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Monitoring to determine the efficacy of utilizing fishless lakes as fish habitat compensation in Labrador

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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.

Research documents are produced in the official language in which they are provided to the Secretariat.

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ABSTRACT

This paper reports on methods for assessing the effectiveness of fish habitat-related measures implemented as part of the regulatory approval for two mining projects in Newfoundland and Labrador. Between 2003 and 2004 works or undertakings associated with two mining projects (one in western Labrador and another in northern Labrador) included activities that, as a condition of regulatory approval, required compensation works to offset the loss of lacustrine habitats though the transfer of fish from the impacted lakes into fishless lakes located within their respective watersheds. After the fish transfers, monitoring programs were required to determine whether there was sustainability of the transferred fish populations. Methods used to determine population sustainability included such things as visual surveys along the shoreline, outlets and into tributaries; electrofishing to determine recruitment success; mark-recapture studies to estimate population size; and collection of various morphometrics to evaluate fish population status/health. At one location an outlet stream was also created to provide for spawning and rearing habitats. Monitoring to determine effectiveness of the created outlet included surveys to assess habitat features, including wetted width, depth, shape, bank height, water discharge/velocity (high, medium, low flows) and habitat utilization (visual and electrofishing surveys).

An evaluation of the above metrics revealed that most metrics utilized were useful, especially when used in conjunction with others. The metrics were successful in identifying changes over time and have enabled the assessment of the status of the compensation and determine whether additional changes were required in order for the compensation to function more effectively. The only metric that was determined to be ineffective was the use of visual surveys for redds. When assessing compensation, metrics should be collected over a sufficient time period, be used in conjunction with other metrics, and should be detailed enough to provide a clear picture of trends. Baseline data is also critical when using fishless lakes as a compensation option as the lake must be determined to be fishless, as well as provide a suitable environment for the transferred populations to survive and successfully reproduce.

Surveillance visant à déterminer l'efficacité de l'utilisation des lacs sans poisson comme mesure de compensation de l'habitat au Labrador

RÉSUMÉ

Le présent document fait état des méthodes pour évaluer l’efficacité des mesures liées à l’habitat du poisson qui ont été mises en œuvre dans le cadre de l’approbation réglementaire de deux projets d’exploitation minière à Terre-Neuve-et-Labrador. Entre 2003 et 2004, les entreprises ou ouvrages liés à deux projets d’exploitation minière (l’un à l’ouest et l’autre au nord du Labrador) comprenaient des activités qui, comme condition préalable à l’approbation réglementaire, demandaient des travaux pour compenser la perte d’habitats lacustres; plus précisément, ces travaux visaient le transfert des poissons provenant des lacs touchés vers des lacs sans poisson situés dans leurs bassins versants respectifs. Après le transfert des poissons, des programmes de surveillance ont été mis en œuvre afin de vérifier la durabilité des populations de poissons transférés. Les méthodes utilisées pour déterminer la durabilité des populations comprenaient des relevés visuels le long de la ligne de côte, dans les décharges et dans les affluents; des activités de pêche à l’électricité afin de déterminer la réussite du recrutement; des études de marquage et de recapture afin d’estimer la taille des populations; et la collecte de diverses données morphométriques pour évaluer l’état et la santé des populations de poissons. Une décharge a aussi été créée à un endroit afin de fournir des habitats de frai et d’élevage. La surveillance pour déterminer l’efficacité de la décharge créée comprenait des relevés visant à évaluer les caractéristiques de l’habitat, y compris la largeur mouillée, la profondeur, la forme, la hauteur de la rive, la décharge et la vitesse de l’eau (débits élevés, moyens, faibles) ainsi que l’utilisation de l’habitat (relevés visuels et activités de pêche à l’électricité).

Une évaluation des paramètres mentionnés ci-dessus a révélé que la plupart des paramètres utilisés sont utiles, notamment lorsqu’ils sont utilisés en conjonction avec d’autres paramètres. Les paramètres ont permis de détecter les changements au fil du temps et d’évaluer l’état de la compensation, en plus de permettre de déterminer si des changements supplémentaires étaient requis pour une plus grande efficacité de la compensation. L’utilisation des relevés visuels pour les frayères est le seul paramètre qui a été considéré comme inefficace. Au moment d’évaluer l’efficacité de la compensation, il faudrait disposer de paramètres recueillis sur une période suffisamment longue, les utiliser en conjonction avec d’autres paramètres, et s’assurer qu’ils sont suffisamment détaillés pour donner un clair aperçu des tendances. Les données de base sont également essentielles lorsque l’on utilise des lacs sans poisson comme option de compensation étant donné qu’il faut déterminer que le lac est sans poisson et offre un environnement adéquat pour que les populations transférées puissent survivre et se reproduire avec succès.

BACKGROUND

Fisheries and Oceans Canada (DFO) typically require proponents of authorized works that harm or destroy fish habitat to create or improve habitat elsewhere as a compensatory or offsetting measure. Habitat compensation or offsetting plans are designed to be comprehensive and scientifically defensible and include monitoring programs to collect the necessary information to determine their effectiveness. Within northern locales finding suitable offsetting options can be challenging, and in particular within Labrador the opportunities to restore degraded habits or enhance existing habitats are very limited. That has led to the need to consider other unique options with one being the use of fishless lakes whereby fish from the impacted lake were transferred to a fishless receiving lake within the same watershed. However, prior to being accepted by DFO as a receiving lake, information was collected to demonstrate that the receiving waterbody was truly fishless and met the habitat requirements necessary to support the various life stages of the transferred species to ensure population survivability and sustainability.

In 2003, the first project which considered the use of a fishless lake to offset the loss of lacustrine fish habitats was associated with the expansion of an iron ore open pit operation located in west central Labrador near Labrador City and the Town of Wabush (Figure 1). The project area included the loss of Hakim Lake within the Luce Lake watershed (red star, Figure 2a), which supported Brook Trout (*Salvelinus fontinalis*) and Lake Chub (*Couesius plumbeus*) fish populations (Figure 2b).

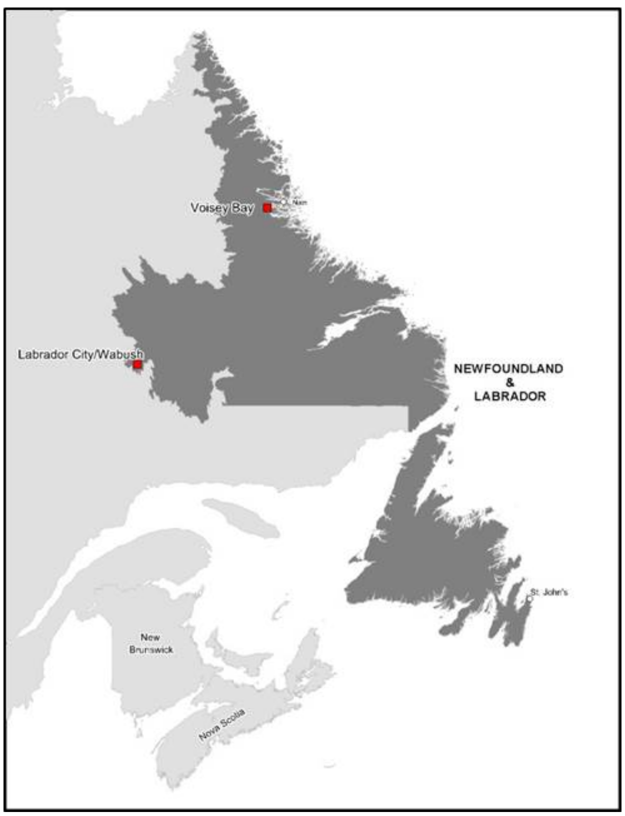

Figure 1. Map depicting location of Labrador City - Wabush and Voisey's Bay in Newfoundland and Labrador.

