

Local Knowledge, Biological Characteristics & Movements of Fish in the Travaillant Lake System



Photo by L. Harris

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SUMMARY

In anticipation of increased hydrocarbon activities within the Mackenzie Valley, a project to identify biophysical information and research gaps associated with hydrocarbon exploration, development and transmission in the Mackenzie Valley was carried out in 2003. As part of this gap analysis exercise, Travaillant Lake was identified as an area of special concern because of its proximity to the proposed Mackenzie Valley pipeline, its cultural and ecological importance to the Gwich'in, and the lack of baseline information on its fish resources.

The current study was initiated to gather local knowledge and baseline scientific information on the biological characteristics, movements and general status of fish resources in the Travaillant lake system, with an emphasis on key harvested species. This report summarizes activities and results from the first year of the study in 2003-2004. This research builds on and complements ongoing fisheries studies by the Gwich'in Renewable Resources Board initiated in 2002.

Interviews with land users and elders from Inuvik and Tsiigehtchic are currently being conducted to gather community knowledge about patterns of fish harvest, distribution, movements, and habitat use within the Travaillant Lake system, as well as physical and ecological characteristics of connecting streams and lakes that define the extent of the Travaillant Lake system. This information will be used to identify any critical or sensitive areas and to document observations of ecological change over time.

Broad whitefish and lake whitefish from Travaillant Lake were tagged with T-Bar Anchor tags and released during the summer 2003, to provide insight on the movements, migrations and critical habitats of key harvested species through tag recoveries. To date, however, no tags have been recovered.

Selected biological data (length, weight, age) were collected from all broad whitefish and lake whitefish tagged in Travaillant Lake during the summer of 2003. During October of 2003 broad and lake whitefish known to be spawning within the Travaillant River (and therefore likely to be residents of the Travaillant lake system) were collected and sampled for more detailed biological information (length, weight, age, sex, maturity, gonad weight and fecundity). This information was analyzed and compared to data from previous studies of these species in Travaillant Lake and other areas of the lower Mackenzie Valley. The biological characteristics were within the general range of observations from other studies in the Lower Mackenzie Region, although mortality rates appeared to be higher than normal for broad whitefish.

Further tagging work and more detailed population assessment of harvested species in Travaillant Lake will be continued in 2004. A review of the local knowledge results will be used to help focus future scientific efforts, where feasible. Due to the lack of success with floy tagging studies in this lake, further studies of fish movements over the next two years will be conducted using radio telemetry methods.

INTRODUCTION

Recently, the Arctic regions of North America have experienced increased development related to both renewable and non-renewable resources (Reist 1997a). An example is the proposed Mackenzie Valley pipeline that is expected to pass directly through the Travaillant Lake system, and within 10 km of Travaillant Lake itself. Pipeline construction can result in complicated and often long term effects on the aquatic environment, particularly for fish (Stein et al. 1973). In anticipation of increased hydrocarbon activities within the Mackenzie Valley, a project to identify biophysical information and research gaps associated with hydrocarbon exploration, development and transmission in the Mackenzie Valley was carried out in 2003 (Gartner Lee Limited, 2003a). As part of this gap analysis exercise, Travaillant Lake was identified as an area of special concern because of its proximity to the proposed Mackenzie Valley pipeline, its cultural and ecological importance to the Gwich'in, and the lack of baseline information on its fish resources (Gartner Lee Limited, 2003b).



Making dry fish

Photo by K. Howland

Travaillant Lake is the largest lake (115 km²) in the Gwich'in Settlement Area (GSA) and is part of a system of large lakes and tributaries connected to the Mackenzie River by the Travaillant River. Historically, the Travaillant Lake system has been of great importance to subsistence harvesters, supporting domestic fisheries primarily for broad whitefish (*Coregonus nasus*), but also for lake whitefish (*C. clupeaformis*), lake trout (*Salvelinus namaycush*), burbot (*Lota lota*), Arctic grayling (*Thymallus arcticus*), and northern pike (*Esox lucius*) (Stewart 1996).

There is local concern that construction of the Mackenzie Valley pipeline could cause irreversible, negative impacts on fish and water quality in the Travaillant Lake system, through the addition of contaminants, increased sedimentation and erosion, and increased access to this otherwise remote lake. This has raised awareness that there is a need to gather preliminary information on the fish species that inhabit this system before pipeline construction takes place.

Although pipeline-related baseline fisheries surveys were conducted in this system during the early 1970s (e.g., Hatfield et al. 1972, Stein et al. 1973) this work was focussed mainly on the Travaillant River and is out of date. Since this time there have not been any published studies of the fish community as a whole and only limited biological information has been collected on the main harvested species, broad whitefish. Chudobiak (1995) examined the life history and morphology of broad whitefish in Travaillant Lake in a comparative study of lacustrine (lake dwelling) and anadromous (sea migrating) forms of broad whitefish, although data were collected over only one field season and are unlikely to represent the full range of variability in biological traits for this population.

Several recent studies have focussed on the question of whether or not broad whitefish in Travaillant Lake complete their entire life cycle within the Travaillant Lake system or migrate to the Mackenzie River (Hesslein et al. 1991, Chudobiak 1995, Babaluk and Reist 1996, Reist 1997b, Chudobiak et al. 2002, Tallman et al. 2002). However, there have not been any direct studies of fish movements or critical habitats for any species in this lake system and there remains uncertainty as to whether the broad whitefish in this lake exist as a closed population.

To protect fish populations of Travaillant Lake from potential impacts, we require a better understanding of both their movements and biological characteristics. Biological indicators such as abundance, size, age, growth, fecundity (number of eggs) and mortality (death rates) can be used to determine the current status or well being of a fish population and through proper monitoring can provide an indication of subsequent changes that may occur from changes in harvest levels, development, environmental disturbance, etc. For such indicators to be of use, however, it is essential to also have a clear understanding of fish movements and population (stock) structuring since the biology may vary among populations (Tallman and Reist 1997). Thus, the uncertainty surrounding the extent of migrations or seasonal movements of broad whitefish in Travaillant Lake needs to be addressed. Such information will be critical not only to population analyses, but will allow us to determine the susceptibility of these fish to local fishing pressures and industrial development at a spatial level.

In response to these knowledge gaps, the current study was initiated to gather local knowledge and baseline scientific information on the population abundance, vital rates (biological characteristics), movements and general status of fish resources in the Travaillant lake system, with an emphasis on key harvested species (broad whitefish and lake whitefish). This report summarizes activities and results from the first year of the study in 2003-2004. The project has three components: 1) Local knowledge of fish movements and habitat use in the Travaillant Lake system, 2) Biological analysis of harvested fish species and general species composition in Travaillant Lake and 3) Identification of movement patterns and critical habitats of harvested species through tagging. This research builds on, and complements ongoing fisheries studies by the Gwich'in Renewable Resources Board (GRRB) initiated in 2002.



Camp at Travaillant Lake

Photo by L. Harris

PROJECT OBJECTIVES

1) Local Knowledge of Fish Movements and Habitat Use in the Travaillant Lake System:

Collect community knowledge about:

- a) Traditional and contemporary patterns of fish harvest within the Travaillant Lake system;
- b) Fish distribution, movements, and habitat use (including spawning, rearing and migration areas) within the Travaillant Lake system;
- c) Physical and ecological characteristics of connecting streams and lakes to define the extent of the Travaillant Lake system and the distribution of fish habitat, as well as identify any critical or sensitive areas and document observations of ecological change over time.

2) Biological analysis of harvested fish species and general species composition in Travaillant Lake:

- a) Determine population health and develop an index of population abundance of valued fishes in Travaillant Lake.
- b) Determine the population size, mortality rates and current status of the most valued species, broad whitefish, in Travaillant Lake.
- c) Identify and determine relative abundance of other species present.

3) Identification of movement patterns and critical habitats of harvested species through tagging:

- a) To document the movements of key species from the Travaillant Lake system using floy tagging and the most valued species, broad whitefish using radio telemetry.
- b) To identify critical habitats of key species from the Travaillant Lake system used for spawning and over wintering.



Travaillant Lake

Photo by L. Harris

MATERIALS AND METHODS

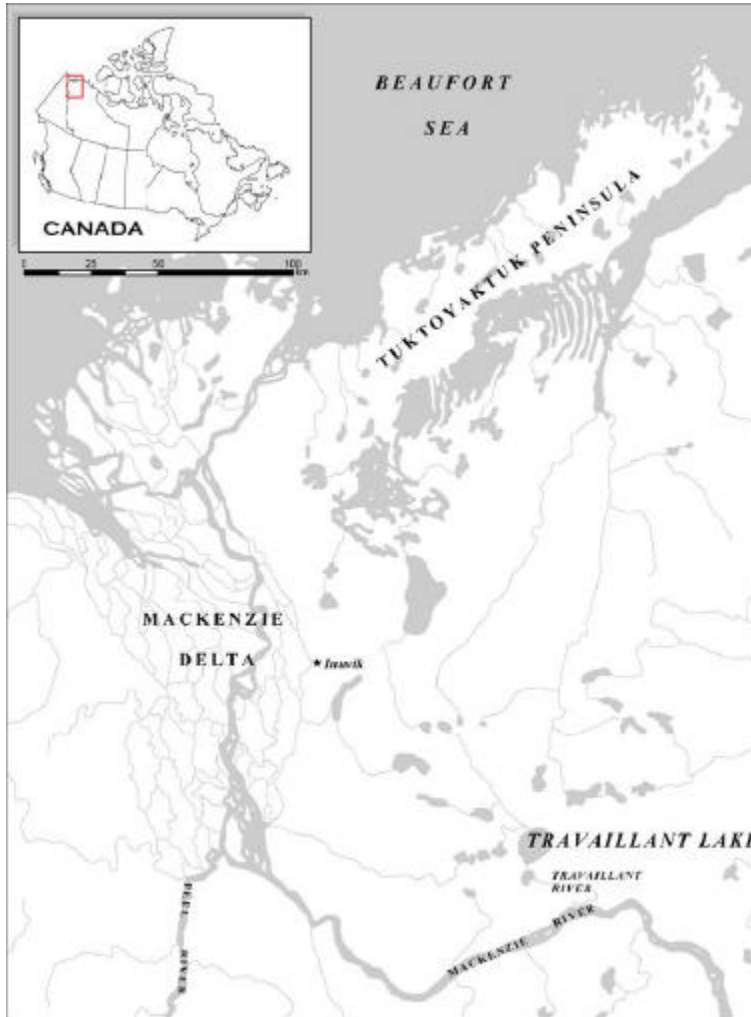


Figure 1. The Mackenzie Delta area and Travaillant Lake

Study Area

Travaillant Lake (67°36'53" N, 131°52'56" W) is located 95 km SE from the town of Inuvik, NT, and 80 km NE from the hamlet of Tsiigehtchic, NT (Fig. 1). It is the largest lake located within the GSA with a surface area of 115 km². The lake itself is almost perfectly round; 13 km long and 11.5 km wide at the longest and widest parts with a maximum depth of 30 m. The main tributary and outlet to the lake is the Travaillant River, which originates some 50 km to the north in the Lost Reindeer Lakes. The Travaillant River leaves from the south side of Travaillant Lake where it flows to the Mackenzie River 40 km to the south. The total length of the river is 126 km and depth ranges from 0.1 to 5m (Hatfield et al. 1972). The lake itself has an abundance of

