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Canadian Science Advisory Secretariat (CSAS)

Research Document 2014/073

Gulf Region

Results of a Multi-year Control and Eradication Program for Smallmouth Bass (*Micropterus dolomieu*) in Miramichi Lake, New Brunswick, 2011-2012

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October 2014

Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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Published by:
Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044

Correct citation for this publication:

Biron, M., Clément, M., Moore, D., and Chaput, G. 2014. Results of a Multi-year Control and Eradication Program for Smallmouth Bass (*Micropterus dolomieu*) in Miramichi Lake, New Brunswick, 2011-2012. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/073. v + 58 p.

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ABSTRACT

Efforts to eradicate Smallmouth Bass (*Micropterus dolomieu*) in Miramichi Lake removed a total of 523 Smallmouth Bass in 2011 and 46 Smallmouth Bass in 2012, compared to 2,584 Smallmouth Bass in 2010. The fishing effort using boat electrofishing, gillnetting and fyke-netting more than doubled in 2011 and 2012, compared to 2010, and the catch-per-unit-effort declined by 99% at the end of the 3 year program. More than 90% of Smallmouth Bass captured and removed from Miramichi Lake were young-of-the-year. The oldest Smallmouth Bass captured was aged 11 years old and belonged to the cohort of 2000. Overall, boat and backpack electrofishing, beach seining and fyke-netting were successful at capturing young-of-the-year while Smallmouth Bass age 1 and older were successfully captured by boat electrofishing (particularly the adults during the spawning season), gillnetting, fyke-netting and angling. The results from the second and third year of the Multi-year Control and Eradication Program are very encouraging since it supports the successful depletion and containment of Smallmouth Bass in Miramichi Lake but eradication has not been achieved yet as demonstrated by the presence of all the life stages of that species in 2012. It is anticipated that elevated fishing effort would be required in future years to capture and remove the last Smallmouth Bass from Miramichi Lake.

Résultats d’un programme pluriannuel de contrôle et d’éradication de l’achigan à petite bouche (*Micropterus dolomieu*) pour le lac Miramichi, Nouveau-Brunswick, 2011-2012

RÉSUMÉ

Les efforts d'éradication de l’achigan à petite bouche (*Micropterus dolomieu*) dans le lac Miramichi ont enlevé un total de 523 achigans en 2011 et 46 achigans en 2012, contre 2,584 achigans en 2010. L'effort de pêche à l'aide du bateau de pêche électrique, aux filets maillants et aux filets verveux ont plus que doublé en 2011 et 2012, par rapport à 2010, et les captures par unité d'effort ont diminué de 99 % par la fin du programme de 3 ans. La plupart (> 90 %) des achigans à petite bouche capturés et retirés du lac Miramichi étaient des jeunes de l'année. Le plus vieil achigan à petite bouche à être capturé était âgé de 11 ans et appartenait à la cohorte de 2000. Dans l'ensemble, le bateau de pêche électrique, les unités de pêche électrique portative, la senne de plage et les filets verveux ont réussi à capturer les jeunes de l'année, tandis que les achigans à petite bouche âgé de 1 an et plus ont été capturés avec succès par la pêche électrique en bateau (en particulier les adultes pendant la saison de ponte), la pêche aux filets maillants, aux filets verveux et la pêche à la ligne. Les résultats de la deuxième et troisième année du programme de contrôle et d'éradication sont très encourageants puisque qu’ils démontrent avec succès l'épuisement et le confinement des achigans à petite bouche dans le lac Miramichi, mais l'éradication n'a pas encore été atteinte comme en témoigne la présence de tous les stades du cycle de vie de cette espèce en 2012. Il est prévu qu’un effort de pêche élevé sera nécessaire dans les années à venir pour capturer et enlever le dernier achigan à petite bouche du lac Miramichi.

INTRODUCTION

In August 2008, anglers reported to the New Brunswick Dept. of Natural Resources the presence of the non-native Smallmouth Bass (*Micropterus dolomieu*) in Miramichi Lake, which drains into a headwater tributary of the South Branch of the Southwest Miramichi River in New Brunswick. A field assessment conducted by the New Brunswick Dept. of Natural Resources and the Univ. of New Brunswick confirmed the presence of Smallmouth Bass (SMB) in Miramichi Lake in September 2008 (O'Donnell and Reid, unpublished manuscript). The discovery of this invasive species in the headwater of the Miramichi River prompted a rapid response from various angler associations and governmental agencies to confine and eradicate SMB from Miramichi Lake. In the fall of 2008 (Oct.-Nov.), a containment barrier with fine meshed nets was installed at the single outlet of Miramichi Lake to prevent SMB from escaping the lake. This barrier was in place until ice up, and the area immediately below the barrier was electrofished weekly in an attempt to remove any SMB which may have escaped from the lake. A total of 17 SMB, including 15 young-of-the-year (YOY) were captured in 2008. The presence of YOY SMB in Miramichi Lake in 2008 was interpreted as having come from spawning of adult SMB in Miramichi Lake in 2008.

In response to concerns about the potential impact of SMB on Atlantic Salmon, a risk assessment of the possible impact of this non-native species introduction in the Miramichi River system was conducted in January 2009 (DFO 2009; Chaput and Caissie 2010). The overall risk to aquatic species in Miramichi Lake was considered to be high with low uncertainty whereas the risk of potential impacts to the ecosystem of the Miramichi River and other rivers of the Gulf Region was judged to be moderate with high uncertainties, principally due to the lack of studies on the effects of SMB on salmon populations (DFO 2009; Valois et al. 2009; Chaput and Caissie 2010).

Meanwhile in 2009, various watershed associations and government agencies operated a containment barrier at the outlet of the lake to prevent dispersal of this species to other tributaries of the Miramichi River drainage basin. Eradication efforts using backpack electrofishing above and below the barrier in Lake Brook, fyke nets and gillnets resulted in the removal of 64 SMB in 2009, including 26 YOY. The 2009 data confirmed the successful spawning and recruitment of SMB in Miramichi Lake.

Following on the risk assessment and the field investigation of 2009, the Department of Fisheries and Oceans (DFO) in collaboration with the Miramichi Watershed Management Committee, the Miramichi Salmon Association and the New Brunswick Department of Natural Resources, initiated in 2010 a three-year containment, control and eradication program (Appendix 1). The program consisted of operating a containment barrier and removing SMB from Miramichi Lake using mechanical technologies (Halfyard 2010), principally boat electrofishing, backpack electrofishing, fyke-netting, gillnetting, beach seining and angling. The first year (2010) of the control and eradication program was successful at removing 2,584 SMB (Chaput and Moore unpubl. report). This report describes the results obtained during the second and third years of the program, with reference to results from 2008, 2009 and 2010 that are only reported in two, yet to be published, as background information to evaluate the current results from the multi-year control and eradication program.

MATERIALS AND METHODS

SITE DESCRIPTION

Miramichi Lake is located in the headwater of the Southwest Miramichi River basin in New Brunswick. It is approximately 2.8 km in length by 0.8 km in width with an estimated surface area of 2.21 km2 (221 ha). Relatively shallow, the majority of the lake is less than 3.75 m deep and has two deep holes with maximum depth less than 7.65 m (Fig. 1). Miramichi Lake drains into its only outlet, Lake Brook, a 4.5 km tributary of the South Branch of the Southwest Miramichi River. The lake was divided into 16 sectors to facilitate localization on the lake during fishing effort (Fig. 1).

FISHING METHODS

Several fishing methods were used to capture and remove SMB from Miramichi Lake in 2011 and 2012. In addition to operating a containment barrier at the outlet of the lake, boat electrofishing, backpack electrofishing, gillnetting, fyke-netting, beach seining and opportunistic angling were conducted throughout the season.

Containment barrier

Soon after the ice cover disappeared from the lake in 2011 and 2012, the containment barrier was installed in the outlet of Miramichi Lake, where it enters Lake Brook, to contain SMB in the lake and prevent dispersal within the Miramichi River water basin. The containment barrier consisted of two fences: the first one made of steel bars installed at 12 mm intervals and lined with a 12 mm mesh net, while the second fence (or debris fence) was installed a few meters upstream of the first fence and was constructed with rebars installed at 2 feet intervals and also lined with a 12 mm mesh net. The containment barrier was usually fished 7 days per week. To allow movement in and out of the lake, the upstream or downstream barriers were open and fish were trapped between the two fences. Beach seining was then conducted between the two barriers to capture and manually transport fish either upstream or downstream of the barriers. All fish captured between the two barriers were examined to ensure that no SMB were released.

There is one modification to the process of moving fish downstream that was implemented following the high mortality rate observed from manipulating YOY gaspereau in 2009 and 2010. Once YOY gaspereau gather in large number (i.e. thousands) upstream of the barrier to move out of the lake, safe passage for them was achieved by lowering a small section of the debris fence, and lifting the net from a small section of the barrier fence, in the opposite corner, to let the fish go through without manipulation. A certain control was kept on the species and size of fish going through by making the fish travel over shallow areas, while being actively monitored by a crew member, ready to block the route if required.

Electrofishing Boat

Electrofishing boats were used to sample shallow waters (depth less than 2 m) along the littoral zone of Miramichi Lake. Two electrofishing boats were used. ‘Boat A’ measured 4.6 m long and was equipped with a Smith-Root 7.5 GPP (Generator Powered Pulsator) electrofishing unit. Two booms measuring 3 m long were positioned at each corner of the bow and held the anode arrays. Anode arrays were configured as six droppers arranged in a 91 cm (36 inch) circular pattern. ‘Boat B’ measured 5 m long and was also equipped with a Smith-Root 7.5 GPP electrofisher with similar booms and anode arrays made of six droppers. Each boat was configured to use the hull as the cathode although Boat B was equipped with additional cathode dropper wires attached along the sides and front of the fishing deck. The voltage was set at 1000 V and 60 Hz.

The crew on each electrofishing boat varied between two and three people. One person operated the boat and electrofishing unit while one or two people were positioned at the bow to capture SMB with dip nets. The distance between the anodes was maintained at approximately 1.5 m when one dip netter was present and 2.5 m when two dip netters were present. To increase the fishing effort and covering a larger area of the Miramichi Lake, only SMB were targeted and captured for the entire field seasons.

Two separate boat electrofishing techniques were used. Both techniques were used extensively in different situations. In the first technique, boat electrofishing was conducted along transects perpendicular to shore, beginning approximately 20-25 m offshore (maximum depth of approximately 2 m) and ending at the shoreline. This technique was used to cover the presumed spawning grounds, where shallow cobble and boulder habitat extended out from shore. The second technique involved electrofishing boats travelling parallel to shore. This technique was used to cover sectors characterized by soft bottom, high quantify of weeds along the shore and rapid increase in depth (> 2 m), which prevented efficient electrofishing along perpendicular transects. One or two passes were conducted along the shore and covered the first 5 - 10 meters out from the shoreline. A mixture of perpendicular and parallel transects were used in covering areas where hard bottomed habitat extended out from shore.

Generally, boat electrofishing was conducted in late evening or after dark. Some daytime electrofishing was conducted when the lake was calm and visibility was good but these conditions were rare. The entire near shore of the lake was electrofished at least once a week to identify the distribution of SMB along the littoral zone of the lake. Two nights with favourable conditions were required to electrofish the entire near shore of the lake. During the remainder of the week, electrofishing effort focused on areas where SMB were captured that week. During the spawning period (late May - June), increased electrofishing efforts were directed toward the spawning grounds (sectors 1 and 16; Fig. 1) to capture spawning adults or males guarding nests. The location of the spawning grounds was identified based on the presence of adults and the location of first YOY occurrence in previous years.

Backpack Electrofishing

Daytime backpack electrofishing was conducted every week in Lake Brook (Fig. 1) to determine if SMB escaped from Miramichi Lake. Smith-Root Model LR 24 or Model 12B electrofisher units were used and the default setting used was I-5 (pulse width = 3 ms, pulse frequency = 50 Hz, standard wave form (uniform pulses)) at voltages ranging from 500 to 700 V. The voltage adjustments were made as needed to adapt to changes in conductivity of the water.

In 2011 and 2012, electrofishing in Lake Brook was conducted from a riffle located approximately 400 m downstream of the barrier (location of a debris dam observed in previous years but displaced in 2011) to the barrier. In 2011, electrofishing was also regularly conducted from the barrier to 1,500 m downstream to search for SMB. Special attention was paid to structures in the brook, especially along the shoreline in slow moving water at depths of 30 to 100 cm. One or two electrofishing units were used at a time. When fishing with one unit, one person operated the backpack unit while another person captured fish with a dip net. Electrofishing was conducted down along the west side of the brook and then back up along the east side. When fishing with two units, two people, each with a backpack unit, walked on each side of the brook.

Backpack electrofishing was also conducted in Miramichi Lake and mainly targeted the YOY in the shallow near shore area of the lake. One or two units were used. When one unit was used, the person carrying the electrofisher moved in a zigzag pattern along the shoreline (up to 20 - 25 meters from shore) and targeted large structures such as rocks and logs. Occasionally, electrofishing was conducted more offshore to sample around large boulders or logs located in

deeper water (maximum depth of 70 cm). When done as a pair, one fisher concentrated on the immediate shoreline (up to 3 meters from shore) and the other stayed in deeper water (0.30 m to 0.70 m) and targeted large structures.

Gillnetting

Twenty-two gillnets of variable mesh sizes and configurations were used in 2011, and seventeen in 2012. Gillnets were constructed of grey, white or green multifilament, with mesh sizes of 3, 3.25, 3.5, 4, and 5 inch stretched mesh. Most nets were 30 m in length but 9 nets were 22.9 m in length and 4 nets were 45.8 m in length. All nets were 2 m deep. Deployed nets were anchored at both ends with steel anchors or cinder blocks and floated with buoys at the surface. Gillnet fishing effort focused in areas of the lake known to support adult SMB from previous years and were mostly installed near the two deep holes of the lake and near shore in sectors 1, 4, 5 and 16 (Fig. 1). Although indicated at the surface by small white buoys, incidents between outboard motors and gillnets set in deeper water occurred twice in 2011 and three times in 2012, and resulted in the loss of five gillnets each year.

In 2011, a 20-day random sampling program was initiated to spread the fishing effort throughout the lake and ensure that no areas that potentially supported adult SMB were overlooked. The lake was divided into a grid of 22 squares of 250 m^2 each (Fig. 2). Twelve gillnets were assigned randomly to a fishing zone. On each day, gillnets were fished, removed and reset to a new random location.

Fyke-netting

Fyke nets were intermittently fished throughout the season in all sectors of Miramichi Lake. Daily fyke-netting efforts varied between four and eight nets and were concentrated in areas known to support SMB along the shallow grounds of the lake. The fyke nets were constructed of 0.5 inch mesh with either 3 x 3 ft or 3 x 6 ft frames. The 3 x 3 ft nets had wings and a leader of either 80 ft, 180 ft or 280 ft depending upon fishing location. The 3 x 6 ft nets had a 100 ft leader but no wings.

Two methods were used to fish the fyke nets. The first was by two crew members pulling the entire net to shore by the wings after removing the trap anchor. The trap would then be untied and emptied into a bin where the catch would be tallied by species. All species other than SMB were released and the trap reset by the original method. The second method was to pull in the trap anchor by the buoy line directly into the boat, and crew members would jump into the water to fish the trap where it laid. The catch was then emptied into the bins and the trap was reset by the original method.

Beach Seining

Both years, beach seining was initiated soon after YOY SMB hatchings had been first observed from boat electrofishing, and stopped one month later. A beach seine measuring 50 m long, 2 m deep with a 12 mm mesh was used in sectors 1, 2, 3, 4, 5, 15 and 16 (Fig. 1). These sectors had suitable depth and substrate for beach seining and were known to support YOY SMB from previous years. The beach seine was fished manually. One person took the net approximately 15 m offshore. With another person on or near shore, the net was dragged along the shoreline. After traveling about 150 to 200 m along the shore, the outer portion of the net was worked back to shore completing a closed loop. The net was then pulled carefully onto shore while keeping the lead line on bottom. A third person followed the seiners to free the net from any structure while fishing the net and pulling it to shore. Once most of the net was pulled to shore from both ends, a bag formed in the net. This bag was used to lift the catch into bins. SMB were separated from all other species and retained; all other species were released back into the lake.

Angling

Opportunistic angling was also conducted on spawning grounds and near large boulders and structures in Miramichi Lake throughout the summer of 2011 and 2012, as well as the entire Lake Brook tributary and part of two inlets (Four Miles Brook and Five Miles Brook) in 2012.

