

# Chum Salmon in the Mackenzie – Liard River

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## TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 INTRODUCTION.....	1
2.0 METHODS .....	3
2.1 Fish Capture .....	3
2.2 Genetic Analysis.....	4
2.2.1 Sample Collection.....	4
2.2.2 Mitochondrial DNA Analysis .....	4
2.3 Stable Isotopic Analysis.....	5
3.0 RESULTS.....	6
3.1 Fish Capture .....	6
3.2 Life-History .....	7
3.3 Specimen Collection.....	8
3.4 Marine Feeding Areas .....	8
3.5 Genetic Analysis.....	9
3.6 Training.....	9
4.0 DISCUSSION.....	10
5.0 REFERENCES.....	12
6.0 ACKNOWLEDGEMENTS .....	15

## LIST OF TABLES

<b>Table 1.</b>	<b>Summary of Genetic Samples</b>
<b>Table 2.</b>	<b>Mitochondrial DNA primer sequences</b>
<b>Table 3.</b>	<b>Summary of fish captured in 2000 and 2001 in the lower Liard River</b>
<b>Table 4.</b>	<b>Summary of fish capture data Lower Liard River, October 2000 and 2001</b>

## LIST OF FIGURES

<b>Figure 1.</b>	<b>Distribution of chum salmon</b>
<b>Figure 2.</b>	<b>Chum salmon capture timing and location, Liard River 1979-80.</b>
<b>Figure 3.</b>	<b>Liard River sampling locations October 2000 and 2001.</b>
<b>Figure 4.</b>	<b>Geographic distribution of genetic samples.</b>
<b>Figure 5.</b>	<b>Stable isotope composition of Liard River chum salmon.</b>
<b>Figure 6.</b>	<b>ND3 gene neighbor-joining tree based on 1000 bootstrap resampling</b>
<b>Figure 7.</b>	<b>ND6 neighbor-joining tree based on 1000 bootstrap resampling</b>

## LIST OF PHOTOGRAPHS

<b>Plate 1</b>	<b>Liard River at Site C.</b>
<b>Plate 2</b>	<b>Natural rock groyne on bank of Liard River</b>
<b>Plate 3</b>	<b>Chum salmon captured in the Liard River at Ft. Liard, NWT, October 2002 (Photo courtesy of Mr. J. Babaluk)</b>

**Plate 4**      **Chum salmon captured in the Mackenzie River near Fort Norman,  
NWT. (Photo courtesy of Mr. Richard Popko).**

## 1.0 INTRODUCTION

Chum salmon (*Oncorhynchus keta*) are one of the five species of Pacific salmon that are found in North America. Historically, chum salmon were distributed across the Pacific Rim, from California to South Korea (Salo 1996; Figure 1). It was thought that spawning populations were restricted to Pacific drainages of North America and Asia. The record of chum salmon in Arctic watersheds dates back to at least 1907, when Prebles (1908) undertook an investigation of the Athabasca and Mackenzie rivers. In the Canadian Arctic, chum salmon have been reported as far east as the Mackenzie River (Scott and Crossman 1973) and possibly the Anderson River (Hunter 1974). Other authors have also documented chum salmon in the Mackenzie River, including Dymond (1940); Hunter (1974); McPhail and Lindsey (1972); Scott and Crossman (1973). In the Russian Arctic, chum salmon have been reported as far west as the Lena River in Russia (Dymond 1940).

The presence of Pacific salmon in the Mackenzie River was first reported by Preble (1908). Sporadic runs have since been reported over the last century and as recently as 1999 (Dymond 1940; Hunter 1974; Scott and Crossman 1973; Toyne and Tallman 2000). Chum salmon runs have been notable in the Peel River and Arctic Red River (Dymond 1940). Chum salmon have also been reported in Great Bear Lake, Great Slave Lake, and the Slave River (Ash et al. 1981; Dymond 1940; Hunter 1974). More recently, chum salmon have been captured at a variety of locations between Great Slave Lake and the Mackenzie Delta in 2003 and 2004 (J. Babaluk, Fisheries Research Biologist, Fisheries and Oceans Canada, Winnipeg, MB, pers. comm.).

The Liard River is a large river tributary of the Mackenzie River that originates in the southern Yukon and flows eastwards through northern BC. The Liard River and its tributaries comprise a unique portion of BC, as the watershed encompasses the majority of the BC's Arctic drainage. The BC distribution of a number of fish species are restricted to the Liard River watershed. In addition, several Arctic species of anadromous fish species are known to occur in the Liard River (e.g., Arctic cisco [*Coregonus autumnalis*] and Arctic lamprey [*Lampetra japonica*]). McLeod and O'Neil (1982) first reported chum salmon in the Liard River. These authors report small runs of chum salmon in the Liard River from September to November in 1979 and again in 1980.

The chum salmon in the Liard/Mackenzie River are now potentially at risk from increased resource extraction that is underway in Mackenzie Valley and northeastern BC. The purpose of the study was to develop a better understanding of the life-history and habitat requirements of chum salmon that return to the Liard River.

The Liard River Corridor Resource Management Zone (RMZ) includes the portion of the Liard River, between Scatter River and the Liard Hot Springs Provincial Park. The Liard River Corridor RMZ has been identified as a Protected Area in the Fort Nelson Land and Resource Management Plan and has been included in the Muskwa-Kechika Management Area. The Liard

River Corridor RMZ contains the Grand Canyon of the Liard River, likely the upper limit of chum salmon movements in the Liard River (Mr. Jim O'Neil, Senior Fisheries Biologist, Golder Associates Ltd., Edmonton, AB, pers. comm.).

In 2001, the Muskwa-Kechika Management Area (M-KMA) funded research to examine chum salmon in the Liard River. The project objectives included:

- Increase the basic understanding of the life-history requirements of Liard River chum salmon;
- Develop an understanding of the genetic relationship that exists between the Liard River chum salmon and other chum salmon populations that exist in North America and Asia.
- Develop additional information for several key fish species in the Liard River;
- Training of residents of north-central BC in fisheries techniques that will be required to complete the study.

This report provides a summary of the activities undertaken and information developed as part of the study funded by the M-KMA.

## 2.0 METHODS

### 2.1 Fish Capture

Fish collections were undertaken in the fall of 2000 and 2001. Sampling was carried out by a three person crew and done in conjunction with an inconnu (*Stenodus leucichthys*) study conducted by Mr. Jeff Burrows (Ministry of Water, Land and Air Protection, Fort St. John, BC). Fish sampling was conducted during a 10-day field season in mid-October of each year. The selection of the mid-October sampling period was intended to coincide with the period when the majority of chum salmon were captured in 1979/80 (R.L. & L. 1980; Figure 2).

