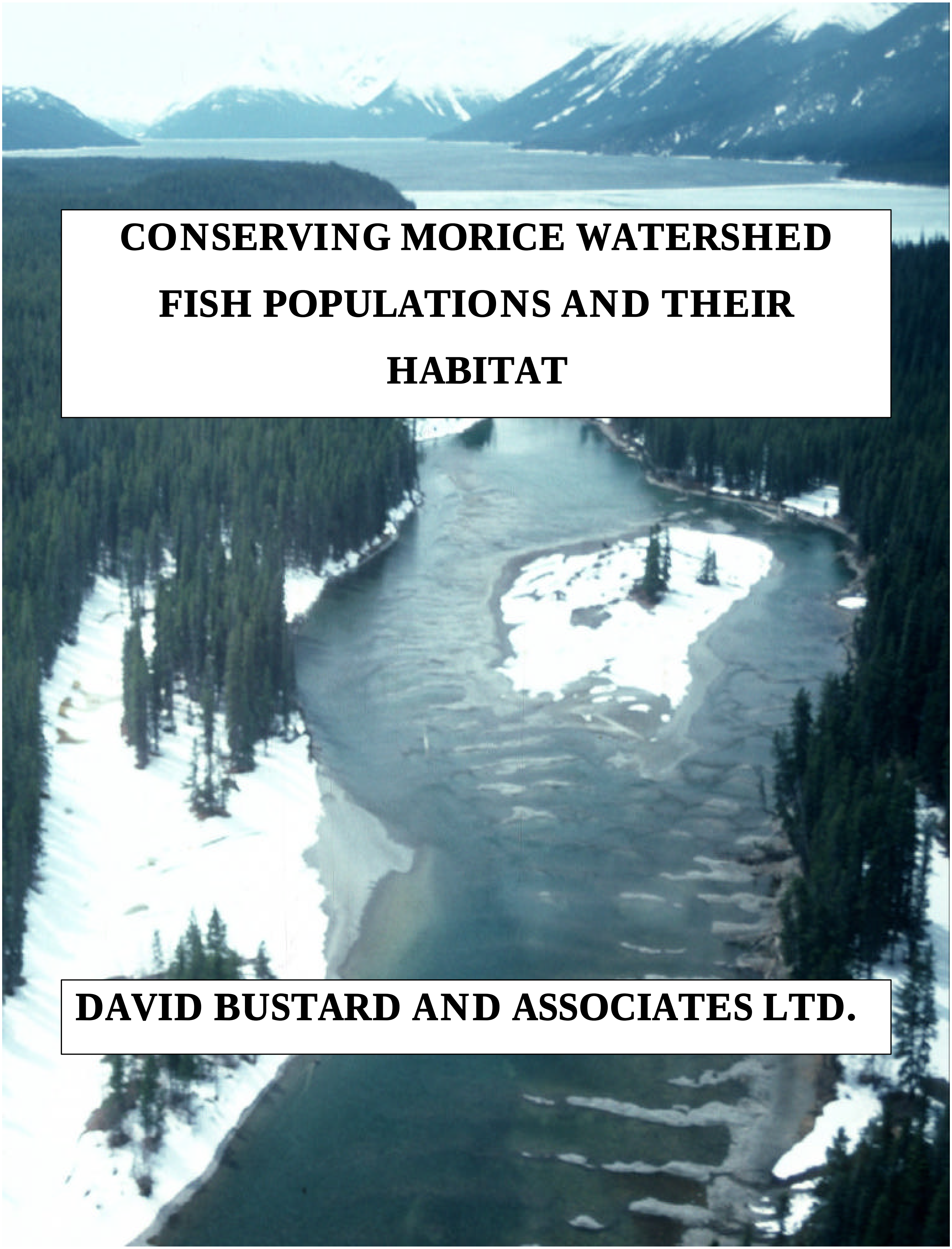


CONSERVING MORICE WATERSHED FISH POPULATIONS AND THEIR HABITAT

DAVID BUSTARD AND ASSOCIATES LTD.

Watershed-Based Fish Sustainability Planning

Conserving Morice Watershed Fish Populations

and

Their Habitat

Stage II Biophysical Profile

David Bustard and Chris Schell

DAVID BUSTARD AND ASSOCIATES LTD.

August 2002

Submitted to: Community Futures Development Corporation of Nadina

Funded by: Habitat Conservation and Stewardship Program of Fisheries and Oceans Canada

Fisheries Renewal BC

ACKNOWLEDGEMENTS

This report was jointly funded by Fisheries and Oceans Canada (Habitat Conservation and Stewardship Program) and Fisheries Renewal BC and administered through the Community Futures Development Corporation of Nadina. Mary Swendson and Greg Tamblyn steered this project through the administrative hurdles. Martin Forbes was the Fisheries and Oceans Canada coordinator. I want to thank them for their support of this project. The Morice Watershed has been a special place for me (Dave) ever since I first snorkelled in the upper river in 1974. This report was an opportunity to retrieve some information that was gradually being lost in the *quagmire of too much data.*

Many people provided assistance in assembling information for this report. We would like to thank the following individuals from Fisheries and Oceans Canada (FOC): Dave Peacock, Steve Cox-Rogers, Brian Spilsted, Barb Spencer, Barry Finnigan, Tom Pendray, Ken Shortreed and Brenda Donas. As well input from Terry Turnbull, formerly from FOC is appreciated.

We would like to acknowledge inputs from the following in Water, Land and Air Protection (WLAP): Mark Beere, Jeff Lough, Dana Atagi, and Paul Giroux. From the Ministry of Sustainable Resource Management (MSRM) we would like to thank Matt Jessop. Dave Wilford, Dave Maloney, and Jim Schwab of the Ministry of Forests (MOF) provided assistance with locating information for the Morice.

Walter Joseph, Stephan Schug and Gary Baptiste provided First Nations input. We would also like to thank Mike O'Neil from the Toboggan Creek Hatchery for his observations, Gord Wadley for sockeye information on Morice Lake, and Melinda Bahr from Applied Ecosystem Manangement for temperature information and her excellent report on bull trout in the Morice. Melissa Todd of Houston Forest Products and Laurence Turney provided helpful suggestions in the development of the terms of reference. Ken Rabnett and Alan Gottesfeld of the Skeena Fisheries Commission were helpful in locating information and providing early drafts of the Morice Stage I report.

Dennis Rasmussen of Lang McCulloch Forest Management Services Ltd. prepared the maps.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PHOTOS

1 INTRODUCTION

Watershed-based Fish Sustainability Planning (WFSP) is a planning process proposed in 2001 by the B.C. Ministry of Fisheries, BC Ministry of Water, Land and Air Protection, and Fisheries and Oceans Canada. "*Its overall goal is to ensure effective long-term conservation of fish and fish habitat - including spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly*" (BC Ministry of Environment Lands and Parks, and Fisheries and Oceans Canada 2001).

The WSFP is based on a four-stage planning sequence as follows:

Stage I - Produces a biophysical and sociopolitical profile of a region and identifies watersheds within the region that are the highest priorities for further planning.

Stage II - Produces a biophysical and sociopolitical profile of each of the priority watershed planning units identified in Stage I and identifies objectives, strategies and targets that must be met to achieve fish sustainability within these watersheds.

Stage III - Produces a detailed fish sustainability action plan that spells out how these objectives, strategies and targets will be met and by whom.

Stage IV - Implementation and monitoring of the effectiveness.

Selection of the Morice for Stage II planning resulted from two independent Stage 1 processes. The first was a Stage 1 process undertaken by the Bulkley-Morice Salmonid Preservation Group, which divided the Bulkley-Morice into four sub-watersheds: the Morice and the upper, middle and lower Bulkley watersheds. Following consultation with the public, First Nations, and government via questionnaires, the Morice River was selected by the planning committee as the priority watershed for continued planning. A second, independent Stage I planning process was undertaken by the Skeena Fisheries Comission for the Skeena Watershed. The resulting report (Gottesfeld et al. 2002 draft) identified the Morice as one of three watersheds in the Skeena with a "Very High" rating for moving forward to a Stage II planning process[1].

This report addresses Stage II of the WFSP process by developing the biophysical profile of the Morice Watershed. We have focused primarily on describing the fisheries resources of the watershed including the fish population status and trends, life history information, distribution and key habitat use, potential limiting factors to fish productivity, and perceived data gaps. As well, for some species, habitat protection issues and past enhancement efforts are summarized. Salmon species and steelhead are the primary focus, but we have also covered the main resident salmonid species including rainbow and cutthroat trout, bull trout, Dolly Varden, lake trout, and mountain whitefish. Short sections identify other fish species present in the watershed where information is available.

While our search for fish distribution information has been exhaustive, it should be recognized that the sheer size of the watershed and abundance of smaller drainages that have not been examined means that the distribution maps are not complete. Our experience suggests that fish distribution for some species such as coho and steelhead can change significantly between years

[1] The other two were the Kispiox and Lakelse watersheds.

depending upon escapements and streamflows, and relying on these maps to tell the "whole story" is not advised. Rather they are meant to assist in identifying the key habitats.

During several meetings with the Bulkley-Morice Planning and Technical committees held in late February and March 2002, the committees identified several resource planning processes already underway. The Morice Land and Resource Management Plan (LRMP) is addressing recreation, wildlife, and timber harvesting issues. At the same time, the Morice TSA is included in an Innovative Forest Practices Agreement led by the forest industry in an effort, amongst other objectives, to incorporate forest certification standards into operational planning. As a result, it was agreed that the Stage II biophysical profile would focus on assimilating the extensive background fisheries information for the Morice Watershed, and not on the complex land-use issues related to forest development planning and priorities. In addition, the mixed-stock Skeena commercial fisheries issues were felt to go beyond the scope of this profile and while identified, were not to be addressed in detail in this report.

In the review of Gottesfeld's draft report, it was felt that the Stage I review of background information describing Geography, Access, First Nations Traditional Use, and Population and Settlement were more than adequate to describe these aspects of the Morice Watershed, so we have not repeated these in the Stage II report.

FIGURE 1:
OVERVIEW MAP OF THE MORICE WATERSHED SHOWING THE MAJOR LAKES AND TRIBUTARY SYSTEMS

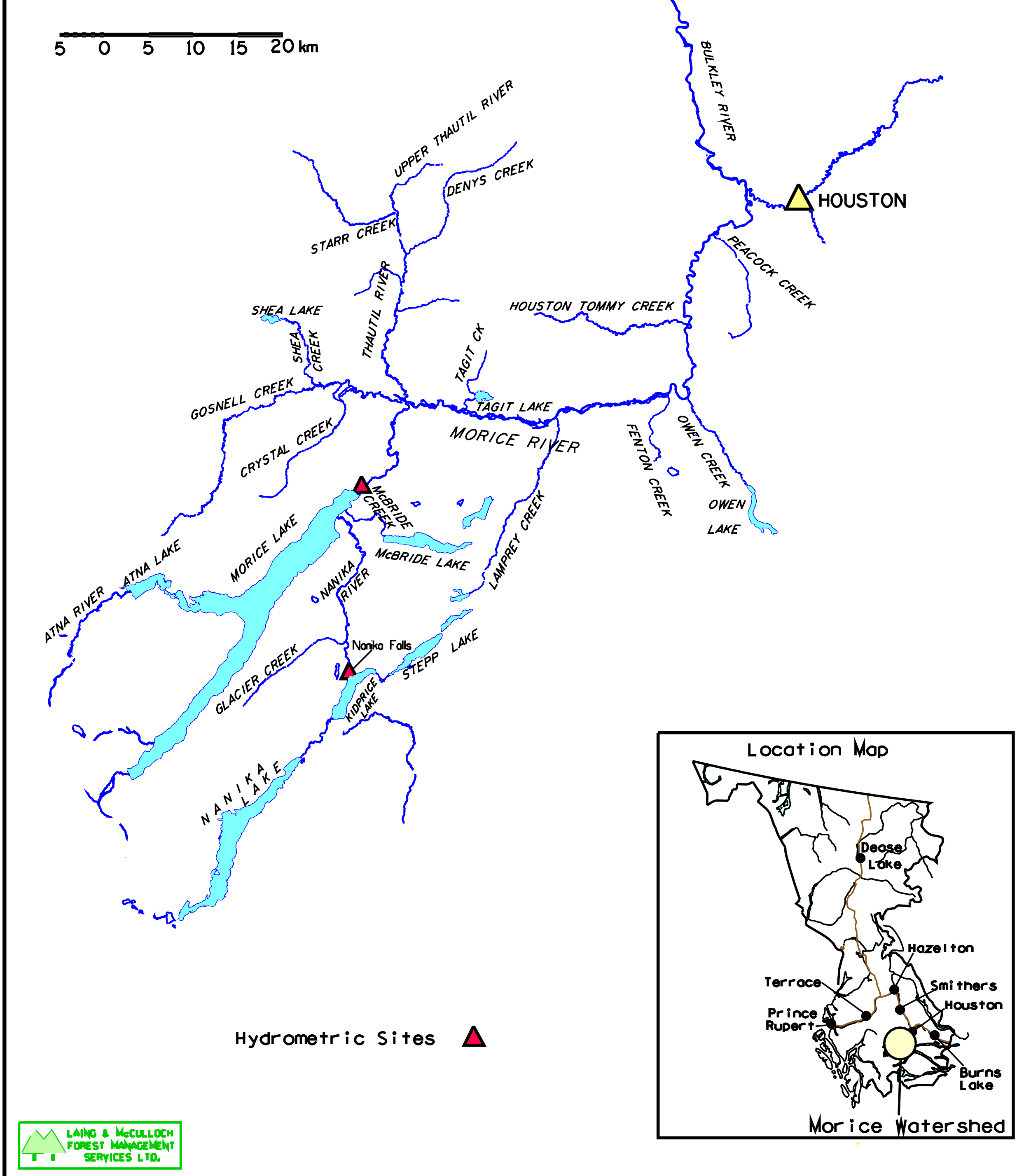


Figure 1. Overview map of the Morice Watershed showing the major lakes and tributary systems.

2 PHYSICAL CHARACTERISTICS OF THE MORICE WATERSHED

2.1 HYDROLOGY

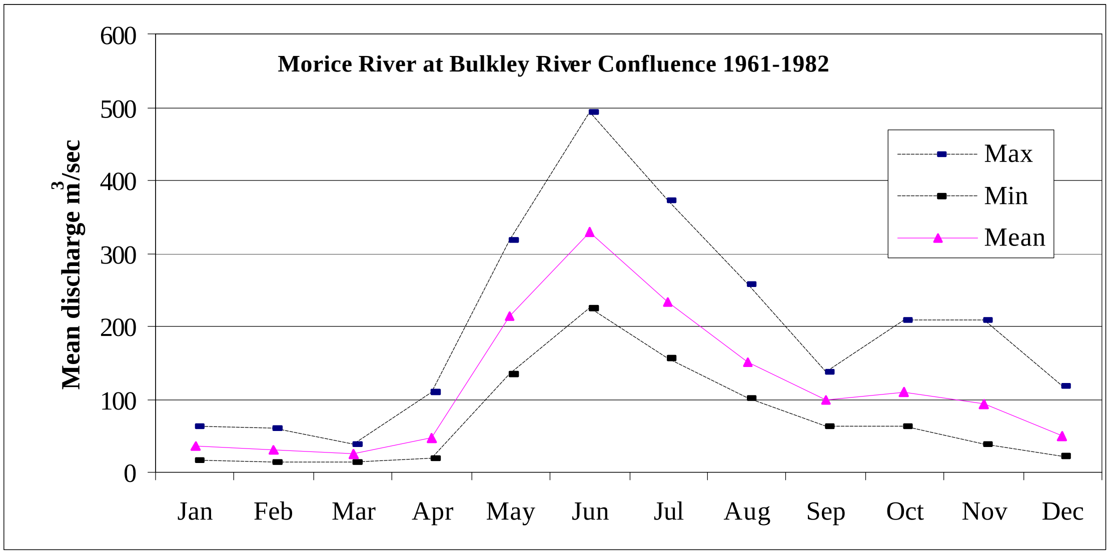
The Morice River has a total catchment area of 4349 km^2 and is comprised of tributaries draining from both the Interior Plateau and the heavily glaciated Coast Mountains. The Morice River originates from Morice Lake and flows in a northeasterly direction for 80 km to join the Bulkley River near Houston.

Two large tributaries feed into Morice Lake – the Nanika River (895 km^2) and the Atna River (300 km^2). Gosnell Creek and the Thautil River together form the largest tributary downstream from Morice Lake (535 km^2) and have the largest influence on flood flows and sediment inputs to the mainstem Morice River.

Photo 1. Gosnell Creek (lower left) and Thautil River (top of photo) are main sources of sediment into the Morice River at a point located 13 km downstream from Morice Lake. This photo was taken in June 1982 prior to any significant road or logging development in these drainages.

Gottesfeld et al. (2002) have summarized the hydrology of the Morice drainage in the Stage 1 report. Water Survey of Canada hydrometric stations are located at the outlets of Kidprice and Morice lakes. The most extensive hydrological studies undertaken in this watershed to date including water temperature modeling, groundwater hydrology, and flood-frequency analyses were conducted during the Kemano Completion studies (Envirocon Ltd. 1984 Volume 2).

Figure 2. Mean monthly discharge estimates in the Morice River at the Bulkley River confluence for period 1961-1982[2].



Peak flows in the Morice River generally result from snowmelt and occur from late May through July (Figure 2). Mean monthly flows are highest in June and approach 500 m^3/sec during high-flow years. During some years, the highest flows have occurred during the late fall, usually the result of rain-on-snow events during late October and early November.

A combination of glacier melt, lake storage and autumn rains maintain moderate flows in the mainstem Morice and Nanika rivers until freeze-up typically in November, so extreme summer low-flows do not occur in the main river. Similarly, snowfields and glaciers keep late summer streamflows relatively high in larger tributaries on the west side of the Morice such as the Thautil River, Gosnell and Houston Tommy creeks.

Smaller west side tributaries such as Tagit Creek and tributaries draining the Interior Plateau areas on the east side of the Morice such as Lamprey, Owen and McBride creeks have limited or no permanent snowfields and can experience low summer flows as shown in Figure 3.

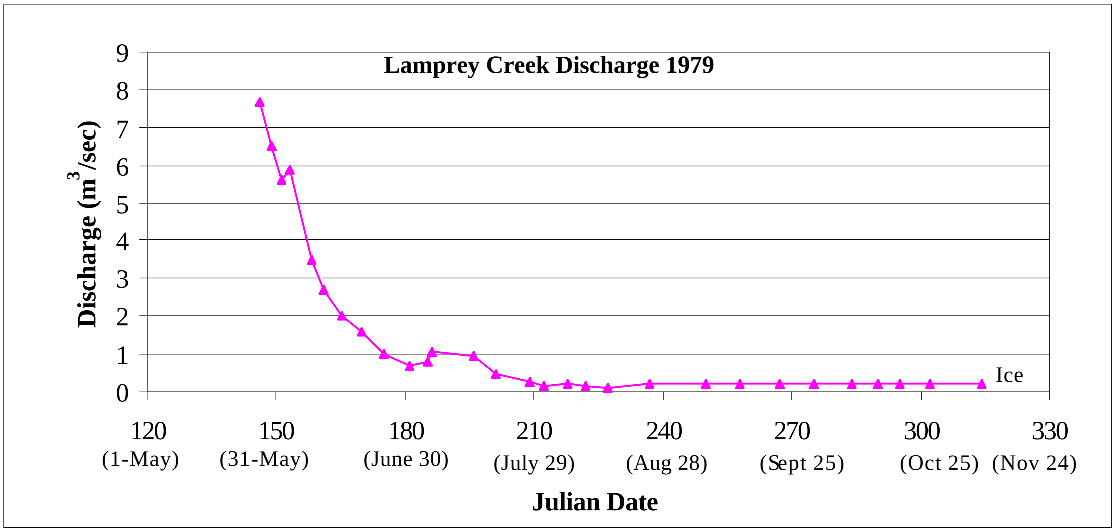
A key feature of both the mainstem rivers and smaller tributaries is that lowest streamflows occur during the late winter period, usually in March and into the middle of April at the higher elevations.

All of the lakes in the watershed ice over during most years. The Morice River from the outlet of Morice Lake to Gosnell Creek and the Nanika River between Kidprice Lake and Glacier Creek remain ice-free. Other small sections of streams at smaller lake outlets and in groundwater-influenced areas can also remain ice-free.

---

[2] Data from Kemano Completion Studies (1984 Volume 2).

Figure 3. Discharge regime for Lamprey Creek based on measurements conducted during the period from late May to November 1979. Note the very low late summer and fall flows in this tributary typical of most years.



2.2 WATER TEMPERATURES

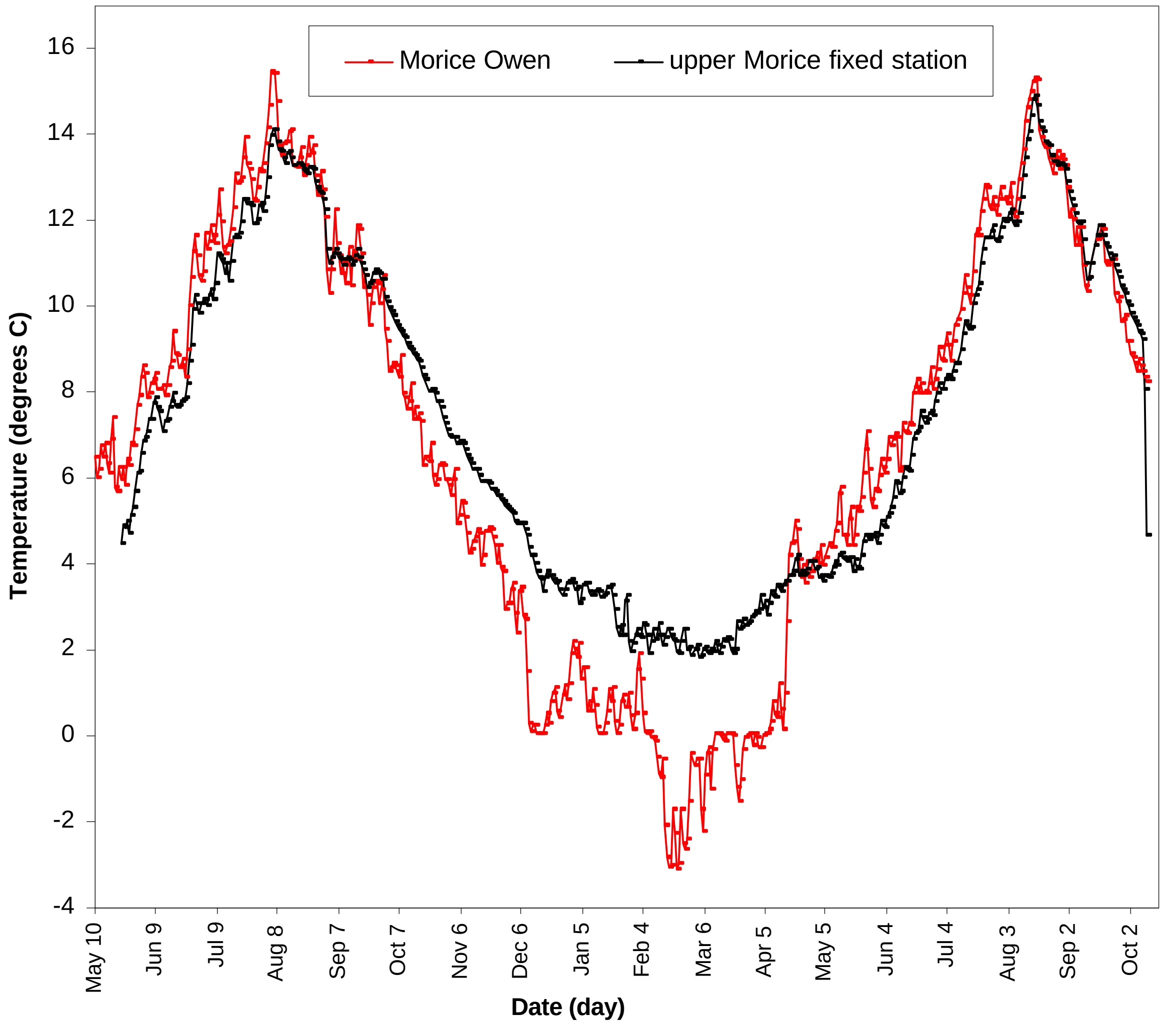
Water temperatures in the Morice River are above 5°C from approximately the beginning of May to early November[3], with maximum water temperatures near 15°C during August (Figure 4). The moderating influence of Morice Lake on the river temperatures is shown in data from the upper Morice station. Temperatures remain warmer in the period October through April in the upper river compared to the Morice River in the vicinity of Owen Creek.

Water temperatures for five Morice tributaries are shown in Figure 5 and indicate there is a wide range of temperature regimes between different tributaries. For example water temperatures in Owen and Lamprey creeks draining the Interior Plateau are significantly warmer than temperatures in Houston Tommy and Crystal creeks that are fed from high elevation snowfields and rarely exceed 10 °C during the warmest periods of the summer.

Temperatures in Owen and Lamprey creeks can exceed 15°C during warm summer periods and have been recorded as high as 19°C during some periods (Envirocon Ltd. 1984). Shea Creek temperatures are between the above examples reflecting the influence of Shea Lake. Water temperatures in off-channel pond habitat can reach 20°C during the mid-summer period (Envirocon Ltd. 1984).

[3] Juvenile salmon and steelhead become less active and seek overwinter habitat when water temperatures are less than 5 C.

Figure 4. Morice River average daily water temperatures between May 10, 2000 and October 2, 2001 at stations located in the upper and mid-reaches of the Morice River[4].

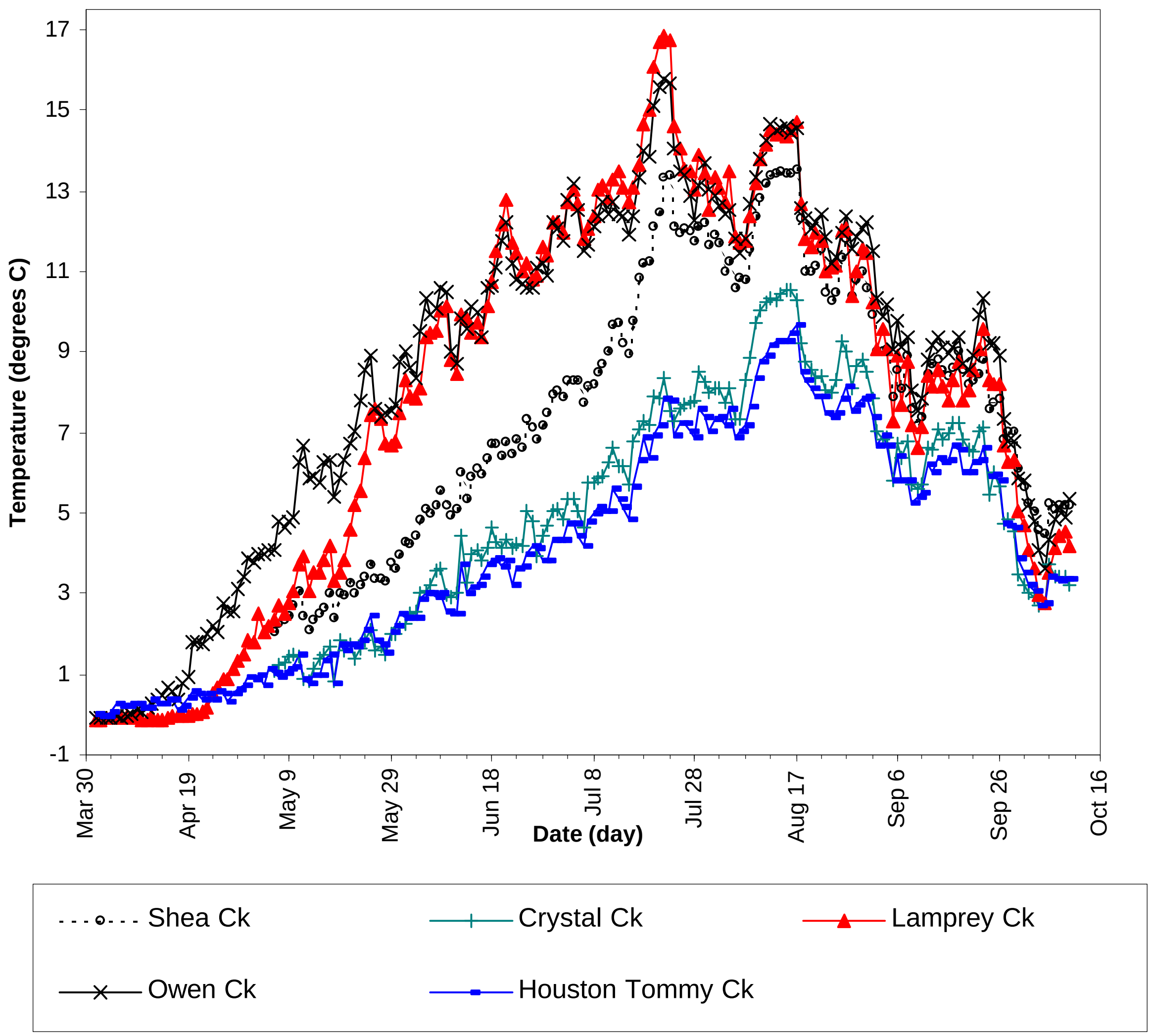


There is extensive water temperature information available for the Morice including data collected during the Kemano Completion Studies (Envirocon Ltd. 1984). However, probably the best temperature information is presented in Bahr (2002) who established 25 strategically located water temperature loggers in the Morice Watershed during her bull trout study.

Water temperature studies related to forest harvesting operations on small streams in the Thautil River have been underway for the past three years. The objective is to examine temperature response to different streamside treatment options in S4 to S6 streams (Hudson 2002).

4 Data derived from Bahr (2002).

Figure 5. Average daily water temperature in five Morice River tributary streams from March 30 to October 16, 2001[5].



[5] Data from Bahr (2002).

2.3 WATER QUALITY

A systematic water quality sampling program was conducted on the lower Morice River for a five-year period from 1983 to 1987 with a sampling frequency of approximately once per month[6]. The results of this program are summarized in Remington (1996), who concluded that Morice River water quality is excellent.

Key values of direct interest to fisheries include a neutral pH, mean alkalinity of 23 mg/l, mean conductivity of 53 ohms/cm, and the lowest coloured waters of the seven Skeena watersheds examined. The review indicates that nutrient levels in the watershed are extremely low, typically below detection limits.

The review presents a summary of metal levels in the Morice, indicating that dissolved metal levels were generally less than the detection limits.

The review identified the inactive Silver Queen Mine on the eastern shore of Owen Lake as a source of Zn contamination in the Owen Watershed.

Increased suspended sediment levels in the Morice related to logging road and cutblock development have been assessed inconsistently over the past decade. Significant natural sediment sources occur in the Thautil, Gosnell and Houston Tommy watersheds on the Morice River, and in Glacier Creek on the Nanika River. Morice and Nanika lakes act as settling basins for high glacial sediment inputs from inlet tributaries draining into these systems.

A program to monitor suspended sediment levels and sources was initiated in the mid-1990's by the Ministry of Forest Research Section and continued for at least two years. The project involved video taping the river during spring, summer and fall periods to identify sources, and to correlate video measurements with "grab" samples[7].

An operational inventory of water quality monitoring in eastern streams in the Skeena included site specific monitoring of one site in the Morice (Chaplin 2001). Benthic invertebrates and surface sediment analysis were conducted at Fenton Creek below a culvert replacement project during 1999 and 2000.

It is important to note that concerns for sediment extend beyond direct impacts on fish spawning and rearing habitats. Reduced water clarity due to sediment inputs has a direct bearing on the fishability of the Morice, a river that has historically provided fishable waters when other regional steelhead rivers are "out" during fall rains.

[6] This program was part of a program to sample major drainages in the Skeena River conducted by the Waste Management Branch of MOELP (Wilkes and Lloyd, 1990).

[7] This program has not been continued due to the low number of samples taken and the lack of funding support (Dave Maloney, MOF, personal communication). Data collected during this program is on file at MOF in Smithers.

2.4 GEOMORPHOLOGY

The Morice floodplain has been the subject of a number of geomorphology studies as outlined in Gottesfeld et al. (2002).

The earliest studies were conducted by Envirocon Ltd. (1984) and assessed the implications reduced streamflows due to a proposed water diversion at Nanika Lake on the morphology of the Nanika and Morice rivers (Envirocon Ltd. 1984 Volume 2). The impacts of reduced peak flows on the channel characteristics of the Morice River, particularly the multiple-channeled section between Gosnell and Fenton Creek, were a major reason not to proceed with the Morice portion of the Kemano Completion Project. Potential changes to bed material characteristics and the abundance and characteristics of side channels in this section, posed unacceptable risks to the high fisheries values, and no satisfactory options for mitigation were identified.

Cobble lithology shows that 98% of the bedload in the Morice floodplain between Gosnell and Fenton creeks is derived from the Thautil River (Gottesfeld and Gottesfeld 1990). Weiland and Schwab (1992) conducted a detailed geomorphic assessment including mapping of this important reach. They determined that extensive bank cutting along the Thautil contributes a large portion of the suspended sediment component and that the Starr Creek basin is the source of much of the bedload. They also indicated that large woody debris inputs from the riparian zone to log jams in this reach were an important component of the process of channel development in the river. Although rapid changes may occur within a narrow corridor along the main channel, the rate of channel migration into the inactive floodplain occurred at a much slower rate of 1 to 1.5 m per year.

Many of the fisheries inventories conducted during the past 30 years have attempted to delineate stream reaches and describe the channels and bed characteristics of the various section of the mainstem river and tributaries. A wide range of methodologies were used during the earlier stream surveys. An example for the mainstem Morice River is presented in Table 1.

Table 1. Summary of some of the reach characteristics of the mainstem Morice River[8].

Reach	Location	Length (km)	Gradient (m/km)	Complexity[9]	Log Jams /km	Bed Material
1	Morice Lake to Gosnell Creek	15.4	3.2	1.7	5-20	Mainly cobbles with some gravels
2	Gosnell Creek to Fenton Creek	33.8	1.9	4.7	20-40	Gravel with cobbles in mainstem
3	Fenton Creek to Peacock Creek	27.8	2.7	1.2	<5	Variable to boulder
4	Peacock to Dockerill Creek	18.1	1.3	2.0	5-20	Gravel and cobble

[8] Data derived from Envirocon Ltd. (1984 Volume 4).
[9] Refers to the total channel length compared to the main channel length during the late summer period.

With the initiation of the Watershed Restoration Program in 1994, the channel assessment procedures became more systematic in an effort to identify logging-related channel changes and restore damaged stream channels. Ecofor (2001 draft) has summarized the watershed restoration efforts in the Morice drainage and has outlined an interim program for future direction with this program.

Low level photography at a 1:5000 scale was produced during September 1996 for the mainstem Morice River, Lamprey Creek, McBride Creek and Houston Tommy Creek[10]. Weiland and Schwab (1992) indicate the earliest air photos available for the Morice were flown in 1949 with seven subsequent flights since that time up to their study in 1992.

[10] These photos are on file at WLAP, Smithers.

3 FISH RESOURCES OF THE MORICE WATERSHED

The Morice Watershed is used by all species of Pacific salmon except chum, possesses an outstanding summer steelhead run, and is used by rainbow and cutthroat trout and kokanee. Three species of char including bull trout, Dolly Varden, and lake trout and three species of whitefish as well as a number of other resident fish species are present in the system including burbot, lake and peamouth chub, longnose and largescale suckers, redside shiners, longnose dace, prickly sculpins and Pacific lamprey. The remainder of this report describes the fisheries resources in the Morice.

3.1 SOCKEYE SALMON

3.1.1 SOCKEYE POPULATION STATUS AND TRENDS

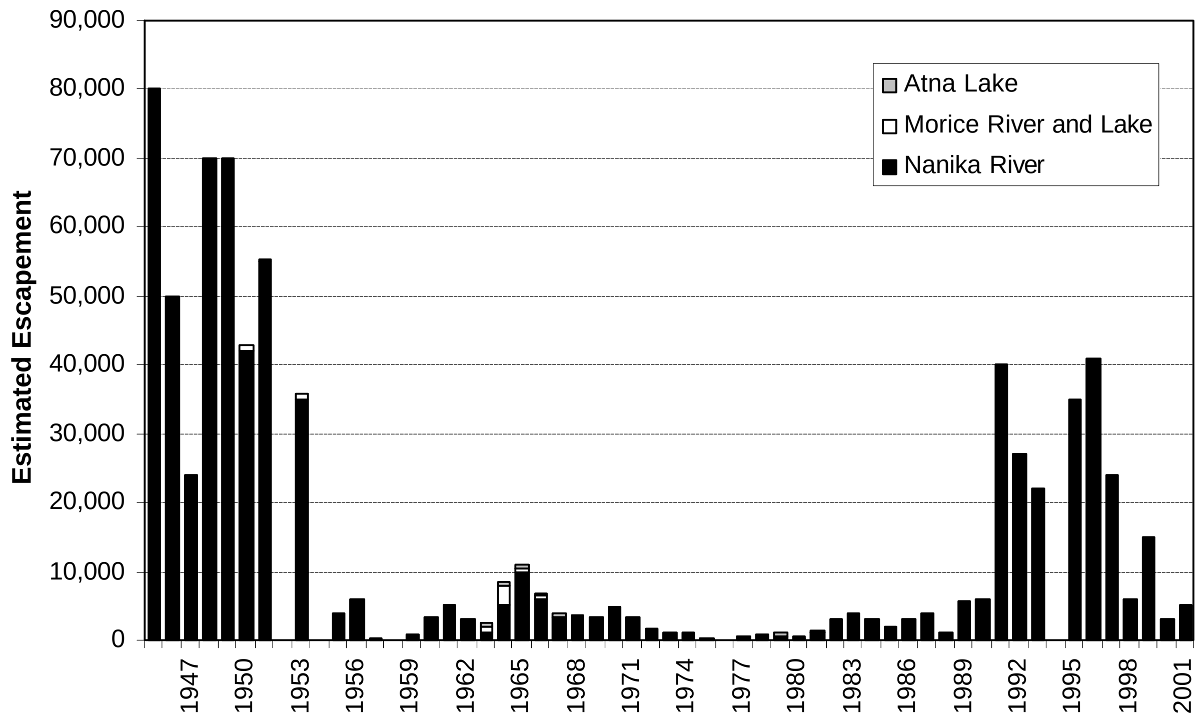
The Morice-Nanika sockeye stock is the largest and only sockeye run of significant size in the Bulkley-Morice sub-unit, and provides an important fishery for the Wet'suwet'en First Nation at the Moricetown canyon. Generally, the Morice-Nanika stock makes up 1-2% of the Skeena escapement, which is dominated by the enhanced Babine stock (91% on average). Due to its smaller size and availability to the commercial fishery targeting Babine sockeye, the Nanika/Morice stock is vulnerable to over-harvesting.

Most of the observed sockeye spawning in the Morice takes place in the Nanika River. Nanika returns prior to the mid 1950's were very high, averaging over 50,000 fish (Figure 6). By 1955, escapement levels had dropped to 4,000 spawners, and (with the exception of 1965) remained below 6,000 until the early 1990's. In 1958 only 75 Nanika sockeye were counted, and from 1975 to 1980, escapement levels ranged from 100 to 700 fish. The stock rebounded from 1991 to 1997 with returns of 22,000-41,000 fish, but dropped again in 1998 and has remained low through to 2001.

Cox-Rogers (2000 and 2001) reviewed exploitation of Morice-Nanika sockeye, including the commercial marine fisheries (Alaskan and Canadian) and all in-river native fisheries. He determined that there was no evidence that harvest rates had driven the historic patterns in Morice-Nanika sockeye escapements, and concluded that, with a few exceptions, harvest rates have tended to track stock size.

Sockeye catch for the in-river food fishery at the Moricetown Canyon is shown in Figure 7. Comparison to the in-river stock shows that catch has generally followed escapement numbers, with harvest rates usually about 25% of the in-river stock. Two significant exceptions to this occurred in the late 1950s and throughout the 1980's. Harvest rates during 1957, 1958, and 1959 were estimated (with unknown error in both stock size and harvest numbers) at 89%, 98%, and 57% respectively. The average estimated harvest rate from 1981 to 1988 is 70% of the in-river stock.

Figure 6. Fisheries and Oceans Canada escapement data for sockeye salmon in the Morice Watershed[11].



3.1.2 SOCKEYE LIFE HISTORY INFORMATION

Shepherd (1979) summarizes a large amount of information describing the size and age characteristics of Nanika River sockeye collected during the period 1965-1974. Length information collected on over 6000 fish indicated Nanika sockeye were slightly smaller than other Skeena sockeye. Another significant difference was the high proportion of Morice fish (86%) that spent two years in freshwater compared to other Skeena sockeye stocks. These fish returned mainly at age five and six-year-old, typically a year older than most other Skeena sockeye.

Studies on the Atna Lake sockeye population in 1980 (Envirocon Ltd. 1984 Appendix K) indicated that most of this population also spent two years in freshwater, but the Atna Lake sockeye population was dominated by fish that had spent three years in the ocean.

Smith and Berezay (1983) operated downstream traps at the outlet of Morice Lake during the spring of 1979 and 1980. Although a significant number of sockeye smolts were captured, only a limited amount of information describing the length and age of migrants was collected. This information suggested that most smolts were age 1+ fish, opposite to the results of age estimates based on scale analysis of returning sockeye spawners.