submerged aquatic vegetation (*Potamogeton sp.*), and the surrounding coniferous forests have stained the water a "tea color". Travaillant lake supports a domestic fishery primarily for broad whitefish (*Coregonus nasus*), but lake whitefish (*C. clupeaformis*), lake trout (*Salvelinus namaycush*), burbot (*Lota lota*), Arctic grayling (*Thymallus arcticus*), and northern pike (*Esox lucius*) are also harvested.

Collection of Local Knowledge on Fish Movements and Habitat Use

For this portion of the project, we are relying on a combination of methods characteristic of Participatory Action Research, including the involvement of locals at all phases of project development and execution. The project is being carried out in two separate research phases to avoid any duplication of efforts among organizations:

- 1) Database and literature searches of previously documented local knowledge; and
- 2) Preliminary interviews with land users and elders from Inuvik and Tsiigehtchic.

The GRRB is working cooperatively with the Tsiigehtchic and Inuvik communities, through local Renewable Resource Councils and community representatives as well as the Gwich'in Social and Cultural Institute (GSCI) to identify elders and harvesters who have spent time in the Travaillant Lake area and have knowledge of the fish and the lakes. An interviewer from each community has been trained to interview people individually. All interviews are being recorded and most transcribed. Information from database and literature searches, contemporary harvest records and interview transcripts will be combined in a Filemaker Pro database, designed for compatibility with existing databases, as well as for future GIS mapping projects. Results are being recorded on a 1:100,000 scale map of the Travaillant Lake Basin. After the interviews are complete, a workshop will be held with the interviewees to discuss and confirm the results.

Fish Capture, Tagging and Biological Sampling

Fieldwork was conducted from 14-27 July, 18-31 August and 18-23 October 2003. Sampling and fish tagging was performed by GRRB biologist Les Harris with assistance from Tsiigehtchic community members Dan Andre, Thomas Kendo and Barney Natsie, and Tsiigehtchic youth Brian Francis. Community knowledge about timing of freeze-up, topography and characteristics of the area was used to help plan field logistics such as where to place field camps, where to set nets and timing of sampling in order to coincide with fish runs.

In July and August, fish were captured using 114-140 mm mesh gill nets ranging in length from 22.9 to 91.4 m, set at various locations along the southwest shore of Travaillant Lake (Table 1, Fig. 2). Broad and lake whitefish were tagged using T-bar anchor

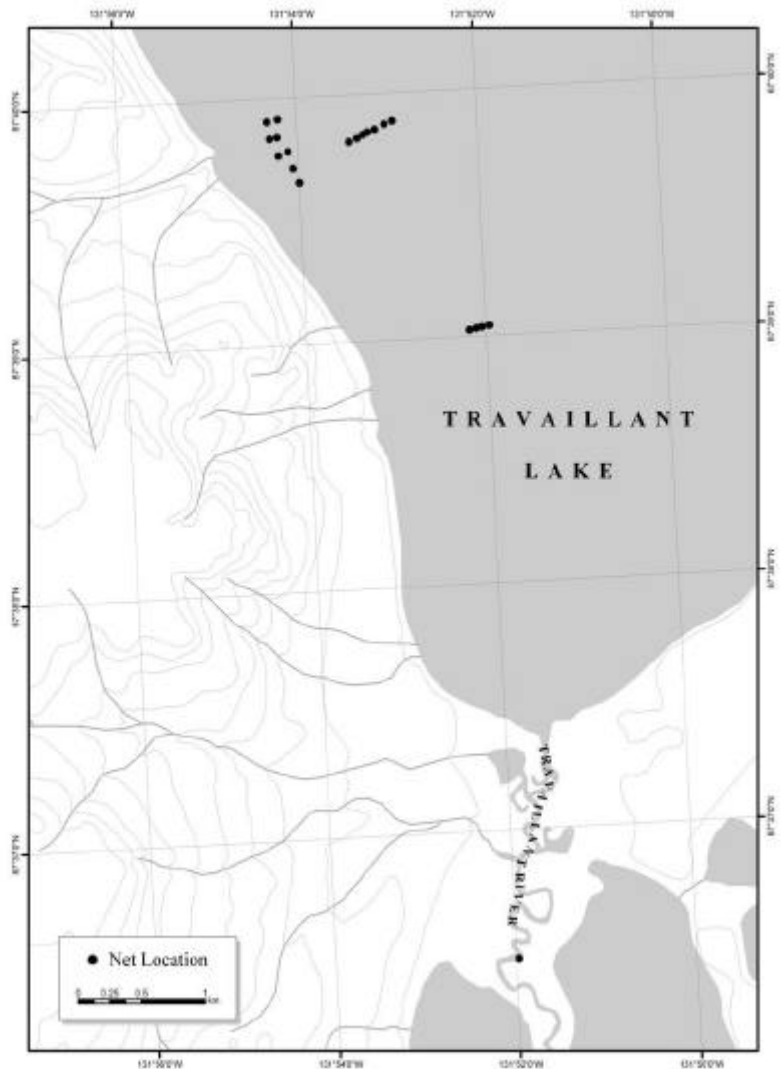


Figure 2. Map of sampling locations in Travaillant Lake.

tags (Floy tags), sampled for fork length (± 1 mm) and round weight (± 50 g), the first two fin rays from the left pelvic fin were clipped, and the fish was released. Fish to be tagged were placed in a measuring trough, tags were inserted in the left side of the fish at the base of the dorsal fin, and anchored between the pterygiophores. Each tag contained a reference number and a return address. To reduce the chance of infection a 10% povidone-iodine topical solution was used after each tagging event to sterilize the tagging needle. Most fish quickly swam out of sight upon release. Those that appeared to be lethargic were retrieved and held in the lake water until fully recovered.

Table 1. Descriptions of the nets used at Travaillant Lake in 2003.

Net Identification	Net Description	Length (m)	Depth (m)
A	4.5" monofilament	22.9	2.4
B	4.5" monofilament	22.9	2.4
C	5" monofilament	22.9	2.4
D	5" monofilament	22.9	2.4
E	5.5" monofilament	45.7	2.4
F	5.5" monofilament	22.9	2.4
H	5" monofilament	91.4	2.4

Lake trout, northern pike and inconnu were sampled for fork length (± 1 mm) and round weight (± 50 g), the first two fin rays from the left pelvic fin were clipped, and the fish were released. These species were not tagged as this study was focussed on the movements of the whitefish species within the lake.



Dan Andre with lake trout

Photo by L. Harris

Any fish found dead in the nets were retained and sampled in greater detail for biological characteristics that could only be collected through lethal analysis. For all dead fish, fork length (± 1 mm), round weight (± 50 g), sex and maturity were recorded, the first two fin rays from the left pelvic fin were clipped and sagittal otoliths were removed from broad whitefish, lake whitefish and lake trout.

To identify possible nursery areas of coregonids in Travaillant Lake, a beach seine was used to capture young-of-the year (YOY) and/or juvenile broad whitefish and lake whitefish, during the July and August field periods. Seining was conducted at various locations on the west side of Travaillant Lake, and in an unnamed creek that entered the lake where the camp was situated. The seine net consisted of 0.48 cm mesh and was 12.2 m in length.

In October, broad whitefish and lake whitefish were collected in the Travaillant River (67°36'28" N, 131°51'58" W) using a 114 mm gill net (Fig. 2). During October, these species congregate in preparation for spawning, and many samples can be collected over a short duration of time. All samples collected in October were retained and analyzed for fork length (± 1 mm), round weight (± 50 g), sex and maturity. The first two fin rays from the left pelvic fin were taken, and sagittal otoliths were removed from all fish for age determination. Ovaries and testes were preserved for determination of gonad weight (± 0.1) and fecundity. Stomachs and tissue samples from all fish were collected and preserved for future analyses.

Tag Recovery

To describe the movements and migration patterns of broad whitefish and lake whitefish, it is necessary to recover tagged fish. As part of this tag-recovery procedure, "reward" posters were distributed to each of the Gwich'in Renewable Resource Councils (GRRC's, Fig. 3). These posters were also distributed to post offices and local stores in each of the four communities in the Gwich'in Settlement Area. A \$10.00 reward was offered to fishermen for each tag that was returned, including information on the date and location the tagged fish was harvested. A reward of \$20.00 was offered for the return of the whole fish, including the date and harvest location information.

\$\$ Reward for 2003 \$\$
Tagged Fish

Help us find out where fish from
Travaillant Lake go and get a reward!

