# Travaillant Lake Fish Movement Study and Population Assessment 2003

**Gwich'in Renewable Resource Board Report**

**by**

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## SUMMARY

During July and August 2003, 174 lake whitefish and 135 broad whitefish from Travaillant Lake were tagged using T-Bar Anchor (Floy) tags, and released back into the lake. The study was conducted to provide insight on the movements and migrations of these species determined from tag recovery information. To date, none of the tags have been returned or recovered.

Selected biological data were also collected for all broad whitefish and lake whitefish captured in 2003. Additionally, sampling was conducted in October for the sole purpose of collecting information on the biology of lake whitefish and broad whitefish when in spawning condition. This biological information was analyzed and compared to data that were collected on Travaillant Lake fish from previous studies.

Due to the lack of success with Floy tagging studies on this lake, further studies of broad whitefish movements over the next two years will be conducted using radio telemetry methods. This study will involve the surgical implantation of radio transmitters (2 year lifespan) in mature broad whitefish, and documentation of their movements and critical habitat using strategically placed fixed station receivers in combination with aerial tracking of individual fish.

## INTRODUCTION

Travaillant Lake is the largest lake (115 km$^2$) 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*).

Recently, the Arctic regions of North America have experienced increased development of both renewable and non-renewable resources (Reist 1997a). Such an example is the Mackenzie Valley pipeline that is proposed to pass directly through the Travaillant Lake system, within 10 km of Travaillant Lake itself. Pipeline construction can result in complicated, and often long term effects on aquatic environment, particularly on fish (Stein *et al.* 1973). There is local concern that construction of the Mackenzie Valley pipeline will cause irreversible, negative impacts on fish and water quality in the Travaillant Lake system, by potentially adding contaminants, increasing sedimentation and erosion, and increasing access to this otherwise inaccessible lake. This has increased the awareness that there is a need to gather preliminary information on the fish resources that inhabit this system before pipeline construction takes place.

Many fish employ seasonal movement or migrational strategies in order to gain access to key habitats that are essential for their survival and development, but are separated in time and space. These movements are often guided by seasonal changes in living conditions (e.g. ice formation), seasonal reproductive patterns (e.g. migrating to suitable breeding sites), and food availability. For instance, broad whitefish display multiple life history patterns including movements between freshwater and estuaries of the coast (amphidromy or anadromy), movements within rivers and movements within lake systems (lacustrine or lake dwelling) (Reist and Bond 1988, Reist and Chang-Kue 1997). Although lacustrine forms of fish may exhibit seasonal migrations between different habitats, these are usually much shorter than those of anadromous fish and never involve marine waters or coastal environments. (Reist and Chang-Kue 1997).

The life history of the lacustrine form of broad whitefish is poorly known but appears to be restricted to local situations involving larger lakes and their tributary systems (Reist and Chang-Kue 1997). With respect to the broad whitefish population(s) in Travaillant Lake, it is unclear whether they complete their entire life cycle within the Travaillant Lake system or if they move into the Mackenzie River and migrate elsewhere to spawn.

Travaillant Lake contains suitable habitat and resources for all stages of broad whitefish life history, therefore, individuals within the lake may exist as a closed population that is able to complete its entire life cycle within the lake (Chudobiak 1995). This hypothesis is supported by results of otolith strontium analyses of Travaillant Lake broad whitefish indicating that they remain in freshwater throughout their lives (Babaluk and Reist 1996). Furthermore, comparisons of genetic and morphological features of broad whitefish from Travaillant Lake suggest that they are a distinct life history form, different from their Mackenzie River counterparts (Chudobiak 1995, Chudobiak *et al.* 2002, Reist 1997b, Tallman *et al.* 2002). In contrast, an examination of sulphur isotopes in the flesh of broad whitefish from Travaillant Lake suggested that they are visitors to the lake, which have assimilated a significant fraction of their sulphur from food sources outside of Travaillant Lake (Hesslein *et al.* 1991).

The uncertainty surrounding the migrations or seasonal movements of broad whitefish in Travaillant Lake needs to be addressed. If the life history of broad whitefish from Travaillant Lake involves regular or long migrations, this may complicate management of fisheries for this species. Depending on the extent of their migrations, these broad whitefish may, spatially, be more susceptible to local fishing pressures and industrial development, and complications with trans-boundary management issues may arise between settlement regions. To protect fish populations of Travaillant Lake from potential impacts, we need a better understanding of their movements and biological characteristics. Information regarding fish movements is essential to studies of fish population dynamics, and for the implementation of effective fisheries management plans and decisions. Although, there has been some documentation and research on the life histories and migrations of anadromous coregonids in the western Arctic (Bond and Erickson 1985, Chang- Kue and Jessop 1983, 1991a, 1991b, 1997, Howland *et al.* 2000**,** Reist and Bond 1988), the movements of their freshwater counterparts are poorly understood and have seldom been documented.

In response to this knowledge gap, the Gwich'in Renewable Resource Board has been conducting a fish movement study on the lake since 2002. Tagging studies can provide information about stock identification, migrations, age and growth rates, mortality rates and abundance (Hilborn *et al.* 1990). In this study we are attempting to determine if fish species (mainly broad whitefish) stay within the Travaillant lake system by tagging live fish, and using harvest location of returned tags to determine fish movements. If fish are recaptured in the Mackenzie River, it will provide conclusive evidence that Travaillant Lake broad whitefish are not a closed population. If fish are re-caught within Travaillant Lake, it will increase the understanding of the utilization of this lake by local fish species.

Accelerated exploration and development in the Mackenzie Valley has intensified the need to gather baseline information on the fish resources that inhabit this system before development occurs. Thus, basic biological information was also collected from all tagged fish. To gain a better understanding of the biology and vital rates of harvested species in Travaillant Lake, a further sample of broad whitefish and lake whitefish were collected for detailed population analysis as part of a collaborative study with DIAND and DFO. This report outlines results of the tagging and biological data collected as part of the 2003 Travaillant Lake fish movement study.