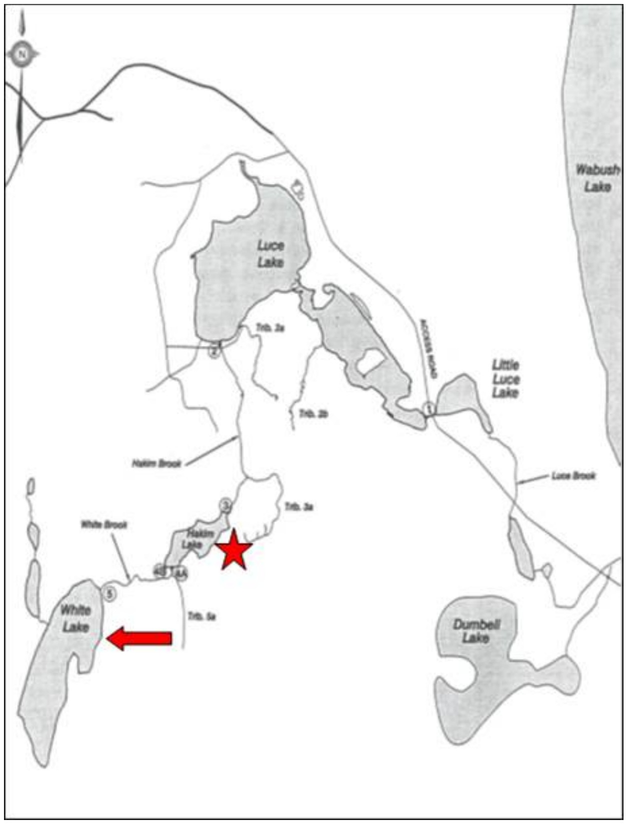

Figure 2a. Map depicting Luce Lake watershed, including the location of Hakim Lake (red star) and the compensation lake named White Lake (red arrow).

Figure 2b. Photograph of White Lake.

White Lake (red arrow) was a fishless lake located in the headwater area of the Luce Lake watershed which had a natural barrier at the outlet and as such it was impassable to fish migration from the lower reaches. In addition to the use of White Lake, a small outlet tributary was created/enhanced to provide additional spawning habitat for transferred Brook Trout.

The second use of a fishless waterbody was undertaken in 2004 for a project involving the construction/operation of a nickel-copper-cobalt mine/mill in Voisey's Bay located in northern Labrador (Figure 1). The project activities included the disposal of tailings and potentially acid-generating waste rock, which resulted in the loss of Headwater Pond (headwater of the Camp Pond watershed – red star, Figure 3a). Headwater Pond supported populations of landlocked Arctic Charr (*Salvelinus alpinus*), Brook Trout (*Salvelinus fontinalis*) and threespine stickleback (*Gasterosteus aculeatus*), and flowed into Reid Brook. The fishless lake proposed as the fish habitat compensation option was named Pond 61 (red arrow), located farther upstream within the Reid Brook watershed which was impassable from Reid Brook due to a natural barrier (Figure 3b).

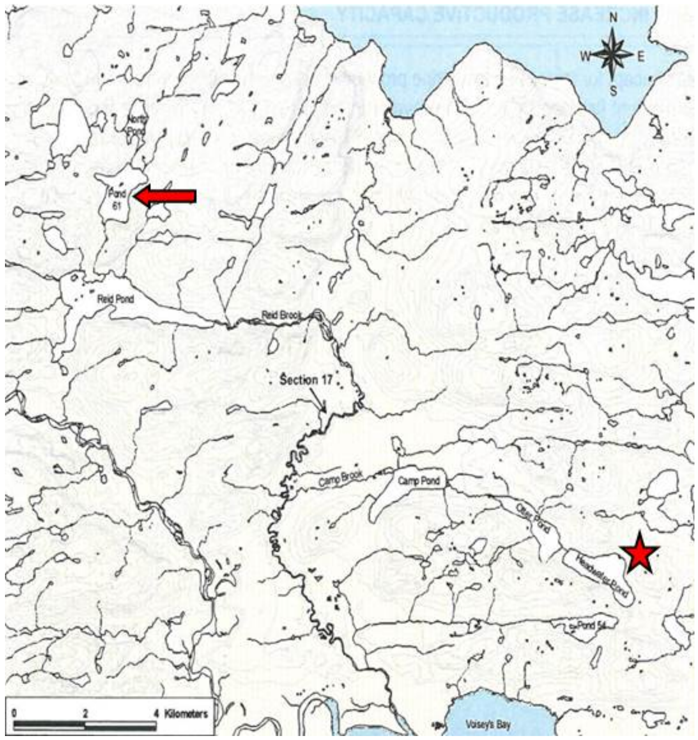

Figure 3a. Map depicting Reid Brook watershed, including the location of Headwater Pond (red star) and the compensation lake named Pond 61 (red arrow).

Figure 3b. Photograph of Pond 61.

The Section 35(2) *Fisheries Act* Authorizations (Authorization) issued to allow for the destruction of fish habitat prescribed multi-year monitoring programs. The White Lake monitoring program occurred between 2004 and 2010 while the Pond 61 monitoring program was conducted between 2005 and 2014. The following outlines the methods utilized in the collection of the data, metrics used and the assessment of the metrics in evaluating effectiveness of fish habitat compensation works. Information presented is based upon data provided in the proponent's monitoring reports which were required as conditions of their Authorization.

METHODS

The main objectives of the monitoring programs for both White Lake and Pond 61 were to determine the effectiveness of transferring fish to a fishless lake as a means to offset the loss of the habitat from impacted waterbodies. Effectiveness was determined through assessment of changes in population size and structure, fish morphometrics and health, and the ability to produce recruits. The methods utilized for measuring these changes were generally the same for both lakes. As to the availability of habitat to support the various life stages of fish, the only difference was that, unlike Pond 61 which had suitable riverine tributary habitats available for use, White Lake required the construction and enhancement of a stream habitat for spawning/rearing. Metrics associated with the creation and structural integrity of the White Lake Channel is not discussed in this document. The following provides a summary of methodologies utilized in the collection of the metrics and the evaluation of the effectiveness of those metrics. Information presented on the fish habitat monitoring programs was based upon data provided in proponent's reports which were required as conditions of the Authorization. White Lake information was from JWEL (1997a), IOCC (2001), Stantec (2002), AMEC (2004a), EcoMetrix (2005), EcoMetrix (2006), EcoMetrix (2007), EcoMetrix (2008), EcoMetrix (2009), and EcoMetrix (2010). Pond 61 information was compiled from JWEL (1997b), AMEC (2004b), AMEC (2004c), AMEC (2006), Minaskuat (2007), Minaskuat (2008), Stantec (2009), Stantec (2011), Stantec (2013) and Stantec (2015).