\$10

Provide the GRRB or your RRC with:

- type of fish
- date when caught
- location where caught
- tag

\$20

Provide the GRRB or your RRC with:

- type of fish
- date when caught
- location where caught
- whole fish with the tag

For example:

Type:	Whitefish
Date:	July 11, 2003
Place:	Mackenzie River, 5 miles downstream of Taigahtichic
Tag:	

For more information contact
Les Harris at the Gwich'in Renewable Resource Board
(867) 777-3429

Figure 3. Examples of the posters that were used in an effort to obtain information regarding the recapture of tagged fish

Lab Analyses of Biological Information



Ages of all live-captured and released broad whitefish and lake whitefish were determined from fin ray sections (Chilton and Beamish 1982). Dead sampled broad whitefish and lake whitefish were aged from otoliths using a modified version of the break burn method (Chilton and Beamish 1982) where the otoliths are polished prior to being burned. Comparative studies of these two aging structures have shown that both produce similar and reliable age estimates (M. Treble, unpublished data).

Fecundity was estimated using methods similar to those used by VanGerwen-Toyne (2001). Ovaries from all mature female broad whitefish and lake whitefish caught in October were preserved in 10% formalin for one week. Once preserved, eggs were rinsed with tap water, separated from connective tissue, and air dried under a fume hood until egg weight was constant (± 5 g). Three sub-samples of 200 eggs were weighed, and fecundity was calculated using the following formula: Fecundity = average weight of subsample (g) / weight of all eggs x size of sub-sample

Data Analyses of Biological Information

For all analyses, data have were separated by season, since we expected that summer and fall samples might not be comparable; the summer sample was collected in Travaillant lake and likely contained whitefish fish at different life history stages (Chudobiak 1995), while the fall sample was collected in the Travaillant River and was composed entirely of whitefish in spawning condition. Wherever possible (fall sample only) we conducted separate analyses for males and females.

Fork length and age frequency distributions, as well as mean length and age were determined for broad and lake whitefish by season and by sex for the fall sample. To examine growth (length) characteristics of broad and lake whitefish we plotted fork length at age by season and by sex (fall sample).

Weight-length relationships for broad whitefish and lake whitefish were determined using the following simple linear model with log transformed data for fork length and weight by season and sex (fall sample): $\text{Log}_{10}W = a + b(\text{log}_{10}L)$, where W = weight (g), L = fork length (mm), a = Y axis intercept and b = slope of the regression line.

Mortality rates of broad and lake whitefish were determined from catch curves (natural log of age class frequency against age) plotted for summer and fall samples of each species. A simple regression was fit to the descending limb of each curve. This regression included the year class with greatest abundance plus one year to the next subsequent year class where $n \leq 1$. Instantaneous mortality rate (Z), annual survival rate (S) and annual mortality rate (A) were calculated as follows: Z =positive slope of regression, $S=e^{-z}$, $A=1-S$ (Ricker 1975).

Although maturities were qualitatively assessed in the field, gonadosomatic index (GSI) was determined for all broad and lake whitefish captured in October to provide a more objective assessment of maturity and gonad development. GSI was calculated as follows: $GSI = (\text{gonad weight (g)} / \text{body weight (g)}) \times 100$

The relationships of fecundity to fork length were examined using simple linear models.

RESULTS AND DISCUSSION

Collection of Local Knowledge on Fish Movements and Habitat Use

This portion of the project is still in progress therefore we have only reported activities to date and expected outputs. A detailed report will be provided when interviews have been completed and the information analyzed. The database and literature search of previously documented local knowledge was largely carried out prior to initiation of the interviews and the information used to help inform and shape the study. Following is a list of some of the sources reviewed for information relevant to the area:

- The Gwich'in Environmental Knowledge Project Database;
- The Gwich'in Harvest Study Database;
- Place name and archaeological databases at the Prince of Wales Heritage Center;
- GCSI publications: "Gwichya Gwich'in Googwandak: the History and Stories of the Gwichya Gwich'in As Told by the Elders of Tsiigehtchic" and "The Traditional Use of the Travaillant Lake Area Using Trails and Place Names of the Gwichya Gwich'in from Arctic Red River, N.W.T.";
- GRRB report: "Travaillant Lake Fish Movement Study: Traditional Knowledge Interviews";
- Regional bibliographies;
- Aurora Research Institute;
- Inuvik Centennial Library;
- Report of the Berger Inquiry.

While some of the literature research is still underway, we are in the process of compiling these results with the preliminary results from the database searches.

To date, eleven individuals in the communities of Inuvik and Tsiigehtchic have been interviewed. Results are being recorded on a 1:100,000 scale map of the Travaillant Lake Basin, and interview transcripts have been prepared to be entered into the database. Contemporary harvest records in the area have been compiled by species and mapped.

Fish Tagging and Tag Returns

A total of 309 fish were tagged and released in 2003. Of these tagged fish, 174 were lake whitefish, and 135 were broad whitefish. Northern pike, lake trout and inconnu were not tagged as the emphasis of this study was on the whitefish species within the lake. In total, including fish marked as part of the 2002 Travaillant Lake Fish Movement Study, 218 lake whitefish, 171 broad whitefish and 14 lake trout have been tagged in Travaillant Lake over the past 2 years. To date, no tags or tagged fish have been returned or reported. Other tagging studies in the Lower Mackenzie River region have yielded tag recovery percentages as high as 2.7 % (Babaluk *et al.* 1997, 2001), however these have been conducted in the lower Mackenzie River on anadromous broad whitefish. Fish in the Mackenzie Delta are more susceptible to recapture for two reasons; 1) spawning migrations of fully anadromous fish occur in specific corridors making them more susceptible to recapture and 2) fishing pressure is much higher in the Mackenzie Delta when compared to that in Travaillant Lake or the Mackenzie River at the mouth of the Travaillant River.

Fish Species Composition

Five different fish species and 643 fish were captured and identified in the gill net catches during the 2003 study (Table 2, Fig. 4). The summer catches within Travaillant lake were dominated by lake whitefish (44.6 %) and broad whitefish (31.7 %), with smaller catches of northern pike (12.2 %) and lake trout (11.2%) and the rare capture of an inconnu (Fig. 4a). In July, broad whitefish (43.3 %) were caught most often, followed by lake whitefish (34.5 %), lake trout (12.5 %), northern pike (9.5 %) and inconnu (0.3 %; Fig. 4b). Lake whitefish (65.0 %), dominated the August catches, followed by northern pike (17.8 %), broad whitefish (8.6 %), and lake trout (8.6 %; Fig. 4c). The summer catches within Travaillant Lake in 2003 were similar to catches reported by VanGerwen-Toyne (2002). Using gill nets, she captured lake whitefish most often, followed by

Table 2. Names and numbers of fish captured at Travaillant Lake in 2003.

Common Name	Scientific Name	Summer			Fall	Total
		Tagged	Released	Dead Sampled	Dead Sampled	
broad whitefish	<i>Coregonus nasus</i>	134	0	22	70	226
lake whitefish	<i>Coregonus clupeaformis</i>	175	2	42	82	301
lake trout	<i>Salvelinus namaycush</i>	0	8	47	0	55
northern pike	<i>Esox lucius</i>	0	46	14	0	60
inconnu	<i>Stenodus leucichthys</i>	0	1	0	0	1
Total		309	57	125	152	643

northern pike, broad whitefish, lake trout and least cisco. In October, lake whitefish (54.0 %) and broad whitefish (46.0 %; Fig. 4d) were the only two species of fish captured within the Travaillant River. The observed differences in species composition may be attributed to the location of the nets and/or the seasons of netting. In particular, the presence of lake and broad whitefish in fall catches within the Travaillant River is not surprising given that both species typically spawn within rivers in the fall. The other two species which were of relatively high abundance in summer lake catches, but were absent from the fall river sample, were lake trout and northern pike. The former is a lake spawner, while the latter does not spawn until spring.

