Fisheries and Oceans Canada / Pêches et Océans Canada
Science / Sciences

C S A S / **S C C S**

Canadian Science Advisory Secretariat / **Secrétariat canadien de consultation scientifique**

Research Document 2010/095 / **Document de recherche 2010/095**

Recommendations for managing brook trout, *Salvelinus fontinalis*, stocks on the Jonathans Brook watershed, Newfoundland and Labrador, Canada, using fisheries dependent and independent data.

Recommandations pour la gestion des stocks d'omble de fontaine, *Salvelinus fontinalis*, du bassin hydrographique Jonathans Brook, à Terre-Neuve-et-Labrador, au Canada, à l'aide de données qui dépendent des pêches ou non

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ISSN 1499-3848 (Printed / Imprimé)
ISSN 1919-5044 (Online / En ligne)

Correct citation for this publication:

Keefe, D.G. and R.C.Perry. 2010. Recommendations for managing brook trout, *Salvelinus fontinalis*, stocks on the Jonathans Brook watershed, Newfoundland and Labrador, Canada, using fisheries dependent and independent data. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/095. iv + 23 p.

ABSTRACT

This study examines the effectiveness of the current brook trout, *Salvelinus fontinalis*, regulations (daily: 12 trout or 2.27 kg + 1 fish, possession: twice daily limit) on the Jonathans Brook watershed, Newfoundland and Labrador, Canada. Attitudinal surveys conducted on the Jonathans brook watershed revealed that anglers believe fish stocks have declined and that the current regulations are ineffective. Fisheries dependant data estimated angler catch at 2.6 fish per trip with the angled catch composition composed, primarily, of small immature fish. Fisheries independent data showed that the majority of fish reached sexual maturity by age 3. On average fish remained in the population for only 3.99 years which limited breeding opportunities. Growth projections derived using the von Bertlanffy growth equation indicated brook trout could reach an asymptotic length of 58 cm. We estimate that brook trout in the system mature between 12.5 and 28.5 cm. Based on length at sexual maturity, we provide data to support establishing a minimum size at retention regulation of 23 cm. This should provide protection for maiden spawning brook trout in the Jonathans Brook watershed. This protection will likely increase the mean size and abundance of brook trout in the lakes, and in angler catches.

RÉSUMÉ

Cette étude se penche sur l'efficacité de la réglementation actuelle concernant l'omble de fontaine, *Salvelinus fontinalis*, (quotidien : 12 truites ou 2,27 kg + 1 poisson, possession : deux fois la limite quotidienne) dans le bassin hydrographique Jonathans Brook, à Terre-Neuve-et-Labrador, au Canada. Les études de comportement effectuées pour le bassin hydrographique ont révélé que les pêcheurs pensent que les stocks de poisson ont diminué et que la réglementation actuelle est inefficace. Selon les données qui dépendent des pêches, on estime le nombre de prises à 2,6 par pêcheur par voyage, les prises consistant principalement en des petits poissons qui n'ont pas atteint la maturité. Les données qui ne dépendent pas des pêches ont indiqué que la majorité des poissons atteignaient la maturité sexuelle avant l'âge de 3 ans. En moyenne, les poissons sont restés au sein de leur population pendant seulement 3,99 ans, ce qui a limité les occasions de reproduction. Les prévisions de croissance obtenues à partir de l'équation de croissance de von Bertlanffy ont indiqué que l'omble de fontaine pouvait atteindre une longueur asymptotique de 58 cm. On estime que l'omble de fontaine atteint la maturité à une longueur se situant entre 12,5 cm et 28,5 cm. Selon la longueur à la maturité sexuelle, nous fournissons des données à l'appui de la mise en place d'une réglementation sur la rétention pour une longueur minimale de 23 cm. Ceci devrait assurer la protection de l'omble de fontaine qui fraie pour la toute première fois dans le bassin hydrographique Jonathans Brook. Cette protection permettra probablement d'augmenter la grosseur moyenne et l'abondance de l'omble de fontaine dans les lacs et pour les prises des pêcheurs.

INTRODUCTION

Brook trout *Salvelinus fontinalis* has long been considered a popular game fish, and is ubiquitous throughout Newfoundland and Labrador (Scott and Crossman 1964). To regulate this fishery, the Department of Fisheries and Oceans (DFO) relies on the manipulation of bag limits and season lengths. In many areas of the province the current bag limit has not been tested to determine its effectiveness for managing fisheries.

The intent of bag limits is to reduce the overall fishing mortality, minimizing the probability of overexploitation, or maintaining the abundance of larger fish commonly sought by anglers. However, bag limits will only be effective where exploitation rates are low. Where angler numbers are great, exploitation rates may be too high for bag limits to be effective (Post et al. 2003). Generally, bag limits continue to be used because they are easily understood by anglers, fish and game officers, and the judicial system. Sociologically, they give anglers a specific goal for their fishing trips and the satisfaction of catching "their limit" of fish (Nobel and Jones 1993).

An alternative or complementary management strategy, which takes into account the exploitation rate, is the application of minimum size limits. Minimum size limits are established based on the average length at which a fish becomes sexually mature. Typically, fish are not allowed to be harvested until they have passed this length at first maturity (Noble and Jones 1993). This gives fish greater opportunities for reproduction. Throughout North America, minimum size limits have been used to protect immature fish, and prevent growth and recruitment overfishing.

The Jonathans Brook watershed, located near the town of Gander, Newfoundland and Labrador, is a popular location for angling brook trout. Anecdotal evidence indicates that brook trout caught in this system have exceeded 1 kg in weight. However, conservation groups and anglers have alleged that both the quantity and size of brook trout in this system have declined. They have expressed concern that the current regulations are an ineffective tool for sustaining the quality fishery.

In this study, we use data collected from the recreational fishery, and index netting surveys to determine if the current management regime (daily: 12 trout or 2.27 kg + 1 fish, possession: twice daily limit) is appropriate for the Jonathans Brook watershed. We also use an angler social survey to assess angler opinion on the status of the fishery.

METHODS

STUDY AREA

The watershed is composed of four lakes which feed into the Gander River by way of Jonathans Brook (Fig. 1). These lakes are Whitmans Pond (Surface Area (SA) = 0. 775 km^2; mean depth = 1.2 m), Big Jonathans Pond (SA = 5.41 km^2; mean depth = 3.8 m), Jonathans Park Pond (SA = 0.789 km^2; mean depth = 1.7 m), and Lower Jonathans Pond (SA = 1.12 km^2; mean depth = 3.5 m) (Fig. 1). Lower Jonathans and Whitmans Pond are accessible by trail, while Jonathans Park Pond and Big Jonathans Pond are accessible by road. Jonathans Park Pond is a bordered by a private park. All lakes in the watershed are accessible by snowmobile during winter. This watershed in located in the Central Newfoundland Ecoregion (Northcentral Subregion) with forests dominated by black spruce and aspen stands (Meades and Moores 1994).

