# Fish Community Assessment of Muldrew Lake

2014

File Report

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Muldrew Lake is a moderately large (420 ha) lake located in the Town of Gravenhurst, about three kilometres from the urban core, within the District of Muskoka. The lake basin is extremely sinuous and narrow, consisting of two main arms and a southern basin, connected by channels. In much of the lake, the littoral area is extremely narrow, typified by steeply sloping, bare bedrock, that extends quickly to depths near or below the thermocline, then levels off to a relatively flat bottom. There are six discrete basins that are deeper than 10 m, each with unique bathymetry and temperature and dissolved oxygen characteristics. The maximum and mean depths are 18 m and 7 m, respectively. The lake is oligotrophic with fairly low water clarity (Spring P: 7.7-10 ug/l, Secchi depth: 2.6 m, DMM 2013), due to yellow-brown staining caused by dissolved organic compounds. Often considered two or even three lakes (North, Middle and South Muldrew), the basins and arms are all connected by deep channels and form one contiguous water body.

The fish community of the lake was first described in 1951, at which time Smallmouth Bass was the only game fish species known to be present. It is not known for certain if bass were native to the lake; stocking occurred as early as 1945 and it is known that both introductory stocking and supplemental stocking of existing populations were common practice at that time. Smallmouth Bass were documented to occur in Loon Lake, upstream, as early as 1931. The proximity of both lakes to settlements and development, particularly railways, a conveyance often used for early introductions, makes the origin of bass uncertain. Other species reported included White Sucker, Cisco, Yellow Perch, Pumpkinseed and Brown Bullhead, all common native species in the area. By 1954, Largemouth Bass were reported to occur (Alley 1954), though there are no stocking records documenting when they were introduced, who did it and by what authority, if any.

The Aquatic Habitat Inventory (Lake Survey) conducted in 1975 confirmed the presence of Largemouth Bass. Rock Bass had become established by that time as well.

Walleye were stocked for several years in the mid-1950's and again in 1985 in attempts to establish a self-sustaining population. While some fish were recaptured immediately post-stocking (Alley (1954) a 1987 post-stocking trap net assessment failed to capture any walleye (Baker 1987). Both efforts are believed to have failed due to the observed absence of any spawning habitat, the limited amount of general habitat for this species and the presence of competing species.

In 2007, an anecdotal report was received that Northern Pike had become established in the lake. Pike had previously been reported upstream in Loon Lake, in 2000. As with Largemouth Bass, the exact date and means of their introduction is unknown.

In 2012, a proposal was made to introduce Black Crappie to several lakes, including Muldrew Lake. Initial screening had identified Muldrew Lake as having suitable habitat and being a low risk for impacting other values. In particular, potential impact to the existing fish community was thought to be low due the absence of walleye (crappie have been implicated in the decline of walleye in some situations (Kerr and Grant 2000). During the Environmental Assessment (EA) process several questions and potential concerns were identified including impact to the existing bass fishery as well as the Cisco population. The EA process has not proceeded further than initial consultation until these questions can be addressed.

A fish community assessment of Muldrew Lake was completed in 2014 to provide information to be used to try to elucidate potential impacts of crappie on Muldrew and other lakes in the District. In particular, the intent is to compare fish community characteristics of lakes with similar physical and chemical attributes but either have crappie present or absent. This report summarizes the results of data collection from

Muldrew Lake. The intent is to present the more detailed comparison of lakes with and without crappie under separate cover at a later date.

## Methods

The Broad-scale Monitoring (BsM) protocol was used (Sandstrom et al., 2010), with supplemental information collected using trap nets. The BsM data provide standardized indices of fish abundance that can be compared to other lakes, or to future surveys in the same lake. The trap nets provided additional samples for describing fish size, age and growth as the BsM survey samples sizes were expected to be too small for a robust analysis on their own.

BsM gear consisted of large mesh and small mesh gill nets. The large mesh gill nets target fish larger than 20 cm in length, typically the size range of interest to anglers. The net gang has a length of 24.8 m and height of 1.8 m consisting of 8 panels of different mesh sizes. Two gangs are generally attached to one another to form one strap. The mesh sizes, in inches, are 1.5", 2.0", 2.5", 3.0", 3.5", 4.0", 4.5" and 5.0". The small mesh gill nets target smaller fish and are intended to detect the presence of other species in the lake. They have a length of 12.5 m, consisting of 5 panels that are 1.8 m high. Mesh sizes, also in inches, are 0.50", 0.75", 1.00", 1.25" and 1.50".