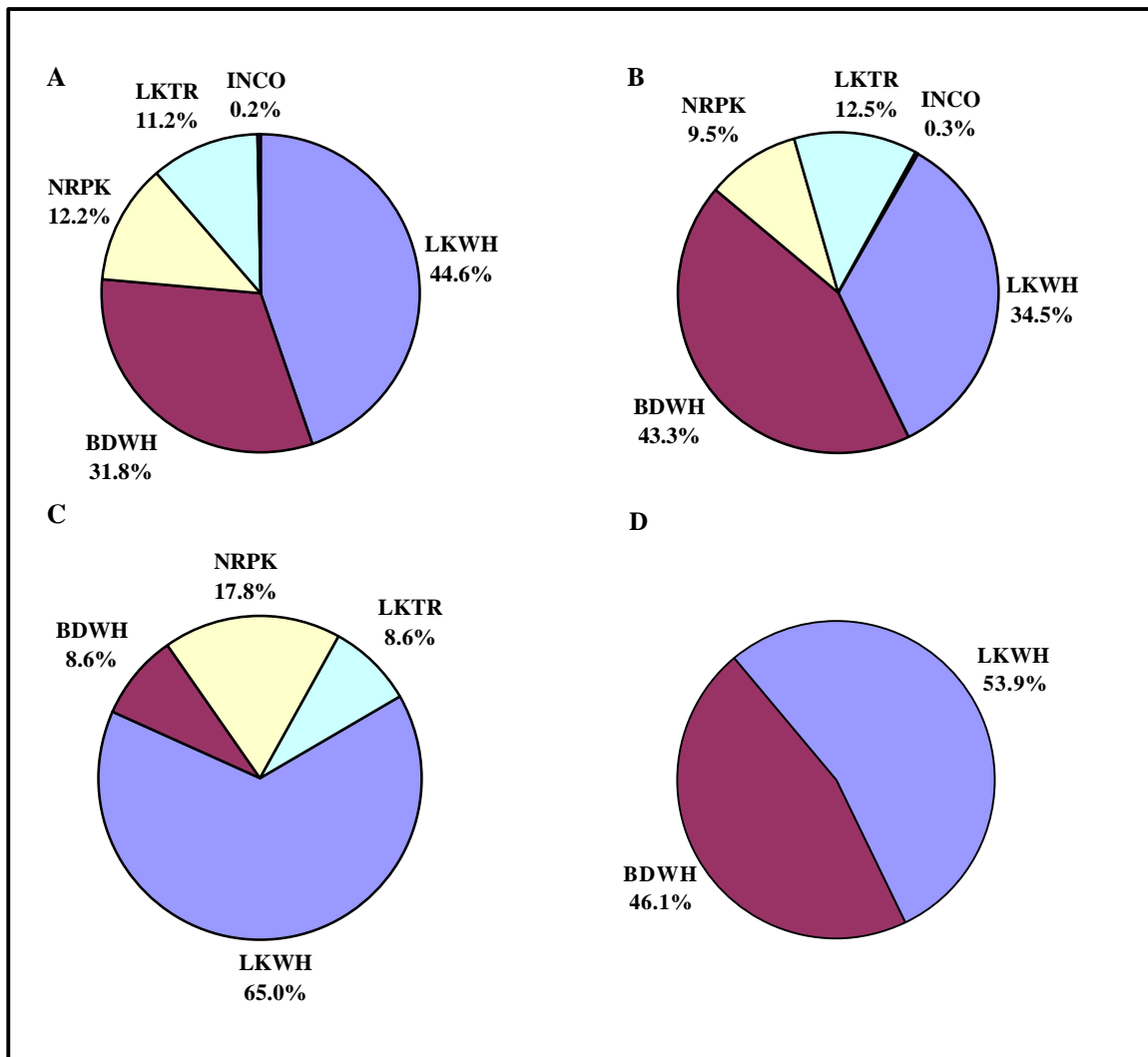
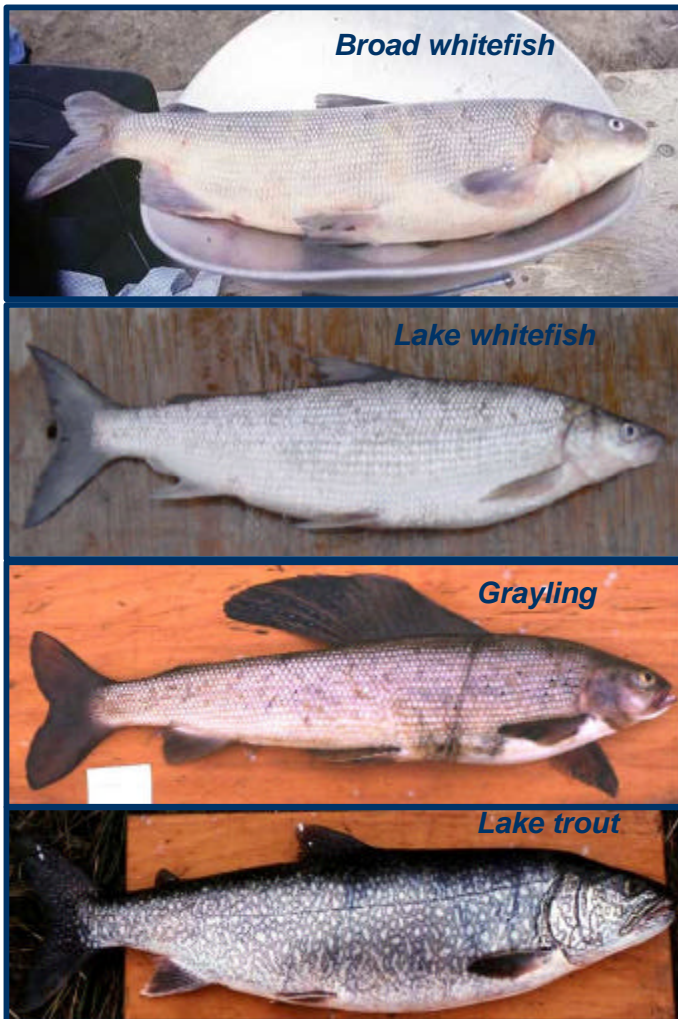


Figure 4. Species composition of the gill net catches from Travaillant Lake in (A) all summer (B) July, (C) August and from Travaillant River in (D) October. BDWH = broad whitefish, LKWH = lake whitefish, NRPK = northern pike, LKTR = lake trout and INCO = inconnu.



Photos by L. Harris and K. Howland

Species captured in Travaillant Lake during summer with the beach seine included juvenile broad whitefish and lake whitefish, juvenile lake trout, juvenile Arctic grayling, brook stickleback (*Culaea inconstans*), white sucker (*Catostomus commersoni*) and sculpins (*Cottus sp.*). Since young-of-the-year broad whitefish and lake whitefish were caught in Travaillant Lake, it may indicate that adults of these fish are spawning in, or near the lake. Chudobiak (1995) suggested that broad whitefish spawn at two locations in Travaillant Lake, the Travaillant River outlet at the south end of the lake and the Travaillant River inlet at the north end of the lake. Stein et al. (1973) also suggested that the Travaillant River is an important nursery area for broad whitefish and lake whitefish.

Biological Evaluation

Fish for this study were captured with large mesh nets (114-140 mm), typical of what is used by subsistence harvesters to capture broad or lake whitefish. Large mesh sizes were used since the main objective during the summer sampling in 2003 was to capture adult broad and lake whitefish for tagging. During the fall sampling period our objective was to capture a sample of broad and lake whitefish known to be spawning within the Travaillant River and therefore likely to be residents of the Travaillant lake system. The data presented below are only representative of the mature component of these fish populations. Ideally, experimental gill-nets with varying mesh size would be used to provide a more complete representation of the population. These methods will be incorporated in a more complete population analysis during 2004.

Broad whitefish

The fork length frequency distributions for all broad whitefish captured in 2003, are presented in Fig. 5. The majority of broad whitefish captured in Travaillant Lake during summer ranged from 370 to 550 mm in fork length, although one individual of 645 mm was captured in our nets (Fig. 5a). The mean size of broad whitefish sampled during this time period was 453.2 mm, with the greatest abundance of individuals occurring in the 420 to 450 mm length classes (Fig. 5a). Other studies of broad whitefish in lake systems have reported fork lengths ranging from 270 to 510 mm (Travaillant Lake, VanGerwen-Toyne 2002) and 146 to 561 mm (Campbell Lake, Read and Roberge 1986), however these studies included the use experimental multi mesh nets (mesh size 38-127 mm) which allowed for the capture of smaller fish at the lower end of these size ranges. Treble and Tallman (1997) reported fork lengths ranging from 253 to 655 mm for broad whitefish captured in 139 mm gillnets over a five year period.

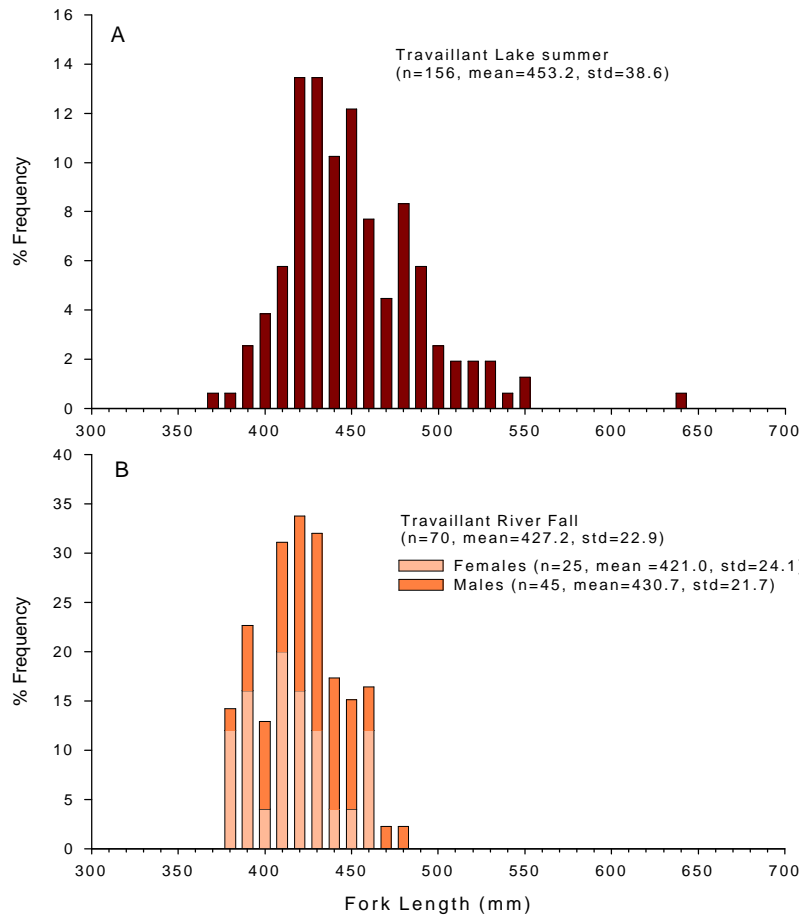


Figure 5. Length frequency distributions of broad whitefish collected in A) Travaillant Lake during summer and B) Travaillant River in fall.

The fall sample of spawning broad whitefish captured in October ranged from 382-486 mm with a mean length of 427.2 mm; the greatest abundance of individuals were in the 410 to 430 mm length classes (Fig. 5b). Male and female broad whitefish in the fall sample had similar length frequency distributions and mean sizes (Fig. 5b).

