Fisheries and Oceans   Pêches et Océans

Newfoundland Region

DFO Science

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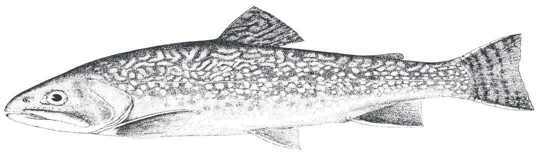

BROOK TROUT IN INDIAN BAY BROOK, NEWFOUNDLAND AND LABRADOR

Background

The brook trout, Salvelinus fontinalis (Mitchill), the most common freshwater sport fish in insular Newfoundland and Labrador, is found almost everywhere in the thousands of lakes and ponds dotting the land. High public participation in the angling fishery augmented by a widespread distribution of brook trout results in the fishery having a high economic value. In Newfoundland and Labrador, brook trout exhibit considerable variability in life history. This variability and the potential for a multitude of separate stocks, results in management of this species being highly dependent on good scientific data. The absence of data coupled with historically high participation rates and increased accessibility to remote ponds-headwaters in the fishery has resulted in the commonly held view by some anglers that brook trout are declining in individual size and abundance. Despite these allegations, few studies have been conducted on brook trout population dynamics or the fisheries exploiting them in Newfoundland and Labrador. In addition, comparative simulation studies on the effect management strategies have on Newfoundland and Labrador brook trout populations are lacking.

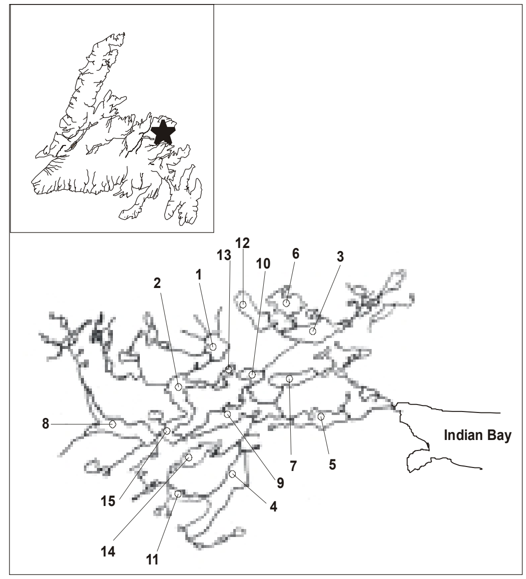

Figure 1. Indian Bay watershed including study lakes. Index of pond names: 1-Alley's, 2-Back-up, 3-Big Bear Cave, 4-Big Wings, 5-First, 6-Forked, 7-Four Mile, 8-Indian Bay, 9-Indian Bay Big Pond, 10-Little Bear Cave, 11-Little Wings,12-Moccassin, 13-Skippers, 14-Southern, and 15-Third.

Summary

A brook trout fishery model using data from Indian Bay Brook (Fig. 1) was developed and indicated the following:

- The model results implied that A) maximum sustainable yield of brook trout on Indian Bay Brook ponds is approximately 0.4 kg per hectare, which is about 2.5 acres; B) maximum yield occurs when angling effort is approximately 3 angler-hours per ha.; and C) maximum sustainable effort is approximately 8 angler-hours per ha.

- The model results suggested that the Indian Bay Brook fishery is operating near full capacity in terms of the brook trout yield that it can supply. Increased fishing effort would result in a decreased yield and degradation of fishing quality.

- Size-based regulations are needed to accommodate increased effort and sustain a high quality fishery. Creel limits that allow 6 fish (or 2 pounds plus 1 fish) are not effective when effort is high (i.e. 7 angler-hours per ha.) because most anglers will not catch their limit.

- None of the regulations evaluated will provide a good food fishery when effort is high.

Species biology

The brook trout is native only to eastern North America occurring from Ungava Bay to northeastern Manitoba and south to Cape Cod, Massachusetts. Brook trout or mud trout as they are sometimes called locally, are the most common fish in the waters of insular Newfoundland, being found in most streams and lakes. Brook trout are a cool water species and prefer slow-moving sections of rivers or ponds with gravel or rocky bottoms. Both sea-going and land-locked forms exist in the same stream but why some choose to remain in freshwater while others go to sea is not understood. Sea trout remain at sea for two to three months in the vicinity of their home river. Brook trout spawn over a gravel bottom in the headwaters of streams or brooks in early to late fall. The eggs remain in the gravel over winter, hatching sometime in spring. Brook trout are carnivorous and consume a wide variety of invertebrate and vertebrate animals. Some predators of brook trout include eels, salmon, mergansers, otters, mink and seals.

