o}C difference. If a difference of more than 5^{o}C was noted, the solution was discarded, and a new solution was formed using fresh lake water.

The fish were placed in the solution until they began to lose equilibrium, which was observed when they lost balance in the water column. Once the fish had lost equilibrium, weight and length measurements were performed. Weight was taken using a wet mesh bag and a hanging scale, whereas length measurements were taken using a semi-submerged trough measuring board. After the measurements were completed in the trough, the fish was tagged with a T-bar Floy tag below the dorsal fin. The fish was then placed in a separate live well to recover and then released into the lake. This entire process lasted approximately 2-4 minutes per fish from time of placement in anaesthesia to time of release. If any fish

did not recover within 5 minutes, or showed signs of being foul hooked, it was euthanized after anaesthesia with a sharp knife into the brain cavity.

Gastric Lavage

Angling was the main sampling method for the biological stomach survey, although boat electrofishing was used when possible to diversify angling selectivity bias. Upon capture, similar to the methods for tagging the fish, each fish was anaesthetized using a 40 mg/L clove oil mixture. This lowered the stress on each fish and minimized unintended mortality throughout the survey. Once extracted (methods outlined below), stomach contents were placed in individual sample containers in ethanol and labelled to allow for later analysis related to fish predator size, location, and date of capture. Contents were preserved in order for case stable isotope analysis to be performed to help calculate the trophic level of the non-native predators.

In an attempt to increase efficiency of stomach content removal, a variation of the "BARF" board was used for this study (Figure 1). A hose attached to a bilge pump was used for water input. The bilge pump was attached to a 12-V battery as the main power source and controlled using a foot pedal so the fish could be easily manipulated during the extraction process. These methods were tested by Hakala and Johnson (2004) on largemouth bass and were shown to have 98.5% efficiency based on number of prey items present. Mortality of the fish after extraction was also low when using these methods as each fish was processed within approximately 30 seconds (Hakala & Johnson, 2004). The board was used to hold the fish during the extraction process. Modified wooden tongs were used to extract large contents that could not be dislodged by water.

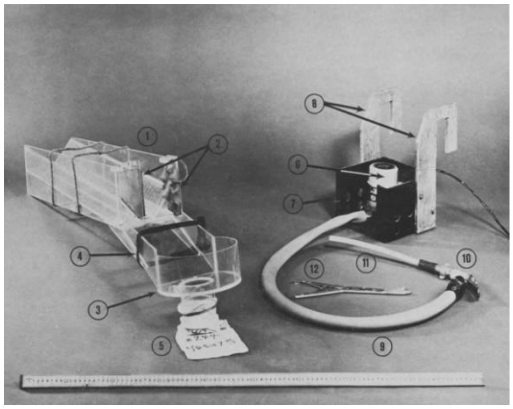

Figure 1. "BARF" board (Board Allowing the Regurgitation of Fish) created to non-lethally extract stomach contents of fish (Source: Crossman and Hamilton, 1978).

Figure 2. Modified "BARF" board used to non-lethally extract stomach samples.

Area of Study

Wentzells Lake is located outside of Bridgewater, Nova Scotia within the LaHave River watershed. This site was chosen due to the combination of the Main River and North Branch of the LaHave feeding into the lake. With two major branches of the LaHave entering this lake, the likelihood of Atlantic salmon smolt using this as a migratory pathway is higher than any other lake within the system. The lake supports populations of both smallmouth bass and chain pickerel, which are the non-native fish that this study is targeting. The lake also has two boat launch sites allowing for easy access.

The lake was split into three sections based on vegetation density, vegetation species, prior angling data, and lake morphology (Figure 3). These sections were labelled W1, W2, and W3. W1 is the area in which the North Branch of the LaHave River enters the lake. This area is shallow and densely vegetated with pickerel weed and rush species. W2 is the shoreline of the lake, with coves that have gradual increases in depth and vegetation consisting of water lily species and pondweed. Finally, W3 is the shoreline that borders the main road and is sparsely vegetated with rush species, containing steep increases in water depth and has little to no lake bottom habitat. A portion of the LaHave River upstream from Wentzells Lake was sampled to estimate emigration rates from the lake. The area of the LaHave River upstream of Wentzells Lake in the Main River section was labelled as R1. The section was sampled until it became unnavigable by boat.