The number of nets set was dictated by the size and depth of the lake, in accordance with the BsM protocol. Net sets were allocated over the depth strata of 1-3, 3-6, 6-12 and 12-20 metres. Nets were set overnight for target durations of 16-22 hours.

Trap netting employed the use of standard 6-foot (1.8 m) trap nets with 46 m (150 ft) leads. Net set site selection was constrained by the bathymetry of the lake to a limited number of non-random locations, some of which exceeded the typical maximum depth at which this gear is set. Nets were set overnight for approximately 24 hours.

The catch was enumerated, by species. Sport fish species were detail sampled including length, weight, and collection of calcified structures for age determination. Dead fish were internally examined for gender, state of maturity and in some cases, stomach contents. Tissue samples for contaminat analyses were collected from a sample of Smallmouth Bass, Northern Pike and Black Crappie; samples were delivered to the Ministry of the Environment. Results of analyses will be reported separately in the Guide to Eating Ontario Sport Fish. Non-game species were generally measured for length only.

A temperature and dissolved oxygen profile was collected in the deepest basins in the north and south arms of the lake.

Project data are archived in the provincial FISHNET database as projects PSD_BS14_MULDREW00 (BsM) and PSD_TN14_MUL (trap net).

## Results

The BsM netting was done from Sept. 15-18, 2014. Twenty-one sets were completed; 11 large mesh and 10 small mesh (Table 1, Figure 1). Three sets for each gear were completed in the 1-3 and 3-6 m depth strata. Three large mesh and two small mesh were set in 6-12 m deep and two sets of each gear were set in the 12-20 m depth stratum. Trap netting was conducted from Sept. 22-25, 2014 (Table 2). Nine

overnight sets were completed, four in the north arm and five in the south arm. The lead was set starting at the shore in all cases and the depth at the gap between the lead and net ranged from 2.0 to 5.7 m.

At the time of netting the lake was still thermally stratified and temperature in the epilimnion was 16-17$^{o}$C (Figure 2). The thermocline occurred from 6 to about 10 m deep. In both basins, dissolved oxygen declined sharply in the first metre of the thermocline. In the north basin the oxygen concentration remained low to the bottom of the lake. In the south basin the oxygen level didn't initially decline as much and recovered somewhat in the hypolimnion due to the greater depth and volume of water in that basin. The profiles in the basins that were not sampled would be expected to vary somewhat from those that were measured, based on their individual depth and volume characteristics.

The net set strata corresponded very well with the thermal strata of the lake; sets up to 6 m deep were in the epilimnion, 6-12 m sets were primarily in the thermocline and 12-20 m sets in the hypolimnion.

Table 1 Net set details, Broad-scale Monitoring survey, Muldrew Lake, 2014.

| Effort | Easting | Northing | Gear | Gangs | Stratum | Start Depth (m) | End Depth (m) | Lift Date |
|---|---|---|---|---|---|---|---|---|
| 1 | 623698 | 4973309 | 2 | 2 | 12 - 20 m | 12.0 | 15.0 | 16-Sep-14 |
| 2 | 622875 | 4973904 | 1 | 2 | 12 - 20 m | 12.0 | 16.0 | 16-Sep-14 |
| 3 | 621749 | 4974568 | 2 | 2 | 06 - 12 m | 7.0 | 6.0 | 16-Sep-14 |
| 4 | 620850 | 4975087 | 1 | 2 | 03 - 06 m | 4.0 | 5.0 | 16-Sep-14 |
| 5 | 624382 | 4973105 | 1 | 2 | 01 - 03 m | 3.0 | 2.0 | 16-Sep-14 |
| 6 | 624731 | 4972667 | 2 | 2 | 01 - 03 m | 2.0 | 3.0 | 16-Sep-14 |
| 7 | 625688 | 4972401 | 1 | 2 | 03 - 06 m | 3.0 | 5.0 | 16-Sep-14 |
| 8 | 620084 | 4974685 | 1 | 2 | 06 - 12 m | 10.0 | 12.0 | 17-Sep-14 |
| 9 | 621070 | 4974089 | 1 | 2 | 03 - 06 m | 5.0 | 5.0 | 17-Sep-14 |
| 10 | 621294 | 4974050 | 2 | 2 | 01 - 03 m | 2.5 | 2.5 | 17-Sep-14 |
| 11 | 621638 | 4973670 | 1 | 2 | 01 - 03 m | 2.0 | 2.0 | 17-Sep-14 |
| 12 | 622041 | 4973477 | 2 | 2 | 03 - 06 m | 3.0 | 5.0 | 17-Sep-14 |
| 13 | 624600 | 4973140 | 1 | 2 | 06 - 12 m | 8.0 | 8.0 | 17-Sep-14 |
| 14 | 623968 | 4973740 | 2 | 2 | 03 - 06 m | 4.0 | 6.0 | 17-Sep-14 |
| 15 | 624107 | 4971263 | 2 | 2 | 03 - 06 m | 3.6 | 5.5 | 18-Sep-14 |
| 16 | 624133 | 4971900 | 1 | 2 | 06 - 12 m | 6.0 | 7.5 | 18-Sep-14 |
| 17 | 625051 | 4971119 | 2 | 1 | 12 - 20 m | 12.0 | 12.9 | 18-Sep-14 |
| 18 | 625360 | 4971702 | 2 | 2 | 01 - 03 m | 2.9 | 2.3 | 18-Sep-14 |
| 19 | 623819 | 4972430 | 1 | 2 | 01 - 03 m | 1.6 | 3.0 | 18-Sep-14 |
| 20 | 622892 | 4972877 | 2 | 1 | 06 - 12 m | 7.8 | 8.0 | 18-Sep-14 |
| 21 | 622985 | 4973137 | 1 | 2 | 12 - 20 m | 14.8 | 18.8 | 18-Sep-14 |