FISHERIES DEPENDANT DATA

Creel Surveys

To obtain catch and effort information, angler surveys were conducted following roving creel methodology (Malvestuto 1996; Pollock et al. 1997) with a progressive count (Hoenig et al. 1993). Surveys were conducted for four years (2004-07). The winter ice fishing season runs February 1 through April 15. Each season Conservation Officers (from the Department of Natural Resources, Government of Newfoundland and Labrador) were asked to perform a minimum of 20 surveys. The surveys collected: the number of anglers in a party, number of rods used, the length of time fished, and the number of fish kept and released by species. Additionally, harvested catch were measured for fork length (mm) and otoliths were removed for age interpretation.

In 2005 and 2006 we added an additional component to the normal survey routine. Upon completion of each interview, officers were instructed to request one person from each angling party to participate in a follow-up survey. They were given self-addressed, postage-paid survey cards to be filled out upon completion of the fishing episode. Each card had a serial number corresponding to the information in the roving creel logbook. The mail-in cards also included a stub that held the angler's name and phone number in the event that follow up phone calls were required. The cards were used to collect complete trip information about the number of people that fished, number of rods used, the length of time fished, and the number of brook trout kept and released. As an incentive to complete and return the cards, each angler was told they would receive an embroidered cooperating angler baseball cap.

Angler Attitudinal Survey

Angler compliance to fisheries regulations is critical to ensure regulative changes reflect the specific user group's attitudes and beliefs. To this end, attitudinal studies provide insight into anglers impressions regarding a fishery and help in identifying the appropriate management strategy (Schoolmaster and Frazier 1985; Fedler and Ditton 1994). As part of our overall assessment of the Jonathans Brook watershed we chose to implement an attitudinal survey of the anglers. Specifically, we hoped to describe demographics and determine if there was consensus amongst anglers on the perceived state of the fishery. In the event that an alternative regulatory strategy was required we also wanted to determine which regulative options would be most acceptable. Demographic, fishery perception, and agree/disagree questions were asked to measure angler attitudes and perceptions (Sheskin 1985; Alreck and Settle 1995). The questionnaire is shown in Appendix A.

FISHERIES INDEPENDENT SAMPLING

A spring littoral index netting program was conducted in 2004 and 2005. Standardized nylon monofilament gill nets increasing in mesh from 0.5 inch to 5.0 inch by 0.5 inch increments were used to sample fish populations. Net locations were chosen randomly and set perpendicular to the shoreline in the sampled lakes. Small fyke nets were used in the littoral zones of shallow bays and inlets to determine what non-game fish species may be present. Sampling commenced in early May. This time period was chosen since lakes are considered to be homoeothermic and species are not stratified based on temperature optimums, reducing potential sample bias. A reproductive survey was conducted during the fall of 2005. Small fyke nets were set near lake inlets and outlets to gather a sample of sexually mature fish.

Fish taken from the nets were catalogued based on site number and mesh size. Lethally sampled fish were measured for fork length (mm), whole weight (g), somatic weight (g), sex, maturity, and stomach contents. Fork length was measured on released fish. Otoliths were removed for age interpretation and a fin clip was taken for archival genetic material.

ANALYSIS

FISHERIES DEPENDANT

Attitudinal Survey

Respondent demographics and responses were analyzed with a chi-square test ($\alpha = 0.05$). Responses to the questionnaire were grouped based on three categories. Those that responded with a ranking that equated to disagree (a ranking of 1 to 3), those whose responses were ambivalent (a ranking of 4), and those whose rankings indicated they agreed (a ranking of 5-7). Tests for significant differences were performed between disagree and agree categories. Additionally, we converted the initial weighted rankings into equivalent rankings by recoding disagree (below 4) and agree (above 4) responses as follows:

Disagree:	1 recoded to 3
	2 recoded to 2
	3 recoded to 1
Agree:	5 recoded to 1
	6 recoded to 2
	7 recoded to 3

Creating equally weighted scorings allowed for the generation of a strength score to evaluate the vehemence of an interviewees opinion.

Roving Winter Creel

Catch and effort statistics were calculated for each year by pond, and then averaged for all years (2004-2007). Catch rate (brook trout caught/ angler-hour) was calculated using the mean of ratios estimator with elimination of short trips (less than 30 minutes) (Hoenig et al. 1997, Pollock et al. 1997, Keefe and Perry 2006). Seasonal effort was determined using the number of anglers counted at each lake during the survey days (Hoenig et al. 1993, Keefe and Perry 2006). Total catch was calculated as the product of effort multiplied by catch rate. Release rates were established based on the number of fish anglers reported returning to the water. Release rate was calculated as $RR = \frac{NR}{NC}$, where *RR* is the release rate, *NR* is the number released and *NC* is the number of fish caught. Additionally, to estimate mean catch (brook trout kept + released) and harvest (brook trout kept) per angler trip, we used estimates derived from the post card survey (Keefe et al. 2009). To model the angled catch, length and age frequency distributions were created.

FISHERIES INDEPENDENT

Survival

Estimates of annual survival (*S*) with a 95% confidence interval (CI) were obtained using Robson and Chapman's (1961) maximum-likelihood estimate of survival as discussed by Ricker (1975) and Miranda and Bettoli (2007) with a 95% confidence interval (CI).

We used Abrosov's index to describe the annual rate of turnover for all lakes in the study and watershed as a whole (Abrosov 1969). The annual rate of turnover refers to the amount of time (in years) a fish remains in a water body until removal. For the purposes of comparison, analysis was performed only on data collected from gill net sampling conducted during the month of May for both sample years (2004 and 2005).

Age, growth, and sexual maturity

Onset of sexual maturity was determined using visual appearance of gonad development during spring and fall dissections as described by Ricker (1970) and Vladykov (1956). Sexual maturity was established based on the age when at least 50% of the age cohort was deemed mature.

Growth (in length) potential for the Jonathans Brook watershed was modeled using the von Bertlanffy (1938) growth equation as described by Isely and Grabowski (2007). Immature and mature brook trout were plotted using age-length error bar graphs with a 95% CI around mean length.

RESULTS

FISHERIES DEPENDANT

Attitudinal Survey

A total of 72 anglers completed the social survey. Of the respondents, 90% were residents of Gander. The mean age of respondents was 52.

Chi-square analysis indicated that anglers significantly disagree with the statement that trout stocks in the Jonathans Watershed are as healthy as they ever were (X^2 = 6.231, P = 0.013, N = 52) (Fig. 2). Anglers also disagreed with the statement "I frequently catch the bag limit on the Jonathans Watershed" (X^2 = 35.267, P < 0.001, N = 60) (Fig. 3).

Fishers significantly agreed with the statement "I support a minimum size limit regulation for trout on the Jonathans Watershed" as well as "I support a bag limit reduction for trout on the Jonathans Watershed" (minimum size: X^2 = 42.639, P < 0.001, N = 61; bag limit: X^2 = 11.655, P = 0.001, N = 58) (Fig. 4 and Fig. 5).

When anglers where posed with statements regarding shortening both winter and summer angling seasons, there was significant disagreement with shortening the winter season (X^2 = 14.516, P < 0.001, N = 62) (Fig. 6). There was not a clear relationship established regarding the summer angling season (X^2 = 2.373, P = 0.123, N = 51) (Fig. 7).