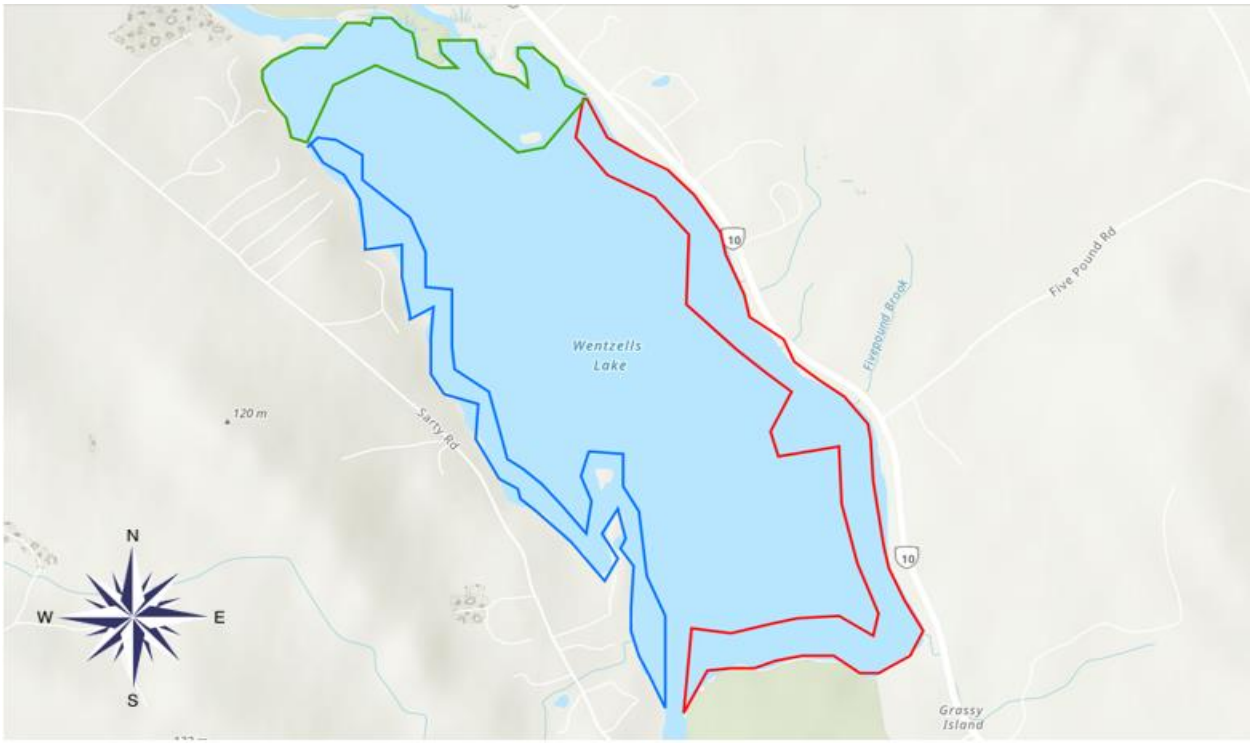

Figure 3. Wentzells Lake divided into sampling sections; Green-W1, Blue-W2, and Red-W3.

Results

*Table 1. Total effort and number of **smallmouth bass** caught during the 2019 field season. Catch per unit effort (CPUE) is shown as number of fish caught divided by effort in hours.*

Location	Effort (hrs)	# of Fish Caught	CPUE (# fish/hr)
W1	45.75	36	0.79
W2	29	34	1.17
W3	22	15	0.68
Total	**96.75**	**85**	**0.88**

*Table 2. Total effort and number of **chain pickerel** caught during the 2019 field season. CPUE is shown as number of fish caught divided by effort in hours.*

Location	Effort (hrs)	# of Fish Caught	CPUE (# fish/hr)
W1	45.75	102	2.23
W2	29	67	2.31
W3	22	31	1.41
Total	**96.75**	**200**	**1.98**

Chain pickerel had a higher catch per unit effort overall and, in individual sections, higher than smallmouth bass, with 1.98 fish per hour and 0.88 fish per hour, respectively. The total CPUE in 2018 for chain pickerel and smallmouth bass was 2.82 and 1.43 respectively.

Table 3. Location and number of chain pickerel recaptured during 2019 sampling season.

Location	Recaptured
W1	8
W2	21
W3	2
R1	0
Unknown	26
Total	**57**

Table 4. Location and number of smallmouth bass recaptured during 2019 sampling season.

Location	Recaptured
W1	1
W2	6
W3	0
R1	3
Unknown	3
Total	**13**

Tagged fish caught during the chain pickerel tournaments, or called in by anglers, did not have a location associated with their recapture and were labelled as unknown.

Table 5. Movement of chain pickerel within Wentzells Lake and the river.