PROCESSING OF CATCHES AND DATA ANALYSIS

All SMB captured were killed and sampled before shipment to the DFO Gulf Fisheries Center where they are preserved in freezers. SMB were sampled for fork length (mm), weighed (g), scale sampled for interpretation of age and sex determined by dissection. Dead by-catch other than SMB was frozen and disposed at facilities in either Miramichi or Fredericton.

RESULTS

CATCHES OF SMALLMOUTH BASS

Catches of SMB occurred between May 16 and October 19, 2011, and between May 4 and October 2, 2012. During these periods, the daily mean water temperature varied from 8.5ºC to 27.5ºC in 2011 and from 8.3ºC to 28.9ºC in 2012 (Fig. 3). A total of 523 SMB were captured and removed from Miramichi Lake in 2011, and 46 in 2012 (Table 1). Most of the captured SMB (92.4% in 2011, 78.3% in 2012) were YOY. Juveniles (age 1 and age 2) represented 1.9% of the catch in 2011 and 15.2% in 2012, while adults (≥ age 3) represented 5.7% of the catch in 2011 and 6.5% in 2012 (Table 1).

The number of SMB captured and removed declined 5-fold in 2011 (523 SMB) compared to 2010 (2,584 SMB), and by 11-fold in 2012 (46 SMB) compared to 2011. The amount of fishing effort was not available for all sampling methods in 2011 and 2012, therefore preventing the comparison of the total catch-per-unit-effort (CPUE) between the three years for all sampling methods. Nonetheless, fishing effort for all three years of the program was available for boat electrofishing, gillnetting and fyke-netting. Sixty percent, 70% and 50% of the SMB were captured using these three fishing methods in 2010, 2011 and 2012, respectively (Table 1), and was used to compare fishing effort and catch-per-unit-effort between years.

The amount of fishing effort doubled in 2011 and 2012 compared to 2010, and the number of SMB captured with these three techniques declined by almost 99% by 2012 compared to 2010 (all life stages combined) (Table 2). More specifically, boat electrofishing effort more than doubled in 2011 (183.4 hrs) compared to 2010 (81.7 hrs) and the total number of SMB captured declined by 75% (Table 2). The vast majority (94%) of captured SMB were YOY. When considering the catches in relation to the amount of fishing effort, the catch-per-unit-effort in 2011 was 1.65 YOY per hr, 0.03 juvenile per hr and 0.07 adults per hr (Table 2). From 2010 to 2011, catch-per-unit-effort decreased by 90% for YOY and by 63% for juveniles. However, the catch-per-unit-effort for adult, although low in both years, increased by 78% in 2011. This can be attributed to an increase in capture efficiency in 2011 due to a better knowledge of the habitat utilization of the species and improved capture technique compared to 2010. When combining all life stages, the total catch-per-unit-effort declined by 89% in 2011 compared to 2010 (Table 2).

The amount of fishing effort decreased for all three methods in 2012 relative to 2011 and the number of SMB captured declined by 9 (fyke nets) to 18-fold (boat electrofishing)(all life stages combined), while there was no bass caught in gillnets (Table 2). Boat electrofishing effort in particular decreased by 32% in 2012 (125.2 hrs) compared to 2011 (183.4 hrs), while the total number of SMB captured declined by 94% (Table 2). The majority (67%) of captured SMB were

YOY. When considering the catches in relation to the amount of fishing effort, the catch-per-unit-effort in 2012 was 0.1 YOY per hr, 0.03 juvenile per hr and 0.02 adults per hr (Table 2). From 2011 to 2012, catch-per-unit-effort decreased by 94% for YOY, remained the same for juveniles, and decreased by 70% for adult. The decrease in boat electrofishing effort in 2012 can be mostly attributed to less favorable weather conditions (wind and/or rain) in 2012 compared to 2011 that translated in 25% less available working days and nights during the months of June to September (Table 3). When combining all life stages, the total catch-per-unit-effort for boat electrofishing declined by 92% in 2012 compared to 2011, and by over 99% compared to 2010 (Table 2).

Gillnetting effort more than doubled in 2011 (2,732 net-days) and 2012 (2,613 net-days) compared to 2010 (1,150 net-days). The total number of SMB captured declined by 56% in 2011 compared to 2010, and by 100% in 2012 compared to 2011 (Table 2). In 2011 and 2012, as in previous years, no YOY were captured by gillnetting due to the larger mesh size. In 2011, a total of 11 SMB were captured with gillnets, resulting in a catch-per-unit-effort of 0.004 SMB per net-day, an 86% decrease in CPUE (all life stages combined) compared to 2010. In 2009, gillnets were not always fished overnight and the unit of effort was not comparable with those in 2010 to 2012. Nonetheless, in 2009, a total of 2,515 hours of gillnetting resulted in the capture of 20 adult SMB (3 and 4 year old). This represents a catch-per-unit-effort much higher compared to 2011, where 2,732 net-days (over 65,500 hours) resulted in the capture of 6 juvenile and 5 adult SMB. For comparison purpose of CPUEs in Table 2, reported effort in 2009 was divided by 24hr period to obtain 105 net-days, and a CPUE of 0.19 SMB/hr.

Fyke-netting effort doubled in 2011 (988 net-days) and 2012 (868 net days) compared to 2010 (487 net-days) and the total number of SMB captured declined by 98% by 2012 compared to 2010 (Table 2). Fyke-netting effort decreased by 12% in 2012 (868 net days) compared to 2011 and the total number of SMB captured declined by 89% (Table 2). In total, 37 SMB were captured in 2011 and 4 in 2012 (Table 2). In 2011, as in 2010, the vast majority (87%) of captured SMB were YOY. The fyke-netting effort resulted in a catch-per-unit-effort of 0.04 SMB per net-day (all life stages combined) in 2011, and 0.005 SMB per net-days in 2012. Compared with 2010, catch-per-unit-effort declined by 90% in 2011 compared to 2010, and by 88% in 2012 compared to 2011 (Table 2).

Detailed information on catches according to all fishing methods in 2011 and 2012 is described in the following sections.

Containment barrier

The containment barrier was operated from May 4 to November 3, 2011, and from May 2 to November 1, 2012. The main barrier was not breached in any high water events, and no SMB were captured in the enclosure between the main barrier and the debris fence during any sweep and sorting process. In 2012, one juvenile SMB was caught by hand against the debris fence, alive but weak. During the previous night the front area of the barrier was extensively and repeatedly boat electrofished, which probably was the cause of its weakness. On August 4, 2011, one YOY SMB was caught 30 m below the main barrier during backpack electrofishing. No SMB were observed below the barrier in 2012.

Boat Electrofishing

In 2011, boat electrofishing was initiated on May 11 and terminated on October 19, while in 2012 it was initiated on May 1 and terminated on October 25. All years considered (2010-2012) boat electrofishing was the most effective gear for capturing SMB (Tables 1 and 2). The amount of electrofishing effort applied with boat “A” totaled 43.8 shocking hours in 2011 and 16.3 hours in 2012, and 139.7 shocking hours for boat “B” in 2011 and 108.9 hours in 2012 (Table 4).

However, catches were not compiled according to the vessel used and it was not possible to compare capture efficiency between boats. After acquiring the new electrofishing boat “B” in 2011, a wider and more stable working platform, boat “A” was used only when enough crew members were present at the lake to operate a second electrofishing vessel or when boat “B” was unavailable. The day-time fishing effort totaled 21.3 hours in 2011 and 14.9 hours in 2012 compared to 162.1 hours at night-time in 2011 and 110.2 hours in 2012 (Table 5). Day-time catch-per-unit-effort was generally lower than night-time, except for July 2011 (Table 5). This was attributed to the capture of 23 YOY on 22 July 2011 in sectors 1 and 16.

With very few exceptions due to mechanical problems or uncooperative weather, the near shore of the lake was entirely electrofished every week to quantify the distribution of SMB. The sectors known to support SMB were thereafter electrofished more intensively (sectors 1 and 16; Table 6). In June 2012, a request was made, and granted, to avoid boat electrofishing in sector 2, a nesting area for loons, after one bird was found dead one morning after electrofishing occurred in that sector the previous night.

From 2010 to 2012, the capture of juveniles and adults was sporadic throughout the sampling period (Table 7). Captures of adults occurred mostly from May to July in sectors located near the spawning grounds (sectors 1, 15 and 16; Table 7). Nonetheless, the highest catch-per-unit-effort for juvenile and adult combined occurred in sector 4 in 2011 (1.48 SMB per hr, Table 8) but this was attributed to the capture of one juvenile with small amount of electrofishing effort in this sector (total of 0.67 hr; Tables 6 and 7).

The first capture of YOY SMB occurred on July 22 in 2011 and on July 26 in 2012 (Table 9). In 2010, the first capture of YOY SMB was also made by boat electrofishing on July 12, 2010. In 2011, the highest catch-per-unit-effort was observed in sectors 1 and 16 (areas known to support spawning grounds). As the season progressed, the catch-per-unit-effort increased in the other sectors, reaching a maximum of 16.90 SMB per hr in sector 4 (September; Table 10). This elevated catch-per-unit-effort was attributed to the capture of one YOY (Table 9) with a small amount of effort (0.06 hr; Table 6). In 2012, all catches of YOY SMB were restricted to sectors 1 and 16.

Backpack electrofishing

Lake Brook

Daytime backpack electrofishing was conducted every week in Lake Brook from May 14 to October 17, 2011, except from August 27 to September 23 2011 due to high water level and technical difficulties, and from May 2 to October 25, 2012. Unfortunately, effort from backpack electrofishing in Lake Brook was not recorded in 2011, therefore preventing the calculation of catch-per-unit-effort for that year. In 2012, a total of 8 hrs of shocking effort throughout the season resulted in no SMB catch in Lake Brook compared to 4 juveniles and 1 YOY SMB captured in 2010 and 1 YOY captured on August 4 in 2011 (Table 11).

Miramichi Lake

Backpack electrofishing was also conducted along the shore of Miramichi Lake (spot checks) from July 26 to October 12, 2011, and from July 18 to October 4, 2012. Backpack electrofishing in Miramichi Lake targeted areas known to support YOY SMB but the effort and locations (shocking seconds) were not recorded in 2011, preventing the calculation of catch-per-unit-effort for that year. Nonetheless, 52 YOY were captured in 2011 in several sectors of the lake but the majority of the SMB were captured in sectors 1 and 16 (Table 11). In 2012, a total of 4.7 hrs of shocking effort resulted in 10 YOY removed from Sectors 1 and 16 in July and August (Table 11).

If we omit data from Lake Brook, seasonal CPUE decreased from 14.5 SMB/hr in 2010 to 0.5 SMB/hr in 2012, while the overall area surveyed and seasonal shocking effort applied in 2012 were three time less than in 2010 (Tables 12 and 13). However, if we compare only Sectors 1 and 16, where effort are more comparable and the majority of the catch occurred in 2010 and 2012 (Tables 11 and 12), CPUE decreased by more than 85% in 2012 compared to 2010, passing from 19.92 SMB/hr in Sector 1 and 15.22 SMB/hr in Sector 16 (18.85 SMB/hr combined) in 2010 to 2.93 SMB/hr in Sector 1 and 1.46 SMB/hr in Sector 16 (2.65 SMB/hr combined) in 2012 (Table 13).

Gillnetting

Gillnetting occurred from May 9 to October 21, 2011, and from April 25 to October 25, 2012. In 2011, a total effort of 2,732 net-days resulted in the capture of 11 adult SMB and a catch-per-unit-effort of 0.004 SMB per net-day, a 5-fold decrease compared to 2010 (Table 14). In 2011, the first two captures of SMB by gillnets occurred on May 16 and other captures were sporadic throughout the sampling season (Table 14). SMB were captured near the deep holes of the lake. In 2012, a total effort of 2,613 net-days resulted in no catch of SMB. Actually, during the last 2 months of the 2012 season, catch of any species of fish with gillnet was a rarity, another indication that large fish have been depleted from the lake over the last three years.

A total of 233 net-days were applied in a randomized fashion throughout the lake in 2011 to determine the distribution of adult SMB. This effort resulted in no catch of SMB.

Fyke-netting

Fyke-netting was initiated on May 11 and terminated on October 27, 2011, and from May 3 to October 25, 2012. In 2011, total effort of 988 net-days resulted in the capture of 37 SMB and a catch-per-unit-effort of 0.037 SMB per net-day (Table 15). The first capture of YOY occurred on August 12, 2011, the first juvenile was captured on July 26, 2011, while one adult was captured on May 31, 2011. In 2012, total effort of 868 net-days resulted in the capture of 4 SMB and a catch-per-unit-effort of 0.003 SMB per net-day, representing a 12-fold decrease compared to 2011 (Table 15). The first of the two captures of YOY occurred on July 31, 2012, and the first of the two juveniles was captured on May 4, 2012.

In 2011, it was not possible to express the fishing effort according to individual sectors, however, 32 YOY SMB were captured in sectors 1, 2, 5 and 16, while four juveniles were captured in sectors 1 and 5 and one adult captured in sector 1 (Table 15). All four SMB captured in 2012 were caught in Sector 1.

Beach seining and angling

Beach seining was initiated from July 27 to August 26, 2011, and from July 22 to August 16, 2012. The amount of beach seining effort (number of sweeps) and location were not always recorded when the SMB catch was null, or catch undifferentiated by sweep when captured in the same sector. Catch-per-unit-of-effort could not be calculated. Nonetheless, a total of 96 YOY were captured by this means and removed from the lake in 2011, and 13 YOY in 2012 (Table 16). In 2011, the first capture occurred on July 27, with the highest number of YOY captures occurring in sectors 1 and 16 (Table 16). In 2012, the first capture of a YOY occurred on July 29, with all the captures occurring in sectors 1 (Table 16).

Sporadic angling effort around large boulders and structures resulted in the capture of six adult SMB in 2011 and one adult in 2012.

Biological characteristics of Smallmouth Bass

A total of 3,153 SMB were removed from Miramichi Lake since the beginning of the eradication program in 2010; 3,217 if we include the catch of 2009 (Table 17). The two oldest SMB captured in Miramichi Lake belonged to the year class of 2000 and were captured in 2010 and 2011 (Table 17). Similarly to 2010, a gap in SMB belonging to the 2001, 2003 and 2004 cohort was observed in 2011, while no fish older than the 2008 cohort were captured in 2012. Most (96%) of the 3,217 SMB captured and removed from Miramichi Lake were YOY. The age distribution (all fishing methods combined) ranged from 0 to 11 years in 2011, and from 0 to 4 years in 2012 (Table 17). In all years, age was estimated based on scales. Otoliths may be examined in the future months to compare age estimation based on both techniques and determine if age was underestimated based on scales (Long and Fisher 2001). Sex could not be determined on YOY and some juveniles due to undeveloped gonads. There were more females than males captured in 2009 and 2011, and more males than females in 2010 and 2012, for an overall sex ratio close to 50/50 when combining all catches, except for the 4 year old age-group that had twice as many female than male captured over the years (Table 18).

The length of the YOY ranged between 26 mm to 95 mm in 2011 and between 29 mm and 106 mm in 2012, for an average of 55.97 ± 18.06 mm in 2011 and 54.40 ± 17.70 mm in 2012 (Table 18; Fig. 4). The YOY gained in length on average 44.6 mm in 2011 and 38.1 mm in 2012 during their first growing season. Most of the growth occurred in August and September (Fig. 4). Growth over time was particularly noticeable for YOY captured by boat electrofishing in 2011 due to the higher sample size and the sampling period covering the entire growth season (Fig. 5). The length of the juveniles (age 1 and 2) was between 75 mm and 209 mm in 2011 and 76 mm and 204 mm in 2012, while the length of the adults (≥ age 3) was between 201 and 460 mm in 2011 and between 233 and 304 mm in 2012 (Table 18; Fig. 6). The number of juvenile and adult SMB captured is too low to calculate growth over time by year for these age groups.

In 2011, the weight of the YOY ranged between 0.45 g and 13.22 g and averaged 3.91 ± 2.75 g (Table 18; Fig. 7). The YOY gained on average 6.13 g in weight during their first growing season. Most of the gain in weight occurred in August and September (Figs. 7 and 8). The weight of the juveniles (age 1 and 2) was between 6.88 g and 131.68 g and the weight of the adults (≥ age 3) was between 115.4 g and 1758 g (Table 18; Fig. 9). The number of juvenile and adult SMB captured is too low to calculate growth for these age groups. There was a strong exponential relationship between fork length and weight for SMB in Miramichi Lake (Fig. 10).