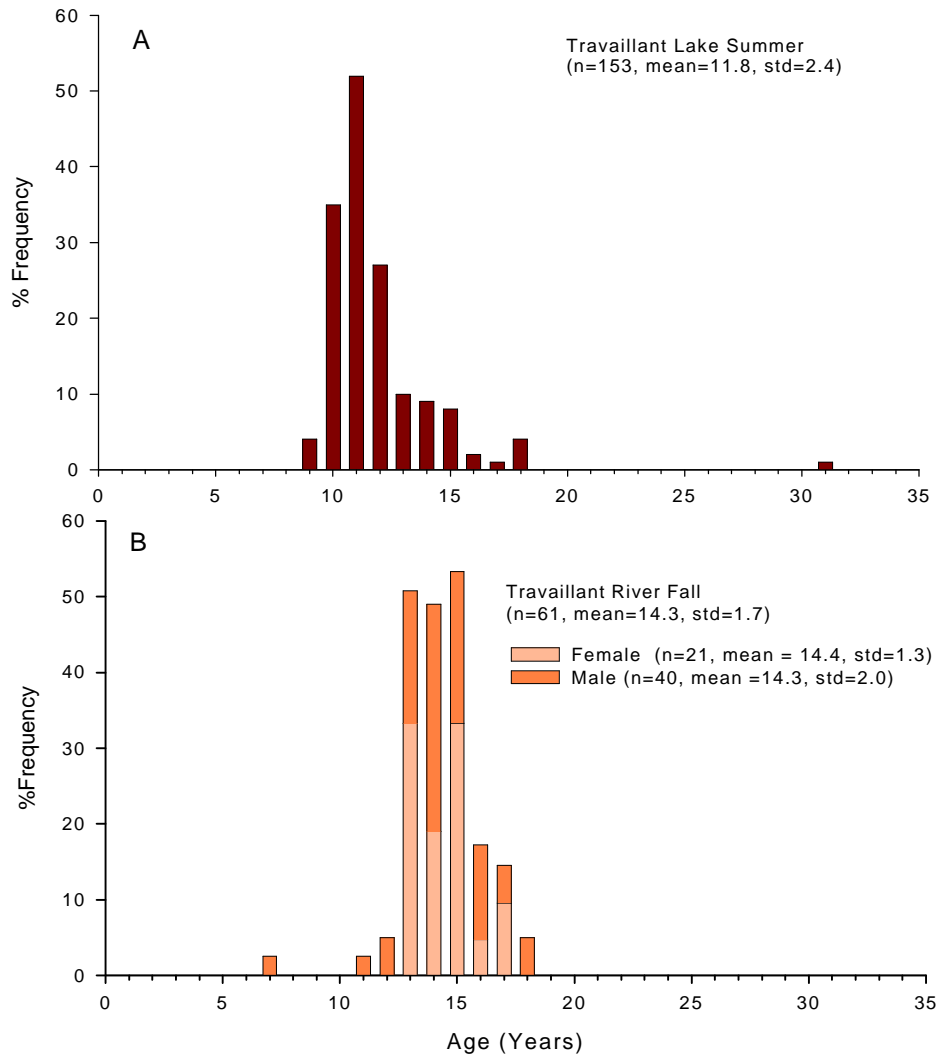


Figure 6. Age frequency distributions of broad whitefish collected in A) Travaillant Lake during summer and B) Travaillant River in fall.

The age frequency distributions for broad whitefish captured in 2003 are presented in Fig. 6. With the exception of one individual aged 31 years, the broad whitefish collected in Travaillant Lake during summer ranged in age from 9 to 18 years with an average age of 11.8, and a modal age of 11 (Fig. 6a). With the exception of one individual aged 7 years, the fall sample of spawning broad whitefish captured in October were older than those captured in the summer, ranging from 11 to 18 years of age with a mean age of 14.3 years; the greatest abundance of individuals were between 13 to 15 years of age (Fig. 5b). Male and female broad whitefish in the fall sample had similar age frequency distributions and mean ages (Fig. 6b). These are similar to the ages for anadromous broad whitefish from the Mackenzie Delta captured in 139 mm gillnets over a five year period (range 3 to 30 years, mean per location and year 8.9 to 12.9 years) reported by Treble and Tallman (1997). Chudobiak (1995) captured broad whitefish in Travaillant Lake and River ranging in age from 1 to 26 years using a combination of 139 mm and multi-mesh experimental nets.

The length at age of broad whitefish captured in 2003 is presented in Fig. 7a. The broad whitefish captured during summer in Travaillant Lake were generally of a greater body size for a given length in comparison to those captured in Travaillant River during the fall (Fig. 7a), suggesting that the former grow at a faster rate than the latter. Male and female broad whitefish in the fall sample were of similar body length at a given age (Fig. 7a).

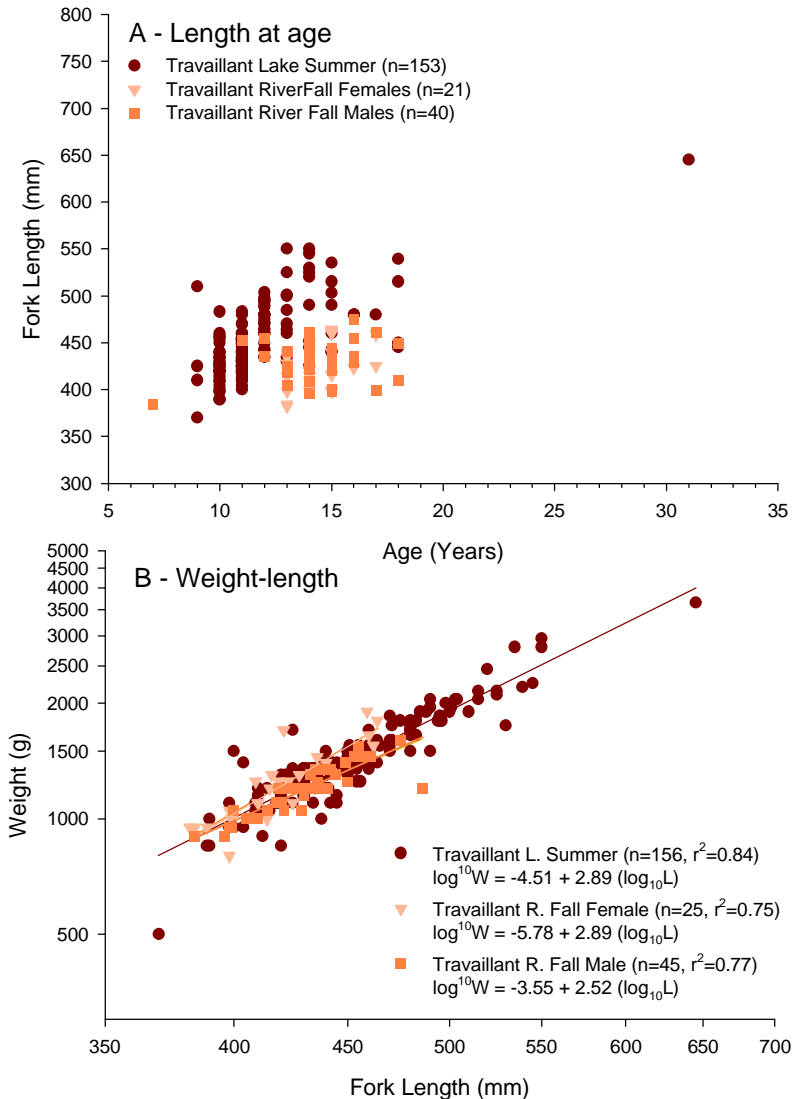


Figure 7. A) length at age and B) weight-length relationships of broad whitefish collected in Travaillant Lake during the summer in the Travaillant River in fall. Note that the lower graph is on a log arithmetic scale.

The relationships between fork length and round weight for broad whitefish captured in 2003 are presented in Fig. 7b. The length-weight relationship of broad whitefish collected in Travaillant Lake during the summer period was similar to those collected from Travaillant River in the fall (Fig. 7b). Likewise, males and females had similar weight length relationships, suggesting that condition varied little with season, reproductive state and sex.

The age and size at full recruitment of broad whitefish to the net sizes used in this study varied between seasons. Broad whitefish captured in Travaillant Lake during the summer season were fully recruited to our sampling gear by the age of 11 years and at a size of 438.2 ± 18.8 mm (mean \pm S.D. fork length) (Fig. 8a), whereas those captured in the fall from Travaillant River were fully recruited at the age of 15 years and an average size of 429.3 ± 23.5 mm (mean \pm S.D. fork length) (Fig. 8b). Mortality rates were similar across seasons and locations ranging from 0.61 to 0.65 (Fig. 8). Studies of broad whitefish in the Mackenzie Delta exploratory fishery using 139 mm gillnets reported ages of recruitment and mortality, ranging from 10-12 years and 0.27 to 0.46, respectively (Treble and Tallman 1997).