FISH POPULATIONS

Population Estimates

Mark-recapture surveys were conducted to obtain information on fish population sizes from both White Lake and Pond 61. Transferred fish, along with adult fish captured in subsequent years, were marked by pit tag and/or fin clip whether captured in nets or during electrofishing surveys. In the years following the transfers, surveys were conducted in shallow and nearshore waters by utilizing trap or fyke nets. Data collected during each monitoring year (i.e., number of fish caught and number of fish caught that were marked), were used in abundance estimates. For White Lake estimates of population size was calculated using Schnabel and Modified Schnabel methods (Ricker 1975). The Peterson Daily method was also used but considered the least accurate and as such no data are presented for this method. The Schnabel multiple-census method was used for fish population estimates for Pond 61.

Relative Abundance

Another indicator of potential success and status of fish populations is to measure changes in the catch per unit effort (CPUE) over time. CPUE is considered an indirect measure of the abundance of a targeted species (Puerta and Bodmer 2004), and in this instance primarily Brook Trout and Arctic Charr from Pond 61 and Brook Trout from White Lake. Changes in the CPUE metric were used to infer changes to the species' abundance. CPUE was determined as number of fish per net hour for White Lake and number of fish per net night for Pond 61.

The net surveys in Pond 61 were conducted during the month of August (except in 2006) using fyke nets with a mesh size of 4-5 mm. In 2007, the gear and locations were standardized to ensure the CPUE metric between years were comparable. Nets were set around the lake perpendicular to shore and usually in 12 locations and fished for approximately 24-hours (Table 1). CPUE was estimated as number of fish per net night.

Table 1. Data on trap net surveys conducted in Pond 61, 2005-14.

Year	Month	#No. Nets Set	No. Nights Fished	Total Net Nights	Hours Net Fished	No. Locations Fished
2005	July	NA	10	68	23	12
2006	Aug	5	5	25	24	12
2007	July	8	7	56	24	12
2008	July	8	9	71	24	13
2010	July	8	9	72	24	14
2012	July	8	9	72	24	12
2014	July	8	10	80	24	12

In White Lake the surveys were conducted using trap nets primarily in September between 2005 and 2008; no trap net survey was undertaken in 2004 as access to the lake was restricted due to a strike at the mine site. Two-three trap nets (9.5 mm mesh size) were set in 5-8 locations over the monitoring period in areas identified as potential upwellings or areas where redds were reported. Netting was conducted between 14-20 days with nets usually being fished for a 24-hour period (Table 2). CPUE was estimated as number of fish per net hour.

Table 2. Data on trap net surveys conducted in White Lake, 2005-08.

Year	Month	#No. Nets Set	No. Nights Fished	Total Net Nights	Hours Net Fished	Total Hours Fished	No. Locations Fished
2005	Last week Aug-Sept	3	14	42	24	1,011	5
2006	Last week Aug-Sept	3	14	42	24	957	6
2008	Last week Aug-Sept	3	19	57	24	1,306	8

Data were collected on numbers of fish caught by species, fork length (mm) and weight (g). Age for fish from White Lake was determined using otoliths in 2005 and 2006 only. No estimate of age was done for fish from Pond 61.

Recruitment

Electrofishing surveys were undertaken to confirm that spawning had occurred thereby producing recruits (i.e., young-of-the-year) and to compare between years. The survey methodology followed the guidelines of Scruton and Gibson (1995) and as outlined in Sooley et al. (1998). Generally electrofishing in the White Lake Channel was undertaken between 2004 and 2010 in the month of August. However in 2004 it was conducted in June (no surveys were conducted in the fall due to a labour strike) and in September of 2005. In Pond 61 electrofishing was undertaken within each of the outlets/tributaries of Pond 61 in mid-late July 2005 and early August, 2006. However, since 2007 the survey time was standardized to occur during the first two weeks of July. Generally in both surveys two sweeps were conducted along the length of the channel with catch pre unit effort (CPUE) measured as fish caught per minute shocking time.

Data on fish caught during the electrofishing surveys from both White lake and Pond 61 included fork length (mm) and weight (g) by fish species.

VISUAL SURVEYS

Spawning Assessment

Not only was it important to determine if fish were surviving, it was also important to assess whether fish were able to reproduce. To determine whether fish were spawning several methods were utilized. Visual surveys were undertaken to determine whether the lakes and/or tributaries were used for spawning, as well as the distribution of spawning sites within the study area. The visual surveys included observations on the presence of gravid fish in the outlets and associated tributaries, locations of gravel bars/upwellings and a count of the number of redds observed.

Lakes

Visual surveys were conducted by traversing the shoreline via boat with two observers utilizing underwater viewers to record the presence of fish or spawning redds. Walking surveys were conducted in gravel bar areas, inflows and upwellings and along the shoreline. The locations of redds were recorded, photographed and totaled according to habitat type. They were carefully examined for presence of eggs by gentle agitation above the redd surface in order to try and eliminate false redds.

Tributaries

Visual surveys were also conducted on any tributaries and outflow streams that would be accessible by fish. Again two observers traversed the stream, one on each side, and recorded the presence of fish and any redds as well as habitat type where found. Observations of spawning activity and the presence of large congregations of fish were also recorded. Redds were also examined for presence of viable eggs and to ensure it was not a false redd.

Recruitment Assessment

Visual surveys were undertaken to determine potential recruitment success within the lakes by traversing the shoreline by boat with two observers utilizing an underwater viewer, with particular attention paid to areas with gravel substrates. Sightings of young-of-the-year, juveniles as well as adults were recorded along with location and water depth. If possible, an estimate of fish length was taken. As well visual observations were made at the outlets and/or tributaries and the presence of young-of-the-year recorded.

Fish Morphometrics

For all fish caught a series of metrics were collected for use in estimating fish population structure and evaluating overall fish growth and health. This included recording information on numbers caught by species, fork length (mm) and weight (g). Information was used to calculate other parameters, including condition (K), length-weight relationships, and growth rates, length and age frequency distributions). In 2005 and 2006, a subsample of fish from White Lake only were aged and an age-length key developed and used to extrapolate ages for fish caught in other years.

RESULTS AND DISCUSSION

Monitoring of fish habitat compensation works is critical in determining whether the compensation is functioning as designed, and in the case of fishless lakes, the ability of the transferred fish to establish sustainable fish populations. Associated with monitoring is the requirement to ensure that the correct metrics are being used to make that evaluation. A wide suite of metrics is possible and they should be designed to ensure that the data collected is needed, relevant to the habitat compensation and measured over time to reflect changes. If the correct metrics are employed they will identify changes whether positive or negative. In the case of negative changes which are identified early in the process it provides opportunities to take corrective measures. Metrics to be used must also take into consideration any challenges with logistics, occupational health and safety and cost, especially when working in remote locations (e.g., northern locales or offshore locations).

