

# Virile Crayfish (Zhaageshii) Monitoring of Stannar, Wolseley, and Pickerel Lake, Quetico Provincial Park

Results of 2015 and 2016 Surveys

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## **Executive Summary**

Surveys were conducted during the summers of 2015 and 2016 in Wolseley Lake, Pickerel Lake and Stannar Lake. Crayfish were captured using modified minnow traps baited with cat food. Information on crayfish size, relative abundance, sex, and habitat distribution was collected. This report also draws from fish stomach samples collected through the 2016 BROADSCALE Fisheries Monitoring program.

Across all lakes 655 crayfish were caught, with the majority (607) caught in Stannar Lake. All crayfish were the native virile crayfish (*O. virilis*). Results suggest that crayfish distribution is influenced by the presence/absence of predators, particularly non-native smallmouth bass. Catch per trap in Stannar Lake (containing no smallmouth bass) was much higher compared to Wolseley and Pickerel Lakes. Crayfish size may be smaller in lakes containing smallmouth bass; however more data is required to confirm this relationship.

Future monitoring recommendations include 1) Include water chemistry measurements, specifically dissolved calcium measurements, in the crayfish sampling protocol. Crayfish survival is expected to be linked to calcium concentrations because this mineral is important for the growth and maintenance of the crayfish's hard exoskeleton. 2) Sample lakes with and without smallmouth bass to better understand the relationship between this predator and crayfish size and abundance, 3) Only use cat food bait for one day of trapping or only use data from the first day of trapping for comparison between studies, because significantly fewer crayfish were caught on the second day of bait use, and 4) Trap crayfish in different habitats to help understand their use of these habitats.

## Introduction

Crayfish (*Zhaaghesii*) are an important part of freshwater ecosystems, making up the majority of benthic invertebrate biomass (Keller and Moore, 2000). They are omnivores, eating a variety of aquatic plants, fish eggs, and benthic organisms (Hanson and Chambers, 1995; Wilson *et al.* 2004), as well as an important source of food for larger fish species (Tetzlaff *et al.* 2011). However, little is known about the mechanisms by which crayfish influence their habitat and other species.

Historically, Quetico Provincial Park has been home to one species of crayfish, the northern or virile crayfish (*Orconectes virilis*). In the past few years non-native rusty crayfish (*Orconectes rusticus*) have arrived and reached high densities in lakes along the southern boarder of Quetico Park. Rusty crayfish are slightly larger and more aggressive than virile crayfish and have been found to displace this native species as they move into lakes (Wilson *et al.* 2004). Decreased macrophyte cover has been associated with the arrival of rusty crayfish (Hanson and Chambers, 1995), which may have subsequent effects on benthic invertebrates and fish communities. However, virile crayfish populations, including their population structure, habitat preferences, and role in freshwater ecosystems have rarely been studied prior to the arrival of rusty crayfish, especially in northwestern Ontario. A guide to identifying virile and rusty crayfish is available in Appendix 1.

Several species of centrachids that are present in Quetico Provincial Park, including pumpkinseed sunfish, bluegill sunfish, rock bass, smallmouth bass, and largemouth bass are known to feed on crayfish (Garvey *et al.* 2003). Bass, particularly smallmouth bass are crayfish specialists. In 2010, Broadscale Fisheries Monitoring (BsM) surveys conducted in Quetico found that 50% of all smallmouth bass caught with food in their stomachs had consumed crayfish (Jackson, 2015b). Comparatively, less than 20% of northern pike with food in their stomachs had consumed crayfish, and less than 10% of walleye. Smallmouth bass have also been shown to be effective at population control of invading rusty crayfish (Hein *et al.* 2006). Smallmouth bass have been caught in all but one of the lakes surveyed by the BsM program within Quetico Park as of fall, 2015, and were introduced to the area in the 1940s. By the 1970s they were wide spread throughout the Park. However, their influence on native crayfish populations in Quetico Provincial Park has not been considered.

## Objectives

These surveys are a first assessment of the abundance, distribution, and size of virile crayfish populations in Quetico Provincial in order to:

- 1) better understand the distribution, size and abundance of native virile crayfish (*O. virilis*) in Quetico Provincial Park.
- 2) begin to understand the impact of introduced smallmouth bass on crayfish populations in Quetico Provincial Park.

## Methods

### Study Sites

Quetico Provincial Park is located between Thunder Bay and Fort Frances in the Province of Ontario, sharing a border with the Boundary Waters Canoe Area in Minnesota. The area is underlain by Canadian Shield bedrock in a transition zone between southern mixedwood forests and northern boreal forests. Numerous lakes and streams support 48 species of fish in cold and warm water habitats. Three lakes in Quetico Provincial Park were selected for this study: Wolseley Lake, Pickerel Lake, and a previously unnamed lake near Stanton Narrows on Pickerel Lake, which will be referred to as Stannar Lake (Table 1).

Table 1: profiles of the lakes trapped in 2015 and 2016

Lake	Stannar	Pickerel	Wolseley
Stain		clear	dark
Thermal Regime	warmwater	coldwater	coldwater
Area (ha)	39	5754	1307
Average Depth (m)		17.7	12.6
Maximum Depth (m)	6		40
Mean Secchi Depth (m)	3.4	4.3	2.6
Mean Conductivity (umhos/cm)	16.5	31.6	30.0
Common Fish Species*	pumpkinseed sunfish, northern pike, walleye, yellow perch	smallmouth bass, pumpkinseed sunfish, northern pike, walleye, lake trout, yellow perch	smallmouth bass, largemouth bass, rock bass, pumpkinseed sunfish, bluegill sunfish, northern pike, walleye, lake trout, yellow perch
Total # Fish Species	7	19	26

\* full fish species list available in Appendix 2

### Trap Method

Modified minnow traps were used as a standardized method of crayfish collection. Though traps are known to select for large, aggressive, male crayfish (Wilson *et al.* 2004; Hein *et al.* 2006), they can still provide accurate assessments of species composition and relative abundance (Capelli, 2003), and assessments of population density and catch rates between sites (Jansen *et al.*, 2009).

Minnow traps were modified to have entrance holes enlarged to 3.5 cm in diameter. Traps were baited with canned fish-based cat food which was used for two consecutive trap days. Traps were set in lines of three, spaced 3 m apart, and running perpendicular to the shore. Four lines of three traps, each approximately 10 m apart, constituted one plot for a total of twelve traps per plot. Plots were chosen by dividing the shoreline (including islands) into 50 m segments and randomly selecting from these segments. Maps of the plot locations are available in Appendix 3. Traps were set over night for a minimum of 12 hours and the depth of each trap measured. Set and lift time, bait type, observers, location, habitat, the number, total length (tip of the rostrum to the tip of the central telson measured on the dorsal surface), carapace length (tip of the rostrum to the back of the carapace measured on the dorsal surface), and sex of each crayfish caught, and a note of any other organisms caught in the trap was recorded. Crayfish were then released at the site that they were trapped. Habitat was classified as cobble, macrophyte (aquatic vegetation), detritus (decaying leaf layer and fallen woody debris) or soft bottom (muck).

### ***Sampling Period***

Sampling occurred June 28 – 30, 2016 on Wolseley Lake, August 2 – 4, 2016 on Stannar Lake, and August 9 – 10, 2016 on Pickerel Lake in Quetico Provincial Park. Additionally data collected using the same protocols from August 29 – 30 in 2015 on Pickerel Lake was included in this analysis to increase the size of the data set available from Pickerel Lake. In total, 10 plots were surveyed on Wolseley Lake (120 trap-days), 10 plots on Stannar Lake (118 trap-days, (one missing trap)), 2 on Pickerel Lake in 2016 (24 trap-days) and 1 on Pickerel Lake in 2015 (12 trap-days).