Table 2 Net set details, trap nets, Muldrew Lake, 2014.

| Effort | Easting | Northing | Gap Depth (m) | Lift Date | Set Duration (h) |
|---|---|---|---|---|---|
| 1 | 625105 | 4972756 | 5.7 | 2014/09/23 | 22.7 |
| 2 | 623788 | 4973833 | 3.3 | 2014/09/23 | 22.8 |
| 3 | 624764 | 4973014 | 5.3 | 2014/09/23 | 23.6 |
| 4 | 620803 | 4975118 | 3.8 | 2014/09/24 | 20.1 |
| 5 | 621572 | 4973706 | 3.9 | 2014/09/24 | 20.6 |
| 6 | 623071 | 4972744 | 5.4 | 2014/09/24 | 22.1 |
| 7 | 625330 | 4971691 | 4.2 | 2014/09/25 | 22.3 |
| 8 | 625068 | 4970938 | 5.2 | 2014/09/25 | 22.8 |
| 9 | 623929 | 4971342 | 2.0 | 2014/09/25 | 23.3 |

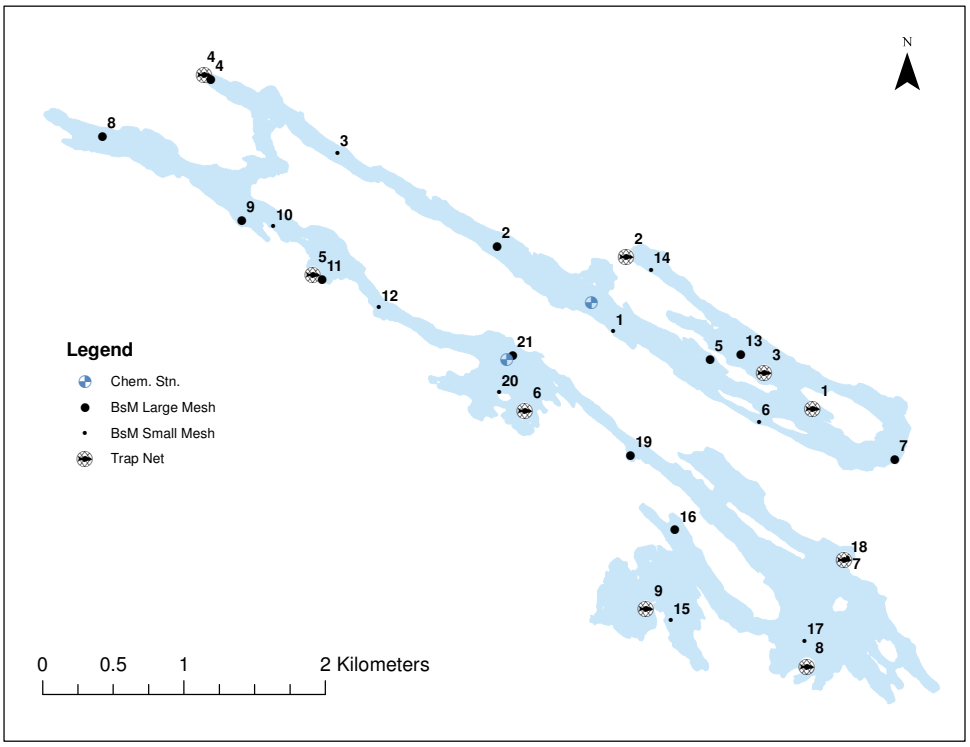



Figure 1 Map showing water chemistry stations and net set locations,by gear type, Muldrew Lake, 2014.

| | North (Sep 15, 2014) | | South (Sep 23, 2014) | |
|---|---|---|---|---|
| | 623543E | 4973508N | 622943E | 4973097N |
| Depth (m) | Temp. | D.O. | Temp. | D.O. |
| 0 | 17.4 | 7.6 | 16.0 | 9.0 |
| 1 | 17.4 | 7.6 | 16.0 | 9.1 |
| 2 | 17.4 | 7.6 | 15.9 | 8.7 |