Roving Winter Creel

As confirmed by the survey questionnaire, the principle sport fish sought by anglers in the watershed was brook trout. Other species caught, incidentally by anglers, include, ouananiche (and salmon) *Salmo salar*, and rainbow smelt *Osmerus mordax*.

Combined mean estimates for seasonal effort, catch rate and total catch were calculated for each pond and for the overall watershed for each year surveyed (Table 1). Mean values for catch rate, effort and total catch varied among ponds and for the watershed. Big Jonathans Pond showed the highest effort at 2469.70 angler-hours/years yet the lowest catch rate at 0.524 brook trout per angler-hour. Average total annual catch for the watershed was recorded as 1294.12 trout. Whitmans Pond received the lowest effort at 200.08 angler-hours/years and subsequently a low average for total annual catch (291.32 brook trout). However, catch rate was highest at 1.456 brook trout per angler-hour. Mean catch and harvest for the Jonathans Brook watershed was estimated at 2.6 and 1.9 fish per angler trip, respectively. The average release rate for the years surveyed was calculated at 17.3% for the entire watershed. Release rates for the total catch during the years surveyed ranged from 3.3% for Whitman's Pond to 27.2% for Jonathans Park Pond (Table 2). Between 2004 and 2007 a total of 422 brook trout were sampled for length and 392 were sub sampled for age (Fig. 8 and Fig. 9). Minimum length recorded was 18 cm and the maximum was 51 cm. The largest proportion of fish measured fell between 21 and 24 cm. Mean age of the angled catch was 3.97 years. The oldest fish was interpreted at 8 years (Fig. 9).

FISHERIES INDEPENDENT

In total, 34 gill nets and 38 fyke nets were set for both sampling years combined. The netting program allowed us to sample 464 brook trout, of which 405 were successfully age interpreted. Fish species identified during netting episodes included brook trout, Atlantic salmon (including ouananiche) *Salmo salar*, American eel *Anguilla rostrata*, rainbow smelt *Osmerus mordax* (found in stomach of brook trout in Big Jonathans Pond), threespine stickleback *Gasterosteus aculeat*us, and ninespine stickleback *Pungitius pungitius*.

Survival

The mean annual survival rate was 45.9% for the entire watershed. At the individual pond level, survival rates ranged between a low of 38.0% in Whitmans Pond to a high of 52.9% in Big Jonathans Pond (Table 3).

Table 4 shows Abrosov's (1969) index values for each pond in the Jonathans Brook watershed. We estimate that brook trout in the Jonathans system survive 0.99 years past the onset of sexual maturity.

Age, growth, and sexual maturity

Table 5 shows percent maturity by age group for brook trout sampled in the Jonathans Brook watershed. The age at which at least 50% of the fish were sexually mature was 3 years. In total, 70.3% of brook trout in this age group were mature. Ninety five percent of the four years old fish were interpreted as being mature. By age 6 all fish were determined to be sexually mature.

Asymptotic length for the Jonathans Brook watershed was estimated at 58 cm using the von Bertlanffy (1938) growth equation (Fig. 10). An age-frequency distribution is shown in Fig. 11. The youngest fish was interpreted at age 1 with the oldest at age 8.

DISCUSSION

It would appear that the majority of anglers fishing the Jonathans Brook watershed believe that the brook trout recreational fishery has declined, and that regulative change is required if the fishery is to improve. In accordance with our attitudinal survey a significant number of the angling population (49.3%) strongly disagreed with the statement that the fishery was of the same quality that it had always been. This was in comparison to 23.9% who indicated that the quality had not changed (Fig. 2). When asked to agree or disagree with the statement that, anglers frequently catch the bag limit, 73.6% indicated that they strongly disagreed with the statement. This result is not surprising, given that anglers fishing the watershed average 2.6 fish per ice fishing trip (Keefe et al. 2009). This figure is significantly below the current regulated daily limit (Daily: 12 trout or 2.27 kg + 1 fish; Possession: twice daily limit).

The age cohort at which 50% of brook trout in the Jonathans Brook watershed were assessed as being sexually mature was 3 years (70.3%). However, the turnover rate calculated using Abrosov's index was approximately 3.99 years. Thus, the vast majority of brook trout are being removed from the population one year subsequent to maturation. The age distribution of fish sampled from the angled catch supports this finding. The vast majority of sampled fish were aged 3 and 4 (72%) (Fig. 11). It is interesting to note that of the 392 fish aged from anglers catch only 1% of the fish were 7 or older. The maximum age was 8.

When we compared fisheries statistics in the Jonathans Brook watershed to that of Indian Bay and Middle Brook watersheds we observed similarities in mortality, effort and catch rates for the time periods surveyed (Appendix B; Table 1). Anglers on both of these watersheds expressed similar concerns regarding the quality of their brook trout fisheries. In both instances, to improve the fishing quality, special management zones were established in which reduced season lengths, bag limits and weight restrictions were implemented. The Jonathans Brook watershed estimates fall within the Middle Brook and Indian Bay estimates, both of which have received special management zone status. Given our reported catch and harvest rates it appears that the current regulations are ineffective for sustaining a quality fishery.

The average length for a three year old fish is 23 cm. Figure 12 shows the zone of maturation (start of maturity and end of immaturity) of brook trout in the Jonathans Brook watershed. The majority of fish smaller than 23 cm are sexually immature. We estimate that 24% of the current harvest is composed of immature fish. We determined the percent of the current harvest to be released was under three hypothetical minimum size limits of 220, 230, and 240 mm as shown in Table 7.

When considering a minimum size recommendation we must evaluate the growth potential for brook trout in our study area. The theoretical asymptotic length for the Jonathans Brook watershed was calculated at 58 cm using the von Bertlanffy (1938) growth equation (Fig. 10). Length data collected from the creel surveys indicates that only a small fraction of the sampled population approaches this length (Fig. 8).

To reduce juvenile mortality rates and thereby increase the numbers of larger fish in the population we are recommending that a minimum size limit is established that takes into account the length at which a fish becomes sexually mature. There is a substantial amount of literature which discusses the benefits of using minimum size limits to improve fisheries (Quinn et al. 1994; Lyons et al. 1996; Power and Power 1996; Munger and Kraai 1997; Maceina et al. 1998; Hale et al. 1999; Post et al. 2003; Perry 2006). While dealing specifically with brook trout, Hunt (1970) concluded that to prevent excessive harvest of brook trout, minimum size limits, if set appropriately, provide the best results for stock enhancement. Furthermore, it has been documented that as size limits for brook trout increase, total catch, yield and numbers of large trout harvested will also increase (Clark et al. 1981).

In Atlantic Canada, the provincial governments of both New Brunswick and Nova Scotia have implemented size limits for brook trout in designated waters and in special trout management areas. MacMillan and Madden (2007) found that a minimum size-limit imposed at West River, Antigonish, Nova Scotia resulted in a dramatic improvement in the quality of a sea-run brook trout fishery. Angler creel surveys on the West River revealed an increase in size, age, and numbers of fish caught post regulatory action. These limits were based predominately on the protection of maiden and second time spawning brook trout.

