OFFICE OF THE WET'SUWET'EN

REBUILDING PLAN FOR THE MORICE SOCKEYE RECOVERY UNIT

2021

MORICE SOCKEYE REBUILDING PLAN

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Acknowledgments

Representatives from the following organizations have participated in the recovery planning process:

Office of the Wet'suwet'en
Fisheries and Oceans Canada
Skeena Fisheries Commission
SkeenaWild Conservation Trust
Simon Fraser University

Disclaimer

The Rebuilding Plan for the Morice Sockeye Recovery Unit was prepared by the Morice Sockeye Recovery Team (MSRT) in consultation with experts and observers to identify recovery goals and objectives that are based on sound biological principles, to protect and recover the population. It does not necessarily represent either the official positions of agencies or the views of all individuals involved in the strategy's preparation. The goals, objectives, and recovery approaches identified in the recovery document are subject to all pertinent sections of the Species At Risk Act as well as the priorities and budgetary constraints of participating jurisdictions and organizations.

Photo Credit: Walter Joseph

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OVERVIEW

The Morice Sockeye Recovery Unit is composed of two distinct Conservation Units (Morice and Atna), each of which host a nursery lake where juvenile sockeye rear for one-to-three years. Beginning in the mid 1950s, the number of adults returning to spawn had declined precipitously, and the population generally has remained diminished and far below historical levels. Current information suggests that the population is limited by the low number of spawners returning each year, and the relatively low productivity of Morice Lake and Atna Lake. While exploitation has been reduced in recent years, fishing mortality remains a concern for this population. The Wet'suwet'en Nation and Fisheries and Oceans Canada jointly began to review available information, evaluate options, and identify activities for recovering sockeye in the mid-2000s. This report is the result of that process, and is intended as a framework towards the recovery of sockeye in the Morice Recovery Unit. A companion document, "Wet'suwet'en Rebuilding Strategy for the Morice Lake and Atna Lake Sockeye Salmon (*Oncorhynchus nerka*) Conservation Units" (Price 2019), can be referred to for further information.

SUMMARY

The Morice Sockeye Recovery Unit is in the traditional territory of the Wet'suwet'en Nation.

The Wet'suwet'en community has been unable to adequately secure sockeye food requirements for more than two decades.

The number of adults returning to spawn declined precipitously in the early-1950s, and the population generally has remained diminished and far below historical levels.

While total exploitation rates for sockeye in the Morice Recovery Unit have been modest (27% average) since 2000, the population sustained high (52% average) exploitation during the 1960-1999 period.

The long-term and recent decline in sockeye can be attributed to at least two primary causes: 1) overexploitation in ocean mixed-stock fisheries, particularly during the 1940s and early 1950s when Babine sockeye returns were low, and 2) poor overall survival since 1993 brood year, which has further reduced abundance.

The Recovery Goal is to reverse the decline in abundance of sockeye from the Morice Recovery Unit, re-establish numbers and production equivalent to best estimates of long-term capacity and historical levels (i.e., 40,000 annually), and maximize the net sustainable ecological, cultural, and economic benefits for the Morice/Atna ecosystem.

The recovery of sockeye in the Morice Recovery Unit will focus on eight objectives and six approaches to achieve the above recovery goal.

Sixteen projects have been prioritized (from Highest to Lowest) to undertake the recovery of sockeye returning to the Morice Recovery Unit.

BACKGROUND

Morice Lake and Atna Lake sockeye salmon (herein, named the Morice Sockeye Recovery Unit) are two of 31 wild sockeye salmon Conservation Units (CU) in the Skeena River watershed. Atna Lake flows into Morice Lake via the 2 km-long Atna River, and Morice Lake flows into the Bulkley River near Houston via the 80 km-long Morice River. The Morice Lake sockeye CU is the largest population in the Bulkley watershed; the Wet'suwet'en, whose territory overlies the Bulkley, have fished sockeye salmon at Hagwilget and Witset (Moricetown) Canyons and numerous terminal sites for at least 6,000 years.