ERADICATION OF SMALLMOUTH BASS

Excluding the fish caught in 2008 (n=17) and 2009 (n=64), a total of 3,153 SMB have been removed from Miramichi Lake between 2010 and 2012: 3,051 YOY, 38 juveniles (age 1 and 2) and 64 adults (>= age 3) (Table 19). By combining all sampling techniques, a total of 523 SMB were captured in 2011 and 46 in 2012. In 2011, this represented an 80% decline in the catch from 2010, where 2,584 SMB were captured, and over 98% decline in 2012 compared to 2010. Fishing effort using boat electrofishing, gillnetting and fyke-netting doubled in 2011 and 2012 compared to 2010, and catch-per-unit-effort declined by 80 to 90% in 2011 and over 98% in 2012.

Overall, boat electrofishing and beach seining were the most successful methods at capturing YOY (representing 70 to 85% of their catch each year), followed by backpack electrofishing and fyke-netting (Fig. 11). Juvenile SMB were successfully captured by boat electrofishing and fyke-netting (with 60 to 100% of their catch each year), while adult SMB were mostly captured by gill-

nets (all ages) and boat electrofishing (3 and 4 year old), followed by fyke-netting and angling (Fig. 11).

Based on the location and timing of capture of YOY, the spawning grounds are likely located in sectors 1 and 16, more specifically along the shallow grounds between the shoreline and the deep hole located in that area. In 2011, as the growing season progressed, the first YOY were caught in the shallow depth on each side of the demarcation line between sectors 1 and 16, and then progressively dispersed along the near shore of the lake each week (Fig. 12) leading to the belief that adults migrated and aggregated in sectors 1 and 16 during the spawning period (late May – early June). In 2012, YOY were first caught in the same area as 2011, and also dispersed along the near shore of the lake each week, but were never captured outside of sectors 1 and 16. The first captures of YOY in 2010 were in sectors 1, 2, 4, 5 and 16, with the majority of the catch that week (76%) coming from sectors 1 and 16.

DISCUSSION

As stated in the Control and Eradication Plan for SMB in Miramichi Lake, the objectives of the three year program were to maintain containment while depleting the SMB population in Miramichi Lake by eliminating spawning and recruitment of future spawners using multiple mechanical methods (Appendix 1). Other goals were to estimate the population size and age structure of SMB in the lake and provide a measure of the effectiveness of the removal strategy. It rapidly became obvious however that for the people involved with Miramichi Lake (camp owners, project's crew, volunteers, other participants) the ultimate goal of eradication had priority over any other objectives, and modifications to the experimental sampling design were made as needed within each field season and through the entire program to maximize the removal of SMB from Miramichi Lake. Hence, protocols were changed, sampling began to target specific areas, and record keeping started to lack rigorousness at times during that process (e.g., unreported effort, undivided effort by sectors, incomplete data collected for other species after 2010). Unaccounted and anecdotal effort sometimes successfully contributed to the removal of fish, such as: professional bass fishermen invited to fish the lake in 2011 and 2012; camp owners and their guests now angling specific areas for bass; kids sent with dip nets under docks and boats to catch YOY SMB, gillnet sets stretching across the width of the lake, trawling with purse seines and gillnets; snorkeling. After the third year of the program, the containment and depletion of the SMB population in Miramichi Lake was considered successful but eradication has not yet been achieved as proven by the capture of all the life stages of that species in 2012. Although the population size of SMB in Miramichi Lake remains unknown, fishery indicators (CPUE, age structure and distribution of catch) provide some indications of the effectiveness of the removal strategy applied between 2010 and 2012.

ERADICATION OF SMALLMOUTH BASS

Eradication efforts applied in 2009 eliminated only 64 SMB but the amount of effort was lower, with no boat electrofishing or beach seining, combined with a lack of specific timing and distribution knowledge applicable to Miramichi Lake. For example, 2.25 km of Miramichi Lake shoreline was backpack electrofished on July 9, 2009, i.e. well before the appearance of YOY, the life stage targeted by this technique during the following years. Furthermore, work conducted in 2009 was in large proportion directed at removing any SMB from Lake Brook. In order to do so, they operated two barrier fences, one in Lake Brook at Miramichi Lake and the other where the brook flows into the Miramichi River, in addition to operating a rotary screw trap and repeated backpack electrofishing of the entire brook (O'Donnell and Reid unpublished manuscript). In the end, 11 SMB (all YOY but for one juvenile) were removed from the upper

section of Lake Brook. Therefore, this preliminary assessment work in 2009 is not directly comparable to the program conducted from 2010 to 2012, but it still contributed to the removal of more than 25% of all adult SMB captured in Miramichi Lake since first reported in 2008.

One of the current strategies to eradicate SMB from Miramichi Lake was to target and remove the adults prior to reproduction by applying mechanical methods on spawning grounds. Brown et al. (2009) reported in their biological synopsis of SMB that the best spawning habitat for nest-building is between 1 to 2.5 m in depth, with substrate particle size near 30 mm, in protected coves, bays, and shorelines where the water warms the earliest. Nests are excavated in clean substrates in areas of good water movement (Wallus and Simon 2008). Infrequently associated with vegetation, SMB will not spawn on heavily silted substrate (Wallus and Simon 2008). Of the 16 sectors in Miramichi Lake, this description fit best sectors 1 and 16. Sector 2 and 10 are organic rich-muddy coves with bogs fed by cold springs; sectors 3 and 4 (South shore) are sandy bottom without any natural structures that are exposed to direct sunlight in the afternoon and evening, and to human disturbance (cottage area of the lake); sectors 5, 6, 7, 8 and 9 (East shore) are a narrow shallow band of ground with steep slope fed by many springs, and are rarely warmed by direct sunlight because of the forest cover (coldest sectors); sectors 11, 12 and 13 (North shore) are muddy with dense aquatic vegetation patches with direct sunlight in the morning and part of the afternoon; sectors 14 and 15 (West shore) are muddy flats, with structures and aquatic vegetation, under direct sunlight all day, that develop a thick layer of algae covering the entire bottom surface from July to September; and sectors 1 and 16 (South-west shore) are a wide and shallow sand-gravel mix bottom with natural structures, algae free and are exposed to the sunlight all day.

In 2011, 94% of the adults (16 of 17 SMB) captured in May and June were caught in sectors 1, 15 and 16, and 76% of all adults caught during the entire season (22 of 30 SMB) were also from sectors 1, 15 and 16. Sector 15, in this context, means the first 100 m from the demarcation line with sector 16, and covers the area upstream of the barrier. This is similar to 2010 where the majority of the adults SMB were captured in sector 1, and to 2012 where all three adults were captured in sectors 1 and 16. Targeting the spawning grounds seems to have been effective at removing adult SMB. The extent of the adult SMB reduction is unknown, but the dramatic decline from the relatively higher annual catch of 30 adults in 2010 and 2011 to 3 in 2012 is significant. O'Donnell and Reid (unpublished manuscript) reported capturing 20 adult SMB in 2,515 hours of gillnetting effort in 2009, while it took almost 28,000 hours of gillnetting effort (1,150 net days) to capture 20 adults in 2010 (Chaput and Moore unpubl. report). By comparison, 2,732 net days in 2011 (almost 65,600 hours) resulted in the capture of 11 adults and 2,613 net days in 2012 (almost 62,700 hours) did not produce any catch. A gross estimation of CPUE based on these numbers shows that seasonal gillnet CPUE dropped from an estimated 0.19 SMB/net-day in 2009 to 0.02 SMB/net-day in 2010, to <0.002 SMB/net-day in 2011 to 0 SMB/net-day in 2012. Chaput and Moore (unpubl. report) had already suggested, based on the same premise, that the population size of adult bass in Miramichi Lake seemed to be quite small when the program started in 2010. However, in 2011 and 2012, the fishing effort was localized and focused on areas known to support overwintering and spawning SMB. Although further efforts would confirm that other areas do not support high densities of adult SMB, the 20-days random gillnetting in 2011 (no SMB catch) and the 2012 gillnetting season (no SMB catch) provided some evidence that the lake did not contain a high abundance of adult SMB.

Successful spawning by SMB was not prevented in 2011 and 2012, as shown by the presence of YOY in both years, but the recruitment to this population has declined steeply since 2010 as indicated by the fishery indicators. Catches of YOY SMB decreased from 2,532 in 2010 to 483 in 2011 to 36 in 2012, while fishing effort doubled in 2011 and 2012 compared to 2010. From

2010 to 2012, CPUEs for YOY SMB dropped by more than 99% for electrofishing boat (from 15.73 SMB/hr to 0.14 SMB/hr) and fyke nets (from 0.71 SMB/net-days to 0.002 SMB/net-days), and by more than 88% for backpack electrofishing (from 6.68 SMB/hr to 0.79 SMB/hr). Several studies reported that electrofishing can also induce elevated mortality rate in embryos, particularly during the early developmental phase of the embryos (Muth and Rupert 1997; Bohl et al. 2009, 2010). High voltage (1000 V) and fishing effort of about 25 hours of electrofishing was applied in sectors 1 and 16 during the incubation period of the embryos (May and June) in 2011 and 2012 compared to 4 hours in 2010. Although the effects of electrofishing on SMB embryo survival were not quantified, it is plausible that the elevated amount of electrofishing effort applied on the deposited eggs may have contributed to the reduction in YOY production.

Habitat utilization of juvenile SMB remains largely unknown in Miramichi Lake. Most captures by gillnets and fyke nets occurred in sectors near the two deep holes (sectors 1 and 5), most captures by electrofishing boat were on what is believed to be the prime spawning grounds (sectors 1 and 16), while the only juvenile SMB captured by backpack electrofishing were in Lake Brook in 2009 (n=1) and 2010 (n=4). In 2010 and 2011, juveniles were mostly captured near the deep hole in sector 5 from May to September, and in sectors 1 and 16 before (early May) and after (late July to October) the spawning period, as well as the area immediately upstream of the barrier (part of sectors 15 and 16) and Lake Brook. In 2012, all seven juveniles were captured in sectors 1 and 16 from May to July, which may be another indication that spawning grounds were less occupied by spawning adults than in previous years.

Further knowledge on habitat utilization of juveniles and adults may be necessary to better target the areas of the lake supporting SMB. At this moment, only the components of the population coming onto the shallow grounds are targeted and deeper areas of the lake cannot be fished with the methods currently used in this program. In 2011, a test-trial using a purse-seine was conducted in the two deep holes to capture SMB ≥ age 1 which are expected to move into deep areas of the lake to overwinter. A first field operation was carried out on October 27, 2011. The purse seine (250 ft long, 23 ft deep and 1⅜ inch mesh) was made according to Levi (1981). The purse seine was operated using two Boston whalers (16 ft long) with a crew of three or four people on each boat. A third boat (with a crew of two people) was in the near vicinity for safety purposes. These test-trials resulted in no capture of SMB.

CONTAINMENT OF SMALLMOUTH BASS

Allowing YOY gaspereau to migrate downstream permitted the barrier to become permeable to young SMB as it was observed in 2009 (n=10), 2010 (n=1) and 2011 (n=1) with the capture of YOY SMB in the upper section of the outlet brook in August and September. It is believed that some of the one-year old juvenile SMB captured downstream of the barrier in 2010 moved into Lake Brook prior to the installation of the containment barrier (Chaput and Moore unpubl. report). However, there are also ample examples over the three years of the program of YOY and juvenile SMB being caught right against the front of the barrier, either by hand while cleaning the debris fence or during boat and backpack electrofishing. SMB catches over the last three years clearly demonstrate the presence of all life stages of SMB in the shallow area upstream of the barrier from May to October. Although the barrier may become permeable to YOY for short periods of time, it does seem to successfully stop larger size escapees. No SMB 2-year or older have been captured in the upper section of Lake brook, nor has SMB of any size been observed in the lower section during repeated backpack electrofishing in 2009 or angling in 2012, nor at the lower barrier and counting wheel in 2009. It should be noted that the upper section of Lake Brook acted more like an extension of Miramichi Lake from 2009 until 2011 when a debris dam let go and that section of the brook became fast flowing again. It is therefore possible that the null catch downstream of the barrier in 2012 may be the result of SMB being

harder to find and capture in rapid water compared to the relatively calm water of 2009-2011. Different habitat in the upper section of Lake Brook combined with lower density of SMB in Miramichi Lake could also contribute to decreasing the possibility of escapees in the brook. No SMB has been observed / reported from other parts of the Miramichi watershed in 2011 and 2012.

POPULATION SIZE OF SMALLMOUTH BASS

The population size of SMB in Miramichi Lake remains unknown. The original experimental design-based sampling suggested in 2010 anticipated using a simple depletion method based on partial captures from techniques employed to eradicate the SMB such as boat electrofishing and gillnetting to estimate population size in Miramichi Lake, but basic assumptions were not respected and data recording was problematic in 2011. Observations since 2009 have shown that SMB are not randomly distributed in Miramichi Lake, nor was the fishing effort constant and randomly applied to all sectors throughout the three years of the eradication program. Over the three years, and over each sampling season, fishing methods were employed where the probability of catching SMB was greatest based on previous observations, such as: gillnetting and fyke-netting mostly around the deep holes and spawning grounds; or beach seining and backpack electrofishing where YOY have been captured in the past but after their presence have been detected by boat electrofishing that year. While boat electrofishing covered the entire lake on a weekly basis with few exceptions, separating the effort and the recorded SMB captured during the weekly near shore coverage of the lake from the effort and captures that occurred in areas known to support SMB (targeted electrofishing) was not feasible for 2011. Fishing effort ‘quality’ for given methods may also have changed over time without being assessed. For example, boat electrofishing saw subtle and not so subtle changes over time. The original electrofishing boat used at the beginning of 2010, ‘boat A1’, caught fire during the summer and saw its electric system entirely rebuilt with a new generator to give ‘boat A2’. ‘Boat A2’ was replaced by a newer, wider and more stable working platform ‘boat B’ during the summer of 2011. And from that point, ‘boat A2’ was used has a spare to ‘boat B’ only when needed.

BIOLOGICAL CHARACTERISTICS OF SMALLMOUTH BASS

Similar to 2010, the oldest (age 11) SMB captured in 2011 belonged to the 2000 cohort, while the oldest SMB captured in 2012 (age 4) belonged to the 2009 cohort. In 2010, a gap in SMB aged 6, 7 and 9 years of age was noted; these fish belonged to the 2001, 2003 and 2004 cohort. In 2011, a gap was observed in the same cohort years (aged 7, 8 and 10). Low survival rates during the winter months have been documented (Shuter et al. 1980) and most SMB smaller than 50 mm in length are not expected to survive their first winter (Curry et al. 2005). Similarly to 2010, all YOY SMB captured were larger than 50 mm in October 2011 and 2012, and ranged from 70 to 100 mm in length. However, growing conditions in 2001, 2003 and 2004 are unknown, and it is possible that reduced growth during the summer contributed to high mortality during the winter months. The few juveniles captured over the years (relative to the other component of the population) may indicate that overwintering survival of YOYs SMB is low in Miramichi Lake or that age group is difficult to capture with the sampling methods currently employed. Nevertheless, we cannot eliminate the fact that other factors likely played a role in the absence of these cohorts, such as they may never have existed and the six older fish belonging to the 2000 and 2002 cohorts that were captured in 2010 and 2011 were part of the illegal introduction in Miramichi Lake.

CONCLUSION

The containment and reduction in numbers of the SMB in Miramichi Lake between 2009 and 2012 was deemed successful as demonstrated by the population reduction. Over 52% of all the life stages of SMB captured in the Miramichi Lake since 2009 were caught in the vicinity of the lake outflow (where the barrier is located). The barrier may become permeable to YOY for short periods of time, but has precluded the passage of larger juvenile and adult SMB during its operation. A reduction in SMB density in the lake during the last three years may have contributed to further decreasing the likelihood for fish to escape from the lake. No SMB have been observed / reported from any other part of the Miramichi watershed.

Total removal of all life stages of SMB in Miramichi Lake was not realized during 2010 to 2012. SMB successfully spawned in 2008 to 2012 although spawning success in 2012 is concluded to have been very limited based on the very low numbers of YOY captured.

Boat electrofishing and beach seining were the most successful methods for capturing YOY SMB. Juvenile SMB were successfully captured by boat electrofishing and fyke-netting while adult SMB were mostly captured by gillnets (all life stages) and boat electrofishing (3 and 4 year old).