To estimate the influence of a minimum size limit on the Jonathans Brook watershed, we incorporated our brook trout life history parameters into a model which predicts the probability of population decline under different management scenarios (Adams et al. 2009). This model was developed specifically for brook trout and validated on 16 lakes in Newfoundland and New Brunswick. Under the current management regime the model predicted a 50% probability of population decline for the watershed. When a 23cm size limit was imposed, the probability was reduced to 32% (Appendix B; Fig. 1). It should be note that increasing the size limit beyond 23 cm would likely have an even greater positive impact. However, we feel that this would be too restrictive on the anglers who are utilizing this fishery and may result in discontent and subsequently non-compliance to any newly established regulation (Renyard and Hilborn 1986).

Subsequent to the establishment of a special management area for the Indian Bay watershed, Lester et al. (1999) underwent a similar modeling exercise. In this exercise they used creel and index fishing data collected from ponds of the watershed, to predict possible outcomes from minimum size limit regulations. Results indicated that size-based management would be effective in improving the brook trout fishery.

In addition, there is strong local support for regulative changes that include size based limits. Our survey indicated that 77.8% of the surveyed population supported the statement favoring minimum size limit regulations. The majority also favored bag limit reductions (58.3%).

If the proposed regulative change is to be effective, education and compliance will be important components of the proposed regulation change. The proposed minimum size limit will result in the release of larger numbers of fish. An outreach program should be initiated whereby anglers should be encouraged to use proper catch and release techniques as well as appropriate fishing gear to avoid excessive hooking mortality of undersized fish. When studying the effects of hooking mortality on brook trout in Montmorency County, Michigan, it was reported that the use of single-pointed hooks in conjunction with a minimum size limit significantly ($P < 0.05$) reduced fish death upon release (Nuhfer and Alexander 1992). Since the Jonathans Brook fishery is predominately a hook and bait fishery, anglers should be encouraged to use single pointed hooks as opposed to two or three pointed treble hooks.

The degree of compliance with a new regulation can also have a significant impact on the regulation's effectiveness. Subsequent to the new regulation being put in place, routine patrols should be established to ensure that the regulations are being followed. Gigliotti and Taylor (1990) used simulation modeling to evaluate the effects of illegal harvest in a minimum size brook trout fishery. They found that as illegal harvest of sublegal fish increased, numbers of legal fish harvested decreased. Although public education will serve as a vital component of the proposed regulations effectiveness, long term compliance monitoring will be essential on the Jonathans Brook watershed.

It would appear that the current management regime on the Jonathans Brook watershed does little to maintain the quality of the fishery. This is likely why the majority of anglers appear to be discontented with the fishery, and are receptive of a change to the current regulations. The data suggest that regulations based on size at sexual maturity have the greatest probability for success to improve the quality of the fishery. This, in combination with a good enforcement and education program should create the desired stock enhancement.

RECOMMENDATIONS

1. We recommend implementation of a 23 cm minimum size limit based on sexual maturity for the Jonathans Brook watershed. The new regulation should provide greater spawning opportunities for fish prior to removal. This regulation should also increase abundance and the presence of larger fish in the watershed.

2. Prior to implementation DFO should host a public meeting in the Town of Gander to consult the angling public that will be affected by the change.

3. An education and outreach program should be launched prior to or in conjunction with the start of the angling season affected. This could involve distribution of pamphlets, tape measures, fishing lures etc… which will help anglers understand the importance of the new regulation. It is hoped that this will be a cooperative venture involving the Wildlife Division, DNR, and DFO.

4. Compliance monitoring (DNR and DFO) should be emphasized in years following the proposed change to ensure success.

ACKNOWLEDGMENTS

We are happy to thank conservation officers Chris Murley, Roger Ward, Ryan Critchley and Tim Andrews of the Department of Natural Resources for assistance with data collection. We would also like to thank Wildlife Division staff Chris Callahan and Jerry Callahan for field assistance. Thanks to Larry Felt for edits and review of the social survey. We are indebted to Amanda LeDrew for collation of the raw data used in this report as well as Mark Young for his expertise in otolith preparation. Finally, thanks to Blair Adams and Christine Doucet for their editorial comments.

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Table 1. Mean fisheries statistics determined for ponds surveyed in the Jonathans Brook watershed years 2004-07 (Total for watershed determined using weighted means of the individual angler-party estimates).

Pond	Effort (hr)	Catch Rate (brook trout/angler-hour)	Total Catch (brook trout)	Number of Interviews
Whitmans	200.08	1.456	291.32	12
Big Jonathans	2469.70	0.524	1294.12	277
Jonathans Park	664.08	0.704	467.51	67
Lower Jonathans	852.74	0.607	517.61	95
Total for Watershed	1046.65	0.592	619.62	451

Table 2. Release rates (for the total catch) determined for ponds in the Jonathans Brook Watershed using winter roving creel data 2004-07.

Pond	Release Rate (%)
Whitmans	3.3
Big Jonathans	18.7
Jonathans park	27.2
Lower Jonathans	8.5

Table 3. Annual survival rate for each pond in the Jonathans Brook watershed determined using Robson and Chapman (1961) maximum likelihood estimate of survival. Approximate 95% confidence intervals are shown.

Pond	Annual Survival (%)	$CI_{0.95}$
Whitmans	41.9	$\pm$ 12.7
Big Jonathans	38.0	$\pm$ 9.4
Jonathans Park	52.9	$\pm$ 16.9
Lower Jonathans	51.0	$\pm$ 9.8

Table 4. Abrosov's rate of turnover, indicating the amount of time (years) a brook trout remains in the population until removal.

Pond	Age (yr)		
	Abrosov's Rate of Turnover	Onset of Sexual Maturity	Survival Past Onset of Sexual Maturity
Whitmans	4.12	3	1.12
Big Jonathans	3.83	3	0.83
Jonathans Park	4.24	3	1.24
Lower Jonathans	3.86	3	0.86
Watershed	3.99	3	0.99

Table 5. Percent maturity by age group for brook trout sampled in the Jonathans Brook watershed.

Age	Percent Mature %	Total Number of Brook Trout
1	8.3	12
2	14.1	78
3	70.3	111
4	95.0	119
5	98.0	49
6	100.0	26
7	100.0	9
8	100.0	1

Table 6. Release percentage of current harvest under three hypothetical minimum size limits for the Jonathans Brook watershed.