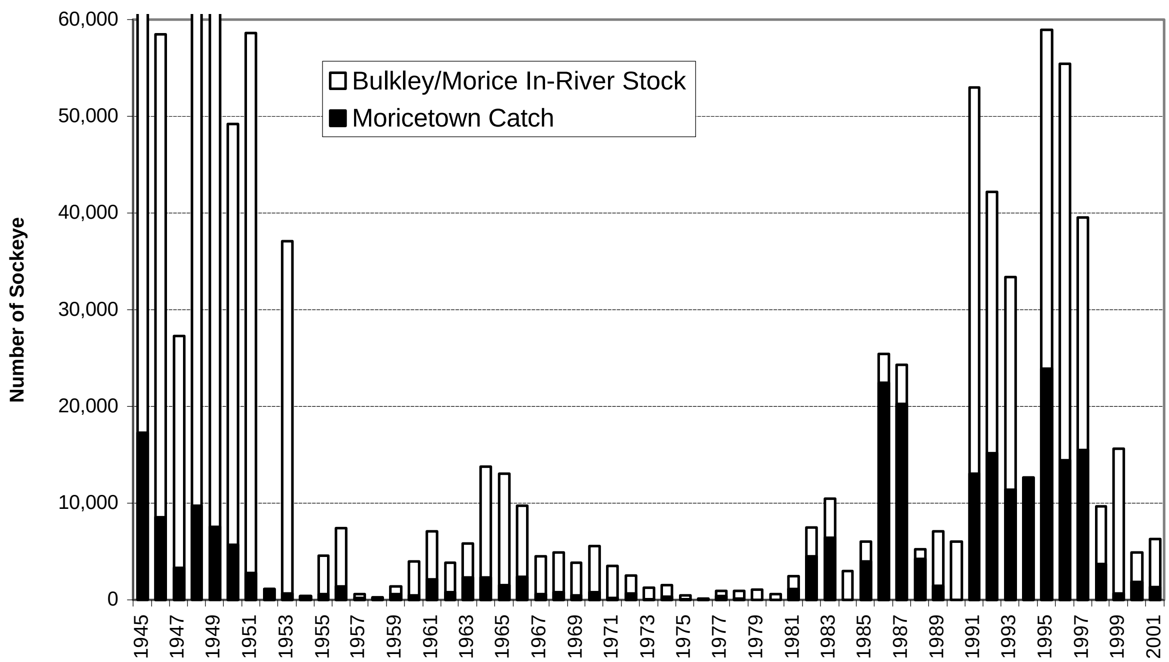
---

[11] 1946-1949, and 2001 data are from Cox-Rogers (2001). 1950-2000 data are SEDS data based on the BC 16 escapement record. 1994 is marked “unknown” in the database, indicating that a survey was made this year, but that the resulting data was insufficient to make an escapement estimate, due to poor counting conditions, etc.

Shepherd (1979) indicates that the smolts that left Morice Lake after one year were small compared to most of the eight other stocks that he had comparative data for, and suggests this reflects the low productivity of Morice Lake. He suggests that the larger two-year-old smolts probably have a better ocean survival, accounting for the higher proportion of older smolts in the scale data.

There is a limited amount of information describing the juvenile sockeye lengths and weights presented in Shepherd (1979) and Smith and Berezay (1983). Envirocon Ltd. (1984) presents monthly size information describing sockeye juveniles rearing in Atna Lake.

Figure 7. Catch of sockeye in the Moricetown Canyon compared to the total in-river stock[12] for the Bulkley-Morice sub-unit.



3.1.3 SOCKEYE SPAWNING

3.1.3.1 Timing

Nanika sockeye pass through the Area 4 commercial fishery in late June through mid-July with a peak in the first week of July (Cox-Rogers 2000). Based on tag recoveries, it takes approximately three weeks for these fish to show up at the Moricetown fishway. The peak of sockeye migration past the Alcan counting tower formerly located just downstream from Owen Creek occurs in mid-August. The peak of spawning in the Nanika typically occurs during the third week of September (Shepherd 1979).

[12] In-river stock = Moricetown catch + Morice-Nanika escapement estimate. Data from Cox-Rogers (2001).

Detailed observations of sockeye movements into Atna Lake at the falls in the outlet river were recorded in 1980 (Envirocon Ltd 1984). Sockeye were observed passing the falls restriction throughout the month of August. Carcass recovery during the beach spawning period suggested that spawning began in early September and peaked in mid-to late September in Atna Lake.

3.1.3.2 Spawner Distribution

The main spawning area for sockeye salmon in the Morice Watershed occurs in the Nanika River upstream from Glacier Creek (Figure 8 and Photo 2). The major spawning area for sockeye salmon (Area A) is located approximately 2 km downstream from the Kidprice Lake outlet and is estimated to comprise approximately 17000 m^2 of suitable spawning gravels (Robertson et al. 1979)

Photo 2. The Nanika River below Nanika Falls during March. This short section of river is the main spawning area for Morice-Nanika sockeye and provides a stable spawning and incubation environment for chinook, coho and rainbow trout as well as overwintering for bull trout. This is one of the two key sections of river in the Morice that remain ice-free through the winter.

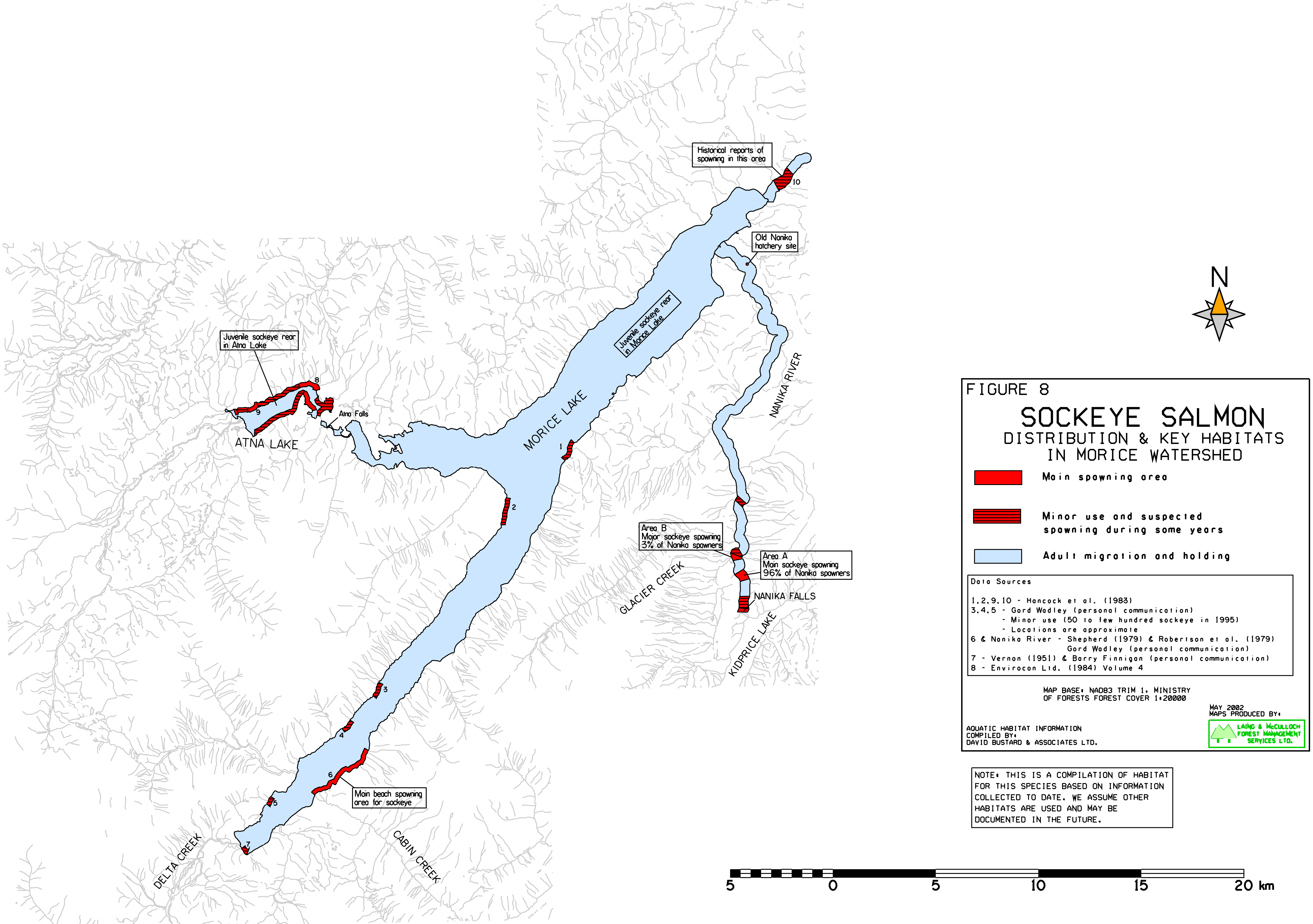


FIGURE 8
SOCKEYE SALMON
DISTRIBUTION & KEY HABITATS IN MORICE WATERSHED

Figure 8. Sockeye salmon distribution and key habitats in the Morice Watershed.

1979). This section is utilized by most Nanika River sockeye. For example, in 1979 approximately 96% of the sockeye escapement used this area.

A second spawning location (Area B) is located approximately 3 km downstream from Kidprice Lake and is estimate to comprise 1500 m^2 of suitable gravels. An estimated 3% of the Nanika sockeye used this area in 1979 (Envirocon Ltd. 1984).

A third spawning location is located approximately 6 km downstream from Kidprice Lake and is utilized by a small proportion of the Nanika sockeye spawners (1% of the 1979 run). Other small pockets of spawning gravels occur between Nanika Falls and the main spawning section and just upstream from the Glacier Creek confluence.

Morice sockeye also use beach spawning locations, particularly at the south end of Morice Lake (Figure 8). A beach spawning area located along the Morice Lake shoreline 3 km north of Cabin Creek is described in Shepherd (1979). During diving surveys conducted in 1974, an estimated 500 sockeye utilized this area to a depth of 10 m. The Nanika River spawner estimates in 1974 were 1200. Shepherd (1979) reported that six years of beach spawning data for this area averaged 300 fish.

Studies of beach spawning sockeye in Atna Lake during 1980 suggested approximately 400 sockeye spawned mainly along the northeast section of the lake (Photo 3). Glacial turbidity restricts accurate counts in Atna Lake and the results are based on observations of fish passing Atna Falls and carcass recovery along the lakeshore. These estimates occurred during a year when sockeye estimates in the Nanika River were only 700 spawners.

The incidental observations at these two beach spawning locations both suggest that beach spawning may comprise a significant proportion of the Morice sockeye spawning during some years. Accurate counts at the two locations are difficult due to turbidity and depth, but in those years that detailed surveys have been undertaken, beach spawning has been significant[13].

A number of sockeye beach spawning areas were identified in Hancock et al. (1983). These sites were located on the east side of Morice Lake across from Atna Bay and on the west side south of Atna Bay (Figure 8). Surveys conducted during 1995 located three previously unidentified areas on the southwest end of Morice Lake near Pyramid Creek that were used by beach spawning sockeye[14].

Summaries of fishery officer reports also suggest that sockeye spawning occurs in the Morice River at the outlet of Morice Lake (Hancock et al. 1983). The last report of sockeye spawning in this location was in 1975. Incidental reports suggest some additional sockeye spawning may occur at the south end of Morice Lake in the vicinity of Delta Creek (Vernon 1951; Barry Finnigan, FOC, personal communication).

---

[13] Tagging studies at Moricetown in 2001 suggest that approximately 5000 sockeye salmon spawned upstream from Moricetown. Steve Cox-Rogers (personal communication) estimates that approximately 80% of these fish spawned in the Nanika River spawning sites.

[14] This information was provided by Gord Wadley (personal communication) based on boat surveys conducted on September 6, 1996. Approximately 50-100 spawners were using each of the three locations. Approximately 800 sockeye were observed in the vicinity of Cabin Creek. Original reports outlining this information were lost in a fire at the Moricetown office of Wet'suwet'en Fisheries. This was a year of high sockeye escapements in the Nanika River (Figure 5).

Photo 3. Atna Lake looking from the inlet towards the main sockeye beach spawning area during the September spawning period. Beach spawning sockeye are difficult to enumerate, but may comprise a significant component of Morice run during some years.

3.1.3.3 Characteristics of Spawning Areas

Robertson et al. (1979) provides detailed hydrographical descriptions of the two main sockeye spawning sites in the Nanika River. The main spawning site is located in a laminar flow section of the Nanika River that is approximately 50 m wide. Water depth in this section of the channel tends to be deep with more that 50% exceeding 0.6 m during the spawning period. Measurements conducted at 39 redd sites in the Nanika spawning area during the spawning period in 1975 indicated nose velocities[15] ranging from 18-40 cm/sec. These are relatively slow water velocities for sockeye spawning.

Shepherd (1979) presents a sketch of a typical beach spawning site in the Cabin Creek area. The site was gently sloping from a cobble beach area to a gravel section extending out from the shoreline up to 40 m and to a depth of 10 m.

3.1.4 SOCKEYE EMERGENCE

Sockeye fry emergence in the Nanika River starts in late May with a peak near mid-June and continues into late July (Shepherd 1979). This is later than many other Skeena sockeye stocks,

---

[15] Water velocity taken 0.12 m above the streambed at the top end of the redd.

and is thought to be specific and timed to coincide with an increase in plankton production in Morice Lake.

Shepherd (1979) suggests that one of the reasons for the failure of the pilot project to establish a hatchery operation on the lower Nanika River was that Pinkut sockeye stock were used and these fish were poorly adapted for Nanika River conditions. Fry were emerging 3 to 4 weeks early, when conditions in Morice Lake were unsuitable for fry rearing.

Studies in Atna Lake indicated that shortly after emergence, many sockeye fry left Atna Lake, presumably to rear in Morice Lake (Envirocon Ltd. 1984 Appendix K). This downstream movement continued through August.

3.1.5 JUVENILE SOCKEYE REARING

Sockeye rearing in the Morice Watershed occurs entirely in Morice and Atna lakes and no juveniles have been reported rearing in any other locations after extensive sampling throughout the Morice and Nanika rivers.

Studies of fish sampling in Morice Lake using tow-net and gill nets indicated that most sockeye rearing was concentrated at the north end of Morice Lake[16]. This coincides with the section of Morice Lake that has the highest nutrient levels as well as highest secondary and primary production (Cleugh and Lawley 1979). The higher productivity at the north end of the lake is likely due to the input of nutrients from the Nanika River compared to the nutrient-poor streams in the remainder of the lake.

Cleugh and Lawley (1979) concluded that the phytoplankton productivity of Morice Lake is very low, reflecting low nutrient levels and cold temperatures especially at the south and mid sections of the lake. This same pattern was also noted for zooplankton and zoobenthos reflecting the cold and low nutrient levels and the relatively small littoral zone of Morice Lake.

More recent surveys summarized in Shortreed *et al.* (2001) indicate that although Morice Lake has excellent physical conditions for juvenile sockeye production, the lake’s productivity is near the lowest for any sockeye rearing lake in B.C. Low plankton and zooplankton biomass levels in the lake have resulted in a poor food supply for sockeye fry. Age 0 fall fry captured in 1993 averaged only 0.8 grams and were the second smallest recorded for a sample of 50 B.C. sockeye nursery lakes. Sockeye fry stomachs were less than 30% full. The estimated density of sockeye fry was also lower than all but two other lakes evaluated.

These studies, in conjunction with the high proportion of age 2 sockeye smolts and their small size, confirm the lake’s low productivity and deficient food supply.

Downstream traps located in the upper Morice River sampled sockeye smolts during 1979 and 1980 (Smith and Berezay 1983). The main sockeye smolt migration occurred during May with a peak in mid-May and a secondary peak at the end of May.

---

[16] Much of this work was conducted by R.N. Palmer during the period 1961-65 (unpublished data summarized in Shepherd 1979).

3.1.6 LIMITING FACTORS TO SOCKEYE PRODUCTION

Identifying factors limiting sockeye production has become an area of considerable interest given the sharp decline in escapements between the mid-1950's through the 1980's, what appeared to be a recovery during the 1990's, and another decline since 1998 (Figure 6). Efforts to conserve the Nanika sockeye affect both the Skeena commercial sockeye fishery focused on the enhanced Babine stocks, and the native fishery for sockeye at Moricetown.

To date there is not a good explanation for the crash of sockeye spawners starting in the mid-1950's and continuing for the next 30 years. Cox-Rogers (2000 and 2001) reviewed exploitation rates and suggests that over-exploitation in the marine and river fisheries is unlikely to be responsible for these fluctuations. Rather he suggests that the Morice-Nanika sockeye are most likely responding to changes in freshwater or marine productivity. Data presented in Figure 7 does suggest that the in-river fishery may have taken a significant portion of the sockeye in-river stock during some years, especially in the 1980's.

3.1.6.1 Low Lake Productivity

There is evidence that the ultra-oligotrophic status of the lake severely limits the growth and productivity of juvenile sockeye (Shortreed *et al.* 2001). The data suggest that the lake is extremely unproductive especially at the southern and middle sections, and that growth of sockeye is slow due to the low concentration of zooplankton. The extra year spent rearing in the lake compared to most sockeye systems, in conjunction with small fry and smolt sizes probably limits sockeye production in the Morice.

3.1.6.2 Inadequate Spawner Recruitment

Irregardless of the cause of declines in spawner abundance, the very low escapements for much of the past half century are nowhere near the predicted potential for the lake rearing capability based on the lake's physical characteristics as outlined in Shortreed *et al.* (2001). Lack of adequate spawner recruitment to the system is limiting fry recruitment. More fry entering the lake during most years should result in greater smolt outputs from the Morice system.

While this appears contradictory to the comments above (section 3.1.6.1, above) it is important to note that Morice Lake's size, depth of photic zone, and low zooplankton concentration would allow for increased fry recruitment without increased competition for food.

3.1.6.3 Available Spawning Area

The total estimated area available for spawning in the Nanika in the two main spawning sites is just under 20,000 m^2 (Robertson et al. 1979). Other more marginal areas are also available in the Nanika River. The amount of potential lake spawning area is unknown.

If we assume a pair of sockeye will use 1 m^2 for a redd[17], then the main Nanika sockeye spawning areas could reasonably accommodate 40,000 fish. At escapements higher than this, we assume that fry production rates will decline due to overcrowding, redd superimposition, and less suitable intragravel conditions. Observations in the main Nanika spawning sites suggest that

---

[17] This is based on observations at Pinkut and Fulton River spawning channels, with maximum fry production per unit area achieved at a spawner density of approximately one female/m^2 (West and Mason 1987).

when sockeye escapements are in the 15,000-30,000 range, fish are crowded in the main spawning sites, and more marginal locations outside of the best spawning sites but upstream of Glacier Creek are utilized (Steve Cox-Rogers, personal communication).

We assume that at escapements higher than 40,000 fish, the amount of suitable spawning habitat may become a limiting factor for the Nanika River sockeye. Similar estimates are not available for the lake spawning portion of the population.

3.1.6.4 Flooding, Redd Dewatering and Freezing

The main sockeye spawning areas in the upper Nanika are relatively deep and subject to stable warm water flows from Kidprice Lake. We suspect that survival of eggs to emergence is good in most of the sites, due to lack of ice, flooding and sediment inputs to the spawning site. Shepherd (1979) reported assessment programs conducted by hatchery staff in the Nanika spawning areas suggested unusually high egg-to-fry survival.

Some of the marginal sites along the secondary spawning area may dewater along the edges during late spring conditions. Sites used by a small proportion of the spawners downstream of Glacier Creek may be subject to flooding, sediment inputs and severe ice conditions during some years.

3.1.6.5 Predation

Foerster (1968) indicates predation studies on sockeye fry between emergence and lake entry ranged between 63 and 84% during four years of study in Scully Creek in the Lakelse Watershed. We suspect that predation on emerging sockeye fry prior to lake entry may be high from bull trout, coho juveniles, rainbow trout and sculpins, all present in the upper Nanika during fry emergence and from lake trout as they enter Morice Lake.

3.1.7 SOCKEYE ENHANCEMENT

A number of enhancement projects have been directed towards increasing sockeye production in the Nanika River (Cox-Rogers 2000):

- The first program was the construction of the Moricetown fishway to assist migration in 1950. This was followed by the removal of a rock obstruction at Hagwilget Canyon where a major rockslide had been in place since about 1900.
- In 1960, the Nanika River hatchery was built to supplement Nanika production with eggs taken from Pinkut Creek. This hatchery was unsuccessful, probably reflecting the poor choice of donor stock that had evolved to a different emergence time than appropriate for Morice Lake. The hatchery was also poorly situated in the lower Nanika, and the water source was subject to severe ice conditions during some years.
- The Lake Enrichment Program as part of the Salmonid Enhancement Program undertook a program of fertilization of Morice Lake during 1980. Morice Lake was fertilized weekly with additions of ammonium nitrate and ammonium phosphate throughout the growing season. The fertilizer was applied with a DC-6B water bomber (Costella et al. 1982).

Morice Lake responded positively to this fertilization, with a 35% increase in phytoplankton biomass and a 60% increase in zooplankton biomass. Shortreed et al. (2001) consider that Morice Lake, due to its large size and morphometric characteristics and low productivity levels, is an excellent candidate for nutrient additions. Based on modeling exercises they suggest Morice Lake is capable of supporting escapements of over 200,000 sockeye. More detailed follow-up plans for assessing lake productivity and the potential for enrichment are planned for the summer of 2002 (Shortreed, personal communication).

- The potential of creating fish passage past the Nanika Falls and introducing sockeye into the Nanika-Kiprice lakes system has been examined by fisheries engineers but is not presently considered an attractive option (Steve Cox-Rogers, personal communication).

Photo 4. Nanika Falls located just downstream from Kidprice Lake is the upper extent of anadromous fish access in the Morice-Nanika system.

3.1.8 SOCKEYE INFORMATION GAPS

- The potential for nutrient enrichment is an ongoing area for research on the Nanika sockeye stocks. There have been several past studies looking at the background levels in Morice Lake, and the response of the lake to enrichment in 1980. If future enrichment studies are to be undertaken they should be designed to also assess the response of fish populations to fertilizer additions. These studies should include sockeye fry condition factors and distribution within the lake compared to some of the past studies. Size and age of sockeye smolts would also be important. The lake fertilization studies should also assess the response of other Morice Lake fish populations such as rainbow trout and lake trout and should monitor nutrient and periphyton response in the Morice River.

- As part of the assessment program, nose-tagging of sockeye smolts would be helpful in determining timing and exploitation rates.
- Estimates of the significance of sockeye carcass contribution to Morice Lake is important in terms of overall nutrient loading to the lake. Comparisons of inputs during low and high escapement years to Morice Lake would be helpful.
- The importance of sockeye beach spawners to the overall Morice escapement is poorly understood. Because of the depth and poor water clarity that these fish spawn at, detailed studies utilizing diving need to be undertaken to compare the proportion of fish that spawn along the shoreline compared to the Nanika River escapements. The few years that detailed studies have been conducted in the Cabin Creek area and in Atna Lake suggest that beach spawning may be important to the overall Morice escapement, especially during low escapement years in the Nanika River. What is the potential of shoreline spawning areas to accommodate sockeye spawners in Morice Lake? This work might be best done in conjunction with sockeye tagging at the Moricetown fishways.
- Evaluation of the spawner crowding and the effects of redd superimposition, and observation of alternate more marginal spawning areas during years of high escapement would be helpful in determining a realistic escapement target for the Nanika River.

3.2 CHINOOK SALMON

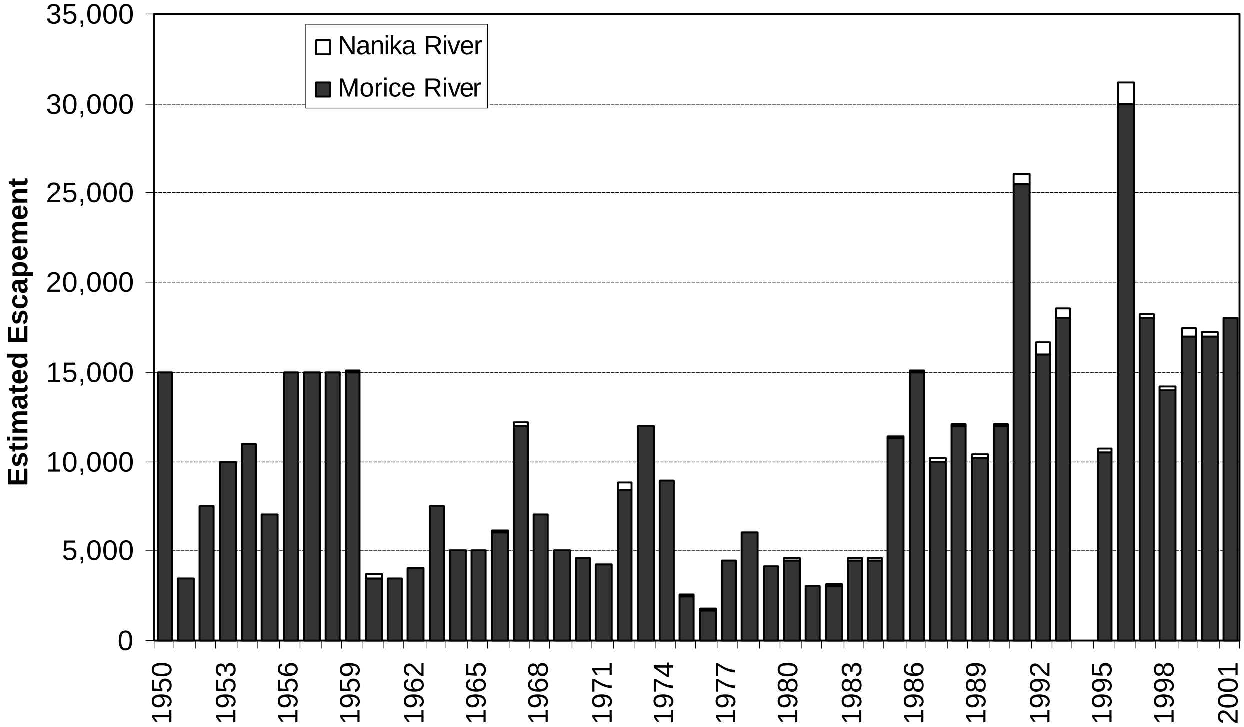
3.2.1 CHINOOK ADULT POPULATION STATUS AND TRENDS

The Morice is one of the three most important chinook rivers in the Skeena Watershed, accounting for an average of 25% (range of 12 to 49%) of Skeena escapements since 1950. During the 1950’s, Morice River chinook escapement varied from 3,500 to 15,000 fish, with returns over 10,000 common (Figure 9). Escapements were depressed during the sixties, seventies, and early eighties, with usually less than 5,000 spawners. Since 1985, chinook escapements have rebounded to some of the highest levels on record, with returns consistently over 10,000 fish, and commonly over 15,000. This trend mirrors a larger pattern in the Skeena as a whole with depressed returns from 1960 to 1985 followed by higher escapements in the last 16 years.

Chinook use of the Nanika River has been recorded consistently since 1975, with only sporadic reports before that. Counts vary from 25 to 1,200 fish with an average of 227.

Morice juvenile chinook were coded wire tagged (CWT) in 1978 and 1979 (Peacock et al. 1996). These pre-Pacific Salmon Treaty data provide a breakdown of the Morice chinook harvest: Alaska commercial fishery 48%, BC troll fishery 26%, BC net fishery 6%, BC tidal sport 12%, and freshwater sport 8%.

Figure 9. Fisheries and Oceans Canada escapement data for chinook salmon in the Morice Watershed[18].



In the Bulkley-Morice sub-unit, chinook salmon are taken in the sport fishery and at the Moricetown food fishery. The Wet'suwet'en have been keeping some catch records since 1930. Chinook retention during this period has ranged from 5,605 (1982) to 88 (1976) (Morrell 1985; Peacock et al. 1996; Walter Joseph, personal communication). Data is available for most years since 1985, and during this period the chinook catch at Moricetown has tended to be in the order of 2000 to 5000 fish.

3.2.2 CHINOOK LIFE HISTORY INFORMATION

Age information describing the Morice River chinook was gathered in 1974 (Shepherd 1979) with additional age information collected during the period 1978 to 1980 (Smith and Berezay 1983). Scale analysis indicated that five ocean and two freshwater age groups were typically present in the chinook population. The samples indicated that most Morice River chinook spawners returned at age 5, followed by age 4 and 6 fish with the Morice population comprised of a higher proportion of age 6 fish compared to other Skeena stocks.

Scale analysis of these fish indicated that although some chinook spent less than one year in freshwater, returning adults were predominantly from juvenile fish that had over-wintered in

[18] 1950-2000 data are from FOC's salmon escapement database (SEDS). 2001 data was obtained from Terry Turnbull, a former FOC officer who conducts the annual Morice chinook counts. 1994 is marked "unknown" in FOC's database, indicating a survey was made this year, but the resulting data was insufficient to make an escapement estimate, due to poor counting conditions, etc.

freshwater prior to ocean entry in three out of four years with age information. Peacock et al. (1996) indicate that the proportion of chinook overwintering in freshwater was underestimated pior to 1980 due to incorrect scale reading, and nearly all Bulkey-Morice chinook overwinter in streams.

Extensive age and growth information for Morice River juvenile and adult chinook salmon is presented in Shepherd (1979), Smith and Berezay (1983) and Envirocon Ltd. (1984).

3.2.3 CHINOOK SPAWNING

3.2.3.1 Timing

Morice River-bound chinook pass through the Tyee Test fishery in the lower Skeena River from May through the first week of July with a peak near the middle of June (Peacock et al. 1996). Chinook salmon migrate into the Morice River from July through late September. The peak of migration past the Alcan counting tower formerly located just downstream from Owen Creek typically occurred during the first two weeks of August (Farina 1982) and adults show up in the top section of the Morice River during late July and early August (Envirocon Ltd. 1984).

Maturing chinook hold in the deep pools in the upper sections of the Morice River and in Morice Lake (Shepherd 1979; Envirocon Ltd. 1984).

Spawning extends from the first week of September to the first week of October, with a peak of spawning typically occurring between September 10 and 25. Some spawning may extend into the end of October. Helicopter counts have been conducted on Morice River chinook salmon since 1961, and considerable effort has gone into developing residence time estimates using these aerial counts to derive total spawner estimates based on spawner residence time on redds (e.g. Neilson and Geen 1981).

3.2.3.2 Spawner Distribution

Nearly all chinook spawning occurs in the main channel of the Morice River between Lamprey Creek and Morice Lake. Chinook spawners also utilize the upper Nanika River from the falls at Kidprice Lake outlet downstream to Glacier Creek. No other significant chinook spawning locations have been identified in the Morice Watershed[19], although a small number of chinook have been recorded spawning during some years downstream from Lamprey Creek and a small number of chinook spawn in the lower 2 kms of the Nanika River during some years (Terry Turnbull, pers. communication). Most chinook spawn in the Nanika at the lower of the three Nanika sites shown in Figure 10, probably reflecting the larger bed material and higher water velocities at this location.

Observations combined for 1978 and 1982 indicate that approximately 63% of the Morice chinook spawned in the upper 4 km section of the Morice River below the lake. Another 21% of

[19] Although chinook juveniles have been located in the lower ends of a number of Morice and Nanika tributaries, we assume these fish move upstream into these tributaries as juveniles during higher flow conditions in the early summer.

the spawners were located between Gosnell Creek and a point 4 km downstream from Morice Lake and 13% spawned between Lamprey and Gosnell creeks[20].

Table 2. Distribution of Morice chinook salmon spawning.

Location	**% of Spawners[21]**
4 km below lake to Morice Lake outlet	63
Gosnell Creek to 4 km below Morice Lake	21
Lamprey Creek to Gosnell Creek	13
Morice River below Lamprey Creek	<1
Upper Nanika River	~2

3.2.3.3 Characteristics of Spawning Areas

Extensive hydrographic studies were conducted during the mid-1970's assessing the physical characteristics of the key spawning area for chinook salmon located 0.5 km downstream from the Morice Lake outlet (Robertson et al. 1979).

A series of cross-sectional surveys were conducted through the key spawning areas over a range of flow conditions. As well, areas of light to heavy spawning activity were mapped, and in conjunction with water velocity and minimum depth criteria[22] were used to develop estimates of the potential capability of the upper river spawning beds to accommodate chinook spawners. Due to the complexity of the sites, the study did not develop a total area of spawning gravel available for chinook spawners in this upper section[23].

This main spawning area is characterized by a series of large gravel dunes generally oriented perpendicular to the direction of flow. The formation of dunes in gravel-bed rivers is uncommon, and it is speculated they have been formed by the combination of heavy salmon spawning activity in conjunction with hydraulic conditions. It was concluded that the dune formations would improve circulation of water through the chinook redds and improve survival rates during the incubation period. This characteristic, in addition to the moderating influence of Morice Lake on both streamflow and water temperatures, creates a very attractive environment for chinook spawning and survival of eggs.

---

[20] Discussions with Terry Turnbull, a contractor who conducts the annual chinook counts indicates that the distribution of chinook spawners is still consistent with these earlier observations, although numbers are significantly higher in recent years compared to the 1981 observations. He has also noted a small number of chinook (<20) spawning in the lower 2 kms of the Nanika during recent flights.

[21] Based on detailed observations collected in 1978 (Smith and Berezay 1983) and in 1982 (Envirocon Ltd. 1984). Nanika River proportion is based on SEDS estimates from 1971-2000.

[22] The spawning studies assumed suitable spawning sites in the upper river were comprised of clean gravels with a minimum nose velocity of 30 cm/sec and a minimum depth of 30 cm. Measurements at redd sites indicated nose velocities could exceed 100 cm/sec at some sites.

[23] Terry Turnbull suggests that, based on his observations during spawner enumeration flights, crowding and redd superimposition may start to occur when chinook numbers exceed 4000 in this upper section.

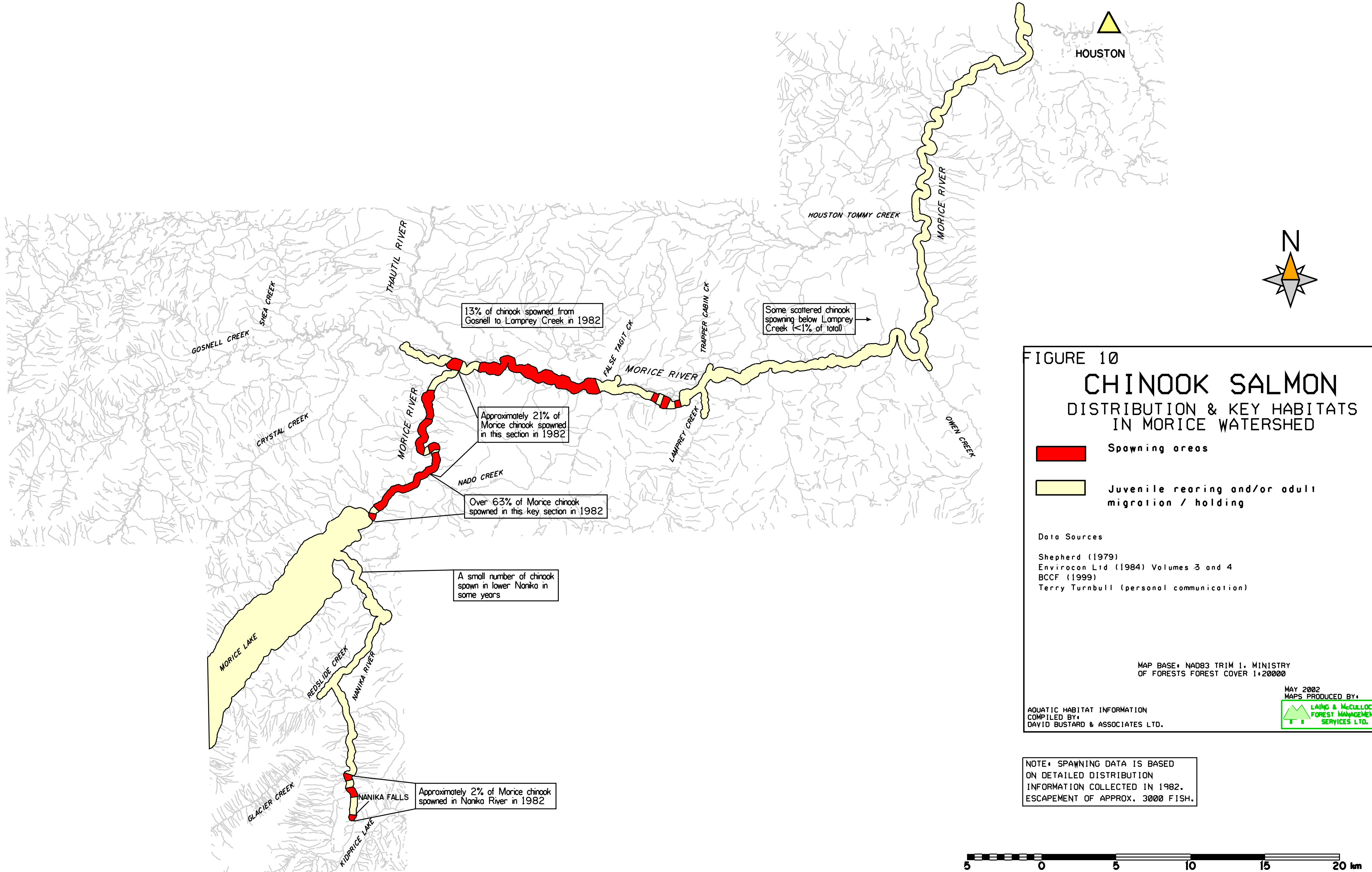

HOUSTON
HOUSTON TOMMY CREEK
MORICE RIVER
THAUTIL RIVER
SHEA CREEK
GOSNELL CREEK
CRYSTAL CREEK
NADO CREEK
FALSE TAGIT CK
TRAPPER CABIN CK
LAMPREY CREEK
OWEN CREEK
MORICE LAKE
REDSLIDE CREEK
NANIKA RIVER
GLACIER CREEK
NANIKA FALLS
KIDPRICE LAKE
13% of chinook spawned from Gosnell to Lamprey Creek in 1982
Some scattered chinook spawning below Lamprey Creek (<1% of total)
Approximately 21% of Morice chinook spawned in this section in 1982
Over 63% of Morice chinook spawned in this key section in 1982
A small number of chinook spawn in lower Nanika in some years
Approximately 2% of Morice chinook spawned in Nanika River in 1982
N
FIGURE 10
CHINOOK SALMON
DISTRIBUTION & KEY HABITATS IN MORICE WATERSHED
Spawning areas
Juvenile rearing and/or adult migration / holding
Data Sources
Shepherd (1979)
Envirocon Ltd (1984) Volumes 3 and 4
BCCF (1999)
Terry Turnbull (personal communication)
MAP BASE: NAD83 TRIM 1. MINISTRY OF FORESTS FOREST COVER 1:20000
MAY 2002
MAPS PRODUCED BY:
LAING & McCULLOCH FOREST MANAGEMENT SERVICES LTD.
AQUATIC HABITAT INFORMATION COMPILED BY: DAVID BUSTARD & ASSOCIATES LTD.
NOTE: SPAWNING DATA IS BASED ON DETAILED DISTRIBUTION INFORMATION COLLECTED IN 1982. ESCAPEMENT OF APPROX. 3000 FISH.
5 0 5 10 15 20 km

Figure 10. Chinook salmon distribution and key habitats in the Morice Watershed.

Photo 5. Chinook salmon “dunes” located in the main chinook spawning area just downstream from Morice Lake during September.

Similar hydrographic surveys were also conducted at two spawning locations in the upper Nanika River approximately 2-3 km downstream from the Kidprice Lake outlet (Robertson et al. 1979). This is the main area utilized by the Nanika chinook salmon. Egg survival rates in the Nanika spawning sites are also assumed to be good despite low late winter flows, as this lake-headed area is not subject to dewatering and freezing during the incubation period.

Chinook spawners utilizing sites below the Morice River dunes tend to spawn in the main channel of the Morice in deeper and faster water than other salmon. Chinook, because of their large size can hold in these fast water areas and move larger bed material.

3.2.4 CHINOOK FRY EMERGENCE

Newly-emerged chinook fry have been observed in the vicinity of redds in the upper Morice as early as March 20. Chinook fry emergence occurs primarily during April and continues into May based on the capture of fry in downstream traps located below the main spawning areas in the upper Morice (Smith and Berezay 1983). Earliest catches coincided with the first increments in river height in the spring. These studies indicated that most emergence starts in early April, peaks about the third week of April and is 90% complete by late April. A major migration of chinook fry occurs shortly after emergence, as fry distribute to downstream rearing areas.

Population estimates of newly-emerged chinook fry in 1979 and 1980 were 1.5 and 3.4 million fry respectively resulting in egg-to-fry survival rates of 12.5% and 23.7% for the two years. These estimates are high compared to a limited amount of egg to fry survival data reported for chinook (Groot and Margolis 1991).

Some chinook fry move up into Morice Lake to rear based on low catches of chinook in beach seine catches at the north end of Morice Lake and trap catches in the upper Morice River (Shepherd 1979).

3.2.5 JUVENILE CHINOOK REARING HABITAT

Extensive studies of chinook fry rearing habitat by season were conducted during the Kemano Completion studies and detailed descriptions of depth, velocity and cover characteristics utilized during the summer period are presented in Envirocon Ltd. (1984) and Shepherd (1979).

