NWRT Project #3-13-27 – Final Report

Project Title: Growth and Sustainable Yield of Lake Trout in Nunavut

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Summary: Lake trout are an important resource in Nunavut, providing a subsistence fishery for many Inuit residents, and increasingly forming a valued target for charter fishing operations. However despite their widespread abundance, and although lake trout biomass is often high in unfished lakes, lake trout populations are easily overfished and slow to recover. Using state of the art ageing methods, we propose to study a range of lakes across Nunavut to determine the age and growth of the resident lake trout populations, then develop a predictive model which will allow the lake trout growth rate in unstudied lakes to be predicted based only on lake characteristics. Over the three-year term of the project, these results will be incorporated with other information to predict the sustainable long-term yield of lake trout from each lake. The final stage of the project will develop an overlay for Google Earth which will allow fishery managers and HTOs to simply point and click on a web-based map to determine the long-term yield of lake trout in any lake in Nunavut.

Project Objectives: Lake trout (*Salvelinus namaycush*) are the most abundant large fish in the Arctic and sub-Arctic regions of Canada. Second only to Arctic charr, lake trout are also of major economic value in the Arctic, providing a subsistence fishery for many Inuit residents, and increasingly forming a valued target for charter fishing operations. The continued good health of lake trout populations in Nunavut is an important component of Nunavut's future prosperity, both in terms of tourist dollars and an Inuit food supply. Yet despite their widespread abundance and distribution, the continued abundance of lake trout in Nunavut is by no means assured. The long-term sustainable yield of lake trout has been determined for only a very small number of lakes, and most of these have been based on out-dated fish ageing methods which are now known to have grossly underestimated the age (and thus the growth rate) of the older fish, leading to unreliable and overly-optimistic estimates of yield and productivity. Perhaps more importantly, it is virtually impossible to assess lake trout status in every one of the thousands of lakes in Nunavut. Over a three-year period, the proposed research will not only develop a predictive model of sustainable lake trout yield based on modern ageing methods, but seamlessly incorporate the model into a web-based application which will allow point-and-click determination of long-term lake trout yield in any lake in Nunavut.

The objectives of this research are to:

1) use modern, accurate ageing methods to determine the age composition, mean and maximum ages of lake trout in a cross section of lakes across Nunavut (Years 1-3);

2) estimate growth rate and von Bertalanffy growth parameters for each of the studied lakes (Years 1-3);
3) measure the key defining characteristics of each of the studied lakes, including area, shoreline, mean and maximum depth, location, altitude, mean water temperature, degree days, relative abundance of lake trout and Arctic charr, and a proxy for fishing history (such as proximity to people) (Years 1-3);
4) develop a growth model for lake trout which will predict growth based on the defining characteristics of the lake (Years 2-3);
5) map the expected surplus production and yield of lake trout throughout the Canadian north based on location and lake characteristics (Year 3);
6) develop a simple, semi-automated overlay for Google Earth which will allow managers to simply point and click on a web-based map to determine the long-term sustainable yield of lake trout in any lake in Nunavut (Years 1-3).

Materials and Methods: In this first year of the project, lake trout were sampled in August 2013 using graded gillnets (1 - 6.5" mesh at 0.5" intervals) from seven lakes on Victoria Island. In addition, some previously-collected otolith samples were obtained from 9 additional lakes in Nunavut and northern Canada. The physical characteristics of each lake were measured and recorded, and temperature-depth recorders were deployed in three lakes (High, North and Central lakes; see Table 1 for locations) to measure water temperature throughout the year.

All otoliths were processed for age determination using modern, accurate embedding, sectioning and image analysis methods (Campana et al. 2008). All ages were based on counts of annual growth increments that were visible in transverse sections of the sagittal otolith. Otoliths to be aged were first embedded in a slow-drying hard epoxy (Araldite epoxy GY502 and hardener HY956 in a 5:1 weight ratio). Sections through the core (~450 µm thickness) were prepared with a single cut using twin blades separated by a spacer on an Isomet low-speed diamond-bladed saw. The sections were subsequently mounted on a standard microscope slide with a thin coat of epoxy, then lightly polished to improve visibility. While under a binocular microscope at 16-40X magnification using reflected light, the growth increment sequence was digitally photographed at a resolution of 4000 x 3000, then digitally enhanced for clarity using Adobe Photoshop CS2. A second set of digital images were collected under transmitted light. Age interpretation was based on the enhanced images. Ageing precision was quantified using the coefficient of variation (CV) (Campana 2001).