The productive capacity of the impacted lakes was considered to be at its maximum natural capability to support/produce healthy fish or produce aquatic organisms upon which fish depend. Given that both receiving lakes, Pond 61 and White Lake, were fishless, a value of zero for the productive capacity was established as the baseline.

From a purely areal extent, White Lake is 33 ha and as such offsets the loss of the 12 ha Hakim Lake. In 2003, 1,081 Brook Trout and 980 Lake Chub (length range=35-151 mm) were relocated from Hakim Lake into White Lake. Monitoring was conducted in 2004, 2005, 2006, 2007, 2008, 2009 and 2010.

Pond 61 is about 94 ha in surface area and offsets the loss associated with the 88 ha Headwater Pond. In 2004, 649 Arctic Charr and 654 Brook Trout along with 35 Threespine Stickleback were relocated from Headwater Pond into Pond 61. Monitoring was conducted between 2005 and 2014 (i.e., 2005, 2006, 2007, 2008, 2010, 2012, and 2014).

VISUAL SURVEYS

Visual surveys can be useful in determining relative changes in habitat utilization by various fish species. In the case of fishless lakes, visual observations, especially in the first few years, provided an indication as to whether the fish that had been transferred were surviving. It also could provide an indication that fish were utilizing the lake and tributaries.

Visual surveys conducted within White Lake in June, 2004 (via walking and boat) did not locate the presence of any fish. Due to a labor dispute at the site, no monitoring was possible for the planned fall survey. Visual surveys conducted in 2005 found no fish but with the use of sonar the presence of fish were noted in deep waters (i.e., >3 m). Due to the depth, numbers of fish were not able to be recorded. In 2006, congregations of adult fish were visually observed in several locations around the lake in nearshore areas. The following years the presence of Brook Trout and Lake Chub continued to be noted during the fall (September-October) surveys within White Lake. In 2008 and 2010, during the fall survey, large schools of Brook Trout (~200 fish of >25 cm in length) were observed primarily in one nearshore area close to the entrance to White Lake Channel. An underwater camera was deployed to identify if there were any upwellings in the area, but none were observed. Thus the visual survey was useful in providing evidence of the utilization of the lake by fish.

Within the White Lake Channel, created to provide an area suitable for Brook Trout spawning, visual surveys conducted between 2004 and 2010 indicted the presence of Brook Trout ages 0+ and 1+ as well as adults (Figure 4).

While no numbers are available for Lake Chub, annual visual observations have indicated the success of Lake Chub being able to survive and reproduce in White Lake/White Lake Channel.

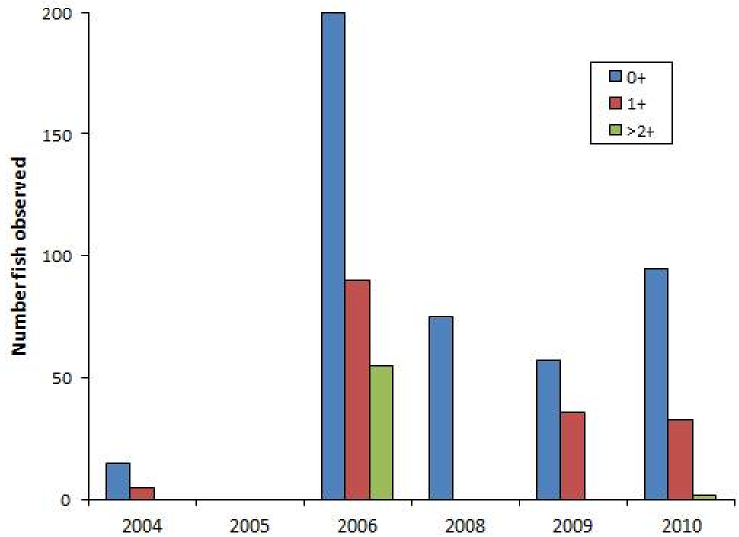

Figure 4. Visual observations of Brook Trout, White Lake Channel, 2004-10.

In Pond 61, visual surveys were conducted on the lake shoreline, as well as on three tributary streams flowing into Pond 61 and the outlet stream. During the first year there was no evidence of spawning activity or the presence of young-of-the-year fish in the lake or tributaries. Between 2006 and 2010, fish were observed in nearshore areas of the Pond 61 and outlets to tributaries. In 2008, there was an observation of large-sized Arctic Charr in the nearshore areas (~50 fish). In 2010, small numbers of young-of-the-year salmonids were observed along the shore edge near tributaries; no large sized fish were seen. Monitoring identified the stream located in the northeast corner as the primary location of Brook Trout spawning and in 2007 trout were found 100 m upstream (Figure 5). Further investigation between 2008 and 2010 revealed fish as far upstream as 220 m, indicating the continued and expanded use of riverine habitat by Brook Trout. Records of actual numbers observed were limited.

Figure 5. Spawning habitat upstream, Pond 61.

Redd Surveys

In White Lake, visual surveys to investigate the presence of redds were conducted in the fall but did not indicate any distinct redds throughout any of the monitoring periods. In 2004, 10 redds were located around the shoreline of White Lake, but with further investigation these redds were determined to be false. Two redds were also found within the White Lake Channel that were also determined to be false.

In Pond 61, visual surveys to identify the presence of redds was undertaken in 2005, but no redds were located. Due to bad weather in 2006, no redd survey was undertaken. Subsequently, given lack of results from previous surveys, it was decided not to continue a fall redd survey.

STATUS OF FISH POPULATIONS AND ABUNDANCE

Netting Surveys

Trap and fyke nets, which are passive gears resulting in little/no harm to fish, were used to collect data for a variety of metrics in order to assess fish populations following introduction. Information collected included fish morphometrics, CPUE, population abundance estimates from mark-unmarked fish caught, and the growth and health of individuals within the fish population. Information collected over long periods of time can show trends to demonstrate the effectiveness of the habitat compensation.

Relative Abundance

Within White Lake itself, trap net surveys were used in three years over a five-year time period between 2004 and 2008 (Figure 6). Unfortunately the survey that was planned for 2004 was not undertaken in due to a labor strike on the site where the lake is located. CPUE from the trap net surveys between 2005 and 2008 indicate that the Brook Trout population had survived but given the fluctuation in CPUE between years the population, as of 2008, was likely still stabilizing. Given Brook Trout were the targeted compensation species, limited information is available from the surveys for Lake Chub but there are indications in 2008 that the Lake Chub population was slowly increasing.