These studies indicated that chinook fry occupied shallow marginal areas along the mainstem shortly after emergence, shifted to predominantly side channels during high flows, and were distributed throughout main and side channel habitats by the fall and winter. During the summer period, chinook preferred low velocity habitats and did not display a close association with cover.

Sampling during November indicated that many chinook fry wintered in clean cobble typically greater than 30 cm diameter along the river margin throughout the mainstem Nanika, Morice, Bulkley and presumably Skeena rivers (Photo 6)**.**

Sampling during low-flow periods in the Morice River in April indicated that yearling chinook were present throughout side channel locations studied. Subsequent sampling during May suggested that yearling chinook had left the Morice River as smolts with rising spring flows and that most out-migration had occurred during late April and May[24].

3.2.5.1 Rearing Distribution

Chinook fry rearing occurs almost exclusively in the Nanika, Morice and Bulkley rivers. Density estimates at index sample sites suggest that by the fall, chinook densities tend to increase with distance downstream, and are higher along the Bulkley River than in the Morice (Figure 11). Sampling during these studies was not extended down into the lower Bulkley and Skeena rivers, but we suspect Morice River juvenile chinook distributed downstream into these systems.

Sampling conducted 1979 indicated minor use by chinook in the lower ends of some tributary streams to the Morice River, and it was assumed that these fry moved into the tributaries during the spring freshet and probably accounted for less than 1% of the overall chinook rearing in the Morice (Figure 10). Most observations suggest that these movements do not exceed 1-2 km.

Chinook fry have been found rearing in the lower ends of Owen (Shepherd 1979; Bustard 1992 and 1993), Lamprey Creek (Envirocon Ltd. 1984; Bustard 1992 and 1993; BCCF 1999), Trapper Cabin Creek, Tagit Creek (Envirocon Ltd. 1984), and Gosnell Creek (Shepherd 1979). As well, chinook fry were present in the lower 1.5 kms of Objective and Redslide creeks in the Nanika River (Envirocon Ltd. 1994; BCCF 1999).

---

[24] Fall chinook smolts were also sampled during September in the Morice River. These fish were typically larger than 75 mm fork length (Envirocon Ltd 1984).

Photo 6. Cobble sites with clean interstices such as this site along the mainstem Morice River provide excellent overwintering sites for chinook and steelhead fry.

3.2.6 LIMITING FACTORS TO CHINOOK PRODUCTION

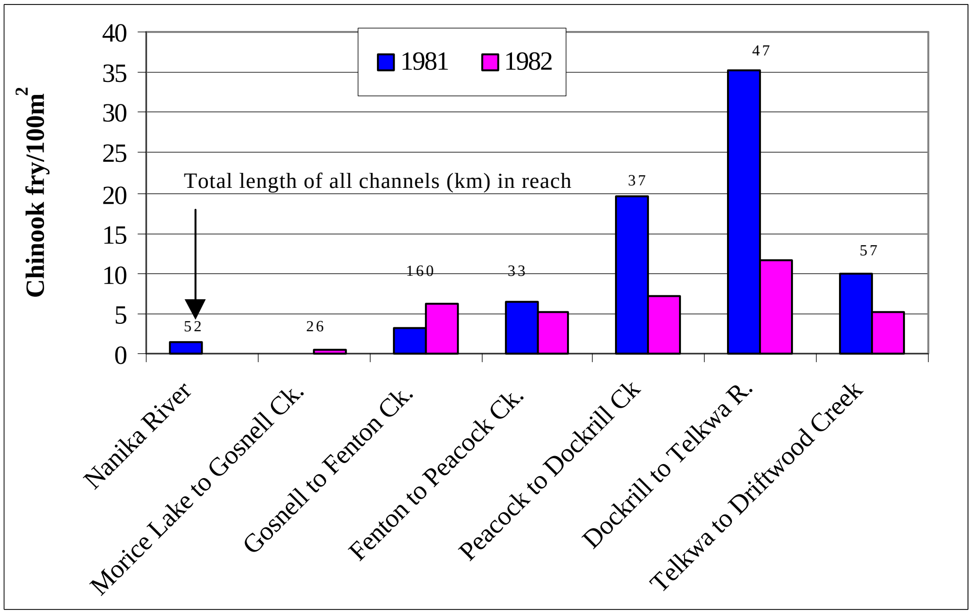
Factors limiting chinook salmon production in the Morice system probably occur during both the spawning and rearing phases.

3.2.6.1 Spawning Limitations

The strong and specific association of chinook spawners for lake-headed spawning locations in the Morice Watershed suggests that these areas provide the most successful incubation environments. Some tributaries such as Owen and Lamprey creeks have inadequate streamflows during the migration period to accommodate chinook during most years.

It is puzzling why some chinook spawners do not use systems such as Shea and lower Gosnell Creek, and possibly the Thautil River. These systems appear large enough to accommodate chinook. Chinook salmon do use smaller tributaries in other Skeena systems such as the Kispiox River.

Figure 11. Density of chinook fry during the fall with distance downstream in the Morice and Bulkley rivers during 1981 and 1982[25].



Floods

A review of literature evaluating chinook salmon survival to emergence typically identifies floods as a major factor leading to poor survival of chinook (Groot and Margolis 1991). While this may be an important factor in some years when there are significant fall floods on the Morice, this probably mainly influences the 15% of the population utilizing the Morice River downstream from the Gosnell-Thautil confluence. The remaining 85% of the chinook are selecting sites moderated from the high flow fluctuations by Morice Lake.

Robertson et al. (1979) report that significant gravel movement in the key spawning areas in the upper Morice River did not occur during freshet events approaching 300 m^3/sec during their studies.

Low Winter Flows and Redd Freezing

This is probably a much more significant factor in the upper Morice during some years. Observations during the low-flow period in the spring (Robertson et al. 1979) indicate that portions of the main spawning section, especially along the margins, become completely exposed at flows less than 13 m^3/sec. Flows can drop to lower levels than this during the spring period, and we suspect that survival of alevins in redds developed in these sites is reduced during years

---

[25] These are the only two years when juvenile fish sampling was conducted from the outlet of Morice Lake downstream to the vicinity of Smithers on the Bulkley River. Juvenile data for other years is incomplete. This information is derived from data presented in Envirocon Ltd. (1984 Appendices B and J).

of lowest flows. Studies have shown that intragravel flows are reduced substantially when the surface of redds are not wetted **(**Photo 7).

Photo 7. Chinook redds in the upper Morice River main spawning area during early May 1982. Intragravel flows are reduced when the surface of redds are not wetted.

Very cold temperatures during the period when redds are exposed could also lead to frost penetration into the redd sites. This is primarily an issue during the spring period, since chinook redds are usually not exposed in the early winter period.

A combination of high flows during the spawning period that pushes spawners more to the river edge, in conjunction with low late winter incubation flows probably leads to poorer chinook egg-to-fry survival in the upper Morice River. These factors would also be important at the main spawning site in the upper Nanika River that is partly located in a shallow edge area.

Redd Superimposition

Chinook spawners in the Morice tend to be very concentrated at those sites offering best potential spawning. Robertson et al. (1979) were unable to calculate a total area available for chinook spawners in the upper river due to the complexity of the hydraulic conditions at the sites.

Since spawning occurs over a period of approximately one month (Neilson and Geen 1981), and the average length of residence on redds declined throughout the spawning period from about 14 days (early in the season) to about 5 days (late in the season), the potential for redd superimposition in Morice chinook is high[26]. Groot and Margolis (1991) present information in their review that clearly shows reduced survival with increased chinook spawner abundance.

Gravel Quantity and Quality

Recruitment of gravel into the key chinook spawning areas at the Morice and Kidprice lake outlets is probably somewhat limited and plays an important role in determining how much gravel is available to spawners utilizing these sites, and its quality over time. The upper Morice gravels are probably mainly recruited from immediate bank erosion in the upper river, while small stream inflows in the upper Nanika may also be important sources of gravel recruitment over time. Robertson et al. (1979) estimated that less than 5 percent of the main Nanika spawning areas are unsuitable for spawning due to accumulated silts.

These spawning sites are only rarely exposed to sediment events where the headwater lakes themselves become turbid and potentially impact the downstream areas. However, logging and road developments in the small watersheds flowing directly into the key spawning areas do have the potential to introduce sediments and reduce the suitability of these key sites.

3.2.6.2 Rearing Limitations

Studies linking chinook production limitations to some aspects of the juvenile rearing phase are rare. Some studies and observations conducted in the Morice River provide insight into potential limitations to chinook production occurring during this phase. These observations suggest that events such as high flows, extreme cold events in the early winter, dewatering leading to stranding during the summer and winter periods and predation probably all can be important sources of mortality during some years.

Flooding – Displacement and Subsequent Stranding

Chinook fry emerge prior to the snowmelt freshet in the Morice River. Observations during the freshet period indicated that newly-emerged chinook fry occupy shallow edge areas, and can be found right up into the seasonally-flooded forest areas. Stranding in small channels and pools was noted as flows receded during studies in 1979 (Envirocon Ltd. 1984). We also assume that many fry are displaced downstream during high flows, and that only some of these fry find suitable rearing sites out of the freshet flows.

We suspect that flood flows during the late fall (e.g. rain-on-snow events during late October and early November) may also impact chinook fry using the spaces in the bed material for cover. At very high flows, high velocities leading to bed material shifting may crush chinook fry.

Freezing and Low-Flow Stranding

During November 1979, a combination of low streamflows, lack of snow cover and very cold temperatures led to the formation of thick ice cover on many of the side channels in the Nanika

[26] Terry Turnbull (personal communication) indicates that when he is counting chinook in the upper Morice River during recent years of high escapements, that spawners appear crowded and the potential for redd superimposition is high.

and Morice rivers, and dead juvenile fish including chinook were noted frozen into the ice or suffocated below the ice cover on these channels (Envirocon Ltd. 1984). Anchor ice formation during the early winter occurs in the lower Morice and Bulkley rivers during extremely cold periods during the early winter prior to ice and snow cover. We suspect this could significantly impact juvenile chinook using cobble areas along the edge of the river.

Studies of overwinter survival of juvenile salmonids in four side channels of the Morice River during 1979 and 1980 indicated a survival rate of approximately 60% for juvenile chinook using these channels between October and the following April. Observations at the side channels during the spring indicated that stranding and freezing of juvenile fish occurred as flows declined through the winter period, and that these factors in conjunction with low dissolved oxygen levels at some of the channels with poor inflows, lead to mortalities. Chinook juveniles tended to leave side channel sites during the winter more readily than other species.

Predation

Predation of juvenile fish along the Morice River margins was noted during most seasons, but was most prevalent in the spring when flows are lowest and fish most concentrated and often isolated into small shallow pools. Mergansers and kingfishers are common predators.

During studies in the Morice, steelhead adults full of newly-emerged chinook fry were captured in the vicinity of chinook redds. We assume that bull trout overwintering in the Morice feed on chinook fry after emergence.

Intra- and Interspecies Competition

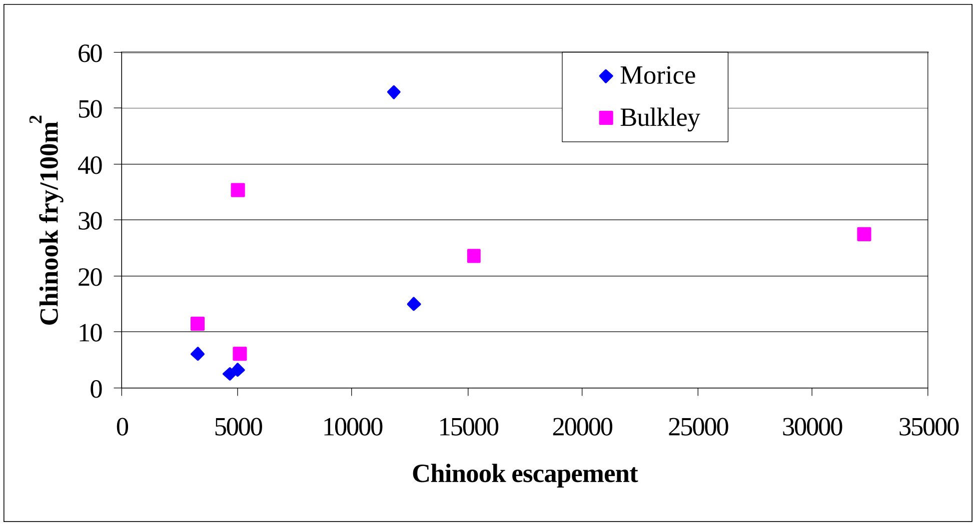
Competition with other species, particularly with young steelhead, may be a limiting factor during some years as chinook and steelhead tend to be found in similar habitats during both the summer and winter periods. Extensive studies by Everest and Chapman (1972) suggest there are small differences in utilization of similar habitats, largely based on size differences that reduce the competition between these two species.

Data derived from juvenile sampling programs during the fall period during a range of studies over the past 25 years in the Bulkley and Morice rivers[27] suggests that chinook fry densities can vary widely between years. For example, in the Bulkley River higher escapements did not necessarily lead to subsequent increases in chinook fry densities by the fall period. It is not known if intraspecific competition at some stage of rearing may play a role in limiting these densities (Figure 12).

In the Morice River, chinook escapements of 5000 or less led to low chinook fry densities compared to escapements exceeding 10000 chinook. The data is limited, but suggests that low chinook escapements may not be adequate to seed the system, and that high escapements lead to higher chinook densities that rarely exceed 40 fry/100m^2. The edge areas along the Bulkley River may be the best habitats for chinook, supporting the highest juvenile densities during low escapement years.

[27] Bulkley River data is for the river section upstream from the Telkwa River to the Walcott area, while the Morice River data is for the section between Owen and Gosnell creeks.

Figure 12. Chinook escapement estimates versus the following year's fry densities in the Morice[28] and Bulkley[29] Rivers.



3.2.7 CHINOOK ENHANCEMENT

The only program for chinook enhancement in the Morice was conducted in the mid-1980's to take eggs from Morice chinook, raise them in the Toboggan Hatchery, and release them as smolts in Toboggan Creek. This program was not successful (Mike O'Neil, personal communication).

The Kemano Completion studies identified several options for mitigation and compensation for chinook salmon. Probably the most significant option was to augment the late winter flows with additional discharge from the proposed dam at the Kidprice Lake outlet to reduce stranding of juveniles in side channels of the Nanika and Morice rivers during the lowest flow period and to provide better incubation flows in the main spawning areas of the Morice River.

3.2.8 CHINOOK INFORMATION GAPS

The studies associated with Kemano Completion have provided a large body of information describing the chinook populations in the Morice and Nanika rivers. A significant development since these studies has been the increased escapements to the system compared to the years when the more intensive studies were undertaken. This leads to an opportunity to build on our understanding of the chinook populations in the Morice watershed. Areas of future studies might include the following:

[28] Morice River data for 1980 (Tredger 1981); 1981 (Envirocon Ltd. 1984); 1982 (Envirocon Ltd.1984); 1986 (Tredger 1986); 1991 (Bustard 1992); 1992 (Bustard 1993).
[29] Bulkley River data for 1981 (Envirocon Ltd 1984); 1982 (Envirocon Ltd. 1984); 1984 (Bustard 1985); 1997 (Bustard et al. 1998); 1999 (Bustard 1999b).

- More detailed delineation of the distribution of chinook spawners during the escapement surveys would be helpful in determining whether the distribution of spawners changes during high escapement years.
- Observations at the spawning sites during years of high escapement could provide information describing spawner densities in these critical habitats and the degree of crowding and redd superimposition that occurs at these sites. This information may help in establishing target escapements for the Morice River.
- More detailed studies to confirm aerial counts of chinook at the high escapements observed would be useful.
- A systematic evaluation of chinook juvenile densities during the fall, and how these relate to spawner abundance would be helpful in establishing what the capabilities of the Morice and Bulkley rivers are to accommodate chinook rearing. Past surveys have focused on other fish species, and have not been systematic in terms of sampling locations to assess chinook abundance after years of low and high escapements.

3.3 COHO SALMON

3.3.1 COHO POPULATION STATUS AND TRENDS

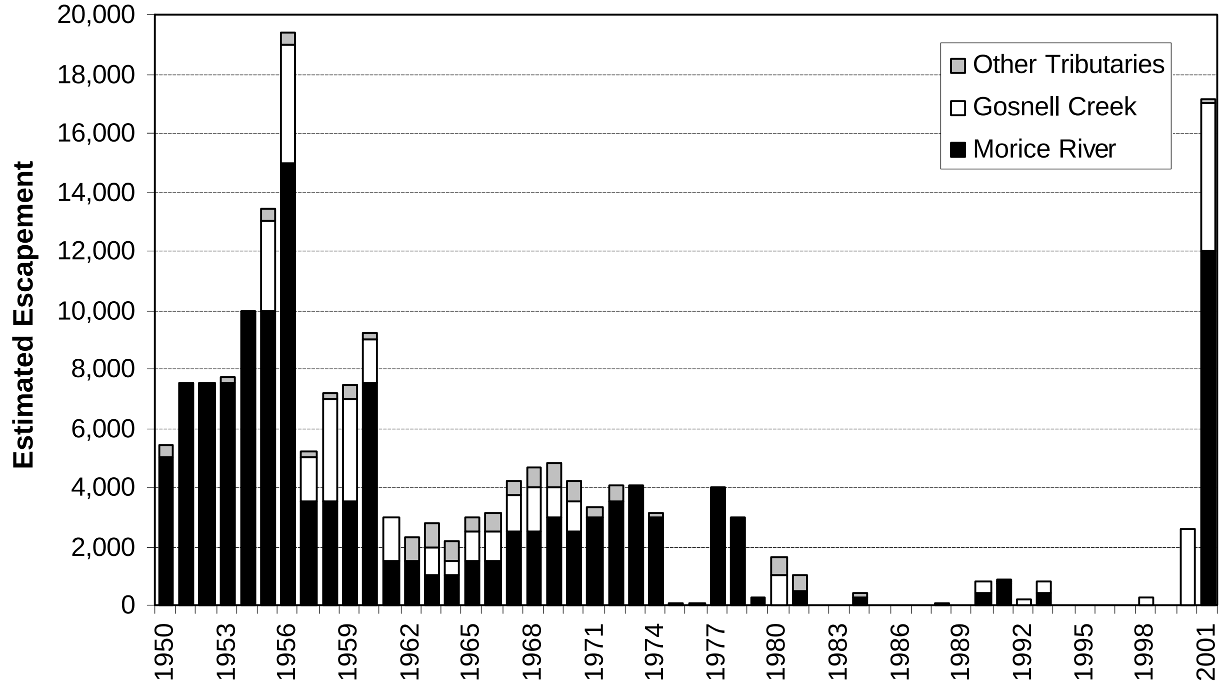
The Morice Watershed coho stock has accounted for an average of 6% (range 0% to 23%) of Skeena runs since 1950. Morice coho returns during the 1950’s were consistently above 3,000 spawners, with a maximum of 15,000 fish in 1956 (Figure 13). During the 1960’s and 1970’s, returns dropped to an average annual count of 1,971 spawners. Escapement numbers fell further to extremely low levels during the 1980’s and 1990’s, with a maximum count of 725 fish in 1991. No coho were observed during the 1988, 1989, and 1992 counts. It should be emphasized that coho salmon are difficult to enumerate effectively due to the long duration of spawning, their widespread distribution within the watershed, and the potential for high flows during the spawning period. Coho spawners are often associated with cover.

The extremely low coho escapements during the 1990’s led to a “coho crisis” and forced FOC to initiate strong conservation measures to protect upper Skeena River coho stocks by curtailing the commercial and sport fisheries. Estimated exploitation rates of Skeena coho were in the order of 65% previous to the conservation measures. Much of this harvest was attributed to the Alaskan troll and net fishery (FOC 1999).

Coho escapements have recovered significantly since the BC commercial fishery was curtailed. Coho mark-recapture estimates have been conducted at Moricetown since 1997 with the following estimates: 1997 - 6500 coho; 1998 - 25104 coho; 1999 - 40702 coho; and 2000 - 19907 coho (Barry Finnigan, personal communication). It is assumed that a high proportion (up to 75%) of these fish eventually spawn in the Morice and tributaries.

Coho spawners have been counted in the Gosnell since 1955, and in most years this tributary accounts for a significant portion of the total Morice returns. Gosnell escapement numbers have followed trends in the Morice and Skeena as a whole, with an average return of 2,833 during the1950’s, 1,109 from 1960-1979, and 447 fish from 1987 to 1995. There are no records for the

Figure 13. Fisheries and Oceans Canada escapement data for coho salmon in the Morice Watershed[30].



Gosnell from 1971 to 1987 (except 1980), and in 1996. The highest escapement for coho since 1959 was observed in 2001, with 5000 coho spawners returning to the Gosnell. Nanika River coho counts have been sporadic except for more consistent counts between 1961 and 1972. Spawner numbers range between 25 and 500 fish.

In the Bulkley-Morice sub-unit there has been no sport fishery for wild coho (since mid-1990's to 2001). Wet'suwet'en records for the dip-net fishery at Moricetown show an average retention of roughly 1500 fish per year prior to 1997 to less than 100 coho per year since then (Morrell 1985; Walter Joseph, personal communication).

3.3.2 COHO LIFE HISTORY INFORMATION

Age information describing Morice River coho was compiled by Shepherd (1979). Morice River coho sampled by beach seining in 1974 were three (75%) and four (25%) year-old fish. The difference in age groups was based on time spent in freshwater, with the three-year-old coho spending one winter in the Morice River. This was comparable to results obtained in the Skeena Test Fishery for other Skeena coho stocks. More recent scale data suggests there may be a

---

[30] Note: SEDS coho escapement data from 1998 onward is not complete due to the difficulty of obtaining reliable estimates in the mainstem Morice Rriver from 1998-2000 (Barry Finnigan, personal communication). The Moricetown mark-recapture data suggests strong runs, especially in 1999. "Other tributaries" includes Lamprey Creek, Morice Lake, Nanika River, Thautil River, Owen Creek, and Atna River.

higher component of coho spending a second winter in freshwater than this earlier information indicates (Tom Pendray, pers. comm. FOC)

The mean size of coho spawners captured at the Morice-Bulkley confluence (69 cm) was also close to that reported in the test fishery on the lower Skeena during the 1974 sampling program (Shepherd 1979).

Considerable age and growth information describing juvenile coho in the Morice Watershed is summarized in Envirocon Ltd. (1984). This data is derived from sampling from May through November throughout the watershed. Additional coho growth information is summarized in Smith and Berezay (1983).

3.3.3 COHO SMOLT SIZE AND TIMING

Morice coho smolts migrate seaward between late April and July (Shepherd 1979). The peak coho smolt movement out of McBride Creek in 1979 occurred from late May to mid-June (Smith and Berezay 1983). Similarly, most coho smolt movement out of Mile 18 Pond (shown as an off-channel pond complex near the mouth of Owen Creek on Figure 14) occurred between June 4 and 20th 1979 (Bustard 1986). Coho smolts were captured in traps in Morice side channels on rising flows in mid-May.

Smolts leaving Mile 18 Pond (Photo 8) averaged 118 and 127 mm fork length for age 1+ and 2+ fish respectively and were approximately 20 mm larger than mainstem coho smolts of comparable ages. Coho smolts leaving McBride Creek were in between these sizes. We suspect that coho rearing in pond type environments achieve a larger size and probably have higher survival rates than mainstem fish. Presumably this reflects the warmer and more productive rearing environment that occurs in the pond and beaver dam habitats.

3.3.4 COHO SPAWNING

3.3.4.1 Timing

Morice-bound coho salmon first arrive at Moricetown Falls in late July, with peak migration during the latter half of August (Palmer 1966). Koski et al. (1995) indicated Morice coho moved at rates averaging 33 km/day as they traveled through the mid-sections of the river. Shepherd (1979) and Farina (1982) indicate that the peak migration of coho into the Morice occurs from the end of August to early September.

The first coho observations at Owen Creek occurred between August 5th and August 28th based on observations from 1956 through 1982 (Farina 1982). Shepherd (1979) indicates the peak of coho spawning based on historical records occurs in mid-October. Envirocon Ltd. (1984) observations indicated coho spawning in side channels of the Morice below Gosnell Creek occurred from mid-October through November with fish still spawning in partially iced-over side channels in late November.

Photo 8. Off-channel habitats such as this wetland complex (Mile 18 Pond) can provide important overwintering areas for Morice coho and produce larger smolts than in the mainstem river. However, poor water quality is an issue at these sites.

Observations in the upper Morice (above Gosnell Creek) suggest that the peak of spawning in the upper section of river takes place in mid- to late November, with some spawning still occurring in the Morice Lake outlet and in the Nanika River during December (Envirocon Ltd. 1984). We suspect the moderating influence of Morice Lake results in warmer incubation temperatures for coho spawning the upper river sections (Figure 4) leading to later spawning in this section compared to downstream areas. Kidprice Lake exerts a similar influence on the Nanika River above Glacier Creek.

3.3.4.2 Distribution of Coho Spawners

The distribution of coho spawners is more widespread than for other salmon species. The depressed spawning populations for most of the past 30 years when the major fisheries inventories have been undertaken means that we have been collecting information based on low escapement years in most of the surveys. However, changes to the commercial fisheries since 1998 has led to some recent high coho escapement years.

The distribution of coho spawners shown in Figure 14 is based on a combination of observations from various data sources. Key information was collected during a very high 2001 escapement summarized in Table 3.

The information indicates that coho spawning occurs throughout the Morice River upstream from Fenton Creek. As well heavy coho spawning was noted in Gosnell Creek especially in the

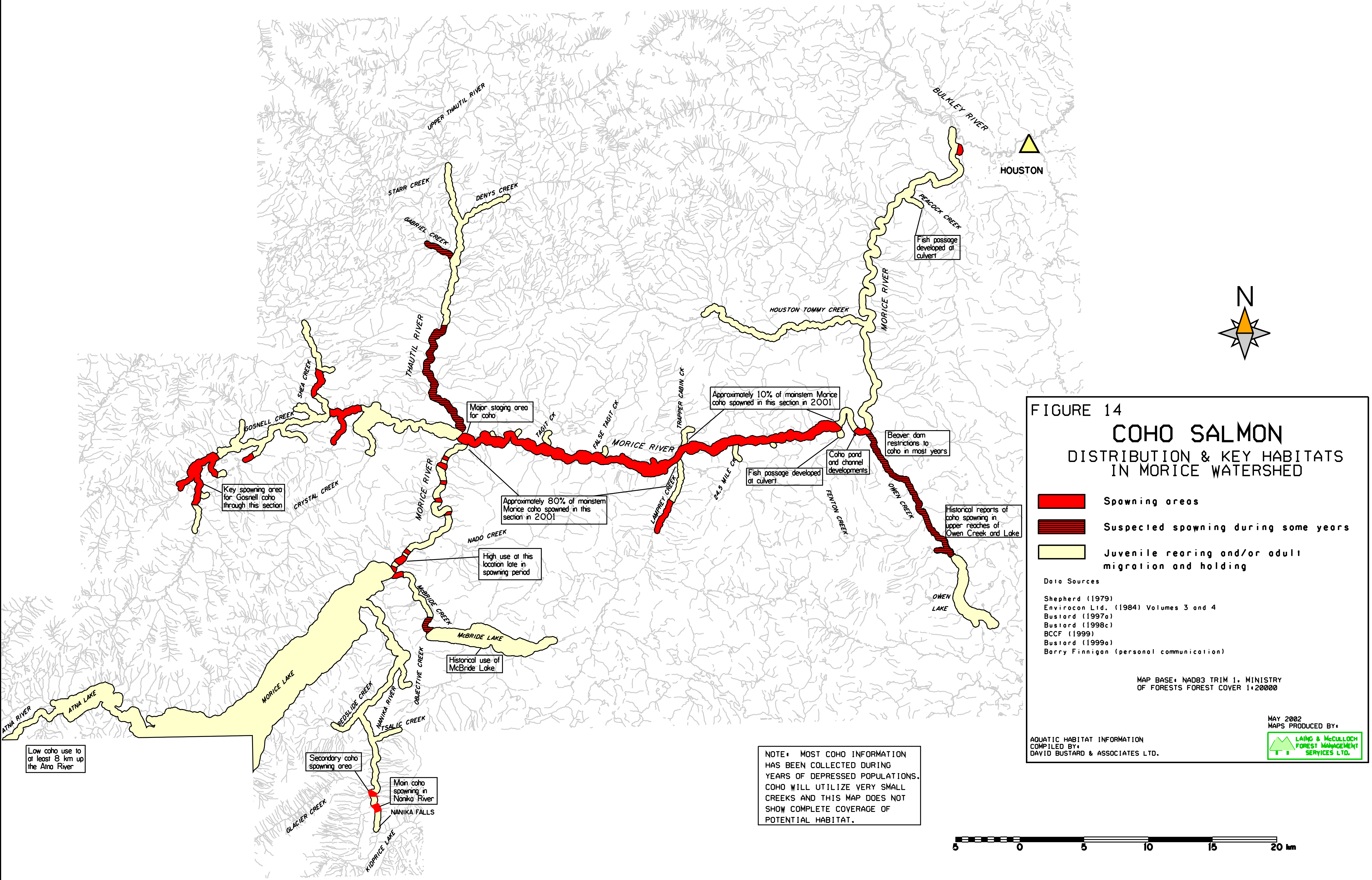


FIGURE 14
COHO SALMON
DISTRIBUTION & KEY HABITATS IN MORICE WATERSHED
Spawning areas
Suspected spawning during some years
Juvenile rearing and/or adult migration and holding
Data Sources
Shepherd (1979)
Envirocon Ltd. (1984) Volumes 3 and 4
Bustard (1997a)
Bustard (1998c)
BCCF (1999)
Bustard (1999a)
Barry Finnigan (personal communication)
MAP BASE: NAD83 TRIM 1. MINISTRY OF FORESTS FOREST COVER 1:20000
MAY 2002
MAPS PRODUCED BY:
LAING & McCULLOCH FOREST MANAGEMENT SERVICES LTD.
AQUATIC HABITAT INFORMATION COMPILED BY: DAVID BUSTARD & ASSOCIATES LTD.
NOTE: MOST COHO INFORMATION HAS BEEN COLLECTED DURING YEARS OF DEPRESSED POPULATIONS. COHO WILL UTILIZE VERY SMALL CREEKS AND THIS MAP DOES NOT SHOW COMPLETE COVERAGE OF POTENTIAL HABITAT.
N
5 0 5 10 15 20 km
HOUSTON
BULKLEY RIVER
PEACOCK CREEK
Fish passage developed at culvert
MORICE RIVER
HOUSTON TOMMY CREEK
UPPER THAUTIL RIVER
STARR CREEK
DENYS CREEK
GABRIEL CREEK
THAUTIL RIVER
Major staging area for coho
TAGIT CK
FALSE TAGIT CK
MORICE RIVER
TRAPPER CABIN CK
Approximately 10% of mainstem Morice coho spawned in this section in 2001
Beaver dam restrictions to coho in most years
Coho pond and channel developments
Fish passage developed at culvert
24.5 MILE CK
FENTON CREEK
OWEN CREEK
Historical reports of coho spawning in upper reaches of Owen Creek and Lake
OWEN LAKE
LAMPREY CREEK
Approximately 80% of mainstem Morice coho spawned in this section in 2001
SHEA CREEK
GOSNELL CREEK
Key spawning area for Gosnell coho through this section
CRYSTAL CREEK
MORICE RIVER
NADO CREEK
High use at this location late in spawning period
McBRIDE CREEK
McBRIDE LAKE
Historical use of McBride Lake
MORICE LAKE
ATNA LAKE
ATNA RIVER
Low coho use to at least 8 km up the Atna River
REDSLIDE CREEK
NANIKA RIVER
OBJECTIVE CREEK
TSALIC CREEK
Secondary coho spawning area
Main coho spawning in Nanika River
NANIKA FALLS
GLACIER CREEK
KIDPRICE LAKE

Figure 14. Coho salmon distribution and key habitats in the Morice Watershed.

mainstem section approximately 10 km upstream from Shea Creek and in several key Gosnell tributaries (Photo 9).

Table 3. Distribution of coho spawners in the Morice River based on observations in 2001[31].

Location	Number Observed	%
Morice Lake to Gosnell Creek	1200	10
Gosnell to Lamprey Creek	9600	80
Lamprey to Fenton Creek	1200	10
Fenton to Bulkley confluence		<1%
Total Morice Observations	12000	
Gosnell	5000	
Nanika	100	
Owen	25	

Smaller numbers of coho spawners were observed in the upper Nanika and in lower Owen Creek. Past observations have indicated coho spawning also occurs during some years in McBride and Lamprey creeks, upper Houston Tommy, and in the Thautil River. We suspect that coho spawning also occurs in the lower ends of smaller tributaries not shown on the distribution map during some years when high flows combine with good escapements. Beaver dams on tributaries such as Owen, Lamprey, McBride and some Gosnell tributaries restrict coho spawner access during most years.

It should be emphasized that many of the stream assessments during the past three decades have been conducted during years of poor coho escapements and the results probably do not reflect the potential of many of the smaller streams for coho production. As well, observers often tend to not record specific spawning locations, making mapping of the spawning locations difficult.

The 2001 spawning data (Table 3 and Figure 14) suggest that the section of the Morice River from Gosnell to Lamprey creek and the mainstem Gosnell above Shea Creek are the core coho spawning habitats in the Morice. Side channel areas in particular were used extensively in the mainstem reach. Long-term observations conducted during the Alcan tower counts[32] suggest that during years with good fall freshets and access into tributaries, most coho will use the tributaries. When autumn flows are low, mainstem spawning predominates.

[31] Data provided by Barry Finnigan, Stock Assessment, FOC.

[32] R. Estabrooks, Alcan fish counting tower crew, quoted in Envirocon Ltd. (1984).

Photo 9. Coho salmon spawn and rear in small creeks such as this Gosnell tributary.

3.3.4.3 Characteristics of Coho Spawning Areas

There have not been specific measurements of the physical characteristics of coho spawning areas in the Morice Watershed. Coho utilize the key spawning sites at the outlet of Morice Lake and in the Nanika, and the characteristics of these locations have been described for sockeye and chinook. Since spawning is later, the flow characteristics would be somewhat different than during the September period, with velocities and depths lower than for the other species.

Specific observations suggest that side channel areas in the mainstem Morice are important, and anecdotal information presented in Envirocon Ltd. (1984) suggested coho were spawning in the vicinity of groundwater upwelling in the side channels. Generally coho will push far enough upstream in the tributaries so that emerging fry can take advantage of good rearing areas associated with beaver ponds and wetlands, although these rearing areas are often not accessible during the spawning period.

3.3.5 COHO FRY EMERGENCE

Coho fry emergence begins in mid-May, peaks in June and continues into early July. Shortly after emergence, coho fry re-distribute downstream in spawning tributaries and along the mainstem river, and move into the lower ends of accessible tributaries and pond areas.

For example, trapping studies at a small off-channel pond in the Morice River just upstream from Owen Creek indicated that peak immigration of newly-emerged coho fry occurred into the pond complex between June 1 and 10th (Bustard 1986).

3.3.6 JUVENILE COHO REARING HABITAT

Detailed studies describing the habitat preferences of juvenile coho were undertaken by Envirocon Ltd. (1984) as well as by Shepherd (1979). The studies indicated high use of side channel areas by coho throughout the summer and fall period, with estimates of over 80% of the coho utilizing side channels compared to mainstem habitats.

During the active rearing period coho fry were most commonly captured in low velocity areas (<15 cm/sec) and at depths greater than 15 cm. Areas such as side-pools, ponds, pool habitat in side channels and flats along the channel margin and log jams were commonly used. Coho fry were usually associated with some form of cover such as debris, root wads and vegetation. Yearling coho tended to be in deeper areas than fry and made greater use of log jams.

Coho fry and yearling move down along the edge of the mainstem river and into the lower ends of tributary streams. The high-flow period is a time of major migrations of juveniles into habitats that may not have been colonized by spawners. Juveniles are able to penetrate past beaver dams during the spring and colonize ponds and small lakes that can provide productive rearing environments. For example, juvenile coho are often found in McBride Creek right up to McBride Lake, despite the inability of adult spawners to access this far up in the system in most years.

Although, the Morice River and Gosnell Creek floodplains have an abundance of ponded habitats utilized by coho, only some of these provide suitable habitat year-round. Beaver-ponded creeks such as McBride and Owen provide excellent year-round habitat for coho if they are able to access these habitats. Shepherd (1979) rated these two systems as the top potential coho tributaries in the Morice based on habitat suitability.

3.3.6.1 Rearing Distribution

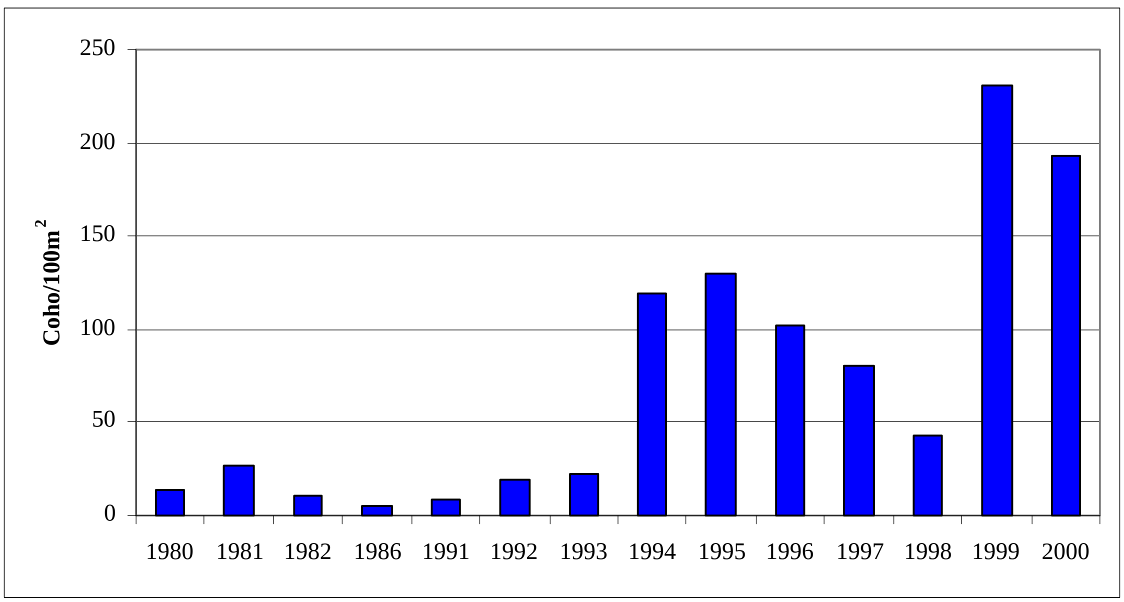
The distribution of coho rearing in the Morice Watershed is outlined in Figure 14. This map includes tributaries where rearing coho have been sampled during a variety of programs conducted in the Morice and based on historical and anecdotal information. For example, coho have been documented to Owen Lake up until the early 1970's (Shepherd 1979) and juveniles have been sampled in McBride Lake (Envirocon Ltd. 1984), although recent use is reduced.

Historical data indicates that coho densities in tributaries used to be higher than during inventories in the 1990's. For example, in the Thautil River, Taylor and Seredick (1968) and Carswell (1979) indicated coho were the dominant species in samples in the mainstem Thautil and Gabriel creeks. During extensive sampling in 1996 (Bustard 1997a) coho comprised less than 1% of the catch at these sites, emphasizing the decline during this period. With this in mind, the distribution of coho shown in Figure 14 should be considered as incomplete. Many small channels accessible from the mainstem creeks may be utilized by rearing coho during some years, especially given the increased escapements that have been occurring in recent years.

In an inventory of the Gosnell Creek drainage (Bustard 1999a), juvenile coho were captured at 34 of 302 locations examined. Stream gradients at the coho sites ranged from 0 to 8% (mean 2.4%). The narrowest channel width in streams used by coho in Gosnell Creek was just over 1 m.

Figure 15 presents a summary of coho rearing densities in Morice River side channels since the 1980's based on a variety of sources. The data suggests that for most years, the side channel habitats of the Morice River have been well below their capability to support juvenile coho. Estimates conducted since 1999 suggest far better seeding of coho fry in the side channels.

Figure 15. Summary of coho juvenile densities in Morice River side channel habitats over time[33].



It should be emphasized that fry densities are not the best measure of the potential productivity from these areas, and that total smolt output would better reflect the system's capability. The late summer and early fall measurements summarized in Figure 15 do indicate far better seeding of fry in the habitats, but these estimates are for fish that have not been subjected to fall and spring freshets and overwinter mortalities. As well, it is difficult to effectively sample the deep debris-covered sites typically used by juvenile coho.

Envirocon Ltd. (1984) conducted a crude estimate of coho production using a combination of channel length corrected for coho densities to estimate where most of the coho production in the Morice Watershed was occurring. These estimates suggested that most coho rearing (two-thirds) occurred in tributaries, with Gosnell Creek accounting for 50% of the coho rearing in tributary streams. McBride and Houston Tommy were identified as significant coho rearing streams

[33] Data for this figure has been compiled from a variety of sources and it should be recognized that there are some differences in sampling methodologies and locations for various years. Sources for data are as follows: 1980 (Tredger (1981); 1981 and 1982 (Envirocon Ltd 1984); 1986 (Tredger 1986); 1991 and 1992 (Bustard 1992 and 1993); 1993 onward – data files FOC provided by Barry Finnegan.

based on the 1979 catches[34]. Most of the coho rearing in the Morice River was estimated to occur in the extensive side channel section extending from Gosnell Creek down to Fenton Creek.