Minimum Size Limit (cm)	Release Requirement (%)
22.0	16.0
23.0	24.0
24.0	32.0

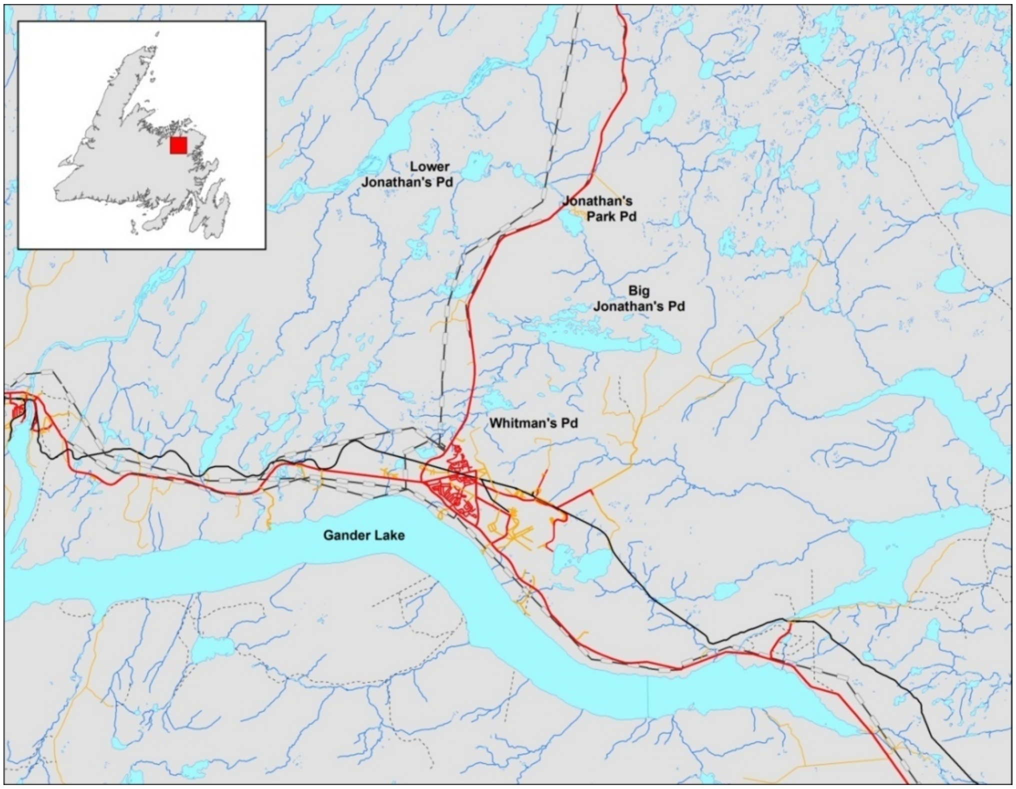


Figure 1. Jonathans Brook watershed showing ponds surveyed located near the town of Gander, Newfoundland and Labrador.

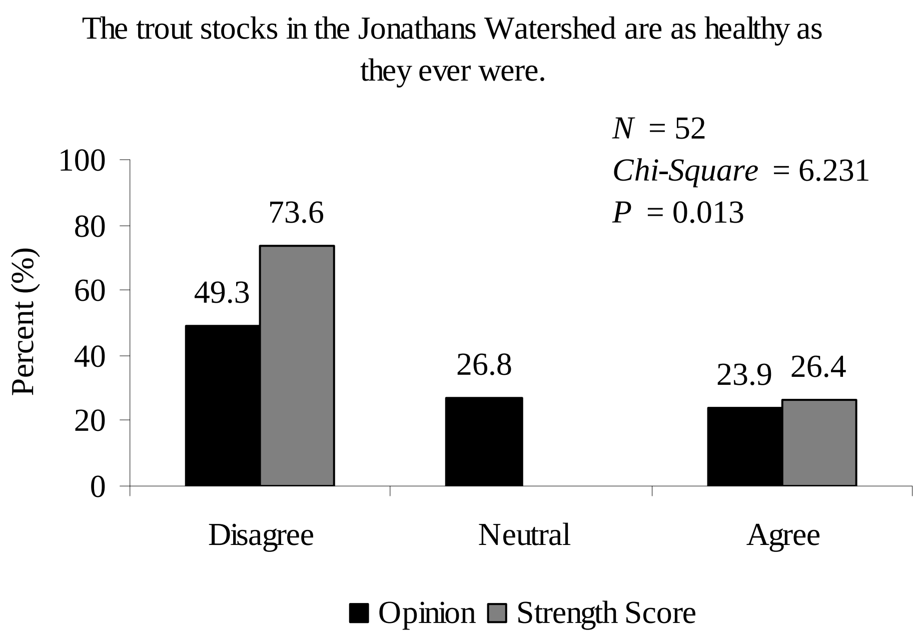
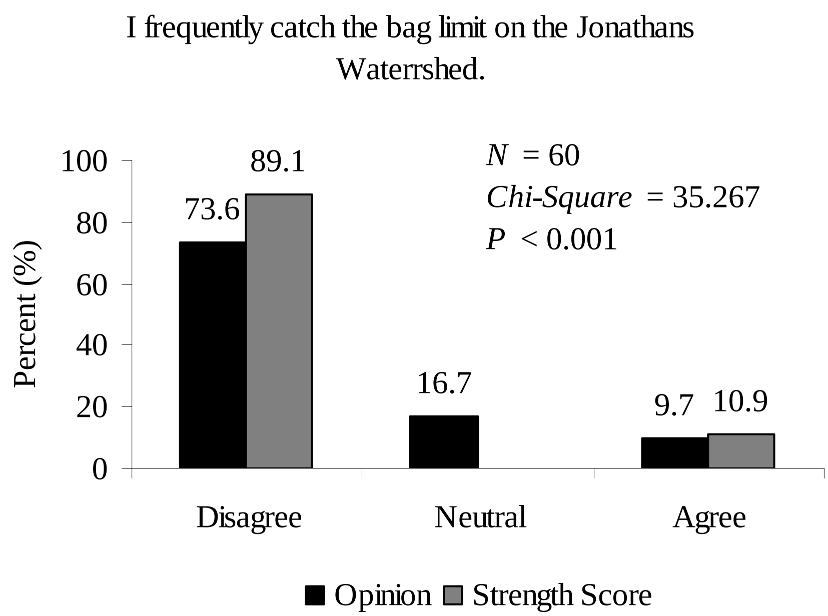


Figure 2. Statement presented to anglers during Jonathans Brook watershed social survey.



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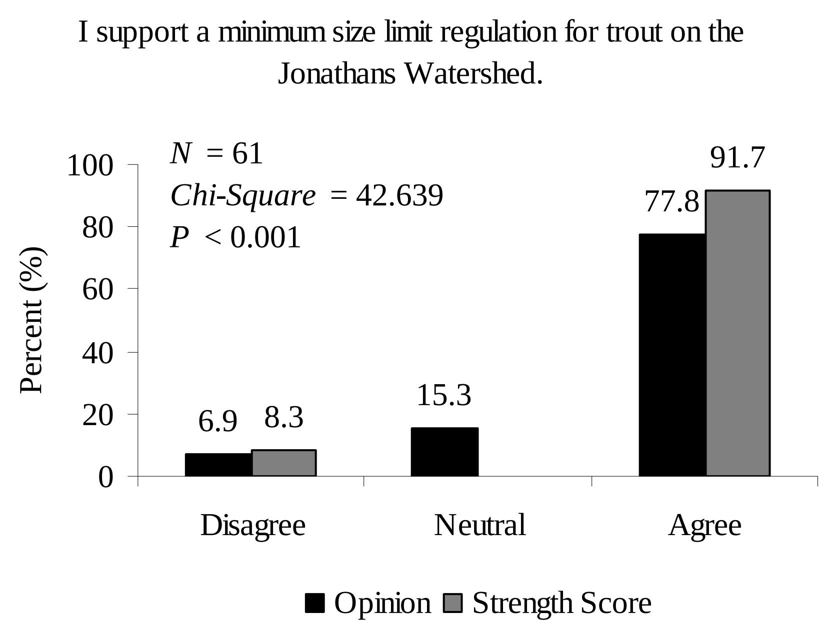