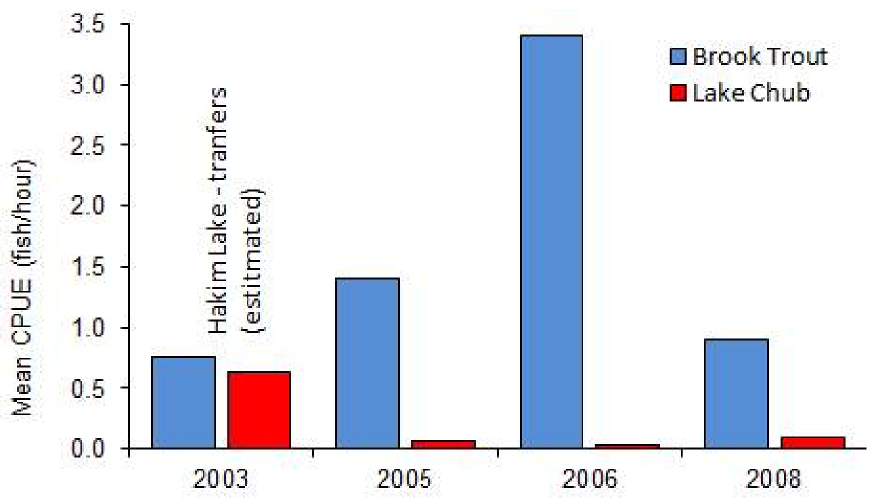

Figure 6. CPUE for Brook Trout and Lake Chub from White Lake, 2005-08.

In Pond 61, fyke net surveys were conducted for six years over a nine-year time period (Figure 7). The metric of CPUE indicates that the relative abundance of Arctic Charr increased between 2006 and 2010 and then decreased between 2010 and 2014. On the other hand, the CPUE for Brook Trout is indicative of a slow start; relative abundance appears to be on a positive incline since 2007.

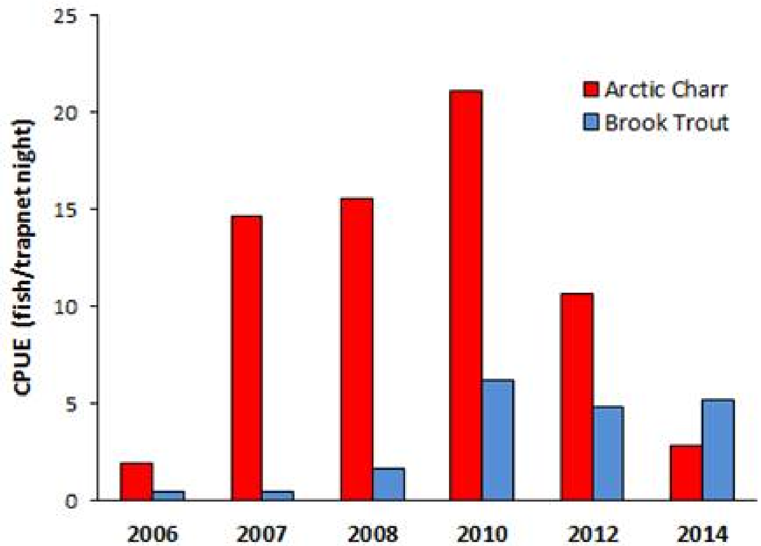

Figure 7. CPUE of Arctic Charr and Brook Trout from Pond 61, 2006-14.

The relative abundance of Stickleback was shown to have drastically increased since the transfer with a CPUE of 0.48 in 2006 to a CPUE of 272.0 in 2010 (Table 3). However, similar to Arctic Charr the CPUE has decreased between 2010 and 2014. This may be indicative of the population stabilizing since being introduced in 2003.

Table 3. CPUE (number per net-night) for Sticklebacks from Pond 61, 2006-2014.

Year	**2006**	**2007**	**2008**	**2010**	**2012**	**2014**
CPUE	0.48	4.26	19.9	272.0	144.0	16.4

Population Size Estimates

Data on mark/recaptures from the trap and fyke net surveys were used to estimate population abundance. In Pond 61, catches from the fyke net surveys in 2005 and 2006 were too low to be able to estimate abundance for Arctic Charr or Brook Trout. Population estimates for Arctic Charr from the mark-recapture surveys conducted in Pond 61 between 2007 and 2014 showed a large increase to 2010 and then a sharp decline to a low of 2069 fish in 2014. However it is believed the population is likely beginning to stabilize since the introduction of 649 Arctic Charr in 2004 (Table 4).

Table 4. Population estimates for Arctic Charr and Brook Trout from mark/recapture surveys from Pond 61, 2007-14 and numbers transferred in 2004.

Arctic Charr	**Number**	**Range**	**Brook Trout**	**Number**	**Range**
2004	649	NA	**2004**	654	NA
2007	5,892	4,293 – 8,089	**2007**	197	35 – 1,330
2008	8,393	6,598 - 10,678	**2008**	297	185 - 476
2010	29,025	19,945 - 42,250	**2010**	896	723 -1,110
2012	10,892	7,276 - 16,354	**2012**	555	444 - 692
2014	2,069	1,048 – 4,098	**2014**	714	581 - 878

Brook Trout however did not show a similar population explosion as Arctic Charr. Initially the number of Brook Trout drastically declined to 197 fish (2007) from the 654 fish transferred into Pond 61 in 2004. The reason for the slow growth of the Brook Trout population and in particular the significant decline between 2004 and 2007 may initially have been the result of competition with Arctic Charr and/or sticklebacks or the limited use of spawning habitats (e.g., visual surveys show that Brook Trout have slowly increased the utilization of riverine habitats to spawn). However between 2008 and 2014 the population size appears to be stabilized and in 2014 is slightly larger (~10%) than the original transferred population.

In White Lake, estimates were calculated using two different methods for Brook Trout but did not appear to differ considerably, i.e. there was a very small range in estimates regardless of the method used (Table 5). In comparison to the actual number of Brook Trout transferred in 2003 (i.e., 1,081), the mark-recaptured survey shows that the Brook Trout population has survived and increased.

Table 5. Population estimates for Brook Trout from mark/recapture surveys from White Lake between 2005 and 2008.

Year	Method	Number	Range
2005	Schnabel	3,211	2,882 – 3,624
2005	Schumacher	3,087	2,600 – 3,797
2006	Schnabel	7,838	7,162 – 8,655
2006	Schumacher	7,509	6,778 – 8,417
2008	Schnabel	5,771	4,787 – 7,263
2008	Schumacher	5,865	5,087 – 6,924

Population estimate for Lake Chub from White Lake was only undertaken in 2008. The Schnabel estimate was 1,402 (962-2,583) while the Schumacher estimate was 1,459 (1,069-2,294). This indicates that while not a large increase in population size from the 982 Lake Chub placed in White Lake in 2003, it is indicative of population survivability and sustainability.

Electrofishing Surveys

Generally electrofishing in the White Lake Channel was undertaken in the month of August but in 2004 it was conducted in June (no surveys were conducted in the fall due to a labour strike) and in 2005 it was undertaken in September (Table 6). Most of the fish caught in the electrofishing surveys were age 0+ and 1+. Numbers caught appear to have increased since 2004 and ranged between 162 and 291. The CPUE in 2009 and 2010 was similar at 18.6 fish per minute which is likely an indication that the size of the recruitment population has likely stabilized and in fact has increased considerably from 2004. In addition, baseline surveys of the Hakim Lake outlet in 1997(Jacques Whitford Environment Limited [JWEL] 1997a, b) indicated a CPUE of 4.35 fish/minute. Thus this is considered indicative that the transferred population is exceeding its original recruitment levels.

Table 6. Electrofishing surveys for Brook Trout from White Lake Channel, 2004-10.