| 3 | 17.4 | 7.6 | 15.8 | 8.7 |
| 4 | 17.4 | 7.6 | 15.6 | 8.7 |
| 5 | 17.4 | 7.6 | 15.5 | 8.7 |
| 6 | 17.0 | 7.4 | 15.3 | 8.7 |
| 7 | 13.2 | 0.7 | 13.2 | 3.0 |
| 8 | 11.8 | 0.6 | 11.5 | 2.0 |
| 9 | 10.6 | 0.3 | 9.9 | 2.8 |
| 10 | 9.8 | 0.6 | 8.5 | 3.0 |
| 11 | 8.9 | 1.1 | 7.6 | 3.7 |
| 12 | 8.3 | 1.3 | 7.2 | 4.1 |
| 13 | 7.9 | 1.1 | 6.8 | 5.0 |
| 14 | 7.7 | 0.6 | 6.5 | 4.5 |
| 15 | 7.5 | 0.4 | 6.2 | 3.9 |
| 16 | 7.3 | 0.3 | 5.8 | 3.8 |
| 17 | | | 5.5 | 1.3 |
| 18 | | | 5.4 | 0.1 |

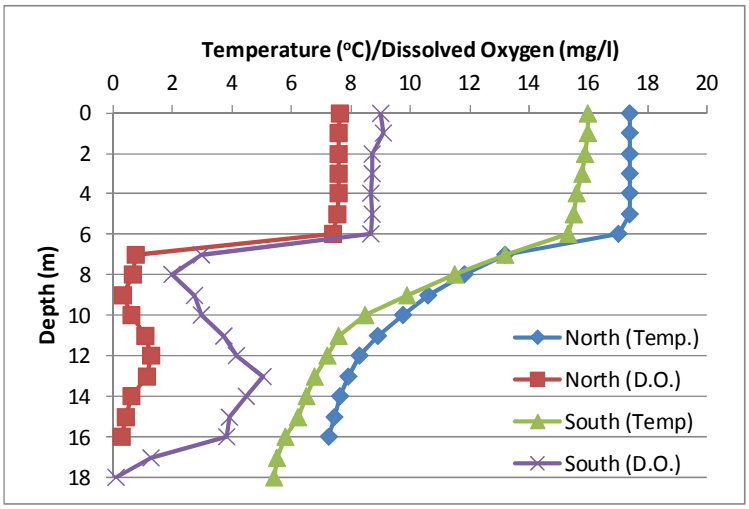



Figure 2 Temperature and dissolved oxygen profiles, Muldrew Lake, September, 2014.

In the BsM survey, a total of 293 fish of 9 species were caught (Table 3). The large mesh catch was dominated by Cisco, with Northern Pike, Rock Bass and Smallmouth Bass comprising most of the remainder of the catch. The small mesh catch was dominated by Cisco, Yellow Perch, Rock Bass and Smallmouth Bass. The small mesh nets did not catch any species that were not also caught in the large mesh nets.