*Making dry fish at camp*

## MATERIALS AND METHODS

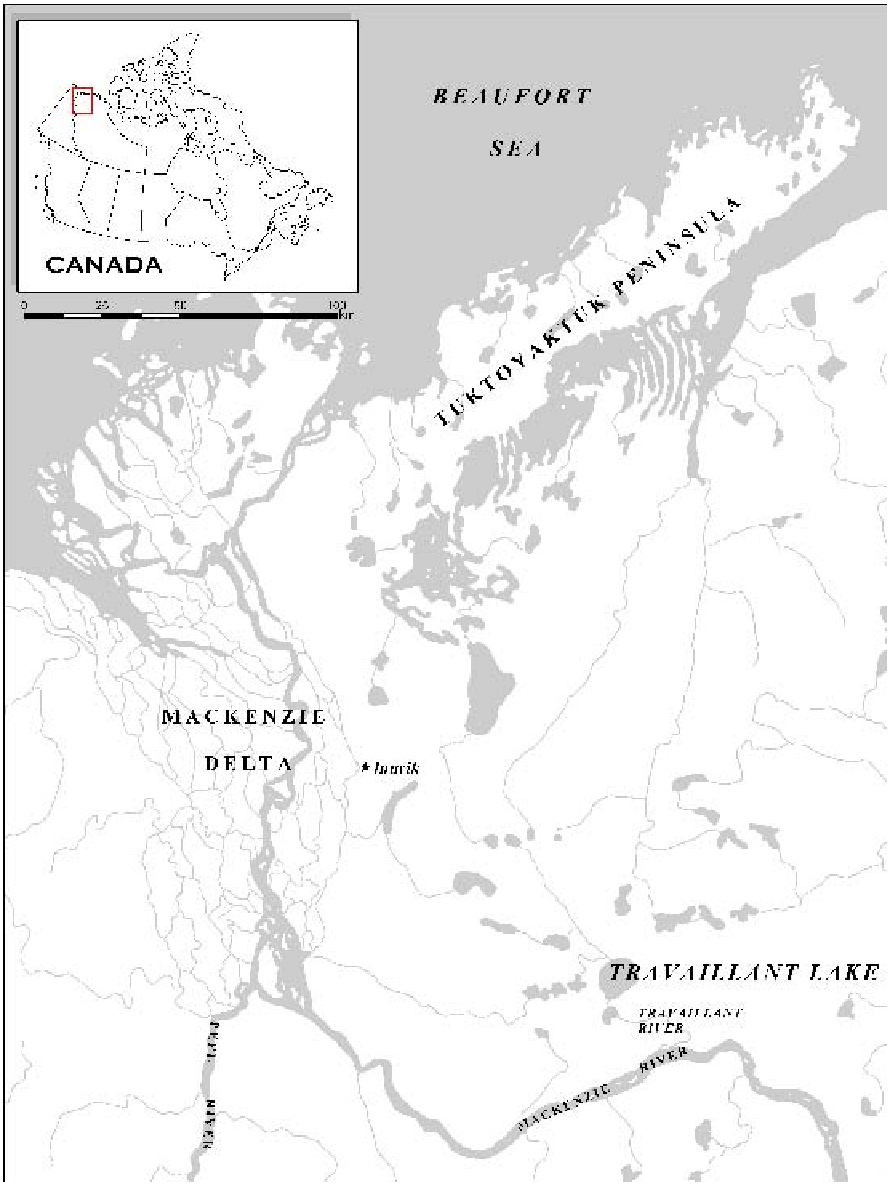


Figure 1. The Mackenzie Delta area and Travaillant Lake.

### Study Area

Travaillant Lake (67°36'3" 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 Gwich'in Settlement Area with a surface area of 115 $km^2$. 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.

## Fish Capture, Tagging and Biological Sampling

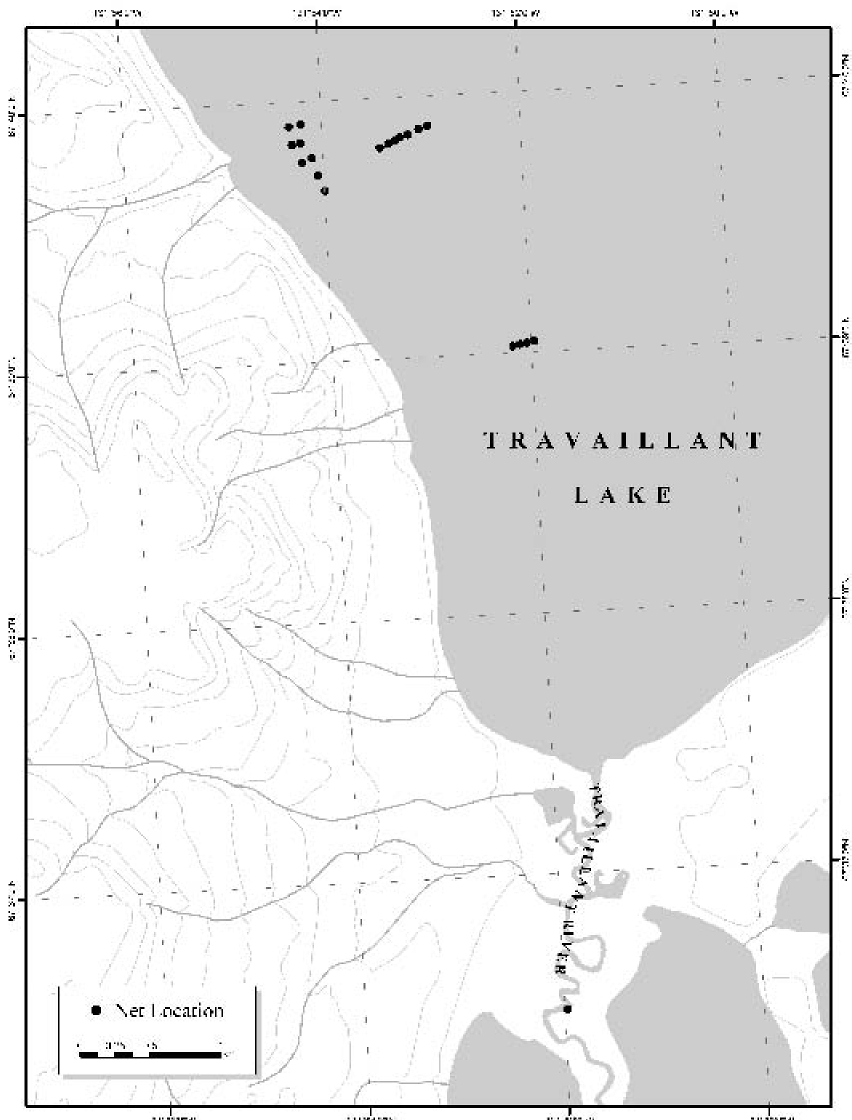


Figure 2. Map of sampling locations in Travaillant Lake.