Growth will later be modelled using the von Bertalanffy growth equation, while long-term, sustainable yield will be calculated using standard yield equations. Using sampled lakes as a guide, the expected growth rate and yield of lake trout will be modelled, and the resulting model used to predict sustainable yield in all other, unsampled lakes.

Results: Progress to this point of the 3-year project have been excellent. A total of 162 lake trout were sampled from seven lakes on Victoria Island in Aug 2013 (Table 1). Otoliths intended for age determination were collected successfully from all fish (Fig. 1), and the physical characteristics of each lake were measured. Year-long temperature recorders were deployed at the bottom of three of the lakes. In addition, 864 previously-collected lake trout otoliths were obtained from other researchers who had sampled 9 other lakes in northern Canada in recent years; these otoliths were then aged. In total, accurate ages were obtained for 1026 lake trout collected from 16 different lakes in this, the first year of the project.

All of the otoliths discussed above have been embedded, sectioned, image enhanced and aged (Fig. 2). Based on previous bomb radiocarbon assays confirming the accuracy of our age determinations (Campana et al. 2008), we know that our ages are accurate to within ±2 years, at least on average. The lake trout that have been aged in this project to date have ranged between 95-1100 mm in fork length, and ages of 3 to 65 years old (Table 1). The mean age of the lake trout collected on Victoria Island in 2013 was 25 years, but most of the trout were about 30 years old (Fig. 3). These are extremely old trout, and appear to be much slower-growing than populations further south. Growth curves will not be fit to the length at age data until the last year of the project, but preliminary length at age curves show obvious and statistically significant differences in growth among lakes (Fig. 4)

A student in Cambridge Bay was hired to interview western Nunavut residents about their lake trout fishing history in the region. Verbal reports from the student indicated that the interviews were proceeding well, but then all contact ceased and we have been unable to locate the student. As a result, no progress was made on the fishermen interviews. A different student will be hired next year.

Although not originally planned for the first year of this project, considerable project has been made in developing a Google Earth overlay for Nunavut lakes and lake trout yield. Algorithms have been developed which will allow the system to automatically estimate the lake characteristics of any Nunavut lake which is "point and clicked" in Google Earth, including lake depth. In addition, the "proof of concept" has been completed, demonstrating that the Google Earth popup overlay is feasible.

Discussion and Management Implications: The sustainable catch of virtually any fishery depends heavily upon the age structure and growth rate of the fish. With many thousands of Nunavut lakes containing lake trout, it will probably never be possible to conduct stock assessments on each individual lake. However, the final stage of this project will be the development of a Google Earth overlay which will automatically calculate lake characteristics for all lakes in Nunavut, then use a statistical yield model to instantly display the estimated long-term catch, mean and maximum size, age composition and other fishery variables for the selected lake. A working prototype of the Google Earth overlay has already been prepared, and it is fast, simple to use and flexible in terms of what information it displays. Once completed, this project appears to hold the potential to revolutionize the management of Arctic lakes. Likely clients of the Google Earth overlay will include not only the NWMB, but fishery managers, HTOs, fishing lodges, and communities who fish local lakes.

Reporting to communities/resource users: Since the original project submission was for a 3-year project, and NWRT funding was for one year, project reporting for this first year of the project was limited to the region which was sampled. Therefore, both preliminary and final project progress reports were sent to the Ekaluktutiak Hunters and Trappers Organization.

References:

Campana, S. E. 2001. Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. J. Fish Biol. 59: 197-242.

Campana, S. E., Casselman, J. M., and Jones, C. M. 2008. Bomb radiocarbon chronologies in the Arctic, with implications for the age validation of lake trout (*Salvelinus namaycush*) and other Arctic species. Can. J. Fish. Aquat. Sci. 65:733-743.

Table 1. Summary of lakes sampled for lake trout age determination.