Table 3 Catch summary, sorted by gear (top: large mesh, bottom,: small mesh) and depth stratum, BsM, Muldrew Lake, 2014

| Effort | Depth (m) | Cisco | Northern Pike | White Sucker | Brown Bull-head | Rock Bass | Pumpkin-seed | Small-mouth Bass | Large-mouth Bass | Yellow Perch |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 1-3 | | 1 | | 1 | | | 1 | 1 | |
| 11 | 1-3 | | | | | 1 | | | | |
| 19 | 1-3 | | 2 | | | 4 | | 1 | | |
| 4 | 3-6 | | 1 | | | | | 1 | | 1 |
| 7 | 3-6 | | 1 | 1 | | 3 | 1 | | | |
| 9 | 3-6 | 1 | 2 | | | | | 1 | | |
| 8 | 6-12 | 5 | | | | | | | | |
| 13 | 6-12 | | | | | | | 1 | | |
| 16 | 6-12 | | | | | | | 1 | | |
| 2 | 12-20 | 6 | | | | | | | | |
| 21 | 12-20 | 2 | | | | | | | | |
| Total | | 14 | 7 | 1 | 1 | 8 | 1 | 6 | 1 | 1 |
| 6 | 1-3 | | 1 | | | 6 | | 1 | | 5 |
| 10 | 1-3 | 1 | | | | 2 | | | | 3 |
| 18 | 1-3 | | | | | 8 | 3 | 2 | 4 | 5 |
| 12 | 3-6 | | | | | 6 | | | | 10 |
| 14 | 3-6 | 1 | | | | 1 | | 1 | | 2 |
| 15 | 3-6 | | | | | 3 | 1 | | | 13 |
| 3 | 6-12 | 48 | | | | | | 3 | | 2 |
| 20 | 6-12 | 2 | | | | | | 2 | | 8 |
| 1 | 12-20 | 90 | | | | | | | | |
| 17 | 12-20 | 17 | | | | | | 2 | | |
| Total | | 159 | 1 | 0 | 0 | 26 | 4 | 11 | 4 | 48 |

Table 4 Trap net catch, Muldrew Lake, 2014.

| Effort | Northern Pike | Brown Bullhead | Rock Bass | Pumpkin-seed | Small-mouth Bass | Large-mouth Bass | Black Crappie |
|---|---|---|---|---|---|---|---|
| 1 | | 2 | 6 | 41 | 7 | 7 | 2 |
| 2 | | | 3 | 4 | 9 | 12 | 1 |
| 3 | | | | 12 | 1 | 3 | |
| 4 | 1 | 5 | 32 | 4 | 5 | 3 | |
| 5 | | 3 | | 13 | 5 | 1 | |
| 6 | | | | 2 | | 1 | |
| 7 | 2 | 1 | 5 | 1 | 1 | 1 | 1 |
| 8 | 1 | 3 | 9 | 5 | 4 | | 2 |
| 9 | | | | 4 | | 9 | 3 |
| Total | 4 | 14 | 55 | 86 | 32 | 37 | 9 |

Trap nets capture fish by entrapment, rather than entanglement as the BsM nets do. Individual species have different vulnerability to the different gear due to their body shape, behaviour and habitat

preference. As a result, the trap net catch composition was different from the BsM nets and had proportionally greater catches of Pumpkinseed, Smallmouth and Largemouth Bass (Table 4). One additional species, Black Crappie, was also detected; the first documentation of the species in the lake.

Smallmouth and Largemouth Bass were the dominant sport fish species caught. A total of 49 smallmouth were caught; six in large-mesh BsM, 11 in small-mesh BsM and 32 in trap nets. The Smallmouth Bass population was dominated by small to medium-size individuals with most fish being between two and four years old and 150 to 300 mm FL and relatively few large fish over 400 mm (Table 5 and 6, Figure 3).

The Largemouth Bass catch was similar to the smallmouth catch; though virtually all were caught in trap nets (37 of 41). The population was also dominated by small to medium-sized fish, though two extremely large individuals were caught.

Table 5 Fork Length frequency distribution, by species, all gear combined, Muldrew Lake, 2014.