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.

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

Table 1. Description 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 then the fish were released. These fish were not tagged as this study was focused on the movements of the whitefish species within the lake.

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 4.8 mm mesh and was 12.2 m in length.

*Travaillant Lake camp*

In October, broad whitefish and lake whitefish were collected in the Travaillant River (67°36'28" N, 131°51'58" W) using a 4.5-inch 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.

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.

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 (g) × size of sub-sample.


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

**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.

## Data Analyses

For all analyses, summer and fall samples were analyzed separately since we expected significant variation between the samples; 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):

$$\text{Log}_{10}W = a + b\,(\log_{10}L)$$

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 maturity was 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 gonadal development. GSI was calculated as follows:

$$\text{GSI} = \frac{\text{gonad weight (g)}}{\text{fish round weight (g)}} \times 100$$

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

## RESULTS AND DISCUSSION

### Species Composition

Five different fish species and 643 fish were captured and identified in the gill net catches during the 2003 study (Table 2, Figure 4). The total catch within Travaillant Lake was dominated by lake whitefish (46.8 %) and broad whitefish (35.1 %), with smaller catches of northern pike (9.3 %), lake trout (8.6 %) and the rare capture of an inconnu (Figure 4). 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 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.

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

| Common Name | Scientific Name | Summer Tagged | Summer Released | Summer Dead Sampled | Fall Dead Sampled | Total |
|---|---|---|---|---|---|---|
| broad whitefish | *Coregonus nasus* | 134 | 0 | 21 | 70 | 226 |
| lake whitefish | *Coregonus clupeaformis* | 175 | 2 | 42 | 82 | 301 |
| lake trout | *Salvelinus namaycush* | 0 | 8 | 47 | 0 | 55 |
| northern pike | *Esox lucius* | 0 | 46 | 14 | 0 | 60 |
| inconnu | *Stenodus leucichthys* | 0 | 1 | 0 | 0 | 1 |
| Total | | 309 | 57 | 125 | 152 | 643 |

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.

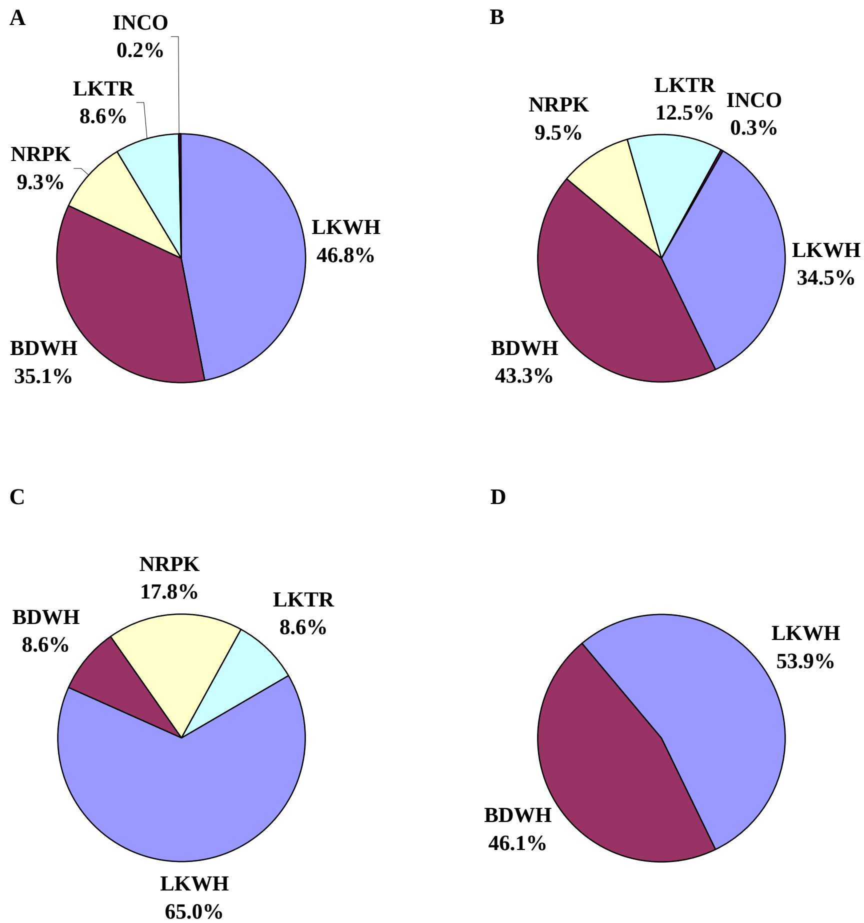


Figure 4. Species composition of the gill net catches from Travaillant Lake in (A) all of 2003, (B) July, (C) August and from the Travaillant River in (D) October. BDWH = broad whitefish, LKWH = lake whitefish, NRPK = northern pike, LKTR = lake trout and INCO = incommu.

### 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.* 2001a), 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.