It should be emphasized that these estimates are rough, and that sampling efficiency of coho in smaller streams is better than in channels in large rivers such as the Morice River and that this work was done during a period of low coho abundance throughout the watershed.

It should also be recognized that a portion of the coho fry produced in the Morice spawning areas disperse downstream and probably rear in the Bulkley River and move into the lower sections of Bulkley tributaries.

3.3.7 LIMITING FACTORS TO COHO PRODUCTION

3.3.7.1 Spawning Limitations

Adequate escapements

Clearly the lack of adequate spawner recruitment to the Morice River and tributaries has been a major limitation to coho production in the system. The combination of poor ocean survival coinciding with high exploitation in both the Alaskan and B.C. commercial fisheries has led to severely depressed populations for much of the past 30 years (Holtby and Finnegan, 1997). The increasing abundance of juveniles resulting from increased escapements in the past few years (**Figure 13**) is clear evidence of significantly higher seeding, and the high capability of habitats in side channels of the Morice River to support coho juveniles during the late summer/fall period when escapements are higher.

Future efforts to sustain coho populations in the Morice are dependant upon a fisheries management program that continues to address the escapement issues through management of the B.C. commercial fisheries and cooperation with the Alaskan fisheries to reduce exploitation rates on Morice-bound coho salmon. These programs will have to be undertaken in cooperation with native fisheries in the Bulkley and the continued management of the sport fishery, to ensure adequate escapements.

Amount and Suitability of Spawning Habitat

Coho spawning is well-dispersed throughout the watershed, and tends to be focused in stream reaches that have significant potential spawning sites with suitable bed material, depths and velocities for coho spawning. Observations during the spawning period, even during the high numbers observed in side channels of the Morice in 2001, do not suggest over-crowding of coho is occurring in key spawning habitats[35]. We suggest that availability of suitable spawning sites in the accessible sections of tributaries is probably not a limiting factor for coho.

[34] This sampling was conducted following extremely high flow events during late October 1978 that enabled coho to penetrate well upstream in Morice tributaries including unusually high densities of coho in McBride Creek. These estimates did not include the Nanika River and tributaries.
[35] B. Finnigan, coho stock assessment biologist, FOC (personal communication).

Accessibility of Potential Spawning Areas

Many of the best potential coho spawning and rearing habitats in Morice tributaries are not accessible to spawners due to the combination of low fall flows and beaver dams. Some of the most outstanding potential coho habitat in the Morice Watershed occurs in systems such as McBride, Owen and Lamprey creeks that are simply not accessible to fall spawners during most years. Seeding of tributary streams is most successful if adult spawners can access areas upstream from good rearing habitats, allowing fry to disperse downstream.

Gottesfeld et al. (2002) present hydrological data for interior watersheds such as the nearby upper Bulkley River suggesting a trend of declining late summer and fall low-flow conditions. These conditions restrict adult coho distribution in smaller streams.

Floods and Redd Scour

Floods, often due to rain-on-snow events in late October and early November assist coho to penetrate further upstream into potential spawning sites. However, late fall freshets may also lead to some redd scouring during some years.

3.3.7.2 Rearing Limitations

Morice coho spend one or two winters in freshwater prior to migrating to the ocean as smolts. Assuming reasonable escapements, we suspect population regulation occurs during the rearing phase. A combination of density-dependant factors during the active rearing phase, and environmental extremes during all rearing phases probably limits smolt output.

Summer Rearing

Coho fry emerge during the spring snowmelt freshet, and the newly-emerged fry disperse downstream from spawning locations in the Morice and tributaries seeking suitable rearing habitat out of cold and high velocity mainstem habitat. Fry seek rearing habitat in areas such as side channels buffered from high flows, alcoves and the lower ends of smaller tributaries and associated ponds and sloughs. Coho fry can achieve quite high densities in these preferred habitats, maintain territories, and directly compete with each other for available food resources. Data collected in the Morice tributaries during some years indicate coho fry can exceed densities of 3 fry/m^2 at some sites during years of high recruitment[36].

Of all of the salmon species, coho rely most on small tributaries for rearing. While these habitats may be very productive during the early summer season providing conditions with higher temperatures and greater food abundance, coho utilizing these habitats run the risk of becoming stranded on declining flows, or subject to unsuitable late summer rearing conditions of high water temperatures and low dissolved oxygen.

The accessibility of these small streams during the early summer determines coho distribution in non-spawning streams. As well, weather conditions during the late summer determine late summer flows and temperatures, directly affecting the suitability of many of the coho rearing habitats. These factors directly influence the abundance of juveniles entering the winter period.

---

[36] Data files for juvenile coho sampling provided by Barry Finnigan, stock assessment biologist, FOC.

Overwinter Rearing

Overwintering studies conducted in four side channels of the Morice River in 1981-82 indicated an average 52% survival rate for coho juveniles (Envirocon Ltd. 1984). This was higher than for steelhead, probably reflecting coho use of deeper pool habitats with complex debris cover. Mortalities in the side channels resulted from dewatering as flows declined during the late winter low-flow period, poor water quality conditions due to minimal flows, and predation as ice cover on the channels melted during the spring.

Sampling during the early winter in the Morice also indicated that coho catches in adjacent ponded habitats were an order of magnitude higher than in the main river, indicative of the importance of off-channel and beaver pond habitats for coho. Follow-up monitoring in off-channel habitats indicates that only some of these areas provide suitable conditions throughout the winter, and that this can vary depending upon the winter. Low dissolved oxygen levels in some of these sites leads to conditions unsuitable for overwintering coho (e.g., Bustard 1996).

Recent studies conducted on several Oregon streams (Solazzi et al. 2000) provide the strongest evidence to date that overwintering habitat limits production in many coho salmon streams. These studies measured smolt output and compared the results to reference streams, as well as provided *before* and *after* treatment measurements. The work demonstrated that increasing the amount of damed pools, alcoves and ponded habitat in small stream basins increased coho smolt output by up to 300%. The researchers involved in this study, along with other studies with less rigid controls, have concluded that coho production in most small coho streams is limited by suitable overwinter rearing habitat.

3.3.8 COHO ENHANCEMENT AND RESTORATION

Several pilot enhancement projects have been undertaken in the Morice Watershed directed towards developing off-channel coho rearing habitat.

- In 1992 a small inlet creek was re-directed into newly-constructed pond habitat linked to the Mile 18 Pond just upstream from Owen Creek (Figure 14). The objective was to increase the amount of off-channel overwinter habitat for Morice coho. Although coho fry moved into the pond complex, subsequent monitoring the following two springs indicate that fish were not surviving the winter in the ponds. We suspect the pond complex was too large for the available water supply to maintain adequate water quality conditions through the winter period.
- An old channel was reactivated at the lower end of Owen Creek during the mid-1990’s. Again, lack of adequate winter flows appeared to limit the potential for this site to overwinter coho.
- Several efforts to conduct coho outplanting have been undertaken during the past decade. In the early 1990’s eggs were collected from Gosnell coho and raised in the Kitimat hatchery and outplanted as smolts. There was little indication of returning adults from this program (Mike O’Neil, Toboggan Creek Hatchery, personal communication).

- More recently, fed fry raised at the Toboggan Creek hatchery from Morice coho were released into Owen Lake in 1999 and 2000[37]. Returns from the first group of fry released appear very positive based on catches in the Alaskan fishery possibly reflecting a positive response to the release into a lake environment (Don Bailey, FOC, pers. comm.).

3.3.9 COHO HABITAT PROTECTION

In our opinion, commercial over-fishing far outweighs coho habitat issues in the Morice Watershed. Most of the coho habitat in the Morice River and tributaries is essentially intact and capable of much higher potential production given adequate escapements, as the past few years have demonstrated.

Coho salmon have a widespread distribution in the Morice Watershed and often use smaller streams than the other salmon species. Some tributaries as small as 1 m wide are used by coho. Habitat protection, particularly related to roads and logging, are important issues for this species.

Habitat protection issues include the following:

- Many of the stream inventories that were conducted in the Morice during the past three decades have been undertaken during a period of severely depressed coho abundance. Coho rearing streams may not have been identified in these inventories and their distribution can change depending upon fall streamflows and spawner abundance.
- Road crossing structures are crucial in coho habitat. Much of the re-distribution of coho in non-spawning streams and off-channel ponds occurs during the high-flow period from May through early July. Newly-emerged coho fry and yearlings have limited ability to move upstream through road culverts.
- Riparian management is very important for coho, a species closely associated with debris cover. The floodplains of the Morice and Nanika rivers and Gosnell Creek are particularly important for coho rearing.
- Rate-of-cut, sediment and temperature issues related to forest development can have significant affects on the small stream and pond habitat utilized by coho, especially during the low-flow periods.

3.3.10 COHO INFORMATION GAPS

The severely depressed status of the Morice coho stocks has been partially responsible for the actions instigated by Fisheries and Oceans to protect Skeena River coho stocks, resulting in drastic cuts to the commercial and sport fisheries starting in 1998. The slow recognition of the depressed stock status partially reflects the lack of good long-term indices for coho stocks in the Morice, and highlights the importance of developing reliable stock assessment indicators, ideally on a tributary-specific basis. The Tyee Test Fishery has been operating since 1956, and in conjunction with coho counts at Babine and Toboggan Creek and fishery officer counts, provided stock status information for upper river coho stocks (Holtby and Finnegan 1997).

---

[37] Approximately 12,700 marked fry were released in 1999 and 30,000 fry (24,000 marked) in 2000. These fry were nose-tagged and fin-clipped. Tag return estimates based on the Alaska commercial and sport fishery suggest these fry had a 0.95% marine survival, higher than concurrent releases in both the Babine and upper Bulkley rivers.

Changes have been underway since the mid-1990's to improve both adult and juvenile indices for coho. For example, juvenile coho index sampling is conducted annually in the Morice River and selected tributaries (e.g., Taylor et al. 1994 to 2001) and adult escapement estimates have been collected in a more rigorous and consistent fashion than in the past, providing more reliable information. The mark-recapture program conducted at Moricetown provides an important estimate of coho escapements in the Morice and Bulkley system.

It is imperative that reliable adult and juvenile monitoring programs be developed, tested and supported in the management of Morice coho stocks. Considerable effort is required to effectively undertake this work, but the consequences of not doing it mean curtailment of commercial, sport, and native fisheries due to lack of information and management strategies.

The following issues are identified as data gaps limiting effective management strategies.

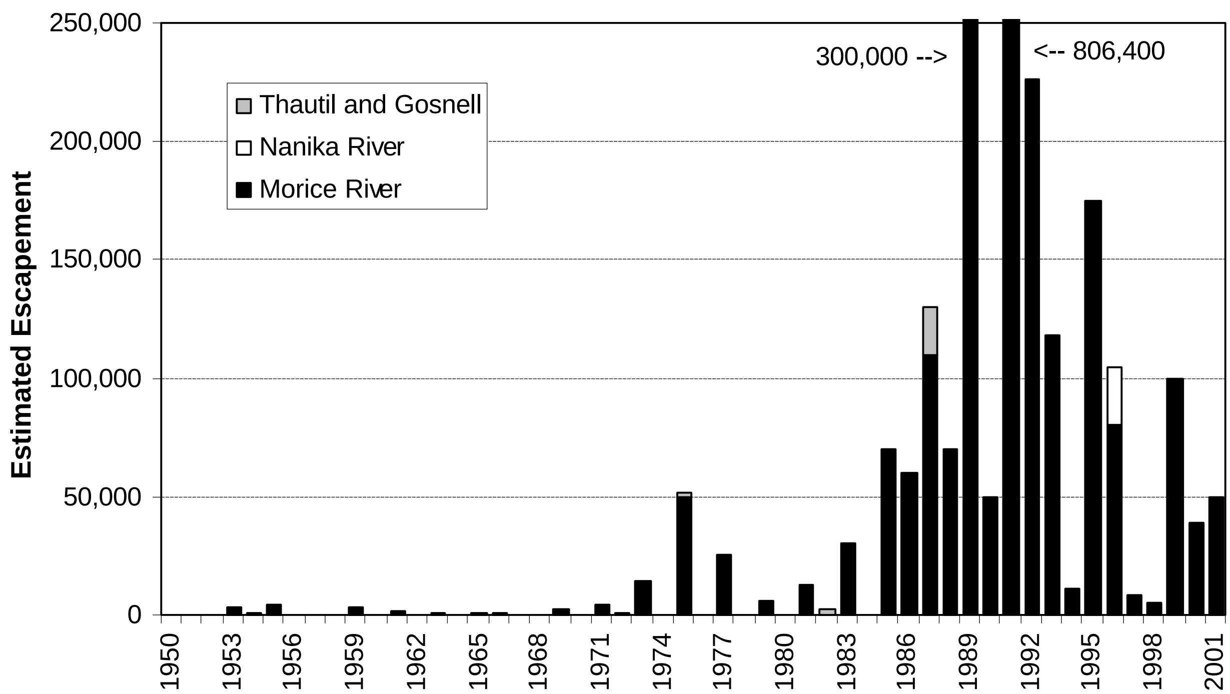
- There is a limited current capacity for stock specific abundance estimates in-season.
- Evauating the utility and methodology of the juvenile index program to determine whether enough sites are being sampled and whether methodologies are giving accurate assessments should be considered.
- In conjunction with the above strategy we suggest the development of a better understanding of carrying capacity of Morice coho tributaries is fundamental to management programs. Determining the seeding requirements for the Morice to sustain maximum smolt yields from the system is needed. What are the target escapements that can achieve this seeding? In order to understand some of these issues, developing a program to assess escapements into a smaller Morice tributary (e.g. in the Gosnell Watershed), measuring juvenile populations during the late summer, and measuring eventual smolt output over a range of escapements would be helpful. This kind of information is needed in a small northern interior wild coho population.
- Outplanting of coho to some of the high potential but under-utilized habitats in the Morice may be a valid stategy in some locations. For example, habitats with high potential for coho rearing such as Owen and McBride creeks are significantly under-utilized by coho. Initial indications from a pilot project in Owen suggest fry plantings in lakes may be effective. Follow-up evaluations, in conjunction with establishing adult access into these systems, needs to be part of a re-building program for Morice coho. Such a program raises concerns in terms of how to mark fry to assess effectiveness. As well, the implications of such a program to steelhead rearing in a system such as Owen Creek would need to be part of the evaluation.
- Overwinter habitat use and mortality factors in the Morice are poorly understood. Studies elsewhere suggest this is an important area to address if population dynamics and habitat requirements are to be fully understood. A full evaluation of off-channel migrations, survival, limitations and potential for development of these habitats over a range of conditions and years would be helpful.

3.4 PINK SALMON

3.4.1 PINK SALMON POPULATION STATUS AND TRENDS

Pink salmon were first observed in the Morice River in 1953. Numbers of spawning pinks observed in the Morice remained low (>5,000) until the mid-seventies when some modest (10,000-50,000) runs were noted (Figure 16). From the mid-eighties to the mid-nineties escapements were higher and more consistent - usually over 50,000 fish, and often over 100,000. 1991 is a particularly noteworthy year, with over 800,000 pinks in the Morice River. Since 1993, pink numbers in the Morice have been somewhat lower then the previous decade average, ranging from 5,000 to 175,000 spawners annually. Since 1985, Morice pinks have made up an average of 9% (range of 2% - 28%) of the Skeena pink escapements.

Figure 16. Fisheries and Oceans Canada escapement data for pink salmon in the Morice Watershed[38].



Pinks have been reported infrequently in the Nanika River with escapements ranging from less than 200 fish in 1986 and 1993 to over 25,000 fish in 1996, representing 24% of the total Morice escapement that year.

Pink salmon estimates in the Gosnell have been sporadic, ranging from no fish in some years to a few thousand fish annually. The largest run was recorded in 1987, with 15,000 pinks in the

[38] 1950-1999 data are from FOC's SEDS database. 2000 and 2001 data were obtained from Terry Turnbull, a contractor, who conducts pink counts in conjunction with chinook escapement estimates.

Gosnell and an additional 5,000 in the Thautil, the only record for this system. These tributaries are not surveyed during most years.

Pink are not generally perceived to be a desirable food fish and the Wet'suwet'en food fishery at the Moricetown Canyon does not target pink. However, the large escapements in the last 15 years have resulted in an average harvest of 3000-4000 pinks per year. In 1992, over 75,000 pinks were taken at Moricetown (Morrell et al. 1985; Walter Joseph, personal communciation).

Since the mid-1990's anglers have been allowed to catch two pinks per day in the Bulkley and the lower 2 kms of the Morice River.

3.4.2 PINK SALMON AGE AND SIZE INFORMATION

There is no pink salmon size information specific to the Morice River. Shepherd (1979) indicated that Morice pink salmon were probably similar to other Skeena sub-stocks with an average length ranging from 48 to 54 cm with all adults returning in their second year after approximately 18 months in the ocean.

3.4.3 PINK SALMON DISTRIBUTION

The Moricetown fishways were installed as an aid to salmon migration in 1950 (Cox-Roger 2000). This enabled pink salmon to colonize previously inaccessible areas upstream in the Bulkley and Morice rivers above Moricetown.

Pinks salmon spawners were first reported in the Morice River above the Bulkley confluence in 1953, were observed as far upstream as Owen Creek by 1961, and were observed for the first time in Gosnell Creek and in the upper Morice River by 1975 (Shepherd 1979).

Pink salmon were noted for the first time in the Nanika River in 1986 (FOC 2001). The Nanika River has potential for more use by pinks, but we suspect that pink salmon migration limits pink use of the Nanika River. Shepherd (1979) indicates that there are no major stocks of pink salmon above lakes in BC.

Pink salmon spawners have been observed during some years in Gosnell and lower Shea creeks (Bustard 1999a; Barry Finnigan, FOC, personal communication), the lower Thautil River, lower Owen Creek (Bustard 1998c), and lower Houston Tommy Creek (T. Turnbull, personal communication).

The most detailed distribution information outlining pink salmon spawning locations in the Morice River was collected in conjunction with the Kemano Completion studies during 1979 and 1981 (Envirocon 1984). Spawner distribution for these years was recorded on air photos and later mapped at a 1:50,000 scale and used in the preparation of Figure 17.

It should be emphasized that this information was collected during two years of modest escapement with an expanding population. Since these studies were undertaken, pink salmon numbers have exploded by ten-fold or more[39]. However, because of the detailed recording of

---

[39] Discussions with Terry Turnbull, a former fisheries officer and now a contractor who conducts the annual escapement counts of pink salmon in the Morice indicate that although the numbers of pinks have increased substantially since these earlier studies, the general distribution of pinks in the system has not changed significantly. He notes most spawning occurs in side channels and along the mainstem Morice River margins with just scattered

this information, these early studies are helpful in their description of both the locations and characteristics of key spawning habitats utilized by Morice River pink salmon.

Most pink salmon spawning occurs in the section of river from Lamprey to Gosnell creek (Table 4). Most of the spawners observed during these two surveys used this section of river. The second key area was the river section between Fenton and Lamprey creeks.

These two reaches are characterized by extensive side channel development. Approximately 75% of the pink spawners were using side channel locations[40]. During the two years of detailed observations, it was noted that pink salmon spawned in many of the same channels in both years despite significant differences in discharge between years (Envirocon 1984).

Table 4. Distribution of pink salmon spawners by reach in the Morice River.

Reach	Location	% of Spawners
1	Gosnell to Morice Lk.	2
2a	Lamprey to Gosnell	66
2b	Fenton to Lamprey	27
3	Peacock to Fenton	1
4	Dockrill to Peacock	3
Tribs	Gosnell etc.	1

spawning in the mainstem Morice upstream from Gosnell Creek. He estimates 90% of the Morice pink spawning occurs in this key section during most years.

[40] Data derived from counts reported in Envirocon Ltd. (1984). We are normally not able to separate out channel types used by spawners, but the pink salmon surveys conducted in 1979 and 1981 involved flying all side channels and mainstem habitats large enough to be used by pinks and recording specific locations, allowing for this separation.

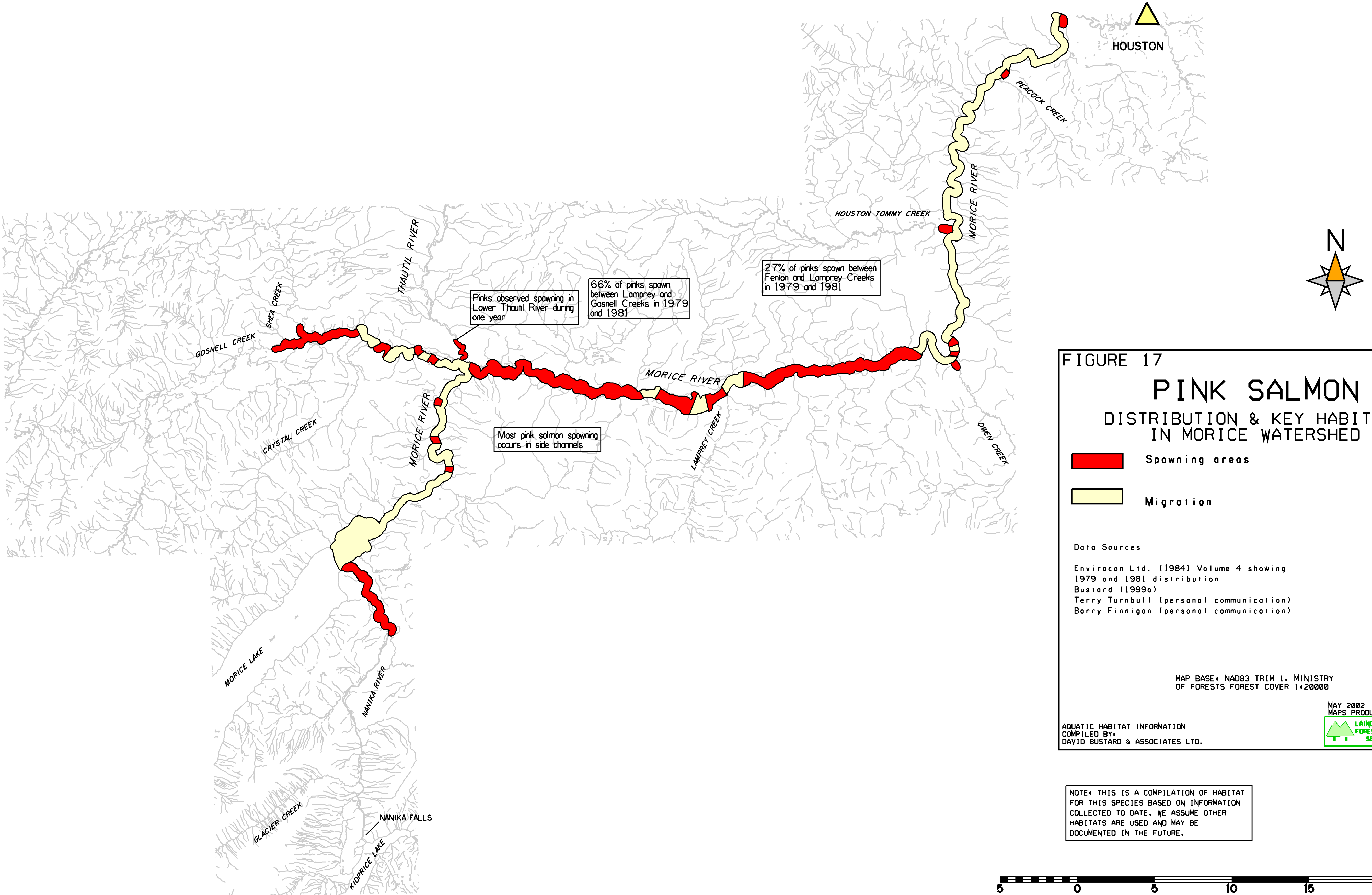


FIGURE 17

PINK SALMON

DISTRIBUTION & KEY HABITATS IN MORICE WATERSHED

Spawning areas

Migration

Data Sources

Envirocon Ltd. (1984) Volume 4 showing 1979 and 1981 distribution
Bustard (1999a)
Terry Turnbull (personal communication)
Barry Finnigan (personal communication)

MAP BASE: NAD83 TRIM 1, MINISTRY OF FORESTS FOREST COVER 1:20000

MAY 2002
MAPS PRODUCED BY:
LAING & McCULLOCH FOREST MANAGEMENT SERVICES LTD.

AQUATIC HABITAT INFORMATION COMPILED BY:
DAVID BUSTARD & ASSOCIATES LTD.

NOTE: THIS IS A COMPILATION OF HABITAT FOR THIS SPECIES BASED ON INFORMATION COLLECTED TO DATE. WE ASSUME OTHER HABITATS ARE USED AND MAY BE DOCUMENTED IN THE FUTURE.

Figure 17. Pink salmon distribution and key habitats in the Morice Watershed.

3.4.4 PINK SALMON MIGRATION

Pink salmon migration into the Morice typically starts in mid-August, reaches a peak during the last week of August with some fish continuing to move into the river during early September (Farina 1982). This information is largely derived from observations conducted by Alcan between 1955 and 1982 at a counting tower in Owen Canyon, just downstream from Owen Creek.

3.4.5 PINK SALMON SPAWNING

3.4.5.1 Timing

The peak of pink salmon spawning in the main spawning sections of the Morice River typically occurs during the first and second week of September and is complete by the end of the third week of September (Shepherd 1979; Envirocon Ltd. 1984). Observations during 1979 and 1981 indicate that spawning occurs earlier in the lower sections of the Morice than in the upper river, and later still in Gosnell Creek. We assume that the later spawning timing in the upper river reflects the warmer incubation environment in the upper Morice River compared to the lower reaches (Figure 4).

3.4.5.2 Habitat Characteristics

Detailed habitat characteristics of pink salmon spawning areas in the Morice River were collected during the Kemano Completion studies (Envirocon Ltd 1984). For example measurements of depth and nose velocity[41] were collected at 150 pink salmon redds in the mainstem and side channel locations during 1979 and 1981.

These studies determined that 90% of the pink salmon redds were located at sites with the following characteristics:

- Water depth – 39 to 110 cm deep
- Nose velocity – 30 to 79 cm/sec
- Mean area occupied by redd – 1.4 m^2
- Clean gravel bed material predominantly less than 15 cm diameter

A comparison of side channel and mainstem sites during a year of relatively low pink abundance (1981) indicated that spawner densities within areas suitable for spawning were approximately 30 times higher in the side channel locations[42].

Studies of the amount of potential spawning habitat and how this changed with discharge in the Morice indicated that while the amount of spawning in side channel locations declined during years when September discharge was low, the amount of mainstem areas suitable for spawning increased, largely reflecting lower water velocities (Envirocon Ltd 1984).

---

[41] Water velocity taken 0.12 m above the streambed at the top end of the redd.

[42] One pair of pinks per 2.3 m^2 of suitable habitat in the side channel compared to one pair per 75 m^2 of suitable habitat in the mainstem.

Observations of pinks spawning in the mainstem river indicate that they tend to utilize the edge areas. We suspect this is a reflection of the water velocities and bed material size. Flows tend to be too fast and the bed material too large away from the edges in much of the mainstem channel.

3.4.6 PINK SALMON HATCHING AND EMERGENCE

Observations in side channels of the Morice River in late November, 1979, indicated that newly-hatched alevins were present in redd sites by that date. Observations in Morice River side channels during the spring suggested that most pink salmon fry emerge with rising water levels during the spring[43]. For example in 1982, most emergence appeared to occur during the period May 1 to 15th. It is assumed that pink fry move downstream to the Skeena estuary immediately after emergence.

3.4.7 PINK SALMON LIMITING FACTORS

Overall freshwater survival of pink salmon from egg to alevin, even in highly productive streams, commonly only reaches 10-20%, and at times is as low as about 1% (Groot and Morgolis 1991). Some of the most comprehensive work assessing factors important in pink salmon survival has taken place in Alaska during the 1960's. These studies concluded that critical environmental factors for pink salmon are primarily focused around supply of dissolved oxygen, stability of spawning beds, and freezing (McNeil and Ahnell 1964; Sheridan 1962; McNeil 1966). On-site observations at pink salmon spawning sites indicate that many of these same factors also play an important role in limiting pink salmon production in the Morice River.

3.4.7.1 Dissolved Oxygen and Water Temperatures

Dissolved oxygen and temperature studies were conducted at 14 pink salmon redd sites in side channels of the Morice in the spring of 1982 (Envirocon Ltd. 1984). These studies indicated that dissolved oxygen levels tended to be low at redd sites with no surface flows. As discharge declines during the winter in the Morice River, subsurface dissolved oxygen levels decline as groundwater inputs comprise a larger proportion of the discharge.

Measurements of dissolved oxygen and water temperatures in side channels, as well as the presence of open water areas during the late winter, suggest that at least some sites selected by pinks are directly influenced by groundwater. While the groundwater keeps water temperatures higher and reduces the risk of freezing, it may compromise water quality by leading to dissolved oxygen levels that either result in direct mortalities to eggs or impact alevin development. Levels measured at one of the two side channels in the Morice River were less than 5 ppm at some of the redd sites, dropping to as low as 1 ppm. Water temperatures in these side channel sites ranged from 1-5ºC compared to near 0ºC and thick ice cover in the mainstem.

---

[43] During gravel sampling in early April 1982 it was noted that pink fry were at least 15 cm below the gravel surface. By the end of April, they were commonly found just below the gravel surface and that emergence had started to occur. By early May large numbers of fry were observed along channel margins, sometimes stranded in isolated pools until rising flows permitted access to downstream areas. No pink fry were observed after the third week of May, possibly reflecting reduced visibility (Envirocon Ltd. 1984). Pink fry emerge predominantly at night.

3.4.7.2 Redd Dewatering and Freezing

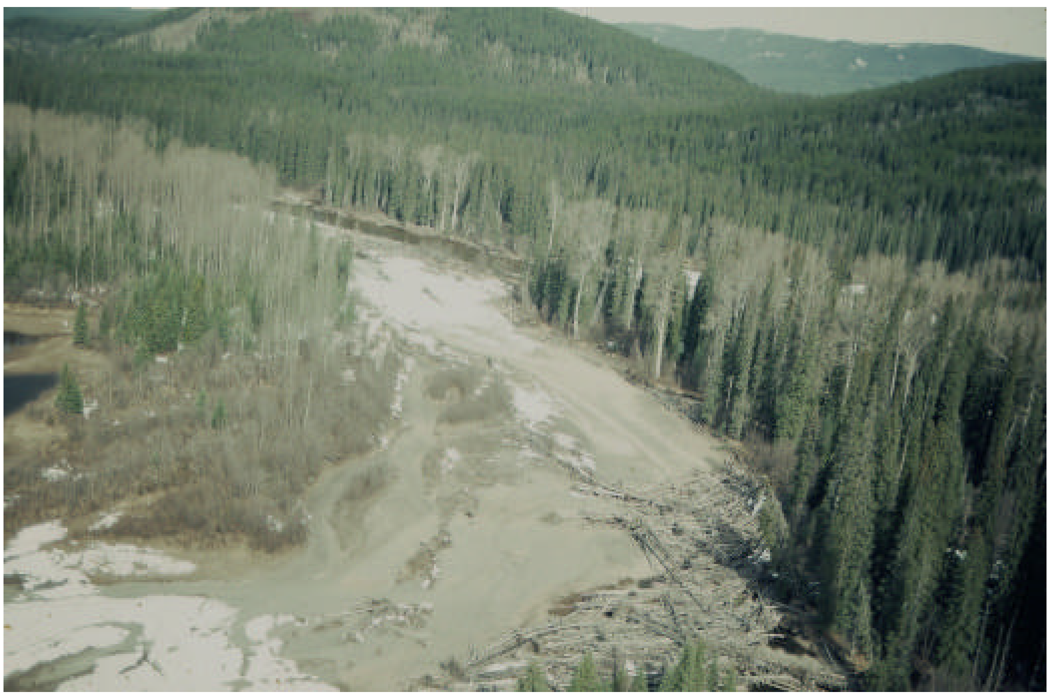
The severity of winter conditions in conjunction with low discharge can play an important role in pink salmon survival in the Morice River (see Photo 10). Low discharge during the early winter of 1979, in conjunction with very cold temperatures and lack of snow cover led to direct freezing of pink redds in some key pink spawning areas in Morice side channels.

3.4.7.3 Spawning Versus Incubation Discharge

Stream discharge at the time of spawning has an important impact on the potential for survival of pink salmon in the Morice. High discharge conditions during the early September period pushing spawners to channel edges that subsequently dewater, can lead to poorer survival than moderate to low discharge conditions during the spawning period and high winter incubation flows.

Similarly, rain-on-snow events leading to extreme freshets after the pink spawning period, can lead to gravel shifting and poor survival. Some very large flood events have occurred in the Morice during October and early November, and we suspect these events have impacted pink spawning areas. The main spawning sites are located downstream from the Thautil–Gosnell confluence, leading to higher instantaneous flows capable of moving the bed material compared to sites located immediately downstream from Morice Lake.

Photo 10. Approximately 1300 pink salmon (10% of the 1981 Morice pink escapement) spawned in this side channel during September 1981. By late April of 1982, this channel was completely dry.



3.4.7.4 Predation

Predation on emerging pink fry can be a significant factor on survival. Mergansers and other birds were observed feeding on pink fry holding in isolated pools until water levels rose in the Morice River during the spring (Envirocon Ltd. 1984). Both coho smolts and stream resident char can be significant predators on pink fry migrating downstream.

3.4.7.5 Gravel Quality/Sediment Deposition

Analysis of 68 gravel samples collected in side channel and mainstem spawning sites in the Morice River indicated gravel characteristics were conducive to good egg survival (Envirocon Ltd. 1984). The sand component (<3.35 mm) comprised under 20% and the fine component (<0.85 mm) comprised less than 9% of the gravel samples collected at the redd sites. Using survival data collected elsewhere, it was concluded that given ideal flow conditions, pink salmon egg-to-fry survival in these types of gravels could range from 70-85%.

The main pink spawning areas in the side channels of the Morice are located downstream from the Thautil and Gosnell rivers. The Thautil River has high natural sediment loads. With the rapid development of logging in these upper watersheds and many smaller systems flowing into the main pink spawning reach of the Morice could lead to increased sediment loading into this reach and subsequent reductions in egg survival.

3.4.8 PINK SALMON INFORMATION GAPS

The pinks are an expanding species in the Morice River. While a considerable amount of information is available specific to the Morice River, a number of areas have been identified for future focus:

- What are the implications of up to 800,000 pink carcasses on nutrient enrichment to the Morice River, a system with naturally low nitrogen and phosphorous levels?
- Present escapement estimates derive a single estimate for the system. A more specific breakout of the distribution of spawners by reach and location would be helpful in monitoring potential changes relative to discharge and escapements. Present aerial surveys do not include the lower ends of tributaries such as Gosnell Creek.
- An assessment of pink salmon spawning sites during very high escapements could provide information describing spawner densities, incidence of redd crowding and superimposition, and some assessment of the capacity of the Morice River to accommodate pink salmon spawners.

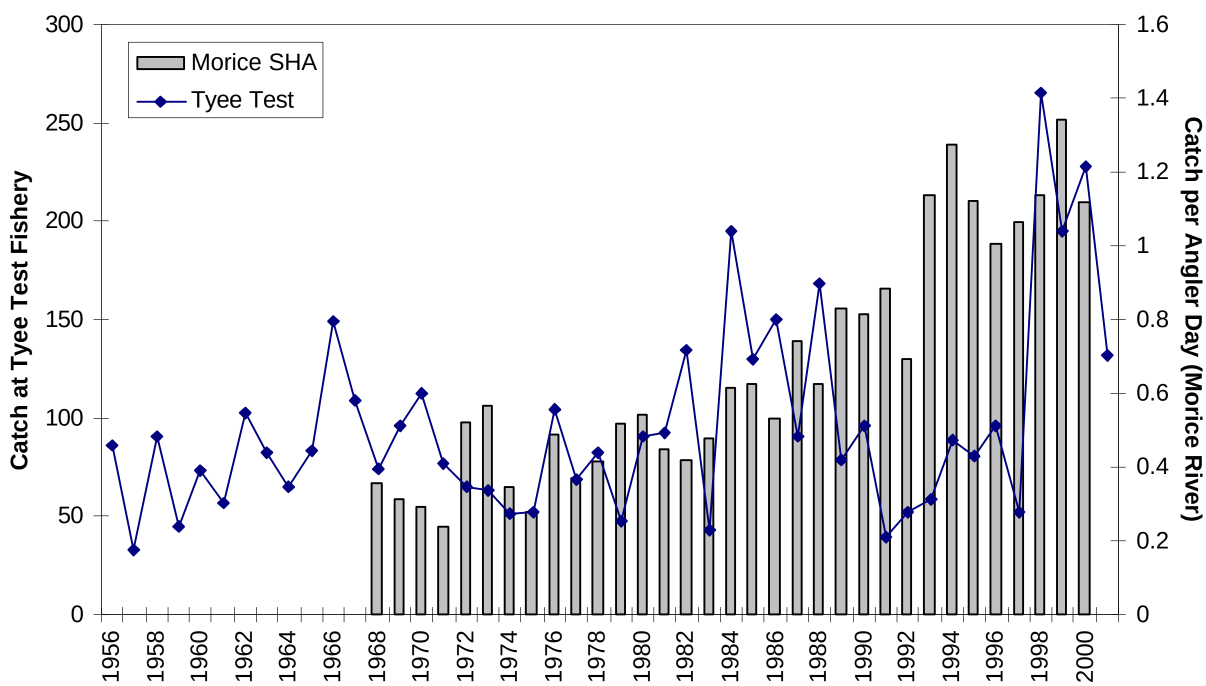
3.5 STEELHEAD

3.5.1 STEELHEAD POPULATION STATUS AND TRENDS

The Bulkley-Morice sub-unit is the most important steelhead system in the Skeena drainage. Several studies suggest that the Bulkley River accounts for much of the escapement to this area. For example, Koski et al. (1995) conducted a Petersen mark-recapture escapement estimate for steelhead in the major Skeena tributaries in 1994 using radio tags. The Bulkley River accounted for 21 (27%) and the Morice for 5 (6%) of the 78 tags recovered in Skeena rivers. Tautz et al. (1992) used map-based modeling in conjunction with field habitat measurements to estimate habitat quantity and potential to produce steelhead smolts in Skeena drainages. The Morice Watershed was estimated to have a capacity of just over 6000 adults, or approximately 8% of the total Skeena capacity of 80,000 steelhead, while the Bulkley River was estimated to have a capacity to produce 22,000 fish, or 27% of the Skeena total.

Two abundance indices have been used by WLAP for Skeena steelhead management - the Tyee Test Fishery steelhead index and the Steelhead Harvest Analysis. Data from the test fishery for steelhead applies to the Skeena steelhead run as a whole and is not stock specific. Changes to nets and how they are fished over time, the effects of varying sockeye numbers, water levels, and water temperatures all lead to variability in the index results. WLAP has developed an extrapolation factor for the index (245) to estimate steelhead escapement for the Skeena (Hooton 1999). Based on these methods, total Skeena steelhead escapement has averaged 22,451 (range of 8,034 to 61,429) since 1956. The Tyee Test Fishery steelhead index is shown in Figure 18.

Figure 18. Tyee Test Fishery Index for steelhead compared with Catch per Angler Day for the Morice derived from the Steelhead Harvest Analysis.



The Steelhead Harvest Analysis is derived from questionnaires mailed to a random sample of steelhead angling license holders. From the respondents an estimation of Catch per Angler Day (CpAD) is calculated and used as an index of steelhead abundance. Information is collected and compiled for individual waterbodies, including the Morice River. The steelhead assessment data for the Morice is shown in Figure 18.

Several estimates of the steelhead escapement in the Bulkley-Morice and the Morice River have been conducted in the past decade. For example, a mark-recapture survey conducted in the Morice River by Lough (1995) for 1993 was just over 3300 fish (Table 5). Escapement estimates for the Morice River in 1994 derived from Koski et al. (1995) was approximately 1,800 steelhead[44]. Two additional mark-recapture estimates for the Bulkley/Morice were conducted in 1999 and 2000 (Mitchell 2000, 2001) by marking fish at Moricetown Canyon and re-capturing fish by angling during the fall or the following spring. The estimate of the Morice portion of fish in the surveys ranged from approximately 4000 to 6750 fish for the two surveys. A number of assumptions that have been made in deriving these rough estimates are outlined in Table 5.

Table 5. Petersen mark-recapture estimates for Bulkley-Morice steelhead.

Year	Bulkley/ Morice Population Estimate	Morice Population Estimate[45]	95% Confidence Interval[46]	Source	Tyee Escapement Estimate[47]
1993		3,316	2,271-5,000	Lough (1995)	1,141
1994		1,834		Koski et al. (1995)	1,140
1999	27,005	6,751	22,261-35,479	Mitchell (2000)	3,824
2000	22,627	3,998	17,200-32,135	Mitchell (2001)	2,574

There has been a catch-and-release only regulation in effect on the steelhead sport fishery in the Morice since the early 1990's, but some steelhead are taken in the food fishery at Moricetown. Wet'suwet'en records for the Moricetown Canyon fishery show that annual catch has averaged about 500 fish since the early 1980's with a range of 142 to 1,837 (Morrell 1985; Walter Joseph, personal communication).