Concerns regarding sockeye abundance in the Bulkley/Morice have been raised since the mid-1950s; since then, sockeye abundance has fluctuated at levels far below historical escapements. Harding (1969) was the first to document the decline of sockeye returning to the Bulkley/Morice. Several enhancement activities have occurred over the decades to increase spawner abundance, including: i) blasting rock out of Witset Canyon falls (1929), ii) installation of fishways in Witset Canyon (1951), iii) blasting of rock in Hagwilget Canyon (1959), iv) hatchery supplementation on Nanika River (1960-1965), and v) fertilization of Morice Lake (1980 and 1985).

In 2005, Wet'suwet'en Fisheries and Fisheries and Oceans Canada initiated the Morice-Nanika Sockeye Recovery Planning Process, which resulted in two reports: 1) Backgrounder (Rabnett 2005), and 2) Evaluation of enhancement options (Rabnett 2006). Following a decade without progress, Wet'suwet'en Fisheries developed a formal recovery strategy for Morice Lake and Atna Lake CUs (Price 2019), which eventually led to the formation of a steering committee that culminated in the present Recovery Plan. Representatives from the following organizations have participated in the recovery planning process:

Office of the Wet'suwet'en
Fisheries and Oceans Canada
Skeena Fisheries Commission
SkeenaWild Conservation Trust
Simon Fraser University

BACKGROUND

Whereas ecological knowledge of Morice Lake is substantial, much less is known of Atna Lake. Formal assessments of adult sockeye returning to Morice Lake began in 1944 (Brett 1952). Limnological studies of Morice Lake also began in 1944 (Alderdice & Foerster 1944; Brett 1945; Brett & Pritchard 1946). The Morice River Migrant Survey occurred during 1961 to 1966 (Palmer 1986). The most extensive studies of Morice Lake and Atna Lake were conducted by Cleugh & Lawley (1979), Stockner & Shortreed (1979), Rankin & Ashton (1980), Simpson et al. (1981), Envirocon (1984), Shortreed et al. (1998, 2001), and Shortreed & Hume (2004); Rabnett (2005), and Price (2019) provide additional background information.

Significant human activity in the Morice Lake watershed began in the 1950s with the construction of the Morice River road from Houston to Morice Lake, and such activity was centered on logging. Clear-cut logging became the dominant activity in the 1970s, utilizing easily accessible timber stands located adjacent to the Morice River road. Logging operations were widespread by the 1980s, and has been significant in the northern sections of the watershed. An associated activity related to forestry is road development, where total road length in the watershed is estimated at 2,020 km, and road density is 0.46 km/km^2. Across the Morice watershed, 8.0% of the riparian area has been altered by logging or road development, and there are 1,043 known stream crossings; the total human development footprint in the Morice watershed comprises ~17% (772 km^2) of the land-area (Office of the Wet'suwet'en 2013). The Atna watershed remains pristine.

POPULATION BIOLOGY

Sockeye that spawn in Nanika River (which constitutes the majority of spawning sockeye in the Morice Recovery Unit) are genetically unique to other sockeye populations in the Skeena (Beacham et al. 2014). While all sockeye returning to the Bulkley/Morice are considered genetically similar, molecular genetic testing has been performed only for fish that spawn in Nanika River and Atna Lake; not for sockeye that spawn in Morice River, on submerged beaches of Morice Lake, or the upper Bulkley. It is probable that each of these spawning areas support genetically distinct populations, but this remains a major data gap.

Sockeye from the Morice Recovery Unit are among the earliest to reach the Skeena River, typically from late-June to mid-July, but are known to be present as late as August. Peak spawning occurs during the third week of September (Shepard 1979). In the Morice CU, sockeye primarily spawn in the Nanika River; spawning also occurs along submerged beaches of Morice Lake and in the Morice River at the outflow of the lake (Figure 1). Spawning in the Atna CU is restricted to submerged beaches of Atna Lake.