**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 Figure 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 (Figure 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 (Figure 5a). Other studies of broad whitefish in lake systems have reported fork lengths ranging from 270 mm to 510 mm (Travaillant Lake, VanGerwen-Toyne 2002) and 146 mm to 561 mm (Campbell Lake, Read and Roberge 1986), however these studies included the use experimental multi mesh

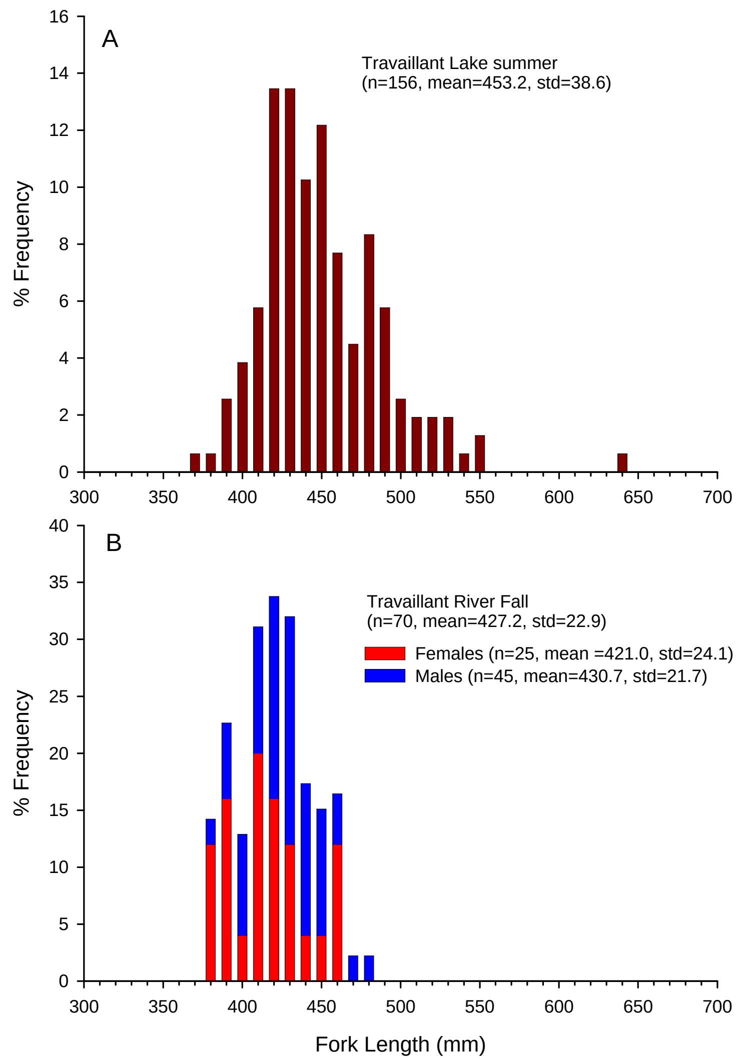


Figure 5. Length frequency distributions of broad whitefish collected in (A) Travaillant Lake during summer and (B) Travaillant River in fall.

nets (mesh size 38-127 mm) which allowed for the capture of smaller fish at the lower end of these size ranges.

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 (Figure 5b). Male and female broad whitefish in the fall sample had similar length frequency distributions and mean sizes (Figure 5b).

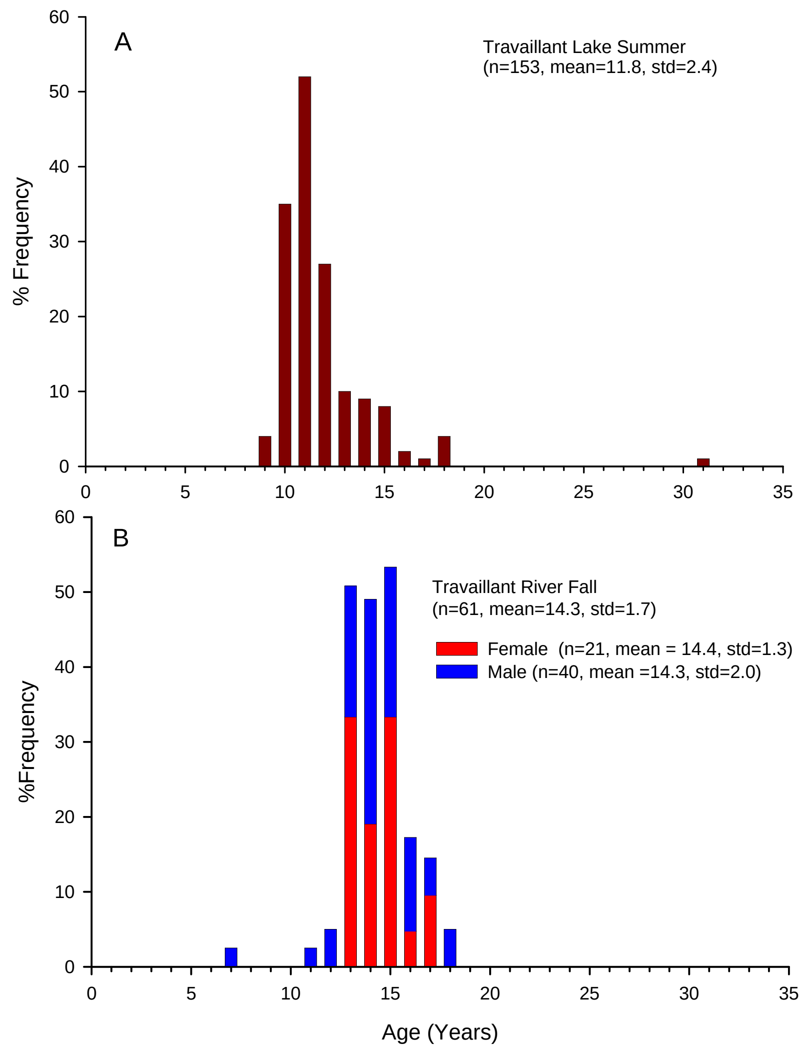


Figure 6. Age frequency distributions of broad whitefish collected in (A) Travaillant Lake during summer and (B) Travaillant River in fall.

The age frequency distributions for broad whitefish captured in 2003 are presented in Figure 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 (Figure 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 of 14.3 years; the greatest abundance of individuals were between 13 to 15 years of age (Figure 5b). Male and female broad whitefish in the fall sample had similar age frequency distributions and mean ages (Figure 6b).

The length at age of broad whitefish captured in 2003 is presented in Figure 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 (Figure 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 (Figure 7a).

The relationships between fork length and round weight for broad whitefish captured in 2003 are presented in Figure 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 (Figure 7b). Likewise, males and females had similar weight length relationships, suggesting that condition varied little with season, reproductive state and sex.