Initial Tag Location	Recapture Location	Second Recapture Location
W3	W1	-
W2	W1	-
W1	W2	-
W1	W1	W2
W1	W2	-
R1	W2	-
W1	W2	-

Table 6. Movement of smallmouth bass within Wentzells Lake and the river.

Initial Tag Location	Recapture Location	Second Recapture Location
W3	W2	W3
W1	W3	-
W3	W1	W1
W2	R1	-
W2	R1	R1
W3	W1	-

Two smallmouth bass were tagged in the W2 section of Wentzells Lake and were recaptured in the upstream river section (R1). This occurred during the spawning season.

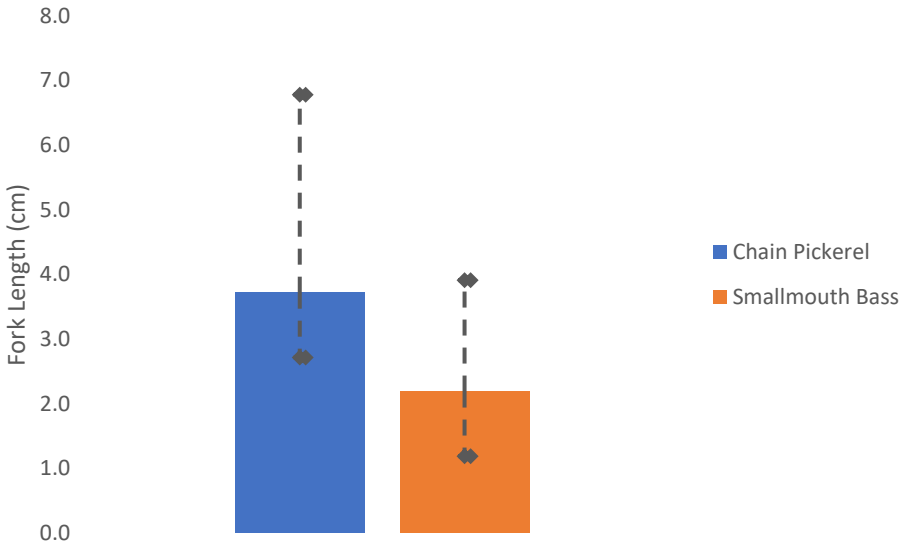

Figure 4. Average fork length growth of chain pickerel and smallmouth bass between 2018 and 2019. Error bars indicate maximum and minimum growth. Growth period depends on initial capture and recapture time.

Growth of both chain pickerel and smallmouth bass were averaged from all size classes. The highest growth of all chain pickerel was noted from fish between 35-40 centimeters fork length and had the longest growth period between captures.

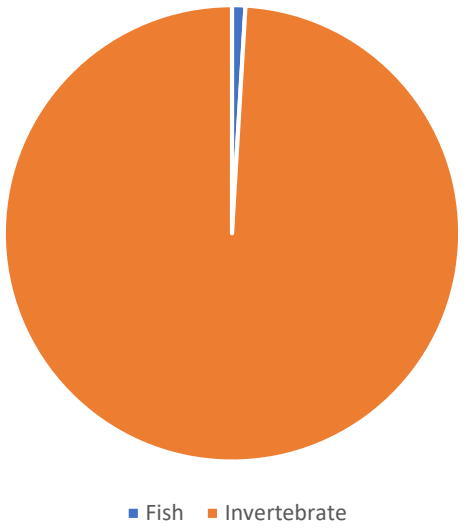

Figure 5. Content of smallmouth bass stomach contents as a percentage based on weight (g) of content. Non-lethal stomach content removal. Sampling season April 25, 2019 – August 25, 2019.

Invertebrates made up over 99% of the sampled smallmouth bass diet based on weight (g). Fish that were void of contents were not included in the stomach diet study.

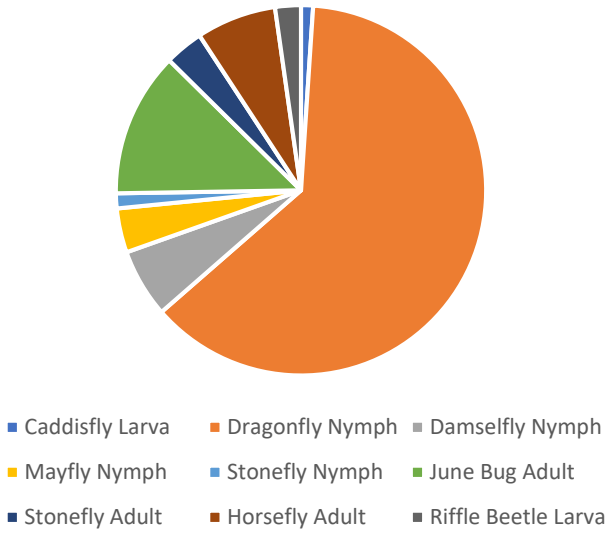

Figure 6. Invertebrate contents sampled from smallmouth bass separated by species and percent abundance based on weight (g). Species with higher than 1% abundance were graphed. Sampling season April 25, 2019 – August 25, 2019.