Experimental test-gang gill nets were the primary method used to capture chum salmon. Both monofilament and braided cotton thread gill nets were used. A 20 m beach seine was also used where conditions warranted. Due to the strong current in the Liard River, gill nets had to be placed where the current would not drag the net anchors and where there was less chance of floating debris (i.e., whole trees) damaging the nets. Gill nets were deployed in areas where natural rock formations created back eddies that salmon could use to propel themselves upstream (Photo 1 and 2). Many of the sample locations were previously sampled by R.L. & L. in 1979 and 1980 (R.L.&L. 1980).

Sampling in 2000 was spread across the portion of the Liard River between the NWT border (downstream limit) and BC Hydro's proposed Site A (~Km 480). Sampling was focused on the area near the Ft. Nelson River confluence in 2001, to reduce the time spent to travel up river (Figure 3) and to focus sampling efforts are areas with relatively high fish capture rates near the Ft. Nelson confluence.

Following the 2001 sampling session, the decision was made to attempt to locate spawning areas by conducting a low-level helicopter overflight of the river, rather than attempt a third sampling session in 2002. The purpose of the overflight was to carry out a visual assessment of the river, to look for congregations of spawning fish or redds. This method of locating spawning areas is a common method of surveying spawning salmon (e.g., Garcia et al. 2004). If either were located, ground surveys were to be done to enumerate fish and document habitat. The overflight was carried out in late November 2001 and examined the Liard River from the Fort Nelson Forks (59° 32' N 124° W) to the Coal River confluence (59° 39' N 126° 56' W). Due to the width of the river, the portion of the river from mid-channel to left downstream bank of the river was flown in the upstream direction and the mid-channel to right downstream bank was flown on the reciprocal course before returning to Fort Nelson.

## 2.2 Genetic Analysis

### 2.2.1 Sample Collection

When the project was initiated, archival specimens from the 1979/80 Liard River sampling had been obtained. During the period of 2001-2004, additional samples for use in the genetic analysis were obtained from archival specimens and freshly captured fish. Samples were obtained from chum salmon populations in the Peel River, Yukon River drainage, coastal Alaska, Siberia and Japan. In late 2003, a number of chum salmon were captured in the subsistence fishery on Mackenzie River. Samples of these fish were obtained in 2004. Table 1 provides a summary of the genetic samples and Figure 4 illustrates the geographic distribution of the samples.

### 2.2.2 Mitochondrial DNA Analysis

Five specimens for 10 different populations spread across the global range of chum salmon were included in the mitochondrial DNA (mtDNA) analysis. These populations represented the Liard River, Mackenzie River, Slave River, Teslin and Kluane rivers from the upper Yukon River watershed (freshwater maturing types), coastal Alaska (Saltery and Kobuk), coastal Russia (Magadan River) and Japan.

DNA was extracted from the various samples and purified using the Qiagen DNeasy Kits (<http://www1.qiagen.com/>). Two mitochondrial DNA (mtDNA) genes were selected for analysis: ND3 and ND6. These genes were selected as Gharrett et al. (2001) were able to use the ND3 and ND6 genes to develop phylogeographic analysis of mtDNA in Alaskan coho salmon (*O. kisutch*).

Gene sequences for the three genes were obtained from Genbank (<http://www.ncbi.nlm.nih.gov/Genbank/index.html>). Primer sequences were generated using Primer 3 (Rozen and Skaletsky 2000) ([http://frodo.wi.mit.edu/cgi-bin/primer3/primer3\\_www.cgi#PRIMER\\_SEQUENCE\\_INPUT](http://frodo.wi.mit.edu/cgi-bin/primer3/primer3_www.cgi#PRIMER_SEQUENCE_INPUT)). Primers were then ordered from Invitrogen (Table 2).

Polymerase chain reaction (PCR) using the protocol outlined by Olson et al. (2004) was used to amplify each gene. Genes were sequenced on a Beckman CEQ model 8000 sequencer. Each gene (300-500 base pairs) was sequenced in the 5' to 3' direction. To assist in the base calling of sequences, several samples from each population were sequenced in the reverse direction. Base calling of the sequence data was carried out using Sequencher software (<http://www.genecodes.com/>).

To assess the phylogentic relationship of the various populations, a neighbor-join tree was constructed based on the Kimura's two-parameter model, using MEGA 3.1 (Kumar et al. 2004).

To test the statistical significant of the trees, the data was re-sampled 1000 times to obtain bootstrap replicates.

### **2.3 Stable Isotopic Analysis**

As animals move between isotopically distinct food webs, they will retain information on previous feeding locations. The length of retention will depend upon elemental turn over rates in the tissue of fish. In the case of fish, fin rays (Clarke et al. in prep.) and otoliths are metabolically inert following synthesis and maintain an isotopic record of where the tissue was synthesized (Hobson 1999). In the case of salmon, fin rays and otoliths are not normally collected from salmon as scales have long been used to age fish (McLellan 1987). Fortunately, several fin rays and gill rakers were amongst the ageing structures taken during the 1979/80 Liard River sampling. These samples were sent to Dr. Keith Hobson (Canadian Wildlife Service, Saskatoon, SK.) for analysis.

Stable isotope values are expressed as a ratio ( $\delta^{13}\text{C}$  or  $\delta^{15}\text{N}$ ), and represent the enrichment or depletion of heavier isotopes of C or N relative to a standard. The marine environment tends to be enriched with  $^{15}\text{N}$  and depleted of  $^{13}\text{C}$ . Therefore,  $\delta^{15}\text{N}$  is expressed as a positive value and  $\delta^{13}\text{C}$  as a negative value.

### 3.0 RESULTS

#### 3.1 Fish Capture

Fish sampling was undertaken between 05-09 October 2000 and 05-10 October 2001. A total of 157 fish were captured during the two sampling sessions, 45 in 2000 and 112 in 2001 (Table 2). Thirteen species of fish were represented in the catch. Inconnu were the most abundant species in the catch ( $n=44$ ), followed by northern pike ( $n=27$ ); lake whitefish ( $n=25$ ), and mountain whitefish ( $n=19$ ). Burbot, walleye, suckers, flathead chub and spoonhead sculpin were present in small numbers. No chum salmon were captured during either of the sampling sessions (Table 3). Table 4 provides a summary of the data collected (i.e., lengths, weights) in the Liard River.

There are several hypotheses for the absence of salmon:

- The salmon captured in the Liard River were an anomaly and had been strays that had found their way into the Mackenzie/Liard River;
- The fish arrived later than what was observed in 1979/80 and therefore the sampling in 2000 and 2001 were too early;
- The chum salmon have a cyclical year class abundance (i.e., cycles low and high numbers) and the 2000 and 2001 sampling sessions occurred in low abundance cycles that would have made it more difficult to capture salmon.

The Liard River chum salmon population is likely relatively small. During the 1979/80 study only 193 chum salmon were captured in the Liard River, out of a total of 4927 fish captured (R.L. & L. 1980).