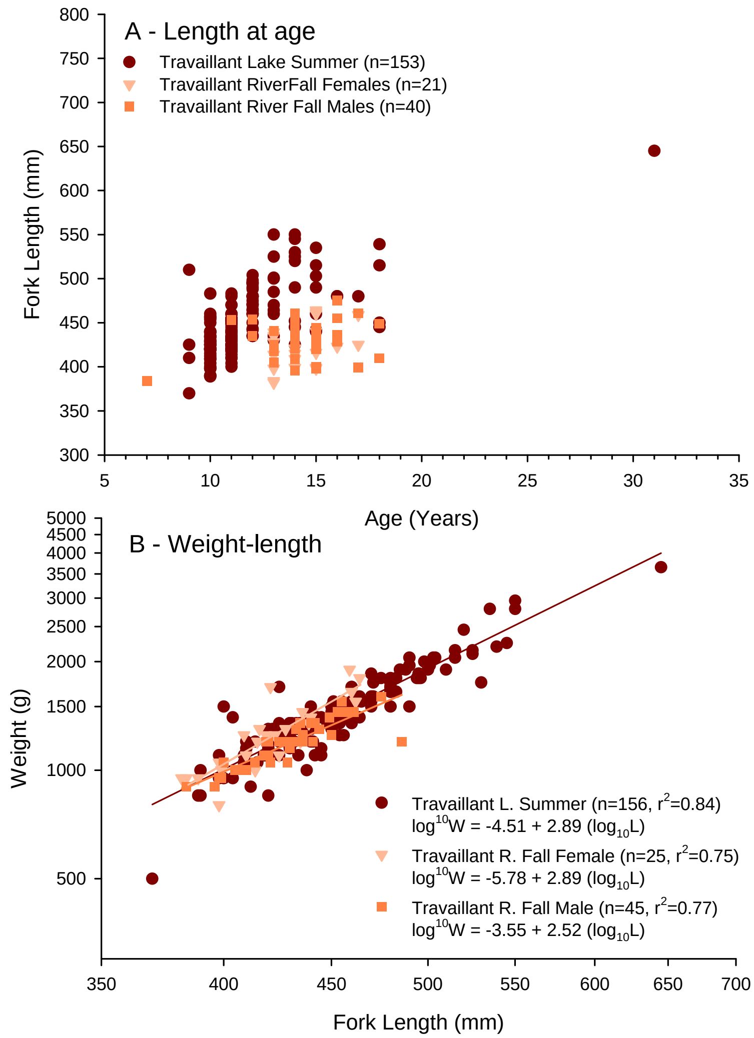


Figure 7. A) length at age and B) weight-length relationships of broad whitefish collected in Travaillant Lake during the summer in the Travaillant River in fall. Note that the lower graph is on a logarithmetic scale.

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 ± S.D. fork length) (Figure 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 ± S.D. fork length) (Figure 8b). Mortality rates were similar across seasons and locations ranging from 0.61 to 0.65 (Figure 8).

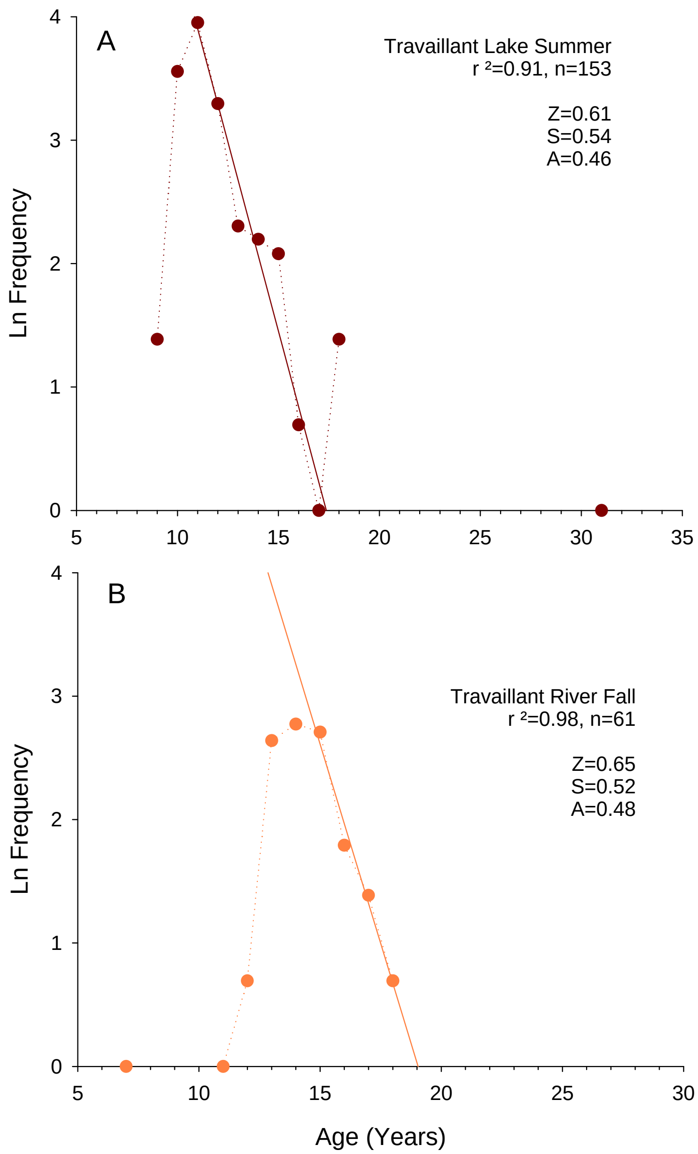


Figure 8. Age frequency catch curves for broad whitefish collected in A) summer and B) fall. Instantaneous mortality (Z), survival (S) and annual mortality (A) have been calculated where appropriate.

Based on visual examination of gonads and the high gonadosomatic indicies (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 raged 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 (1997) who found that spawning females in the Travaillant River had GSI values ranging from 9.0 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.

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 1997). 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.

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.

| | **Female** | | | **Male** | | |
|---|---|---|---|---|---|---|
| **Maturity** | **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 | 15 | 11.00 | 0.10-0.25 |

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) (Figure 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 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.