### ***Statistical Analysis***

Total number of males vs female crayfish and pair-wise comparisons between trapping days, males and females within habitats and within depth stratum were made using a two sample t-test for populations with equal variances. Equal variance between populations was verified using an f-test statistic. Single factor ANOVA was used to compare crayfish size and number per trap across four habitats and five depth strata. Following detection of a difference between populations, two sample t-tests for populations with equal variances were used to determine which pairs of habitats were significantly different. The significance of a linear line of best fit for the ratio between total length and carapace length was determined using regression analysis. A p-value of 0.05 was used as the cut-off for all determinations of statistical significance. Statistical analysis was completed using MS Excel. Data summaries are available in Appendix 4.

### **Results**

A total of 655 virile crayfish were caught across all lakes and both years. 607 of these crayfish were captured on Stannar Lake, 13 on Wolseley Lake and the remaining 35 from Pickerel Lake. This represents a catch per trap of 5.14 crayfish on Stannar Lake which is significantly higher than on Pickerel (1.13 crayfish per trap,  $p = 5.4E-12$ ), and on Wolseley (0.12 crayfish per trap,  $p = 1.3E-30$ ) (Figure 1). No rusty crayfish were caught.

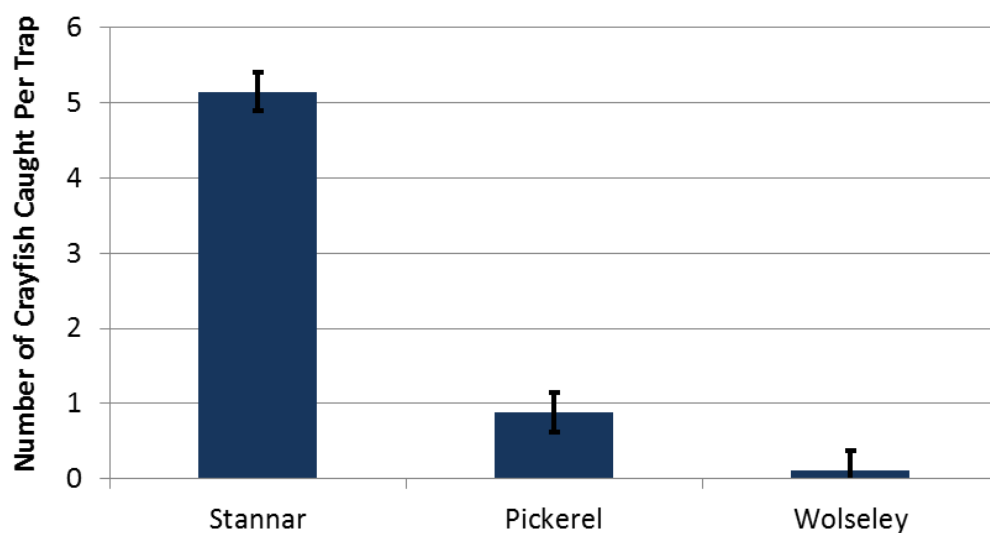


Figure 1: Virile crayfish catch per trap for 2015 and 2016 trapping on Stannar, Wolseley and Pickerel Lakes

Due to the volume of crayfish caught and time constraints, size sampling was not completed for 145 crayfish from Stannar Lake. Furthermore, size data collected from the crayfish caught in Pickerel Lake in 2016 had concerns about its reliability and therefore will not be used in this analysis. Due to the low sample size of crayfish caught in Wolseley and Pickerel Lake limited conclusions can be drawn from these data.

### ***Carapace – Total Length Ratio***

Consistent with surveys of rusty crayfish completed last year (Jackson, 2015a), total length and carapace length of virile crayfish are significantly correlated (regression analysis, p value < 0.05) for virile crayfish captured from Stannar Lake (Figure 2). Virile crayfish sampled from Pickerel Lake in 2015 have carapace lengths that fit the Stannar Lake regression well, though two of the five individuals have shorter total lengths and carapace lengths than observed in Stannar. Three of the thirteen virile crayfish sampled from Wolseley Lake were also outside the lower range observed in Stannar Lake, though most overlap.

Carapace length is a more reliable measurement than total length (as well as being faster and easier to obtain in the field) because crayfish can bend their tails while being measured. This leads to total length measurements that often underestimate the true value. In addition to representing crayfish caught in Wolseley and Pickerel Lakes, the regression line relating total length to carapace length for virile crayfish obtained from Stannar Lake is similar to the relationship observed for virile crayfish caught in Basswood and Crooked Lakes in Quetico Park last year (Jackson, 2015). This indicates that measurements of carapace length can be reliably related to crayfish total length. For ease of interpretation, further data analysis and results presented in this report will work from a calculated total length obtained using the Stannar Lake carapace-total length regression equation (Equation 1).

Equation 1: Calculating total length using the carapace-total length regression equation obtained from crayfish caught on Stannar Lake. n = 74

$$\text{Calculated Total Length (mm)} = \text{Carapace Length (mm)} \times 1.643 + 8.063$$

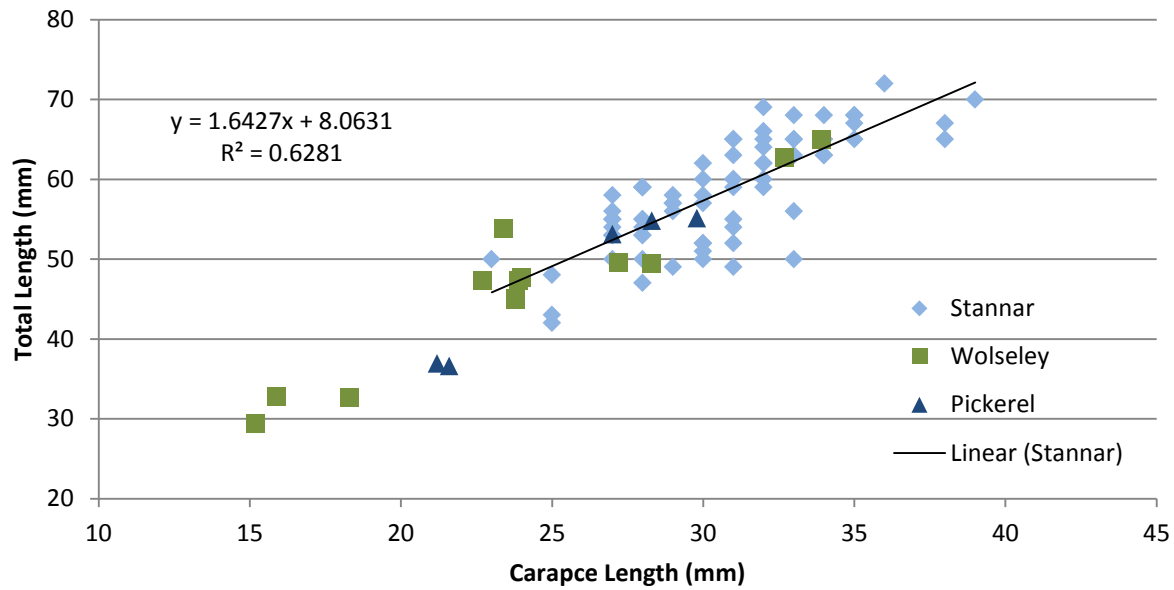


Figure 2: Total length vs carapace length of virile collected from a) Stannar Lake (2016) n = 74, b) Wolseley Lake (2015) n = 13, and c) Pickerel Lake (2015 only) n = 5

### ***Size Distribution***

On Stannar Lake, the calculated total length of all crayfish caught ranged in size from 39 to 72 mm. Female virile crayfish (average calculated total length 54.6 mm) were significantly ( $p = 3.52E-21$ ) smaller than males (average calculated total length 60.1 mm) (Figure 3). In Wolseley and Pickerel Lake, sample sizes were too small to determine if a difference in size existed between female and male virile crayfish. Calculated total lengths from Pickerel fall within the range observed from Stannar Lake, while the calculated total lengths of 3 out of 13 virile crayfish caught in Wolseley Lake are outside the lower range of those observed on Stannar. Average calculated total length of crayfish in Stannar Lake was 58.5 mm. T-tests using the available data indicate that virile crayfish caught on Stannar Lake were significantly larger than crayfish in either Wolseley or Pickerel Lakes (average 47.62 mm,  $p = 6.99E-10$  and average = 50.1 mm,  $p = 0.002$  respectively). However, sample sizes from both Pickerel and Wolseley Lake are too small to make accurate comparisons of crayfish size between lakes.