An examination of archival material in long-term storage at the Freshwater Institute in Winnipeg, found that a chum salmon were captured in the Liard River as part of the subsistence harvest at Fort Liard, NWT in October 2002. One individual was captured; a ripe female, with a fork length of 612 mm and weighed 3413 g (Plate 3). In 2003, a number of chum salmon were captured in the upper Mackenzie, near Norman Wells and Fort Norman. The mild fall and late on-set of freezing enable subsistence fishing to continue later than normal and a number of fishermen report capturing salmon. Additionally, one fisherman reported 30 salmon in his catch in October 2003 (Mr. Richard Popko, Wildlife Technician, Resources Wildlife and Economic Development, Government of the NWT, Norman Wells, pers. comm. 31 October 2003). It is believed that these fish were also chum salmon. Chum salmon were captured in the Mackenzie River delta in 2004 and 2005 during the subsistence fishery (Mr. J. Babaluk, Fisheries Research Biologist, Fisheries and Oceans Canada, Winnipeg, MB, pers. comm.). Therefore, it appears that despite the absence of chum salmon in the catch in 2000 and 2001, chum salmon are still being captured in the Liard and Mackenzie rivers.

### 3.2 Life-History

The objective of increasing the understanding of the life-history and habitat requirements of chum salmon in the Liard River was severely impaired by the lack of salmon during the 2000 and 2001 sampling sessions. This prevented the deployment of radio tags that would have enabled salmon to be tracked to potential spawning areas.

Some life-history information about salmon use of the Liard River can be inferred from the historical record and observational information. The timing of chum salmon entrance into the Liard River is between mid-September and mid November (R.L. & L. 1980). The capture of a chum salmon at Fort Liard, NWT in October 2002 supports the timing of movements into the river. Chum salmon captured near Fort Norman, NWT in late October 2003 had not fully developed secondary sexual characteristics (i.e., vertical banding, enlarged kype; Photo 4), which suggest that spawning is likely to occur late in the fall or early winter. Data reported by R.L.&L. (1980) indicates that mature males and females were captured in the Liard River through out October and the middle of November. Therefore, spawning likely occurs in late November or early December in the Liard River.

Timing of entrance into the Mackenzie River can be inferred assuming the chum salmon can migrate approximately 50 km/day (Quinn 2005) and a distance of approximately 1500 river kilometers to be traverse to reach the capture area near Site A on the Liard River. Fish captured in October in the Liard River would have entered the Mackenzie River approximately 30 days prior to capture. R.L. & L. (1980) documented entrance of chum salmon into the Liard River can occur as early as mid-September, therefore, chum salmon could be entering the Mackenzie River as early as mid-August.

It is still uncertain if successful spawning occurs in the Liard River. The persistent reports of chum salmon in the upper Mackenzie River drainage and the genetic information (Section 3.5) suggests that successful spawning occurs in the upper Mackenzie tributaries. If spawning does occur, there remains the question of where do the salmon spawn? A helicopter survey of the river was undertaken in early November 2001, from Fort Nelson Forks (i.e., confluence of Fort Nelson and Liard rivers) upstream to Coal River, to look for congregations of fish or redds. Between the Beaver River and the Rapids of the Drowned, visibility was hampered by ice accumulations in the river. Upstream of the narrows in the Grand Canyon of the Liard River, the river was free of ice and water clarity was excellent. No obvious signs of fish congregations or redds was observed during the flight.

Chum salmon appear to be less capable of surmounting rapids and waterfalls, than other species of Pacific salmon (Hale et al. 1985). There is a constriction and falls near the lower end of the canyon that is likely a barrier to upstream movements of chum salmon. This conclusion is

supported by the lack of chum salmon during sampling in and upstream of the Grand Canyon of the Liard River in 1979/80 (R.L. & L. 1980).

Chum salmon tend to prefer areas with clear water for spawning (Hale et al. 1985). Based on observations of the Liard River made by one of us during five years of working in the watershed, water clarity significantly increases upstream of the Beaver River (JDH). Therefore, it is likely that spawning habitat would be located between Site C and the lower end of the Grand Canyon of the Liard River. It is also possible that chum salmon could move into the lower reaches of some of the tributaries in this reach of the river, such as the Grayling, Toad or Scatter rivers, which tend to have low total suspended sediments loads late in the year (D. Hamilton, unpublished data), compared to other tributaries such as the Beaver and Fort Nelson rivers.

### **3.3 Specimen Collection**

The lack of salmon in the 2000 and 2001 fish collections seriously hampered the ability to answer some of the research questions the study was attempting to address. Therefore, alternative methods for examining life-history and genetic questions had to be pursued. During the period of 2002 to 2004 efforts were made to collect archival material that would assist in expanding the sample set for the Mackenzie River chum salmon. This effort was successful in that 13 specimens were located by DFO staff in the long-term cold storage archive at the Freshwater Institute, Winnipeg, MB. These specimens were captured during the period of 1972 to 1999 at a variety of locations from Richardson Island in the Beaufort Sea to Norman Wells, in the middle portion of the Mackenzie River. Additional samples were obtained from fish captured in the 2002 and 2003 subsistence fishery.

### **3.4 Marine Feeding Areas**

Following entry to the marine environment, chum salmon from Asia and North America migrate to the northern part of the Pacific Ocean to rear and feed. Chum salmon will spend three to five years at sea before returning to natal streams to spawn. Stable isotopes can be used to identify the food web in which a fish has been feeding.

Stable isotopes of carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) can be used to assess a variety of life-history questions about the migration and nutritional origin of animals (Hesslein et al. 1991; Hobson 1999; Hobson and Schell 1998; McCarthy and Waldron 2000). The use of stable isotopes relies upon the fact that food web isotopic signatures are reflected in the tissue of organisms. The individual signature of the food webs is controlled by biogeochemical processes and vary spatially (Hobson 1999). Of particular relevance to the present study is the ability to identify the type of marine environment that the fish have been exposed to as this would give some indication of where the chum salmon have been rearing during their marine phase.

The fin rays in the 1979/80 archival collection were analyzed for  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  and compared to literature values for north Pacific salmon. The Liard population of chum salmon were isotopically different from that of the mean value reported by Satterfield and Finney (1992) for chum salmon captured in the north Pacific. The Liard population of chum salmon were also different from those reported by Hoekstra et al. (2002) for chum salmon captured off Barrow, AK (Figure 5). The stable signature of the Liard River chum salmon suggests that these fish do not return to the north Pacific to rear.

The isotopic signature is similar to that of fish that reside in an estuarine environment rather than fish living in open ocean. This would suggest that the chum salmon from the Liard River may be residing in the brackish water in the near coastal areas.

### **3.5 Genetic Analysis**

Phylogenetic inference using the ND3 and ND6 genes produced two slightly different trees (Figures 6 and 7). The phylogenetic tree constructed using the ND 3 gene illustrate that the Liard and Slave River samples from the late 1970's and early 1980's clustered with several individuals captured in 2003. Specimens 283 and 284 were captured in the Aklavik region of the Mackenzie Delta and 294 was captured in Great Slave Lake. Five of the specimens captured in the Tulita region of the Mackenzie River (i.e., near the Great Bear River confluence) grouped together and on the same branch as the sea-maturing populations from coastal Alaska and Japan. This would suggest that there are two different groups of chum salmon in the Mackenzie River.