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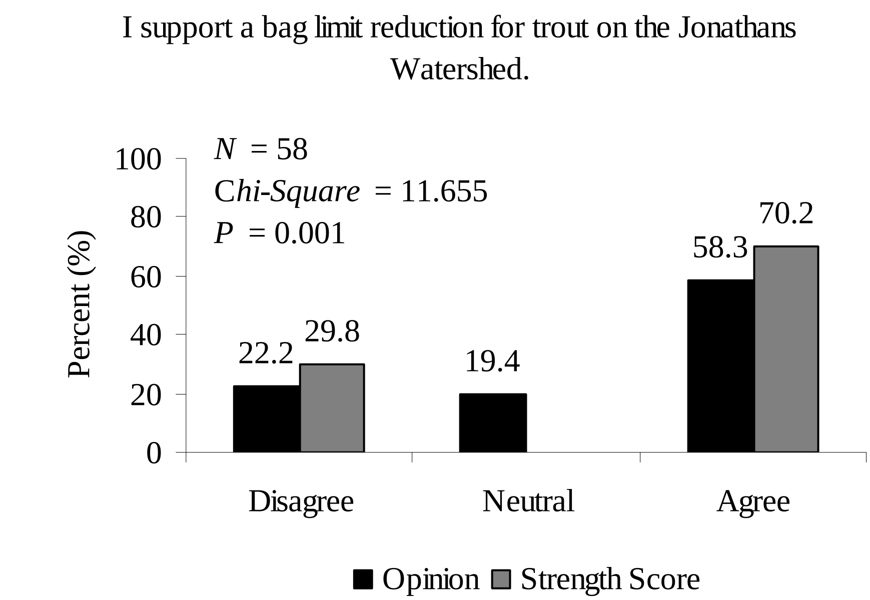

Figure 5. Statement presented to anglers during Jonathans Brook watershed social survey.

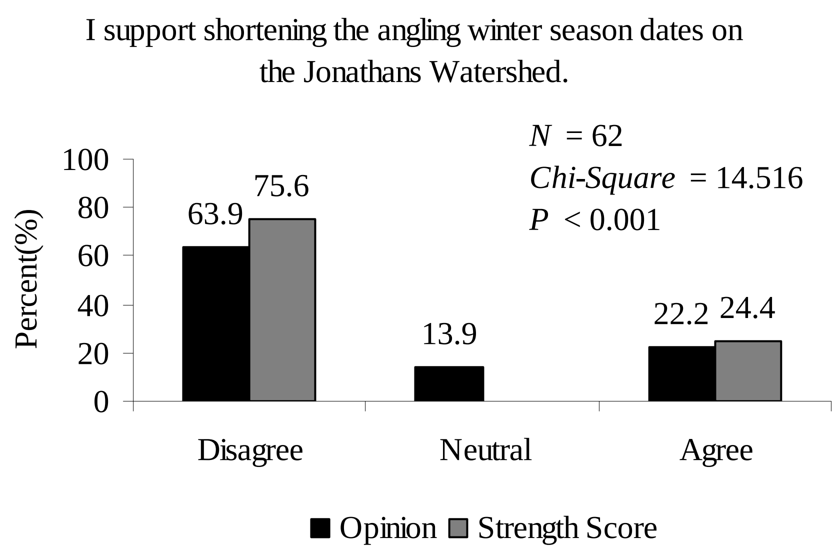

Figure 6. Statement presented to anglers during Jonathans Brook watershed social survey.

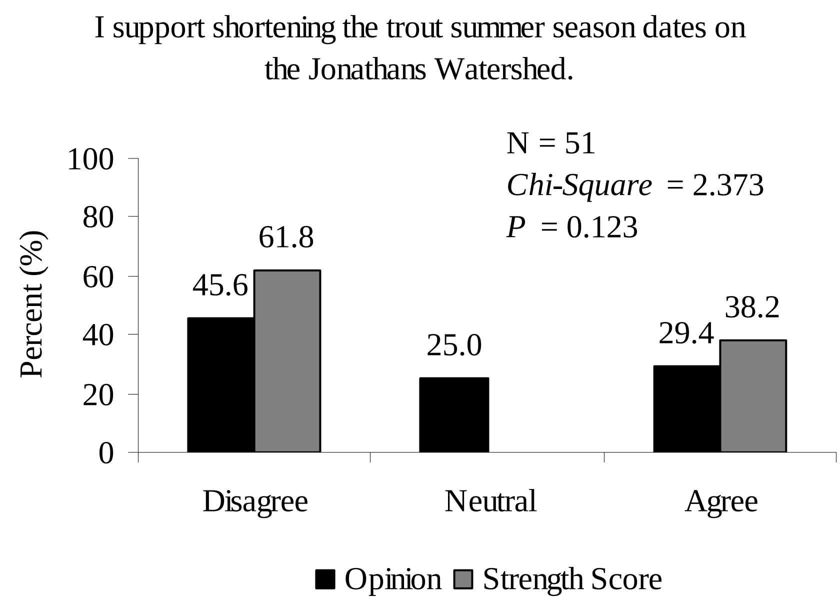

Figure 7. Statement presented to anglers during Jonathans Brook watershed social survey.

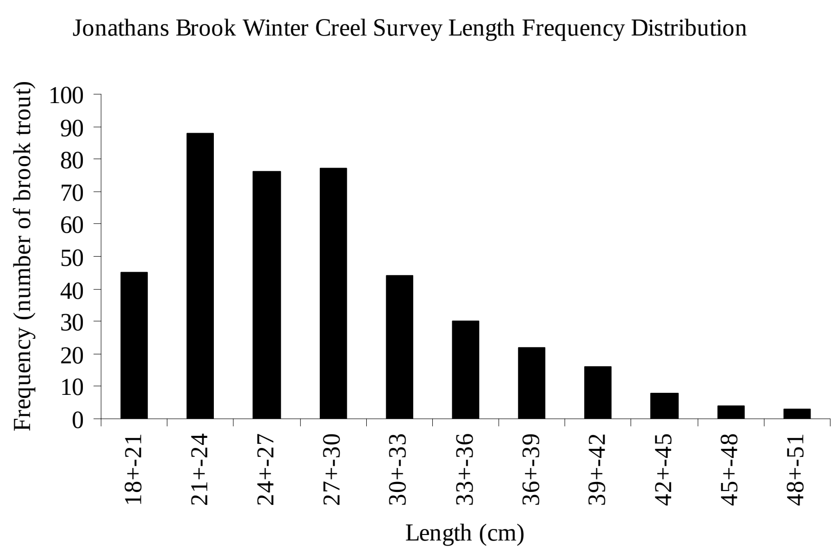

Figure 8. Length frequency distribution for fish measured during roving winter creel surveys conducted 2004-07.