The Fishery

The brook trout fishery in insular Newfoundland is of considerable social and economic importance. In 1995, approximately 130,000 adult anglers took part in this fishery and if families are included, the total exceeded 250,000 participants (Anon. 1995). Local participation in a fishery regarded as a provincial pastime is high and the fishery exists in all areas of the province. In 1995, the total number of angling days fished was almost 2 million with an estimated catch of almost 5 million brook trout; of which, 3.3 million were kept (Anon. 1995). In 1995, direct expenditures (i.e., food, transportation, supplies, lodging and guide services) in the Newfoundland recreational fishery were about 52 million Canadian dollars (Anon. 1995).

Indian Bay Brook Trout Studies

In 1995, a multi-year research project in Indian Bay Brook, Bonavista Bay, Newfoundland was initiated to provide information for a brook trout stock assessment (Fig. 1). The Indian Bay Brook studies were conducted by the Indian Bay Ecosystem Corporation and the Government of Newfoundland and Labrador. Indian Bay Brook was chosen for these studies due to historic reports of abundant trout stocks with large individual fish. Indian Bay Brook watershed lies in the central Newfoundland eco-region in the black spruce forests and stands of aspen that dominate the area. From 1995-1998, 15 lakes were sampled using standard stock assessment procedures including standardized Fyke netting (trap) and mark-recapture to provide population estimates and sampling of all captured fish for size and age determination. Angling catches were monitored during the winter and summer fishing seasons. The overall objectives of the Indian Bay Brook project were:

- to provide the scientific data needed to evaluate the status of trout populations and offer informed advice for management plans; and,

- to increase our understanding of the life history of inland fish species in Newfoundland and measure the effects of natural, fishing and other human-related stresses on brook trout in Indian Bay Brook.

Brook Trout Exploitation Model

Since it is expected that demands for fishing will grow and eventually exceed the capacity of an unregulated system, well designed and enforced fishing regulations are needed to protect fish populations from overexploitation. The major question becomes what management strategy can be put in place that best protects fish stocks and provides for a good fishing experience? In order to explore various management options, a mathematical representation or 'model' of a simulated brook trout population involving the effects of fishing as a key factor and biology of the fish was developed. This biological model was used to predict the effects of angling on the yield and fishing quality of a brook trout fishery in Indian Bay Brook, Newfoundland. The model was designed to address several key questions:

- What is the maximum potential yield (kg. per ha.)?
- How much fishing effort will result in this maximum yield?
- How much fishing effort can be sustained?

The model supplied key reference points (e.g. effort at maximum yield and effort at extinction) for evaluating various levels of fishing exploitation and compared the effectiveness of various management actions. Furthermore, the model was age-structured because of the different fishing rates on trout of various ages in the population. Also, an age-structured model described the relationship between yield and fishing mortality rate on various components of the trout population. Specifically, the model included:

1. A number of life history factors, defining rates of growth, natural mortality and reproduction in the absence of intraspecific competition;

2. Habitat quantity factors, defining the rates at which early survival and fecundity are reduced from their maximal values as the population fills available habitat and approaches its carrying capacity; and,

3. Fishery factors, defining what part of the population is exploited and the intensity of exploitation.

Biology

Population estimates were completed on a total of 9 ponds some with multiple-year estimates. Estimates ranged from 1,938 to 21,618 fish on various ponds. Estimates of population density ranged from 3.6 to 179 fish per ha. on Little Bear Cave Pond and Skipper's Pond, respectively. Biomass ranged from 0.43 kg per ha to 15.55 kg. per ha. in Indian Bay Pond and Skipper's Pond, respectively.

The average number of eggs per kg. of fish for all ponds was estimated at 2,540 with a range of 2,398 to 2,634 in Four Mile Pond and Alleys Pond, respectively.