Lake name	Sampling date	Latitude	Longitude	Number of lake trout	Fork length range (mm)	Age range (yr)
High	04-Aug-13	N70 17.10	W106 48.09	25	180-927	4-62
High B	07-Aug-13	N70 15.93	W106 47.72	3	559-799	10-33
High C	08-Aug-13	N70 15.72	W106 48.93	34	403-851	14-57
North	11-Aug-13	N70 52.18	W106 40.15	30	187-792	6-39
North B	14-Aug-13	N70 42.52	W106 17.72	31	120-797	3-48
Central	17-Aug-13	N70 15.00	W106 00.58	39	133-733	3-56
Central B	22-Aug-13	N70 15.53	W105 54.97	0		
Couture	25-Jul-02	N60 07.83	W75 24.900	110	166-956	5-51
McAlpine	29-Aug-03	N66 35.42	W102 46.62	169	134-878	5-57
Strange	01-Sep-02	N56 2.61	W63 35.28	138	95-851	2-42
Tasiat	23-Jul-02	N59 11.18	W75 17.342	159	173-800	5-44
Zeta	26-Aug-03	N71 06.40	W106 33.53	201	126-1100	5-65
Alexie	20-Aug-11	N62 40.7	W114 4.8	34	317-728	5-34
Baptiste	17-Aug-11	N62 42.3	W114 12.3	19	300-605	8-30
Chitty	21-Aug-11	N62 42.6	W114 7.6	11	131-611	2-29
Drygeese	17-Aug-11	N62 44.0	W114 10.1	23	322-575	6-35

Fig. 1. Paired sagittal otoliths from an adult lake trout.

Fig. 2. Annual growth increments in a transverse otolith section of a 56-cm, 29-yr old lake trout (*Salvelinus namaycush*). Inset shows the axis used for age determination and annotated growth increments. The image has been contrast-enhanced. Bar = 100 µm.

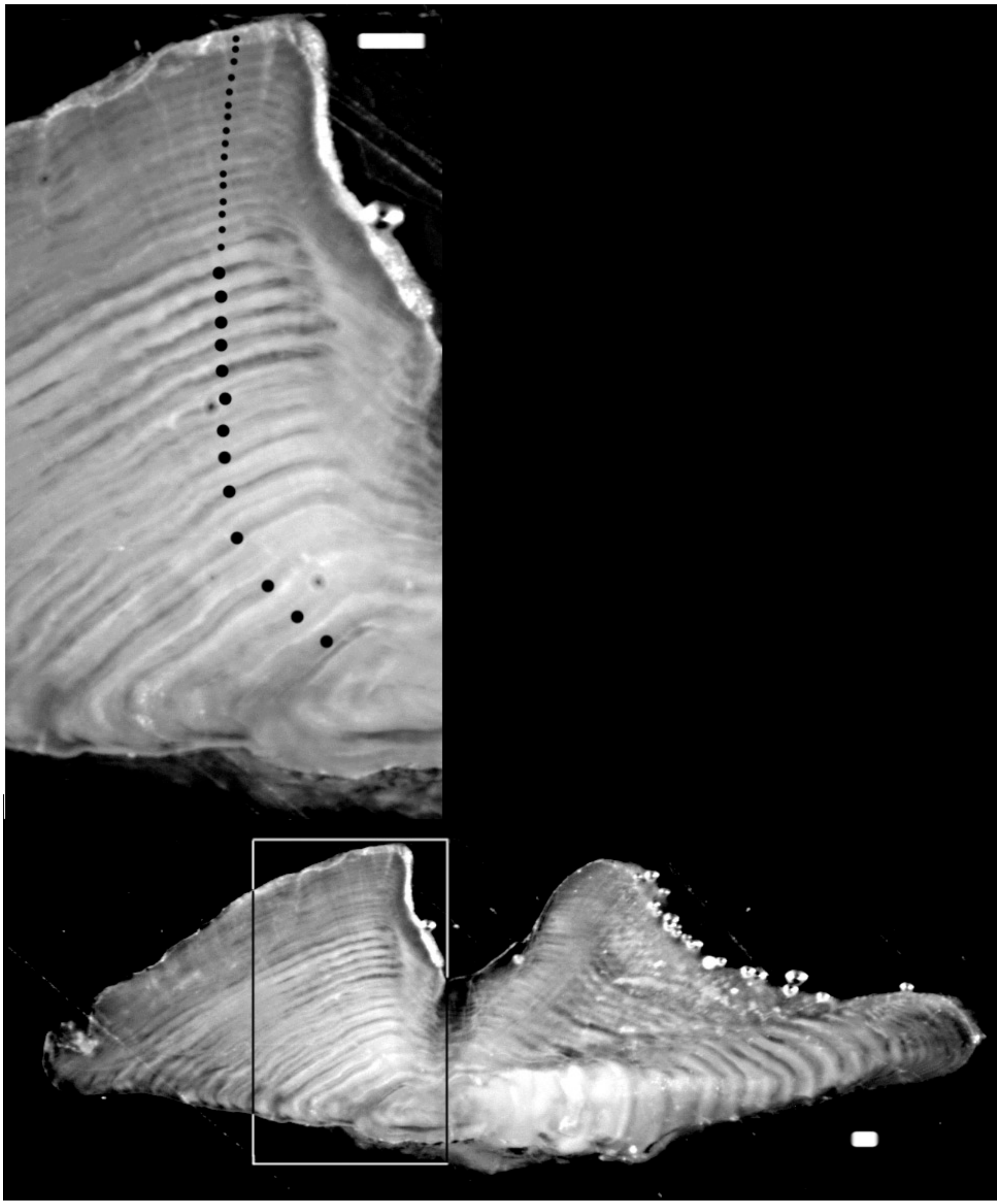

Fig. 3. Age-frequency histogram of lake trout on Victoria Island, NU. Most of the trout collected were about 30 years old.