The ND6 phylogenetic tree shows a strong distinct separation of the Slave River and Liard river specimens, which is supported by high bootstrap value (88%). The 2003 specimens cluster together as a distinct group within a separate branch of the tree topology (Figure 7).

The clustering within the tree is not as distinct as expected and may reflect intermixing and adjustment that is still ongoing after the recolonization of the northern watersheds of North America after following the last glacial maximum. The phylogenetic trees indicate the fish from the Mackenzie River are genetically different from other Pacific chum salmon populations included in the analysis.

### **3.6 Training**

The project has resulted in the training of residents of northern British Columbia. The project has provided the opportunity to train a PhD level graduate student and an undergraduate student at the University of Northern British Columbia. The project also involved the transfer of knowledge and skills to professionals working in environmental consulting industry in northern British Columbia, which has enabled them to bring new skills to resource management projects being carried out in the north.

#### 4.0 DISCUSSION

The presence of chum salmon in the Mackenzie River watershed have been documented in the scientific literature for almost 100 years. Chum salmon were first reported in the Arctic drainage of BC by McLeod and O'Neil (1983), who captured chum salmon in the Liard River watershed in 1979/80. Attempts to capture salmon during the 2000 and 2001 sampling sessions were unsuccessful; however, a chum salmon was captured in the 2002 subsistence fishery at Ft. Liard, NWT (Babaluk pers. comm.).

Entrance of chum salmon into the Liard River occurs between September and November (R.L. & L. 1980; Babaluk pers. comm.). Arrival late in the year combined with ice conditions, makes it difficult to study and capture these fish. Based on the maturity condition of fish examined in 1979 and 1980, many of fish in the Liard River were ripe (i.e., eggs and milt were easily expressed). This suggests that spawning likely occurs in late fall or possibly in the early winter (i.e., after third week of November).

The phylogenetic analysis suggests that the Mackenzie River chum salmon are distinct from the coastal (sea maturing) and upper Yukon River (freshwater maturing) populations included in the phylogenetic analysis. The clustering of the upper Mackenzie tributaries (Liard and Slave) using the ND3 and ND6 gene suggest that the upper tributaries are different from the fish captured in the Tulita area in 2003.

The stable isotope analysis of the Liard River chum salmon indicate that the Liard chum are isotopically different from the populations that rear in the north Pacific. This would support the genetic typology that Liard River chum are a different population. In addition, the isotopic data also suggests that these fish do not return to the north Pacific to rear to adulthood, rather they are spending time in a more estuarine environment.

The estuarine like conditions could be found off the Mackenzie Delta and north slope rivers in the winter. A large freshwater lake develops off the Mackenzie Delta each winter after the Beaufort Sea freezes. This estuarine like environment could provide a refuge area where chum salmon could reside and avoid lethal sub-zero water temperatures in the Beaufort. Future work to examine the otolith microchemistry will attempt to confirm this hypothesis.

Based on the genetic and stable isotope information, the salmon captured in the upper reaches of the Mackenzie River, including the Liard River are distinct from other chum salmon populations. As such they should be managed as a distinct population, rather than as simple strays from the north Pacific.

The population is presently at the limits of distribution. It is unclear what the population size is, although it is likely small as only 193 salmon were captured in the 1979/80 sampling. Presently

there is a small subsistence fishery that collects chum as bi-catch. Salmon are not specifically targeted as they arrive in the river late in the year, when few people are fishing due to ice conditions. As climate changes and fall temperatures become warmer (as occurred in November 2003), it is possible that the chum population in the Mackenzie and Liard rivers could become systematically exploited. Therefore, careful management of the population is in order.

Specific to the mandate of the M-KMA, it is very likely that spawning areas are located within the Liard River Corridor RMZ. Although specific spawning areas were not located in the present study, it is likely that spawning areas are located in clear water reaches of the river, between the lower end of the Grand Canyon of the Liard River and the Toad River confluence. Therefore, the inclusion of the RMZ as part of the MKMA and BC Park system, will ensure that potential spawning areas are not disturbed or impacted by anthropogenic activities.

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BC Ministry of Environment, Fort St. John.

Slocan Forest Products Ltd., Fort Nelson, BC provided accommodations for the field crews at Liard Camp.

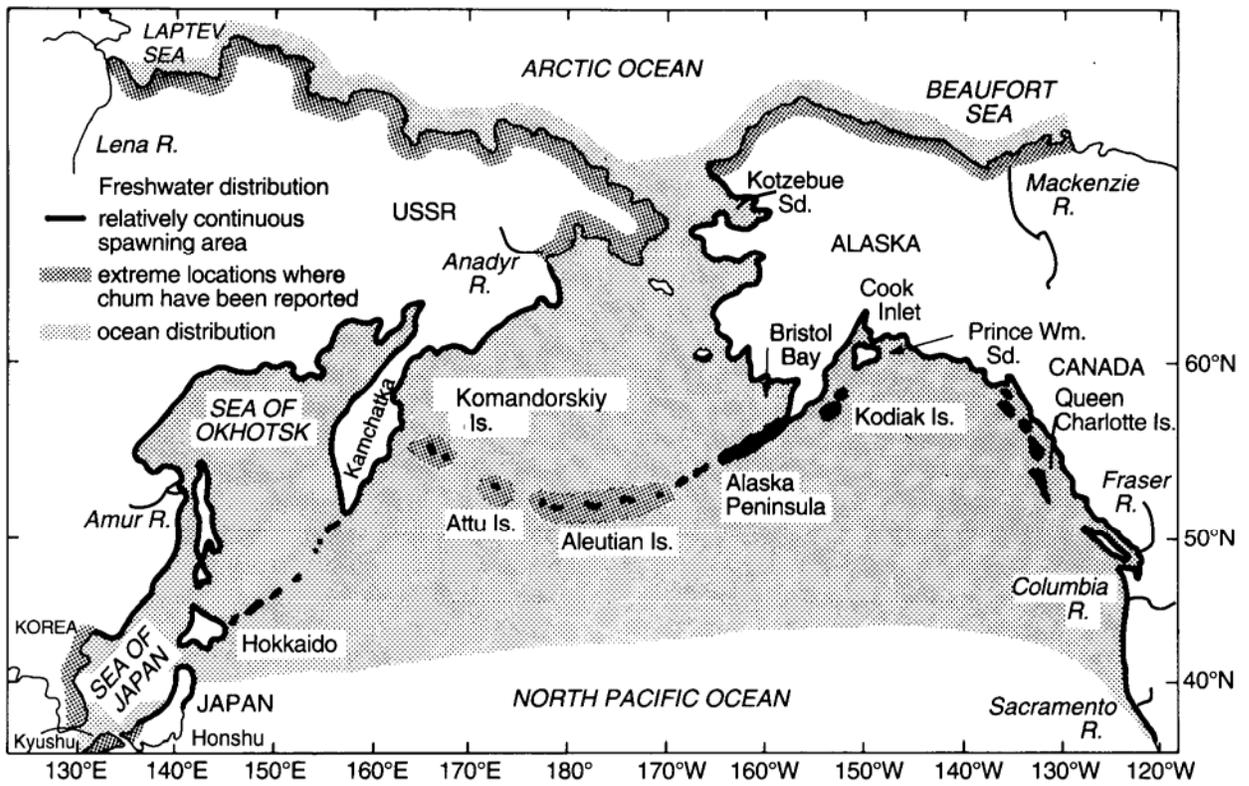
### **In-kind contributions were provided by:**