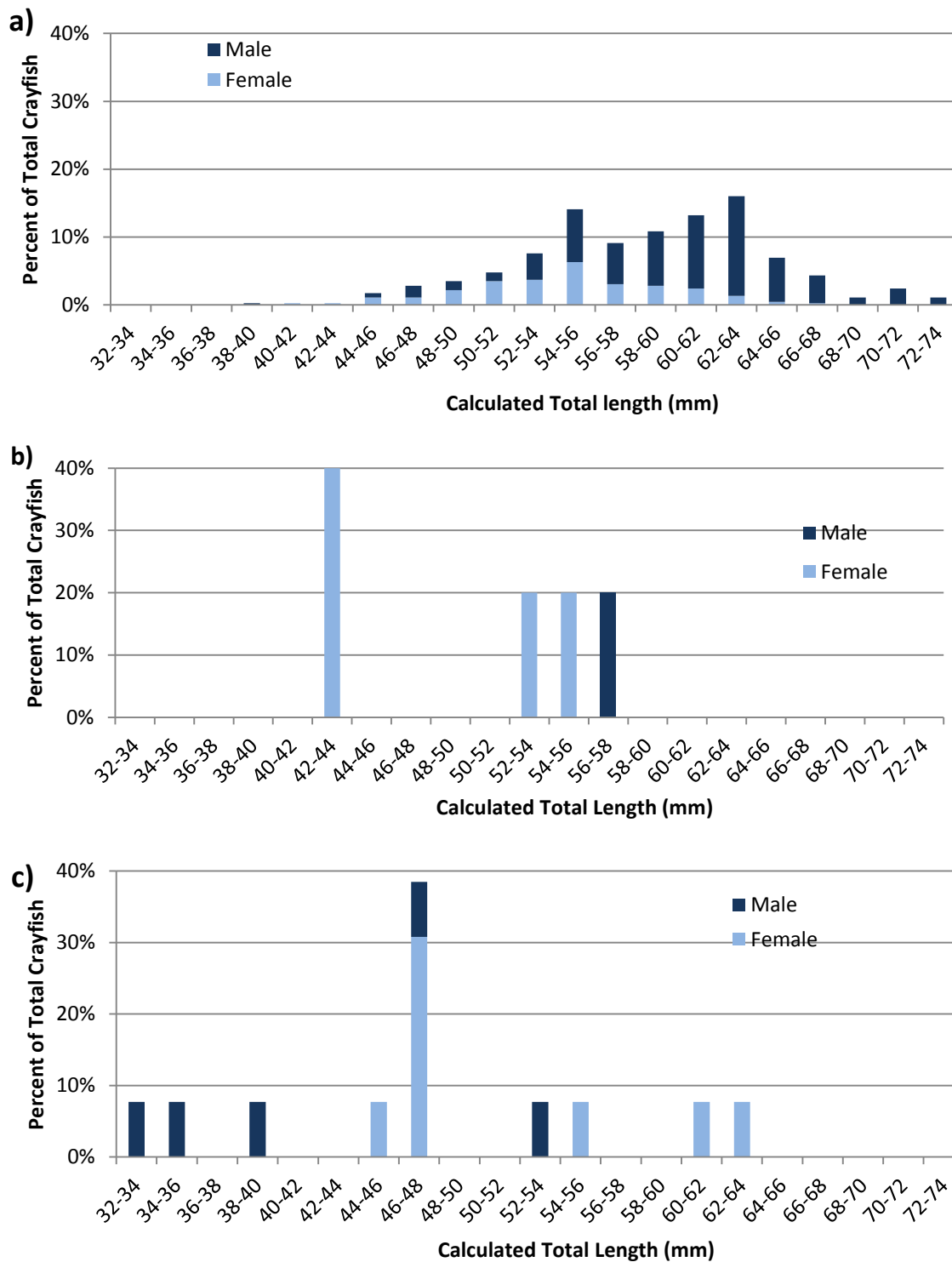


Figure 3: Calculated total length distribution (mm) for virile crayfish collected from a) Stannar Lake (2016) n = 462, b) Pickerel Lake (2015 only) n = 5 and c) Wolseley Lake (2015) n = 13.

### ***Habitat Preferences***

In Stannar Lake, significantly more virile crayfish were caught per trap in the macrophyte habitat (mean 8.09, 5.46, 5.06, 4.22 virile crayfish per trap for macrophyte, cobble, detritus, and soft bottom respectively) compared to all other habitat types ( $p = 0.034$  macrophyte-detritus,  $p = 0.031$  macrophyte-soft bottom, and  $p = 0.017$  macrophyte-cobble) (Figure 4). No significant difference was found between cobble, detritus or the soft bottom habitats. Within habitats, significantly more male virile crayfish per trap compared to female virile crayfish were found in the cobble and macrophyte habitats though there was no difference in sex ratio for the detritus and soft bottom habitats. No significant difference in virile crayfish size was detected between habitats. Traps were placed only in cobble habitats in Pickerel Lake. Traps were placed in cobble and macrophyte habitats in Wolseley Lake, however though more virile crayfish were trapped in the cobble habitats, the sample size was too low to determine if this was significant.

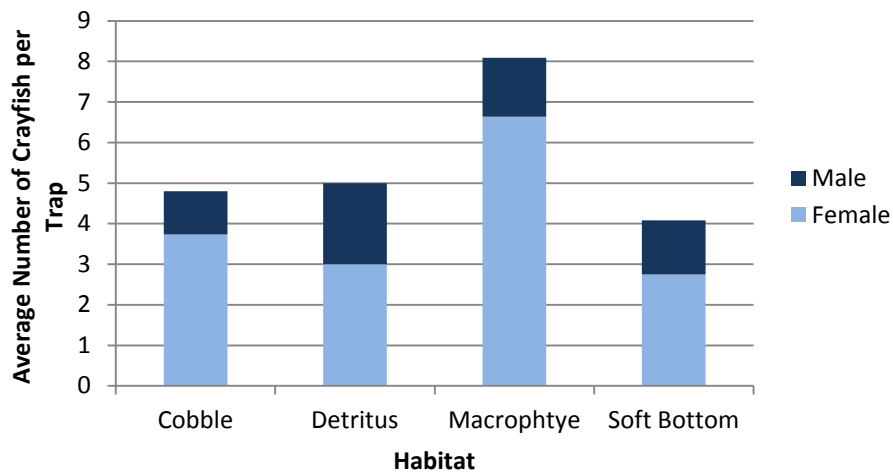


Figure 4: Average number of virile caught per trap across four habitats in Stannar Lake, 2016. Cobble = 71 traps, Detritus = 15 traps, Macrophyte = 11 traps, Soft bottom = 12 traps.