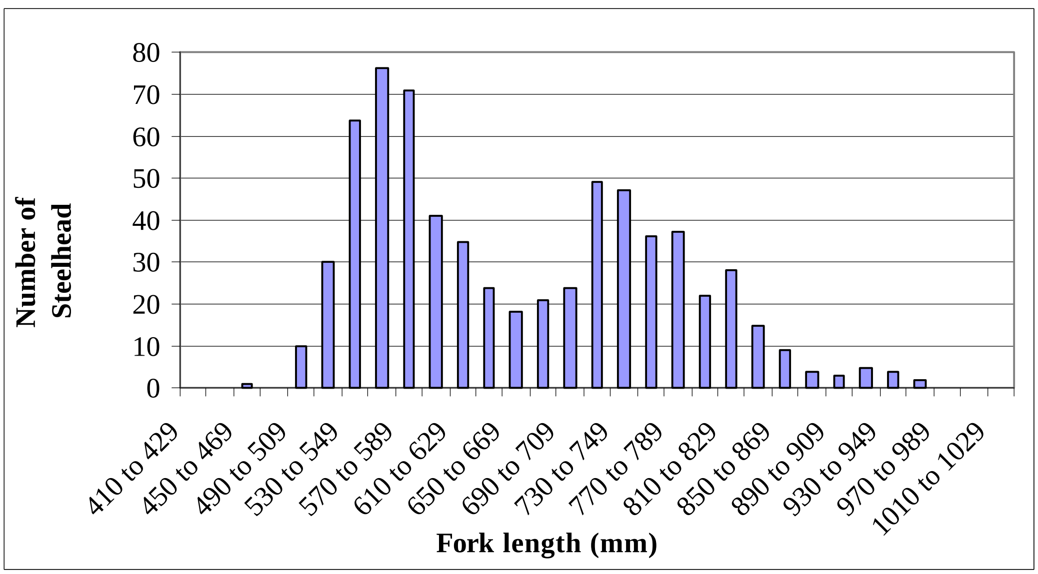
[44] This estimate was based on a small sample size of fish.
[45] The 1999 and 2000 Morice River estimates are based on the spatial distribution of recovered tags. With all these mark-recapture estimates, there is an underlying assumption that the waterbody where the tagged fish was recaptured is where it will spawn.
[46] For 1999 and 2000, the confidence intervals apply to Bulkley-Morice estimates.
[47] Based on Tautz et al. (1992) and Koski et al. (1995) we are calculating the Tyee escapement estimate for the Morice by multiplying the Tyee Skeena escapement estimate by 8%.

3.5.2 STEELHEAD LIFE HISTORY INFORMATION

Studies conducted in the Morice during the 1970's indicated that a high proportion of Morice River steelhead trout (59%) spent only a single year in the ocean before returning to spawn (Table 6). A review of current WLAP database files summarized in Table 6 indicates that one-year ocean fish continue to dominate the Morice River steelhead population based on an updated amalgamation of scale data for this system. For comparison, steelhead in the Kispiox and Babine Rivers, also summer steelhead systems, typically returned after two and three years in the ocean.

A review of length information for Morice steelhead (Figure 19) indicates a bimodal distribution of size classes representing the two predominant ocean age classes of fish (one and two year ocean fish). Since the length and weight of returning steelhead depends on the number of years spent in the ocean environment, Morice steelhead tend to be smaller than nearby systems such as the Babine and Kispiox rivers (Table 6). Morice steelhead have a longer freshwater residency time than some other summer steelhead systems in northwestern B.C., suggesting a less productive rearing environment for juveniles (Table 6). Some biologists feel that steelhead that spend an extra year in fresh water tend to spend less time in the ocean. As a result, they return to freshwater at a smaller size.

Figure 19. Summary of length-frequency of Morice River steelhead[48].



[48] Data derived from WLAP tag database, Smithers.

Table 6. Comparison of freshwater and ocean residence periods of steelhead trout from the Morice, Babine and Kispiox Rivers (expressed as % of total sample).

	Morice1[49]	Morice2[50]	Babine	Kispiox
Freshwater Age				
2	0.2	0.1	2.0	1.5
3	23.5	31.7	82.0	40.0
4	69.9	63.0	15.0	55.0
5	6.4	5.1	1.0	2.6
n =	518	659	100	195.0
Ocean Age				
1	59.1	58.1	10.2	5.7
2	39.7	40.6	69.5	58.5
3	1.2	1.3	20.3	32.1
4				3.1
5				0.6
n =	484	687	117	159

3.5.3 STEELHEAD UPSTREAM MIGRATION

The recovery of marked steelhead in the lower Skeena indicated that steelhead bound for the Morice River moved through the lower Skeena from July through mid-September (Ward et al. 1995). The peak migration date for Morice River steelhead past the Tyee Test Fishery in the lower Skeena is typically during the first week of August based on the recovery of tagged fish and reconstructed timing based on location of capture[51]. The Morice River steelhead move through the lower river the earliest of the main Skeena steelhead stocks.

Lewis (2000) presents evidence suggesting that the population characteristics of Skeena summer steelhead is shifting towards fish that enter the river later than historically was the case, reflecting higher commercial fishing pressure on the early-returning component of the run.

The first steelhead appear in the Morice River early to mid-August (M. Beere pers. comm., Whately et al. 1978) and continue to move into the river throughout the autumn. Specific observations during snorkel surveys indicated that in 1979, steelhead first arrived in the upper Morice River below Morice Lake between August 8 and 22nd. Angler catch data indicate that steelhead are distributed throughout the Morice River during the fall (Whately et al. 1978).

[49] Morice1 information from Whately et al. (1978); Babine River information from Narver (1969); Kispiox River information from Whately (1977).
[50] Morice2 data from steelhead database, WLAP, Smithers
[51] This is based on a combination of tag recoveries from nose-tagged fry releases in the Morice and floy tagged steelhead recoveries in the Area 4 fisheries, Tyee Test Fishery and bar fishermen on the lower Skeena (Ward et al. 1995). This timing also concurs with racial analysis based on steelhead scale data.

3.5.4 STEELHEAD OVERWINTERING

Radio-telemetry studies indicate that adult steelhead overwinter throughout the Morice and Bulkley rivers (Lough 1981). A small percentage of the overall steelhead population is thought to winter in the open-water section below Morice Lake. Population estimates conducted during 1993 and 1994 suggested that approximately 2% of the Morice steelhead population were present from the lake outlet to the bridge upstream from Gosnell Creek. Some steelhead are also thought to overwinter in Morice Lake (Envirocon Ltd. 1984). Morice steelhead adults do not overwinter in tributary streams.

Lough (1995) suggests approximately 18% of the Morice steelhead overwintered in the section from Owen Canyon to Aspen Campground, compared to 57% from Lamprey Creek to Owen Canyon, and 22% from the bridge above the Gosnell to Lamprey Creek. Over 200 steelhead were observed in an 8 km-section of the Morice below Owen Creek during a snorkel survey in mid-March 1998 (Bustard 1998b).

Steelhead moved both upstream and downstream during the winter under the ice based on radio-telemetry observations. Distance moved ranged from 10 to 70 km (Envirocon Ltd. 1984).

Nearly all steelhead observed during a March snorkel survey in the upper Morice River were holding at the tail of runs, usually in 1 to 2 m of water over gravel and cobble bed material, in areas with water velocities up to 1 m/sec.

3.5.5 STEELHEAD SPAWNING

3.5.5.1 Timing of Spawning

Steelhead start to move upstream to their eventual spawning locations in late April and early May, coinciding with increased streamflows and a water temperature of 5°C. Radio telemetry studies indicated that Morice steelhead move into Owen, Lamprey and Gosnell creeks during the period of high spring discharge enabling them to penetrate high into the watersheds past beaver dams that might pose barriers during lower flow periods.

In 1979 and 1982, peak steelhead spawning occurred from the last week of May to the first week of June inclusive, although the spawning period probably extends from May 15 to at least June 15 in some tributaries (Envirocon Ltd. 1984).

Mainstem Morice River spawning occurred on the increasing freshet at water temperatures of 3 to 7°C. Tributary spawning temperatures were 8 to 12°C during the steelhead spawning period. Water clarity in spawning areas varied from clear to heavily silted (Envirocon Ltd. 1984).

While some steelhead, usually the males, remain in the Morice for a period following spawning, others leave fairly soon afterwards. For example, one fish located at a spawning area in Owen Creek on June 10 was located 120 km downstream five days later. Another steelhead kelt was captured by an angler in Atna Bay of Morice Lake in late June (Envirocon Ltd. 1984).

3.5.5.2 Distribution of Spawners

Steelhead spawning is widely dispersed between key tributary streams and the mainstem river (Figure 20). Spawning areas delineated in Figure 20 are far from a complete documentation of all steelhead spawning sites in the Morice, since this species spawns during the highest flow periods and redds and spawners are usually not conspicuous.

Of 16 steelhead tagged and followed to their eventual spawning locations in 1979, nine spawned in the mainstem Morice (four in the main channel, four in side channels and one indistinguishable). The remaining seven fish spawned in tributaries including four in Owen Creek, two in Shea Creek (Gosnell tributary), and one in upper Lamprey Creek (Lough 1981). These three tributaries together comprise very important steelhead spawning and early rearing systems and have been subject to extensive fry sampling to provide an index of the strength of the steelhead spawning run.

A small number of steelhead utilize the Nanika River upstream from Glacier Creek (Envirocon Ltd. 1984 Volume 3). During concentrated studies in the Nanika River in late May and June of 1979 and 1980, up to a dozen steelhead were observed, all during the 1979 surveys.

Other specific steelhead spawning sites were identified during snorkel surveys in the upper river including the riffle immediately upstream from the Gosnell confluence and the dunes area in the upper Morice River. Angling and tag recaptures in the 2 km section below Morice Lake during the May and early June period of 1980 suggested several hundred steelhead may have been spawning in this area at the time (Envirocon Ltd. 1984).

The presence of newly-emerged steelhead fry during late summer surveys also provides an important indication of potential steelhead spawning sites. High densities of steelhead fry were sampled in the upper Thautil River just upstream from the Starr Creek confluence (Bustard 1997a). We suspect this section of the Thautil is the key spawning section for Thautil River steelhead (Photo 12). Evidence of steelhead redds have also been identified in this stream reach. High densities of newly-emerged steelhead fry have also been sampled in Hagman Creek in the Thautil.

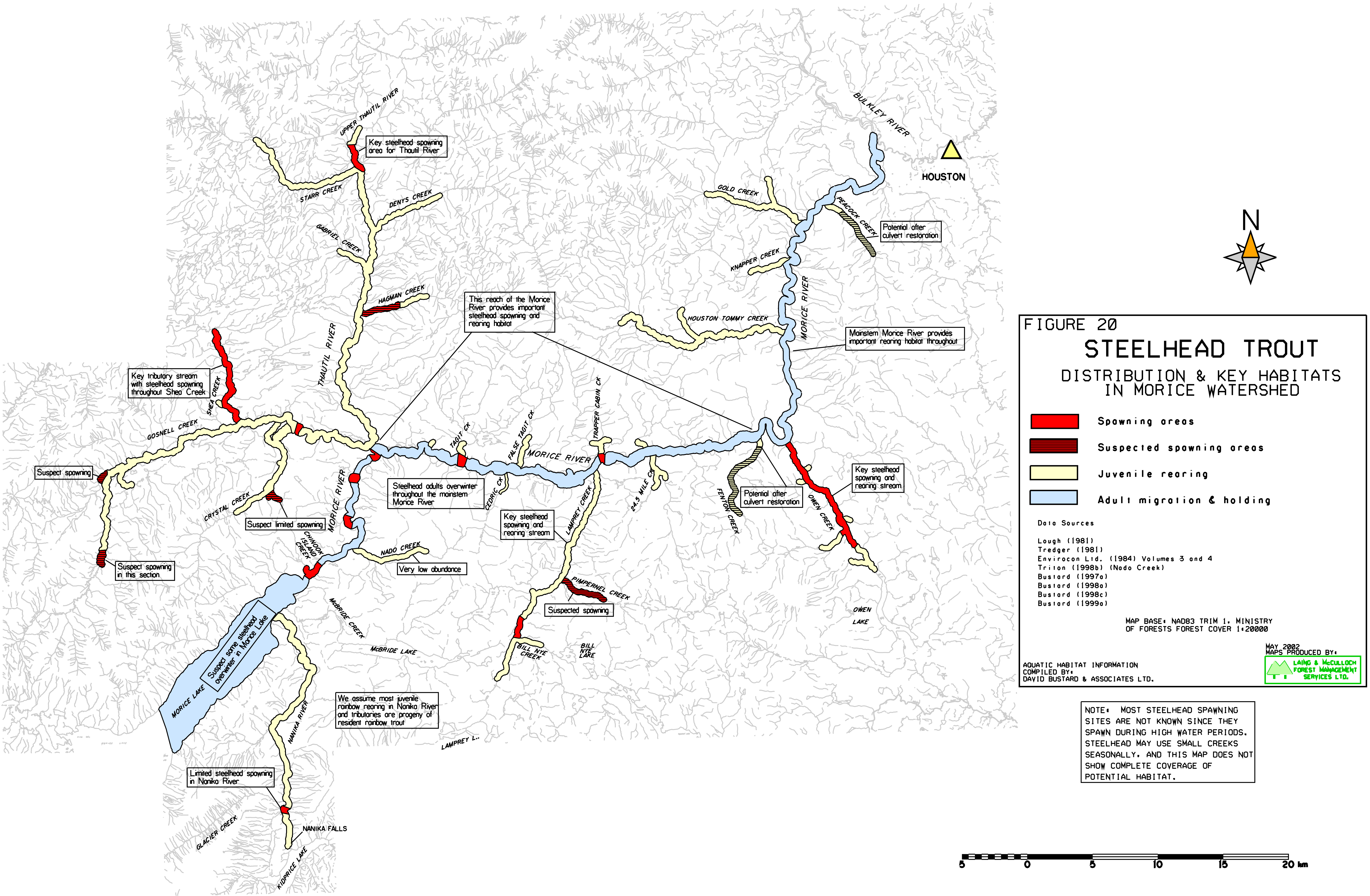


FIGURE 20
STEELHEAD TROUT
DISTRIBUTION & KEY HABITATS IN MORICE WATERSHED
Spawning areas
Suspected spawning areas
Juvenile rearing
Adult migration & holding
Data Sources
Lough (1981)
Tredger (1981)
Envirocon Ltd. (1984) Volumes 3 and 4
Triton (1998b) (Nado Creek)
Bustard (1997a)
Bustard (1998a)
Bustard (1998c)
Bustard (1999a)
MAP BASE: NAD83 TRIM 1. MINISTRY OF FORESTS FOREST COVER 1:20000
MAY 2002
MAPS PRODUCED BY:
LAING & McCULLOCH FOREST MANAGEMENT SERVICES LTD.
AQUATIC HABITAT INFORMATION COMPILED BY: DAVID BUSTARD & ASSOCIATES LTD.
NOTE: MOST STEELHEAD SPAWNING SITES ARE NOT KNOWN SINCE THEY SPAWN DURING HIGH WATER PERIODS. STEELHEAD MAY USE SMALL CREEKS SEASONALLY, AND THIS MAP DOES NOT SHOW COMPLETE COVERAGE OF POTENTIAL HABITAT.
N
HOUSTON
BULKLEY RIVER
UPPER THAUTIL RIVER
Key steelhead spawning area for Thautil River
STARR CREEK
DENYS CREEK
GABRIEL CREEK
HAGMAN CREEK
THAUTIL RIVER
This reach of the Morice River provides important steelhead spawning and rearing habitat
GOLD CREEK
PEACOCK CREEK
Potential after culvert restoration
KNAPPER CREEK
HOUSTON TOMMY CREEK
MORICE RIVER
Mainstem Morice River provides important rearing habitat throughout
Key tributary stream with steelhead spawning throughout Shea Creek
SHEA CREEK
GOSNELL CREEK
Suspect spawning
CRYSTAL CREEK
Suspect limited spawning
Suspect spawning in this section
TAGIT CK
FALSE TAGIT CK
TRAPPER CABIN CK
CEDRIC CK
Steelhead adults overwinter throughout the mainstem Morice River
24.5 MILE CK
FENTON CREEK
Potential after culvert restoration
Key steelhead spawning and rearing stream
OWEN CREEK
CHINOOK ISLAND CREEK
NADO CREEK
Very low abundance
Key steelhead spawning and rearing stream
LAMPREY CREEK
PIMPERNEL CREEK
Suspected spawning
McBRIDE CREEK
McBRIDE LAKE
BILL NYE CREEK
BILL NYE LAKE
OWEN LAKE
Suspect some steelhead overwinter in Morice Lake
MORICE LAKE
We assume most juvenile rainbow rearing in Nanika River and tributaries are progeny of resident rainbow trout
NANIKA RIVER
LAMPREY L.
Limited steelhead spawning in Nanika River
NANIKA FALLS
GLACIER CREEK
KIDPRICE LAKE
5 0 5 10 15 20 km

Figure 20. Steelhead trout distribution and key habitats in the Morice Watershed.

Photo 11. This critical habitat in the Morice River above Gosnell Creek is utilized by steelhead, chinook, coho and pink salmon spawners.

Photo 12. Key steelhead spawning area in Thautil River upstream from Starr Creek.

3.5.5.3 Characteristic of Steelhead Spawning Areas

Envirocon Ltd (1984) conducted detailed measurements on steelhead redd sites in the Morice River during 1979 and 1982. Redds were located in low velocity runs or at the tail end of a pool just upstream from a riffle, often in side channel locations. Bed material was 1 to 15 cm diameter and not compacted. Nose velocities ranged from 46 to 86 cm/sec and depths ranged from 55 to 175 cm. Most spawning areas were located close to cover such as logs, overhanging banks, and vegetation. Detailed measurements at tributary redd sites have not been conducted.

Common characteristics of most of the spawning areas is the association with lake-headed tributaries. We suspect this reflects the need for moderated flow conditions that reduce the incidence of redd scour during the freshet period, yet at the same time ensure adequate flows by the late summer period.

Two pairs of steelhead spawners were observed utilizing a small seasonally-wetted stream in the upper Morice entering at the main spawning area, indicating just how small some steelhead spawning tributaries actually are. This stream dewatered shortly after steelhead fry emergence in the late summer, indicating there is a tight window between fry emergence and downstream movement into the Morice River to prevent stranding during the late summer period. In the Morice Watershed, the use of very small seasonally-wetted streams by steelhead spawners is probably the exception rather than typical, as most spawning streams are wetted year-round.

The spawning area in the upper Thautil River is different than most other sites since it is not lake-headed. However, much of the streamflow in the spawning reach appears to be subsurface through porous gravels, and steelhead redds were still visible post-freshet, suggesting stable flows in this reach despite a large headwater area with no significant lakes.

3.5.6 STEELHEAD FRY EMERGENCE

Studies conducted in the mainstem Morice during 1982 indicated that steelhead fry emergence occurred throughout August with a peak during the period August 9-13th (Envirocon Ltd. 1984 Appendix E). Observations suggest that in some tributaries, emergence may occur in late July, probably a result of earlier spawning dates and higher incubation temperatures. Newly-emerged steelhead fry are typically 27-32 mm fork length.

3.5.7 JUVENILE STEELHEAD REARING HABITAT

Scale analysis indicates that most adult Morice steelhead had remained in freshwater for three (24%) and four (70%) winters prior to smolting (Table 6). Steelhead that leave freshwater after four winters have spent approximately 45 months in the river, 19 of these months in an active growing period from mid-May until the end of October and 26 months in a relatively inactive period from November through mid-May.

Considerable effort was extended during the Kemano Completion Studies to delineate the types of habitat utilized by steelhead fry and parr in the Morice River (Envirocon Ltd. 1984).

Prior to the end of October, Morice steelhead fry typically utilized shallow margin areas with water velocities less than 35 cm/sec. Shallow riffles, side pools and marginal flats were preferred areas and generally some form of cover was present within one meter. By November, fry had moved into overwintering areas, and most fish were utilizing interstices of cobble and boulder habitat.

Steelhead parr were found throughout mainstem and side channel habitats and favored areas greater than 15 cm deep and were present in water velocities up to 60 cm/sec.

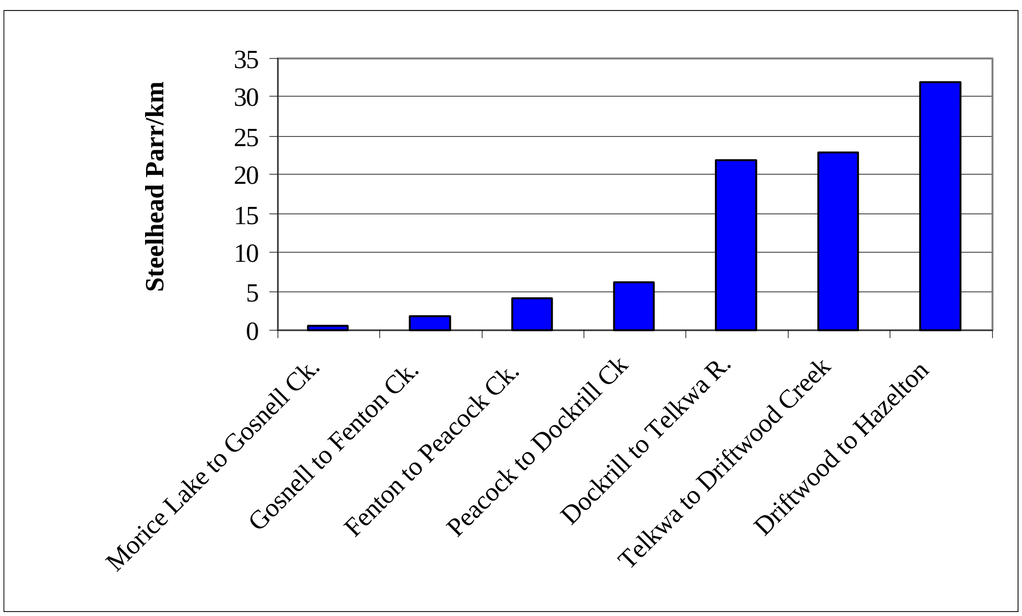
Most of the surveys in the Morice have not been effective at sampling the older age component of steelhead parr (particularly age 3 parr). We suspect these larger fish were not sampled due to the faster and deeper habitats they utilize. Boat electrofishing surveys conducted in selected sections of the Morice and Bulkley rivers during the fall of 1982 indicated that larger parr abundance increased with distance downstream, and that the mainstem Bulkley River was utilized extensively by larger steelhead parr compared to the upper Morice (Figure 21).

The boat shocking information probably underestimates the upper Morice River parr rearing due to lower conductivity and inability to sample log jams. Studies by Shepard and Algard (1977) indicated larger steelhead parr in the Morice River were most abundant in log jams during the summer.

Steelhead parr overwintered in low velocity sites with debris, log and boulder cover. We suspect the large number of log jams in the Morice River provide important overwintering areas for steelhead parr based on observations elsewhere (e.g., Hartman 1965).

Older steelhead parr were often missing from samples collected in the spawning tributaries and it is probable that the larger steelhead parr drop down out of the smaller tributaries as flows decline during the summer to rear in the mainstem river (Tredger 1981).

Figure 21. Relative abundance estimates of steelhead parr in the Morice and Bulkley Rivers based on boat electrofishing in September 1982[52].



[52] Adapted from Envirocon Ltd. 1984 Appendix F.

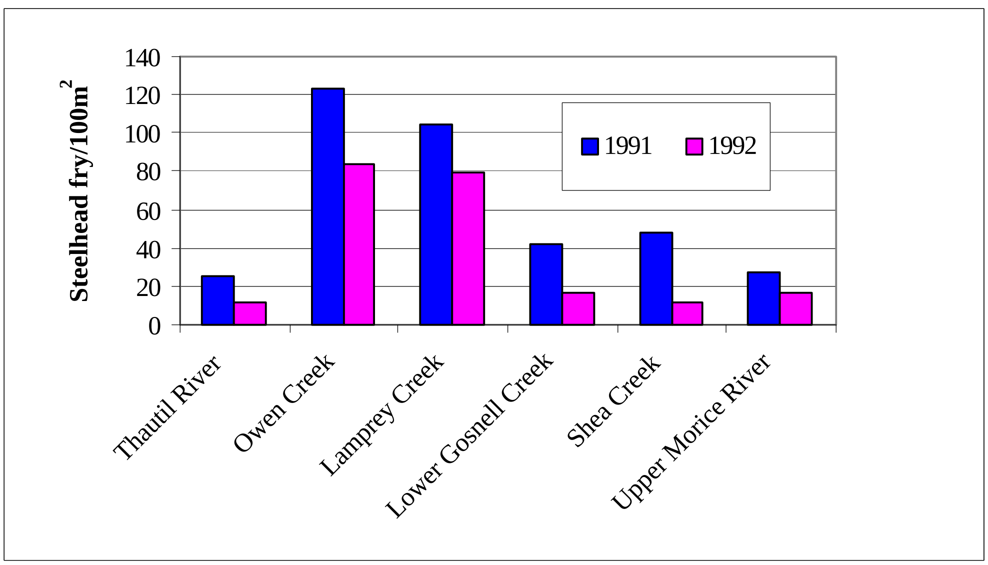
3.5.7.1 Steelhead Rearing Distribution

There have been extensive studies delineating the extent of steelhead juvenile rearing throughout the Morice Watershed during the past 30 years including early surveys by Morris and Eccles (1975), Shepard and Algard (1977), Envirocon Ltd. (1984), Tredger (1981 to 1986), as well as a number of forest inventory studies of specific watersheds.

A variety of methodologies have been used in collecting this information, and it is often difficult to compare abundance estimates from year–to-year due to these differences. We have used data collected during juvenile surveys conducted during steelhead index work in 1991 and 1992 (Bustard 1992 and 1993) to compare the densities of steelhead in key locations in the Morice Watershed since this work incorporated complete site enclosures and two-pass removal within a wide range of sites within the watershed.

Steelhead fry sampling indicate that highest densities occurred in Owen and Lamprey creeks, with densities exceeding 100 fry/100m^2 during some years (Figure 22). These are high steelhead fry densities for the Morice. Densities in lower Gosnell and Shea creeks also indicate these systems are significant steelhead fry production areas. Mainstem Morice River densities were lower, and comparable to those measured in the Thautil River[53].

Figure 22. Density of steelhead fry during the fall in key Morice tributaries and the upper reach of the mainstem Morice River in 1991 and 1992[54].



Owen Creek stands out as an outstanding system for steelhead parr rearing, with catches up to 30 parr/100 m^2 of habitat. Most of the parr captured in the tributary streams tend to be age 1+ . Lamprey Creek is capable of supporting high parr densities near those measured in Owen during some years (Tredger 1981 to 1986), but this did not occur during 1991 and 1992, two summers

[53] The Thautil River sample sites were not located in the Thautil River upstream from Starr Creek, an area that has subsequently been identified as a significant spawning section. Sampling at an index site in the upper Thautil River in 1996 indicated fry densities approached 1 fry/m^2 at one of the upper sites (Bustard 1997a).
[54] Adapted from Bustard (1992 and 1993).

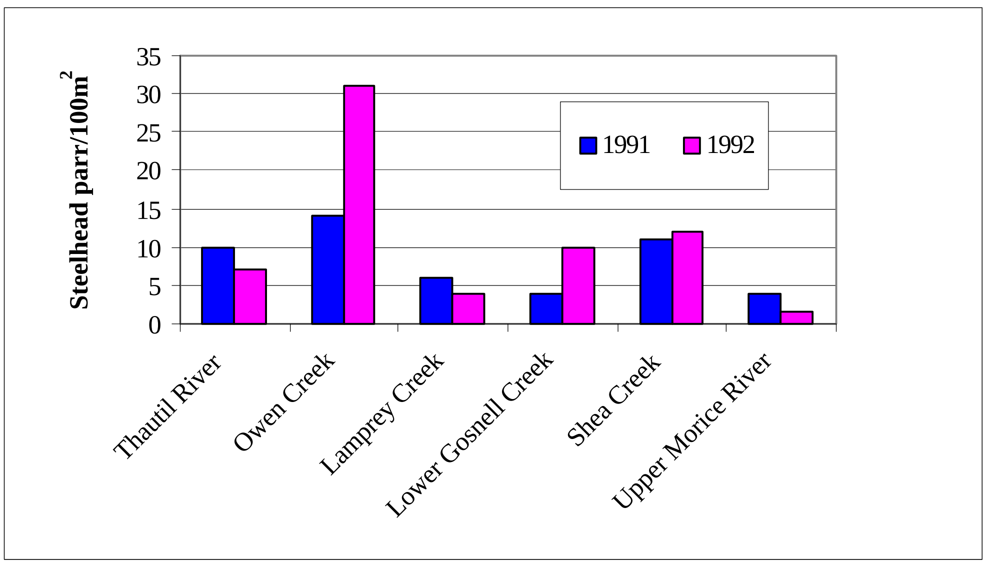
with very low streamflows. Shea Creek parr estimates shown in Figure 23 are also low compared to estimates collected during some years (e.g. Tredger 1983).

Envirocon Ltd. (1984), in a crude estimate using total channel length and fish densities, estimated that just over 50% of the steelhead fry and smaller parr production occurred in the mainstem Morice River with the remainder occurring in tributaries. Between 75-85% of the steelhead fry and parr rearing in tributaries occurred in the four systems (Owen, Lamprey, and Gosnell creeks and the Thautil River). Eleven other tributaries accounted for the remainder of the tributary production.

Although steelhead have been identified in the Nanika River, we suspect that most of the juvenile rainbow sampled in this system, including its tributaries, are progeny of resident rainbow trout. This has not been verified.

Nado Creek has been identified as a steelhead creek based on results at a single site in the mid-reaches (Triton 2000). Most past sampling in Nado Creek indicates extremely low fish use in this system.

Figure 23. Density of steelhead parr during the fall in key Morice tributaries and the upper reach of the mainstem Morice River in 1991 and 1992.



3.5.8 LIMITING FACTORS TO STEELHEAD PRODUCTION

3.5.8.1 Spawning Limitations

Adequate Escapements

Achieving adequate escapements of steelhead spawners to seed spawning streams has been the subject of enormous debate within the Skeena fisheries management program and is beyond the scope of this review to analyze. However, it is important to identify that the mixed stock fishery that occurs in Alaska and Canadian waters, combined with a native fishery, and incidental mortalities[55] together can account for significant exploitation rates estimated to be in the range of 60% during some years (Ward et al. 1995).

The implications of this high interception to spawner recruitment have been major, and indicate that management activities related to the commercial and other fisheries probably over-ride in-stream population bottlenecks during most years in terms of regulating steelhead populations in the Morice Watershed.

Concern for the impacts of the commercial interception impacts on steelhead stocks led to the development of the Wild Steelhead Campaign and to the formation of the Skeena Watershed Committee during the early 1990s. The history of angler efforts to develop a sustainable fisheries for steelhead stocks in the Skeena is documented in Lewis (2000).

Efforts to estimate steelhead trout productivity and stream carrying capacity have been made for the Skeena resulting in the development of a model to predict the capacity of the Skeena steelhead tributaries to produce smolts and to predict the number of steelhead spawners to sustain these populations (Tautz et al. 1992).

These analyses conducted during the early 1990's suggested that low productivity Skeena stocks such as the Morice steelhead are probably over-exploited and well below target escapements considered adequate to seed the steelhead spawning streams during most years. The lower productivity systems such as the Morice have been used to set target escapement goals for Skeena steelhead stocks.

The assumptions used in developing the smolt model, as well as the methods of determining steelhead escapements (e.g. using the Tyee Test fishery) have been subject to criticism for lack of rigorous supporting data and calibration (e.g. Mitchell 1998). However, the smolt model was peer reviewed as part of the PSARC process, and many of the criticisms focussing on it have been dealt with by the authors.

Recent observations also suggest that changes in the ocean environment have affected survival rates for steelhead. This topic is beyond the scope of this review.

---

[55] Steelhead angling in the Morice is catch-and-release and hooking mortalities are suspected to be minor (Hooton 1987). There is an unknown impact due to poaching.

Amount and Suitability of Spawning Habitat

Steelhead spawning tends to be well-dispersed throughout many locations in the Morice Watershed. The spawning sites tend to be located in stream reaches that have relatively large areas of suitable depth, velocity and bed material for steelhead spawning. Observations during the spawning period do not suggest steelhead are spawning in high concentrations or that they are pushed to marginal sites due to high densities. As a general comment within the watershed, we suggest that lack of suitable spawning sites for steelhead is not a limiting factor.

Measurements comparing changes in amount of suitable spawning habitat at different discharges in the upper Morice were conducted by Envirocon Ltd. (1984). These studies indicated that while mainstem spawning sites declined at high discharges, the amount of spawning habitat in side channels increased.

Floods and redd scour

Steelhead spawning occurs during the spring snowmelt freshet and spawning sites that are inappropriately located may be subject to scour and egg displacement. However, Morice steelhead often select spawning sites in lake-headed systems such as Owen and Shea creeks where the potential for redd scour is reduced. Some tributary streams such as Pimpernel, Houston Tommy, Hagman and Starr creeks and in Morice River side channels downstream from Gosnell Creek may be susceptible to scour, especially during years with high snowpack and a late snowmelt freshet due to cool spring weather that delays run-off until after the spawning period.

We are not aware of any direct observations of steelhead redd scour reported in studies for the Morice.

3.5.8.2 Rearing Limitations

We suspect that given adequate escapements, key factors limiting steelhead production in the Morice are related to juvenile rearing. The Morice River steelhead are subject to a combination of density factors controlling late summer populations in some of the tributaries combined with environmental extremes such as severe ice, low winter flows and freshets that all may have a significant influence over steelhead populations and eventual smolt output.

The Morice population is slow-growing and steelhead are subject to these mortality factors for more years than most steelhead populations.

Limited evidence collected in nearby Buck Creek (Bustard 1993) suggests that significant variability occurs in fry densities, often associated with variable steelhead escapements. However parr densities remained fairly constant most years unless fry abundances were severely depressed, suggesting that population adjustments may be occurring mainly during the period between the fry and the early parr rearing stage.

Water Levels, Temperatures, and Intra- and Interspecies Competition

Low summer flows that restrict the availability of rearing areas occur in some of the Morice steelhead tributaries and probably have a large influence on potential production of both fry and parr. The two significant tributaries that appear to be particularly vulnerable to low flows during the late summer are Lamprey and Owen creeks. These tributaries drain the low and mid-elevation terrain on the east side of the Morice and both experience low summer flows (e.g. Figure 2). These systems receive minor use by other salmonid species in the main steelhead-producing sections.

We suspect the presence of the snowfields located on Nadina Mountain are critical to maintaining minimal rearing flows and cool water temperatures in both Owen (Puport) and Lamprey (Pimpernel) creeks and are key to these two tributaries' ability to sustain steelhead populations.

Water temperatures in upper Owen Creek at two index sites exceeded 18°C during late summer surveys in 1997 (Bustard 1998c), and we suspect that small increases in water temperature would favor species such as longnose dace that already comprise up to 30% of the fish abundance in Owen and occupy similar habitat areas in the stream.

Tributaries draining the west side of the Morice including the Thautil River, Gosnell and Houston Tommy creeks tend to have more high elevation areas with snowfields that keep late summer flows higher, and we suspect crowding and competition during low summer flow is less prevalent. However stranding probably still occurs in those parts of these tributaries with muti-channeled sections subject to dewatering.

Morice River flows remain relatively high during the summer period due to high elevation melt. Estimates of available summer rearing habitat for steelhead in the Morice River were made over a range of flow conditions and indicated mainstem river rearing habitat for steelhead fry and parr remained high through the range of flow conditions experienced from May through late October (Envirocon Ltd. 1984).

Juvenile steelhead rearing in the mainstem Morice River, especially fry and smaller parr, may compete with other salmonids, especially juvenile chinook.

Overwinter Rearing

Similar to observations made for chinook juveniles, the winter can be a period of significant impacts on rearing steelhead. Severe ice conditions during the early winter have been observed to impact steelhead fry and smaller parr utilizing shallow side channel locations (Envirocon Ltd. 1984).

A study of overwinter survival in four side channel locations in the Morice River during 1981-82 (Envirocon Ltd. 1984) indicated that as flows declined during the winter, the wetted area of the channels was reduced by 87%. The resulting stranding, water quality deterioration and predation by birds on fish isolated in shallow pools in the early spring resulted in poor survival of steelhead fry and parr using these channels (estimated 23% and 30% respectively).

Spring Freshet

During May and June juvenile steelhead are subjected to high flows during the snowmelt freshet. We suspect fry and small yearlings unable to find suitable cover may be subject to displacement during high flow conditions. Late fall freshets (rain-on-snow events) during late October and early November have also led to some of the highest flow conditions in the Morice Watershed during certain years. Juvenile fish rearing in tributaries with confined single channels such as lower Houston Tommy could be impacted significantly during these events.

3.5.9 STEELHEAD ENHANCEMENT AND RESTORATION

The focus of the provincial fisheries steelhead program has always been to maintain wild stocks of Morice steelhead, and to not move in the direction of hatcheries to offset habitat and interception losses.

Several small enhancement and restoration projects have been directed towards increasing or restoring steelhead production in the Morice Watershed:

- A steelhead fry headwater stocking program was undertaken in the Morice in 1985 and 1986. Steelhead fry were released to upper Houston Tommy Creek, the mainstem Morice and Gosnell Creek. Assessment work to evaluate the effectiveness of this program was not undertaken due to a shift in management direction[56]. Thirty-five nose-tagged steelhead from this program were recovered in the Area 4 fishery during the period 1989 through 1992 (Ward et al. 1995).
- An impassable culvert installed on lower Fenton Creek since the early 1960's was upgraded with an arch culvert during the summer of 1999 re-establishing steelhead access to approximately 7 km of spawning and rearing habitat in this watershed (Watershed Restoration Program 2000). A second impassable culvert on Peacock Creek was modified during the same period in an effort to restore steelhead access to upstream areas.

3.5.10 STEELHEAD HABITAT PROTECTION CONCERNS

Steelhead have a widespread distribution in the Morice Watershed and in some cases utilize quite small streams. Some of the key habitats for steelhead in the Morice tributaries include sections of streams that are subject to low summer flows, potentially high temperatures, and are located in areas with high soil erosion potential.

- Since some of the key steelhead spawning locations are located downstream from headwater lakes, the more moderate flow regimes are not as capable of transporting sediments through the system. For example, poor construction practices when the mainline forest development road was built through the Owen drainage in the 1970's and poor road building and logging practices in the Owen Watershed during the 1980's resulted in considerable sediment inputs into this system during this period. Nortec (1998) identified a number of watershed issues

---

[56] The program was terminated based on a cost vs. benefit assessment by B. Hooton. Poor results from similar programs on Vancouver Island were considered in this analysis.

related to logging and road building in Owen, Fenton and Peacock creeks. FOC has continued to be concerned with chronic sediment inputs along sections of th Morice mainlikne related to road maintenance and heavy truck traffic (Tom Pendrey, FOC, pers. comm.).

- Poor logging practices have also been identified with small streams in Lamprey Creek (BCCF 1999) including the headwater areas of core steelhead-producing sections such as Pimpernel Creek.
- Careful attention to protecting riparian areas and maintaining water temperatures in some of these smaller lake-headed tributaries is critical. A small increase in water temperatures in section of Lamprey and Owen could push them out of the zone suitable for juvenile steelhead rearing.
- There is evidence that some very small steelhead streams that flow directly into the Morice River actually dewater during the late summer and early fall during some years. For example, Chinook Island Creek (Figure 20), which flows into the Morice River just downstream from Morice Lake, was utilized by steelhead for spawning and early rearing with fry dropping out as flows decline during the late summer. These types of streams are difficult to identify with standard inventory procedures.

3.5.11 STEELHEAD INFORMATION GAPS

The implications of modifying the commercial fisheries to accommodate steelhead spawner recruitment combined with what has become an internationally significant and growing sport fishery for Bulkley and Morice steelhead makes it imperative that a solid adult and juvenile database be developed for the management of this stock. The present staffing and funding for steelhead management is inadequate to properly address these issues.

- Despite 30 years of on- and-off again juvenile work in the Morice, we are still left with a lack of understanding of the bottlenecks to smolt production for steelhead in the Morice. The management program needs a systematic program of juvenile assessment in key locations that monitors fry and parr production through years of high and low escapements. Factors to remove sampling variability due to timing, site locations and different sample methods need to be standardized. The program should continue annually over a range of escapements to provide a good index of carrying capacity of the major steelhead tributaries. Over the long-term, this program would provide the information needed to evaluate adequate spawner recruitment to the system. This requires a significant and sustained commitment of funds to sample an adequate number of sites. Any mainstem work should be done in conjunction with chinook and coho monitoring.

- Linking some of the indices presently used in assessing the strength of the steelhead spawner escapement to reliable estimates of spawner abundance is an important step in any steelhead management program for the Morice River. While attempts to correlate Tyee counts to Sustut and Toboggan fence counts or Moricetown catches have not yet yielded any consistent stronger relationship (M. Beere pers. comm.), these efforts are critical to improved Morice steelhead management. Tag recoveries from Moricetown fisheries provide an opportunity to develop adult escapement estimates that can be compared to long-term indices at the Tyee Test Fishery to validate the extrapolations presently being made.

- There is still a lack of understanding of juvenile steelhead movements between tributaries and the mainstem Morice River, and subsequent downstream movements within the mainstem river from parr to smolt stage. The linkage of movements in and out of tributaries to discharge and water temperatures is an important area of understanding for Skeena steelhead stocks.