Year	Month	No. Fish Caught	CPUE (fish/minute)
2004	September	20	0.63
2005	September	233	NC[1]
2006	August	171	NC[1]
2008	August	210	NC[1]
2009	August	291	18.6
2010	August	162	18.6

NC[1] - not calculated

While there are no recordings reported of Lake Chub from the electrofishing surveys in the channel except for two in 2004, given that the trap net surveys showed CPUE for Lake Chub slowly increasing this suggests they did survive but may not be utilizing the channel for spawning/rearing.

This difference between the visual surveys and electrofishing survey has identified the need not to rely on a single method when evaluating the establishment of fish populations in particular changes in levels of recruitment. It also identifies the requirement to ensure data are collected and reported in the same manner each monitoring year.

Electrofishing conducted in Pond 61 was conducted at different times in 2005 (no CPUE was estimated) and 2006, mid-late July and early August, respectively. Since 2007 the survey time has occurred during the first two weeks of July. The estimate of relative abundance for Arctic Charr recruits between 2006 and 2014 varied however it would appear to be stabilizing (Figure 8).

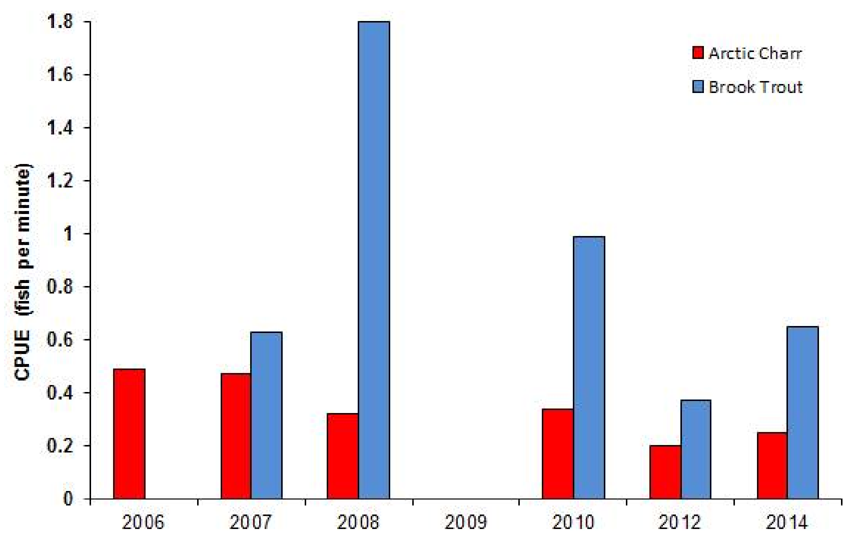

Figure 8. CPUE for Arctic Charr and Brook Trout from Pond 61 tributaries, 2006-14.

There was a large increase in relative abundance of Brook Trout between 2007 and 2008. Since 2008 CPUE has decreased however it appears to be stabilizing in the later years, which is indicative of increased use of riverine habitats and production of recruits (age 0+). As seen in the trap net surveys (Figure 7) CPUE for Brook Trout from electrofishing show similar trend towards stabilization.

Fish Population Structure

Metrics taken on fish caught included fork length and weight. From those data, length frequency histograms were created and an estimate of condition factor (K) was calculated. These metrics were used to evaluate the population structure, health and growth of the transferred fish over time. For White Lake, data were presented based upon length and/or age frequency histograms where both mean weight and condition factor were calculated for each age class. Information for Pond 61 data was presented as means only.

Length

Length frequencies for Brook Trout transferred from Hakim Lake in 2003 are compared to Brook Trout in White Lake between 2005 and 2008. The length frequency demonstrates the changes in the population over time and in particular that fish are reproducing as evidenced by the annual presence of small-sized fish in each monitoring year since 2005 (Figure 9). It appears that by 2008 the population may be returning to pre-transfer condition.

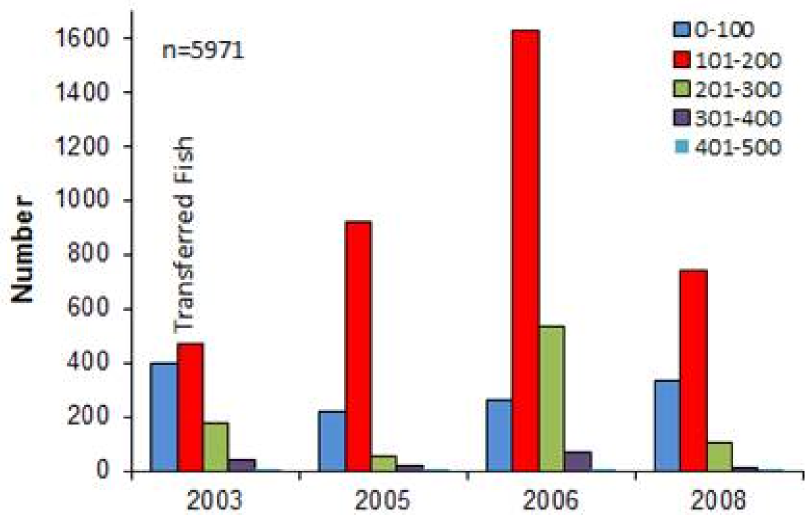

Figure 9. Length frequency for Brook Trout, White Lake, 2003-08.

Length frequencies for Arctic Charr and Brook Trout from 2004, when fish were transferred from Headwater Pond, are compared to those for Pond 61 between 2005 and 2014 (Figure 10). Brook Trout length frequencies distributions indicate a period of adjustment between the fish transfer and 2008. Between 2008 and 2012 there has been an increase in the number of young fish indicating recruitment is occurring. As well by 2010 there is evidence of an increase in the presence of older aged fish. The reason for the decrease in the Brook Trout 0-100 mm length group in 2014 is unknown however the electrofishing surveys indicates that Brook Trout are in fact spawning in the tributaries. Overall the population structure in Pond 61 is now comprised of multiple length groups and may have reached a stabilized state.

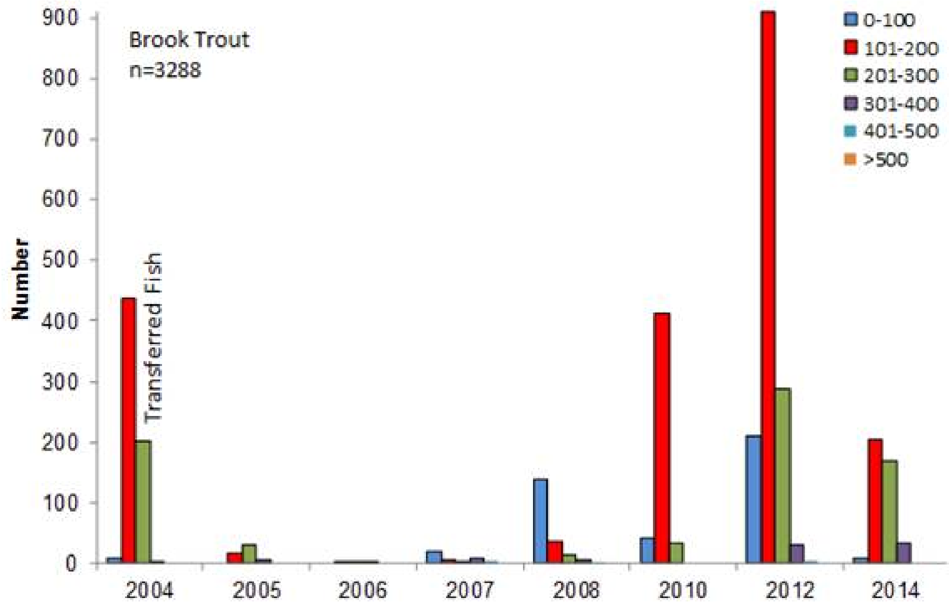

Figure 10. Length frequencies for Brook Trout from Pond 61, 2005–2014.