### ***Trapping Biases***

Sampling conducted in Stannar Lake confirms many of the trapping biases noted in other studies. Significantly more virile crayfish were caught per trap on Day 1 compared to Day 2 (Day 1 mean = 5.84, Day 2 mean = 4.44,  $p = 0.030$ ) (Figure 5). More male virile crayfish were also caught per trap on Day 1, though no significant difference was detected between the number of females caught per trap on Day 1 and Day 2 (Males Day 1 mean = 4.69, Males Day 2 = 3.02,  $p = 0.017$ ). No difference in calculated total length was detected between Day 1 and Day 2 though female virile crayfish were slightly larger on day two of trapping (Female Calculated Total Length Mean Day 1 = 53.11, Female Calculated Total Length Mean Day 2 = 55.45,  $p = 0.009$ ). Overall difference in number of crayfish caught and size between days is likely because bait was used two days in a row at different trapping locations. Therefore, all Day Two plots were baited with cat food that had been in the lake overnight, and may have lost some of its efficiency at attracting crayfish.

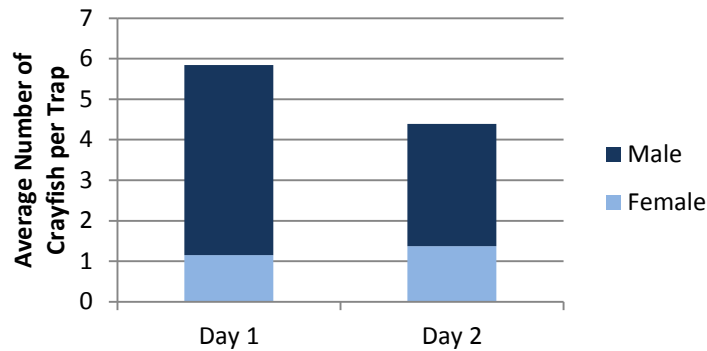


Figure 5: Average number of virile crayfish caught per trap on the first and second day of bait use in Stannar Lake, 2016. Total 607 crayfish, 118 traps.

No relationship between trap depth and number of virile crayfish caught was found overall or within each habitat. This is contrary to the findings of Jansen *et al.* (2009) who found that the catch per trap varied with depth, depending on the crayfish species under consideration. However, trap lines set by Jansen *et al.* ranged from 0.5 to 12 m in depth, much deeper than the traps set for this study. Traps set with a maximum depth of 2.5 m may not be sufficient to capture this relationship.

### Discussion of Findings

Crayfish predators, specifically smallmouth bass, have been shown to effectively reduce crayfish numbers through predation on small and young of the year crayfish (Hein *et al.*, 2006). This is consistent with the lower catch per trap found in Wolseley and Pickerel Lakes, both of which contain smallmouth bass in addition to other generalist predators. Stannar Lake, on the other hand, does not contain smallmouth bass, though other crayfish predators are present in the lake.

Predation pressure is higher on small crayfish, which are less formidable and can be eaten by small as well as larger fish species. As a result, Keller and Moore (2000) showed that smaller crayfish tend to be more stationary overall, and remain stationary longer after the presence of a predator compared to larger crayfish. Therefore, in lakes with predators, it is expected that a higher proportion of large crayfish exist compared to lakes without predators, and that these crayfish are more likely to be caught in traps. Contrary to this prediction, five of the virile crayfish caught in Wolseley and Pickerel Lake, which both contain smallmouth bass, are outside the lower end of the size range of virile crayfish caught in Stannar Lake, with no specialist crayfish predators. However, without sufficient sample sizes from Pickerel and Wolseley Lake it is difficult to determine if the relative abundance of large crayfish is larger in Stannar Lake.

Sampling in Wolseley and Stannar Lake occurred during potential moulting periods, which may have influenced the catch per trap reported and the size distribution of virile crayfish discussed above. Crayfish moult twice per season, during mid to late June and again from late July to early August, depending on the lake and the species (Capelli, 2003). During, and in the few days following a moult, the usually hard carapace is soft, leaving crayfish more vulnerable to predation. The moulting period usually occurs over the course of 7-10 days for the entire population within a lake. During this period crayfish will remain relatively stationary and hidden in refugia and are less likely to be caught in traps (Edwards, Jackson, and Sommers, 2009).

In Stannar Lake, more crayfish were caught in macrophyte habitats compared to cobble, detritus, and soft bottom areas. This is consistent with the findings of Hill and Lodge (1994) who showed in a controlled experiment that in the absence of predators, virile crayfish would choose habitat based on food availability. Habitats with more refugia (hiding places) were preferred once a predator was introduced. Furthermore, crayfish preferred cobble habitats during the day when bass are active and moved into macrophyte habitats at night to forage. Stannar Lake has fewer fish species that prey on crayfish, and specifically does not contain smallmouth bass, which has been shown to be a crayfish specialist (Jackson, 2015b). Crayfish in this lake are therefore able to move into macrophyte areas with less risk of predation. In Pickerel and Wolseley, however, it could be expected that crayfish would make more use of cobble habitats for protection.

## **Future Monitoring**

1) Take water samples or conductivity measurements at each lake that crayfish are trapped in next year to determine the concentration of calcium present in the lake.

The success of crustaceans is linked to calcium concentrations because it is an essential nutrient for shell construction and maintenance. Edwards *et al.* (2013) exposed crayfish to calcium concentrations currently found in lakes located on the Canadian Shield and expected future concentrations as the climate surrounding these lakes changes. Both concentrations were sufficient to stress the crayfish, resulting in increased vigilance, decreased grooming behaviour, and altered locomotion. In extreme cases, crayfish did not survive after they moulted. It is thought that the altered water chemistry found in Shield lakes may impede the northward expansion of rusty crayfish and it is possible that changing water chemistry with climate change will affect established populations of rusty crayfish. Water samples would help to understand how crayfish are responding to differences in water chemistry between lakes.

2) Use a fresh tin of cat food in every trap set to prevent Day 1 (fresh bait) vs Day 2 (day old bait) trapping biases.

Significantly more virile crayfish were captured per trap with fresh (Day One) cat food compared to old (Day Two) cat food. This bias could be prevented by always using fresh bait. However, cat food can become very heavy to carry into remote trap sites. Alternatively, less remote sites trapped using fresh bait every day would provide a method of standardizing data collected with fresh and day old bait. Data analysis could also only use Day 1 trap data when comparing between lakes and studies.

3) Continue to collect crayfish size data through the Broadscale Monitoring program to help determine the size of crayfish that are vulnerable to predation as well as which fish species prey most heavily on native crayfish.

Broadscale Monitoring in Fisheries Management Zone 5 in 2010 showed that over 50% of all smallmouth bass and rock bass caught with food in their stomach had eaten crayfish (Jackson, 2015b). Continued sampling on Wolseley and Pickerel Lakes will allow for more accurate size distributions of consumed crayfish for these lakes. Additional sampling should continue to look

at lakes with and without smallmouth and rock bass because predation pressure from these species may influence crayfish densities and distribution across habitats.

4) Traps should be set in multiple habitats within each lake to allow for a better comparison of crayfish distribution between habitats.

This and other studies have suggested that crayfish preferentially select habitat depending on predation pressure. Understanding how this selection pressure combined with food and shelter availability influences the distribution of crayfish will help illuminate how crayfish interact with the benthic community.