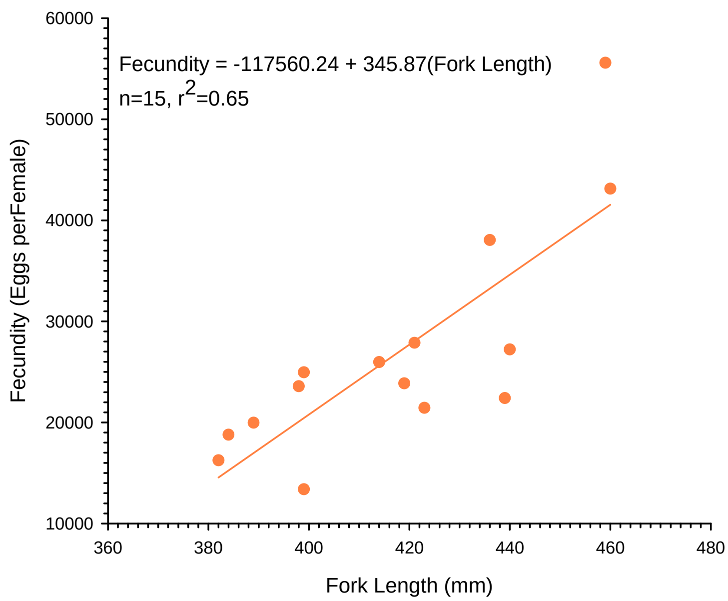


Figure 9. Relationship between fecundity and body size (fork length) for broad whitefish from the Travaillant River in fall just prior to spawning.

*Lake whitefish*

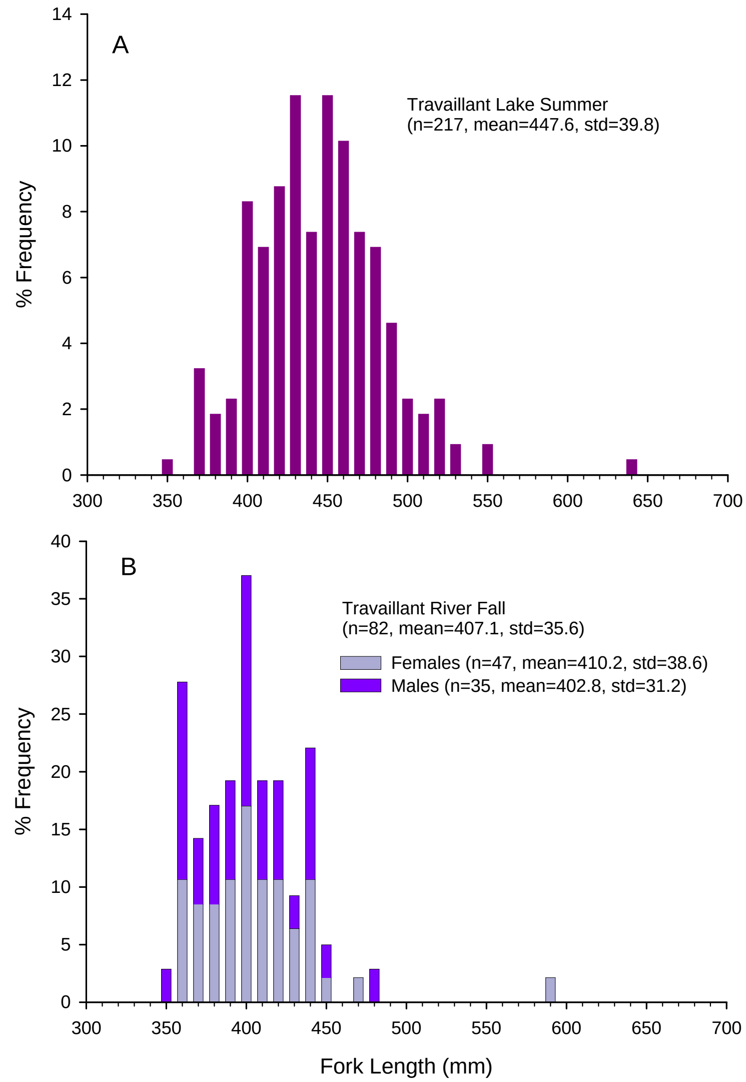


Figure 10. Length frequency distributions of lake whitefish collected in A) Travaillant Lake during summer and B) Travaillant River in fall.

The fork length frequency distributions for all lake whitefish captured in 2003, are shown in Figure 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 (Figure 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 (Figure 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).

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 (Figure 10b). Mean length was 407.1 mm with the greatest abundance of individuals occurring in the 400 mm length class (Figure 10b). Male and female lake whitefish in the fall sample had similar length frequency distributions and mean sizes (Figure 10b).

The age frequency distributions for lake whitefish captured in 2003 are shown in Figure 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 (Figure 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 (Figure 11b). Male and female lake whitefish in the fall sample had similar age frequency distributions and mean ages (Figure 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. 2001). Read and Roberge (1986) reported ages ranging from 2 to 17 years for lake whitefish captured in Campbell Lake using experimental multi-mesh gillnets.