| Fork Length (mm) | Cisco | Northern Pike | White Sucker | Brown Bull-head | Rock Bass | Pumpkin-seed | Small-mouth Bass | Large-mouth Bass | Black Crappie | Yellow Perch |
|---|---|---|---|---|---|---|---|---|---|---|
| 50-99 | 7 | | | | 1 | 2 | 1 | 3 | | 5 |
| 100-149 | 88 | | | | 45 | 10 | | | | 12 |
| 150-199 | 76 | | | 1 | 42 | 56 | 9 | 4 | | 33 |
| 200-249 | 2 | | | 5 | 1 | 19 | 7 | 12 | 9 | |
| 250-299 | | | | 4 | | | 10 | 5 | | |
| 300-349 | | | | 3 | | | 4 | 8 | | |
| 350-399 | | 2 | | 1 | | | 8 | 4 | | |
| 400-449 | | 1 | | | | | 2 | 1 | | |
| 450-499 | | 1 | | | | | | 1 | | |
| 500-549 | | | 1 | | | | | 1 | | |
| 550-599 | | 1 | | | | | | | | |
| 600-649 | | 1 | | | | | | | | |
| 650-699 | | 2 | | | | | | | | |
| 700-749 | | 2 | | | | | | | | |
| 750-799 | | | | | | | | | | |
| 800-849 | | 2 | | | | | | | | |

Table 6 Descriptive statistics of size (fork length), by species, Muldrew Lake, 2014. All gears combined (excluding Cisco, Rock Bass and Yellow Perch caught in small mesh BsM gear).

| | Cisco | Northern Pike | White Sucker | Brown Bullhead | Rock Bass | Pumpkin-seed | Small-mouth Bass | Large-mouth Bass | Black Crappie | Yellow Perch |
|---|---|---|---|---|---|---|---|---|---|---|
| n | 15 | 12 | 1 | 1 | 14 | 5 | 41 | 39 | 9 | 7 |
| Min. | 145 | 368 | 515 | 245 | 105 | 90 | 90 | 70 | 221 | 70 |
| Max. | 185 | 812 | 515 | 245 | 185 | 195 | 421 | 537 | 245 | 185 |
| Mean | 166 | 607 | 515 | 245 | 132 | 135 | 271 | 268 | 232 | 134 |
| S.D. | 13 | 150 | 0 | 0 | 21 | 44 | 83 | 101 | 8 | 44 |

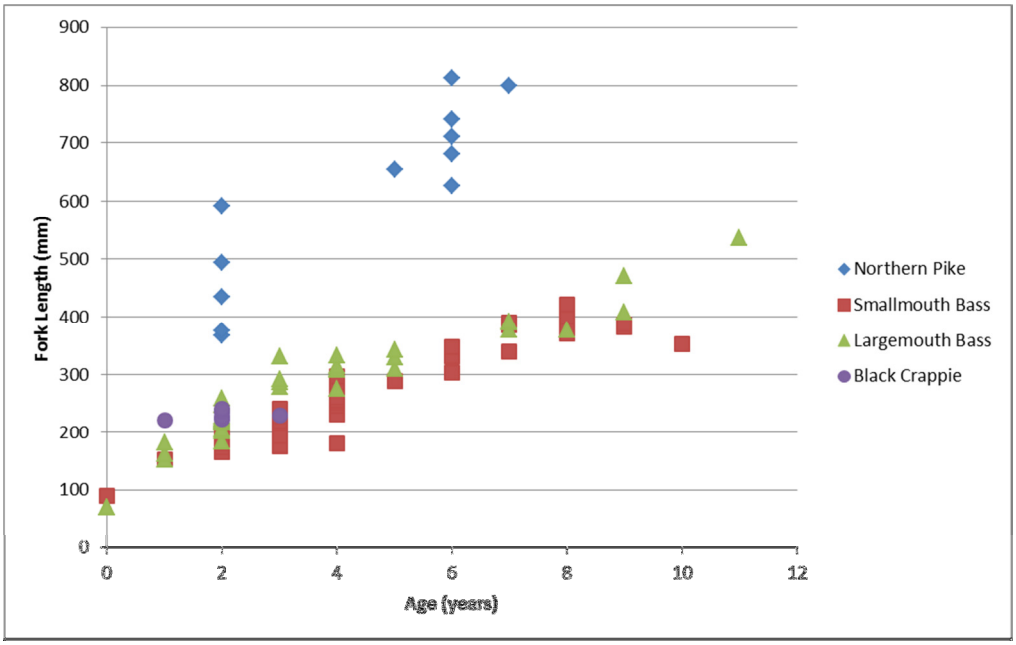



Figure 3 Scatter plots of size-at-age (fork length), by species, all gears combined, Muldrew Lake 2014

This survey confirmed the reported presence of Northern Pike. Eight were caught in the BsM nets and 4 in trap nets. A well distributed range of sizes, but limited age distribution was caught.