The length frequencies for Arctic Charr are indicative of an initial decline, similar to Brook Trout, but since 2007 the population structure seems to be stabilizing and in fact appears to be more robust than the population prior to the transfer (Figure 11).

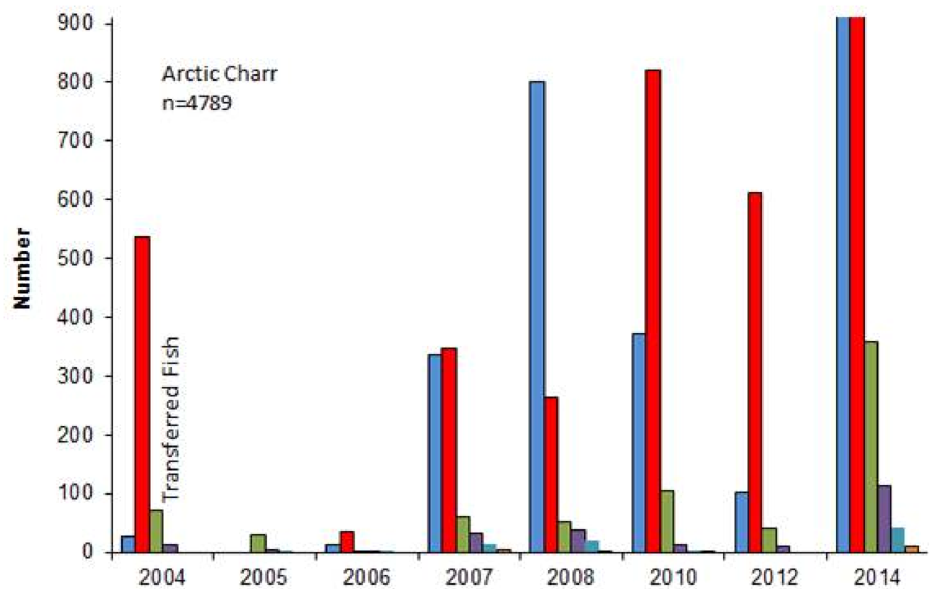

Figure 11. Length frequencies for Arctic Charr from Pond 61, 2005-14.

Age

Aging of fish was only done for Brook Trout from White Lake. The continued presence of age 0+ and 1+ demonstrate that there is an ongoing level of recruitment (Figure 12).

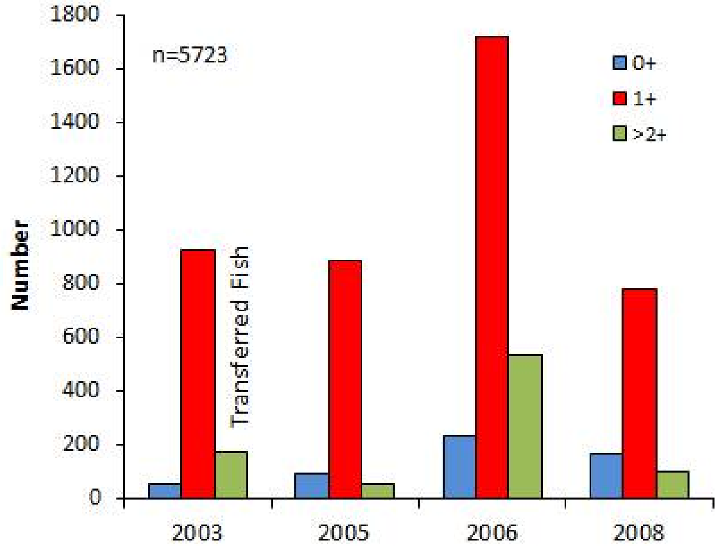

Figure 12. Length frequencies for Brook Trout from White Lake, 2005-08.

Weight

Figure 13 compares weight-by length group for Brook Trout transferred in 2003 to those in White Lake from 2005-08. For the first few years, fish gained weight much faster but as time passed, growth began to taper off and appears to be returning to similar levels prior to the transfer from Hakim Lake in 2003. This may be an indication that the population has reached its carrying capacity. Given that there are reports of fishing pressure for Brook Trout over the past few years it could also be an indication that larger sized fish are being removed from the population.

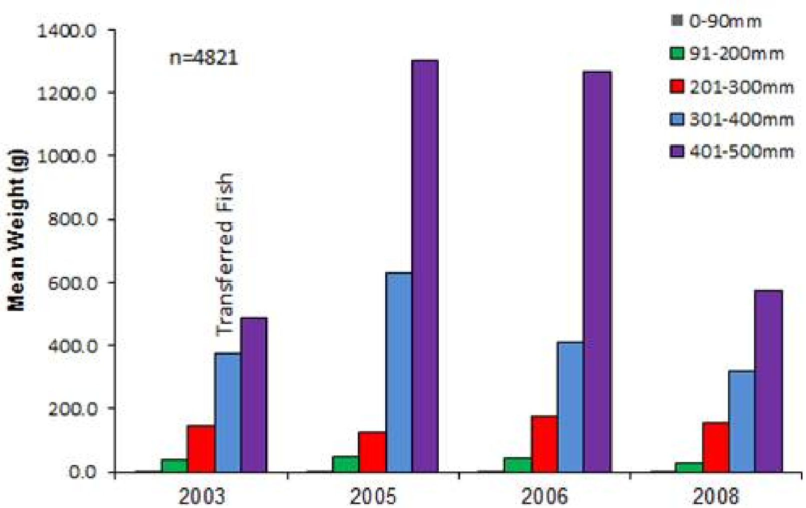

Figure 13. Weight-by-length group for Brook Trout from White Lake, 2004-08.

The weight by length group for Arctic Charr and Brook Trout from Pond 61 are depicted in Figure 14. Brook Trout mean weight for the smaller length groups appears to have increased initially up to 2007 but since 2008 have declined back to levels similar to that prior to the transfer (Figure 14). This may be an indication that the growth rates may be stabilizing. Given the small sample size for the larger fish (e.g. 1-3 fish) it is difficult to determine any trends over time.