### **Acknowledgements**

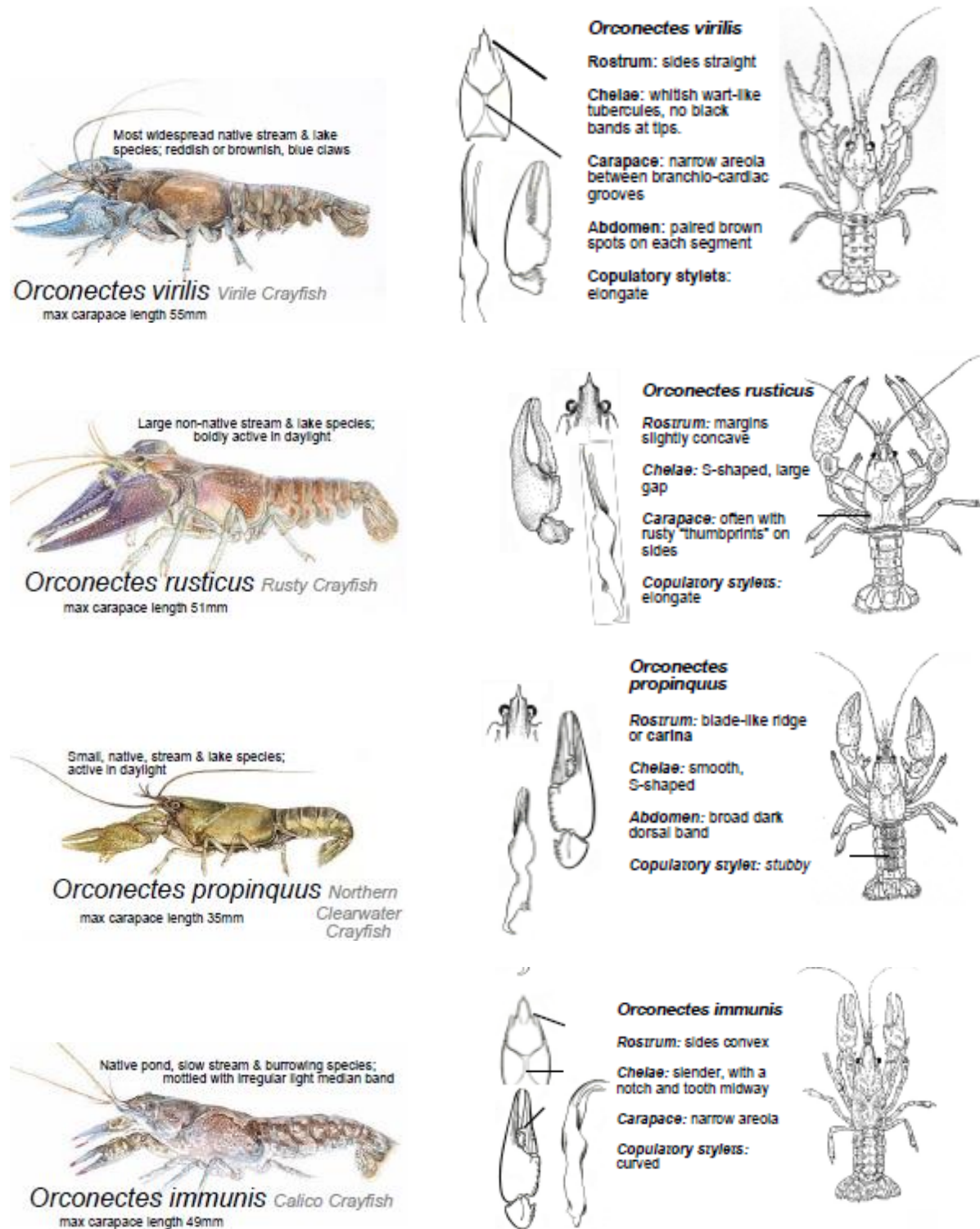
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## Appendix 1

### Identification of Crayfish Species Found in Quetico Park



(from <http://pinicola.ca/crayfishontario/index.htm>)

## **Appendix 2**

### ***Study Lakes Fish Species Lists***

#### *Wolseley Lake*

Black Crappie	Mottled Sculpin
Blacknose Shiner	Northern Pike
Bluegill Sunfish	Pumpkinseed Sunfish
Bluntnosed Minnow	Rock Bass
burbot	Sauger
Common Shiner	Smallmouth Bass
Finescale Dace	Spottail Shiner
Iowa Darter	Tadpole Madtom
Herring	Trout Perch
Johnny Darter	Walleye
Lake Trout	Whitefish
Marge Mouth Bass	White Sucker
Log Perch	Yellow Perch
Mimic Shiner	

#### *Stannar Lake*

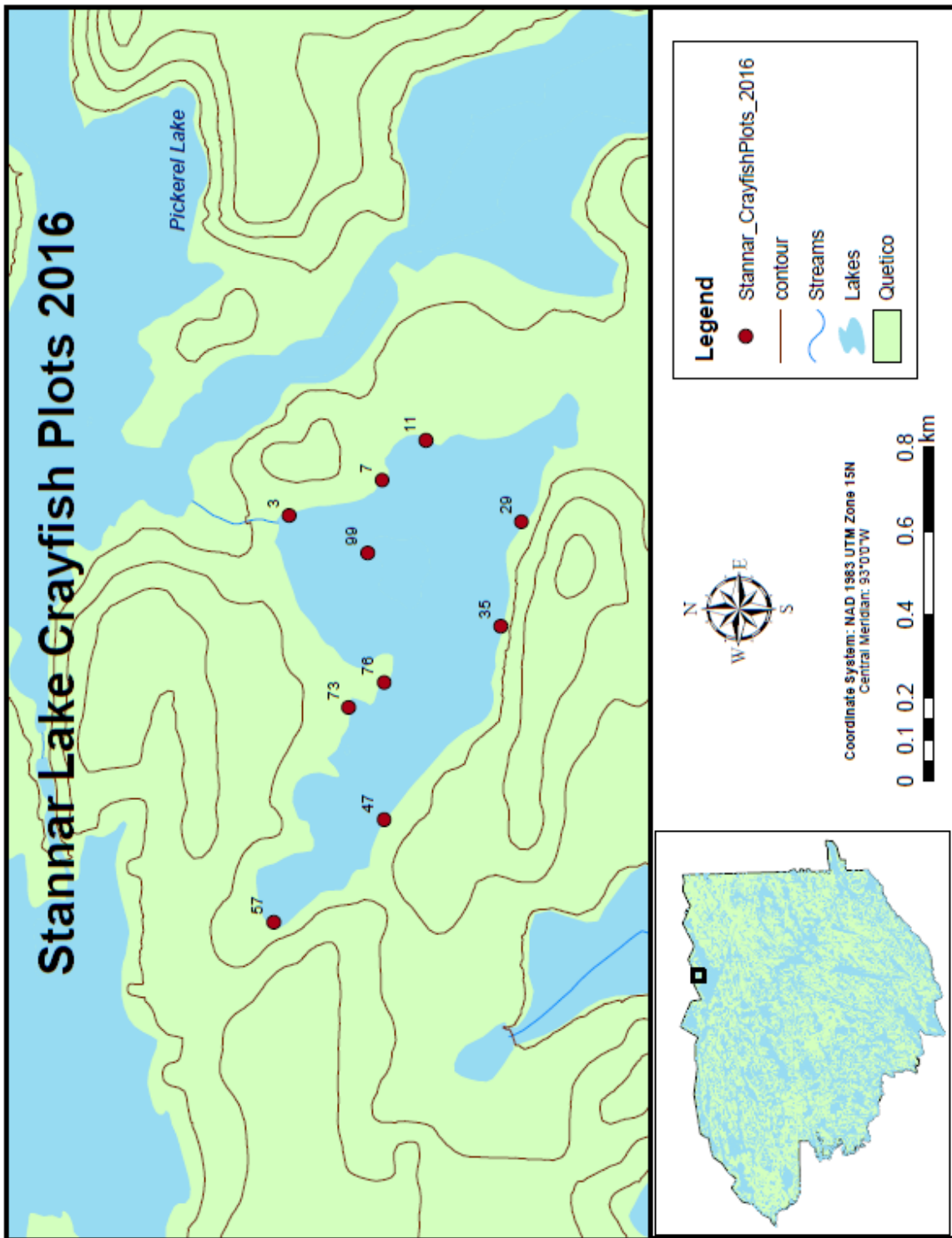
Black Nose Shiner	Pumpkinseed Sunfish
Darter spp.	Walleye
(likely Johnny Darter)	White Sucker
Northern Pike	Yellow Perch