Cisco were the most numerous species caught. At least some were caught in all small-mesh gill net sets in the 6 m and deeper depth strata, where they are largely confined by temperature during thermal stratification, and despite low oxygen levels in some cases. Few were caught in the large mesh nets but the body size of fish in this population were too small to be vulnerable to most of the large mesh sizes. The average size was unusually small and perhaps a reflection of the apparent high density. A sample of Cisco was examined for state of maturity; most males were mature at 120-129 mm and most females at 130-139 mm (Table 7).

Table 7 State of maturity of Cisco, by fork length, Muldrew Lake, 2014.

| | Male | | Female | | Unknown |
|---|---|---|---|---|---|
| Fork Length (mm) | Imm | Mat | Imm | Mat | Mat |
| 100-109 | | | 1 | | |
| 110-119 | 3 | | | | |
| 120-129 | 1 | 3 | 3 | | |
| 130-139 | 1 | 2 | 1 | 3 | |
| 140-149 | | 2 | | 3 | |
| 150-159 | | | | 1 | |
| 160-169 | | | | | 2 |
| 170-179 | | | | | 3 |
| 180-189 | | | | | 1 |
| 190-199 | | | | | |

**Discussion**

The BsM protocol is a standard netting technique used across the province. The use of standardized gear set in a random fashion is intended to obtain an index of fish abundance (i.e. the catch rate (number or weight of fish caught per net) being proportional to the size of the population), and is used for comparing populations in different lakes or monitoring how an individual lake changes over time. The BsM program is still relatively new and benchmarks for comparisons are still being developed.

The trap nets were effective at supplementing the catches of some species, particularly Smallmouth and Largemouth Bass, which are not typically caught in large numbers in BsM nets. The nets were set in areas of relatively shallow waters with flat or gently sloping bottom. This habitat is not typical of most of the lake, therefore the trap net catch would not be representative of the average abundance of fish in the lake.

Nine black crappie were caught, the first documentation of this species in the lake. They were almost certainly introduced intentionally to Muldrew, or a connected lake, such as Turtle Lake, upstream. Notwithstaining the small sample size, the narrow size distribution suggests that the introduction was relatively recent, as a long-established population would be expected to have a wider range of sizes and ages present. The capture of nine individuals indicates there are a substantial number in the lake. The number caught was small but crappie have a low vulnerability to gill nets due to their body shape. Their tendency to suspend offshore over deep water in a lake like Muldrew renders them invulnerable to both gill and trap nets. As a comparision, only eight were caught in nearby Riley Lake in 2013 with about 2/3 of the amount of netting effort (Scholten 2014). Riley Lake is known to support a substantial population of, and fishery for, crappie.

It is interesting that the existence of crappie in the lake was not revealed by the initial public consultation done for the EA process. Their unauthorized introduction renders the EA process redundant, and also for Morrison Lake, downstream, which will probably be colonized eventually as well. The detection of crappie soon after their introduction presents an opportunity to monitor the lake in the future for impacts of the species on the remainder of the fish community.

This survey also confirmed the previously reported occurrence of Northern Pike. The relative scarcity of suitable spawning and nursery habitat in the form of extensive areas of shallow water supporting aquatic vegetation results in a low lake-wide density of pike. Considering the small sample size, a reasonable range of ages and sizes was caught and growth was at or above average for Ontario populations (Malette and Morgan 2005).

The large-mesh BsM nets, which provided the index of abundance for this project only caught 6 Smallmouth Bass. Though diagnostic values for BsM surveys are not yet available, the catch is relatively low, and reflects the limited amount of littoral habitat and the difficulty of sampling it, both due to the bathymetric features of the lake. The trap nets caught a respectable 32 smallmouth, indicating that they are common in suitable habitat. The abundance (BsM large mesh catch rate), age distruction and growth rate of Smallmouth and Largemouth Bass were similar to those caught in similar Riley Lake in 2013, suggesting that the introduction of crappie has not greatly impacted the catchable-populations of these species in that lake.

Though seldom seen and of little sport value, the Cisco of Muldrew Lake are a major part of the fish community. The extremely small body size is an interesting expression of this highly variable species. They are probably an important forage fish, at least seasonally, for bass and pike, especially considering the relatively small amount of littoral habitat in much of the lake and limited catch of other forage species.