EDI Environmental Dynamics Inc., Prince George, BC

Golder Associates Ltd., Prince George, BC and Edmonton, AB

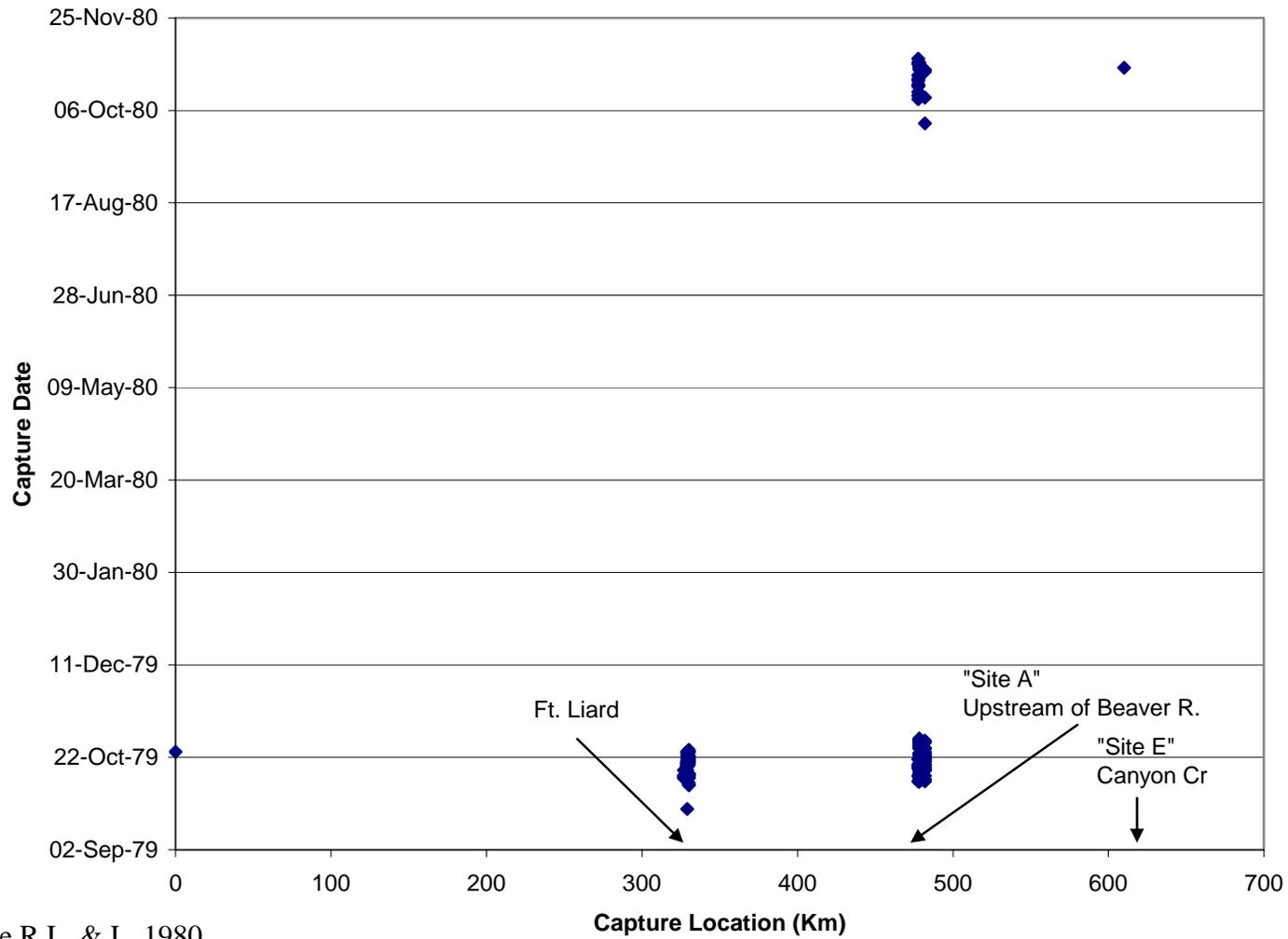
I would also like to thank all the people around the world, who provided the genetic samples.