Substantial new knowledge on SMB in Miramichi Lake has been gained from the work conducted during 2009 to 2012. A preferred spawning area has been inferred which can be used to focus future activities with the objective of preventing spawning and ultimately recruitment to the lake. Based on the location and timing of capture of adult and YOY SMB, there is strong evidence that the favoured spawning area is situated in sectors 1 and 16, more specifically along the shallow grounds between the shoreline and the deep hole located in that area (Fig. 1). Sustained sampling efforts with the electrofishing boat and with large mesh gillnets as conducted in 2011 and 2012 during the potential spawning and incubation period could be an effective means of achieving the objective of preventing spawning and removing adult SMB from the lake. Targeted boat electrofishing may be effective at disrupting the guarding males and negatively affecting the development of the eggs. YOY SMB are easily captured with the electrofishing boat and evidence of spawning success could be obtained by targeted sampling with this gear at the end of July and early August.

At this moment, only the components of the population coming onto the shallow grounds are targeted and the central area of the lake could not be fished adequately with the gear deployed to date. Floating gillnets set at the surface were used and there were conflicts with the recreational boating activities on the lake in the summer. The use of sinking gillnets should be considered in the future as well as the use of smaller mesh sizes which have been effective at sampling SMB elsewhere. Targeting electrofishing activities to the shallow near shore areas in late fall could also be used to remove YOY SMB as they are known to seek overwintering refuge in coarse substrate.

There is also a need to sample deeper water (>2m deep) to verify the low density / absence of juvenile and adult SMB outside the shallow grounds in summer time. Anecdotal sampling in the last three years seems to support the absence of high density of adults in deeper water. Boat electrofishing in deeper water should also be considered as it may be enough to disrupt the guarding male and affect the development of the eggs, even if it does not end with the capture of SMB. From past experience, Miramichi Lake has the particularity to be of “tea stained” color that will darken even more after a rain even to the point that the bottom of the lake is not visible below 1 to 1.5 meter of depth. Sampling would remain in <1 m depth during those events in order to increase the possibility of captures.

Failure of an eradication program is easy to demonstrate, as was the case in 2010 to 2012. Successful eradication on the other hand is very difficult to prove. As the population declines in abundance, more effort is required to capture the fewer remaining individuals. Simulation studies from the 2010 sampling activities indicate that it would take a very large sampling effort to be reasonably confident (90% certainty) that the failure to catch any SMB is indicative of eradication of the species in Miramichi Lake.

ACKNOWLEDGEMENTS

Field support in 2011 and 2012 was provided by the Miramichi Watershed Management Committee (Natasha Ouellet, Dave Patriquen, Shane Price, Fred Richard, Jacob Richard, Omer Richard) and the Miramichi Headwaters Salmon Association (Brian Richard). St-Mary's First Nation contributed to the backpack electrofishing of Lake Brook in 2011. Chris Connell from the New Brunswick Department of Natural Resources conducted the bathymetry map of Lake Miramichi. Rejean Vienneau (Department of Fisheries and Oceans) provided maintenance, technical support and modifications to the boat electrofisher. Noella MacDonald (Department of Fisheries and Oceans) interpreted the age of the bass from scales.

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TABLES

Table 1. Catches of Smallmouth Bass by life stage (YOY = young-of-the-year; juvenile = age 1 and 2; adult = age 3 and older) and in total by fishing methods used in Miramichi Lake, 2009 to 2012. Data for 2009 are from O'Donnell and Reid (unpubl. manuscript). Data for 2010 are from Chaput and Moore (unpubl. report).

Life stage	Boat electrofishing	Backpack electrofishing	Gill-netting	Fyke-netting	Beach Seining	Angling	Barrier	Other	Total
				2009					
YOY	0	6	0	20	0	0	0	0	26
Juvenile	0	1	0	16	0	0	0	0	17
Adult	0	0	20	1	0	0	0	0	21
Total	0	7	20	37	0	0	0	0	64
				2010					
YOY	1,285	179	0	190	815	0	5	58	2,532
Juvenile	6	4	5	6	0	0	0	0	21
Adult	3	0	20	6	0	2	0	0	31
Total	1294	183	25	202	815	2	5	58	2584
				2011					
YOY	302	53	0	32	96	0	0	0	483
Juvenile	6	0	0	4	0	0	0	0	10
Adult	12	0	11	1	0	6	0	0	30
Total	320	53	11	37	96	6	0	0	523
				2012					
YOY	12	9	0	2	13	0	0	0	36
Juvenile	4	0	0	2	0	0	1	0	7
Adult	2	0	0	0	0	1	0	0	3
Total	18	9	0	4	13	1	1	0	46

Table 2. Comparison of the fishing effort, catches, and catch per unit of effort (CPUE) of Smallmouth Bass (SMB) by life stage (YOY = young-of-the-year; juvenile = age 1 and 2; adult = age 3 and older) and by fishing method and year in Miramichi Lake, 2009 to 2012. Data for 2009 are from O'Donnell and Reid (unpubl. manuscript). Data for 2010 are from Chaput and Moore (unpubl. report). For 2009, the gillnetting effort of 105 net-days was calculated based on a reported effort of 2,515 hours assuming 24 hours of fishing effort per day.

Fishing method (effort unit)	Year	Total effort	Number of SMB captured				Catch Per Unit of Effort (CPUE)			
			YOY	Juvenile	Adult	All	YOY	Juvenile	Adult	All
Boat electrofishing (hours)	2010	81.7	1,285	6	3	1,294	15.73	0.07	0.04	15.84
	2011	183.4	302	6	12	320	1.65	0.03	0.07	1.74
	2012	125.2	12	4	2	18	0.10	0.03	0.02	0.14
Gill-netting (net-days)	2009	105	0	0	20	20	0	0	0.19	0.19
	2010	1,150	0	5	20	25	0	0.004	0.02	0.02
	2011	2,732	0	6	5	11	0	0.002	0.002	0.004
	2012	2,613	0	0	0	0	0	0	0	0
Fyke-netting (net-days)	2009	83	20	16	1	37	0.01	0.19	0.01	0.45
	2010	487	190	3	9	202	0.39	0.01	0.02	0.41
	2011	988	32	4	1	37	0.03	0.004	0.001	0.04
	2012	868	2	2	0	4	0.002	0.002	0	0.005

Table 3. Available and fished days (good weather conditions) for boat electrofishing and number of days fished in 2011 and 2012.

Month	2011 available	2011 fished	2012 available	2012 fished
May	22	11	23	12
June	22	12	21	8
July	21	18	22	13
August	23	16	23	12
September	22	17	20	9
October	20	6	23	7
Total	130	80	132	61

Table 4. Electrofishing effort in hours by month using Boat A and Boat B in Miramichi Lake, 2010 to 2012.

Month	Boat A 2010	Boat A 2011	Boat A 2012	Boat B 2010	Boat B 2011	Boat B 2012
May	8.54	21.29	11.91	0	0	23.13
June	1.80	3.98	4.34	0	31.85	15.77
July	5.37	11.64	0	0	35.02	22.81
Aug.	15.96	1.54	0	0	24.48	16.07
Sept.	32.48	5.32	0	0	34.76	15.30
Oct.	17.55	0	0	0	13.54	15.83
Total	81.70	43.78	16.25	0	139.65	108.91

Table 5. Comparison of boat electrofishing effort (hours), catches, and catch per unit effort (CPUE) of Smallmouth Bass (SMB) between day and night-time in Miramichi Lake by month and overall, 2010 to 2012.

Time period	Effort (hours)		Number of SMB captured			CPUE (number per hour)		
	Day	Night	Day	Night	Total	Day	Night	Total
				2010				
May	0.20	8.35	0	0	0	0	0	0
June	0	1.80	na	0	0	na	0	0
July	0.30	5.07	3	16	19	9.95	3.16	0.23
Aug.	0.43	15.53	3	330	333	6.96	21.25	4.08
Sept.	9.20	23.29	157	520	677	17.07	22.33	8.29
Oct.	8.90	8.64	99	157	256	11.12	18.17	3.13
Total	19.03	62.67	262	1023	1285	13.77	16.32	15.73
				2011				
May	8.83	12.46	0	3	3	0	0.24	0.02
June	5.20	30.63	0	8	8	0	0.26	0.04
July	5.86	40.80	24	38	62	4.09	0.93	0.34
Aug.	0	26.02	na	93	93	na	3.57	0.51
Sept.	1.41	38.67	3	128	131	2.12	3.31	0.71
Oct.	0	13.54	na	23	23	na	1.70	0.13
Total	21.30	162.12	27	293	320	1.27	1.81	1.74
				2012				
May	9.40	25.64	0	0	0	0	0	0.00
June	5.52	14.58	0	1	1	0	0.07	0.01
July	0	22.81	na	12	12	na	0.53	0.10
Aug.	0	16.07	na	2	2	na	0.12	0.02
Sept.	0	15.30	na	6	6	na	0.39	0.05
Oct.	0	15.83	na	2	2	na	0.13	0.02
Total	14.92	110.24	0	23	23	0	0.21	0.18

Table 6. Boat electrofishing effort (hours of shocking time) by shore sector and month in Miramichi Lake, 2010 to 2012. The sectors are arranged sequentially around the lake, centered around sectors 16 and 1 which border Lake Brook, the outlet to Miramichi Lake.

Shore Sector	May	June	July	August	September	October	Total
			2010				
10	1.13	0.10	0.59	0	1.26	1.57	7.15
11	0	0	0	0.39	1.21	0.89	0
12	0	0.09	0.20	0.35	1.00	1.23	2.88
13	0	0.08	0	0.32	0.73	0.87	2.01
14	0	0	0	0	1.33	1.12	2.44
15	0.86	0	0	0	3.52	0.96	5.34
16	0.76	0.09	0.30	1.16	5.48	2.81	10.61
1	2.55	0.74	1.29	12.58	11.14	2.53	30.83
2	0	0.09	0.97	0.39	0.26	0.45	2.17
3	0	0	0.63	0	0	0	0.63
4	0	0	0.48	0.08	0	0	0.55
5	0.69	0.19	0.40	0.24	2.28	1.52	5.32
6	0.22	0	0	0	1.73	1.07	3.02
7	1.57	0	0	0	0.86	0.51	2.93
8	0.08	0.14	0.50	0.25	0.80	0.89	2.66
9	0.67	0.28	0	0.20	0.88	1.12	3.15
Total	8.54	1.80	5.37	15.96	32.48	17.55	81.70
			2011				
10	0.20	1.51	2.91	0.30	2.54	0.66	8.12
11	0	1.15	1.47	0.39	1.15	0.23	4.40
12	0.48	1.14	1.84	0.78	2.02	0.33	6.59
13	0.50	0.97	1.60	0.77	1.85	0.32	6.00
14	0.77	1.59	1.72	0.86	2.35	0.55	7.84
15	1.63	5.01	4.71	1.07	2.85	0.69	15.96
16	2.68	5.65	9.10	1.20	5.26	2.64	26.52
1	10.76	11.41	13.80	2.14	13.41	5.62	57.14
2	0.53	0.51	0.55	0.23	0.55	0.04	2.42
3	0	0.32	1.19	0	0.94	0.38	2.83
4	0	0	0.61	0	0.06	0	0.67
5	1.49	0.95	2.28	1.36	2.28	0.59	8.94
6	0.70	0.22	1.22	1.14	1.62	0.56	5.45
7	0.15	0.30	0.63	0.68	0.86	0.28	2.91
8	0.35	0.26	0.98	0.91	1.25	0.37	4.11
9	0.81	0.26	0.60	0.73	1.09	0.28	3.76
Spot checks*	0.25	4.57	1.46	13.46	0	0	19.76
Total	21.29	35.83	46.67	26.02	40.09	13.54	183.43
			2012				
10	2.31	2.33	0.23	0	0	0	4.86
11	1.03	1.26	1.14	1.42	0.89	0.29	6.04
12	1.25	1.42	1.24	1.57	1.05	0.35	6.89
13	0.86	1.14	0.97	1.35	0	0	4.32
14	1.41	1.34	0.87	1.46	`0	0	5.08
15	1.61	1.02	0.94	0.88	0.57	2.55	7.57
16	3.40	1.45	4.29	2.38	3.21	4.36	19.11
1	15.95	2.44	9.30	3.01	5.76	5.90	42.37
2	1.02	1.72	0	0	0	0	2.74
3	0.52	0.83	0.03	0.05	0.07	0	1.50
4	0.41	0.74	0.02	0.24	0.05	0	1.46
5	1.54	1.47	0.95	1.06	0.94	0.73	6.68

Shore Sector	May	June	July	August	September	October	Total
6	1.42	1.12	0.95	1.01	1.09	0.81	6.40
7	0.74	0.57	0.55	0.52	0.54	0.27	3.19
8	0.99	0.75	0.73	0.66	0.68	0.34	4.15
9	0.58	0.49	0.59	0.46	0.45	0.23	2.81
Total	35.04	20.10	22.81	16.07	15.30	15.83	125.16

*Spot checks were sporadically conducted in various sectors in 2011.

Table 7. Number of juvenile and adult (in bracket) Smallmouth Bass captured by boat electrofishing by shore sector and month in Miramichi Lake, 2010 to 2012. The sectors are arranged sequentially around the lake, centered around sectors 16 and 1 which border Lake Brook, the outlet to Miramichi Lake.

Shore Sector	May	June	July	August	September	October	Total
			2010				
10	0	0	0	na	0	0	0
11	na	na	na	0	0	0	na
12	na	0	0	0	0	0	0
13	na	0	na	0	0	0	0
14	na	na	na	na	0	0	0
15	0	na	na	na	0	0	0
16	0	0	0	0	0	0	0
1	4	0	0	2 (2)	0	0	6 (2)
2	na	0	(1)	0	0	0	(1)
3	na	na	0	na	na	na	0
4	na	na	0	0	na	na	0
5	0	0	0	0	0	0	0
6	0	na	na	na	0	0	0
7	0	na	na	na	0	0	0
8	0	0	0	0	0	0	0
9	0	0	na	0	0	0	0
Total	4	0	(1)	2 (2)	0	0	6 (3)
			2011				
10	0	0	0	1	0	0	1
11	na	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	(5)	0	0	0	0	(5)
16	0	(1)	0	0	0	0	(1)
1	(2)	(1)	(2)	3	0	0	3 (5)
2	0	0	0	0	0	0	0
3	na	0	0	na	0	0	0
4	na	na	(1)	na	0	na	(1)
5	1	0	0	0	0	0	1
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	1	0	0	0	0	1
Spot checks*	0	0	0	0	na	na	0
Total	1 (2)	1 (7)	(3)	4	0	0	6 (12)
			2012				
10	0	0	0	na	na	na	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	na	na	0
14	0	0	0	0	0	na	0
15	0	0	1	0	0	0	1
16	0	0	1 (2)	0	0	0	1 (2)
1	0	1	1	0	0	0	2

Shore Sector	May	June	July	August	September	October	Total
2	0	0	na	na	na	na	0
3	0	0	0	0	0	na	0
4	0	0	0	0	0	na	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
Total	0	1	3 (2)	0	0	0	4 (2)

*Spot checks were sporadically conducted in various sectors in 2011.

Table 8. Catch-per-unit-effort (number per hour) of juvenile and adults (in brackets) Smallmouth Bass captured by boat electrofishing by shore sector and month in Miramichi Lake, 2010 to 2012. The catch-per-unit-effort over all months is presented for life stages combined. The sectors are arranged sequentially around the lake, centered around sectors 16 and 1 which border Lake Brook, the outlet to Miramichi Lake.

Shore Sector	May	June	July	August	September	October	Total
				2010			
10	0	0	0	na	0	0	0
11	na	na	na	0	0	0	na
12	na	0	0	0	0	0	0
13	na	0	na	0	0	0	0
14	na	na	na	na	0	0	0
15	0	na	na	na	0	0	0
16	0	0	0	0	0	0	0
1	1.57	0	0	0.16 (0.16)	0	0	0.26
2	na	0	(1.03)	0	0	0	0.46
3	na	na	0	na	na	na	0
4	na	na	0	0	na	na	0
5	0	0	0	0	0	0	0
6	0	na	na	na	0	0	0
7	0	na	na	na	0	0	0
8	0	0	0	0	0	0	0
9	0	0	na	0	0	0	0
Total	0.47	0	0.19	0.25	0	0	0.11
				2011			
10	0	0	0	3.38	0	0	0.12
11	na	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	(1.00)	0	0	0	0	0.31
16	0	(0.18)	0	0	0	0	0.04
1	(0.19)	(0.09)	(0.15)	1.4	0	0	0.14
2	0	0	0	0	0	0	0
3	na	0	0	na	0	0	0
4	na	na	(1.63)	na	0	na	1.48
5	0.67	0	0	0	0	0	0.11
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	3.81	0	0	0	0	0.27
Spot checks*	0	0	0	0	na	na	0
Total	0.14	0.22	0.06	0.15	0	0	0.10
				2012			
10	0	0	0	na	na	na	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	na	na	0
14	0	0	0	0	0	na	0
15	0	0	(1.06)	0	0	0	0.13
16	0	0	0.23 (0.47)	0	0	0	0.16

Shore Sector	May	June	July	August	September	October	Total
1	0	(0.41)	(0.11)	0	0	0	0.05
2	0	0	na	na	na	na	0
3	0	0	0	0	0	na	0
4	0	0	0	0	0	na	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
Total	0	0.05	0.22	0	0	0	0.05

*Spot checks were sporadically conducted in various sectors in 2011.