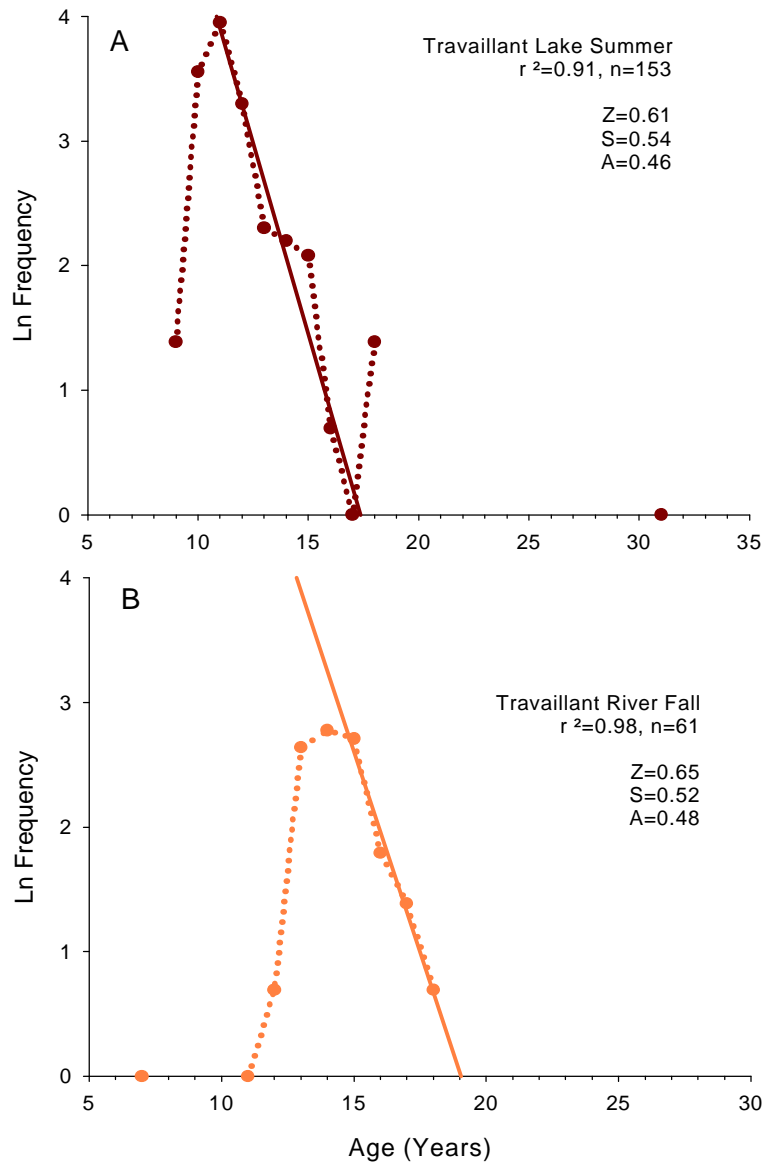


Figure 8. Age frequency catch curves for broad whitefish collected in A) summer and B) fall. Instantaneous mortality (Z), survival (S) and annual mortality (A) have been calculated where appropriate.

Based on visual examination of gonads and the high gonadosomatic indices (GSI), the majority of male and female broad whitefish captured in the fall sample from the Travaillant River were mature or running ripe and about to spawn or spawning (Females 88%, Males 89%; Table 3). The remaining fish in the fall sample were either spent or resting. For females, GSI of mature spawning fish ranged from 11.64 to 21.8, while GSI of spent or resting individuals ranged from 0.56-1.08. For males, GSI of spawners ranged from 0.64 to 1.35 and GSI of spent or resting individuals ranged from 0.10 to 0.25 (Table 3). Our observations are similar to those reported by Chudobiak (1995) who found that spawning females in the Travaillant River had GSI values ranging from 9.7 to 23.5. Treble and Tallman (1997) reported GSI indices for broad whitefish captured from the Mackenzie River over a five year exploratory fishery of between 0.07 and 31.67 for females and 0.04 and 3.08 for males. Their data included mature spawning fish as well as fish at other maturity stages. Bond and Erickson (1985) found that GSI of female broad whitefish in the Delta-Beaufort Sea region typically exceeded 20.0 by spawning time.

Table 3. Range of GSI values and proportion of individuals categorized at different stages of maturity, for broad whitefish captured in the Travaillant River in October.

Maturity	Female			Male		
	n	%	GSI	n	%	GSI
Mature	13	52.00	11.64-21.75	33	73.33	0.64-1.35
Running Ripe	9	36.00	-	7	15.56	0.66-1.00
Spent or Resting	3	12.00	0.56-1.08	5	11.11	0.10-0.25

Male broad whitefish were nearly twice as abundant as females. The ratio of males to females was 1.75:1 in the summer sample (n=22) and 1.8:1 in the fall sample (n=70). It should be noted that the summer sample may not be fully representative since sex of the fish was only determined for individuals found dead in the gill nets. Previous studies of spawning broad whitefish in the Travaillant River reported a 1.1:1 ratio of males to females (Chudobiak 1995). Approximately equal ratios of males to females were also observed for anadromous broad whitefish in the Mackenzie delta (Treble and Tallman 1997). The skewed ratios observed in the present study could be related to low sample sizes or to the short period of time over which fall sampling was carried out, and should therefore be interpreted with caution.

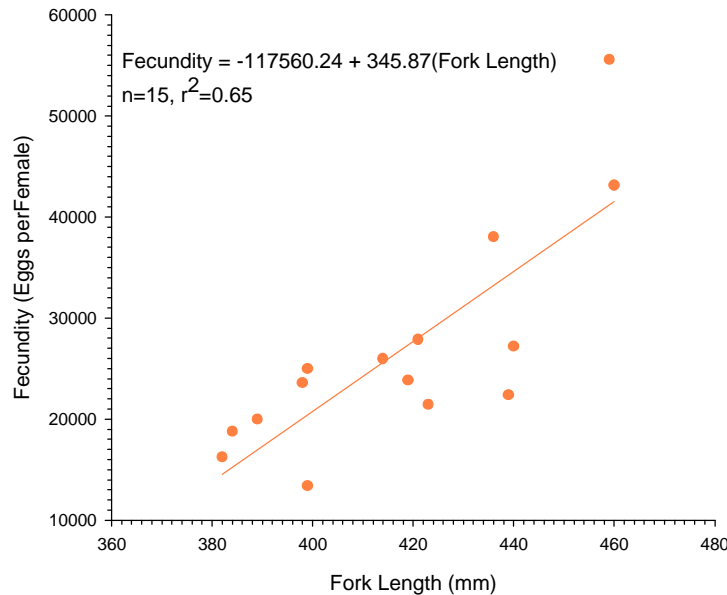


Figure 9. Relationship between fecundity and body size (fork length) for broad whitefish from the Travaillant River in fall just prior to spawning.

River broad whitefish ranging from 10 070 and 117 687 eggs per female. Chudobiak (1995) also investigated reproductive investment and found that broad whitefish from the Mackenzie River had a significantly higher average fecundity than those in Travaillant Lake.

Lake whitefish

The fork length frequency distributions for all lake whitefish captured in 2003, are shown in Fig. 10. The majority of lake whitefish captured in Travaillant Lake during summer ranged from 350 to 550 mm in fork length, although one individual of 646 mm was captured (Fig. 10a). The mean size of lake whitefish sampled during this time period was 447.6 mm, with the greatest abundance of individuals occurring in the 430 and 450 mm length classes (Fig. 10a). These values are generally within the size range reported for other studies of lake whitefish. For example, VanGerwen-Toyne (2002) reported lengths ranging from 270 to 550 mm for Travaillant Lake lake whitefish caught in 2002 and Read and Roberge (1986) reported catches of lake whitefish in Campbell lake ranging between 158 and 525 mm. It should be noted that these two studies included the use of experimental multi mesh nets (mesh size 38-127 mm) which would have allowed for the capture of smaller fish at the lower end of the reported size distributions. Lake whitefish captured in the Mackenzie Delta over a five year period using 139 mm large mesh nets ranged in size from 370 to 569 mm, with location and year specific means of 451 to 478 mm (Howland et al. 2001a).

Fecundity of broad whitefish collected from the Travaillant River increased linearly with body size ($r^2=0.65$, $p<0.001$) ranging from 13 384 to 55 576 with a mean fecundity of 27 846 eggs per female ($n=15$, S.D. = 11,786) (Fig. 9). Tallman et al. (2002) reported a similar range in the fecundity of Travaillant Lake broad whitefish of between 13 823 and 51 333 eggs per female ($n=25$). Previous studies on anadromous or semi-anadromous stocks of broad whitefish have shown higher fecundities than those estimated for Travaillant Lake fish. For example, Van Gerwen–Toyne and Walker-Larsen (unpublished data) reported fecundities of Peel

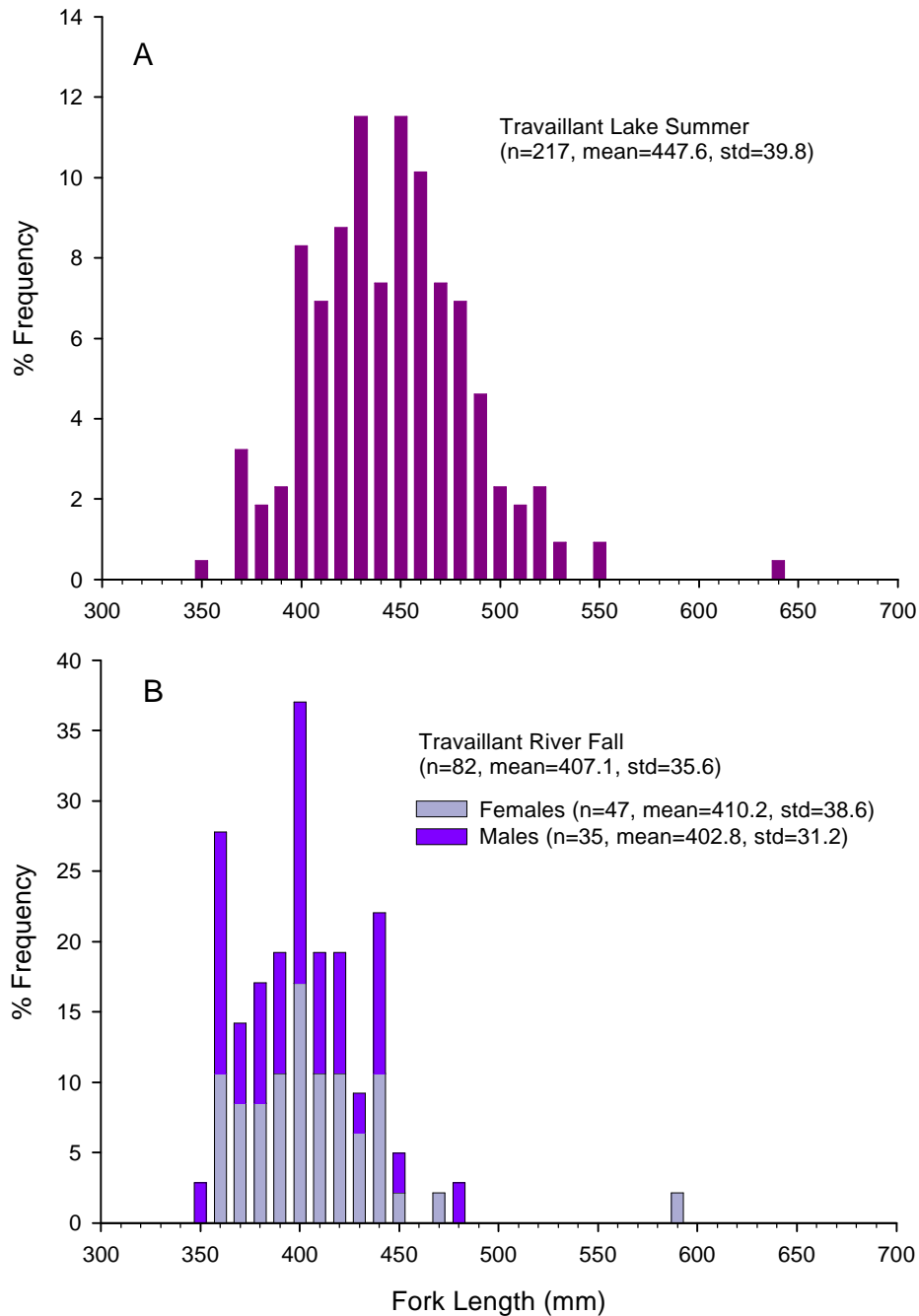


Figure 10. Length frequency distributions of lake whitefish collected in A) Travaillant Lake during summer and B) Travaillant River in fall.