## **FIGURES**



Source: Salo 1991

**Figure 1. Distribution of chum salmon**



Source R.L. & L. 1980

**Figure 2. Chum salmon capture timing and location, Liard River 1979-80.**

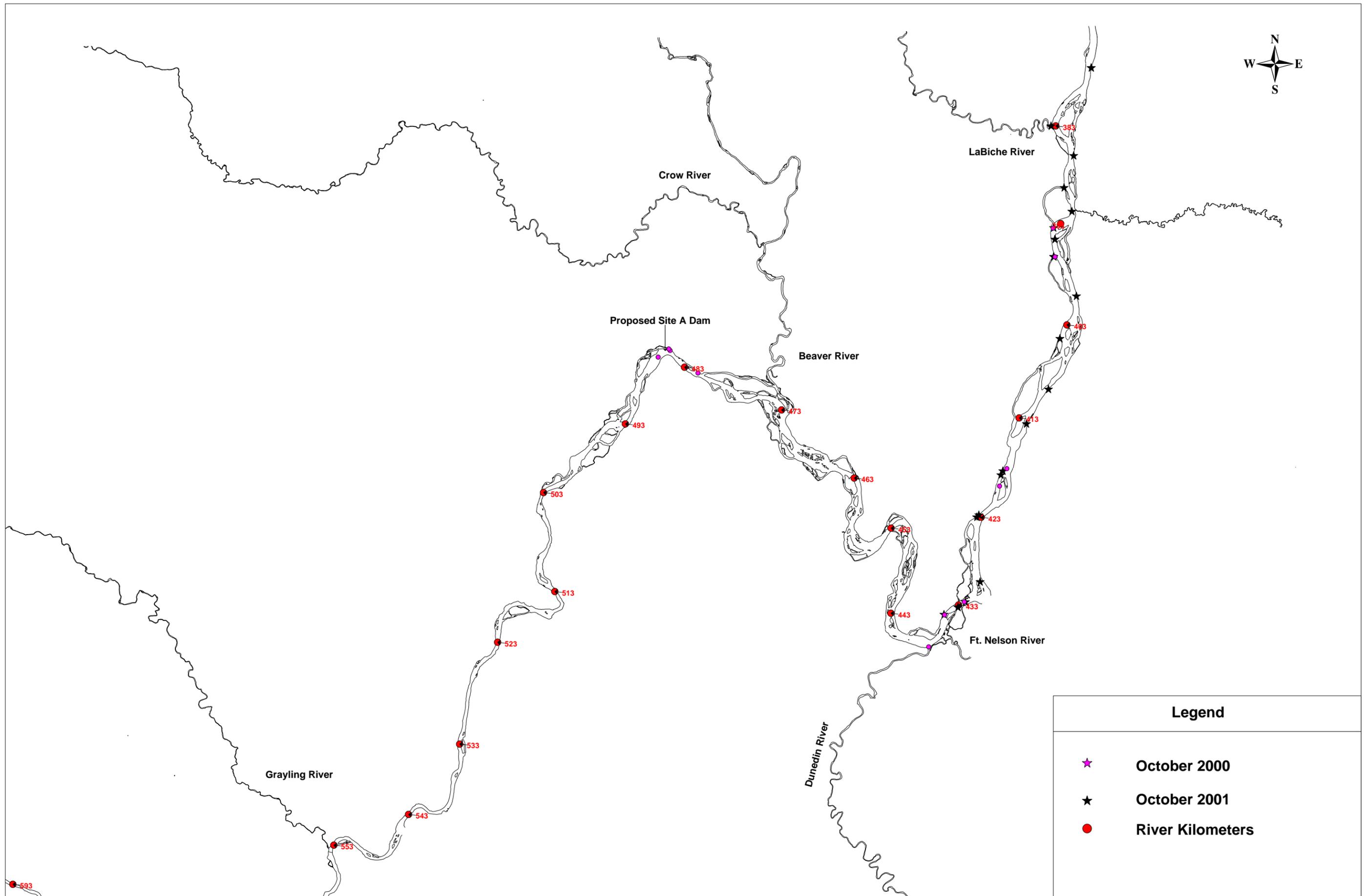
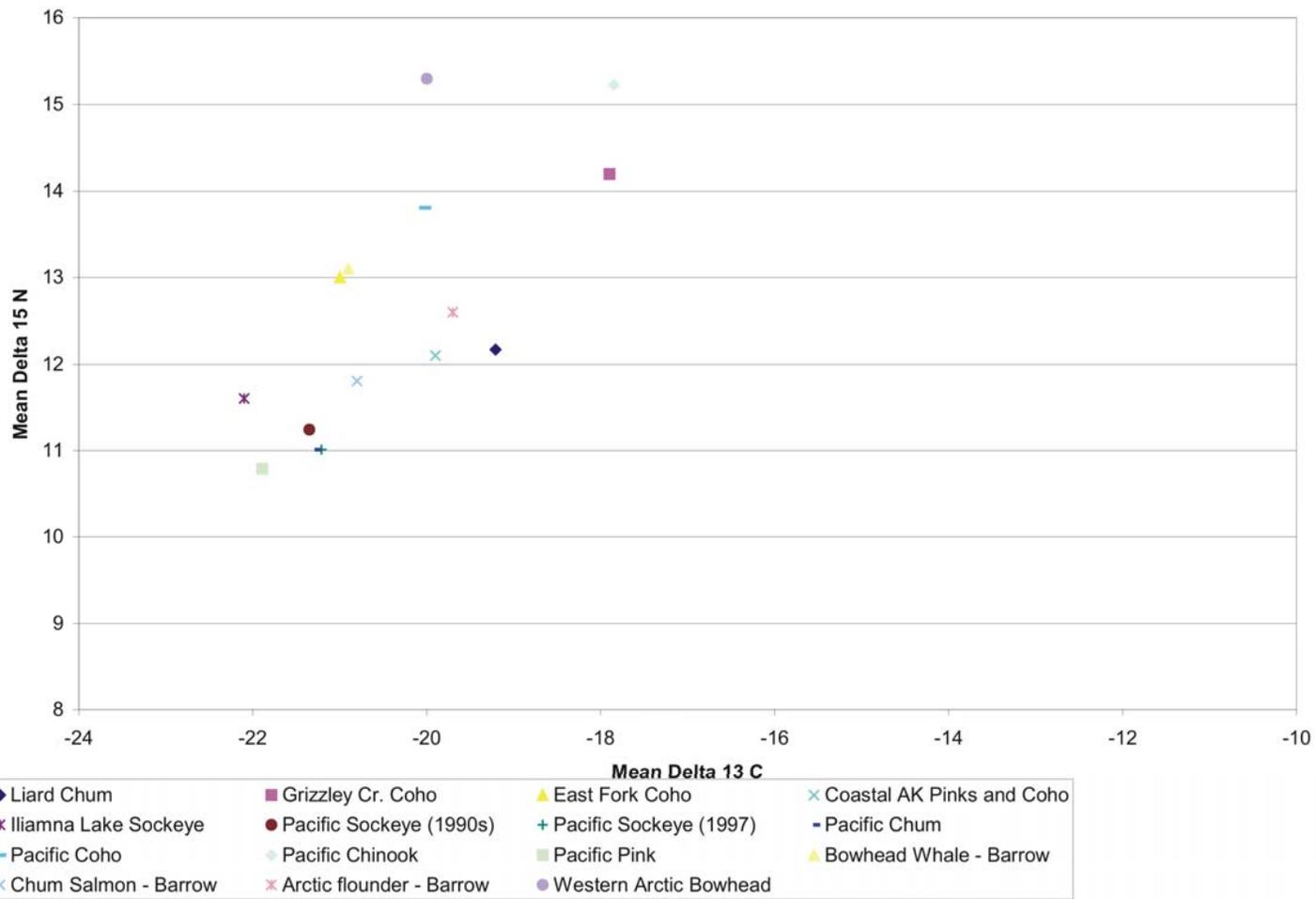