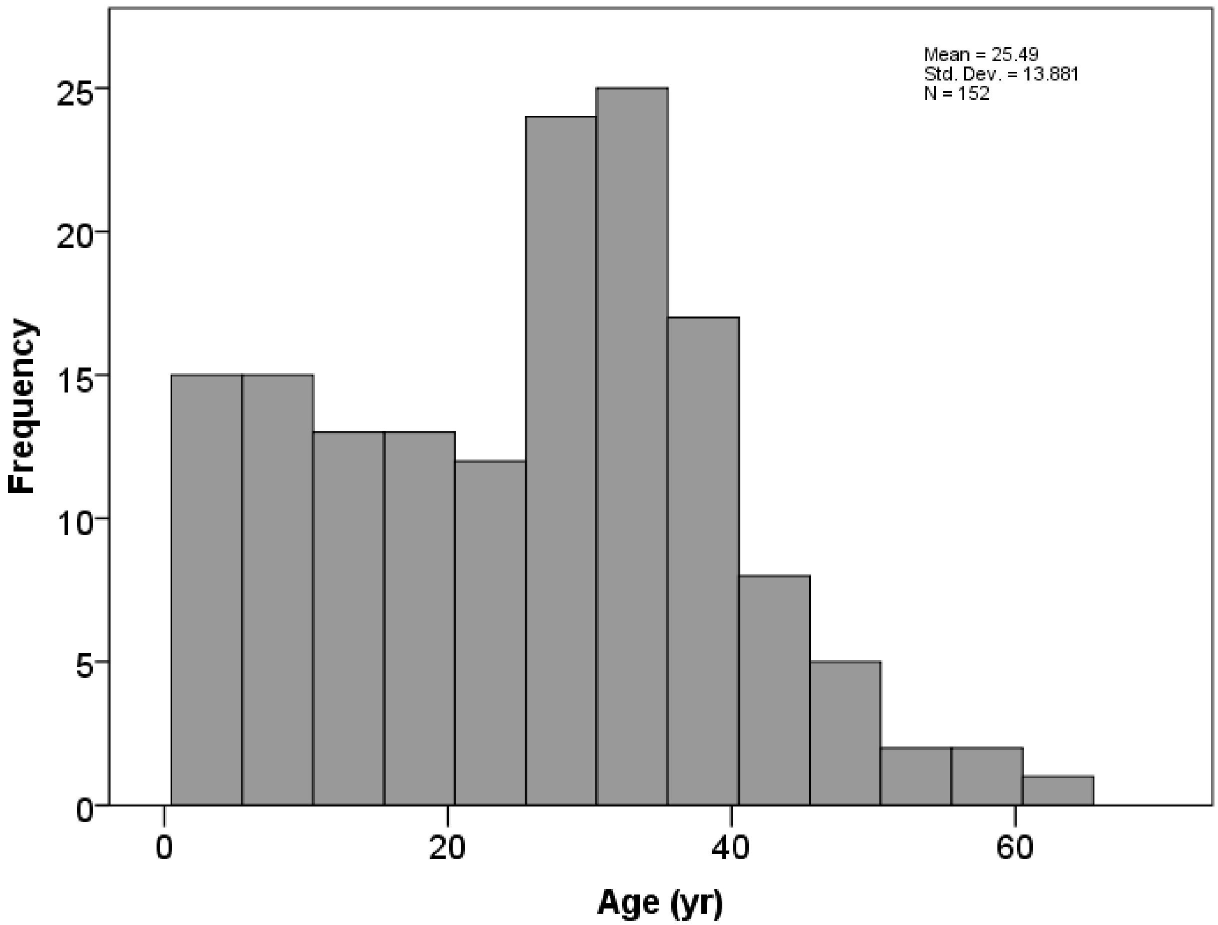

Fig. 4. Length at age of lake trout collected from 7 lakes on Victoria Island, NU. Growth rate differed significantly across lakes.