The capture of several large Smallmouth Bass in and below the thermocline indicates they were foraging for Cisco. A review of basic ecology of crappie undertaken for the EA process suggested that crappie may potentially impact Cisco by competing for food with and preying on the pelagic young of Cisco. We speculate that the effect may be more pronounced in a lake with bathymetry like Muldrew Lake where there may a large overlap in habitat use and feeding niche. In Riley Lake, which is quite similar physically to Muldrew Lake but has had crappie established for a number of years, no Cisco were caught in 2013 despite being caught in large numbers in earlier surveys, leading to speculaton that crappie have reduced or eliminated the population in that lake (Scholten 2014).

Similar to this project, the 1987 trap net survey was constrained to a limited number of non-random set locations. In 1987, 12 nets sets were completed, but unlike this project, some sites were fished for more than one night, one of the three nets used was a smaller, 4-foot design and netting occurred in the early summer. In addtion to the catches of pike and crappie which had been introduced since 1987, differences in the catch included proportionally fewer Brown Bullhead, Rock Bass and Yellow Perch and more Pumpkinseed and Largemouth Bass in 2014 (Table 8). The small samples sizes and differences in gear and methods between years makes comparisons speculative but it is possible that some of these differences are due to the introduction of pike which may preferentially prey on Yellow Perch and Rock Bass. The much larger catch of Largemouth Bass may be largely due to the timing of the survey as fish will be more mobile and more vulnerable to capture in the fall than during the stable summer period. Largemouth may also be benefiting from changing climate, as they have a higher temperature preference than Smallmouth Bass (Scott and Crossman 1973).

Table 8 Catch summary for trap nets, Muldrew Laek, 1987 and 2014.

| | 1987 | | 2014 | |
|---|---|---|---|---|
| Species | Number | % | Number | % |
| Northern Pike | | 0.0 | 4 | 1.7 |
| White Sucker | 1 | 0.4 | | 0.0 |
| Brown Bullhead | 31 | 10.9 | 14 | 5.9 |
| Rock Bass | 126 | 44.4 | 55 | 23.2 |
| Pumpkinseed | 54 | 19.0 | 86 | 36.3 |
| Smallmouth bass | 45 | 15.8 | 32 | 13.5 |
| Largemouth Bass | 4 | 1.4 | 37 | 15.6 |
| Black Crappie | | 0.0 | 9 | 3.8 |
| Yellow Perch | 23 | 8.1 | | 0.0 |
| | 284 | | 237 | |

In summary, Muldrew Lake supports a diverse warm water fish community dominated by introduced species. The lake-wide abundance of most sport fish species is limited by the natural bathymetry and water quality of the lake which provide narrow and shallow littoral and euphotic zones. The recent unauthorized introduction of Black Crappie supersedes the EA process initated in 2012 and presents the opportunity for monitoring the impact of the species on this and similar lakes. It is speculated that crappie will cause severe impact to the Cisco population. Impacts on other species may be more subtle and difficult to detect given the multitude of other factors that effect populations and the large amount of effort required to achieve high sampling precision.

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Appendix Size-ate-age (fork length), by species, all gear types combined, Muldrew Lake, 2014.

| Species | Age | n | Mean | S.D. |
|---|---|---|---|---|
| Northern | 2 | 5 | 453 | 83 |
| Pike | 5 | 1 | 655 | 0 |
| | 6 | 5 | 714 | 62 |
| | 7 | 1 | 800 | 0 |
| Smallmouth | 0 | 1 | 90 | 0 |
| Bass | 1 | 1 | 152 | 0 |
| | 2 | 5 | 182 | 12 |
| | 3 | 7 | 207 | 24 |
| | 4 | 12 | 255 | 28 |
| | 5 | 1 | 288 | 0 |
| | 6 | 3 | 327 | 19 |
| | 7 | 3 | 372 | 23 |
| | 8 | 5 | 391 | 18 |
| | 9 | 2 | 385 | 3 |
| | 10 | 1 | 353 | 0 |
| Largemouth | 0 | 3 | 70 | 0 |
| Bass | 1 | 3 | 165 | 12 |
| | 2 | 14 | 220 | 18 |
| | 3 | 4 | 297 | 20 |
| | 4 | 5 | 308 | 19 |
| | 5 | 3 | 327 | 13 |
| | 7 | 3 | 387 | 7 |
| | 8 | 1 | 377 | 0 |
| | 9 | 2 | 439 | 31 |
| | 11 | 1 | 537 | 0 |
| Black | 1 | 1 | 221 | 0 |
| Crappie | 2 | 7 | 233 | 8 |
| | 3 | 1 | 230 | 0 |