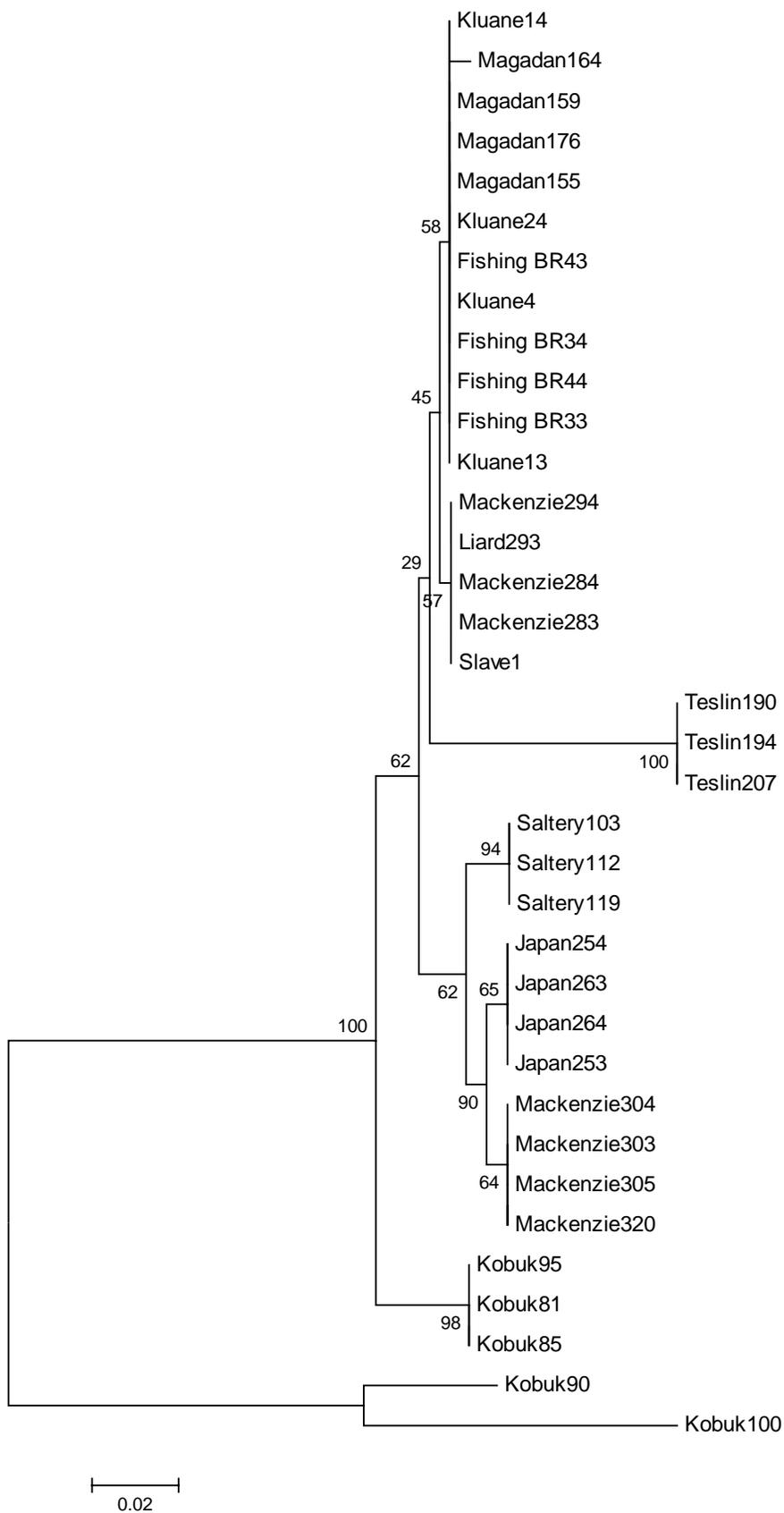
Figure 3. Liard River sampling locations October 2000 and 2001



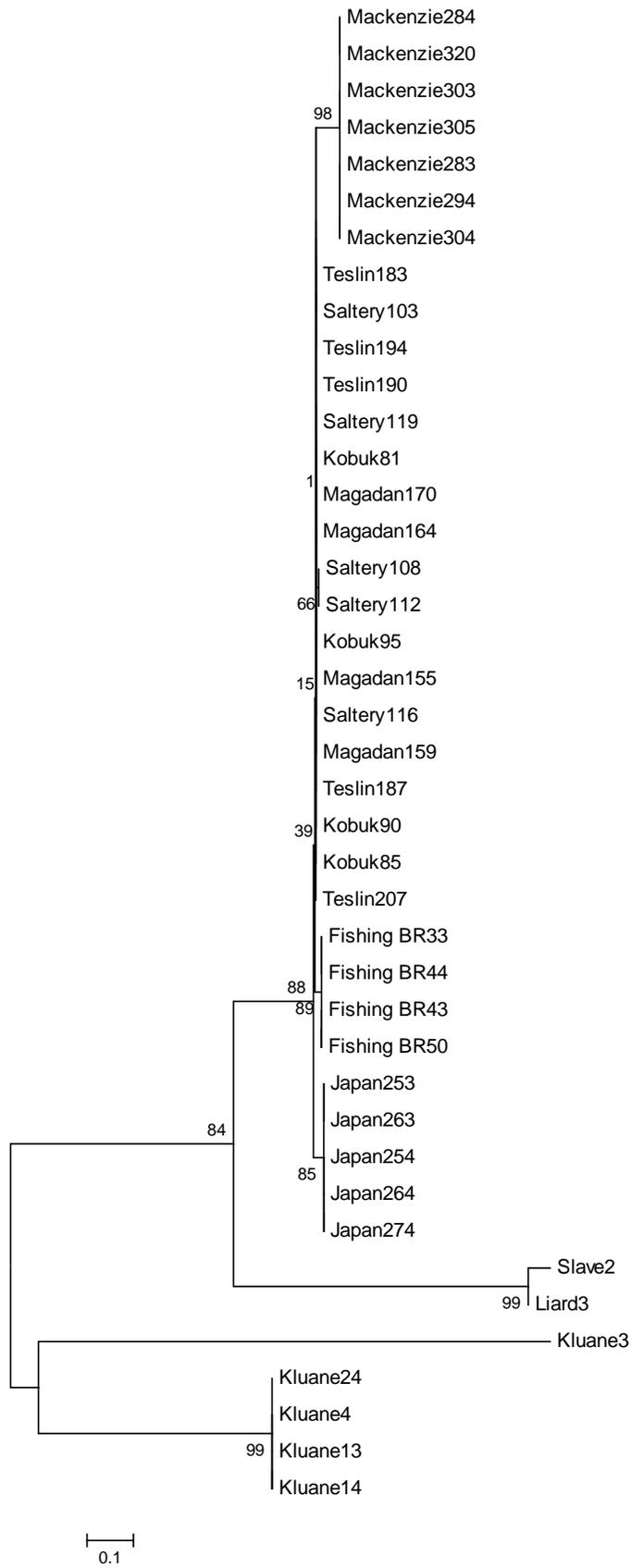
Figure 4. Geographic distribution of genetic samples.