3.6 RAINBOW TROUT

3.6.1 RAINBOW TROUT DISTRIBUTION

Resident rainbow trout are associated with a number of the larger lake systems in the Morice Watershed (Figure 24). Populations occur in Morice and Owen lakes as well as throughout the Nanika-Kiprice lakes system above Nanika Falls. Resident rainbow populations are present in upper Lamprey Creek and Lamprey, Phipps and Bill Nye lakes (Tredger 1981).

Several more isolated populations of rainbow trout have been identified within the Morice Watershed. For example, a resident rainbow trout population was identified in the mainstem and some tributaries of Houston Tommy Creek upstream from an impassable barrier (Tredger 1983; Triton Environmental Consultants 1998). Resident rainbow were identified in the headwaters of Fenton Creek and are thought to have residualized in this area when steelhead access was restricted by an impassable road culvert (Bustard 1998a). A localized population of resident rainbow trout was sampled in a small lake in the mid-reaches of the Gosnell, and it was assumed that these fish accessed this system from the Burnie River (Bustard 1999a). Other small resident populations may be present, but in much of the Morice Watershed, most juvenile rainbow trout sampled below a stream barrier, are assumed to be the progeny of steelhead.

The population of resident rainbow trout centered around Morice Lake, the upper Morice River and the Nanika River has been the subject of past assessments, mainly associated with the Kemano Completion studies. Tagging studies were conducted in these locations during 1979 and 1980 (Envirocon Ltd. 1984).

Based on the predominance of adult rainbow compared to steelhead trout in the Nanika River, we assume that most of juveniles rearing in the Nanika River below Nanika Falls are the progeny of resident rainbow. Sampling in the Nanika indicated several age classes of juveniles were present, and that rearing occurred throughout the Nanika River. Rainbow juveniles constituted over 40% of the fish catch in the Nanika and the overall densities of rainbow fry and parr were high (Envirocon Ltd. 1984 Volume 3).

Juvenile rainbow have also been sampled in the lower reaches of several Nanika River tributaries including Tsalic, Redslide, and Objective creeks (Envirocon Ltd. 1984; BCCF 1999).

Adult rainbow trout occur in low numbers throughout the Morice River. Resident rainbow smaller than 25 cm fork length cannot be visually separated from steelhead and it has been assumed that most juvenile rainbow sampled in the Morice River, because of the predominance of steelhead spawners in the system, are the progeny of steelhead. During the period September through November 1976, 101 resident rainbow were angled in the Morice between Barrett and Morice Lake, with approximately 50% of these fish angled below Owen Creek, indicating a widespread distribution[57].

Snorkel surveys conducted in the upper Morice from March through November 1979 indicated resident rainbow trout numbers increased in this section of river during August and September, presumably associated with chinook salmon spawning (Envirocon Ltd. 1984 Volume 4).

The rainbow trout populations in the Nanika-Kidprice lakes areas were studied during the 1970's when the Kemano Project proposed to raise water levels in Kidprice Lake and inundate most of the inlet tributaries to this lake (Ministry of Environment 1979). Additional assessment of the Nanika-Kidprice rainbow are reported in Envirocon Ltd. (1984). These studies identified an extremely high incidence of parasitism in the Nanika-Kidprice rainbow population, in particular the tapeworm *Diphyllobothrium*.

3.6.2 RAINBOW TROUT POPULATION STATUS AND TRENDS

3.6.2.1 Morice Lake Population

Morice rainbow trout were first described by Fennelly (1963) based on his 1951 visit to the Morice Lake outlet where he found steady fishing action with the "brightest and firmest rainbow trout he had ever encountered…". After releasing at least a dozen rainbow, his party left that day with 18 Morice rainbow trout together weighing 20 kg. This anecdote gives us some indication of the early status of Morice Lake rainbow trout populations.

A creel survey conducted from May through October 1979 (Envirocon Ltd. 1984) indicated rainbow trout were the most common sportfish captured in Morice Lake (58% of total catch). The survey estimated approximately 600 fish were angled in just under 1200 angler-days on the lake (0.5 rainbow trout/day).

Envirocon Ltd (1984) made a crude estimate of the Morice rainbow trout population based on the lake catch estimates and returns of 16 of 128 tagged rainbow (12.5%) during a tagging study on Morice Lake, the upper Morice River and Nanika River in 1980. The rainbow trout population larger than 25 cm fork length was estimated to range from 4000-7000 fish, probably an over-estimate since it assumed no spawning mortalities during the 1980 season.

The relatively high return of tags from rainbow trout captured by anglers combined with observations of high angling pressure on the upper Morice River in August 1979 suggested that these rainbow trout were actually under significant pressure at the time. Regulation changes introduced since 1980 to protect chinook and steelhead that restrict angling in the upper Morice River during September, have probably helped this population of rainbow trout recover.

---

[57] B.C. Fish and Wildlife Branch file data reported in Envirocon Ltd. (1984). These fish were 26 to 50 cm fork length. These fish are larger than steelhead smolts and smaller than adult steelhead.

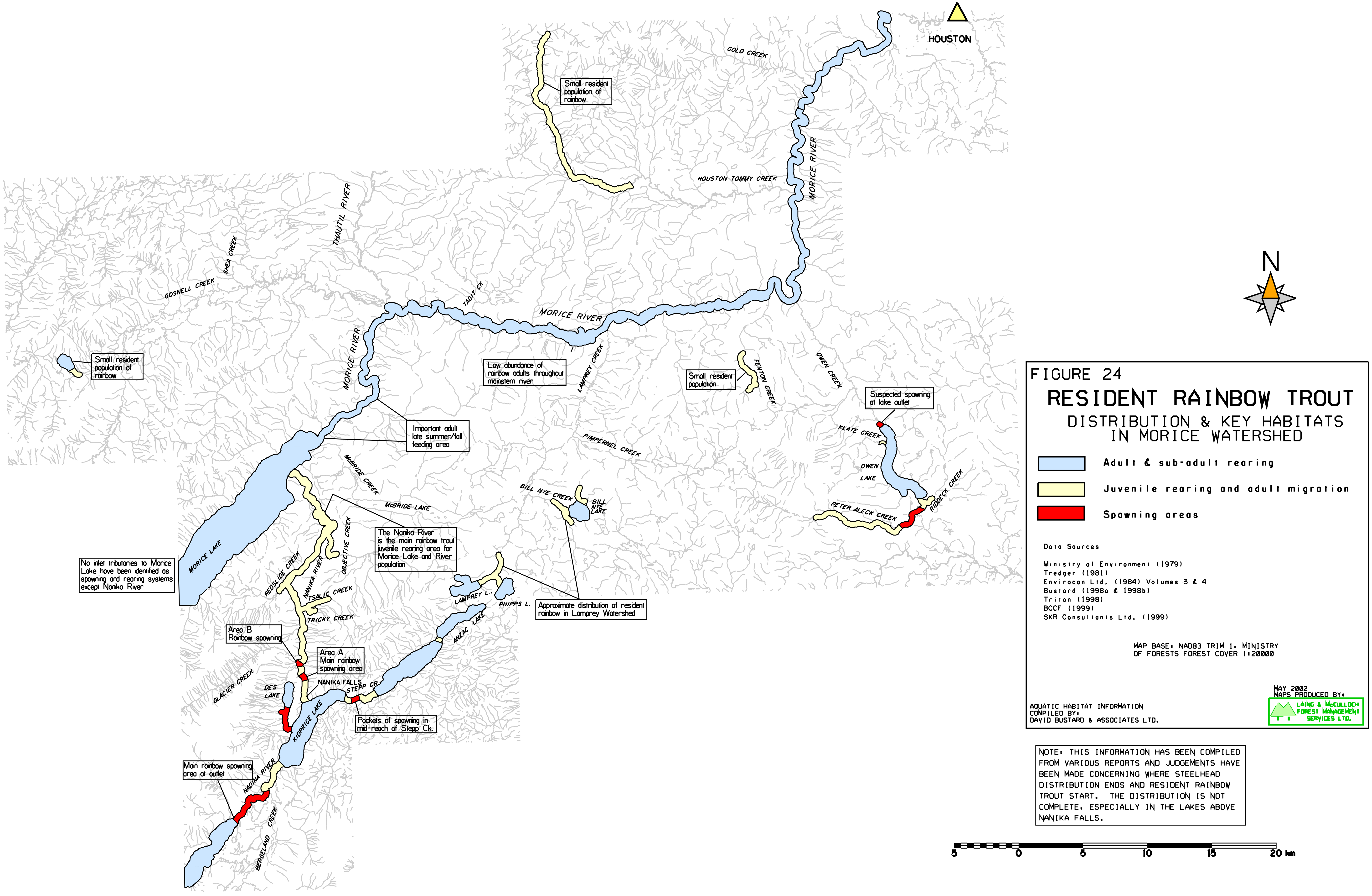

HOUSTON
GOLD CREEK
Small resident population of rainbow
HOUSTON TOMMY CREEK
MORICE RIVER
THAUTIL RIVER
SHEA CREEK
GOSNELL CREEK
TAGIT CK
MORICE RIVER
Small resident population of rainbow
Low abundance of rainbow adults throughout mainstem river
LAMPREY CREEK
Small resident population
FENTON CREEK
OWEN CREEK
Suspected spawning at lake outlet
KLATE CREEK
OWEN LAKE
RIDDECK CREEK
PETER ALECK CREEK
Important adult late summer/fall feeding area
PIMPERNEL CREEK
McBRIDE CREEK
McBRIDE LAKE
BILL NYE CREEK
BILL NYE LAKE
The Nanika River is the main rainbow trout juvenile rearing area for Morice Lake and River population
No inlet tributaries to Morice Lake have been identified as spawning and rearing systems except Nanika River
MORICE LAKE
REDSLIDE CREEK
NANIKA RIVER
OBJECTIVE CREEK
TSALIC CREEK
TRICKY CREEK
LAMPREY L.
PHIPPS L.
Approximate distribution of resident rainbow in Lamprey Watershed
ANZAC LAKE
Area B Rainbow spawning
Area A Main rainbow spawning area
NANIKA FALLS
STEPP CR.
GLACIER CREEK
DES LAKE
KIDPRICE LAKE
Pockets of spawning in mid-reach of Stepp Ck.
Main rainbow spawning area at outlet
NADINA RIVER
BERGELAND CREEK
N
FIGURE 24
RESIDENT RAINBOW TROUT
DISTRIBUTION & KEY HABITATS IN MORICE WATERSHED
Adult & sub-adult rearing
Juvenile rearing and adult migration
Spawning areas
Data Sources
Ministry of Environment (1979)
Tredger (1981)
Envirocon Ltd. (1984) Volumes 3 & 4
Bustard (1998a & 1998b)
Triton (1998)
BCCF (1999)
SKR Consultants Ltd. (1999)
MAP BASE: NAD83 TRIM 1. MINISTRY OF FORESTS FOREST COVER 1:20000
MAY 2002
MAPS PRODUCED BY:
LAING & McCULLOCH FOREST MANAGEMENT SERVICES LTD.
AQUATIC HABITAT INFORMATION COMPILED BY: DAVID BUSTARD & ASSOCIATES LTD.
NOTE: THIS INFORMATION HAS BEEN COMPILED FROM VARIOUS REPORTS AND JUDGEMENTS HAVE BEEN MADE CONCERNING WHERE STEELHEAD DISTRIBUTION ENDS AND RESIDENT RAINBOW TROUT START. THE DISTRIBUTION IS NOT COMPLETE, ESPECIALLY IN THE LAKES ABOVE NANIKA FALLS.
5 0 5 10 15 20 km

Figure 24. Rainbow trout distribution and key habitats in the Morice Watershed.

3.6.2.2 Nanika-Kidprice Lakes

No estimates are available describing the stock status of the Nanika-Kidprice lakes rainbow trout populations other than catch per unit effort (CPUE) per gill net hour in Nanika, Kidprice, Stepp and Des (Spill) lakes for 1974 and 1975[58]. The rainbow trout CPUE in Des Lake was more than three times higher than in Nanika and Stepp lakes. Kidprice Lake CPUE was less than half of the Nanika Lake catch during the two years of survey.

Des Lake is accessible by float plane and walking in from Kidprice Lake, and is well known locally for its excellent rainbow trout fishing. Although the lake is small (approximately 2 km in length), it is sheltered from the winds and more suited for fishermen than the larger Kidprice and Nanika lakes, which can become quite rough and dangerous.

3.6.3 RAINBOW TROUT LIFE HISTORY INFORMATION

3.6.3.1 Morice Lake Rainbow Trout

Tagging studies conducted in the upper Nanika, Morice Lake and upper Morice River during 1979 and 1980 verified that rainbow trout moved between these areas (Envirocon Ltd. 1984). Rainbow trout that were tagged while on the spawning grounds in the Nanika River were recaptured in Morice Lake. Fish tagged in Morice Lake were captured in the upper Morice River and vice versa, suggesting we are probably dealing with a single population of fish that moves between the lake and river locations for feeding and spawning.

Angler catch data indicated Morice Lake rainbow trout ranged in size from 24-61 cm in length (Table 7). Some of these rainbow were age 10+ and 11+, indicative of a very slow-growing long-lived population. Most spawners in the Nanika River were greater than 40 cm fork length and age 6+ or older (Envirocon Ltd. 1984 Volume 3).

A stream resident population of rainbow located in upper Houston Tommy Creek did not exceed 21 cm fork length (Triton 1998).

---

[58] Catches for Des and Stepp lakes were only conducted during 1974.

Table 7. Mean and range of fork lengths for different Morice rainbow trout populations.

Year	System	Fork Length (cm) Mean	Range	Sample Size
1979	Morice Lake[59]	36.7	24-61	110
1980	Morice Lake	37.6	25-50	67
1979	Nanika River	43.7	26-54	21
1980	Nanika River	43.3	30-58	56
1974	Nanika Lake[60]	34.1	26-44	305
1975	Nanika Lake	33.6	24-47	56
1974	Kidprice Lake	27.9	14-32	31
1975	Kidprice Lake	25.9	14-40	20
1974	Stepp Lake	23.4	17-32	68
1974	Des Lake	22.1	17-31	16
1981	Des Lake[61]	40.0	35-45	6
1996	Des Lake	23.0	11-34	40

3.6.3.2 Other Lake Populations

Rainbow trout fork lengths in populations in other lake systems within the Morice Watershed indicate that, on average rainbow in these other systems were smaller than in Morice Lake (Table 7). Rainbow trout in Nanika Lake are the next closest in size with the largest fish to 47 cm long while rainbow trout in Des Lake can achieve a size of up to 45 cm.

Length versus age information for Nanika and Kidprice lakes rainbow trout indicated the oldest rainbow trout were age 8+ (Ministry of Environment 1979).

[59] Based on angler catches for 1979 data and mix of gillnet and angling data collected during the tagging studies in 1980 (Envirocon Ltd. 1984).

[60] Nanika, Kidprice and Stepp and Des lakes information from gillnet sets reported in Ministry of Environment (1979) and lake survey data (DeGisi and Schell 1997c).

[61] Based on angling six kelts in the outlet stream (Envirocon Ltd.1984 Volume 3 Appendix C).

3.6.4 RAINBOW TROUT SPAWNING

3.6.4.1 Timing

Based on visual observations and the capture of ripe rainbow and kelts in the main spawning area in the Nanika River (below Nanika Falls), most rainbow trout spawned from mid-May to the end of the third week of June in 1979 and 1980. Observations suggested a three-week difference in the timing of spawning between years (Envirocon Ltd. 1984 Volume 3).

Studies conducted in the Nanika River between Nanika and Kidprice lakes and in Stepp Creek indicated rainbow spawning was underway during the period June 6-12th (Envirocon Ltd. 1984). Des Creek rainbow spawning had finished by the June 19th survey date in 1982.

3.6.4.2 Spawner Distribution

Morice Lake and River

Despite extensive efforts to locate Morice Lake rainbow trout spawning tributaries, the only sites identified were also the two main areas also utilized by Nanika sockeye (Figure 24). Most spawners used the upper main spawning site in 1979, while the distribution between the two spawning sites was approximately equal in 1980. Eight of 72 rainbow tagged on these spawning sites were recaptured in Morice Lake and the upper Morice River establishing a connection between the spawning sites and these other locations.

Angling and gillnet surveys on Morice Lake and the upper Morice River throughout May and June indicated that rainbow spawners were not present at these locations in mid-June[62]. No rainbow spawners or juvenile fish were sampled in the inlet tributaries to Morice Lake examined during 1979 and 1980 (Envirocon Ltd. 1984). Rainbow trout are not present in the Atna Lake system.

These results indicate the short section of the Nanika River upstream from Glacier Creek is critical to the Morice Lake and river rainbow trout population (Photo 2). Rainbow juveniles have been sampled in several inlet tributaries to the Nanika River suggesting rainbow trout spawning may also occur in these smaller streams.

Owen Lake

Surveys conducted in the Owen Lake watershed suggest that most rainbow trout in this lake probably spawn in Peter Aleck Creek, the main inlet to Owen Lake (Figure 24). Some spawning may also occur in the lake outlet and in Klate Creek, a small lake-headed tributary (Tredger 1981; Bustard 1999b).

Nanika-Kidprice Lakes

Rainbow trout spawning in these headwater lakes has been documented at three locations - the upper Nanika River at the outlet of Nanika Lake (99% of observations made in 1979), the mid-

[62] A single ripe rainbow was captured in the lake across from Atna Bay.

reach of Stepp Creek (1% of observations made in 1979), and in Des Creek (based on observations made in 1981 and 1982). Surveys in Des Creek in 1982 indicated this tributary has up to 3000 m^2 of potential rainbow trout spawning habitat at the outlet of Des Lake (Photo 13) and in the lower section of creek above Kidprice Lake (Envirocon Ltd. 1984 Volume 3).

Surveys conducted throughout the Nanika and Kidprice system indicated that most of the inlet tributaries to these lakes had little potential for spawning, although small numbers of rearing juveniles were found in several of them (Ministry of Environment 1979). Further observations during the rainbow spawning period in 1979 verified this conclusion of very little potential for rainbow trout spawning other than in the river section between the lakes (Envirocon Ltd. 1984 Volume 3).

Photo 13. Resident rainbow trout spawn in the outlet tributary between Des and Kidprice lakes.

The key spawning area identified in the upper lake system was an 80 m-long gravel section at the outlet to Nanika Lake (Photo 14). Spawning was scattered from this location down to the Bergland Creek confluence. A total of 335 rainbow spawners were observed in this section in early June 1979.

Observations were made at the rainbow trout redd sites at the outlet of Nanika Lakes during the summer of 1975. These studies suggested that fry emergence occurred during late August based on the presence of alevins at the redd sites up until at least August 20th (Ministry of Environment 1979).

The results of seining along the lake shoreline of Nanika and Kidprice lakes, especially near creek mouths, indicated that some rainbow enter these lakes as fry. However sampling throughout Des Creek indicated that at least three age classes of juvenile rainbow trout were present in this tributary during the June survey (Envirocon Ltd. 1984 Volume 3), suggesting rainbow populations in these upper lakes have several life history strategies.

Photo 14. An 80-m long stream section at the outlet of Nanika Lake is a key spawning section for rainbow trout in the upper lakes system.

3.6.4.3 Spawning Site Characteristics

Key rainbow trout spawning sites throughout the Morice were located in lake-headed tributaries where water conditions were clear despite high flows during the snowmelt freshet.

Water temperatures during the spawning period in the Nanika River below Nanika Falls ranged from 5 to 9.5ºC during the spawning period. Depth and velocity measurement in the vicinity of the two spawning sites in 1979 indicated that fish were spawning at an average depth of 2 m, with nose velocities ranging from 25 to 55 cm/sec (Envirocon Ltd. 1984 Volume 3).

Water temperatures in the key spawning area at the outlet of Nanika Lake were 7.5ºC during the spawning period. Mean water depth ranged from 45-54 cm and velocities averaged 43-52 cm/sec during two visits[63]. Temperatures at spawning sites in Stepp Creek were 9 C with a mean depth of 38 cm and velocities averaging 56 cm/sec (Envirocon Ltd. 1984 Volume 3).

3.6.5 RAINBOW TROUT LIMITING FACTORS

The following factors may limit rainbow trout production in the Morice Watershed:

3.6.5.1 Interspecies Competition

Resident rainbow are either not present or in low abundance at locations where significant steelhead populations occur. We suspect there is direct competition between steelhead and resident rainbow since the habitat requirements of the juveniles are indistinguishable. The Nanika River is used to a lesser extent by steelhead, and offers suitable habitat for resident rainbow trout without significant competition from steelhead[64].

3.6.5.2 Stable Spawning Locations

The main rainbow trout spawning areas at the outlet of Nanika Lake and below Nanika Falls are located in very stable environments presumably leading to minimal redd scour. Water temperatures are also adequate to enable incubation to occur quickly enough for fry to emerge and still put on some growth prior to winter.

Many of the inlet tributaries along Morice, Nanika and Kidprice lakes tend to be cold, are relatively steep gradient leading to channel instability during the snowmelt period, and can carry high sediment loads during the spawning period. Inlet tributaries along Owen Lake are subject to low, late summer flows, and subject to dewatering before fry emergence might occur.

3.6.5.3 Unproductive Rearing Environment

Rainbow trout utilizing Morice Lake are slow-growing and late maturing, presumably reflecting a low productivity rearing environment. Adult populations appear to be opportunistic and take advantage of specific food sources such as feeding at the mouth of inlet tributaries in Morice Lake or moving into the upper Morice River during the salmon spawning period.

Most rainbow trout populations in the Morice Watershed are associated with lakes. Without associated lake systems, the headwater residents reported in upper Houston Tommy Creek and upper Fenton do not achieve a size much larger than 20 cm. We suspect the small size of headwater residents reflects limited food availability.

3.6.5.4 Nanika River Juvenile Rearing

At least some populations of resident rainbow trout reside in inlet streams prior to lake entry. We assume the Morice Lake rainbow juveniles utilize the Nanika River for up to three years prior to lake entry. Observations of rearing fish utilizing this river indicate they are subject to

---

[63] Based on 25 measurements made during visits on June 6 and 12, 1979.

[64] Steelhead do not typically pass through lakes and spawn in inlet tributary streams.

dewatering and freezing in side channel habitats, as well as possible displacement during floods. These environmental extremes may impact juvenile recruitment into Morice Lake and ultimately influence eventual fish populations.

3.6.5.5 Angling Pressure

We suspect that up until 1980, high angling pressure associated with the salmon fishery in the upper river probably impacted the Morice rainbow population. The tighter regulations closing the upper Morice River during the chinook salmon spawning period[65] imposed in 1980 eased the angling pressure on this population of fish.

The quality rainbow fishery at Des Lake could be impacted by developing easy access to this lake resulting in increased angling pressure.

3.6.6 RAINBOW TROUT INFORMATION GAPS

- The Morice Lake rainbow population is probably the most significant population in the watershed. Of particular interest is the status of this population and whether or not other spawning sites than the Nanika River exist. A radio-telemetry study would help to identify other locations, but is not a high priority given the extent of past studies looking for spawning areas for this group of fish.
- Any lake enrichment work on Morice Lake should include growth and abundance studies of the rainbow trout population.
- Genetic sampling of Nanika River and tributaries juvenile rainbow to determine whether these fish are progeny of steelhead or resident rainbow trout is important in terms of understanding the strategies of rainbow and steelhead in this watershed.

[65] The upper river is closed until September 30th.

3.7 CUTTHROAT TROUT

3.7.1 CUTTHROAT TROUT LIFE HISTORY INFORMATION

Information compiled mainly during forest inventories in the Gosnell and Tagit creek watersheds, provides a reasonable background of the typical life history pattern of resident cutthroat populations in the Morice Watershed.

Timing of cutthroat spawning is based on observations in Tagit Creek (Bustard 1998d). Ripe cutthroat spawners were captured in Tagit Creek during the end of May, while kelts were captured from mid-June through early July indicating most cutthroat spawning occurs during June.

Newly-emerged cutthroat trout fry (25-30 mm fork length) were captured in Gosnell tributaries during the period August 10-20th. Many fry during this period were larger suggesting that most cutthroat emergence occurred during July and early August.

Sampling during mid-August and September indicated that three age classes of cutthroat were present in Gosnell tributaries (age 0+ to age 2+). We suspect that most cutthroat parr larger than 100 mm move into pond and lake habitats associated with those streams used for spawning and rearing.

Cutthroat trout in the 27-30 cm fork length range have been angled in small lakes along the mainstem Gosnell (Bustard 1998a). The largest cutthroat taken during lake surveys in Julian Holland Lake was 31 cm fork length (Degisi and Schell 1997a), and cutthroat trout spawners in Tagit Creek ranged from 20 to 28 cm fork length.

Taylor and Seredick (1968) reported three cutthroat angled in upper Morice River were between 28-34 cm fork length, a similar size to the four cutthroat trout reported in the creel survey at Morice Lake during 1979 (Envirocon Ltd. 1984).

3.7.2 CUTTHROAT TROUT DISTRIBUTION

In their review of cutthroat trout distribution in the Morice, Applied Ecosystem Management (2001) indicated cutthroat were present in 24 of the 69 watercourses for which data was found. Cutthroat trout distribution based on a search of FISS files is shown in Figure 25.

Cutthroat trout are uncommon in the mainstem Morice River, Morice Lake and the Nanika River. For example, during the fall of 1976, only 13 cutthroat were reported angled in the Morice River between Morice Lake and Peacock Creek[66]. Only two juvenile cutthroat were sampled in the mainstem Morice River during all of the Kemano Completion studies (Envirocon Ltd. 1984). We suspect cutthroat trout use of the mainstem Morice River and Morice Lake is probably comprised of incidental fish that drop out of tributary streams. Similarly, only a single cutthroat trout was captured in the Nanika River below Kidprice Lake during two years of study (Envirocon Ltd. 1984 Volume 3), although they are present in tributary streams to the Nanika (BCCF 1999).

---

[66] On file, WLAP, Smithers as reported in Envirocon Ltd. (1984).

Cutthroat trout have a widespread distribution in the Gosnell Watershed including throughout the Shea Lake watershed above the barrier falls. However, they were not present in the mainstem habitats in Gosnell, lower Shea or Crystal creeks. Cutthroat trout were not present in the Thautil Watershed, probably reflecting the lack of accessible lake habitat in this tributary (Bustard 1997a).

Cutthroat trout are present in larger lakes and associated tributaries within the watershed including McBride, Collins, Chisholm, Julian Holland and many smaller lakes and ponds. Cutthroat trout were also sampled in smaller tributaries to the Morice River including Peacock, Cedric, Gold, Trapper Cabin and 24.5 Mile creeks (Envirocon Ltd. 1984).

In the Owen Watershed cutthroat trout were only present in Klate Lake. We suspect these fish were stocked in this lake (Bustard 1998b).

3.7.3 KEY CUTTHROAT HABITATS

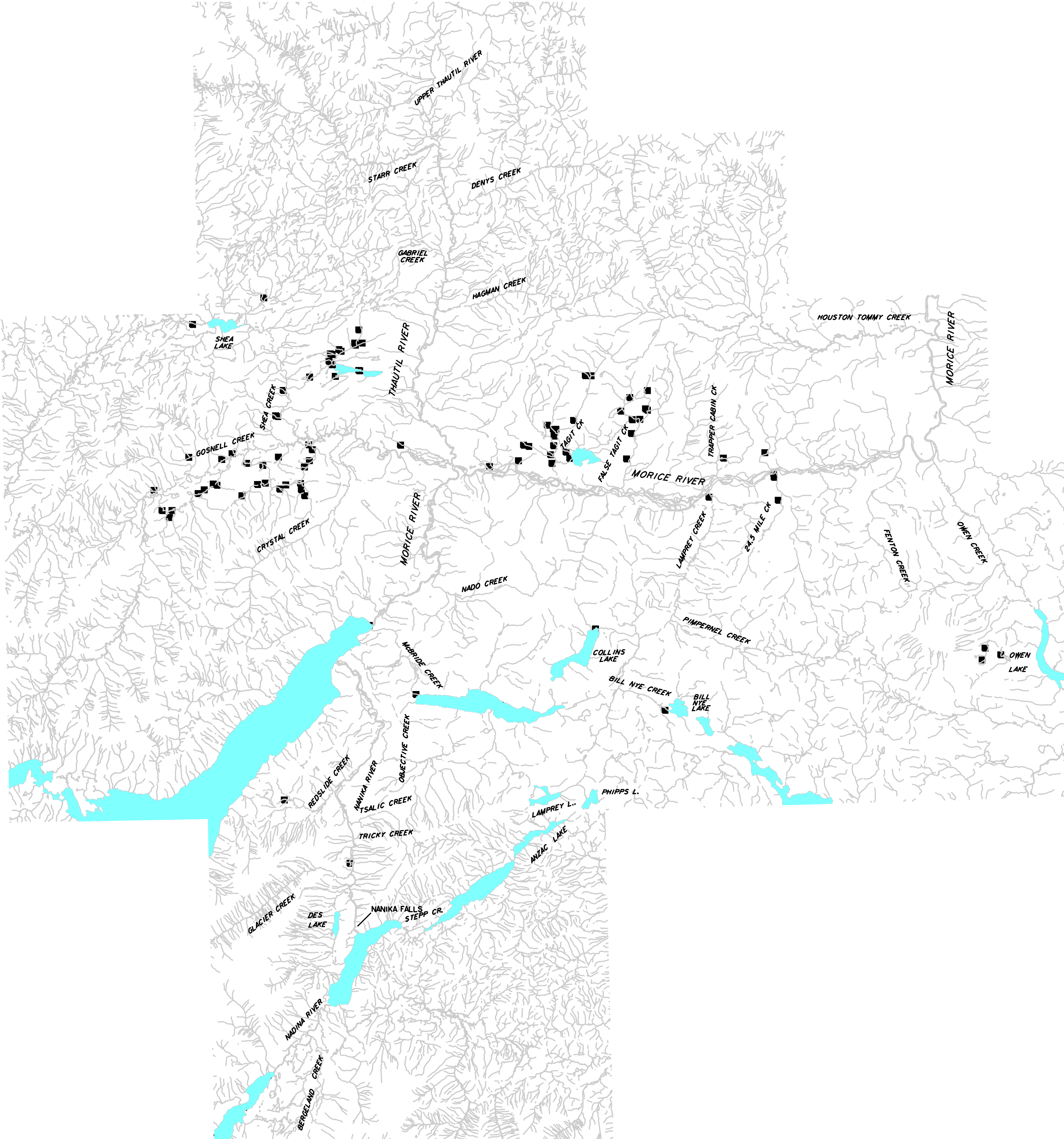
Based on watershed-wide inventories in the Gosnell (Bustard 1999a) and Tagit (Bustard 1998d) watersheds cutthroat trout appear to be dispersed in the lower and mid-reaches of these systems in smaller tributaries that have lake and pond habitat (Photo 14). We suspect that the lakes and ponds are utilized by the older age classes of cutthroat, and that juvenile cutthroat must be able to freely move between stream and lake habitat. Spawning appears to occur over a range of sites within the tributary streams, and those systems with a combination of spawning sites, adequate early stream rearing for juveniles, and a lake/pond complex for older fish are the key cutthroat streams.

Photo 14. Cutthroat trout use habitats with lakes and associated tributaries such as this site in Gosnell Creek.

Based on a sample of 42 sites where cutthroat trout were sampled in Gosnell Creek, stream gradients ranged from 0 to 8% (mean 2.8%) with channels widths down to 1 m wide (Bustard 1998a).

3.7.4 CUTTHROAT TROUT HABITAT PROTECTION ISSUES

- Most habitat issues for cutthroat trout in the watershed are linked to stream crossings and the ability of juvenile cutthroat to move between spawning and rearing areas and upstream ponds and lakes. Poorly installed crossing structures that do not allow for juvenile movements could be critical in the maintenance of cutthroat populations.
- Cutthroat trout utilize small streams and careful attention to protecting riparian areas and upstream sites from sediment, hydrological changes leading to low flow and peak flow impacts, and increased water temperatures are important on these small systems. The small lakes and ponds in the watershed provide some opportunity for a sport fishery for fish up to just over 30 cm fork length. Road development and access management to the smaller ponds and lakes compared to larger lakes such as Julian Holland should be a factor in forest development planning in the watershed.



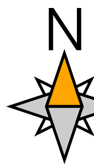


FIGURE 25

CUTTHROAT TROUT

DISTRIBUTION IN MORICE WATERSHED

■ Point locations derived from FISS data query

NOTE: CUTTHROAT TROUT ARE WIDELY DISTRIBUTED IN THE MORICE TRIBUTARIES AND SMALL LAKES NOT SHOWN ON THIS MAP

MAP BASE: NAD83 TRIM 1. MINISTRY OF FORESTS FOREST COVER 1:20000

MAY 2002
MAPS PRODUCED BY:
LAING & McCULLOCH FOREST MANAGEMENT SERVICES LTD.

AQUATIC HABITAT INFORMATION
COMPILED BY:
DAVID BUSTARD & ASSOCIATES LTD.

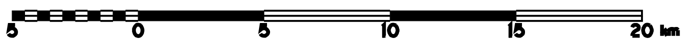


Figure 25. Cutthroat trout distribution in the Morice Watershed.

3.8 BULL TROUT

Bull trout were not treated as a separate species from Dolly Varden until studies by Cavender (1978) and Haas and McPhail (1991). Bull trout in British Columbia are now designated as a blue-listed species with populations considered vulnerable and at risk. They are the only fish species given *identified wildlife* status under the Forest Practices Code and with this listing they receive special management consideration to protect key habitat components. Bull trout are listed as an endangered species in the United States and extensive restoration programs have been undertaken throughout Western Canada to address concerns that many populations have declined sharply from historical levels.

During the past decade a huge effort has gone into developing a better understanding of bull trout biology and assessing appropriate management tools for this species culminating with several major conferences devoted to exchanging information between managers and researchers (Mackay et al. 1994; Brewin et al. 1999). McPhail and Baxter (1996) provide a good summary of studies to date describing habitat requirements.

There have been a number of studies of bull trout in the Morice River. The earlier studies refer to the char in the mainstem Morice as Dolly Varden, but we now know nearly all of these mainstem fish are, in fact, bull trout. Taylor and Seredick (1968) collected information describing upper Morice River char during the late 1960's. Studies associated with Kemano Completion describe mainstem char populations in the upper 13 kms of the Morice River based on a series of snorkel surveys conducted between March and November 1979 (Envirocon Ltd. 1984). Additional information, including tag recaptures, was also collected in the upper Nanika River and in Morice Lake as part of the Kemano completion studies.

Char studies conducted in the Morice Watershed since the mid-1990's have separated bull trout and Dolly Varden juveniles and adults. Forest inventory studies in the Thautil River (Bustard 1997a) and the Gosnell (Bustard 1999a) indicated that both Dolly Varden and bull trout were present throughout these watersheds. A major extension of our understanding of bull trout populations in the Morice Watershed has come with radio-telemetry studies conducted during 2000 and 2001 (Bahr 2002).

3.8.1 BULL TROUT POPULATION STATUS AND TRENDS

We can only speculate about the present status of bull trout populations in the Morice Watershed relative to their potential. McPhail and Baxter (1996) indicate that bull trout are vulnerable to overfishing in systems with good access. Sport fishing has been occurring in the Morice River since the early 1950's. Perhaps John Fennelly, one of the earliest anglers to record his activities in the upper Morice, sums up the attitude of earlier angler's to bull trout with the following comments about fishing during these early years in his book *Steelhead Paradise*. "Because they prey on young rainbows and salmon fry we always killed the Dolly Varden and left them on the shore for bears and eagles."

Angler surveys between September and early December 1976 estimate 295 bull trout were angled between Barrett and Morice Lake[67]. A creel survey conducted on Morice Lake during 1979 estimated 88 bull trout angled in the lake (Envirocon Ltd. 1984). Bahr (2002) tagged 93 bull trout adults (larger than 40 cm) during radio-telemetry studies using at least 74 angler-days of effort.

Due to the difficulty of conducting adult bull trout counts, many studies have resorted to using redd counts to provide an index of bull trout population status. Limited redd counts are available in the Morice Watershed. Bahr (2002) counted 82 bull trout redds in the key spawning area of the upper Gosnell River (Figure 26). This compares to 47 redds counted in this same section in 1998 (Bustard 1999a).

The maximum number of bull trout counted during snorkel surveys in the upper 13 kms of the Morice River[68] was 74 during early October 1979 (Envirocon Ltd. 1984). A total of 22 adult bull trout were observed during a March 1998 snorkel surveys in an 8-km long section of the Morice downstream from Owen Creek (Bustard 1998b). These incidental observations along with the redd counts, together suggest that the total bull trout population in the Morice Watershed might be quite small. We could very well be dealing with a potential spawning population of less than 1000 fish.

3.8.2 BULL TROUT LIFE HISTORY INFORMATION

Adult bull trout in the Morice Watershed typically range from 30-60 cm fork length (Table 8). We suspect that most spawners exceed 35 cm fork length, and that bull trout between approximately 14 and 35 cm that rear in the mainstem Morice and Nanika rivers are sub-adults that drop out of the rearing tributaries.

Table 8. Summary of bull trout fork lengths in the upper Morice River, Morice Lake and the upper Nanika River.

	Mean FL (cm)	Range (cm)	Sample Size
		Upper Morice River	
Bahr (2002)	45.6	38-54	21
Taylor and Seredick (1968)	38.0	27-49	51
		Morice Lake	
Bahr (2002)	42.5	40-47	3
Envirocon Ltd. (1984)	39.2	30-61	39
		Nanika River	
Bahr (2002)	48.0	37-74	31
Envirocon Ltd. (1984)	47.4	30-80	37

[67] Data on file, WLAP, Smithers.
[68] The upper Morice River was identified as a key feeding and overwintering area for Morice bull trout (Bahr 2002).

For example, only two of 214 juvenile bull trout sampled in the Thautil River and Gosnell Creek exceeded 12 cm (Bustard 1997a and 1999a). Nearly all bull trout rearing in these tributaries were fish age 2+ or less.

A component of the Nanika River bull trout population may be larger than bull trout found in other parts of the watershed. Three larger bull trout (64 to 75 cm fork length and 11 to 14 years in age) tagged by Bahr (2002) eventually spawned in Glacier Creek[69]. Three larger bull trout (80 cm fork length) were also sampled in the Nanika River below Nanika Falls in 1979 (Envirocon Ltd. 1984). These data suggest that a component of the Nanika River run that spawns in Glacier Creek may achieve a larger size than other bull trout in the Morice River.

Data presented in Bahr (2002) indicates that there is considerable movement of bull trout between the Nanika River, Morice Lake and the Morice River and tributaries below the lake, suggesting a single population of fish. However, the large size of some of the Nanika bull trout along with preliminary genetic sampling results suggest that bull trout spawning in the Nanika/Glacier Creek have grouped separately from the Thautil/Gosnell spawners, evidence suggesting possible subpopulations of bull trout in the Morice. Alternatively, the larger spawners in Glacier Creek may simply reflect the older age the Nanika population may achieve due to lower angling pressure compared to Morice fish.

Bustard (1997a) found stream resident populations of bull trout present in the Thautil headwaters upstream from falls barrier on both the East and West Forks of Starr Creek (Figure 26).

Age data presented in Bahr (2002) indicates that bull trout growth rates are slow during the first three years[70]. Coinciding with young bull trout migrating down into the Morice or Nanika rivers at approximately age 3, growth rates increase to approximately age 7 or 8 when growth tends to slow down. Much of the aging information collected for Morice bull trout presented in the forest inventory studies and in Bahr (2002) is based on fin rays that tend to underestimate bull trout ages by one year.

3.8.3 BULL TROUT SPAWNING

3.8.3.1 Timing

Bull trout movement to the spawning grounds spanned a broad period from June through September during the two years of telemetry studies (Bahr 2002). However, spawning occurred during a relatively narrow window from approximately August 23 to September 15. Fish typically spent 8 to 14 days at the spawning sites.

Only three of the radio-tagged bull trout spawned in consecutive years during the study, and a number of fish that were tracked over the two-year period did not appear to spawn in either year.

---

[69] Incorrectly referred to as Redslide Creek in Bahr (2002).

[70] Most bull trout aging information in the Morice Watershed is based on fin rays. Data presented in Bahr (2002) and collected at Kemess (Bustard 2002) shows that fin rays often result in underage estimates.

3.8.3.2 Spawner Distribution

Bull trout spawner distribution in the Morice Watershed is outlined in Figure 26**.** Telemetry studies undertaken by Bahr (2002) indicate spawning occurs in upper Gosnell Creek and in a large tributary (Crystal Creek), Denys, Houston Tommy and Gold creeks, and in Glacier Creek in the Nanika (Table 9).

Gosnell Creek fish accounted for 42% of the tributary bull trout observations during the telemetry studies. Bahr (2002) identified 82 redd sites in the upper Gosnell and an additional eight redds in Crystal Creek. Previous inventories had identified the main spawning areas in upper Gosnell Creek and in Crystal Creek based on observations of 57 redds in the upper Gosnell and four redds in Crystal Creek (Bustard 1999a).

The Thautil River accounted for 29% of the bull trout tributary observations during the telemetry studies (Table 9). Bahr (2002) identified 17 bull trout redds in Denys Creek. Bull trout spawning in Denys Creek had been identified during forest inventory studies in this system with two bull trout redds located in Loljuh Creek (tributary to Denys Creek) and a single redd located farther upstream in Denys Creek than noted in the telemetry studies (Bustard 1997a).