Dragonfly nymph were the most abundant prey item for smallmouth bass. Of the 99% invertebrate diet, 60% was found to be dragonfly nymphs. June bug adults were second most abundant with just over 12% of the total invertebrate portion of the diet. Species that made up less than one percent of the invertebrate portion of the diet, and were not included in the graph, were adult dragonfly and damselfly, water strider, adult crane fly, water beetle, and hoverfly. A single freshwater mussel was found in the stomach contents as well but may have been an unintended bycatch by a smallmouth bass during ingestion of a prey item.

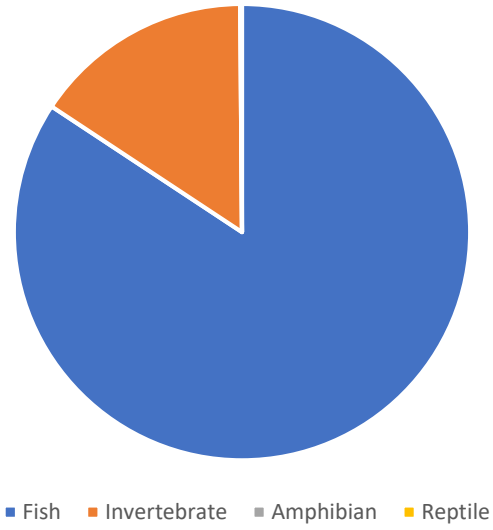

Figure 7. Content of chain pickerel stomach contents as a percentage based on weight (g) of content. Non-lethal stomach content removal. Sampling season April 25, 2019 – August 25, 2019.

When compared with smallmouth bass, chain pickerel in Wentzells Lake prey on fish more readily, and throughout the entire sampling season. The sampled chain pickerel diet consisted of just under 85% fish. Amphibian and reptile remains were also found in the sampled stomach contents, but were highly decomposed and were reduced in weight due to the decomposition.

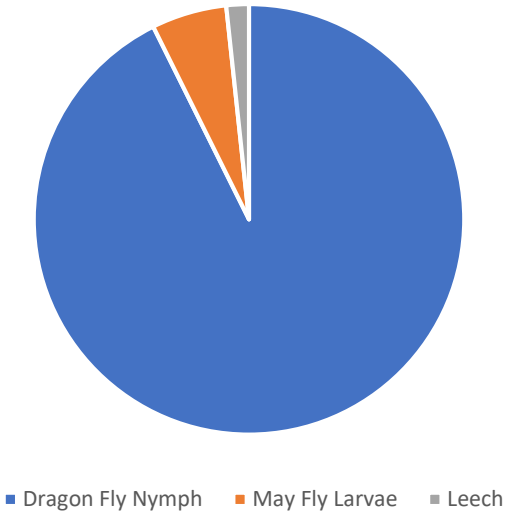

Figure 8. Invertebrate contents sampled from chain pickerel separated by species and percent abundance based on weight (g). Species with higher than 1% abundance were graphed. Sampling season April 25, 2019 – August 25, 2019.

Of the 15% portion of the diet that consisted of invertebrates, 89% of the weight was dragonfly nymphs. Mayfly and dragonfly nymph stage made up just under 97% of the entire invertebrate portion of the diet.

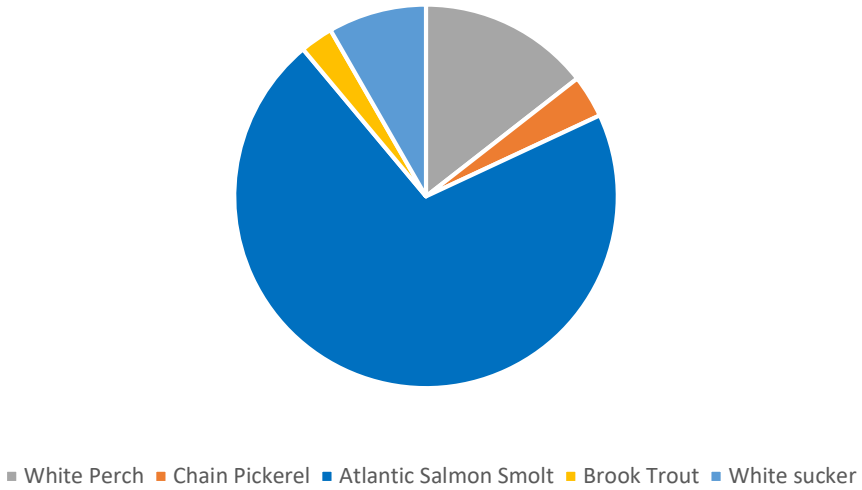

Figure 9. Fish contents from chain pickerel separated by species and percent abundance based on weight (g). Sampling season April 25, 2019 – August 25, 2019.