Table 9. Number of young-of-the-year Smallmouth Bass captured by boat electrofishing by shore sector and month in Miramichi Lake, 2010 to 2012. The sectors are arranged sequentially around the lake, centered around sectors 16 and 1 which border Lake Brook, the outlet to Miramichi Lake.

Shore Sector	May	June	July	August	September	October	Total
			2010				
10	0	0	0	na	35	35	87
11	na	na	na	4	7	6	na
12	na	0	0	1	11	9	21
13	na	0	na	1	5	25	31
14	na	na	na	na	16	16	32
15	0	na	na	na	48	13	61
16	0	0	3	23	120	33	179
1	0	0	6	289	298	58	651
2	na	0	6	0	2	5	13
3	na	na	2	na	na	na	2
4	na	na	1	3	na	na	4
5	0	0	1	3	18	11	33
6	0	na	na	na	37	5	42
7	0	na	na	na	21	4	25
8	0	0	0	5	38	10	53
9	0	0	na	4	21	26	51
Total	0	0	19	333	677	256	1285
			2011				
10	0	0	0	1	9	2	12
11	na	0	0	0	0	0	0
12	0	0	0	2	3	2	7
13	0	0	0	3	11	1	15
14	0	0	0	8	7	0	15
15	0	0	2	14	5	1	22
16	0	0	38	20	17	4	79
1	0	0	19	32	47	11	109
2	0	0	0	1	2	0	3
3	na	0	0	na	6	0	6
4	na	na	0	na	1	na	1
5	0	0	0	2	1	0	3
6	0	0	0	4	7	0	11
7	0	0	0	1	2	1	4
8	0	0	0	5	3	0	8
9	0	0	0	1	5	1	7
Spot checks*	0	0	0	0	na	na	0
Total	0	0	59	94	126	23	302
			2012				
10	0	0	0	na	na	na	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	na	na	0
14	0	0	0	0	0	na	0
15	0	0	0	0	0	0	0
16	0	0	0	1	4	1	6
1	0	0	1	2	2	1	6

Shore Sector	May	June	July	August	September	October	Total
2	0	0	na	na	na	na	0
3	0	0	0	0	0	na	0
4	0	0	0	0	0	na	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
Total	0	0	1	2	6	2	12

*Spot checks were sporadically conducted in various sectors in 2011.

Table 10. Catch-per-unit-effort (number per hour) of young-of-the-year Smallmouth Bass by boat electrofishing by shore sector and month in Miramichi Lake, 2010 to 2012. The sectors are arranged sequentially around the lake, centered around sectors 16 and 1 which border Lake Brook, the outlet to Miramichi Lake.

Shore Sector	May	June	July	August	September	October	Total
			2010				
10	0	0	0	na	27.69	22.29	12.17
11	na	na	na	10.30	5.76	6.75	na
12	na	0	0	2.83	10.95	7.33	7.28
13	na	0	na	3.13	6.84	28.60	15.46
14	na	na	na	na	12.05	14.34	13.09
15	0	na	na	na	13.64	13.53	11.42
16	0	0	9.95	19.80	21.89	11.73	16.87
1	0	0	4.65	22.97	26.76	22.92	21.12
2	na	0	6.16	0	7.70	11.02	5.99
3	na	na	3.15	na	na	na	3.15
4	na	na	2.10	38.57	na	na	7.21
5	0	0	2.53	12.66	7.88	7.22	6.20
6	0	na	na	na	21.40	4.66	13.89
7	0	na	na	na	24.56	7.90	8.53
8	0	0	0	19.82	47.78	11.26	19.91
9	0	0	na	19.89	23.74	23.27	16.19
Total	0	0	3.54	20.86	20.84	14.59	15.73
			2011				
10	0	0	0	3.38	3.54	3.02	1.48
11	na	0	0	0	0	0	0
12	0	0	0	2.56	1.48	6.00	1.06
13	0	0	0	3.88	5.96	3.16	2.50
14	0	0	0	9.26	2.98	0	1.91
15	0	0	0.42	13.06	1.76	1.44	1.38
16	0	0	4.18	16.71	3.23	1.52	2.98
1	0	0	1.38	14.98	3.50	1.96	1.91
2	0	0	0	4.30	3.61	0	1.24
3	na	0	0	na	6.36	0	2.12
4	na	na	0	na	16.9	na	1.48
5	0	0	0	1.48	0.44	0	0.34
6	0	0	0	3.50	4.31	0	2.02
7	0	0	0	1.48	2.32	3.53	1.37
8	0	0	0	5.51	2.40	0	1.94
9	0	0	0	1.37	4.60	3.58	1.86
Spot checks*	0	0	0	0	na	na	0
Total	0	0	1.26	3.61	3.14	1.70	1.65
			2012				
10	0	0	0	na	na	na	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	na	na	0
14	0	0	0	0	0	na	0
15	0	0	0	0	0	0	0
16	0	0	0	0	1.24	0.23	0.31
1	0	0	0.11	0.66	0.35	0.17	0.14

Shore Sector	May	June	July	August	September	October	Total
2	0	0	na	na	na	na	0
3	0	0	0	0	0	na	0
4	0	0	0	0	0	na	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
Total	0	0	0.04	0.12	0.39	0.13	0.10

*Spot checks were sporadically conducted in various sectors in 2011.

Table 11. Number of young-of-the-year and one-year old juvenile (in brackets) Smallmouth Bass captured by backpack electrofishing by shore sector and month in Miramichi Lake and Lake Brook, 2010 to 2012. The sectors are arranged sequentially around the lake, centered around sectors 16 and 1 which border Lake Brook, the outlet to Miramichi.

Shore Sector	May	June	July	August	September	October	Total
			2010				
10	na	na	na	2	na	na	2
11	na	na	na	1	na	na	1
12	na	na	1	4	na	na	5
13	na	na	1	na	na	na	1
14	na	na	na	na	na	na	na
15	na	na	1	na	na	na	1
16	na	na	6	8	3	na	17
1	na	na	9	54	12	na	75
2	na	na	3	16	na	na	19
3	na	na	na	28	7	na	35
4	na	na	na	17	na	na	17
5	na	na	1	na	na	na	1
6	na	na	2	na	na	na	2
7	na	na	na	na	na	na	na
8	na	na	1	na	na	na	1
9	na	na	na	1	na	na	1
Lake Brook	3	0	0	0	1 (1)	0	5
Total	3	0	25	131	22	0	183
			2011				
10	0	0	0	0	2	0	2
11	0	0	0	0	0	0	0
12	0	0	0	0	1	0	1
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	0	0	0	1	0	1
16	0	0	6	0	0	0	6
1	0	0	30	3	0	0	33
2	0	0	0	0	0	0	0
3	0	0	0	7	0	0	7
4	0	0	0	1	1	0	2
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
Lake Brook	0	0	0	1	0	0	0
Total	0	0	36	12	5	0	53
			2012				
10	na	na	na	na	na	na	na
11	na	na	na	na	na	na	na
12	na	na	na	na	na	na	na
13	na	na	na	na	na	na	na
14	na	na	na	na	na	na	na
15	na	na	na	0	0	na	0
16	na	na	0	1	0	na	1

Shore Sector	May	June	July	August	September	October	Total
1	na	na	6	3	0	na	9
2	na	na	na	0	na	na	0
3	na	na	na	0	0	0	0
4	na	na	na	na	0	na	0
5	na	na	na	na	na	na	na
6	na	na	na	na	na	na	na
7	na	na	na	na	na	na	na
8	na	na	na	na	na	na	na
9	na	na	na	na	na	na	na
Lake Brook	0	0	0	0	0	0	0
Total	0	0	6	4	0	0	10

Table 12. Backpack electrofishing effort (hours of shocking time) by shore sector and month in Miramichi Lake, 2010 and 2012. No effort data were recorded for 2011. The sectors are arranged sequentially around the lake, centered around sectors 16 and 1 which border Lake Brook, the outlet to Miramichi.

Shore Sector	May	June	July	August	September	October	Total
			2010				
10	0	0	0	0.27	0	0	0.27
11	0	0	0	0.04	0	0	0.04
12	0	0	0.44	0.19	0	0	0.63
13	0	0	0.22	0	0	0	0.22
14	0	0	0	0	0	0	0
15	0	0	0.22	0	0	0	0.22
16	0	0	0.43	0.47	0.22	0	1.12
1	0	0	0.56	2.51	0.69	0	3.76
2	0	0	0.44	1.78	0	0	2.22
3	0	0	0	1.35	0.55	0	1.90
4	0	0	0	1.02	0	0	1.02
5	0	0	0.35	0	0	0	0.35
6	0	0	0.22	0	0	0	0.22
7	0	0	0	0	0	0	0
8	0	0	0.22	0	0	0	0.22
9	0	0	0	0.11	0	0	0.11
Lake Brook	3.33	2.13	2.62	2.17	2.62	2.22	15.09
Total	3.33	2.13	5.73	9.90	4.09	2.22	27.39
			2012				
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	0	0	0.16	0.04	0	0.19
16	0	0	0.04	0.59	0.06	0	0.69
1	0	0	1.29	1.63	0.15	0	3.08
2	0	0	0	0.06	0	0	0.06
3	0	0	0	0.14	0.33	0.07	0.54
4	0	0	0	0	0.14	0	0.14
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
Lake Brook	1.95	1.48	1.20	1.28	1.28	0.82	8.01
Total	1.95	1.48	2.53	3.86	1.99	0.89	12.70

Table 13. Catch-per-unit-effort (number per hour) of young-of-the-year and one-year old juvenile Smallmouth Bass by backpack electrofishing by shore sector and month in Miramichi Lake, 2010 and 2012. No effort data were recorded in 2011. The sectors are arranged sequentially around the lake, centered around sectors 16 and 1 which border Lake Brook, the outlet to Miramichi Lake.

Shore Sector	May	June	July	August	September	October	Total
			2010				
10	na	na	na	7.50	na	na	7.50
11	na	na	na	24.66	na	na	24.66
12	na	na	2.26	21.43	na	na	7.94
13	na	na	4.50	na	na	na	4.50
14	na	na	na	na	na	na	na
15	na	na	4.5	na	na	na	4.50
16	na	na	13.99	17.17	13.50	na	15.22
1	na	na	16.20	21.54	17.27	na	19.96
2	na	na	6.75	9.01	na	na	8.56
3	na	na	na	20.68	12.82	na	18.42
4	na	na	na	16.64	na	na	16.64
5	na	na	2.84	na	na	na	2.84
6	na	na	9.00	na	na	na	9.00
7	na	na	na	na	na	na	na
8	na	na	4.50	na	na	na	4.50
9	na	na	na	9.00	na	na	9.00
Lake Brook	0.90	0	0	0	0.76	0	0.33
Total	0.90	0	4.36	13.24	5.38	0	6.68
			2012				
10	na	na	na	na	na	na	na
11	na	na	na	na	na	na	na
12	na	na	na	na	na	na	na
13	na	na	na	na	na	na	na
14	na	na	na	na	na	na	na
15	na	na	na	0	0	na	0
16	na	na	0	1.70	0	na	1.46
1	na	na	4.66	1.84	0	na	2.93
2	na	na	na	0	na	na	0
3	na	na	na	0	0	0	0
4	na	na	na	na	0	na	0
5	na	na	na	na	na	na	na
6	na	na	na	na	na	na	na
7	na	na	na	na	na	na	na
8	na	na	na	na	na	na	na
9	na	na	na	na	na	na	na
Lake Brook	0	0	0	0	0	0	0
Total	0	0	2.37	1.04	0	0	0.79

Table 14. Summary of gillnetting effort (net-days), catches (number of fish) and catch-per-unit-effort (number per net-day) of Smallmouth Bass (SMB) by month in Miramichi Lake, 2010 to 2012.

Effort and catches	April	May	June	July	August	September	October	Total
			2010					
Effort (net-days)	26	90	137	121	160	261	355	1150
Catches of SMB	0	1	1	8	3	8	5	26
Catch-per-unit-effort	0	0.01	0.01	0.07	0.02	0.03	0.01	0.02
			2011					
Effort (net-days)	0	393	300	568	518	470	483	2732
Catches of SMB	na	2	0	2	1	5	1	11
Catch-per-unit-effort	na	0.005	0	0.004	0.002	0.011	0.002	0.004
			2012					
Effort (net-days)	68	527	510	434	434	420	220	2613
Catches of SMB	0	0	0	0	0	0	0	0
Catch-per-unit-effort	0	0	0	0	0	0	0	0

Table 15. Summary of fishing effort (net-days), catch (number of fish) and catch-per-unit-effort (number per net-day) of Smallmouth Bass by life stage (YOY = young-of-the-year; juvenile = age 1 and 2; adult = age 3 and older) in fyke nets by month in Miramichi Lake, 2010 to 2012.

Effort and catches	April	May	June	July	August	September	October	November	Total	*CPUE by life stage*
					2010					
Effort (net-days)	4	33	0	71	89	56	10	0	263	na
Total catch	0	0	na	100	74	22	0	na	196	0.74
Catch of YOY	0	0	na	94	70	22	0	na	186	0.71
Catch of juveniles	0	0	na	0	3	0	0	na	3	0.01
Catch of adults	0	0	na	6	1	0	0	na	7	0.03
Total CPUE (all life stages)	0	0	na	1.41	0.83	0.39	0	na	0.75	0.74
					2011					
Effort (net-days)	0	67	277	48	196	240	144	16	988	na
Total catch	na	1	0	1	11	18	6	0	37	0.037
Catch of YOY	na	0	0	0	10	16	6	0	32	0.032
Catch of juveniles	na	0	0	1	1	2	0	0	4	0.004
Catch of adults	na	1	0	0	0	0	0	0	1	0.001
Total CPUE (all life stages)	na	0.01	0	0.02	0.06	0.08	0.04	0	0.04	0.037
					2012					
Effort (net-days)	0	70	142	148	142	224	142	0	868	na
Total catch	na	1	0	2	0	0	0	na	3	0.003
Catch of YOY	na	0	0	1	0	1	0	na	2	0.002
Catch of juveniles	na	1	0	1	0	0	0	na	2	0.002
Catch of adults	na	0	0	0	0	0	0	na	0	0
Total CPUE (all life stages)	na	0.01	0.00	0.01	0.00	0.00	0.00	na	0.003	0.003

Table 16. Catch of young-of-the-year Smallmouth Bass by month and shore sectors during beach seining in Miramichi Lake, 2010 to 2012.

Sectors	July	August	September	Total
		2010		
1	na	4	86	90
2-4	na	96	12	108
5-10	na	428	163	591
11-15	na	14	4	18
16	na	8	0	8
Total	na	550	265	815
		2011		
1	0	50	na	50
2-4	0	8	na	8
5-10	0	17	na	17
11-15	0	na	na	0
16	4	17	na	21
Total	4	92	na	96
		2012		
1	10	3	na	13
2-4	0	0	na	0
5-10	0	0	na	0
11-15	0	0	na	0
16	0	0	na	0
Total	10	3	na	13

Table 17. Number of Smallmouth Bass by year class removed from Miramichi Lake by year of removal, 2009 to 2012. Data for 2009 are from O'Donnell and Reid (unpubl. manuscript). Data for 2010 are from Chaput and Moore (unpubl. report).

Year class	2009	2010	2011	2012	Total
2000	0	1	1	0	2
2001	0	0	0	0	0
2002	0	3	1	0	4
2003	0	0	0	0	0
2004	0	0	0	0	0
2005	10	6	2	0	18
2006	11	8	3	0	22
2007	4	13	6	0	23
2008	13	16	17	2	48
2009	26	5	1	1	33
2010	na	2,532	9	3	2,544
2011	na	na	483	4	487
2012	na	na	na	36	36
All year classes	64	2,584	523	46	3,217

Table 18. Biological characteristics by age (years) of Smallmouth Bass captured in Miramichi Lake, 2009 to 2012. Data for 2009 are from O'Donnell and Reid (unpubl. manuscript). Data for 2010 are from Chaput and Moore (unpubl. report).