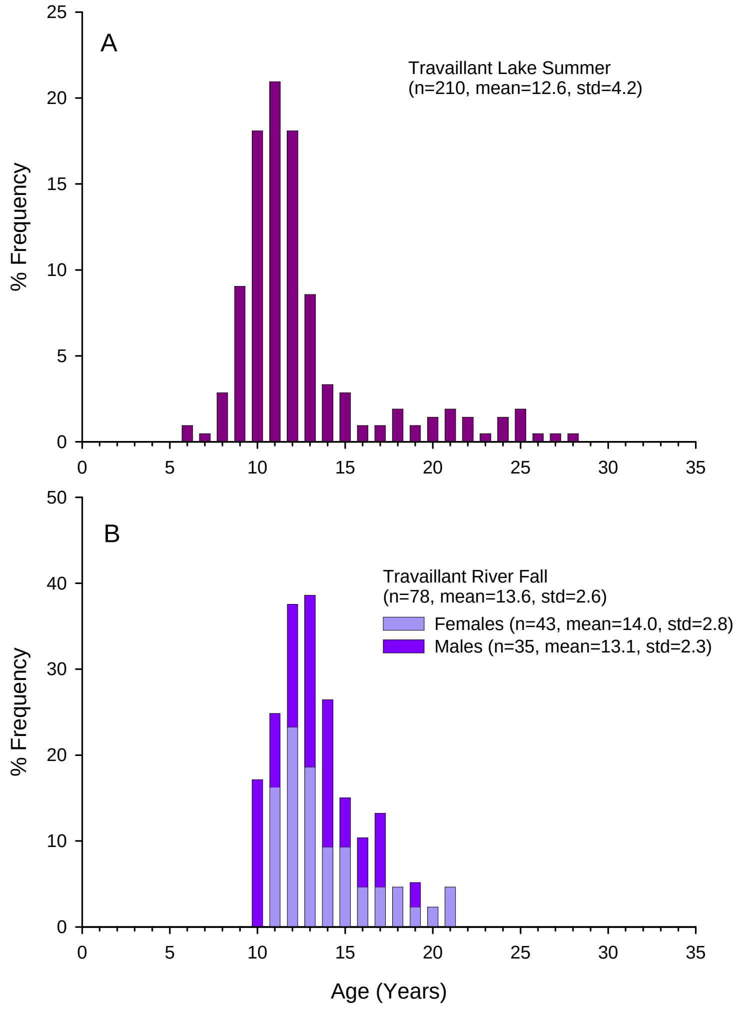


Figure 11. Age frequencydistributions of lake whitefish collected in A) Travaillant Lake during summer and B) the Travaillant River in fall.

The length at age of lake whitefish captured in 2003 is presented in Figure 12a. 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 (Figure 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 (Figure 12a).

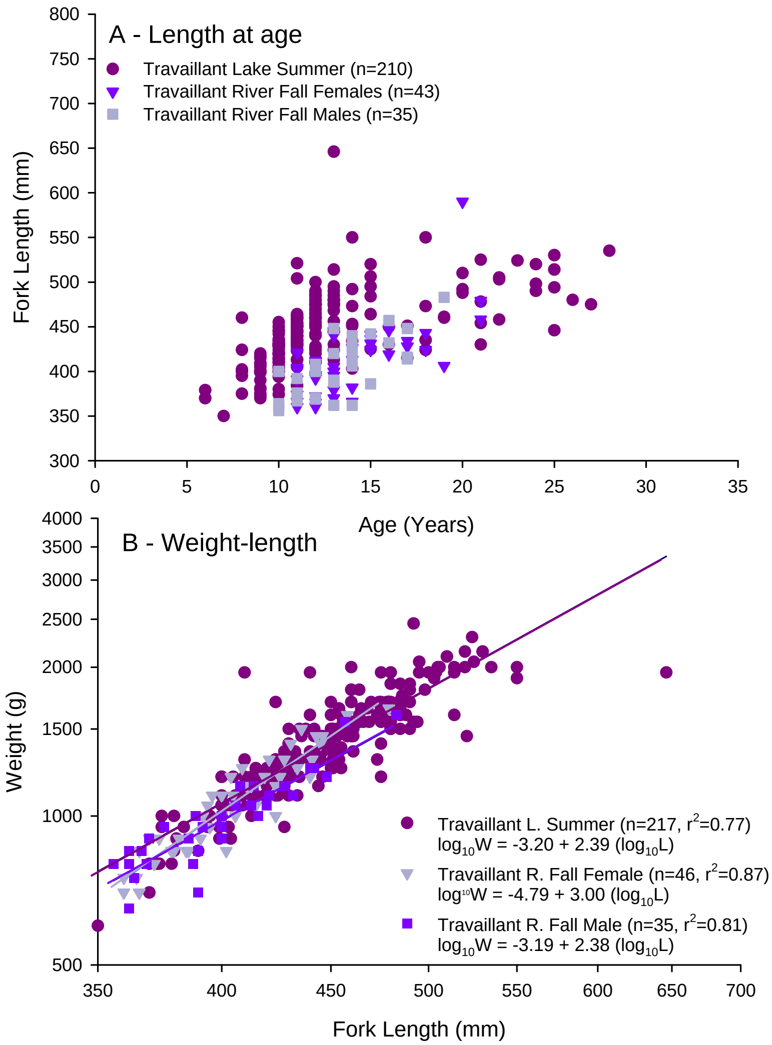


Figure 12. A) length at age and B) weight-length relationships of lake whitefish collected in Travaillant Lake during the summer in the Travaillant River in fall. Note that the lower graph is on a logarithmetic scale.

The relationships between fork length and round weight for lake whitefish captured in 2003 are presented in Figure 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 (Figure 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 ± S.D. fork length) (Figure 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 ± S.D. fork length) (Figure 13b). Estimated mortality rates were 0.22 and 0.35 for the summer and fall samples, respectively (Figure 13).

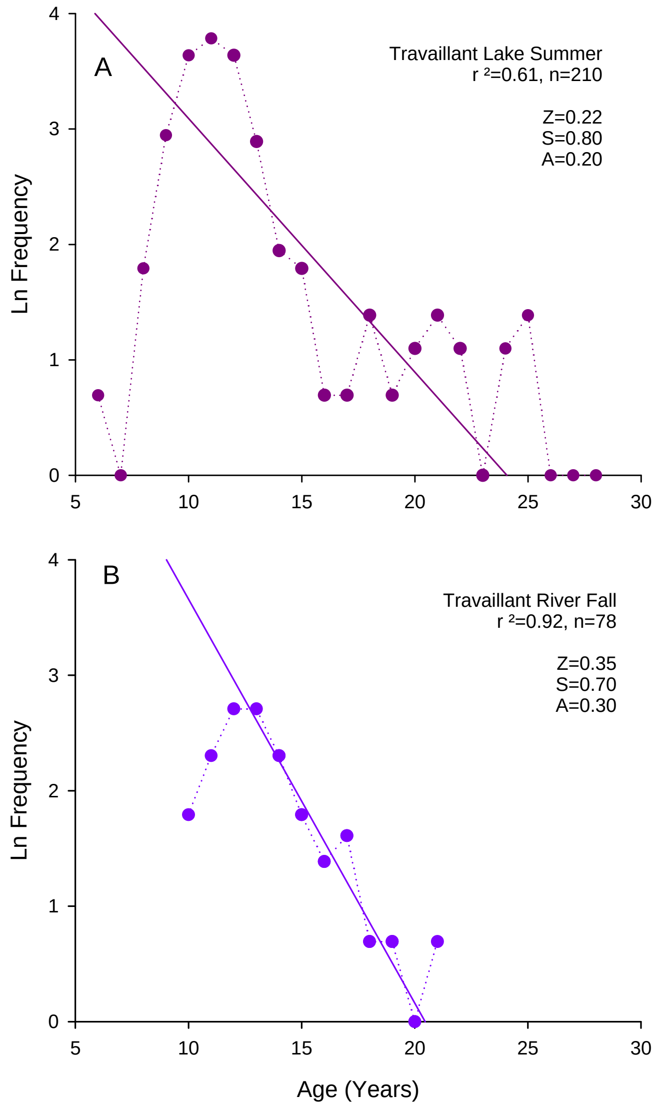


Figure 13. Age frequencycatch curves for lake whitefish collected in A) summer and B) fall. Instantaneous mortality (Z), survival (S) and annual mortality (A) have been calculated where appropriate.