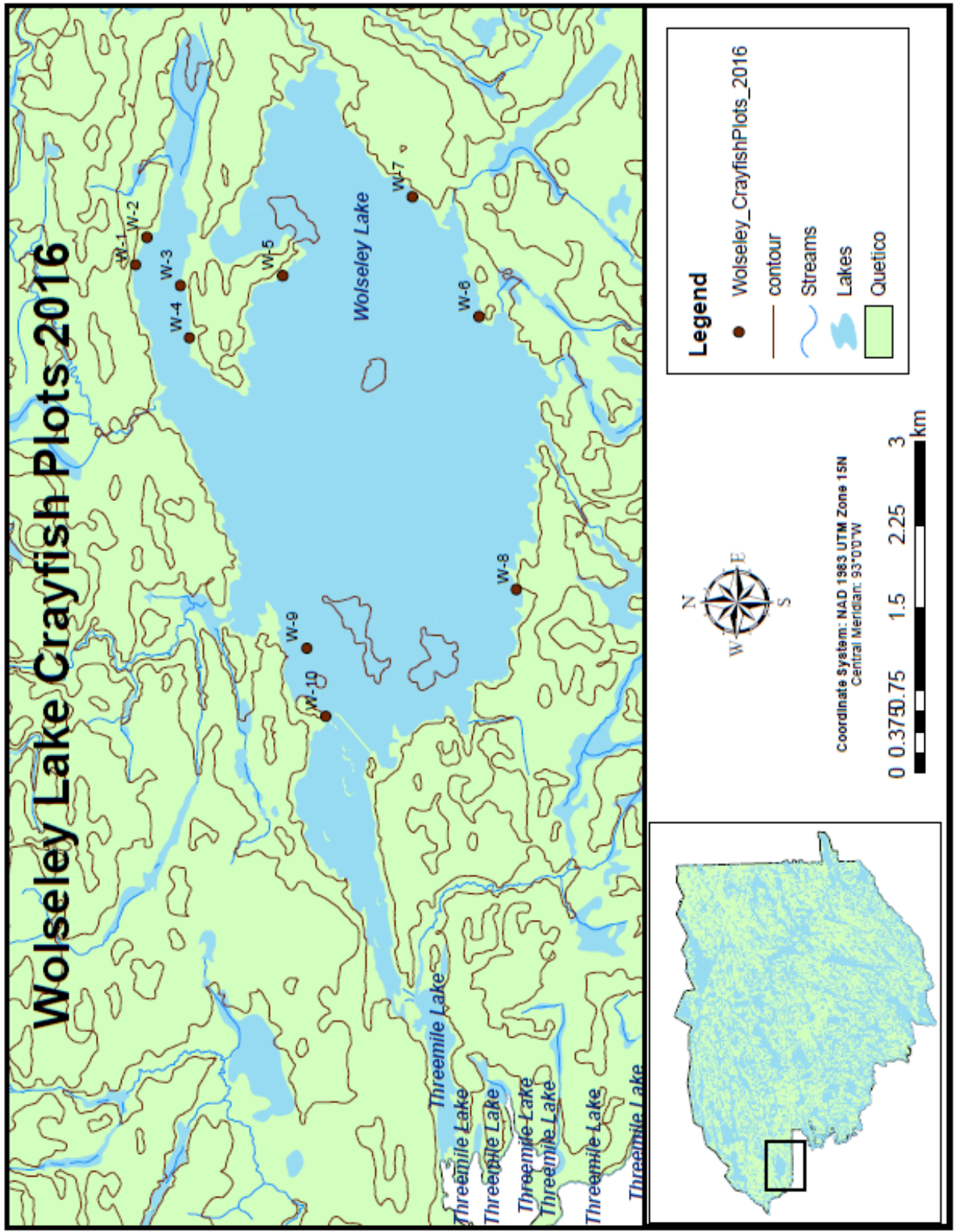
#### *Pickerel Lake*

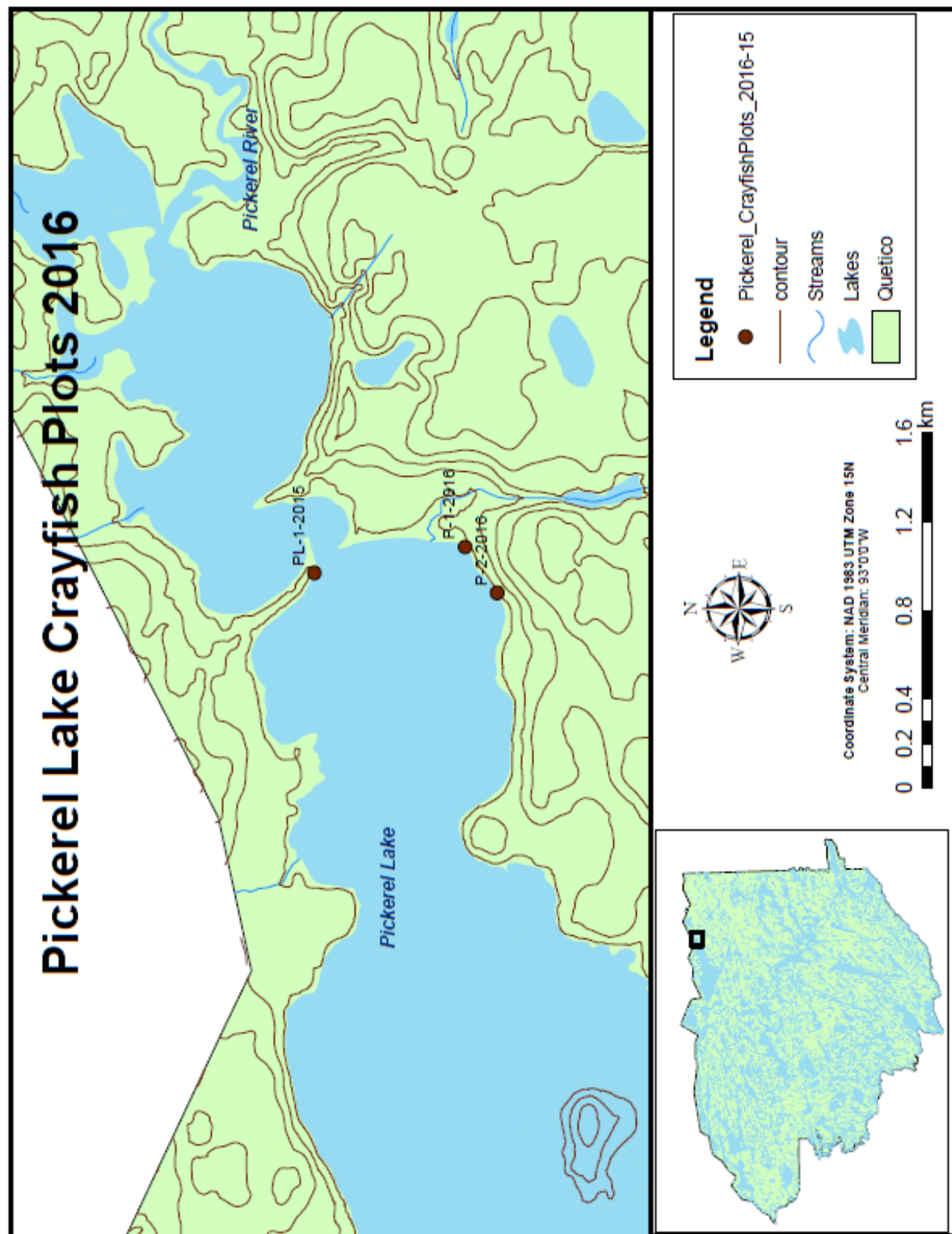
Black Nose Shiner	Smallmouth Bass
Burbot	Spottail Shiner
Cisco	Trout Perch
Deepwater Sculpin	Walleye
Johnny Darter	Whitefish
Lake Trout	White Sucker
Log Perch	Yellow Perch
Mimic Shiner	
Northern Pike	
Sauger	
Rainbow Smelt	
Redfin Shiner	
Shorthead Redhorse	
Slimy Sculpin	