Female: male ratios in fall fyke netting surveys were approximately 1 to 1. Length at maturity was calculated from fall fyke netting surveys in 1998. The length at 50% maturity was 22.5 cm, length at 5% was 15.0 cm and length at 95% maturity was 30.0 cm.

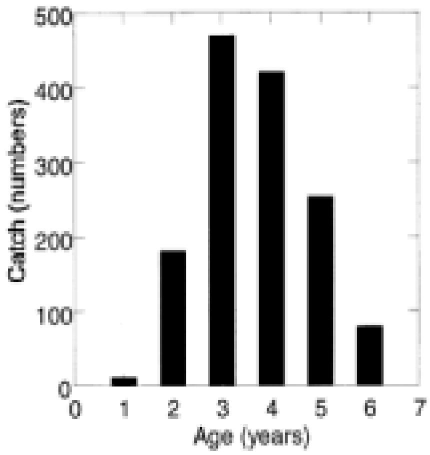

Fig. 2. Age composition of harvested brook trout for all ponds for the period of 1994-1998.

Fisheries

Combined annual yield for winter and summer had a mean of 0.31 kg. per ha. with a mean annual effort of 2.67 angler hours per ha. The mean annual catch rate was 1.33 fish per hour and harvest rate was 0.33 kg. per hour. There was considerable variation among ponds surveyed. The mean annual summer effort ranged from 40 in Indian Bay Pond to 4,068 in Indian Bay Big Pond. Yield varied from 0.001 to 0.49 kg per ha and a mean annual effort ranged from 0.004 to 4.58 angler hrs. per ha. Yield in winter was less variable but still exhibited a wide range of values with an annual mean that ranges from 0.09 to 1.56 angler hrs. per ha. The catch rate and harvest rates varied from 0.04 to 0.45 kg. per ha., respectively. A summary of these statistics are displayed in Table 1. Figure 2 shows the age composition of the harvest, which was used to estimate the length at full vulnerability. Length was set at 20 cm, 15 cm and 25 cm for 5%, 50% and 95% vulnerability, respectively for input into the harvest model.

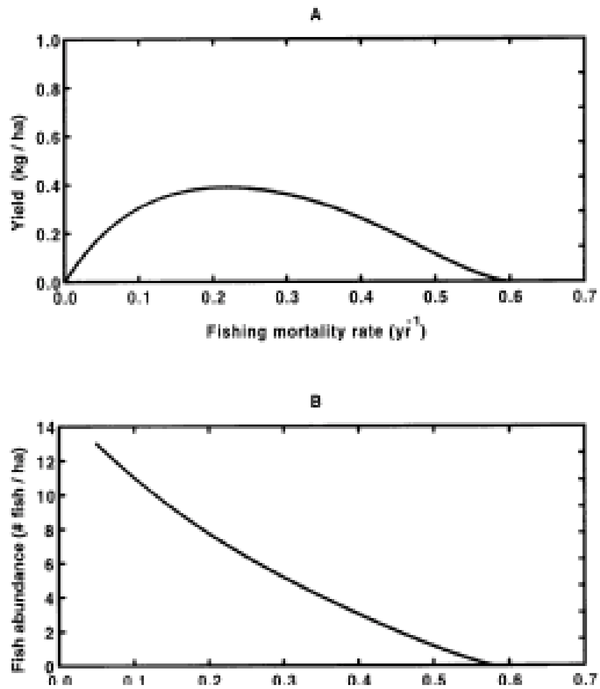

Fig. 3. Predicted relationships for yield versus fishing mortality rate and for fish abundance versus fishing mortality rate.

Table 1. Mean effort (hours fished), yield (numbers, weight, and kg per hectare), effort (angler hours per hectare), CUE (number of fish caught per hour), and HWUE (kg per hour) for each pond, for combined winter, summer, and annual fishery.