Age	Catch by Sex				Fork length (mm)				Weight (g)			
(years)	Female	Male	Unknown	Total	Mean (N)	STDEV	Min.	Max.	Mean (N)	STDEV	Min.	Max.
0	na	na	3,077	3,077	58 (3,055)	15	26	110	4.0 (446)	2.7	0.45	13.2
1	3	4	24	31	130 (31)	34	72	174	46 (25)	25	5	85
2	11	12	1	24	197 (24)	33	131	240	133 (21)	59	28	221
3	18	18	6	42	257 (40)	27	201	313	287 (41)	103	115	483
4	17	8	1	26	303 (26)	34	239	350	499 (24)	185	218	799
5	4	4	1	9	340 (9)	20	317	375	641 (8)	126	507	850
6	1	1	0	2	391 (2)	36	365	416	1,015 (2)	473	680	1,349
7	0	0	0	0	na	na	na	na	na	na	na	na
8	1	2	0	3	419 (3)	17	409	438	1,463 (3)	294	1,162	1,750
9	0	1	0	1	425 (1)	na	na	na	1,378 (1)	na	na	na
10	1	0	0	1	477 (1)	na	na	na	1,853 (1)	na	na	na
11	0	1	0	1	460 (1)	na	na	na	1,758 (1)	na	na	na
Total	56	51	33	3,217	na	na	na	na	na	na	na	na

*Table 19. Catch of Smallmouth Bass by age and by sampling method in Miramichi Lake, 2009 to 2012. Data for 2009 was obtained from O'Donnell and Reid (*unpubl. manuscript*). Data for 2010 was obtained from Chaput and Moore (*unpubl. report*).*

Age	Boat electrofishing	Backpack electrofishing	Gill Netting	Fyke netting	Beach Seining	Angling	Barrier	Other	Total
				2009					
0	0	6	0	20	0	0	0	0	26
1	0	1	0	12	0	0	0	0	13
2	0	0	0	4	0	0	0	0	4
3	0	0	12	1	0	0	0	0	13
4	0	0	8	0	0	0	0	0	8
Total	0	7	20	27	0	0	0	0	64
				2010					
0	1285	179	0	190	815	0	5	58	2532
1	6	4	0	1	0	0	0	0	11
2	1	0	5	5	0	0	0	0	11
3	1	0	6	5	0	1	0	0	13
4	1	0	7	0	0	0	0	0	8
5	0	0	5	0	0	0	0	0	5
8	0	0	2	0	0	1	0	0	3
10	0	0	0	1	0	0	0	0	1
Total	1,294	183	25	202	815	2	5	58	2,584
				2011					
0	302	53	0	32	96	0	0	0	483
1	5	0	0	4	0	0	0	0	9
2	1	0	0	0	0	0	0	0	1
3	7	0	6	1	0	3	0	0	17
4	4	0	1	0	0	1	0	0	6
5	1	0	1	0	0	1	0	0	3
6	0	0	1	0	0	1	0	0	2
9	0	0	1	0	0	0	0	0	1
11	0	0	1	0	0	0	0	0	1
Total	320	53	11	37	96	6	0	0	523
				2012					
0	12	9	0	2	13	0	0	0	36
1	3	0	0	0	0	0	1	0	4
2	1	0	0	2	0	0	0	0	3
3	0	0	0	0	0	1	0	0	1
4	2	0	0	0	0	0	0	0	2
Total	18	9	0	4	13	1	1	0	46
				2010-2012					
0	1,599	241	0	224	924	0	5	58	3051
1	14	4	0	5	0	0	1	0	24
2	3	0	5	7	0	0	0	0	15
3	8	0	12	6	0	5	0	0	31
4	7	0	8	0	0	1	0	0	16
5	1	0	6	0	0	1	0	0	8
6	0	0	1	0	0	1	0	0	2
7	0	0	0	0	0	0	0	0	0
8	0	0	2	0	0	1	0	0	3
9	0	0	1	0	0	0	0	0	1
10	0	0	0	1	0	0	0	0	1
11	0	0	1	0	0	0	0	0	1
Total	1,632	245	36	243	924	9	0	58	3,153

FIGURES

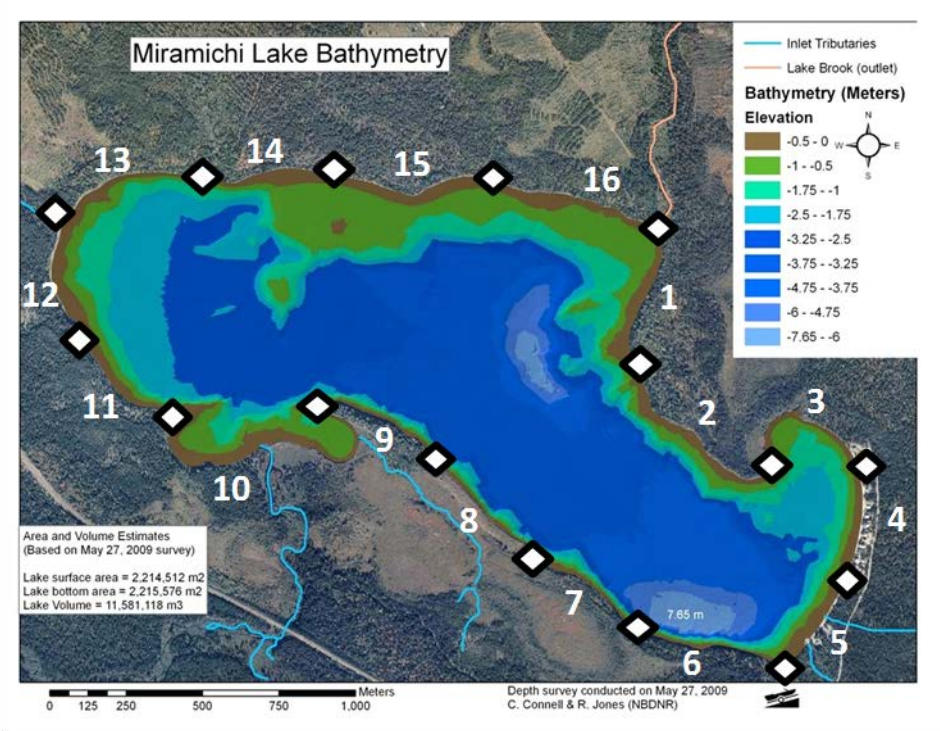

Figure 1. Bathymetry of Miramichi Lake and location of sectors and sector boundaries. Bathymetric data and profiles were provided by C. Connell and R. Jones, New Brunswick Department of Natural Resources.

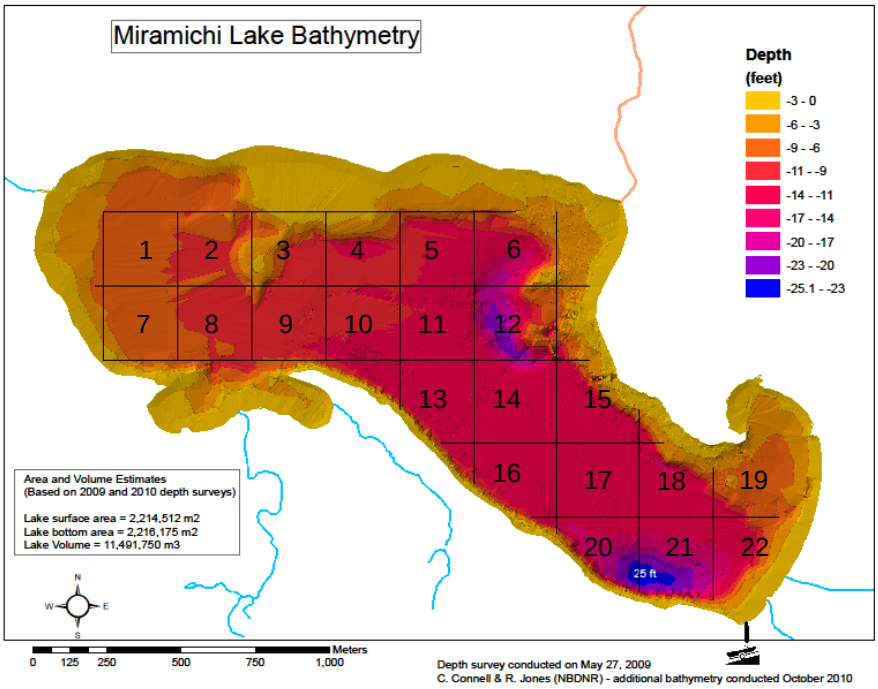

Figure 2. Gillnet random sampling program design to assess adult SMB distribution in August 2011.

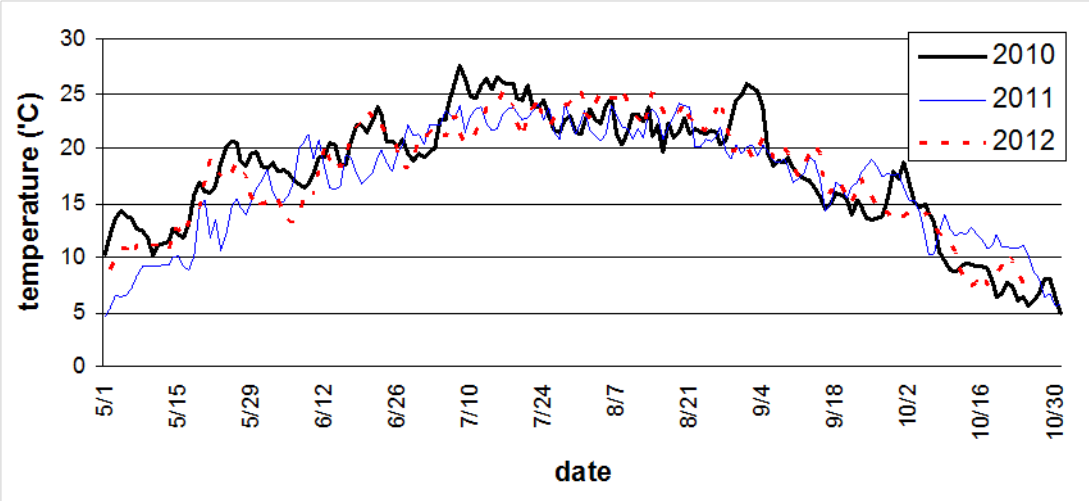

Figure 3. Mean daily water temperature at the outlet of Miramichi Lake, 2010 to 2012.

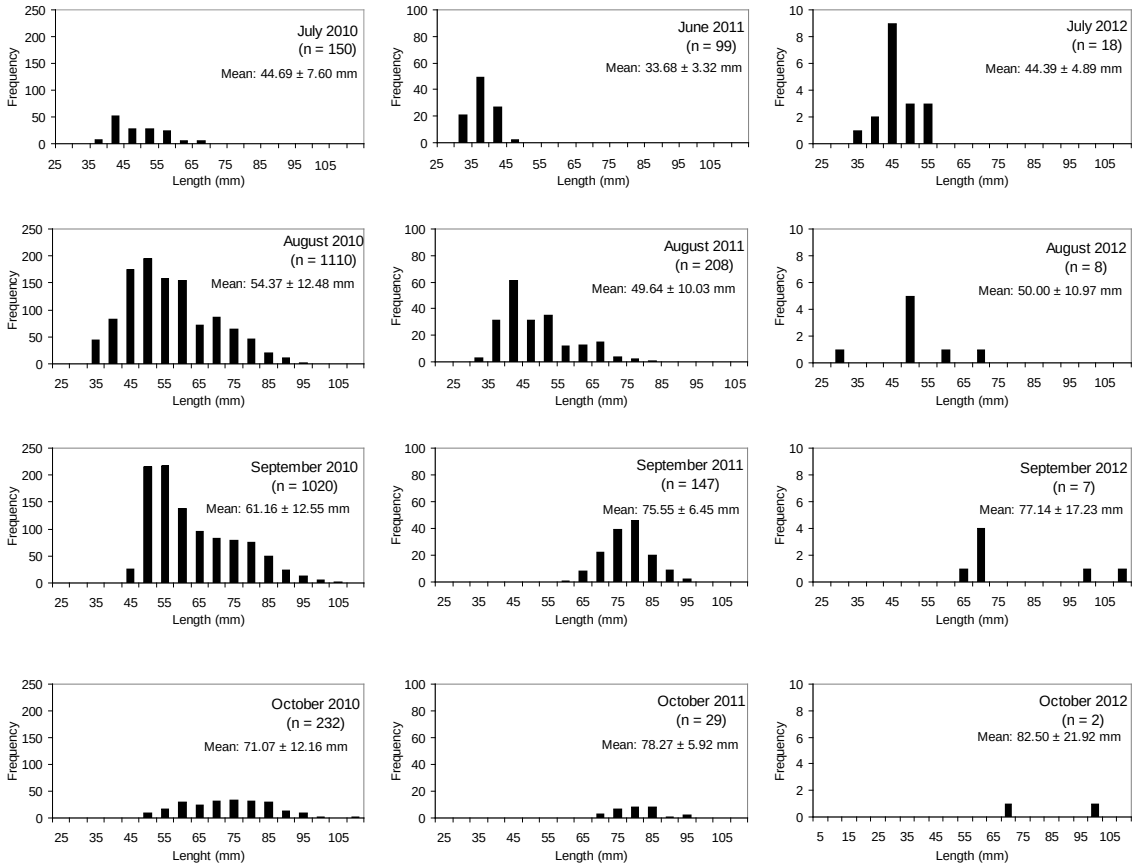

Figure 4. Fork length distribution of young-of-the-year Smallmouth Bass (all fishing methods combined) by month of sampling captured in Miramichi Lake, 2010 to 2012 (n = sample size).

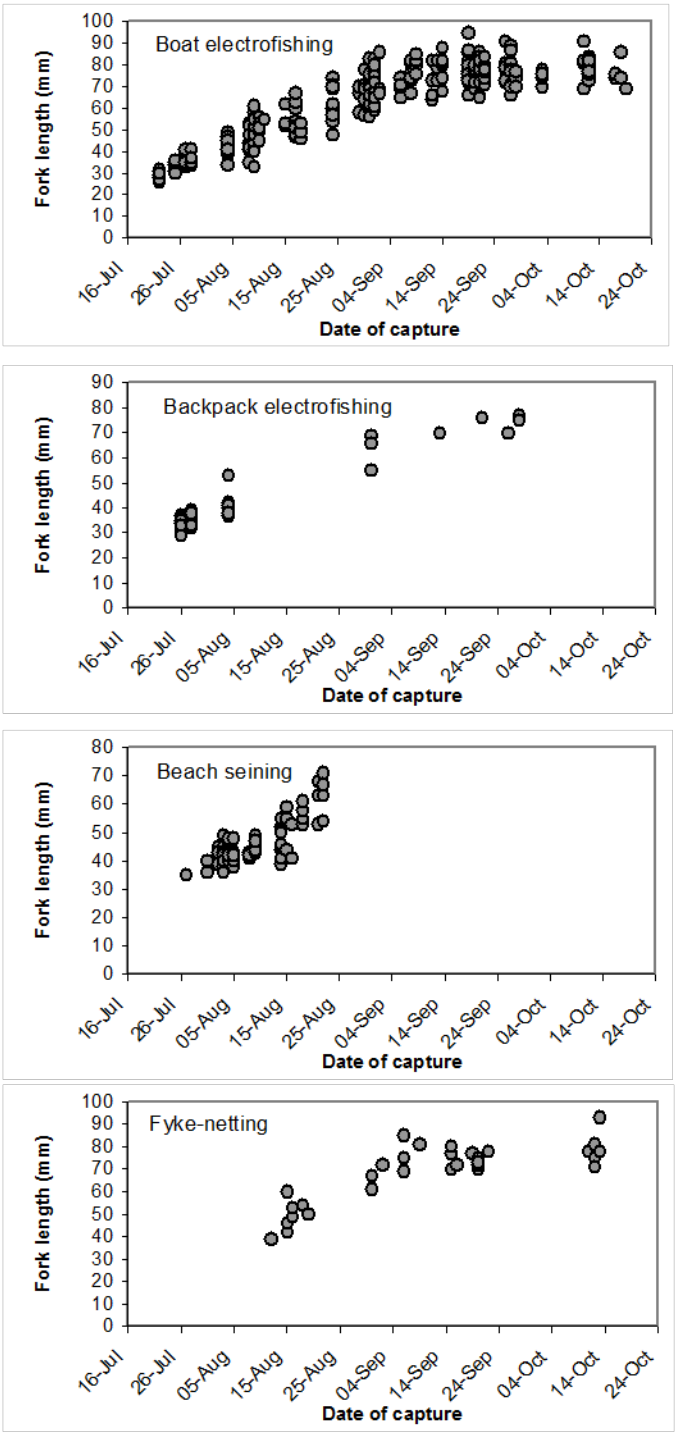

Figure 5. Fork length of young-of-the-year Smallmouth Bass captured by various fishing methods by date of sampling in Miramichi Lake, 2011.