Atlantic salmon smolt were the most abundant fish in the chain pickerel diet in Wentzells Lake. They were also the most abundant prey item in the diet, as a whole, with 59% of the entire diet (invertebrate portion included) consisting of Atlantic salmon smolt. White perch were the second most abundant fish sampled in the diet and were also noted in Wentzells Lake as being an abundant prey species present during sampling.

Discussion

Although overall sample numbers were lower in 2019 than in 2018, the number of recaptures was higher. The recapture rate was also higher, meaning that of the decreased sample size more were recaptures. This infers that a larger portion of the population was tagged by 2019, thus more fish sampled were previously tagged. Angling effort remained relatively similar between 2018 and 2019, with the exception of boat electrofishing. Electrofishing was not used as a secondary sampling method in 2019 due to the low recapture efficiency during the 2018 electrofishing sampling. Heavy rain events in the late spring of 2019 minimized sampling efficiency during the end of the smolt migration. This may have caused a bias in smallmouth bass sampling due to the timing of heavy rain events coinciding with the early smallmouth bass spawning season.

The timing of the rain events may have forced the sampling period to miss the height of the Gaspereau migration. Gaspereau have been found in the stomach contents of chain pickerel in previous sampling years in Wentzells Lake and are likely missing from this dataset simply due to lack of sampling.

The length of the sampling period being a full season (April-August) has introduced bias against species that are only present during migration periods or hatch periods. Atlantic salmon smolt were present in the data for approximately four weeks in May and early June. Outside of this migration window there were no smolt present in Wentzells Lake and, therefore, could not appear in the stomach contents of either chain pickerel or smallmouth bass. This would dilute the abundance of Atlantic salmon smolt as a prey item in the diets of both invasive predators. Even with this bias against Atlantic salmon smolt, they remained the most abundant prey item in the chain pickerel diet based on weight (g).

In contrast, the presence of Dragonly nymph year-round may have provided a bias for the abundance of the nymphs in the diet of both smallmouth bass and chain pickerel. Although, of the invertebrates found in the stomach contents sampled, Dragonfly nymphs are the largest and possibly a better prey item for the fish based on total effort of catch and caloric intake.

Decomposition levels of prey items can also introduce bias. As observed with amphibians and reptiles in the diet of chain pickerel, the highly decomposed remains had a lower abundance due to the decreased weight. If these items were at a lower level of decomposition, they would have had more weight and, therefore, more abundance within the diet. Decomposition rates can introduce bias when using weights. If there are portions of an item that decompose at a higher rate than others, it can bias the weight and abundance for that prey item based on which portions decompose slower. It will also depend on ingestion

time relative to sample time as to whether that item will contribute a higher weight to the overall abundance of the item.

It is important to note that the abundance of prey items based on weight does not show the true importance of that prey item to the predator. The weight of each prey item is simply a way of portioning the diet of the invasive predators in a precise calculation. A caloric value for each prey item must be found to give each item an importance rating to the predator. Theoretically, if white perch had a higher caloric value than Atlantic salmon, they may hold a higher importance to chain pickerel even when the Atlantic salmon smolt were more abundant in the diet.

References

Crossman, E., & Hamilton, J. (1978). An apparatus for sampling gut contents of large, living fishes. Royal Ontario Museum, University of Toronto. Environmental Biology of Fishes, 3: 297-300.

Hakala, J. P., & Johnson, F. D. (2004). Evaluation of a Gastric Lavage Method for Use on Largemouth Bass. *North American Journal of Fisheries Management*, 24(4), 1398–1403. https://doi.org/10.1577/m03-092.1

LeBlanc, J. E. (2010). Geographic distribution of Smallmouth Bass, Micropterus dolomieu, in Nova Scotia: history of early introductions and factors affecting current range. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/028. Iv. 25.

Mitchell, S.C., J. E. Leblanc, and A. J. Heggelin. (2011). Impact of Introduced Chain Pickerel (Esox niger) on Lake Fish Communities in Nova Scotia, Canada.