None of the telemetry fish spawned in the East Fork of Starr Creek, an area where six bull trout redds were identified during inventory studies (Bustard 1997a). A single fish was noted in the lower section of the East Fork of Starr during the spawning period.

Table 9. Percentage distribution of bull trout using Morice and Nanika tributaries during the spawning period[71].

System	Number Bull Trout	Percent
Gosnell Creek	26	41.9
Thautil River	18	29.0
Gosnell and Thautil	2	3.2
Glacier (Redslide)	9	14.5
Houston Tommy Creek	3	4.8
Gold Creek	4	6.5
Total	62	100

The telemetry studies identified bull trout spawning in Houston Tommy and Gold creeks, as well as the important discovery of bull trout spawning in Glacier Creek in the Nanika River. The Kemano Completion project had assumed that there was no significant fish use of this tributary and had proposed to re-direct Glacier Creek into Kidprice Lake.

It should be emphasized that Morice-Nanika bull trout spawning tributaries arise in high elevations areas with glaciers and permanent snow fields that keep stream temperatures cool. For example, maximum daily water temperatures in the vicinity of spawning sites in Gosnell and

[71] Data derived from Bahr (2002).

Denys creeks did not exceed 10ºC during the summer of 2001. Tributaries with lakes or that drain areas with primarily low to mid-elevation terrain are not used by bull trout. These systems include Owen, Lamprey, Shea, Tagit Creek and adjacent streams and Fenton Creek and adjacent creeks (Bustard 1998a to c).

3.8.3.3 Characteristics of Spawning Areas

Bahr (2002) collected detailed physical measurements at 109 bull trout redd sites during her study. Redds were in gravel bed material with redd dimensions averaging 1-2 m^2. Water velocities at redd sites were 30-50 cm/sec and depths were 30-40 cm. Many of the redd sites were within 2 m of some form of cover. These characterisitics are similar to information for other bull trout populations in B.C. reported in Baxter and McPhail (1996).

Water temperatures in the vicinity of spawning sites in the upper Gosnell and in Denys Creek did not exceed 9ºC at any time during the summer (Figure 5), and were less than 8ºC during the spawning period despite water temperatures several degrees higher in the lower sections of these two streams (Bahr 2002).

Bustard (1997a and 1999a) indicated that all bull trout spawning sites in Gosnell Creek and Thautil watersheds were located in stream reaches exceeding 7 m channel width and in gradients ranging from 1 to 4%. Spawning sites tend to be in the upper accessible sections of the Morice tributaries, sometimes just below barriers. Presumably this maximizes fry dispersal into downstream rearing areas. Some of the spawning locations such as those in East Starr Creek and the upper Gosnell are characterized by seepage channels and the spawning success at these areas may be linked to groundwater inflows.

3.8.4 BULL TROUT STAGING AREAS

Bull trout often stage in areas prior to migration into spawning sites. Identification of staging areas is very important for this species, since they may hold at locations for a considerable length of time during the late summer period when they may be particularly vulnerable to angling.

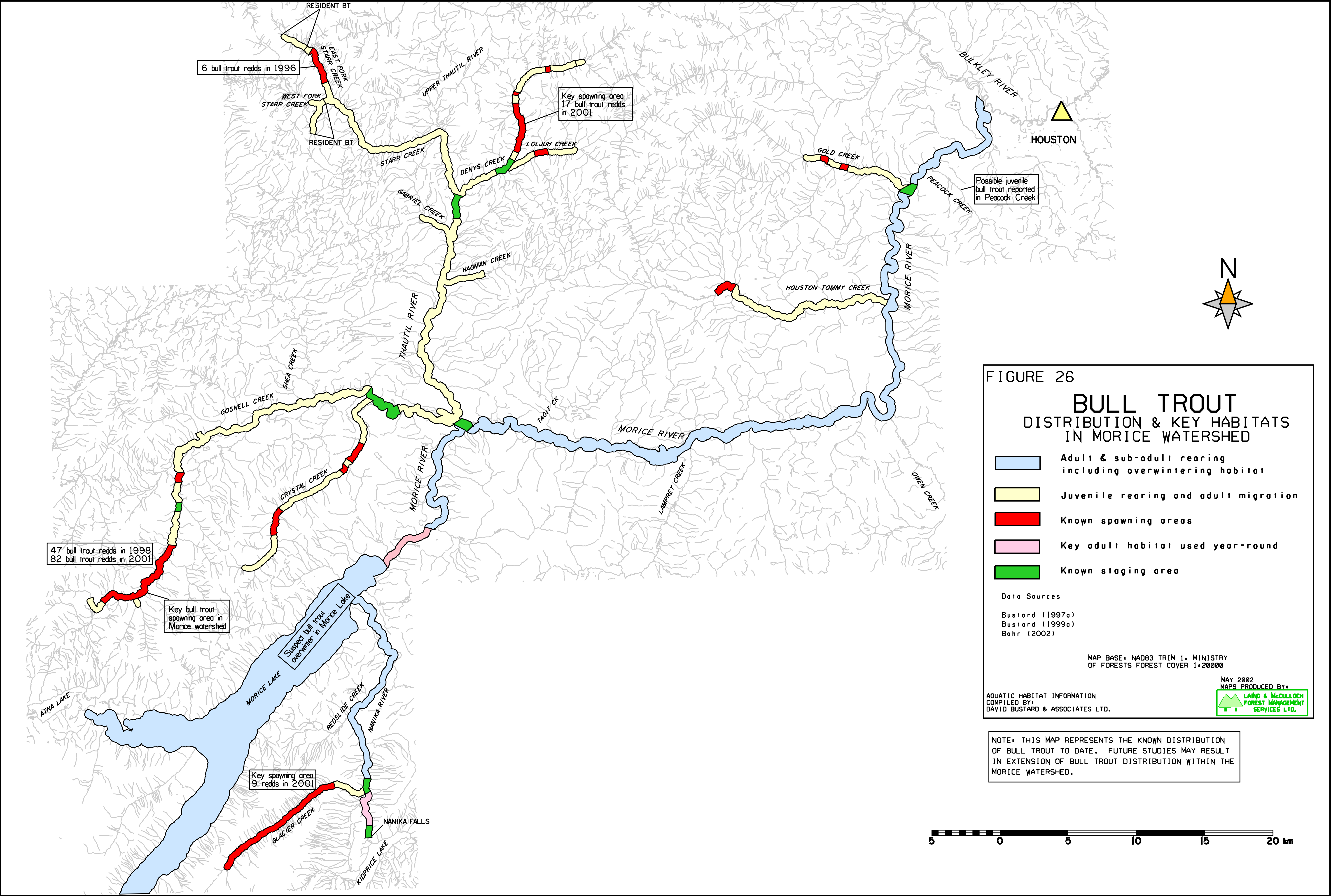
Bahr (2002) identified five key staging areas during her studies: The Thautil/Gosnell confluence; various pools in Gosnell especially in the vicinity of Crystal Creek, the confluence of Denys Creek and the Thautil River, the Morice River at the confluence of Gold Creek, and the confluence area of Glacier Creek and the Nanika River. We have added an additional staging area identified by Hatlevik (1981) located just downstream from a 1.9 m falls in the mid-reaches of Gosnell Creek (Photo 15). The location of these staging areas is shown in Figure 26.

Photo 15. Bull trout stage below this 1.9 m falls on Gosnell Creek during the late summer. The most important bull trout spawning areas in the Morice are located in the Gosnell mainstem upstream from this site.

3.8.5 BULL TROUT ADULT OVERWINTERING AREAS

Bull trout overwintering information was collected by Bahr (2002) during the telemetry studies. These studies indicated that bull trout overwintered throughout the Morice River, particularly in the vicinity of the Morice Lake outlet. Three fish overwintered in the Bulkey River and four of the tagged bull trout overwintered in Morice Lake. The upper Nanika River was also an important overwintering area for bull trout adults. None of the tagged fish overwintered in any of the tributaries.

Most (25) of the 41 tagged fish followed through the winter remained relatively stationary between mid-November and mid-March. Many of these fish made specific migrations to overwintering areas during the month prior to mid-November. Some bull trout continued movements during the winter period including one fish that moved from the outlet of Morice Lake downstream to the vicinity of Telkwa in the Bulkley River between mid-November and mid-December.



RESIDENT BT
6 bull trout redds in 1996
EAST FORK STARR CREEK
WEST FORK STARR CREEK
RESIDENT BT
UPPER THAUTIL RIVER
Key spawning area 17 bull trout redds in 2001
LOLJUH CREEK
DENYS CREEK
STARR CREEK
GABRIEL CREEK
HAGMAN CREEK
THAUTIL RIVER
BULKLEY RIVER
HOUSTON
GOLD CREEK
PEACOCK CREEK
Possible juvenile bull trout reported in Peacock Creek
HOUSTON TOMMY CREEK
MORICE RIVER
SHEA CREEK
GOSNELL CREEK
TAGIT CK
MORICE RIVER
CRYSTAL CREEK
MORICE RIVER
LAMPREY CREEK
OWEN CREEK
47 bull trout redds in 1998
82 bull trout redds in 2001
Key bull trout spawning area in Morice watershed
Suspect bull trout overwinter in Morice Lake
MORICE LAKE
ATNA LAKE
REDSLIDE CREEK
NANIKA RIVER
Key spawning area 9 redds in 2001
GLACIER CREEK
NANIKA FALLS
KIDPRICE LAKE
N
FIGURE 26
BULL TROUT
DISTRIBUTION & KEY HABITATS IN MORICE WATERSHED
Adult & sub-adult rearing including overwintering habitat
Juvenile rearing and adult migration
Known spawning areas
Key adult habitat used year-round
Known staging area
Data Sources
Bustard (1997a)
Bustard (1999a)
Bahr (2002)
MAP BASE: NAD83 TRIM 1. MINISTRY OF FORESTS FOREST COVER 1:20000
MAY 2002
MAPS PRODUCED BY:
LAING & McCULLOCH FOREST MANAGEMENT SERVICES LTD.
AQUATIC HABITAT INFORMATION COMPILED BY:
DAVID BUSTARD & ASSOCIATES LTD.
NOTE: THIS MAP REPRESENTS THE KNOWN DISTRIBUTION OF BULL TROUT TO DATE. FUTURE STUDIES MAY RESULT IN EXTENSION OF BULL TROUT DISTRIBUTION WITHIN THE MORICE WATERSHED.
5 0 5 10 15 20 km

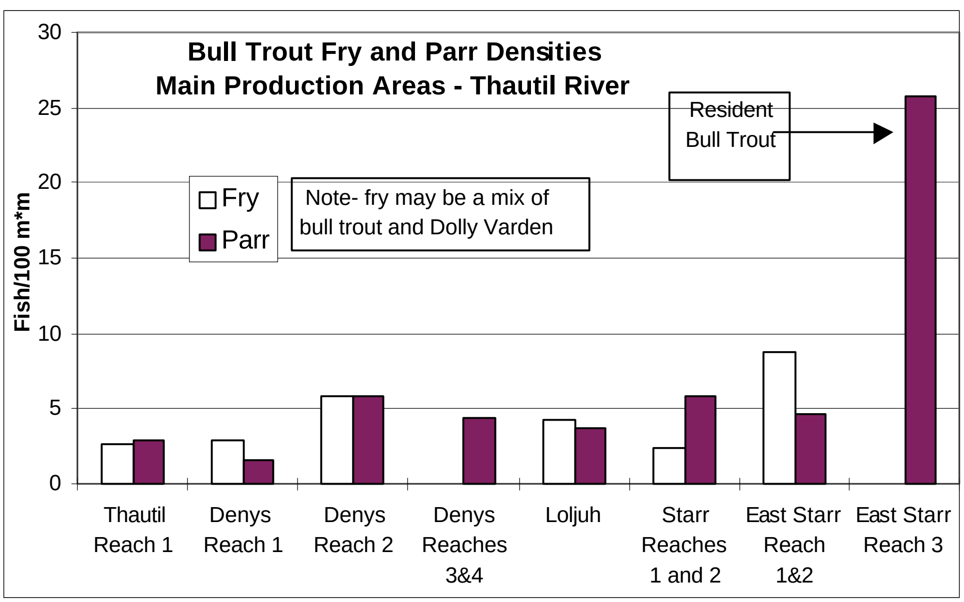
Figure 26. Bull trout distribution and key habitats in the Morice Watershed.

3.8.6 JUVENILE BULL TROUT REARING

Juvenile bull trout were located in low densities in stream sections below bull trout spawning areas in Morice tributaries. For example, in Gosnell Creek bull trout juvenile densities did not exceed 5 fish/100 m^2 of habitat and in most reaches were less than 2 fish/100 m^2 (Bustard 1999a). The low densities of juvenile bull trout in the Gosnell Creek would not account for the number that might be expected given the abundance of redd sites in upper Gosnell Creek. Studies in Goathorn Creek (Bustard 1997b) and Kemess Creek (Bustard 2002) suggest that bull trout may move from spawning and fry rearing locations to specific downstream sites used by yearling fish. The sample sites in Gosnell Creek may have been too widely dispersed to identify the key rearing locations.

Low juvenile bull trout densities were also obtained at index sites located throughout the Thautil River, although juveniles were more widely distributed and numerous throughout the Thautil River than in Gosnell Creek (Figure 27). The Thautil River juvenile bull trout densities are quite comparable to bull trout yearling densities measured in Kemess Creek for the past eight years. Despite considerable variation in fry abundance, yearlings have averaged 6 to 8 fish/100 m^2 in this system every year of study (Bustard 2002).

Figure 27. Comparison of bull trout fry and juvenile densities in the main bull trout areas in the Thautil River[72].



Juvenile bull trout have been sampled in the lower reaches of several tributaries in Gosnell Creek and the Thautil River where spawning has not been identified (Figure 26). It is assumed that bull trout juveniles might move into these tributaries after emergence. Hagman Creek in the lower Thautil may be utilized by bull trout spawners.

[72] Data from Bustard (1997a).

It is interesting to note the exceptionally high densities of bull trout present in the upper reach of East Starr Creek (Figure 27). These densities may reflect the lack of competition from any other fish species in this headwater location.

Based on a sample of 33 locations throughout the Thautil River and Gosnell Creek, bull trout reared in streams with gradients ranging from 1 to 14.5% (mean 3.2%). Channel widths ranged from 1.5 m to 53 m wide.

3.8.7 LIMITING FACTORS TO BULL TROUT PRODUCTION

McPhail and Baxter (1996) discuss a number of factors that may control bull trout populations including juvenile rearing capacity in spawning streams as well as lack of suitable spawning sites. We suggest a number of these factors strongly influence bull trout distribution in the Morice and lead to limitations to production:

3.8.7.1 Low Water Temperatures

Bull trout are clearly a cold-water species. Their distribution in the Morice is strongly correlated with the coldest systems in the watershed. These are the systems with glaciers and permanent snowfields that maintain cool summer temperatures and late summer streamflows at moderate levels during the migration period. Spawning sites rarely exceed 10ºC and juvenile bull trout rearing area temperatures typically do not exceed 12ºC[73]. This agrees with observations of bull trout elsewhere as reviewed in Baxter and McPhail (1996).

It is interesting to note that researchers (McPhail and Murray 1979) report bull trout fry grew larger and had better survival at low water temperatures (4ºC). We have observed bull trout fry and yearlings active in side channels of Kemess Creek at water temperatures near 1ºC during mid-October. Most other rearing salmonids are inactive and haved moved into overwinter cover at these temperatures.

3.8.7.2 Interspecies Competition

Bull trout juveniles in Morice tributaries tend to be most abundant in those stream sections that are not utilized by steelhead and coho salmon. Bull trout are probably not effective competitors with these other species in the lower reaches of tributaries that achieve warmer temperatures. However, they have a competitive advantage in the upper reaches based on their adaptation to cold water compared to these other species.

Dolly Varden are more tolerant of a wider range of temperature conditions than bull trout, and are far more widely distributed in tributaries in the Morice. Observations at Kemess suggests that the presence of resident Dolly Varden sub-adults and adults may cause bull trout to drop out of the tributaries earlier in areas where the two species occur together, compared to sites where no Dolly Varden are present. This suggests competition amongst larger juveniles of the two species.

---

[73] Based on data presented in Bahr (2002). Mean daily water temperatures in Houston Tommy, Crystal, upper Denys and upper Gosnell did not exceed 10ºC during the summer of 2001.

3.8.7.3 Suitable Spawning Habitats

Although there is wide consistency across river systems in terms of the physical descriptions of spawning sites, it is not clear why bull trout select sites in only a small fraction of the apparently suitable areas. The influence of groundwater has been identified as an important feature of spawning area. However, our observations in the Morice tributaries suggest that lack of suitable spawning sites is probably not a significant limiting factor in most cases. Redds were typically well dispersed within the main spawning areas, and there was not evidence of redd crowding in potential spawning areas in the upper Gosnell and Denys Creek sites (Bustard 1997a and 1999a).

The stability of redd sites would be an issue, particularly in systems such as Crystal and Glacier creeks. These tributaries are highly dynamic and we suspect that late fall freshets in bull trout spawning sites could lead to poor fry survival at redd sites in these systems during some years. For example, Bahr (2002) was unable to locate redd sites in Glacier Creek after late September following freshet conditions.

3.8.7.4 Early Fry Rearing

Cold springs leading to a late snowmelt freshet has been identified as an important factor affecting bull trout fry survival in Kemess Creek (Bustard 2002). Late freshets may lead to fry displacement. Side channel locations buffered from the full freshet flows appear to be important refuge areas for bull trout fry during freshet conditions at Kemess. We suspect these same conditions apply to the Morice.

3.8.7.5 Predation

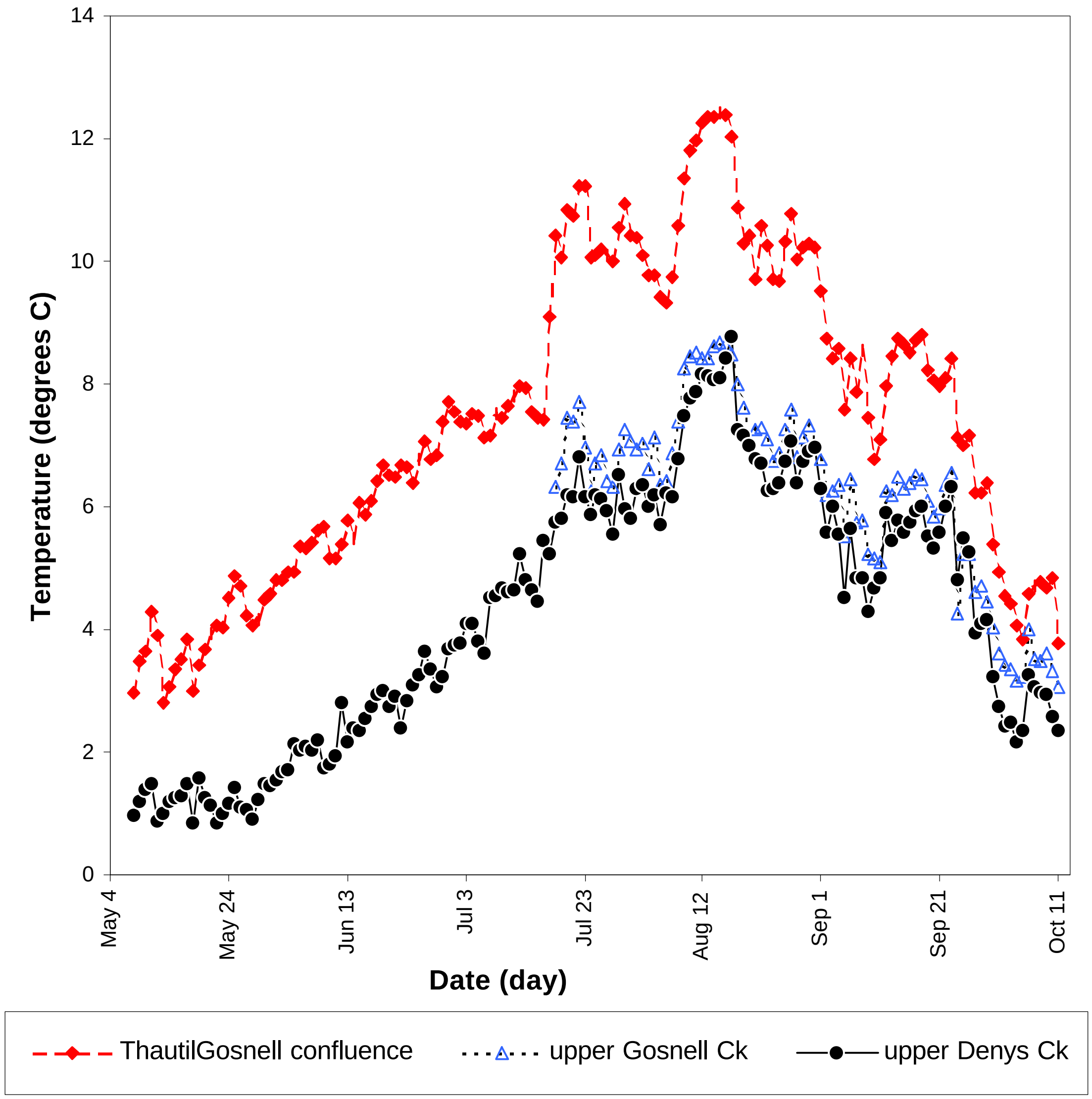
Bahr (2002) reported high mortalities (nearly 40%) of bull trout adults during her radio-tagging study in the Morice. It was suggested that high visibility at low streamflows combined with spawning activity increase the vulnerability of bull trout to predation. This level of mortality for a slow-maturing species that can live to at least age 14 in the Morice seems too high. For example, less than 10 bull trout carcasses have been found after 8 years of ground surveys on a population of bull trout spawners exceeding 400 fish, in Thutade Watershed. These results suggest low natural mortality rates on the spawning grounds in that study (Bustard 2002).

3.8.7.6 Angling

After examining factors affecting bull trout populations, McPhail and Baxter (1996) concluded that "… it is now clear that over most of the species' range human activities are the major cause of population declines".

Morice bull trout adults spend much of their time in areas accessible to anglers. The mainstem Morice River and to a lesser extent, the upper Nanika River receive considerable angling activity. Anglers in the Nanika and Morice rivers returned tags from three of 30 bull trout tagged during 1979 and 1980 (Envirocon Ltd. 1984.) Use of the Kidprice Lake area for recreation has increased since that period, and we suspect that bull trout in the Nanika Falls area may be vulnerable to angling pressure.

Figure 28. Average daily water temperatures in the vicinity of bull trout spawning sites in the upper Gosnell and Denys creeks compared to temperatures in the vicinity of the Gosnell-Thautil confluence with the Morice River[74].



Anglers returned one transmitter from 93 tagged bull trout in the Morice River study (Bahr 2002). However, an additional nine tagged fish disappeared and may have been taken by anglers. Bahr suggests that the key bull trout staging area at the Thautil-Gosnell confluence is an area particularly susceptible to angling pressure. Studies during the past decade[75] have indicated that changes in angling regulations for bull trout have lead to significant, and in some cases, spectacular improvements in bull trout spawner recruitment. These results indicate that angling had a major influence on bull trout populations in accessible river systems.

---

[74] Data from Bahr (2002).

[75] Allan (1999) in Line Creek and Bill Westover (WLAP, personal communication) in Wigwam River BC.

Anglers in the Morice are permitted daily catch quotas of up to three bull trout per day between 30 and 50 cm fork length. This size range encompasses most of the adult bull trout size range in the Morice population (Table 8).

3.8.8 BULL TROUT INFORMATION GAPS

With the completion of the radio-telemetry studies in the Morice system the understanding of adult bull trout populations in the watershed is excellent relative to most areas. Similarly, juvenile bull trout distribution in most of the watershed is well documented. Data gaps exist in the following areas:

- Monitoring of both adult and juvenile populations provides an important tool for assessing the status of bull trout populations over time. With the extensive forest development already underway this is important, particularly since some of the most important habitats are in the upper areas in the tributary watersheds. Establishing long-term index sites for juveniles and redd counts on key spawning sections in upper Gosnell, Denys and upper Starr Creek would be very helpful in understanding trends in the Morice bull trout populations.
- Bull trout appear to be very temperature sensitive and monitoring of stream temperatures in key systems is important in terms of land-use activities in these watersheds. These types of studies have been initiated in the Thautil River (Hudson 2002).
- Understanding why densities in resident bull trout populations are so high (e.g. Upper Starr Creek) versus juvenile sites immediately downstream may be an interesting area of study.
- Monitoring the impacts of angling on adult bull trout populations is needed for the Morice River. Specific restrictions relative to angling at staging and major concentrations at holding areas in the lake outlet sections of the upper Morice and Nanika rivers may be required to protect these populations. Angling regulations in other parts of BC such as the Kootenays and Prince George Region are considerably more restrictive. The upper size restriction of 50 cm in these areas protects most of the spawning population for adfluvial populations, but is not protecting mainly fluvial bull trout populations such as in the Morice.

3.8.9 BULL TROUT HABITAT PROTECTION ISSUES

A number of bull trout habitat protection issues related to forestry development in the Morice Watershed should be addressed in the Local Resource Management Plan. These include the following:

- **Temperature sensitivity**, particularly the importance of maintaining cold temperatures in bull trout streams. This has implications to riparian management and treatment of small feeder non fish-bearing streams flowing into bull trout habitat.
- **Groundwater and seepage channels** are important habitats associated with bull trout spawning areas. Interception of groundwater and small seepage flows by adjacent road development can potentially affect bull trout spawning areas.
- **Channel stability** is an important factor in bull trout spawning and rearing streams such as Crystal and Glacier creeks. Road crossing on these creeks, especially in fan area, along with introduction of debris and coarser sediments can lead to instability in these fragile systems.

- **Suspended sediments** are also a concern in bull trout systems. Observations at Kemess Creek during mine construction activity suggest adults may avoid systems traditionally used if they develop chronic sediment problems.
- Poorly-planned forest development roads that result in **access** to key staging, spawning, overwintering and holding areas can impact bull trout due to angler harvest – legal or otherwise.

3.9 DOLLY VARDEN

Much of the early information describing Dolly Varden in the Morice Watershed was, in fact, describing bull trout as discussed in Section 3.8. Most of the Dolly Varden information presented in this section is based on studies conducted since the two species have been separated, and relies on information collected during forest inventory studies in the watershed.

3.9.1 DOLLY VARDEN POPULATION STATUS AND TRENDS

There have not been any studies directly examining the status of Dolly Varden stocks in the Morice drainage. Comparisons of Dolly Varden abundance in selected tributaries have been presented in forest inventory reports conducted in the Owen (Bustard 1998c), Thautil (Bustard 1997a) and Gosnell (Bustard 1999a) drainages. Studies in these watersheds indicate that Dolly Varden juvenile/adult abundance estimates at most locations are less than 10 fish/100 m^2. Densities at some headwater locations, for example in the upper Gosnell, can approach 20 fish/100 m^2.

Data available for some of these tributaries based on past index site sampling (targeting steelhead and coho) indicates that estimates have been relatively low in these systems dating back to the early 1980's. We suspect that Dolly Varden tend to achieve relatively low densities in most stream systems, and that stocks are not threatened or declining in the Morice Watershed.

3.9.2 DOLLY VARDEN LIFE HISTORY INFORMATION

Length-frequency information was collected for over 1300 stream resident Dolly Varden during studies in the Gosnell (Bustard 1999a) and over 300 specimens in the Thautil River (Bustard 1997a). Less than 2% of the total samples exceeded 150 mm fork length. The largest Dolly Varden sampled in these systems was a 230 mm male captured in seepage habitat in the upper Gosnell. Many of the Dolly Varden exceeding 110 mm fork length were sexually mature, maturing, ripe or spent fish indicating these fish are stream residents that achieve a relatively small size. These stream resident Dolly Varden mature early, typically age 3+ to 5+.

Dolly Varden utilizing lake environments achieve a larger size. For example, Dolly Varden sampled in Kidprice Lake ranged from 16-33 cm fork length with the larger fish up to 8 years old (Ministry of Environment 1979). We assume that char captured in the Nanika-Kidprice lakes system are Dolly Varden based on the recent lake sampling undertaken at Des Lake that indicated char in this lake were Dolly Varden (Degisi and Schell 1997c).

Studies in the Gosnell and Thautil watersheds suggests that most Dolly Varden spawning occurs from mid-September onward into October. There were many direct observations of Dolly Varden on redds in the upper watershed during the period starting September 15 with a probable peak at the end of September and carrying on into October. Dolly Varden spawning in the Thautil was completed by approximately October 15th. Dolly Varden spawning occurs approximately three weeks to a month later than bull trout spawning in the same systems.

3.9.3 DOLLY VARDEN DISTRIBUTION

Dolly Varden are the most widely distributed fish species in the Morice Watershed and dominate the catches in many of the smaller tributaries. For example, in the Gosnell drainage, Dolly Varden were present at 131 of the 163 sites with fish present (Bustard 1999a). In the Thautil drainage, Dolly Varden were present in 63 of 68 sites with fish (Bustard 1997a). They are present in all of the other major drainages including Houston Tommy, Lamprey, Owen, Nanika, and Atna. Dolly Varden distribution in the Morice Watershed based on a FISS data query is presented in Figure 29.

Dolly Varden are present in many of the lakes in the Morice watershed such as the Nanika, Kidprice, Shea, Owen and Lamprey lakes. It is interesting to note that Dolly Varden are not present in many of the headwater locations above significant barriers in the Thautil, Houston Tommy and Gosnell Creek areas. We assume the distribution of Dolly Varden in these watersheds has been determined by early colonization following glacial retreat, in conjunction with gradual changes in channels that led to barriers forming in sections of streams previously accessible from downstream areas.

Dolly Varden stream habitat is characterized by a wide range of slope and channel characteristics. For example, they were sampled in channels ranging from 0.3 m to 95 m wide and up to just under 15% slope (Bustard 1997a and 1999a). Dolly Varden tend to be less temperature sensitive than bull trout, and are found in warmer lake-headed streams such as Owen and Lamprey creeks as well as in the cool headwater systems characteristic of bull trout.

3.9.4 DOLLY VARDEN KEY HABITATS

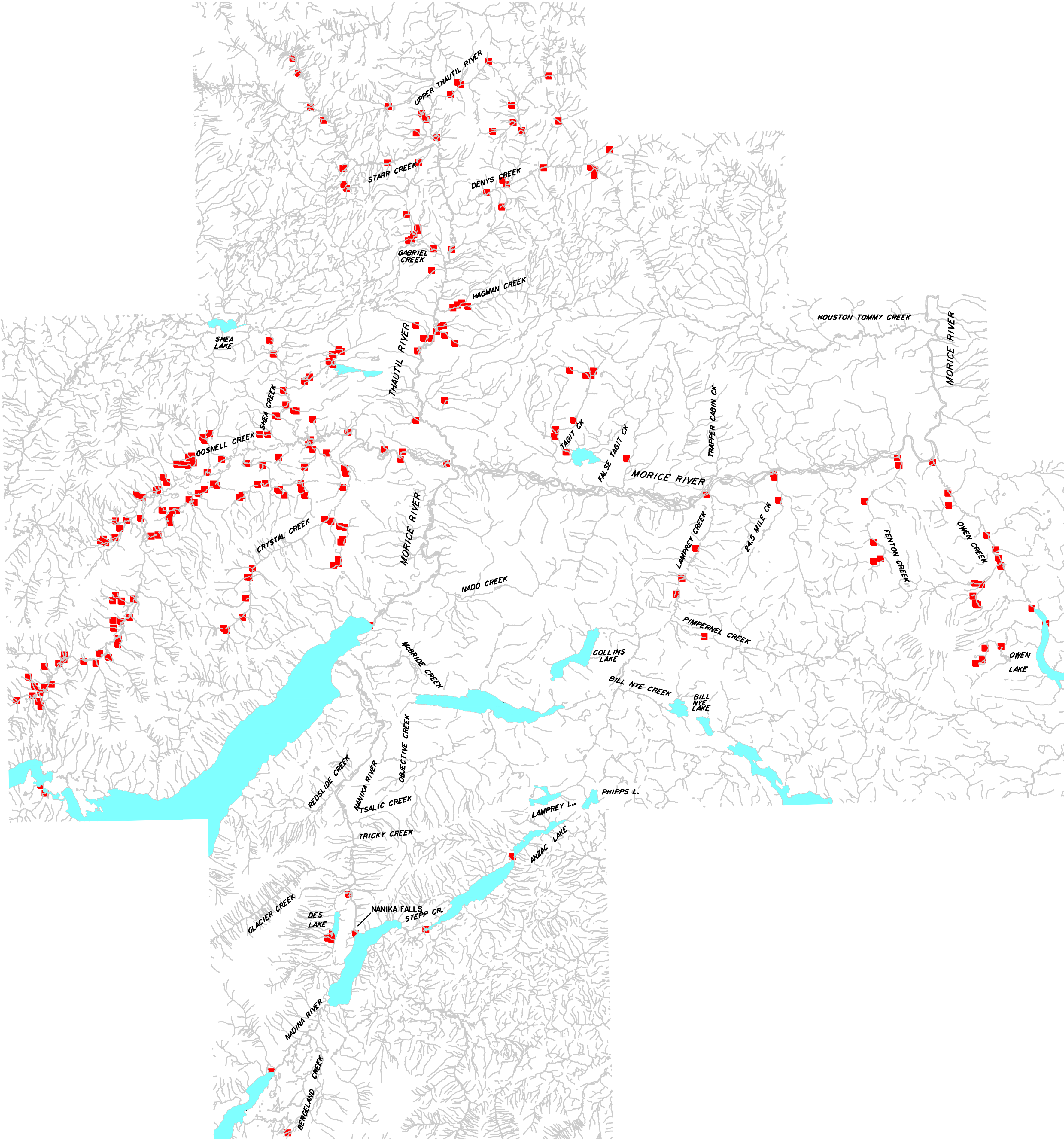
Although Dolly Varden are dispersed throughout a wide range of habitats in the Morice Watershed, they achieve their highest densities in smaller streams typically less than 8% slope and 10 m wide. For example, in the Gosnell watershed, sampling indicated that char fry and juvenile/adult Dolly Varden abundance tended to be highest in the uppermost reaches of the watershed (Bustard 1999a). We suspect that in the lower reaches of accessible tributaries Dolly Varden do not successfully compete with steelhead and coho juveniles.

Observations in both the Gosnell and Thautil watersheds suggest a strong association of Dolly Varden spawners with groundwater-fed seepage sites along both mainstem channels and in smaller tributaries (Photo 16). Some of the sites used by Dolly Varden spawners do not appear on 1:20,000 base maps and are not identified in standard reconnaissance inventories.

The presence of groundwater presumably provides a stable incubation environment and helps to reduce ice formation at redd sites during the winter incubation period. These channels are also less subject to high flows during the fry emergence period, providing a less extreme environment for Dolly Varden fry emergence and early fry rearing.

Stream resident Dolly Varden are small and not capable of moving larger gravel materials at sites used by bull trout. Instead, sites with pea-sized gravels and slow water velocities combined with groundwater inflows are critical habitats. The warmer incubation temperatures at these sites leads to a later spawning time for Dolly Varden than bull trout, helping to isolate the two char species that may both be present in the same stream reach.

Photo 16. Small channels with groundwater inflows such as this site in the Gosnell Watershed provide important spawning and rearing habitat for Dolly Varden.



N

5 0 5 10 15 20 km

FIGURE 29

DOLLY VARDEN

DISTRIBUTION IN MORICE WATERSHED

■ Point locations derived from FISS data query

NOTE: DOLLY VARDEN ARE WIDELY DISTRIBUTED IN THE MORICE WATERSHED. THIS MAP IS NOT A COMPLETE COVERAGE OF THEIR DISTRIBUTION. DOLLY VARDEN CAN UTILIZE VERY SMALL CREEKS.

MAP BASE: NAD83 TRIM 1. MINISTRY OF FORESTS FOREST COVER 1:20000

MAY 2002
MAPS PRODUCED BY:

AQUATIC HABITAT INFORMATION
COMPILED BY:
DAVID BUSTARD & ASSOCIATES LTD.

LAING & McCULLOCH FOREST MANAGEMENT SERVICES LTD.

Figure 29. Dolly Varden distribution in the Morice Watershed.

3.9.5 DOLLY VARDEN HABITAT PROTECTION ISSUES

Dolly Varden may be present in low abundance in some steep streams, with only a few individuals present in a 100 m section of stream in the more marginal habitats. This low abundance and widespread distribution in conjunction with the small size of Dolly Varden (i.e., they do not normally constitute a fishery) can lead to habitat protection issues including the following:

- Installing stream crossing structures that allow for fish passage in the small steep creeks utilized by Dolly Varden poses a challenge for forest management.
- Identifying key seepage habitat within proposed harvesting areas requires careful attention to road development and harvesting layout. Some of these locations may only be identified during the spawning period. Drainage changes due to roads upslope may lead to impacts at these sites.
- Dolly Varden utilize small streams and careful attention to protecting riparian areas and upstream sites from sediment, hydrological changes leading to low flow and peak flow impacts, and increased water temperatures are important on these small systems.

3.10 LAKE TROUT

A review of lake survey files[76] indicates lake trout are present in four lakes in the Morice Watershed - Morice, Owen, McBride and Atna[77] lakes.

Lake trout have been reported in Nanika Lake but we assume that two specimens reported by Morley and Whately (1974) were mis-identified. Extensive gill netting (including many deep sets) in Nanika and Kidprice lakes in 1974 and 1975 did not yield any additional specimens of lake trout (Ministry of Environment 1979). Similarly, additional sampling during parasite studies in 1980 by Envirocon Ltd. did not result in any lake trout captured.

Creel surveys on Morice Lake during 1979 (Envirocon Ltd. 1984) estimated that 204 lake trout were angled in the lake comprising approximately 20% of the sport fish captured in that year. Fork lengths ranged from 35 to 89 cm with a mean of 45 cm. A 92 cm lake trout weighing 11 kg was captured in Morice Lake in late May 1980 (Envirocon Ltd. 1984). No age information was collected during this study.

Large lake trout are infrequent in Morice Lake. The preponderance of small lake trout in this unproductive lake environment raises concerns for the lake trout stock status. Lake trout are known to congregate in the vicinity of the Nanika River and are vulnerable to angling at this location.

In Atna Lake, lake trout represented 28% of the gill net catch (Envirocon Ltd. 1984). Lake trout fork lengths ranged from 15 to 75 cm fork length. Some age information collected in the Atna

[76] Lake survey files, WLAP, Smithers
[77] Envirocon Ltd. 1984 Appendix K

study indicated fish to 11 years were present. Since the aging was based on scales, the study probably underestimated the true age for Atna lake trout.

Lake trout were generally present in deeper waters in Atna, although some were captured in shallower shoal areas, especially during the evening feeding on sockeye. Smaller char (17-32 cm fork length) were present along littoral areas of Anta Lake and in the small lake above the falls on the outlet stream. Only a single young-of-the–year lake trout was sampled in Atna Lake.

Six lake trout captured in McBride Lake ranged from 35 to 56 cm (mean 45 cm) during the 1974 lake survey[78].

3.11 KOKANEE

Kokanee have only been reported in two lake systems in the Morice Watershed - Morice and Shea lakes.

Kokanee are infrequent in Morice Lake, and comprise 1% of the total angler catch during 1979 (Envirocon Ltd. 1984). Two fish samples averaged 24.5 cm fork length.

DeGisi and Schell (1997b) reported kokanee comprised 38% of the 39 salmonids captured in an overnight gillnet set in Shea Lake. They include some length, age and maturity data in their report. This is an interesting observation, since this is the third time that a lake survey and gillnetting was conducted on Shea Lake[79], but the first report of kokanee in the lake. Photos in DeGisi and Schell (1997b) confirm the identification

3.12 WHITEFISH

Three species of whitefish have been reported in the Morice Watershed based on a search of the FISS database (Applied Ecosystem Management 2001). Pygmy whitefish are reported in Owen and Morice lakes, and lake whitefish have been sampled in McBride and Morice lakes. Mountain whitefish are more widespread in the watershed and this section summarizes information for that species.

3.12.1 MOUNTAIN WHITEFISH POPULATION STATUS AND TRENDS

There have not been specific studies to examine the status of mountain whitefish stocks. Data collected during a series of snorkel surveys in the Morice River during March to November 1979 indicated that whitefish (assumed to be predominantly mountain whitefish) comprised 85% of the resident fish species observed in the upper section on the river (Envirocon Ltd. 1984). Boat electrofishing studies in the Morice and Bulkley rivers during September 1982 (Envirocon Ltd.

---

[78] Lake survey files, WLAP, Smithers
[79] Lake survey files, WLAP, Smithers.

1984 Appendix F) also indicated that whitefish were the most abundant fish species present throughout the mainstem rivers.

Gillnet sampling in Morice Lake indicated 34% of the 113 fish captured were whitefish[80]. Sampling in Atna Lake indicated mountain whitefish comprised approximately 20% of gillnet catches and up to 50% of the seine catches in the lake (Envirocon Ltd. 1984 Appendix K).

3.12.2 MOUNTAIN WHITEFISH LIFE HISTORY INFORMATION

Newly-emerged whitefish fry (20-37 mm fork length) were captured in early July along the mainstem Morice River margin as well as in Atna Lake and at the mouth of the upper Atna River (Envirocon Ltd. 1984). Whitefish fry grow quickly and typically achieve a size of 55-75 mm by the end of their first growing season in the Morice River. Atna Lake whitefish grow more slowly. Detailed length-frequency and growth information for Atna Lake whitefish is presented in Envirocon Ltd. (1984 Appendix K). Mountain whitefish to age 11+ were reported in the Atna Lake program.