Pond	Effort	Yield	Yeild	Yield	Effort	CUE	HWUE
Alleys	1367	583	154	0.37	3.38	0.43	0.11
Back-up	977	724	187	0.12	1.02	0.74	0.19
Big Bear Cave	2661	1205	319	0.63	5.19	0.45	0.12
Big Wings	188	182	47	0.14	0.71	0.97	0.25
First	1265	302	79	0.07	2.26	0.24	0.07
Four Mile	777	487	125	0.3	1.86	0.63	0.16
Forked	360	494	126	0.49	0.63	1.37	0.35
Indian Bay	167	138	35	0.035	0.13	0.82	0.21
Indian Bay Big	4536	1973	436	0.39	4.44	0.29	0.10
Little Bear Cave	1179	380	102	0.51	5.95	0.32	0.09
Little Wings	392	405	101	0.73	2.84	1.03	0.25
Mocassin	629	114	30	0.06	1.25	0.18	0.05
Skippers	614	451	116	1	5.29	0.73	0.19
Southern	655	314	79	0.21	1.8	0.48	0.12
Third	442	360	91	0.33	1.63	0.81	0.20

SUMMARY

Winter	4169	4229	967	0.12	0.51	1.01	0.23
Summer	12401	3883	1050	0.19	2.16	0.32	0.10
Annual	16570	8112	2017	0.31	2.67	-	-

Model Results

The model predicts that yield increases while fishing mortality rate remains less than 0.22 achieving a maximum of 0.4 kg per ha (Fig. 3A). As mortality rate increases further, yield decreases eventually to zero when mortality equals approximately 0.6. This extinction of yield is due to the decrease in fish abundance that results from higher fishing mortality (Fig. 3B).

Angling catch rates were compared to estimates of fish density. Younger fish were excluded because they are not vulnerable to angling. The relationship between angling catch rate and the fyke net (trap) fishing index of abundance was asymptotic. When abundance is high, there is no relationship between catch rate and abundance. At lower levels of abundance (i.e. < 6 fish per ha.), catch rate declines approximately in a straight line, indicating that catchability is constant.

In conclusion, the relationship between catch rate and abundance is not linear. Substantial reduction in fish abundance could occur before angling catch rate is impacted. Once a critical level is reached, catch rate decreases roughly in proportion to abundance. The critical abundance level was approximately 12 fish per ha. Once again using standard fish assessment equations, increasing effort by one angler-hour per hectare increases fishing mortality rate by 0.072 units.

Outlook

Study results suggest that some ponds are being over exploited but the system, as a whole, is operating near full capacity. Although some ponds are over exploited, these excesses are compensated by under-utilization of other ponds. Given open access to all ponds, one expects angler migration between ponds would be influenced by differences in catch rates and would eventually result in a distribution of fishing effort that equalizes catch rate. Thus, over the long term all ponds would be exploited near the optimum level.

Increases in fishing effort could occur on some ponds, depending on management objectives, without endangering fish stocks. However, there would be a cost to increasing fishing effort. These costs are:

1) further degradation of fishing quality; and
2) an increased likelihood of endangering fish stocks.

If it is desirable to avoid these costs then fishing regulations that dampen the impact of fishing effort are needed.

Management Scenarios

The Fisheries Management Support System (FMSS), developed by the Ontario Ministry of Natural Resources, was used to simulate the effect of the following regulations pertaining to size limits on a brook trout stock based on the data from Indian Bay Brook and the modelling exercise:

1. No regulations
2. Limit = 6 fish or 2 lbs + 1 fish
3. Minimum size = 22.5 cm
4. Minimum size = 28 cm
5. Minimum size = 35 cm
6. Protected size = 22.5 – 28 cm
7. Maximum size = 35 cm

The size-based regulations used criteria related to the growth and maturation of Indian Bay Brook trout (Fig.4). The first minimum size regulation (#3) implies that all fish less than the expected size of maturity (i.e. 22.5 cm) must be released. The next minimum size regulation (#4, 28 cm) implies that the average fish would reproduce once before reaching a size that could be harvested by anglers. The last minimum size regulation (#5, 35 cm) implies the average fish would reproduce three times before reaching a vulnerable size. The protected size (22.5-28 cm) implies fish could not be harvested during their first year of reproduction. The maximum size regulation (35 cm) implies that large and relatively old fish would be protected. For each scenario, effort at a fixed level (7 hours per ha) and a simulated brook trout population for 50 years were used. The response after 25 years was used to compare the effects of each regulation. The response variables measured included:

Adult abundance - Number fish per ha, Catch rate - Number fish caught per angler- hour, Catch rate 35- Number of fish greater than 35 cm caught per angler-hour, and
Harvest rate (weight) - Kilograms of fish harvested per angler-hour.