Appendix 3  
Plot Locations







## Appendix 4

### Data Summaries

#### Size Data (All Lakes)

Calculated Total Length (mm)	Stannar Lake		Wolseley Lake		Pickerel Lake	
	Number of <i>O. virilis</i> Females	Number of <i>O. virilis</i> Males	Number of <i>O. virilis</i> Females	Number of <i>O. virilis</i> Males	Number of <i>O. virilis</i> Females	Number of <i>O. virilis</i> Males
32-34	0	0	0	1	0	0
34-36	0	0	0	1	0	0
36-38	0	0	0	0	0	0
38-40	0	1	0	1	0	0
40-42	1	0	0	0	0	0
42-44	1	0	0	0	2	0
44-46	5	3	1	0	0	0
46-48	5	8	4	1	0	0
48-50	10	6	0	0	0	0
50-52	16	6	0	0	0	0
52-54	17	18	0	1	1	0
54-56	29	36	1	0	1	0
56-58	14	28	0	0	0	1
58-60	13	37	0	0	0	0
60-62	11	50	1	0	0	0
62-64	6	68	1	0	0	0
64-66	2	30	0	0	0	0
66-68	1	19	0	0	0	0
68-70	0	5	0	0	0	0
70-72	0	11	0	0	0	0
72-74	0	5	0	0	0	0

*Trap Data, Stannar Lake*

Plot ID	Trapline #	Trap #	Habitat	Depth (cm)	<i>O. virilis</i> Male	<i>O. virilis</i> Female
3	1	1	cobble	50	6	3
3	1	2	cobble	80	1	0
3	1	3	cobble	95	9	4
3	2	1	cobble	50	2	1
3	2	2	cobble	120	9	3
3	2	3	cobble	130	9	1
3	3	1	cobble	60	5	1
3	3	2	cobble	100	4	0
3	3	3	cobble	120	2	0
3	4	1	cobble	40	6	2
3	4	2	cobble	90	6	4
3	4	3	cobble	110	4	3
7	1	1	cobble	70	6	2
7	1	2	cobble	90	2	2
7	1	3	cobble	110	2	1
7	2	1	cobble	60	2	1
7	2	2	cobble	100	4	1
7	2	3	cobble	110	4	0
7	3	1	cobble	60	6	3
7	3	2	cobble	80	3	0
7	3	3	cobble	100	4	3
7	4	1	cobble	60	3	3
7	4	2	cobble	90	1	0
7	4	3	cobble	110	0	0
29	1	1	cobble	90	3	0
29	1	2	cobble	140	8	1
29	1	3	cobble	150	1	3
29	2	1	cobble	120	5	1
29	2	2	cobble	140	2	0
29	2	3	cobble	160	0	0
29	3	1	cobble	100	4	0
29	3	2	cobble	170	11	4
29	3	3	cobble	200	6	0
29	4	1	?*	80	0	1
29	4	2	?	180	4	0
29	4	3	?	210	6	2
47	1	1	cobble	75	4	0
47	1	2	cobble	150	6	0
47	1	3	cobble	220	5	2
47	2	1	detritus	100	1	0
47	2	2	detritus	190	1	0
47	2	3	detritus	230	3	2
47	3	1	cobble	110	3	0
47	3	2	cobble	190	5	2
47	3	3	cobble	240	6	1
47	4	1	?	70	3	1
47	4	2	?	200	8	0

47	4	3	?	220	8	3
76	1	1	macrophyte	80	15	2
76	1	2	macrophyte	110	10	1
76	1	3	macrophyte	130	12	1
76	2	1	cobble	50	6	0
76	2	2	cobble	90	0	0
76	2	3	cobble	120	7	1
76	3	1	cobble	60	5	0
76	3	2	cobble	95	7	0
76	3	3	cobble	150	0	1
76	4	1	cobble	75	5	0
76	4	2	cobble	140	7	1
76	4	-	_***	-	-	-
99	1	1	soft bottom	100	1	1
99	1	2	soft bottom	150	4	0
99	1	3	soft bottom	190	3	2
99	2	1	soft bottom	70	1	2
99	2	2	soft bottom	110	5	2
99	2	3	soft bottom	150	2	1
99	3	1	soft bottom	60	7	3
99	3	2	soft bottom	110	3	0
99	3	3	soft bottom	120	0	1
99	4	1	?	80	0	0
99	4	2	?	100	7	2
99	4	3	?	110	3	2
11	1	1	cobble	50	0	0
11	1	2	cobble	100	2	1
11	1	3	cobble	120	3	1
11	2	1	cobble	40	0	0
11	2	2	cobble	90	2	0
11	2	3	cobble	120	3	1
11	3	1	cobble	40	0	0
11	3	2	cobble	90	2	0
11	3	3	cobble	120	1	2
11	4	1	soft bottom	60	3	1
11	4	2	soft bottom	90	2	3
11	4	3	soft bottom	120	2	0
35	1	1	cobble	120	0	0
35	1	2	cobble	210	11	1
35	1	3	cobble	250	3	1
35	2	1	cobble	50	0	2
35	2	2	cobble	100	0	2
35	2	3	cobble	195	5	1
35	3	1	cobble	50	1	0
35	3	2	cobble	160	0	0
35	3	3	cobble	230	4	1
35	4	1	cobble	100	1	1
35	4	2	cobble	160	5	0
35	4	3	cobble	230	5	0
57	1	1	detritus	40	6	2

57	1	2	detritus	60	0	0
57	1	3	detritus	70	3	2
57	2	1	detritus	40	3	2
57	2	2	detritus	50	0	2
57	2	3	detritus	60	3	3
57	3	1	detritus	50	7	0
57	3	2	detritus	60	6	5
57	3	3	detritus	80	0	3
57	4	1	detritus	45	6	4
57	4	2	detritus	50	3	4
57	4	3	detritus	60	3	1
73	1	1	macrophyte	50	4	1
73	1	2	macrophyte	100	6	1
73	1	-	-	-	-	-
73	2	1	macrophyte	50	2	1
73	2	2	macrophyte	70	6	1
73	2	3	macrophyte	90	5	2
73	3	1	macrophyte	60	4	0
73	3	2	macrophyte	90	4	4
73	3	3	macrophyte	90	5	2
73	4	1	cobble	50	7	1
73	4	2	cobble	75	1	4
73	4	3	cobble	90	3	2