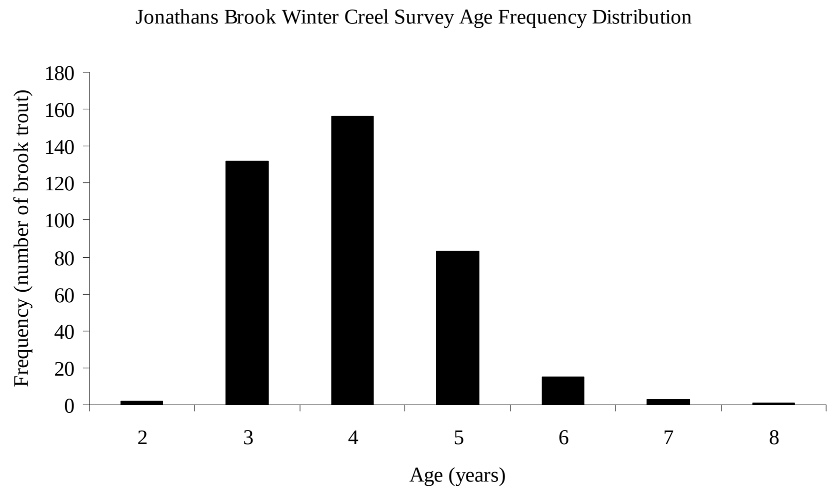

Figure 9. Age frequency distribution for brook trout sampled during winter roving creel surveys 2004-07.

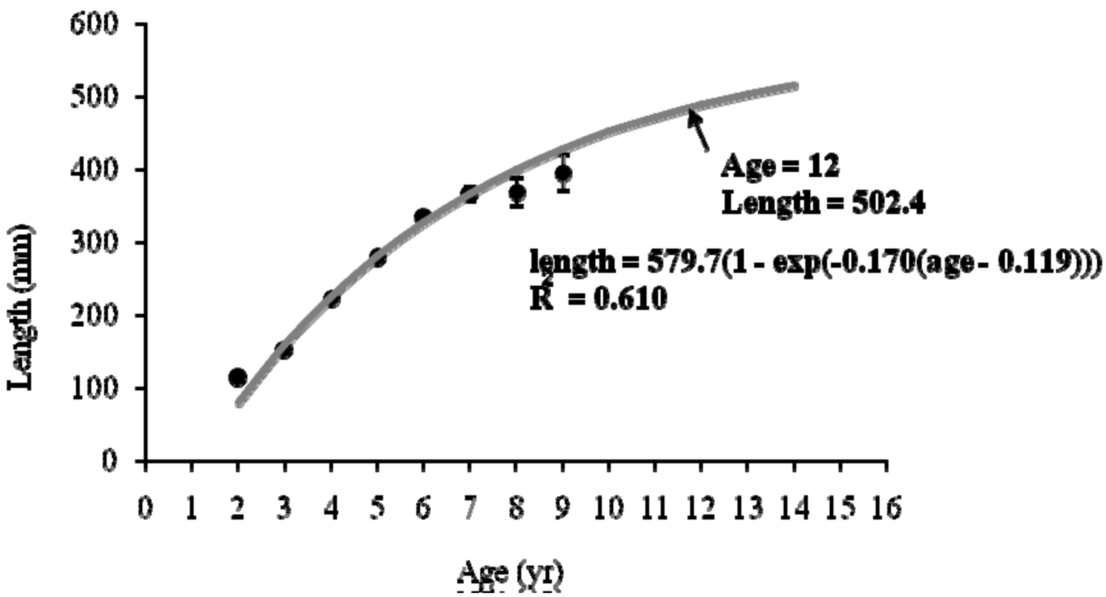

Figure 10. Growth curve using von Bertalanffy (1938) equation with means and standard errors of data points for fork length for all ponds combined on the Jonathans Brook watershed.

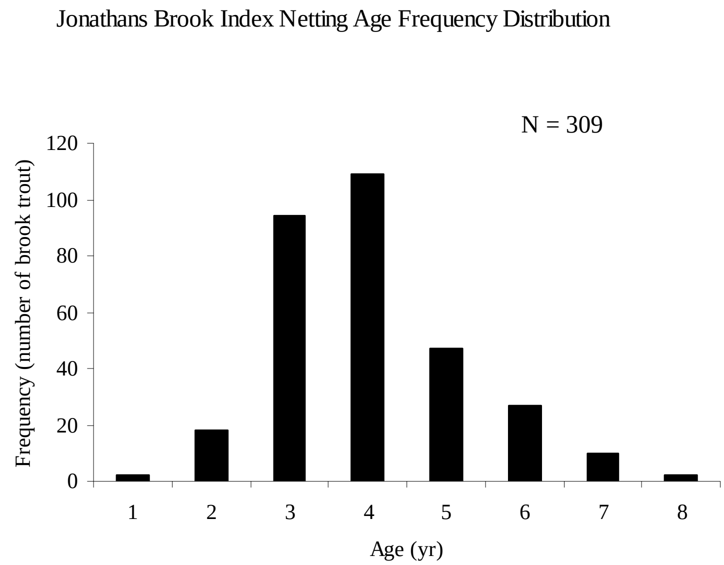

Figure 11. Age frequency distribution for brook trout sampled during spring littoral index gill netting (2004 and 2005).

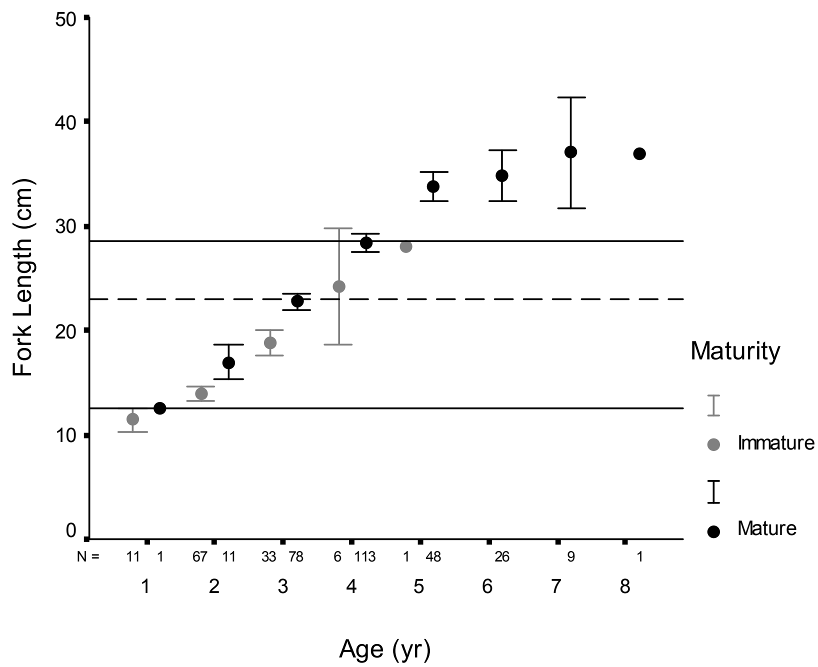

Figure 12. Zone of maturation (start of maturity and end of immaturity) of brook trout in the Jonathans Brook watershed. Solid line represents the lower and upper limit. The dotted line represents 23 cm. Error bars represent the 95% confidence interval around mean fork length for immature and mature fish.