The fishing quality variables reflect different aspects of the fishing experience. Catch rate indicates whether the angler is catching fish, catch rate 35 indicates the chance of catching a large fish, and harvest rate in weight indicates whether the angler can expect to bring home dinner.

The results of the analysis indicate that regulation by creel limits were not effective. When fishing effort is high, catch rate is low and most anglers do not catch their limit. Consequently, the effect of a creel limit is the same as no regulation at all. Size-based regulations varied in terms of their effectiveness. Management options that protected small fish (< 22.5 cm, immature) and large fish (> 35 cm) were marginally effective. Those protecting fish during the first year of reproduction (22.5 - 28 cm) were

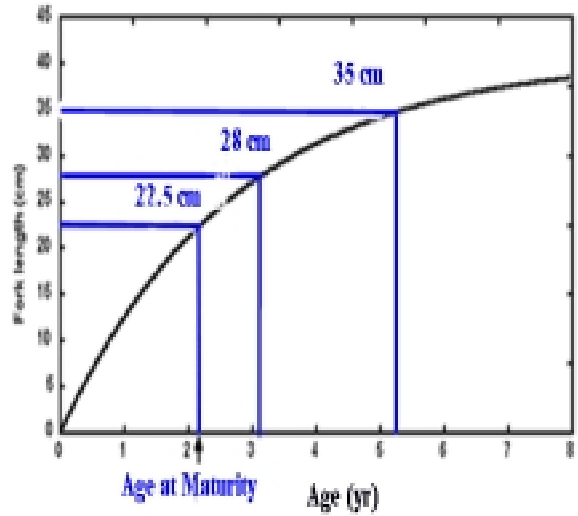

Fig. 3. Expected lifetime growth of Indian Bay brook trout. The values used in evaluating different regulations are indicated.

more effective. Minimum sizes of 28 cm and 35 cm were by far the most effective of the regulations examined. The 28 cm regulation resulted in a higher rate of harvest weight, implying a better food fishery, but in all other measures the 35 cm minimum size excelled.

The success in the simulation exercise of a 35 cm minimum size is hardly surprising. When given the growth and natural mortality rates used in the study, the probability that a fish survives to reach this size is only 0.10. Thus, this size regulation will result in mainly a catch-and-release fishery. Although a minimum size of 28 cm results in a higher kill rate, the difference in terms of kilograms kept per hour of fishing is marginal. For both scenarios, kilograms kept per hour of fishing is in the order of 0.6 kg per hour, implying that approximately 16 angler-hours of fishing would be needed to bring home 1 kg of fish. For other regulations, the take home rate is even smaller. Clearly, none of these regulations will support a food fishery when effort is as high as 7 hours per ha.

Management Considerations

There are several management issues resulting from the brook trout work at Indian Bay which are:

1. Size-based regulations have been identified as the best management measure for Indian Bay Brook trout stocks.

2. Enforcement of any new regulations is required if results from the Indian Bay Brook studies are to be achieved.

3. Results must be treated as Indian Bay Brook stock assessment advice and should not be generalized to other trout stocks around the province.

4. Although data from Indian Bay Brook cannot be transferred to brook trout in other areas of the province, the techniques and models developed can be. Therefore, standardized stock assessment programs are required in other areas to provide specific information on a wider regional basis.

5. Benchmarks or indicators of fishery condition should be developed based on relevant and applicable regional data for stock assessment advice.

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For more Information

Contact: Dave Reddin
Dept. of Fisheries and Oceans
P.O. Box 5667
St. John's, NF A1C 5X1

Tel: (709) 772-4484
Fax: (709) 772-4105
E-Mail: reddind@dfo-mpo.gc.ca

This report is available from the:

Science, Oceans and Environment Branch
Department of Fisheries and Oceans
Newfoundland Region
P.O. Box 5667
St. John's, NF A1C 5X1

Phone Number (709) 772-2027
Fax Number (709) 772-6100
e-mail address tillmanj@dfo-mpo.gc.ca
Internet address
http:/www.dfo-mpo.gc.ca/csas

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