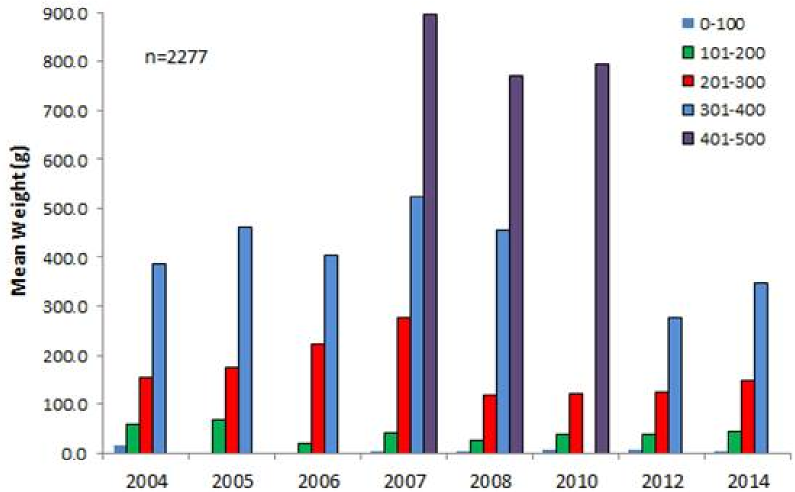

Figure 14. Weight-by-length group for Brook Trout from Pond 61, 2005-14.

A similar pattern is observed for growth rates for Arctic Charr at sizes less than 400 mm (Figure 15). Since 2007 larger sized Arctic Charr (>401 mm) are being caught and their growth rates appear to be on the increase with all length classes being represented at mean weights similar between years. This is indicative of a healthy sustaining population.

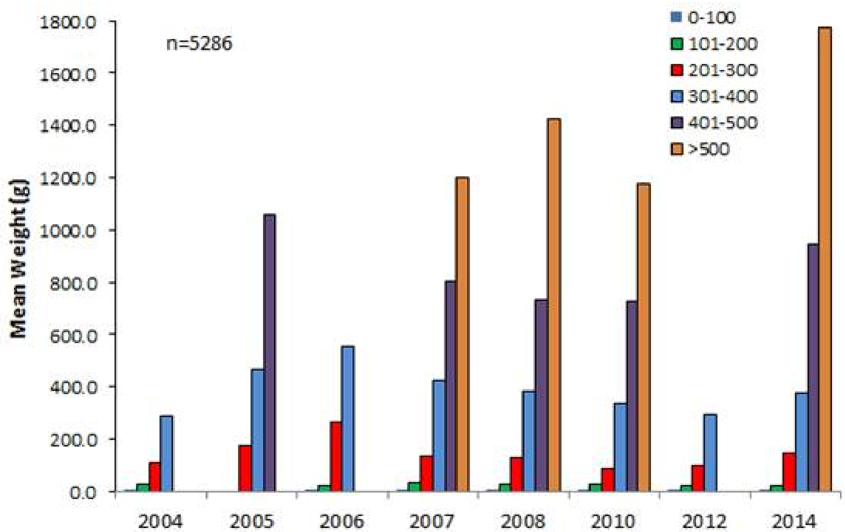

Figure 15. Weight-by-length group for Arctic Charr from Pond 61, 2005-2014.

Condition

The condition factors for Brook Trout from White Lake have shown changes over the years. In 2003 the condition factor was generally 1.0 for most age classes (range 0.6-1.3). Between 2004 and 2006 the condition factor increased for all age classes but in 2008, condition factors decreased and ranged 0.9-1.0. These values are comparable to pre-transfer state and may be indicative that the population has reached its carrying capacity.

Like the length and weight metrics for Arctic Charr and Brook Trout from Pond 61, only mean condition values (K) were provided. In 2004, the mean condition factor for Arctic Charr was 0.95. It then increased to 1.28 in 2005, generally stayed between 0.90-0.97 between 2006 and 2008. In 2010 a decrease was observed and since then the condition factor fluctuated but in

2014 it was back to a value of 0.87. While the value is below the value for fish transferred in 2004, it is believed the decline is due to the population reaching its carrying capacity.

A similar trend was observed for Brook Trout. The condition factor for Brook Trout was initially 1.04 in 2004. It then increased to 1.18 dropping generally to between 1.05 and 1.07 between 2006 and 2010. Subsequently the condition factor appears to have stabilized as it ranged between 0.9-0.97 between 2010 and 2014.

This trend in condition factors for both Brook Trout and Arctic Charr could indicate that the carrying capacity of Pond 61 has been reached. Also, as mentioned previously, condition factors by age class or length group provides a clearer picture on changes in population than just reporting mean condition.

CONCLUSIONS

Monitoring fish habitat compensation must be undertaken for a long enough period of time in order to allow changes to be detected, and to identify if modification of the habitat compensation if necessary. Data support the requirement that monitoring at a minimum should be conducted for a least one life cycle of the target fish species. While Quigley et al. (2006) suggest at least monitoring for two life cycles of the target species, the logistics and cost especially in northern locations, may be prohibitive. At least one full life cycle was evaluated and given that the life cycle of Brook Trout is considered short-lived in western Labrador, a five-year monitoring program was considered suitable (Grant and Lee 2004). A similar time period was considered suitable to determine changes in the Lake Chub population. Two additional years of data collection (2009-10) were only required for the White Lake channel due to modifications to the control weir at the downstream end of the channel. Because the life span of non-anadromous Arctic Charr is longer than for Brook Trout (estimated 9 years) additional years of monitoring were required for Pond 61 (i.e., 10 years).

As evidenced from both survey results for White Lake and Pond 61, fall redd surveys have been shown to be an ineffective metric, and as such is not recommended as a suitable tool for evaluating spawning habitat utilizations. On the other hand a visual survey to assess the presence of young-of-the-year fish has been shown to have some level of value in evaluating the success of spawning. This metric provided annual observations showing 0+ and 1+ fish utilizing spawning/rearing habitats which is an indication of annual recruitment into the populations. However a visual survey can only be useful if combined with a detailed survey demonstrating the level of use, e.g., electrofishing survey.

CPUE can be a useful metric in providing a measure of relative abundance over time. However, it is important to sample using similar gear types and conduct sampling at similar time periods in order to reduce variability. Another consideration is the location of sampling. This is demonstrated when comparing the CPUE for Lake Chub in White Lake versus the spawning channel. There were no Lake Chub being caught during the electrofishing surveys in the channel, however the trap net surveys showed CPUE for Lake Chub slowly increasing. The first would give an indication that Lake Chub did not survive the transfer, while the trap net indicates survival but no utilization of the channel. This difference between the metrics from two methods has identified the need not to rely on a single method when determining the establishment of fish populations.

It is also important to have metrics on population structure and fish health. As seen between White Lake and Pond 61 data, effective presentation of the information is also necessary. Providing metrics based on age class would likely be more effective in describing changes to population structure than by length group alone.

Another important consideration to is to ensure there are baseline data to compare to the monitoring results. In the instances of fishless lakes, metrics on the fish to be transferred are critical in determining the success or failure of the compensation option. Along with this, there is a requirement to ensure suitable metrics are collected on the receiving waterbody prior to its consideration as a suitable compensation option. It is suggested that reporting metrics on population structure provide a clear picture of changes over time. As well metrics such as condition factor can be influenced by age, maturity state, gut fullness, etc. so long term data are required to verify changes. Overall the metrics employed in monitoring the habitat utilization and fish assessment/health appear to be effective, and demonstrate the level of success in establishing fish populations in fishless lakes.

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