**Figure 5. Stable isotope composition of Liard River chum salmon.**

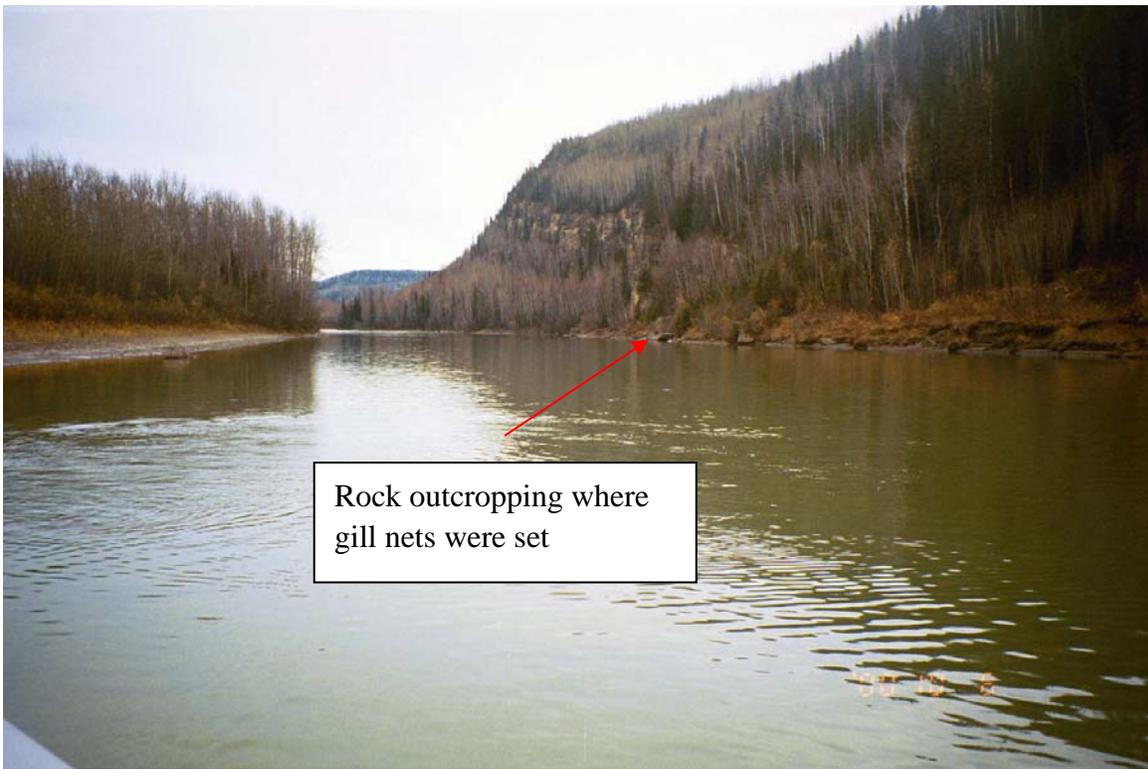


**Figure 6. ND3 gene neighbor-joining tree based on 1000 bootstrap resampling**



**Figure 7. ND6 neighbor-joining tree based on 1000 bootstrap resampling**

## **PHOTOGRAPHS**



**Plate 1**      **Liard River at Site C.**



**Plate 2**      **Natural cobble and boulder groyne on bank of Liard River**



**Plate 3** Chum salmon captured in the Liard River at Ft. Liard, NWT, October 2002  
(Photo courtesy of Mr. J. Babaluk)



**Plate 4** Chum salmon captured in the Mackenzie River near Fort Norman, NWT.  
(Photo courtesy of Mr. Richard Popko).

## **TABLES**

**Table 1. Summary of Genetic Samples**

<b>Location</b>	<b>Number of Samples</b>	<b>Source</b>	<b>Year Samples Received</b>
Liard River, BC and NWT	90	Mr. Jim O'Neil / Mr. Curtiss McLeod, Golder Associates Ltd.	1999
Liard River, NWT	1	Dr. Jim Reist / Mr. John Babaluk –Fisheries and Oceans Canada, Winnipeg, MB	2004
Slave River, NWT	9	Mr. Blair Flannery – US Fish and Wildlife Service – Alaska	2002
Mackenzie River (various locations between Aklavik, Tulita, Norman Wells, and Great Slave Lake).	40	Dr. Jim Reist / Mr. John Babaluk –Fisheries and Oceans Canada, Winnipeg, MB	2004
Peel River, NWT	40	Dr. Ross Tallman –Fisheries and Oceans Canada, Winnipeg, MB	2001
Mackenzie Delta/Beaufort Sea, NWT	14	Dr. Jim Reist / Mr. John Babaluk –Fisheries and Oceans Canada, Winnipeg, MB	2004
Fishing Branch River	30	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Teslin River, YK	30	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Kluane River, YK	30	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Chandalar River, AK	30	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Kobuk River, AK	20	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Saltery River	20	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Joshua Green River	30	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Kancholan River, Russia	30	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Anadyr River, Russia	30	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Kamchatka River	30	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Magadan River	30	Mr. Blair Flannery – US Fish and Wildlife Service - Alaska	2002
Hokkaido, Japan	30	Dr. Iwata, Kitasato University, Japan	2002

**Table 2. Mitochondrial DNA primer sequences**

Gene	Genebank Locus Number	Left Primer		Right Primer	
		Starting Base Pair	Sequence	Starting Base Pair	Sequence
ND3	AF055089	32	ccatcacattgtccgcagta	351	ctattcggctcattccaagc
ND6	AF125051	206	caaaataagcccgccactaa	431	ggttggttagcagcaggt
		87	caattaacattccccctcca	324	ttgcttattcagcggctt

**Table 3. Summary of fish captured in 2000 and 2001 in the lower Liard River**

Common Name	Scientific Name	Number of Fish Captured per Year		
		2000	2001	Total
Burbot	<i>Lota lota</i>		1	1
Spoonhead Sculpin	<i>Cottus ricei</i>	1		1
Flathead Chub	<i>Platygobio gracilis</i>		2	2
Goldeye	<i>Hiodon alosoides</i>		3	3
Arctic grayling	<i>Thymallus arcticus</i>	3	5	8
Inconnu	<i>Stenodus leucichthys</i>	8	36	44
Coarsescale sucker	<i>Catostomus macrocheilus</i>		1	1
Longnose sucker	<i>C. catostomus</i>	5	7	12
Lake whitefish	<i>Coregonus clupeaformis</i>	8	17	25
Mountain whitefish	<i>Prosopium williamsoni</i>	10	9	19
Northern pike	<i>Esox lucius</i>	4	23	27
Trout-perch	<i>Percopsis omiscomaycus</i>	6		6
Walleye	<i>Sander vitreus</i>		8	8
<b>Total</b>		<b>45</b>	<b>112</b>	<b>157</b>

**Table 4. Summary of fish capture data Lower Liard River, October 2000 and 2001**

Species	Number	Length (mm)			Weight (g)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
Burbot	1	885			5200		
Spoonhead sculpin	1	80			40		
Coursescale sucker	1	485			1305		
Longnose sucker	12	396	143	525	1177	355	3000
Flathead chub	2	260.5	246	275	237.5	235	240
Goldeye	3	318	254	374	412	180	685
Arctic grayling	8	274.6	185	345	291.9	120	455
Inconnu	44	653.4	470	820	2773	950	5200
Lake whitefish	25	389	150	642	945	340	3400
Mountain whitefish	19	321	119	465	465	50	1150
Northern pike	27	776	220	671	1436	67	4100
Trout-perch	6	68	55	82	400	400	400
Walleye	8	389	174	494	781	41	1480