\* Habitat type is unknown

\*\* Trap was missing

*Trap Data, Wolseley Lake*

Plot ID	Trapline #	Trap #	Habitat	Depth (cm)	<i>O. virilis</i> Male	<i>O. virilis</i> Female
W-1	1	1	cobble	50	0	0
W-1	1	2	cobble	130	0	0
W-1	1	3	cobble	200	0	1
W-1	2	1	cobble	50	0	0
W-1	2	2	cobble	140	0	1
W-1	2	3	cobble	150	0	0
W-1	3	1	cobble	100	0	0
W-1	3	2	cobble	200	1	0
W-1	3	3	cobble	250	0	0
W-1	4	1	cobble	50	0	0
W-1	4	2	cobble	150	0	0
W-1	4	3	cobble	170	0	0
W-2	1	1	macrophyte	50	0	0
W-2	1	2	macrophyte	120	0	0
W-2	1	3	macrophyte	170	0	0
W-2	2	1	macrophyte	50	0	0
W-2	2	2	macrophyte	75	0	0
W-2	2	3	macrophyte	140	0	0
W-2	3	1	macrophyte	50	0	0
W-2	3	2	macrophyte	100	0	0
W-2	3	3	macrophyte	150	0	0
W-2	4	1	?*	40	0	0
W-2	4	2	?	100	0	0
W-2	4	3	?	170	0	0
W-3	1	1	macrophyte	50	0	0
W-3	1	2	macrophyte	100	0	0
W-3	1	3	macrophyte	150	0	0
W-3	2	1	macrophyte	50	0	0
W-3	2	2	macrophyte	80	0	0
W-3	2	3	macrophyte	120	0	0
W-3	3	1	macrophyte	40	0	0
W-3	3	2	macrophyte	60	0	0
W-3	3	3	macrophyte	110	0	0
W-3	4	1	macrophyte	50	0	0
W-3	4	2	macrophyte	60	0	0
W-3	4	3	macrophyte	100	0	0
W-4	1	1	macrophyte	50	0	0
W-4	1	2	macrophyte	70	0	0
W-4	1	3	macrophyte	75	0	0
W-4	2	1	macrophyte	50	0	0
W-4	2	2	macrophyte	50	0	0
W-4	2	3	macrophyte	70	0	0
W-4	3	1	macrophyte	50	0	0
W-4	3	2	macrophyte	70	0	0
W-4	3	3	macrophyte	110	0	0
W-4	4	1	macrophyte	50	1	0



W-4	4	2	macrophyte	70	0	0
W-4	4	3	macrophyte	100	0	0
W-5	1	1	cobble	50	0	0
W-5	1	2	cobble	180	0	0
W-5	1	3	cobble	250	0	0
W-5	2	1	cobble	50	0	0
W-5	2	2	cobble	170	0	1
W-5	2	3	cobble	250	0	0
W-5	3	1	cobble	50	0	0
W-5	3	2	cobble	130	0	0
W-5	3	3	cobble	250	0	0
W-5	4	1	cobble	50	0	0
W-5	4	2	cobble	70	0	0
W-5	4	3	cobble	100	0	0
W-6	1	1	cobble	50	0	0
W-6	1	2	cobble	80	0	0
W-6	1	3	cobble	130	0	0
W-6	2	1	cobble	50	0	0
W-6	2	2	cobble	90	0	0
W-6	2	3	cobble	140	1	0
W-6	3	1	cobble	50	0	0
W-6	3	2	cobble	90	0	0
W-6	3	3	cobble	110	0	0
W-6	4	1	?	30	0	0
W-6	4	2	?	100	0	0
W-6	4	3	?	140	0	0
W-7	1	1	cobble	50	0	0
W-7	1	2	cobble	130	0	0
W-7	1	3	cobble	170	0	0
W-7	2	1	cobble	70	0	0
W-7	2	2	cobble	110	0	0
W-7	2	3	cobble	130	0	0
W-7	3	1	cobble	150	0	0
W-7	3	2	cobble	110	0	0
W-7	3	3	cobble	140	0	0
W-7	4	1	cobble	50	0	0
W-7	4	2	cobble	90	0	0
W-7	4	3	cobble	140	0	0
W-8	1	1	cobble	50	0	0
W-8	1	2	cobble	80	0	0
W-8	1	3	cobble	110	0	0
W-8	2	1	cobble	50	1	0
W-8	2	2	cobble	90	0	0
W-8	2	3	cobble	90	0	0
W-8	3	1	cobble	50	0	0
W-8	3	2	cobble	100	0	0
W-8	3	3	cobble	200	0	0
W-8	4	1	cobble	70	0	0
W-8	4	2	cobble	110	0	0
W-8	4	3	cobble	250	0	0

W-9	1	1	cobble	55	0	0
W-9	1	2	cobble	65	0	0
W-9	1	3	cobble	70	0	0
W-9	2	1	cobble	40	0	0
W-9	2	2	cobble	100	0	1
W-9	2	3	cobble	160	0	0
W-9	3	1	cobble	90	0	0
W-9	3	2	cobble	180	0	0
W-9	3	3	cobble	240	0	1
W-9	4	1	cobble	60	0	0
W-9	4	2	cobble	140	0	0
W-9	4	3	cobble	190	0	0
W-10	1	1	cobble	80	0	0
W-10	1	2	cobble	150	0	0
W-10	1	3	cobble	180	0	0
W-10	2	1	cobble	50	0	0
W-10	2	2	cobble	120	0	1
W-10	2	3	cobble	140	0	0
W-10	3	1	cobble	50	0	0
W-10	3	2	cobble	110	0	0
W-10	3	3	cobble	150	0	0
W-10	4	1	cobble	50	0	0
W-10	4	2	cobble	130	1	2
W-10	4	3	cobble	140	0	0

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\* Habitat type is unknown

*Trap Data, Pickerel Lake*

Plot ID	Trapline #	Trap #	Habitat	Depth (cm)	<i>O. virilis</i> Male	<i>O. virilis</i> Female
P-1	1	1	cobble	50	5	2
P-1	1	2	cobble	50	0	2
P-1	1	3	cobble	55	0	0
P-1	2	1	cobble	50	1	0
P-1	2	2	cobble	50	0	1
P-1	2	3	cobble	50	1	0
P-1	3	1	cobble	30	0	0
P-1	3	2	cobble	100	3	1
P-1	3	3	cobble	90	2	1
P-1	4	1	cobble	45	0	0
P-1	4	2	cobble	60	0	0
P-1	4	3	cobble	95	0	0
P-2	1	1	cobble over sand	50	1	0
P-2	1	2	cobble over sand	60	0	1
P-2	1	3	cobble over sand	75	0	0
P-2	2	1	cobble	50	0	0
P-2	2	2	cobble	63	0	0
P-2	2	3	cobble	80	1	0
P-2	3	1	cobble	45	0	1
P-2	3	2	cobble	55	2	1
P-2	3	3	cobble	75	0	0
P-2	4	1	cobble	40	3	0
P-2	4	2	cobble	60	1	0
P-2	4	3	cobble	70	0	0
PL-1-15	1	1	cobble	50	0	0
PL-1-15	1	2	cobble	100	0	0
PL-1-15	1	3	cobble	150	0	0
PL-1-15	2	1	cobble	50	0	0
PL-1-15	2	2	cobble	150	1	2
PL-1-15	2	3	cobble	150	0	0
PL-1-15	3	1	cobble	30	0	0
PL-1-15	3	2	cobble	100	0	0
PL-1-15	3	3	cobble	150	0	0
PL-1-15	4	1	cobble	100	0	2
PL-1-15	4	2	cobble	150	0	0
PL-1-15	4	3	cobble	200	0	0