The fall sample of spawning lake whitefish captured in October ranged from 356 to 483 mm in length, with the exception of one individual of 590 mm (Fig. 10b). Mean length was 407.1 mm with the greatest abundance of individuals occurring in the 400 mm length class (Fig. 10b). Male and female lake whitefish in the fall sample had similar length frequency distributions and mean sizes (Fig. 10b).

The age frequency distributions for lake whitefish captured in 2003 are shown in Fig. 11. Lake whitefish collected in Travaillant Lake during summer ranged in age from 6 to 28, with an average age of 12.6 and a modal age of 11 (Fig. 11a). The fall sample of spawning lake whitefish ranged from 10 to 21 years of age with a mean of 13.6 years; the greatest abundance of individuals were between 12 and 13 years of age (Fig. 11b). Male and female lake whitefish in the fall sample had similar age frequency distributions and mean ages (Fig. 11b). Ages from this study were within the range of 5 to 34 years (mean ages of 9 to 17.4 years) reported for lake whitefish captured in the Mackenzie Delta over a five year period using 139 mm large mesh nets (Howland et al. 2001a). Read and Roberge (1986) reported ages ranging from 2 to 17 years for lake whitefish captured in Campbell Lake using experimental multi-mesh gillnets.

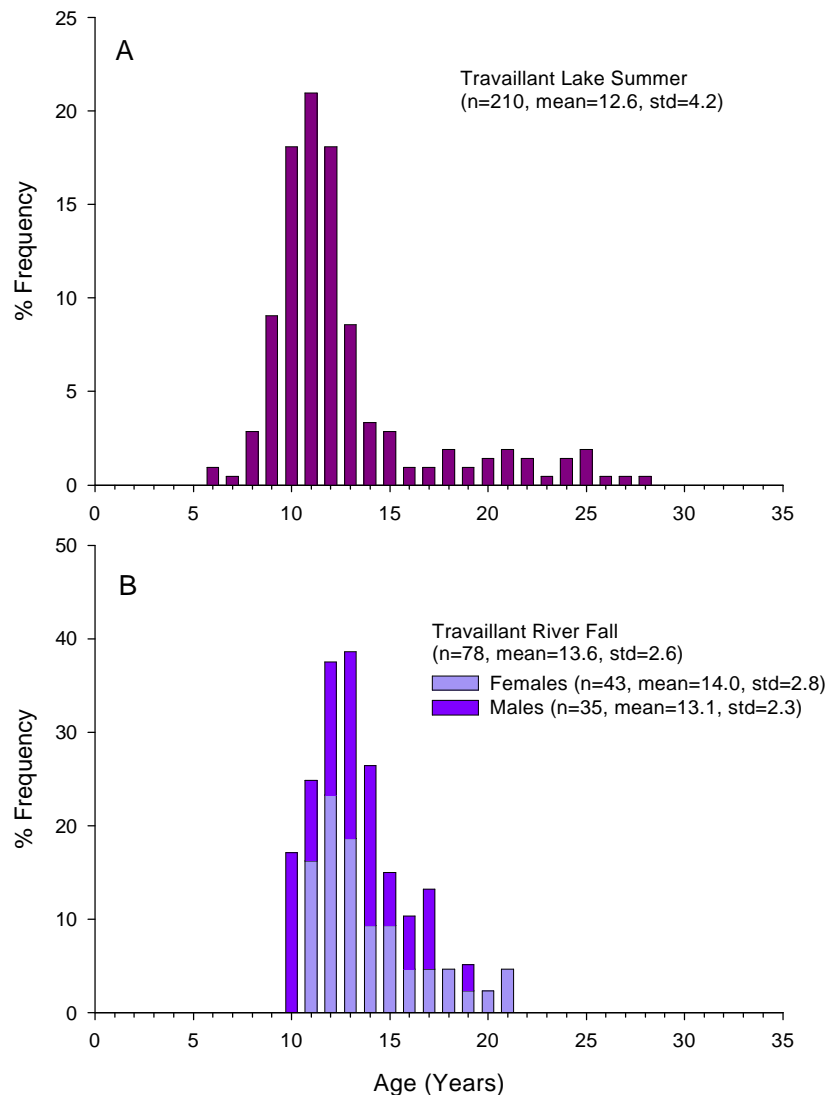


Figure 11. Age frequency distributions of lake whitefish collected in A) Travaillant Lake during summer and B) Travaillant River in fall

The length at age of lake whitefish captured in 2003 is presented in Fig. 11a. The lake whitefish captured during summer in Travaillant Lake were generally of a greater body size for a given length in comparison to those captured in Travaillant River during the fall (Fig. 12a), suggesting that the former grow at a faster rate than the latter. Male and female lake whitefish in the fall sample were of similar body length at a given age (Fig. 12a).

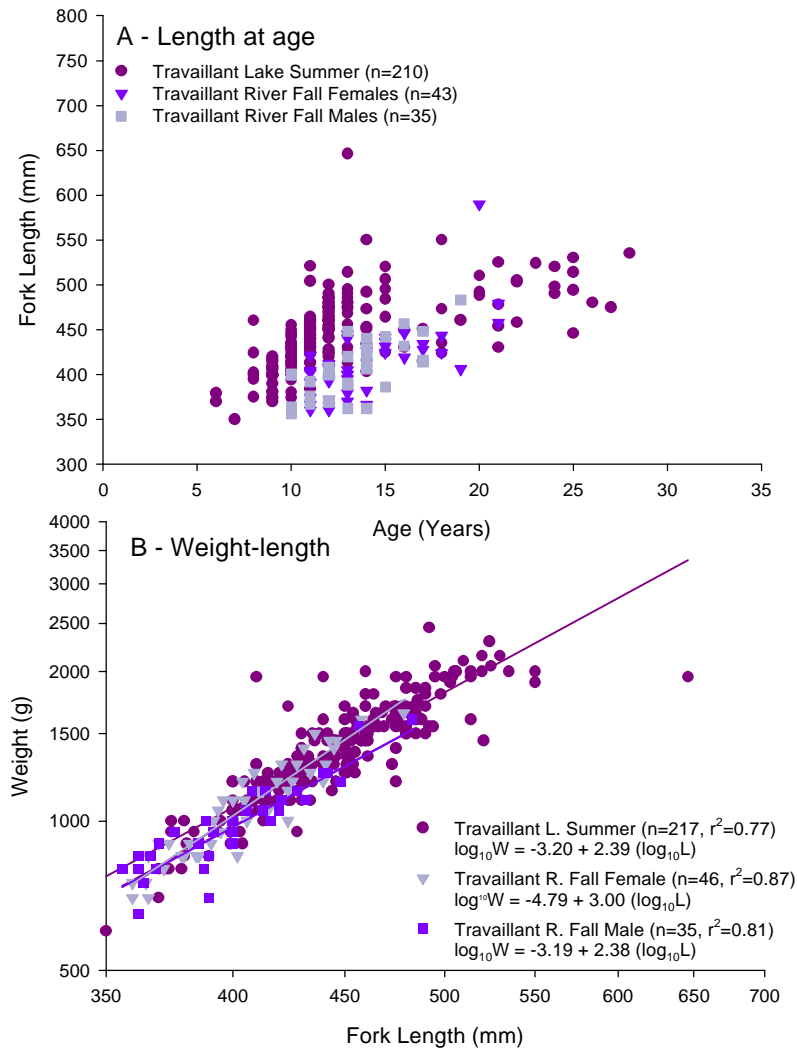


Figure 12. A) length at age and B) weight-length relationships of lake whitefish collected in Travaillant Lake during the summer in the Travaillant River in fall. Note that the lower graph is on a log arithmetic scale.

The relationships between fork length and round weight for lake whitefish captured in 2003 are presented in Fig. 12b. The length-weight relationship of lake whitefish collected in Travaillant Lake during the summer period was similar to those collected from Travaillant River in the fall (Fig. 12b). Likewise, males and females had similar weight length relationships, suggesting that condition varied little with season, reproductive state and sex.

The age and size at full recruitment of lake whitefish to the net sizes used in this study varied between seasons. Lake whitefish captured in Travaillant Lake during the summer season were fully recruited to our sampling gear by the age of 11 years and at a size of 461.8 ± 21.1 mm (mean \pm S.D. fork length) (Fig. 13a), whereas those captured in the fall from Travaillant River were fully recruited at the age of 13 years and an average size of 401.4 ± 23.5 mm (mean \pm S.D. fork length) (Fig. 13b). Estimated mortality rates were 0.22 and 0.35 for the summer and fall samples, respectively (Fig. 12). Studies of lake whitefish in the Mackenzie Delta exploratory fishery using 139 mm gillnets reported similar ages of recruitment and mortality, ranging from 12-14 years, 0.14 to 0.51, respectively (Howland et al. 2001a). These levels are within the range of natural mortality rates observed in unexploited lake whitefish populations (Healy 1975) suggesting that existing harvest levels are a minor contributing factor to overall mortality.