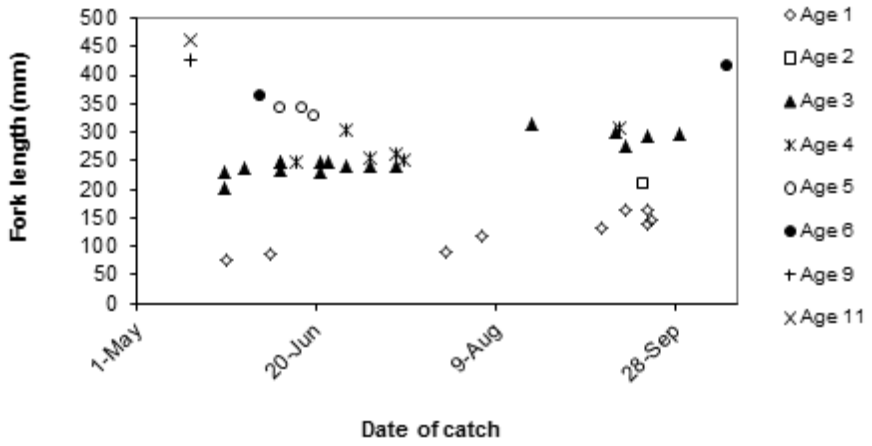

Figure 6. Fork length by age (years) of juvenile (age 1 and 2) and adult (≥ age 3) Smallmouth Bass by date of catch from various fishing methods in Miramichi Lake, 2011.

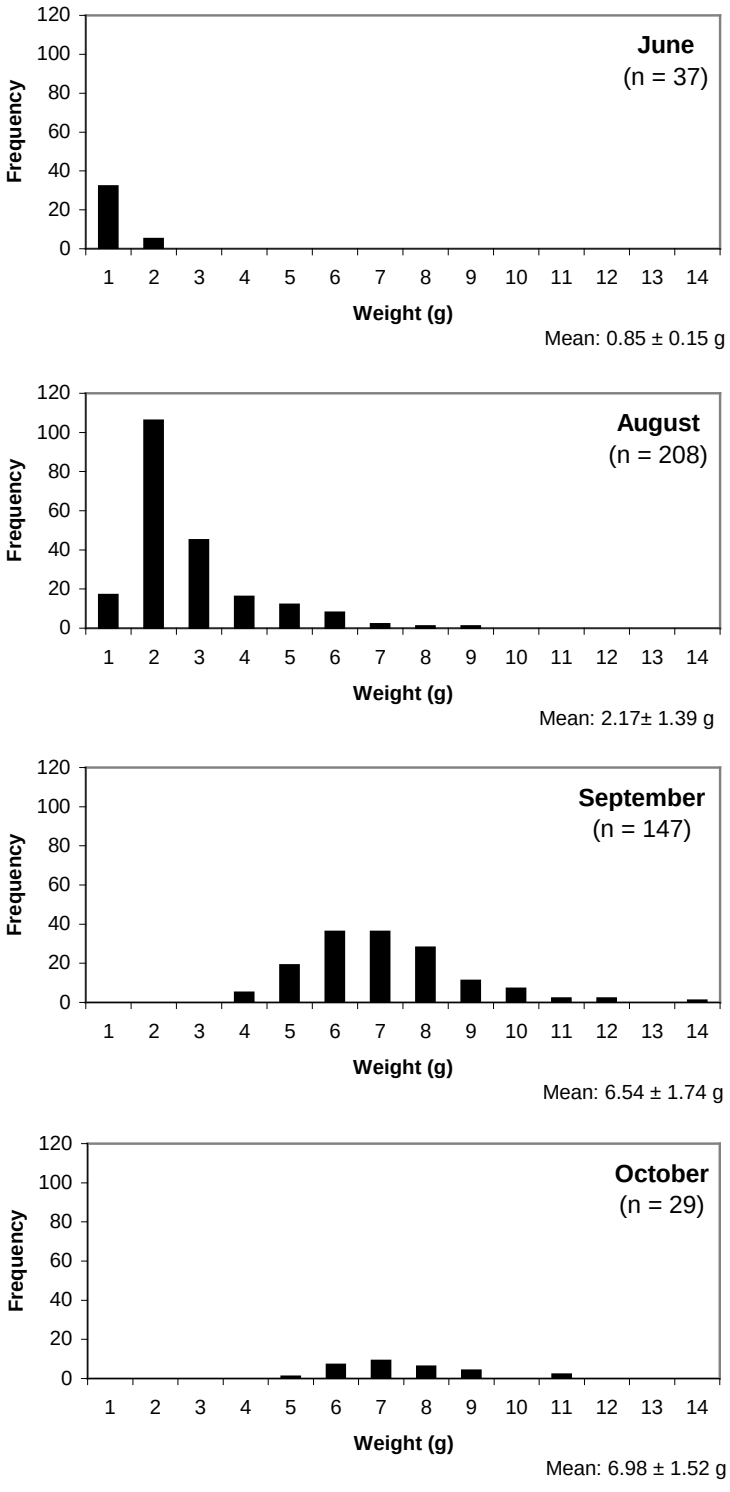

Figure 7. Weight (g) distribution of young-of-the-year Smallmouth Bass (all fishing methods combined) captured in Miramichi Lake, 2011 (n = sample size).

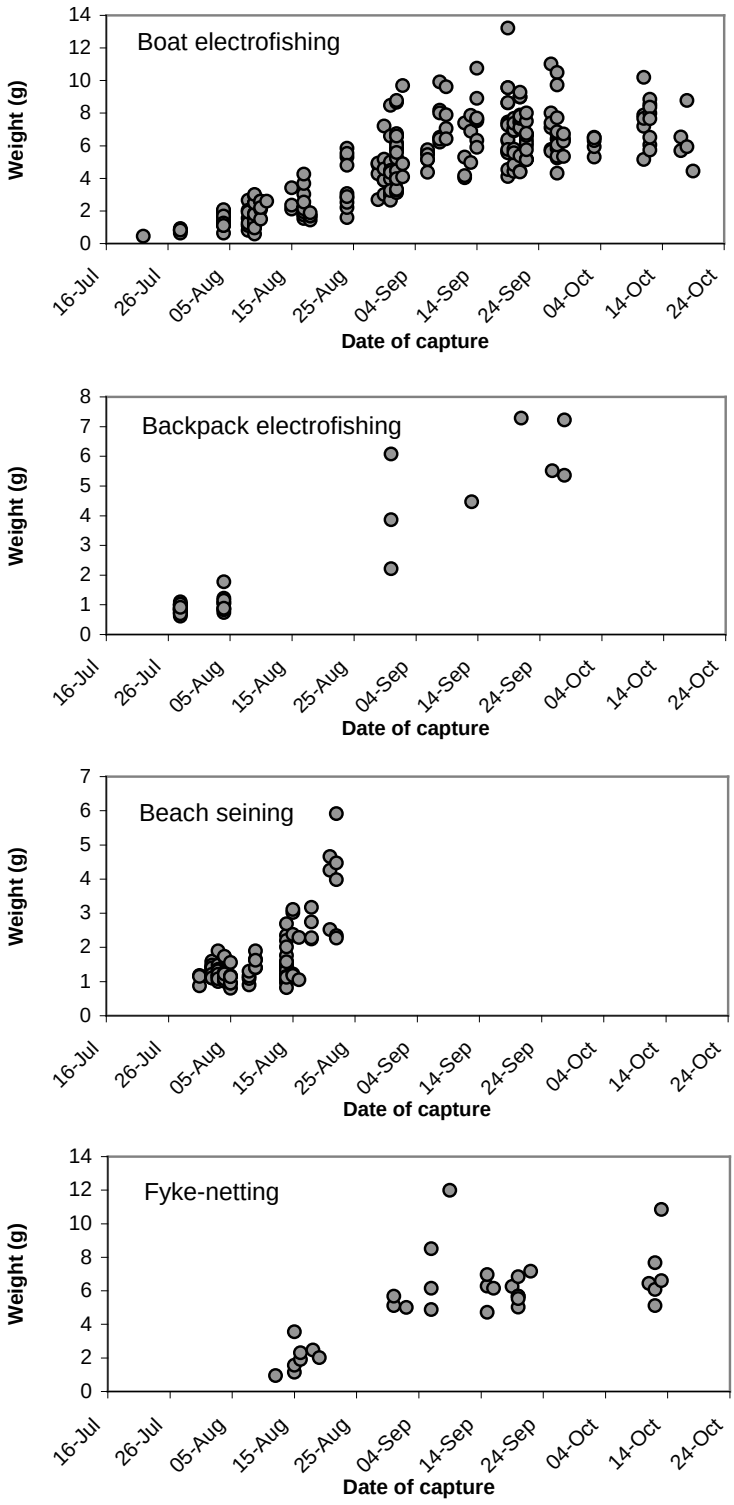

Figure 8. Weight (g) of young-of-the-year Smallmouth Bass by date of capture by various fishing methods in Miramichi Lake, 2011.

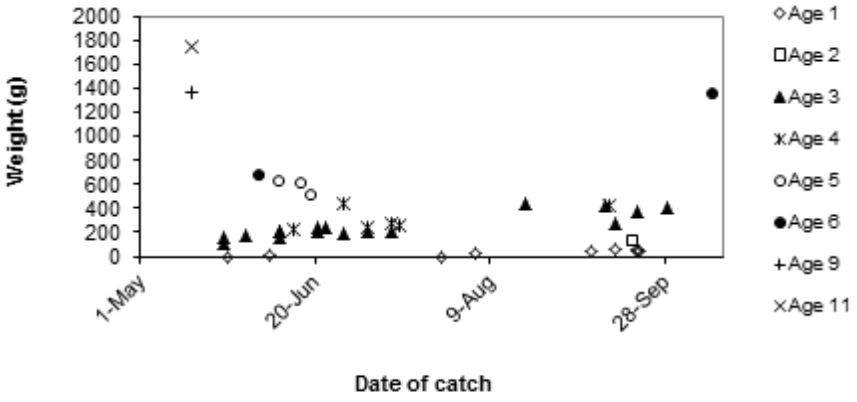

Figure 9. Weight (g) at age of juvenile (age 1 and 2) and adult (≥ age 3) Smallmouth Bass by date of capture by various fishing methods in Miramichi Lake, 2011.

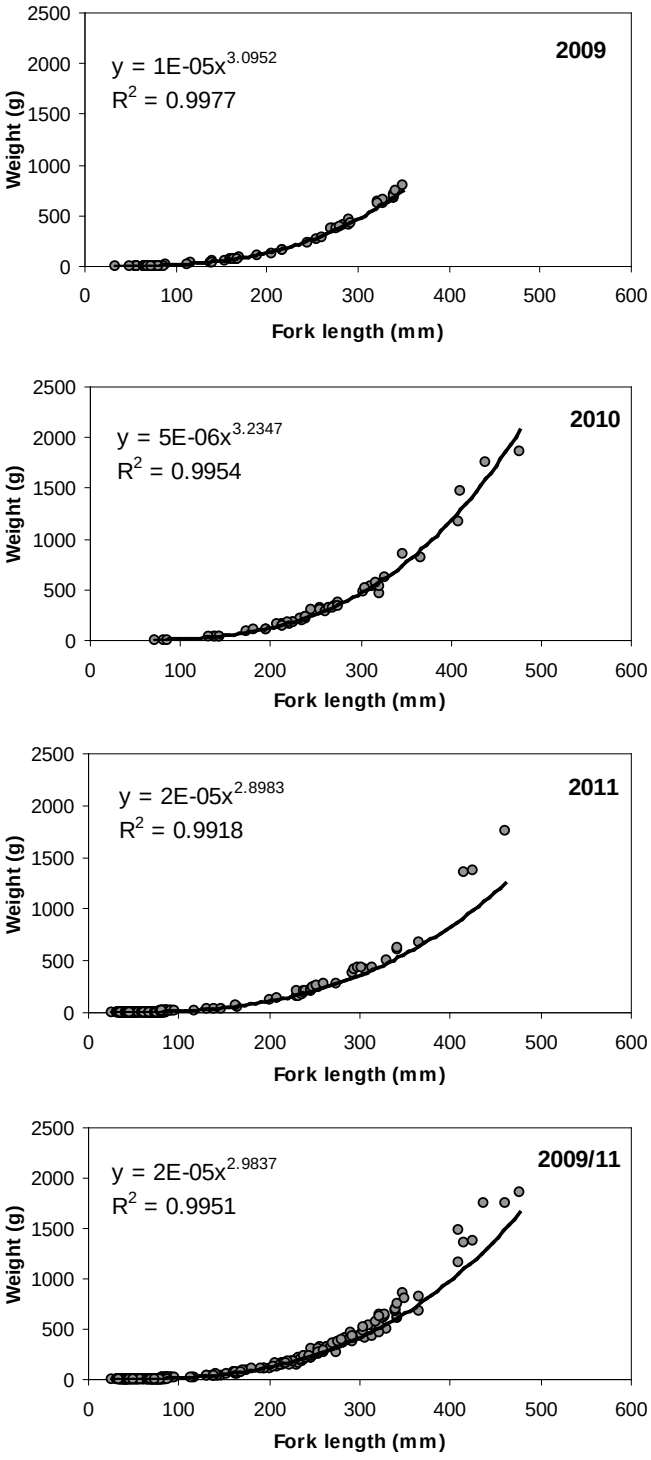

Figure 10. Fork length (mm) to weight (g) relationship for Smallmouth Bass (SMB) captured in Miramichi Lake, 2009 to 2011.

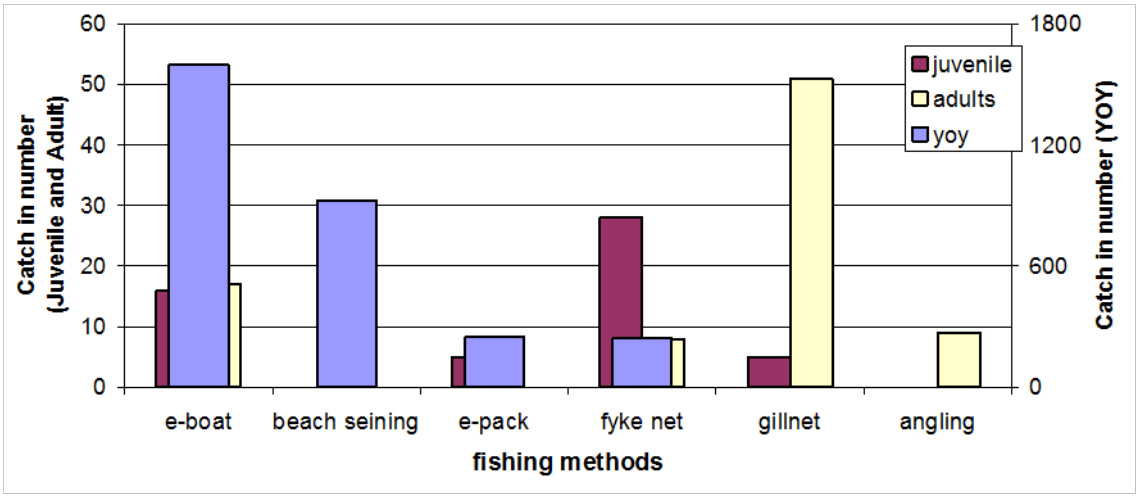

Figure 11. Total catches of Smallmouth Bass by life stage (YOY = young-of-the-year; juvenile = age 1 and 2; adult = age 3 and older) by fishing method in Miramichi Lake, 2010 to 2012.