Based on visual examination of gonads and the high gonadosomatic indicies (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 raged 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). Our observations are similar to those reported by Chudobiak (1997) who found that spawning females in the Travaillant River had GSI values ranging from 9.0 to 23.5. 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.

| | Female | | | Male | | |
|---|---|---|---|---|---|---|
| **Maturity** | **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. 2001).

Fecundity of lake whitefish collected from the Travaillant River increased linearly with body size ($r^2$=0.58, p<0.001)

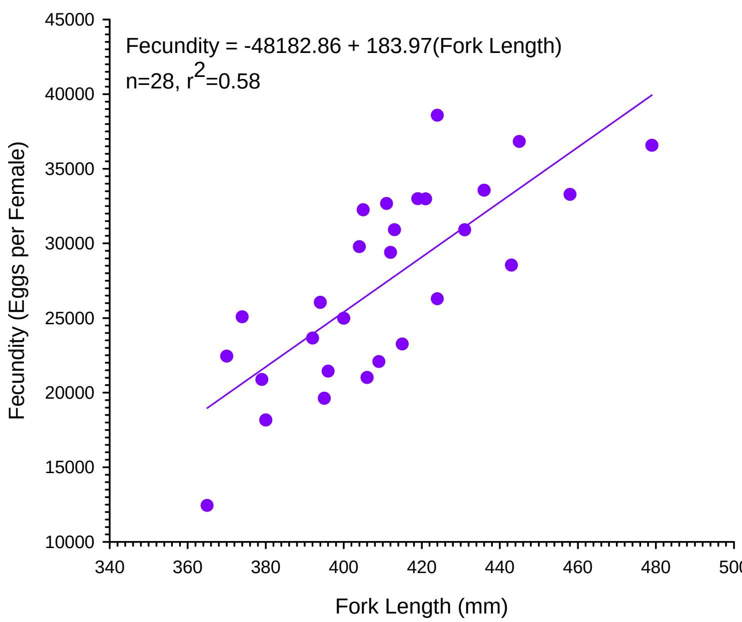


Figure 14. Relationship between fecundity and body size (fork length) for lake whitefish from the Travaillant River in fall just prior to spawning.

ranging from 4406 to 38 578 with a mean of 26 705 eggs per female (n = 30, S.D. = 7571) (Figure 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

It is not unlikely that broad whitefish from Travaillant Lake are spawning within the lake, or within the Travaillant River, a short distance from the lake itself. The large size, varying depths, and shallow and deep areas in the same lake make Travaillant Lake ideal for rearing and feeding for 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). Also, the Travaillant River freezes to the bottom in certain regions during some winters, (Chudobiak 1995) creating a seasonal barrier, and preventing the movement of fish. Any such barrier woud block the connection between Travaillant Lake and the Mackenzie River during spawning migrations (Chudobiak *et al.* 2002). The capture of young-of-the-year and juvenile coregonids, with seine nets in the summer, and the capture of mature female and male fish in the Travaillant River in the fall, may also indicate that spawning and/or rearing habitat is nearby.

If broad whitefish from Travaillant Lake do have a life history that involves regular or long migrations to spawning areas, this could result in complications regarding the management of this species. However, if broad whitefish are contained to the Travaillant Lake system, complications regarding broad whitefish management may be minimized. Because the life history of the lacustrine type is local and in most cases contained within the boundaries of a single settlement region, the management of this form could be conducted by the locally responsible board without reference to trans boundary issues (Reist and Chang-Kue 1997).

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.

Because of the many limitations associated with tagging studies, and the fact that this tagging study has been ongoing for two years without a tag return, different methods to track and document fish movement will be employed at Travaillant Lake in the future. Radio telemetry has been used, and proven effective, in numerous studies to track the movements and document life histories of arctic fishes (Howland *et al*. 2000**,** Babaluk *et al.* 2001b**,** Chang-Kue and Jessop 1983, 1991a, 1991b, 1997). Other methods, which may help determine movements of broad whitefish, include the use of stable isotopes, or comparing chemical markers found within the otoliths.

Although the use of stable isotopes (e.g., Hesslein *et al.* 1991, Kline *et al.* 1998, Guiguer *et al.* 2002) and otolith strontium (e.g., Babaluk and Reist 1996, Babaluk 1997b, Howland *et al.* 2001b) are effective for determining fish movements, or discriminating between fish stocks in the arctic, they are usually used to differentiate the migrations or trophic ecology between marine and freshwater environments. To determine or describe fish movements wholly within freshwater systems, especially where tagging studies alone may not provide sufficient information, a closer examination of otolith chemistries may be an alternative to otolith strontium analysis and the use of stable isotopes. If the system shows a great deal of heterogeneity in the water chemistry, examinations of a suite of chemical markers may be used to describe the movements of fish in that freshwater system. Wells *et al.* (2003) quantified the variation of elemental signatures and found that hard-part microchemistry could be used to determine the origins of individual fish. They suggest that the chemistries of otoliths and scales hold promise as keys to clarify the movements of fish within freshwater.

In 2004 the Travaillant Lake Fish Movement Study will be expanded to track and document the movements of broad whitefish through the use of radio telemetry over the next two years. 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. Determination of fish movements or migrations is still the priority, but will be better-documented using radio telemetry.

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.

*Travaillant Lake sunset*

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