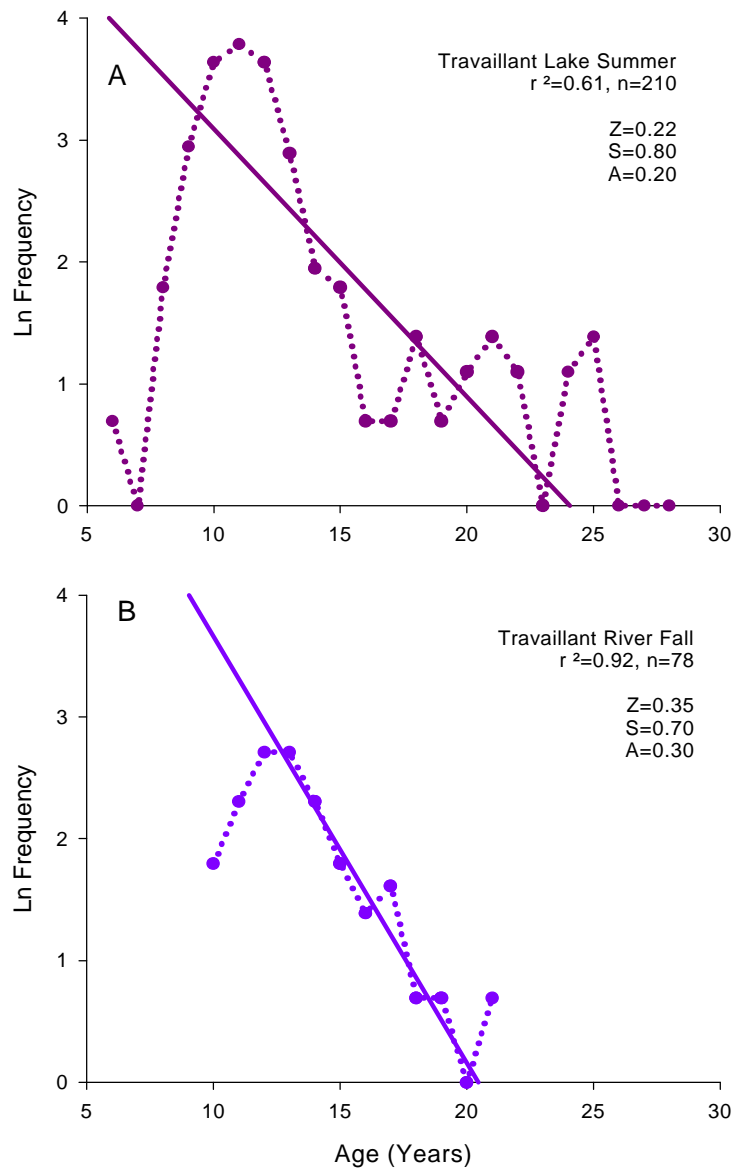


Figure 13. Age frequency catch curves for lake whitefish collected in A) summer and B) fall. Instantaneous mortality (Z), survival (S) and annual mortality (A) have been calculated where appropriate.

Based on visual examination of gonads and the high gonadosomatic indices (GSI), the majority of male and female lake whitefish captured in the fall sample from the Travaillant River were mature or running ripe and about to spawn or spawning (Females 70.2%, Males 90.6%; Table 4). The remaining fish in the fall sample were either spent or resting. For females, GSI of mature spawning fish ranged from 7.47 to 15.04, while GSI of spent or resting individuals ranged from 0.44 to 1.15. For males, GSI of spawners ranged from 0.51 to 2.66 and GSI of spent or resting individuals ranged from 0.18 to 0.30 (Table 4). Howland et al. (2001a) assessed lake whitefish biological characteristics of the five year exploratory fishery in the Lower Mackenzie River, and reported GSI values for female lake whitefish ranging between 0.08 and 27.8, and GSI values for male lake whitefish between 0.11 and 3.71. Their data included mature spawning fish as well as fish at other maturity stages. Bond and Erickson (1985) indicate that in the Delta-Beaufort Sea region GSI for mature lake whitefish in late summer can be as high as 20.9.

Table 4. Range of GSI values and proportion of individuals categorized at different stages of maturity, for lake whitefish captured in the Travaillant River in October.

Maturity	Female			Male		
	n	%	GSI	n	%	GSI
Mature	32	68.09	7.47-15.04	28	80.00	0.51-2.08
Running Ripe	1	2.13	-	5	10.64	0.64-2.66
Spent or Resting	14	29.79	0.44-1.15	2	4.26	0.18-0.30

The ratio of males to female lake whitefish in the summer sample (n=42) was 1.1:1 and in the fall sample was 0.74:1 (n=82). It should be noted that the summer sample may not be fully representative since sex of the fish was only determined for individuals found dead in the gill nets. The observed sex ratios in our study are well within the range of 0.68:1 to 1.28:1 reported for lake whitefish captured in the Mackenzie delta exploratory fishery ranged from (Howland et al. 2001a).

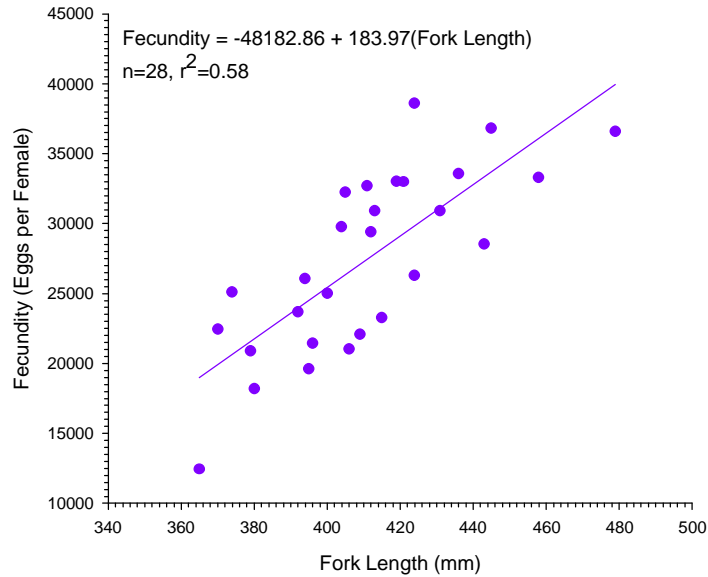


Figure 14. Relationship between fecundity and body size (fork length) for lake whitefish from the Travaillant River in fall just prior to spawning.

Fecundity of lake whitefish collected from the Travaillant River increased linearly with body size ($r^2=0.58, p<0.001$) ranging from 4406 to 38 578 with a mean of 26 705 eggs per female ($n = 30, \text{S.D.} = 7571$) (Fig. 14). Fecundity of anadromous lake whitefish from the Peel River, was found to range between 11 787 and 73 683 eggs per individual with a mean of 32 937 (VanGerwen-Toyne and Walker-Larsen, unpublished data).

CONCLUSIONS AND FURTHER RESEARCH

Although floy tagging studies can be very effective way to determine fish movement, fish capture and harvest mortality, they are only of use if tag return information can be obtained. A variety of factors may influence the success of returns including mortality, loss of tags after release, non-return of tags by fishermen and tagging too small a sample of a particular species (Jessop *et al.* 1973). In the case of this study we suspect that a combination of low sample size and a low number of harvesters (due to the remote location of Travaillant Lake) were the main reasons for poor tag return success.

Given the limitations associated with floy tagging studies, particularly in remote locations and the fact that two years of floy tagging in Travaillant Lake has not resulted in any tag returns, we plan to track and document fish movements in 2004 using radio telemetry methods. Radio telemetry has proven effective in a number of studies of movements and life histories of arctic fishes (Howland *et al.* 2000, Babaluk *et al.* 2001b, Chang-Kue and Jessop 1983, 1991a, 1991b, 1997). This research will involve the surgical implantation of radio transmitters (2 year life) in mature broad whitefish and documentation their movements and critical habitat using a series of fixed station receivers in combination with aerial tracking techniques.

Although the tagging studies to date have not helped to resolve the issue of whether or not whitefish in Travaillant Lake exist as a closed population, the capture of young-of-the-year and juvenile coregonids in the summer, and the capture of mature female and male coregonids in the Travaillant River in the fall of 2003, indicate that spawning and rearing habitats of both broad and lake whitefish are located close to our sampling sites and likely within the Travaillant Lake system. This is quite plausible given that Travaillant

Lake is large and of varying depths making it ideal for rearing, feeding and over wintering of coregonids (Craig 1989). In addition, the size of the substrate and the water clarity, make the entire Travaillant River system adequate for whitefish spawning (Chudobiak 1995).

The species composition and biological characteristics of harvested species were within the general range of observations from previous studies in the Lower Mackenzie Region, although mortality rates appeared to be higher than normal for broad whitefish. There were some differences in the biological characteristics of broad and lake whitefish samples collected in summer and fall which could be an indication that there are multiple stocks of each species within the lake system or that different life history stages were represented in samples collected during different seasons. This could not be assessed from the data collected in 2003 since the majority of fish in the summer sample were tagged and could not be sampled for stage of maturity. Caution should be used in interpretation of the results to date since only one season of data have been collected and a limited range of sampling gear were used. Further studies in 2004 will be expanded to include the use of gillnets with a greater range of mesh sizes in order to more fully represent the fish community and individual fish populations as a whole. Detailed sampling for population analyses will be conducted in the lake during summer as well as in the two main spawning areas during fall in order to obtain a better representation of the range of variability that may exist within populations (stocks) in this lake system.

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Dan Andre with lake trout *Photo by L. Harris*

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