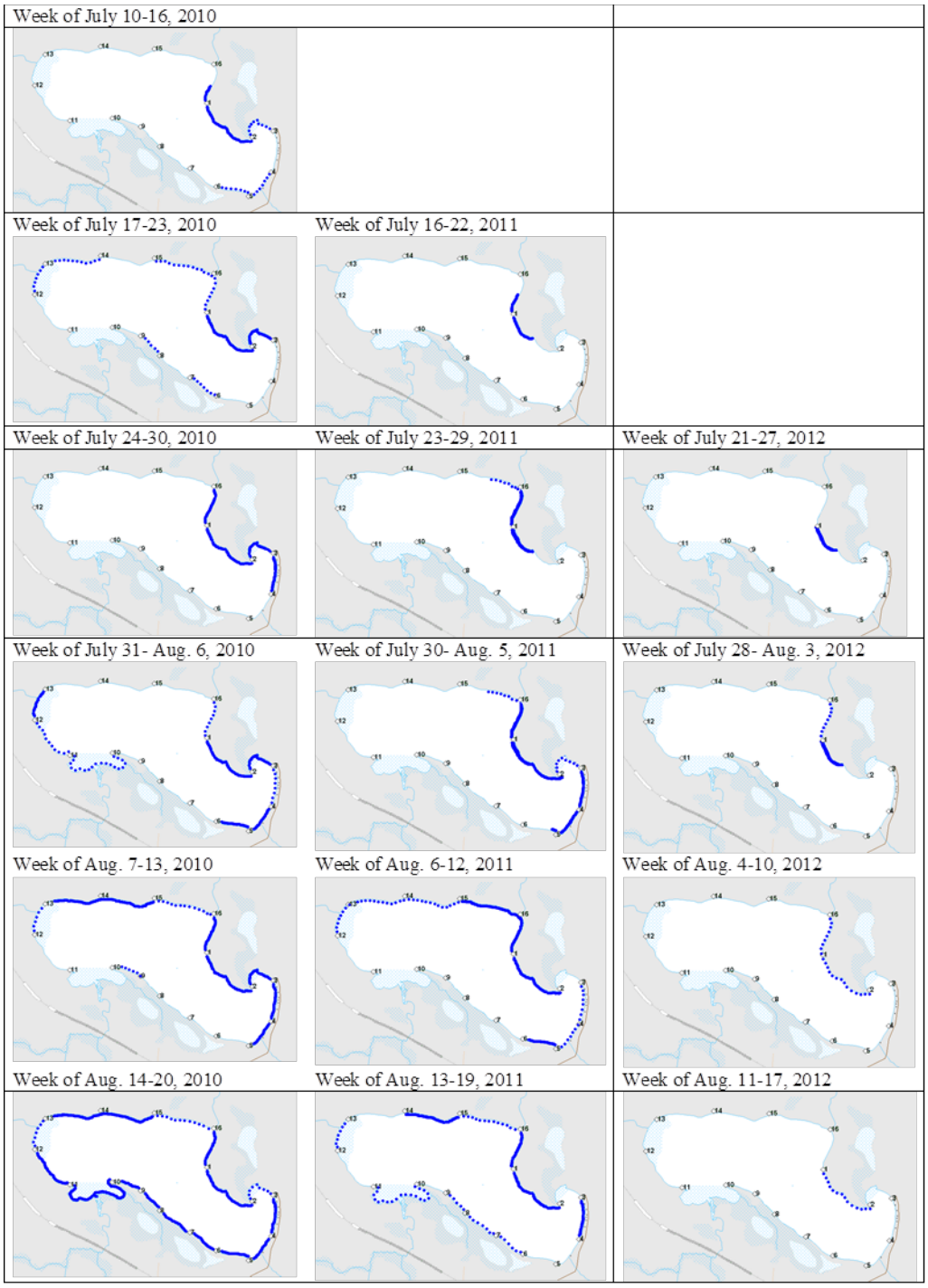

Figure 12. In-season distribution (presence) by week of catches of young-of-the-year (YOY) Smallmouth Bass in Miramichi Lake in 2010, 2011 and 2012 based on all methods of capture. Dotted lines represent captures of 1 or 2 YOY per sector; solid lines represent captures of 3 or more YOY per sector.

APPENDIX

Appendix 1. Proposed 3 Year Containment and Eradication Plan Using Mechanical Methods for Smallmouth Bass in Miramichi Lake

Introduction:

Smallmouth bass (SMB) presence in Miramichi Lake was reported to NB DNRE in late summer 2008. Fish and Wildlife Branch biologists confirmed their presence by successful capturing young-of-the-year (YOY) SMB in early fall. Since that time barriers have been installed to contain the SMB in Miramichi Lake. Surveys of the outlet stream and the Southwest Miramichi River near the outlet stream have failed to detect any SMB except in the upper 350 meters of the outlet stream which is effectively an extension of the lake. Any SMB encountered in this stream section have been removed by weekly backpack electrofishing.

Five year classes, ages 0+, 1+, 2+, 3+, and 4+, were found in the 64 SMB captured during extensive fishing in Miramichi Lake during 2009. Although spawning appears to have been successful for several years in succession, abundance remains low.

This field plan is a strategy to maintain containment while depleting the SMB in Miramichi Lake with the goal of eradication. Other important goals are to estimate the population size and age structure of SMB in Miramichi Lake and with this provide a measure of the effectiveness of the removal strategy at the end of each season.

Beginning as soon as roads are passable and Miramichi Lake is ice free measures will be taken to ensure the Smallmouth Bass in Miramichi Lake are prevented from moving into the Southwest Miramichi River. This will involve installation of a single barrier with a fine mesh liner at the head of Lake Brook as in 2009.

A variety of fishing techniques will be employed to capture and remove SMB from the lake. It must be emphasized that this fishing will be intensive and bycatch of other fish species is unavoidable. As much as possible live release of bycatch will be practiced. Gear selections detailed in the methods below will be modified as needed during the field season to maximize the catch and removal of SMB from Miramichi Lake.

Methods and Equipment

Start-Up Activities

Training: All field staff will need to be trained in first aid and cardiopulmonary resuscitation (CPR).

Boat operators must be trained to the standard for their organization (DFO standard = Small Vessel Operator Proficiency for commercial vessels up to 12 meters / 13 tons , Transport Canada Standard for water bodies the size of Miramichi Lake = Pleasure Craft Operator Proficiency).

Electrofishing crews will need to be led by crew leaders certified in backpack / boat electrofishing and all crew members must be given orientation on safety procedures in advance.

Designating Shoreline Sections: The shoreline of Miramichi Lake is 8,000 meters long. This will need to be divided into sixteen 500 meter long segments with shoreline markers beginning at Lake Brook and proceeding clockwise around the lake. The markers should

be large enough to be clearly visible from 200 meters and have retro-reflective tape for viewing during night electrofishing operations.

Staff and Facilities: Proposed manpower for the program would be three field staff from the MWMC. In addition a graduate student would be living on site leading the team for the field season. These staff would be assisted by a DFO project coordinator who would help with field programs and equipment as required, especially for the first weeks and/or months until field staff can receive required training.

Additional help from collaborators (DFO, DNRE, CRI, and MSA) would be welcome especially during May – June for intensive boat electrofishing.

The graduate student and DFO coordinator would need use of the DFO C&P camp in Juniper for accommodations, freezers, phones, and internet. It is hoped that a camp on Miramichi Lake could be rented for at least part of the season for accommodations, plus be a convenient boat and equipment storage site.

Containment Barrier: The barrier materials are still on site from 2008/09. The barrier requires some modifications to allow better passage of adult gaspereau into the lake to spawn. It also will require additional modifications to allow downstream migration of YOY gaspereau while preventing coincidental escape of SMB. Initial drawings of the required structures are in separate attachments and can be discussed.

Also it must be noted that cleaning the barriers does take time. During high water events or when debris is present (algae, leaves, etc) the barrier must be checked multiple times per day. In those instances cleaning the barrier can take up to 4 hours per day. On a good day with no debris cleaning the barrier will take 1 hour.

Daily records of barrier data will be completed (barrier data sheet attached) documenting status of the barrier and fish moved upstream (into the lake) and downstream (into the outlet stream).

Boats: An electrofishing boat plus an all purpose boat (johnboat or robust scow with a 15-25 HP outboard motor) would be required. The all purpose boat will be used daily from ice out until November and should remain in the lake for that period. The electrofishing boat would be required from May until October when the water cools and SMB have moved to deep water.

Backpack Electrofishing: The upper 350 meter section of Lake Brook which is below the barrier but above a debris dam needs to be electrofished to remove any YOY or Age 1+ SMB which get past the barrier. This was found to be necessary in 2008 and 2009 and should be continued in 2010. Frequency should be once every week.

Boat Electrofishing: Other programs aimed at capturing SMB in lakes have found that boat electrofishing is the most effective method for capturing bass (Weidel et al 2007). In addition the technique allows live release of non target species so impact is minimized.

SMB would be vulnerable to boat electrofishing from May when the lake water reaches temperatures above 10 degrees C and greater until fall when water temperatures drop below 10 degrees (Armour 1993).

A major effort should be placed on boat electrofishing from May until the end of June to target spawning fish and males guarding nests. This is the best opportunity to prevent / minimize successful reproduction of SMB by removing greater than 90% of the spawning population.

What level of effort is needed to prevent successful spawning: In an Adirondak Lake (Northern New York State) an estimated removal rate of 72% did not result in collapsing the population (Zipkin 2008). An evaluation of boat electrofishing removal rates estimated that, on average, 36% of the SMB population was removed per sweep (Odenkirk and Smith 2005). If this efficiency is achieved in Miramichi Lake than removal rates would follow the table below:

Removal Rate Per Sweep			36%
Initial Population			250
Sweep	Removed	Free	Total % Removed
1	90	160	36.0%
2	58	102	59.0%
3	37	66	73.8%
4	24	42	83.2%
5	15	27	89.3%
6	10	17	93.1%
7	6	11	95.6%
8	4	7	97.2%
9	3	5	98.2%
10	2	3	98.8%
11	1	2	99.3%
12	1	1	99.5%
13	0	1	99.7%
14	0	0	99.8%
15	0	0	99.9%

We propose a target removal rate of 90% of SMB spawners during the May – June reproduction period for SMB which would require 6 sweeps. If the efficiency is lower (26%) this would result in 8 sweeps being needed however higher efficiency (46%) would result in the need for only 4 sweeps. Regardless of the removal rate the amount of boat electrofishing effort needs to be large and 6 or more sweeps of the littoral zone will likely be needed.

How many hours of boat electrofishing? Boat electrofishing is effective in depths of 2 meters or less (Brousseau et al 2005). In small lakes in Nova Scotia SMB successful spawning occurred within 20 meters of shore at depths of 0.1 to 1.6 meters (Jason LeBlanc pers comm.). Therefore a sweep for the May – June period would include all waters within 20 m of shore and depths less than 2 meters – the entire shoreline of the lake.

Boat electrofishing is carried out at a boat speed of 0.3 m / sec and proceeds by approaching the shore from offshore, then backing out over the same territory and repeating the process on the adjacent strip of shoreline. Adapting the protocol from DFO Great Lakes Laboratory (Brousseau et al 2005) it is estimate that the initial sweep of Miramichi Lake could take 40 hours. Subsequent sweeps could eliminate areas where SMB were not found decreasing the sweep time by 50% for sweep 2, and an additional 10% for each successive sweep. Using this approach produces an estimate of 100 – 120 hours of boat electrofishing time for the 6 sweeps of Miramichi Lake needed to remove over 90% of SMB.

Boat Electrofishing at Night: Electrofishing catch rates for SMB have been found to be 2.1 to 4.1 X catch rates during daylight (Paragamian 1989). Nighttime operations are recommended to improve gear efficiency and increase the number of SMB removed per hour. The electrofishing boat must be equipped with lights to allow electrofishing after dark.

After spawning season: Boat electrofishing is likely going to remain the most effective method for capturing and removing SMB. The abundance will be much reduced and the objective should be to complete a sweep of the entire lake each week, targeting areas where SMB have been captured earlier in the season.

September-October: Typically this has been the time when boat electrofishing surveys were done on lakes as capture rates are highest at this time of year. Young-of-the-year SMB will be caught, if early efforts were insufficient to prevent successful reproduction. Note that YOY disperse short distances (88 +/- 61 meters) from their natal nests (Gross and Kapuscinski 1997).

Nest Location Verification and Destruction: All locations where SMB adults are captured will be recorded by GPS during boat electrofishing. Each of these sites will be visited during daylight hours when these potential nest sites are visually examined by snorkeling. Upon verification of an existing nest any eggs or larvae remaining will be removed by slurp gun. The snorkeling will also allow additional removal of adults (pole spear) and nest destruction.

Fyke netting: A commercial approach to fishing this gear is recommended. This would involve having one index fyke net where all species are sorted and counted plus SMB removed. All other fyke nets would have SMB removed and counted but other species released without sorting and counting. Two additional fyke nets with 50-100 ft leaders should be purchased to bring the total nets available to 4.

Fyke nets will be deployed once water temperatures have reached 10 degrees C until fall when the water temperatures fall below 10 degrees and SMB are no longer catchable. Initially, vents allowing smaller fish to escape will be installed to decrease the bycatch and target larger spawning adult SMB. In June the escape vents will be removed but if bycatch is unmanageable then decisions will need to be made in the field as to how many nets w/o escape vents can be operated.

Fyke nets are fished in the same shallow water habitat where boat electrofishing is taking place. Information on the location of SMB from boat electrofishing will be used to place fyke nets in areas where SMB are found.

Gillnetting: Gillnets are the gear for targeting SMB in deeper (3 to 7 meters) part of Miramichi Lake. They can be deployed for the entire length of the field season since SMB move to deep water when water temperatures are below 10 degrees C but use deep lake waters in summer.

Gillnet fishing intensity will vary throughout the season. Initially effort will be high to remove as many adult SMB as possible before spawning begins in late May. Adult SMB will be moving from deep holes to shallow spawning sites and should be vulnerable to capture. Overnight sets will be used. However if bycatch is unmanageable gillnets sets could be restricted to daylight hours to decrease the bycatch (Honda and Fujita 2005). Upon arrival of adult gaspereau in late May or early June the gillnetting effort would be reduced to only the 4 and 5 inch mesh nets which would not retain gaspereau.

A commercial approach to fishing gillnets is recommended with the addition of one index gillnet set/day where all species are sorted and counted. Mesh sizes will be from 2 to 5 inches to target the 20 to 50 cm adult SMB in the lake (table below from Fujita et al 2007).

Mesh Size (inches)	Mesh Size (cm)	Total Length (cm)
0.8	2	8
1.2	3	12
1.6	4	16
2.0	5	20
2.4	6	24
2.8	7	28
3.1	8	32
3.5	9	36
3.9	10	40
4.3	11	44
4.7	12	48
5.1	13	52

Angling: Angling will not be part of the program as abundance of SMB is too low for good angling success.

Evaluation

Regular consultations with the MLWG will be held via teleconference throughout the field season (May to October). These will provide updates of removals (catches) of SMB by age group and time period and allow input from MLWG on changes in field operations (less/more fyke netting, gillnetting, boat electrofishing, …). A report of all operations on Miramichi Lake will be provided to MLWG after the end of field operations in November – December.

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Appendix Table 1. Schedule of Activities

Activity	Time	Equipment	Reasons
Barrier: Install barrier and fine mesh liner to contain small bass Extra barrier maintenance Allow controlled downstream passage of juvenile gaspereau w/o YOY SMB escapees Removal	April / early May various July 26-Aug 13 November	Barrier fence material supplied by JD Irving Downstream passage installed on barrier	Ensure containment before water warms and SMB leave deep holes in lake. During periods of high discharge, high debris, and late summer algal accumulation on liner YOY SMB escaped from the lake when barrier nets were lifted to allow juvenile gaspereau to pass in 2009 SMB inactive due to low water temperature
Backpack electrofishing: upper 300 meters of Lake Brook once per week.	May thru November	Backpack Electrofisher, sampling gear	YOY and Age 1+ SMB were found in this area in 2008 and 2009. They need to be removed.
Designating shoreline sectors:	Early May	Utility boat, surveyors tape, retro-reflective signs	To enable boat electrofishing and net captures of SMB to be easily geo referenced
Boat electrofishing: Entire lake littoral zone shoreline 3 -5 or more days per week	mid-May, all of June July-Oct	Electrofishing boat and portable GPS	Remove 90% of males on nests, remove a large %age of all other age/sex classes Continue to remove all ages of remaining SMB – detect presence of YOY SMB
Verifying and Destroying Nests:	May - June	Utility boat, snorkel gear, GPS, slurp gun	Verify location of SMB nests initially indicated from boat electrofishing – remove eggs / larvae
Fyke netting:	May – June Aug-Sept -Oct	4 fyke nets and escape vents Attempt netting w/o escape vents	Adult bass moving around looking for spawning sites Target juveniles in areas where they are caught with fishing boat
Gillnetting: Lake – 3-5 days / week - 24hr sets	Early May June July - October	Monofilament gillnets mesh sizes from 2 to 5 inches, boat, sampling gear only 4 and 5 inch mesh Mesh sizes from 2 to 5 inch	Target adults prior to spawning –moving from deep water to shallows Target females after spawning Target deep areas which cannot be reached with other gears.
Data analysis, report preparation	November-December		