A sample of 113 mountain whitefish angled in the upper Morice River ranged in length from 19-39 cm with a mean fork length of 30 cm (Taylor and Seredick 1968).

3.12.3 MOUNTAIN WHITEFISH DISTRIBUTION

Mountain whitefish are present in Morice, Owen , McBride, Shea and Lamprey lakes (Applied Ecosystem Management 2001) and in Atna Lake (Envirocon Ltd. 1984). The highest concentrations of both juvenile and adult whitefish appears to be associated with the mainstem Morice River and downstream throughout the Bulkley River.

Juvenile sampling indicated that mountain whitefish comprised 8-9% of the overall catch in the mainstem Morice-Bulkley sites in 1981 and 1982. However, whitefish juveniles comprised only 2% of the 1979 catch[81].

Whitefish use of Morice tributaries appears to be minor. For example, whitefish comprised less than 1% of the catch in the Thautil River (Bustard 1997a), Gosnell Creek (Bustard 1999a), Lamprey Creek (Bustard 1993) and the Nanika River in 1979 and 1982 (Envirocon Ltd. 1984 Volume 3). Whitefish comprise approximately 2% of the overall catch in Owen Creek based on nine years of data summarized in Bustard (1998c). Only 16 juvenile whitefish were sampled in Atna Lake tributaries during an entire season of sampling (Envirocon Ltd. 1984)

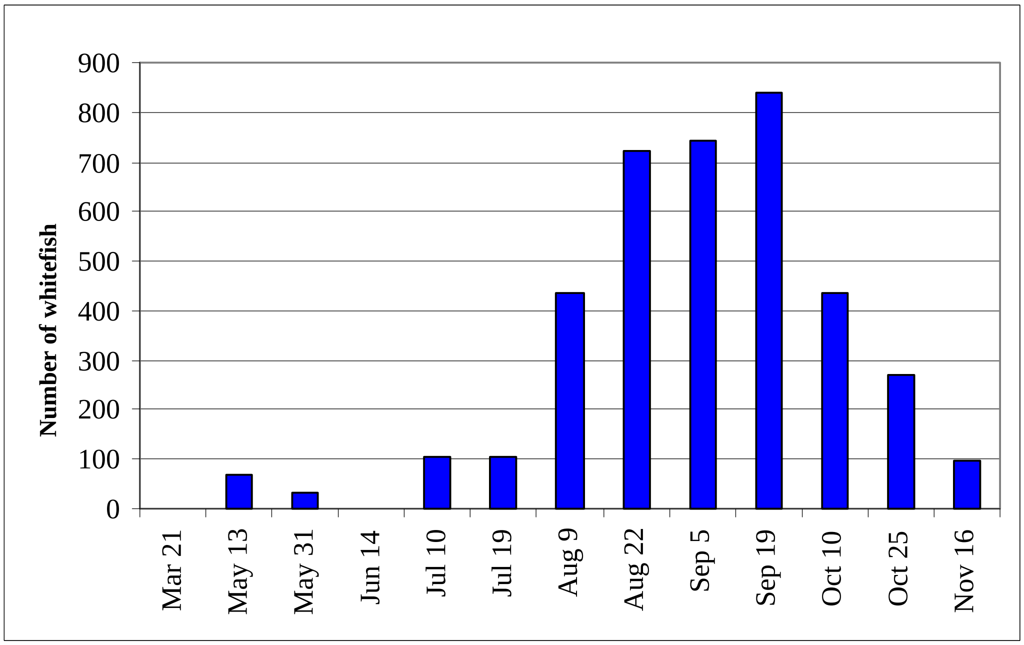
No whitefish were observed during the March surveys in the upper river, suggesting that adults may overwinter in Morice Lake. Numbers of adults gradually increased through the summer with a peak during the September surveys (Figure 30) coinciding with the peak of chinook spawning. Many whitefish were observed holding immediately downstream from spawning chinook, apparently feeding on eggs and insects dislodged during digging. Whitefish were also observed holding in the vicinity of steelhead redds in June as well as at pink salmon redds in

[80] May 1980 sample data on file WLAP, Smithers.
[81] There was an extremely large flood event in late October 1978 and it has been suggested that this flood severely affected whitefish survival leading to low abundance in 1979.

September. By November, nearly all whitefish observed in the upper river were within 3 km of Morice Lake, usually in schools.

Mountain whitefish occupy a greater range of fast water habitats in the mainstem river than other fish species observed (Envirocon Ltd. 1984). They were frequently observed in deep fast water areas holding close to the substrate. Cover and depth did not appear to be important in determining areas preferred by mountain whitefish, and they were often observed in midstream areas, many meters from the margin or from cover and in a range of depths. A similar pattern of utilizing mid-channel areas was determined during the boat electrofishing surveys (Envirocon Ltd. 1984).

Figure 30. Number of whitefish observed during snorkel surveys in the upper Morice River[82] between March and November 1979.



3.12.4 MOUNTAIN WHITEFISH KEY HABITATS

There is limited information describing whitefish spawning habitat in the Morice Watershed. Taylor and Seredick (1968) found that most whitefish captured on October 15 in the upper Morice River were in spawning condition. The large number of whitefish observed in the upper 10 km of the Morice River during late October may be associated with spawning in this section of river. Thompson and Davies (1976), in their detailed study of mountain whitefish in Sheep River Alberta, report that mountain whitefish spawn in small groups of 2 to 20 fish in substrate ranging from 5 to 80 cm diameter. Average water velocities on spawning sites ranged from 60 to 150 cm/sec and water depths were 30 to 65 cm. Water temperatures were less than 8 C.

---

[82] Snorkel surveys were typically conducted by two swimmers in the section from the outlet of Morice Lake to Gosnell Creek.

Whitefish fry tend to be found in schools during the early fall, and gradually move from the edge and side channel areas out into faster water with increased size. Sampling in Atna Lake indicated young-of-the-year fish entered the lake and utilized the littoral areas.

3.13 OTHER SPECIES

A number of other fish species are present in the Morice Watershed but are not dealt with in any detail in this report.

3.13.1 BURBOT

This species has been identified in McBride[83], Morice and Owen lakes, but no life history, stock status or distribution information is available (Applied Ecosystem Management 2001).

3.13.2 LAKE CHUB

This species is identified as of regional importance within the Morice Forest District (Applied Ecosystem Management 2001)[84]. Lake chub are present in the Gosnell (13 sites), Thautil (1 site), Lamprey[85] and Owen creeks (2 sites) and Morice and Owen lakes.

3.13.3 LONGNOSE SUCKERS

Longnose suckers are reported in McBride, Tagit, Owen, and Lamprey creeks and associated lakes, but not in the mainstem Morice or Nanika rivers. They are also present throughout the Nanika-Kidprice lakes system.

Longnose suckers were the only fish species present in Tsalitpn Lake at the headwaters of Puport Creek in the Owen. This is an anomaly for fish distribution in the Morice, but is not thought to have resulted from a unique zoogeographical event qualifying for regional significance. Degisi and Schell (1997d) suggest the lack of other fish species in Tsaltipn Lake may be the result of winter kill based on their finding of an anoxic hyplimion during summer sampling.

3.13.4 LARGESCALE SUCKERS

Largescale suckers are common throughout the mainstem Morice and Bulkley rivers. They comprised 6% of the snorkel observations of resident fish in the upper Morice River (Envirocon Ltd. 1984). Large numbers of largescale suckers overwinter in the mainstem Morice River between Owen and Gosnell creeks, with nearly 800 counted during aerial surveys in late November 1979. It is thought that these fish move out of the numerous backwater habitats utilized during the summer into the mainstem river to avoid ice conditions.

---

[83] Two burbot were sampled in both McBride and Owen lakes surveys – data on file, WLAP, Smithers

[84] This status was applied to lake chub in the Morice based on their presence in upper Pimpernel Creek above a barrier (P.Giroux, WLAP, Smithers).

[85] Includes a headwater population upstream from Pimpernel Creek falls.

Applied Ecosystem Management (2001) reports largescale suckers in Collins, McBride, Morice, and Owen lakes.

3.13.5 REDSIDE SHINERS

Redside shiners have been reported in Owen, Collins, McBride, and Morice lakes and Tagit Creek (Applied Ecosystem Management 2001).

3.13.6 LONGNOSE DACE

Longnose dace are abundant throughout the mainstem Morice River, Lamprey and Owen and McBride creeks. Approximately 9% of the mainstem river sample was comprised of longnose dace during 1979 but this percentage declined in subsequent years. They are also present in the Nanika River and at least one tributary (Envirocon Ltd 1984).

3.13.7 PRICKLY SCULPINS

Prickly sculpins are common in the Morice and Nanika rivers, and in lower McBride and Lamprey creeks. They are also present in Owen and lower Gosnell creeks.

3.13.8 PACIFIC LAMPREY

Pacific lamprey up to 70 cm in length are abundant and widely distributed in the Morice drainage. In the past, some lamprey have been taken for food at Moricetown Falls if salmon were in short supply[86]. They can be smoked, sun-dried or salted. Envirocon Ltd. (1984) presents a map showing distribution of lamprey in the watershed. Large numbers of Pacific lamprey have been observed spawning in Owen and Lamprey creeks during June and July and in the Morice River during late July after spending nearly a year hiding in the boulder bed material along the river margin.

Incidental reports of other fish species in the Morice as summarized in FISS include reports of peamouth chub[87] and white suckers[88]. Triton (2000) indicates coastrange sculpins and northern pike minnows were present in a reconnaissance inventory.

---

[86] Information provided by Les Cox, former conservation officer, MELP, Smithers. Reported in Envirocon Ltd. (1984).
[87] Lake surveys for Owen and McBride lakes, WLAP, Smithers.
[88] Identified in upper Pimpernel Creek (J. Dore, Triton, personal communication)

4 CONCLUSIONS

The Morice Watershed provides exceptional habitat for significant runs of sockeye, chinook coho and pink salmon as well as an outstanding summer-run steelhead population. This watershed also supports populations of resident rainbow and bull trout. Dolly Varden and cutthroat populations are also widespread throughout the watershed.

This biophysical profile has attempted to bring together the extensive amount of information describing fish populations and trends over time, their distribution and key habitats within the watershed. As well, an effort has been made to identify bottlenecks to fish production in the Morice on a species specific basis, and to identify past restoration and enhancement efforts and potential habitat protection concerns for the main fish species.

The ultimate goal is to provide the background fish and fish habitat information to help develop strategic planning options for the maintenance and restoration of fish populations and habitats within the Morice planning unit.

4.1 KEY MORICE WATERSHED HABITATS

This report has identified key habitats within the Morice Watershed that provide the core of the production for the major species. We are fortunate in the Morice Watershed in that there is an abundance of background fisheries information available to help identify key habitats, and that major land-use developments leading to permanent changes in the critical habitats have not occurred on a large scale in this watershed.

It should be emphasized that although these habitats are important for the species involved, other habitats that are utilized at less critical times or are marginal compared to the core areas, should not be treated as unimportant. Since we don’t completely understand fish requirements, movement patterns, and year-to-year variability in the use of areas, all of these habitats may be important and contribute to the long-term sustainability and diversity of fish populations. At the same time, activities in headwater areas influences the temperature, sediment, hydrology and food supplies of downstream fish habitats currently listed as key habitat.

1. **Upper Nanika River (Nanika Falls to Glacier Creek)**
   - This section of river is the only significant spawning area for Nanika sockeye.
   - The upper Nanika is the only known spawning area for resident rainbow trout using the Nanika River, Morice Lake and upper Morice River.
   - The upper Nanika River is also used by smaller runs of chinook and coho salmon and small number of steelhead in some years.
   - This section of the Nanika River is one of two key year-round holding areas for bull trout.

2. **Upper Morice River (Morice Lake to Gosnell Creek)**
   - This section of the Morice River is the main holding and spawning area for over 80% of the very large Morice chinook run – one of the top chinook producers in the Skeena Watershed. The top 4 km section is the most heavily utilized.
   - The upper Morice is used by smaller numbers of coho and summer steelhead.
   - The upper section of the Morice River is one of two core year-round holding and feeding areas for bull trout.
   - The upper Morice River provides important adult rearing habitat for Morice rainbow trout.

3. **Mid-Reach Morice River (Gosnell to Owen Creek floodplain)**
   - Major spawning of coho and steelhead occurs in this reach, especially in side channels.
   - Significant chinook spawning takes place from Gosnell Creek down to Lamprey Creek in the mainstem river.
   - Over 90% of the pink salmon spawning occurs in this section, especially in side channels.
   - This reach is a main rearing section for coho and chinook salmon juveniles and steelhead trout.

4. **Key Steelhead Tributaries (spawning and early juvenile rearing)**
   - Owen Creek including lower Puport.
   - Lamprey Creek including lower Pimpernel.
   - Shea Creek up to the falls.
   - Upper Thautil River above Starr Creek.

5 Key Coho Tributaries (spawning and rearing)

- Gosnell Creek floodplain, especially a key spawning section in the mainstem Gosnell and tributaries located upstream from Shea Creek.
- McBride and Owen creeks have high coho potential but are limited by poor spawner access during most years.
- The lower accessible ends of smaller tributaries along the mainstem Morice and Nanika rivers provide important rearing areas for coho juveniles.

6. Key Bull Trout Tributaries

- The upper reaches of Gosnell Creek are the key bull trout spawning areas in the Morice.
- Denys, Loljuh and upper Starr creeks in the Thautil Watershed are important bull trout spawning and juvenile rearing areas.
- Glacier Creek is the main spawning and juvenile rearing area for Nanika bull trout.
- Bull trout also spawn in Houston Tommy and Gold creeks.

7. Nanika-Kidprice Lakes Area

- The key rainbow trout spawning area is the Nanika River from the outlet of Nanika Lake to Bergeland Creek. Most spawning occurs right at the Nanika Lake outlet.
- Des Creek is an important spawning creek for Des Lake and presumably Kidprice Lake.

4.2 IMPORTANT FACTORS AFFECTING MORICE FISH POPULATIONS

In our opinion, commercial and sport fishery harvest levels are currently the dominant factors influencing the health of Morice fish populations. Though somewhat impacted, fish habitat in the Morice is for the most part intact. However, forest development is the major land use activity in the Morice and the cumulative effects of poor forest road construction and timber harvest practices could significantly impact the productive capacity of fish habitat in the Morice.

4.2.1 COMMERCIAL AND IN-RIVER FISHING PRESSURE

In reviewing past studies and population trends for Morice fish populations, it is clear that fishing has had a dominant impact on the salmon, steelhead and other sport fish populations in the Morice Watershed. Commercial interceptions, and in some years, in-river fisheries, have severely impacted salmon and steelhead populations.

Substantive changes to the commercial fisheries in the past decade have provided us with evidence of the impressive habitat capabilities of the Morice Watershed given adequate spawner escapements with reduced exploitation rates. Chinook and steelhead populations, and most recently coho populations have had strong escapements and provide an indication of what the watershed is capable of producing. Sockeye appeared to be well on their way to recovery to historic levels, but significant declines since 1998 have confounded the sockeye situation.

In the case of bull trout, lake trout and the Morice Lake rainbow populations, we have essentially no hard data with which to make informed decisions regarding angler harvest. These slow-growing and relatively unproductive stocks have been subject to relatively liberal fishing regulations for the past 50 years.

4.2.2 LAND-USE ACTIVITIES

A major hydro-electric proposal (Kemano Completion), and a proposal for a pulp mill at Houston have both been abandoned due to the recognized high fisheries values in the Morice that were threatened by these projects. There is currently a proposal for a co-generation plant in Houston, requiring water use from the Morice River. Present land-use in the Morice Watershed is predominantly forestry-related with minor amounts of grazing, and mineral exploration and development.

This report did not focus on forestry issues due to ongoing long-term planning processes underway. Never the less, in reviewing watershed assessments it is clear that some smaller fish streams in the Morice Watershed have been impacted by past logging activities (BCCF 1999). Recent improvements in forest practices and restoration efforts should help to minimize these impacts. However, as forest development continues, some long-term, cumulative impacts on fish habitat can be expected. Key forest development issues that came to our attention during this review include the following:

4.2.2.1 Small channels

Small resident Dolly Varden and cutthroat streams are in the front line of potential impacts from forest development. This is due to these species' widespread distribution in small streams often away from areas considered to be the key fish habitat areas. Some of the small creeks utilized by these species are not even shown on 1:20,000 maps (examples in Bustard 1999a). Poor stream crossings preventing fish access and damage to the riparian area in these creeks can have impacts on local populations of these species.

Both cutthroat trout and Dolly Varden have been identified as blue-listed species provincially. However, we do not think their populations in the Morice Watershed are at risk. Lake and stream inventories conducted within the Morice indicate that these two fish species are relatively abundant and have widespread distributions within the watershed. With careful construction of stream crossings that allow fish passage, and good riparian management strategies, impacts to fish species in small creeks can be minimized.

4.2.2.2 Sediment Control

Important spawning areas for coho, chinook, pink and steelhead are located in the mainstem Morice River downstream from the Gosnell-Thautil confluence. With rapid development of logging in these upper, high gradient watersheds and smaller creeks flowing directly into this important reach, increased sediment and debris loading could affect the stability of the reach and the quality of the spawning and rearing areas.

While Morice and Kidprice lakes buffer the upper Morice and upper Nanika rivers from sediment deposition, special consideration must be given to the small systems that drain directly into these reaches. Careful riparian management adjacent to high gradient creeks and careful attention to slope stabilization and sediment control during road construction is warranted in all tributaries to the key habitat areas listed in Section 4.1. Some higher risk small watersheds draining directly into key spawning sites may need to be excluded from logging.

4.2.2.3 Water temperature

Water temperature changes related to land-use and future global warming are an important area of concern. The cold-water requirements of bull trout, and the vulnerability of several very important steelhead streams (e.g., Owen and Lamprey creeks) to small increases in temperature from logging and/or climate change are key issues. Monitoring of water temperature changes associated with small stream treatments should be expanded to include these high value systems. Special consideration should be given to the removal of any riparian vegetation if continued monitoring shows increased temperatures in these systems.

It is worth reiterating that protection of the important fish habitat in the larger river reaches (Morice and Nanika) is dependent on careful land use management in the smaller tributary systems.

4.2.3 FISH FARMS

It is important to identify the hazard associated with the recent initiatives to establish fish farms on the North Coast. The potential introduction of Atlantic salmon into the Skeena Watershed could pose a threat to Morice steelhead as discussed in Gottesfeld et al. (2002).

5 RECOMMENDATIONS

5.1 BETTER MONITORING OF FISH STOCKS

The total effort that goes into monitoring Morice River fish populations (adult and juvenile) is not in line with the economic and social consequences of management decisions made to protect these stocks. It is imperative that long-term reliable adult and juvenile databases be developed and monitored in response to management strategies, particularly for the anadromous fish stocks. Many poor decisions can be made because of lack of good quantitative information describing these fish stocks.

Improvements including genetic stock testing at the test fishery and more consistency to escapement data collection have been initiated for coho, chinook and sockeye in an effort to connect adult counts and run timing to the test fishery indices. However, questions concerning the reliability of the database and the linkage of the adult escapements to resulting juvenile production arise for all species. In particular, chinook and steelhead adult and juvenile estimates are lacking more detailed and consistent assessments, especially during years of high escapements. At the present time, only juvenile coho populations are assessed on an annual basis.

We suggest that increased emphasis and support for stock monitoring including analysis of numbers of sample sites and tests of the reliability of methods being used is necessary. All of the major anadromous species should be part of the stock assessment program. Establishing a linkage between real escapement estimates conducted in the field should be made with the long-term indices established for the Skeena as a whole.

Some of the most liberal angling regulations in the province are in place for relatively unproductive stocks of rainbow, bull trout and lake trout in the Morice Lake and upper Morice River. This raises concern in terms of long-term sustainability of these stocks, and we suggest that management regulations for these stocks be reviewed to ensure their long-term viability.

5.2 LAND-USE MONITORING

The impacts of forestry operations, especially on the smaller fish streams, should be a continued area of support including studies of water temperature, riparian impacts, and sediment and hydrological issues.

The present program looking at the effectiveness of streamside treatments on maintaining water temperatures in small streams is an important direction for monitoring. Two important steelhead streams where water temperatures may be critical are Owen and Lamprey creeks.

Similarly the importance of groundwater to many of the spawning fish populations in the Morice, and possible changes to small drainages by road building and cutblocks warrants careful attention.

Suspended sediment monitoring has been attempted and subsequently abandoned in the Morice due to funding limitations. It is an important area to monitor for both fish protection and the maintenance of fishable sections of stream. The Thautil, Gosnell and Houston Tommy watersheds are natural sources of high natural sediment loading, and monitoring background levels versus logging-induced sediment loading should be a priority.

5.3 SPECIFIC FISH STOCK ISSUES

Based on this review, a number of specific fish stock issues were identified as priority areas of concern in terms of maintaining or restoring runs**.**

5.3.1 SOCKEYE SALMON

Morice sockeye should be a high priority target species for future Morice studies due to their importance to the Wet'suwet'en traditional fisheries and the implications that protecting this stock has on the commercial fisheries. There are unanswered questions surrounding the overall potential of Morice stocks, as well as the reasons for the long decline, apparent recovery and subsequent collapse in sockeye escapements. As well, the whole issue of beach spawning and role of carcasses in the nutrient loading of Morice Lake is important. Fertilization studies can affect other fish populations and an assessment of these affects should be part of the study plan for future work at Morice Lake.

5.3.2 BULL TROUT

We recommend that monitoring of bull trout using redd counts at several key locations in Gosnell and the Thautil River be done on an annual basis to assess the stock status of this species.

We also recommend assessing the existing fishing regulations that presently allow a retention of up to three bull trout per day in the Morice and Nanika rivers including staging areas for most size classes of bull trout spawners.

5.3.3 COHO AND STEELHEAD

Coho and steelhead are high priority species given their use of smaller tributaries, and their vulnerability to both fisheries management strategies and habitat protection concerns. Stock identification, reliable enumeration and linkage to indices, as well as habitat capabilities relative to escapements are areas of considerable management interest.

6 LITERATURE CITED

Allan, J. 1999. Increases in the number of bull trout spawning in Line Creek, British Columbia. An update. *In*: Brewin, M.K., A.J. Paul, and M. Monita (Eds). Ecology and management of Northwest salmonids: Bull trout II conference proceedings. Trout Unlimited Canada, Calgary.

Applied Ecosystem Management. 2001. Morice Forest District fisheries data and information compilation project. Prepared for Min. of Environment, Lands and Parks. Skeena Region.

Bahr, M. 2002. Examination of bull trout (*Salvelinus confluentus*) in the Morice River watershed. Report prepared for Forest Renewal B.C. University of Northern B.C.

Baxter, J.S. and J.D. McPhail. 1996. Bull trout spawning and rearing habitat requirements: summary of literature. Fish. Tech. Circular No. 98. Fisheries Branch, Min. of Environment, Lands and Parks.

Brewin, M.K., A.J. Paul, and M. Monita. 1999. Ecology and management of Northwest salmonids: Bull trout II conference proceedings. Trout Unlimited Canada, Calgary.

BCCF. 1999. Morice detailed fish habitat/riparian/channel assessement for watershed restoration – Nanika and Lamprey sub-basins. British Columbia Conservation Foundation, Smithers, B.C.

BC Ministry of Environment, Lands and Parks, Fisheries and Oceans Canada. 2001. Watershed-based Fish Sustainability Planning. Conserving BC Fish Populations and their Habitat. A Guidebook for Participants.

Bustard, D. 1985. Aquatic Resource Assessment of the Telkwa Coal Project 1984 Studies. Prepared for Crowsnest Resources Ltd.

Bustard D. 1986. Some difference between coastal and interior stream ecosystems and the implications to juvenile fish production. *In*: Proceedings of the Workshop on Habitat Improvements, Whistler, B.C. 8-10 May 1984. Can. Tech. Report of Fisheries and Aquatic Sciences No. 1483.

Bustard D. 1992. Juvenile steelhead surveys in the Kitwanga, Morice, Sustut and Zymoetz rivers 1991. Prepared for BC Environment, Smithers.

Bustard D. 1993. Juvenile steelhead surveys in the Kitwanga, Morice, Sustut and Zymoetz rivers 1992. Prepared for BC Environment, Smithers.

Bustard, D. 1996. Winter measurements of dissolved oxygen at selected sites in the Bulkley Watershed. Man. Report prepared for Dept. of Fisheries and Oceans, Northern Salmon Stock Assessment.

Bustard, D. 1997a. Stream inventory Thautil River Watershed 1996. Prepared for Forest Renewal B.C. (Houston Forest Products Ltd.).

Bustard, D. 1998a. Stream inventory Fenton Creek and adjacent tributaries 1997. Prepared for Forest Renewal B.C. (Houston Forest Products Ltd.).

Bustard, D. 1998b. Fisheries assessment of proposed rip-rap sites from Km 17 to Km 25 Morice River. Prepared for Min. of Forests, Morice District.

Bustard D. 1998c. Stream inventory Owen Creek Watershed 1998. Report prepared for Forest Renewal B.C. (Houston Forest Products Ltd.).

Bustard, D. 1998d. Stream inventory Tagit Creek and adjacent tributaries 1997. Report prepared for Forest Renewal B.C. (Houston Forest Products Ltd.).

Bustard, D. 1999a. 1998 stream inventory report Gosnell Creek Watershed. Report prepared for Forest Renewal B.C. (Northwood Inc.).

Bustard, D. 1999b. Sustut and Bulkley rivers juvenile steelhead surveys 1999. Prepared for Ministry of Environment, Lands and Parks, Smithers.

Bustard, D. 2002. Kemess South Project fish monitoring studies 2001. Prepared for Kemess Mines Ltd.

Bustard, D. and Limnotek Research Inc. 1998 (Draft). Aquatic resource baseline studies Telkwa Coal Project 1997. Report prepared for Manalta Coal Ltd.

Carswell, R. 1979. An inventory of Thautil River and tributaries. Stream Inventory. B.C. Fish and Wildlife Branch, Victoria.

Cavender, T.M. 1978. Taxonomy and distribution of the bull trout, *Salvelinus confluentus*, from the American Northwest. Calif. Fish and Game 64: 139-174.

Chaplin, J. 2001. Operational inventory of water quality and quantity of rivers ecosystems in the Bulkley, Lakes, and Morice Districts of the Skeena Region, Northwest British Columbia. Prepared for Ministry of Environment, Lands and Parks, Skeena Region, Smithers.

Cleugh, T.R. and B.C. Lawley. 1979. Salmon Studies Associated with the Potential of Kemano II Hydroelectric Development. Vol. 4. Limnology of Morice Lake.

Costella, A.C., B. Nidle, R. Bocking, and K.S. Shortreed. 1982. Limnological Results from the 1980 Lake Enrichment Program. Can. Man Report Fisheries and Aquatic Sciences No. 1635.

Cox-Rogers,S. 2000. Skeena Sockeye and Nanika Production Trends. Memo to file dated November 28, 2000 (DFO Prince Rupert).

Cox-Rogers, S. 2001 Assessment Update for Morice-Nanika Sockeye. Memo to file dated October 30, 2001. (DFO Prince Rupert)

Degisi, J.S. and C. Schell. 1997a. Reconnaissance inventory of West Julian Holland Lake. Watershed code 460-6006508-005-283-218-502. Survey dates: August 3-5, 1996. Prepared for MELP, Fisheries Branch, Skeena Region.

Degisi, J.S. and C. Schell. 1997b. Reconnaissance inventory of Shea Lake Watershed code 460-6006508-005-283-01. Survey dates: August 9-10, 1996. Prepared for MELP, Fisheries Branch, Skeena Region.

Degisi, J.S. and C. Schell. 1997c. Reconnaissance inventory of unnamed lake. Watershed code 460-6006-644-380-01. Survey dates: August 13-14, 1996. Prepared for MELP, Fisheries Branch, Skeena Region.

DeGisi, J.S. and C. Schell. 1997d. Reconnaissance inventory of Tsalitpn LakeWatershed code 460-6006-239-433-01. Prepared for MELP, Fisheries Branch, Skeena Region.

Ecofor Consulting. 2001 (draft). 2001 FRBC Watershed Restoration Program. Interim Restoration Plans for the Buck, Houston Tommy, Kidprice, Morice Lake, Nadina, and Owen Watershed Units within the Morice Forest District. Prepared for Houston Forest Products and Canfor – Houston Division.

Envirocon Ltd. 1984. Physical and hydrological baseline information. Vol. 2. In: Environmental studies associated with the proposed Kemano Completion Hydroelectric development. Aluminum Company of Canada, Vancouver.

Envirocon Ltd. 1984. Fisheries resources of the Nanika River system: Baseline information. Vol. 3. In: Environmental studies associated with the proposed Kemano Completion Hydroelectric development. Aluminum Company of Canada, Vancouver.

Envirocon Ltd. 1984. Fisheries resources of the Morice River system: Baseline information. Vol. 4. In: Environmental studies associated with the proposed Kemano Completion Hydroelectric development. Aluminum Company of Canada, Vancouver.

Everest, F. and D. W. Chapman. 1972. Habitat selection and spatial interaction by juvenile chinook and steelhead trout in two Idaho streams. J. Fish. Res. Bd. Canada 29:91-100.

Farina, J. 1982. A study of salmon migration and spawning in the Nechako River system and the Morice and Nanika rivers 1982. Prepared for Alcan Smelters and Chemicals Ltd. Kitimat.

FOC. 1999. Stock status of Skeena River coho salmon. DFO Stock Status Report D6-02

FOC 2001. Salmon Escapement Database System. Area 4 Escapement. Fisheries and Oceans Canada. Prince Rupert.

Fennely, J. 1963. Steelhead Paradise. Published by Mitchell Press, Vancouver.

Foerster, R.E. 1968. The sockeye salmon. Fish. Res. Bd. Can. Bulletin 162.

Gottesfeld, A.S., K. Rabnett, and P.E. Hall. 2002. Conserving Skeena Fish Populations and Their Habitat. Skeena Stage I Watershed-based Fish Sustainability Plan.

Gottesfeld, A. and L. Gottesfeld. 1990. Floodplain dynamics of a wandering river, dendrochronology of the Morice River, British Columbia, Canada. Geomorphology, V0l. 3. pp. 159-179.

Groot, C. and L. Margolis. 1991. Pacific salmon life histories. UBC Press, Vancouver.

Hartman,G.F. 1965. The role of behaviour in the ecology and interaction of underyearling coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). J. Fish. Res. Bd. Can. 22:1035-1081.

Haas, G.R. and J.D. McPhail. 1991. Systematics and distributions of Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) in North America. Can. J. Fish. Aquat. Sci. 48:2191-2211.

Hancock, M.J. A.J. Leaney-East and D.E. Marshall. 1983. Catalogue of Salmon Spawning Stream and Spawning Escapements of Statistical Area 4 (Upper Skeena River). Canadian Data Report of Fisheries and Aquatic Sciences No. 394.

Hatlevik, S. 1981. A fisheries inventory of the Gosnell watershed April 1981. Skeena Fisheries Report No. 80-6. Smithers.

Holtby, L. B. and B. Finnegan. 1997. A biological assessment of the coho salmon of the Skeena River, British Columbiua, and recommendations for fisheries in 1998. PSARC Working Paper S97-12.

Hooton, R.S. 1987. Catch and release as a management strategy for steelhead in British Columbia. Pp 143-156. In: R.A. Barnhart and T.D. Roelefs (eds) Catch –and-release fishing – a decade of experience. National sportfishing symposium, Humboldt State University, Arcata, Calif.

Hooton, R.S. 1999. Skeena perspectives. International Journal of Salmon Conservation. 1(5):1-16.

Hudson, P. 2002. Data summary report of the 2001 field season for the Morice and Lakes Districts small stream temperature projects. Prepared for Houston Forest Products Ltd.

Koski, W.R., R.F. Alexander and Karl English. 1995. Distribution, timing and numbers of coho salmon and steelhead returning to the Skeena Watershed in 1994. Prepared for Fisheries Branch, B.C. Ministry of Environment, Lands and Parks, Victoria.

Lewis, A. 2000. Skeena steelhead and salmon – a report to stakeholders. Prepared for Steelhead Society of B.C. Bulkley Valley Branch, Smithers.

Lough, J. 1995 (draft report). Estimating the population of adult steelhead in the Morice River using mark-recapture methods, 1993/94. Skeena Fisheries Section, Smithers.

Lough, M. 1980. Radio telemetry studies of summer run steelhead trout in the Skeena River drainage, 1979 with particular reference to Morice, Suskwa, Kispiox and Zymoetz river stocks. Skeena Fisheries Report #79-05, Smithers, B.C.

Lough, M. 1981. Commercial interceptions of steelhead trout in the Skeena River – Radio telemetry studies of stock identification and rates of migration. Skeena Fishries Report #80-03, Smithers, B.C.

McNeil, W.J. 1966. Effects of the spawning bed environment on reproduction of pink and chum salmon. Fish. Bull. (U.S.) 65:495-523.

McNeil, W.J. and W.H. Ahnell. 1964. Success of pink salmon spawning relative to size of bed materials. U.S. Fish and Wildl. Serv. Spec. Sci. Rep. Fish. 469: 15p.

McPhail, J.D. and J.S. Baxter. 1996. A review of bull trout (*Salvelinus confluentus*) life-history and habitat use in relation to compensation and improvement opportunities. Fish. Man. Rep. No. 104. Fisheries Branch, Min. of Environment, Lands and Parks

McPhail, J.D. and C.B. Murray. 1979. The early life history and ecology of Dolly Varden (*Salvelinus malma*) in the upper Arrow Lakes. Report of the Institute of Animal Resource Ecology and Departmetn of Zoology (UBC) to BC Hydro and Ministry of Environment, Fisheries Section, Nelson, BC.

Mackay, W.C., M.K. Brewin, and M. Monita. 1994. Friends of the bull trout conference proceedings. Trout Unlimited Canada, Calgary.

Ministry of Environment. 1979. Assessment of the impact of the Kemano II proposal on the fish and wildlife resources of the Nanika-Kidprice and Morice systems. Prepared for Habitat Protection Section, Fish and Wildlife Branch, Victoria.

Mitchell S. 1998. Steelhead trout productivity and stream carrying capacity for rivers of the Skeena drainage – a critique. Prepared for Nortec Consulting.

Mitchell, S. 2000. A Peterson mark-recapture estimate of the steelhead population of the Bulkley/Morice river systems upstream of Moricetown Canyon. Submitted to Fisheries Renewal British Columbia.

Mitchell, S. 2001 A Petersen capture-recapture estimate of the steelhead population of the Bulkley/Morice river systems upstream of Moricetown Canyon during autumn, 200, including synthesis with 1998 and 1999 results. Submitted to Steelhead Society of British Columbia, Bulkley Valley Branch.

Morrell, M. 1985. The Gitksan and Wet'suwet'en fishery in the Skeena River System. Final Report of the Gitksan-Wet'suwet'en Fish Management Study.

Morris, M. and B. Eccles. 1975. Morice River stream survey. B.C. Fish and Wildlife Branch, Smithers.

Morley, R.L. and M. Whately. 1974. The effects of the implementation of the Kemano II Project on sports fisheries, wildlife, and recreation (preliminary report). Fish and Wildlife Branch, Victoria, BC.

Narver, D. 1969. Age and size of steelhead trout in the Babine River, British Columbia. J. Fish. Res. Board Can. 26:2754-2760.

Neilson, J.D. and G.H. Geen. 1981. Enumeration of spawning salmon from spawner residence time and aerial counts. Trans. Amer. Fish. Soc. 110:554-556.

Nortec Consulting 1998. Morice Watershed Restoration Program. Morice Forest District 1996/97. Prepared for Wet’suwet’en Office of the Hereditary Chiefs, Moricetown.

Palmer, R.N., 1966. An assessment of the native food fishery at Moricetown Falls in 1965. Dept. of Fisheries of Canada. 9pp. Unpublished.

Peacock, D., B. Spilsted, and B. Snyder. 1996. A review of stock assessment information for Skeena River chinook. PSARC Working Paper S96-7.

Remington, D. 1996. Review and assessment of water quality in the Skeena River Watershed, British Columbia, 1995. Can. Data Report of Fisheries and Aquatic Sciences 1003.

Robertson, R.A., B.R. Eliasen, and O.K. Johansen. 1979. Hydrographical studies associated with salmon in the Nanika and Morice rivers. Vol. 6. *In*: Salmon studies associated with the potential Kemano II hydroelectric development. Dept. of Fisheries and the Environment, Vancouver.

Solazzi, M., T. Nickelson, S.L. Johnson, and J.D. Rodgers. 2000. Effects of increasing winter rearing habitat on abundance of salmonids in two coastal Oregon streams. Can. J. Aquat. Sci. 57:906-914.

Shepherd, B. 1979. Salmon studies on Nanika and Morice rivers and Morice Lake. Vol 5. *In*: Salmon studies associated with the potential Kemano II hydroelectric development. Dept. of Fisheries and the Environment, Vancouver.

Shepard, C. and J. Algard. 1977. A preliminary survey of juvenile steelhead/rainbow trout distribution and rearing habitat in the Morice River system. B.C. Fish and Wildlife Branch, Smithers, 49pp. Unpublished.

Sheridan, W.L. 1962. Waterflow through a salmon spawning riffle in Southeastern Alaska. U.S. Fish and Wildlife Serv. Spec. Sci. Rep. Fish. 407: 20 p.

Shortreed, K.S., K.F. Morton, K. Malange and J.M.B. Hume. 2001. Factors limiting sockeye production in selected B.C. nursery lakes. Can. Stock Assessment Secretariat. Research Document 2001/xxxx (in press).

Smith, J.L. and G.F. Berezay. 1983. Biophysical reconnaissance of the Morice River system 1978-1980. Man. report prepared for Fisheries and Oceans, SEP Operations, Vancouver.

Tautz, A.F., B.R. Ward, and R.A. Ptolemy. 1992. Steelhead trout productivity and stream carrying capacity for rivers of the Skeena drainage. PSARC Working Paper S92-6 and 8.

Taylor, J.A. 1994 to 2001 (excluding 1997). Synoptic surveys of juvenile coho populations in selected lakes and streams within the Skeena River Watershed, British Columbia. Prepared for Dept. of Fisheries and Oceans, Pacific Biological Station, Nanaimo.

Taylor, G.D. and R.W. Seredick. 1968a. Thautil-Denys Creek inventory. Man. Report prepared by Fish and Wildlife Branch, Victoria.

Taylor, G.D. and R. W. Seredick. 1968b. Feeding habits of some salmonids in the upper Morice River. B.C. Fish and Wildlife Branch, Prince George.

Thompson, G.E. and R.W. Davies. 1976. Observations of the age, growth, reproduction and feeding of mountain whitefish (*Proposium williamsoni*) in the Sheep River, Alberta. Trans. Amer. Fish. Soc. 105(2):208-219.

Tredger, D. 1981. Assessment of steelhead enhancement opportunities in the Morice River system. Progress in 1980. Fish Habitat Improvement Section, Ministry of Environment, Victoria

Tredger, D. 1983. Juvenile steelhead populations in the Morice River System, 1980 to 1982. Fish Habitat Improvement Section, Ministry of Environment, Victoria

Tredger, D. 1986. Bulkley/Morice steelhead stock monitoring report. Fisheries Improvement Unit. Recreational Fisheries Branch, Victoria, B.C.

Triton Environmental Consultants Ltd. 1998. Reconnaissance (1:20,000) fish and fish habitat inventory in the Houston Tommy Creek Watershed. Prepared for Northwood Pulp and Timber Ltd. Houston.

Triton Environmental Consultants Ltd. 2000. Reconnaissance (1:20,000) fish and fish habitat inventory in the Morice River Watershed. Prepared for Northwood Pulp and Timber Ltd. Houston.

Vernon, E.H. 1951. The utilization of spawning grounds on the Morice River System by sockeye salmon. B.A. Thesis, Univ. B.C., Vancouver.

Ward, B. R., A.F. Tautz, S. Cox-Rogers, and R.S. Hooton. 1995. Migration timing and harvest rates of the steelhead trout populations of the Skeena River system. PSARC Working Paper S92-07.

Watershed Restoration Program. 2000. Annual Compendium of Aquatic Rehabilitation Projects for the Watershed Restoration Program 1999-2000. Watershed Restoration Project Report No. 18.

Weiland, I. and J. Schwab. 1992. Floodplain stability, Morice River, between Owen Creek and Thautil River. Prepared for B.C. Forest Service, Houston.

West, C.J. and J.C. Mason. 1987. Evaluation of sockeye salmon (*Oncorhynchus nerka*) production from the Babine Lake development project. *In*: Sockeye salmon population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Whately, M.R. 1977. Kispiox River steelhead trout: The 1975 sport fishery and life history characteristics of angler's catches. Fisheries Tech. Cir. No. 30, B.C. Fish and Wildlife Branch, Smithers.

Whately, M.R., W.E. Chudyk, and M. C. Morris. 1978. Morice River steelhead trout: The 1976 and 1977 sport fishery and life history characteristics from angler's catches. Fisheries Tech. Cir. No. 36, B.C. Fish and Wildlife Branch, Smithers.

Wilkes, B. and R. Lloyd. 1990. Water quality summaries for eight rivers in the Skeena River drainage, 1983 –1987: the Bulkley, Morice, Telkwa, Kispiox, Skeena, Lakelse, and Kitimat Rivers. Skeena Region MOELP Environmental Section Report 90-04.