APPENDIX A

Jonathans Brook Watershed **Trout Management Social Survey**

(1) Date: __________________

(2. Where are you from? ___________________________________

(3) How old are you? __________

(4) How many years have you been an angler? ________________

(5) Do you belong to a rod and gun club? _____________________

If yes, which one? ______________________________________

(6) Do you belong to a conservation group? _________________

If yes, which one? ______________________________________

(7) Which of these statement best describes your attitude toward trout fishing on the Jonathans system?

Circle One

(A) I like to keep everything I catch

(B) I like to keep a few fish and let the rest go

(C) I like to keep one trophy (large fish) fish and let the rest go

(D) I release everything I catch

(8) How many times did you trout fish this summer?

Circle one

0 1-3 3-5 6-8 9-11 12-15 16-18 19-21 More then 21

(9) What do you think the current bag limit for trout on the Jonathans Brook Watershed should be? Circle one

(A) 1 to 3 trout (D) 12 or more trout

(B) 4 to 6 trout (E) Remain the Same

(C) 6 to 12 trout

(10) Rank each of the following ponds on the Jonathans Brook Watershed.

	Poor Fishing				**Excellent Fishing**
Whitmans Pond	1	2	3	4	5
	Poor Fishing				**Excellent Fishing**
Jonathans Pond (Big J's)	1	2	3	4	5
	Poor Fishing				**Excellent Fishing**
Third Pond (Park Pond)	1	2	3	4	5
	Poor Fishing				**Excellent Fishing**
Second Pond (Steady)	1	2	3	4	5
	Poor Fishing				**Excellent Fishing**
First Pond	1	2	3	4	5

<u>Trout management</u>

Please circle the appropriate response

(1) The trout stocks in the Jonathans Brook Watershed are healthy as they ever were.

Strongly Disagree			**Neutral**			**Strongly Agree**
1	2	3	4	5	6	7

(2) I am satisfied with respect to the Federal Governments' (DFO) current management of the recreational fishery for trout in the Jonathans Brook Watershed.

Strongly Disagree			**Neutral**			**Strongly Agree**
1	2	3	4	5	6	7

(3) I am satisfied with the current level of fisheries enforcement for trout in the Jonathans Brook Watershed.

Strongly Disagree			**Neutral**			**Strongly Agree**
1	2	3	4	5	6	7

(4) I support size-based retention regulations of trout on the Jonathans Brook Watershed.

Strongly Disagree			Neutral			Strongly Agree
1	2	3	4	5	6	7

(5) I support a minimum size limit regulation on the Jonathans Brook Watershed.

Strongly Disagree			Neutral			Strongly Agree
1	2	3	4	5	6	7

(6) I support a bag limit reduction on the Jonathans Brook Watershed.

Strongly Disagree			Neutral			Strongly Agree
1	2	3	4	5	6	7

(7) I frequently catch the bag limit on the Jonathans Brook Watershed.

Strongly Disagree			Neutral			Strongly Agree
1	2	3	4	5	6	7

APPENDIX B

Table 1. Annual mortality rate for the Middle Brook, Indian Bay, and Jonathans Brook watersheds determined using Robson and Chapman (1961) maximum likelihood estimate of survival. (Estimates for the Middle Brook and Indian bay watersheds provided by Robert Perry, Wildlife Division).

Watershed	Annual Mortality (%)
Middle Brook	61.1
Indian Bay	59.0
Jonathans Brook	54.1

Table 2. A comparison of mean seasonal effort and catch rate estimates for the Middle Brook, Indian Bay, and Jonathans Brook watersheds for years 2004 through 2007 (Estimates for the Middle Brook and Indian bay watersheds provided by Robert Perry, Wildlife Division).

Watershed	Effort (hr)	Catch Rate (brook trout/angler-hour)	Years
Middle Brook	1164	0.782	2004-07
Indian Bay	915	0.375	2004-07
Jonathans Brook	1034	0.595	2004-07

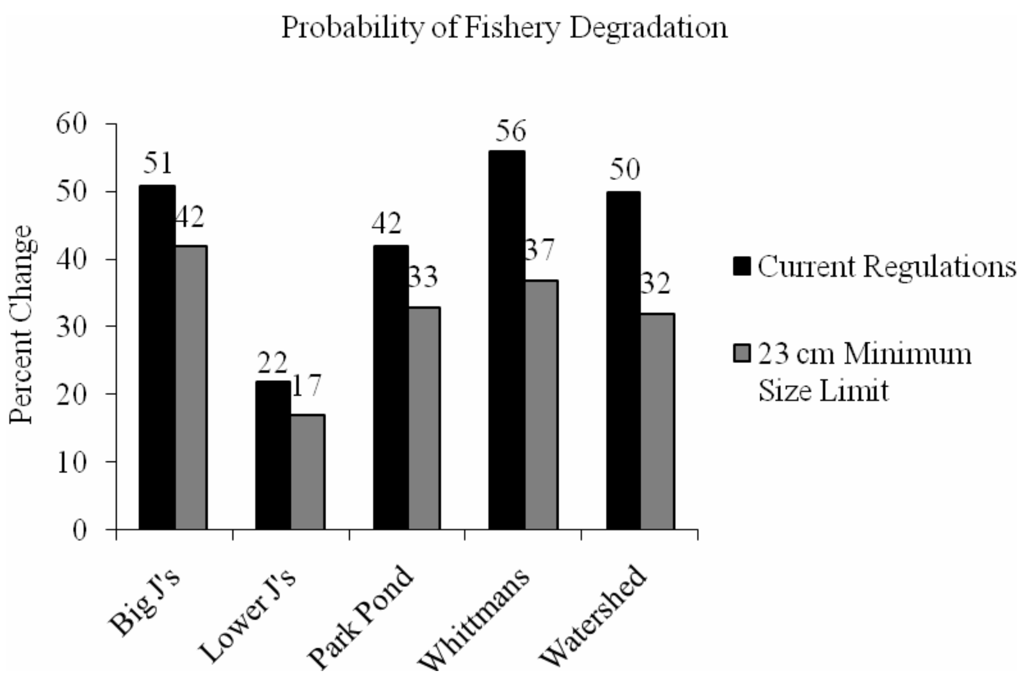

Figure 1. Probability of fishery degradation under existing angling regulations and the proposed minimum size limit on the Jonathans Brook watershed using the brook trout life history model (Adams et al. 2009). Each pond as well as the entire watershed is represented. Percent change indicates the probability of a negative impact on fish populations.