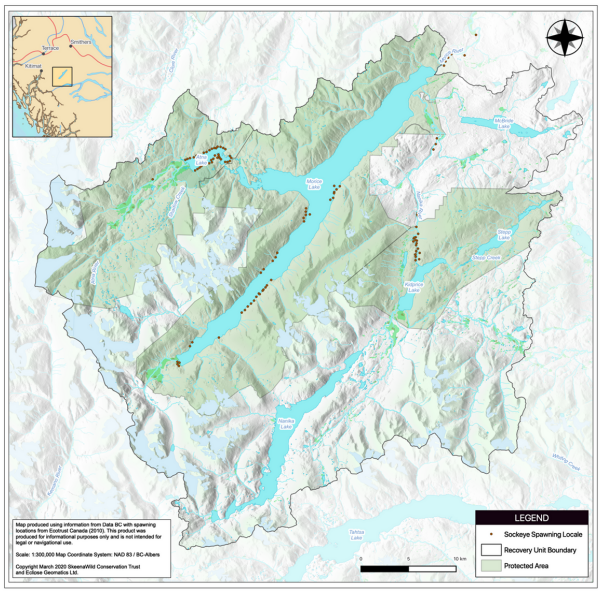

Figure 1. Map of the Morice Sockeye Recovery Unit; red dots denote sockeye spawning locations, and dark green shade is protected habitat.

Sockeye fry migrate downstream from Nanika River into Morice Lake from late-May to late-July with a peak period during mid-June (Shepherd 1979); it remains unknown whether fry in Morice River migrate upstream to rear in Morice Lake or whether they are a stream-type population. Emergence of fry in Atna Lake occurs before the end of May, and likely extends through July. Movement of sockeye fry out of Atna Lake has been observed from late May through August, and it's presumed that these fish subsequently rear in Morice Lake before smolting. Unlike most other Skeena sockeye populations, fry rear for up to three years in Morice Lake, and smolts migrate to sea from late April to early June, with a peak period during mid-May (Palmer 1986). Chatham Sound and Ogden Channel appear to be areas of the highest sockeye smolt usage in the Skeena estuary. Specifically, near-shore areas of east Chatham Sound, such as Flora Bank, were reported to host the highest abundances of juvenile sockeye during sampling in 2007 and 2013 (Gottesfeld et al. 2008; Carr-Harris et al. 2015). These smolts move northward from the Skeena estuary along the coast and offshore into the north Pacific Ocean. Most adult Morice sockeye return at age five or six; the Atna population was thought to be comprised primarily of four and five year-olds (Envirocon 1984), though recent data suggest a predominance of five and six year-olds. Available age data is summarized in Appendix A.

LAKE ECOLOGY

Morice Lake is large (9,737 ha), deep, and hosts excellent physical conditions for juvenile sockeye (Stockner & Shortreed 1979; Costella et al. 1982; Shortreed et al. 1998, 2001). However, the lake is considered ultra-oligotrophic, with low total phosphorus and zooplankton biomass; both of which result in very slow growth rates for fry (Shortreed et al. 2001). Lake productivity appears to be phosphorus limited. The northern section of the Lake near Nanika River outlet is the most productive (Cleugh & Lawley 1979). Average zooplankton biomass is relatively high (648 mg wt/m^3) considering its ultra-oligotrophic status, with the cladoceran Holopedium composing the majority of the biomass and prey for sockeye fry. Other common prey include small cladocerans (Daphnia and Eubosmina) and copepods (Diacyclops). Based on a photosynthetic-rate model, the mean estimated rearing capacity of Morice Lake for sockeye is 6 kg/ha (range = 3.65 kg/ha to 8.35 kg/ha). While current juvenile sockeye abundance in Morice Lake is roughly 2% of the estimated rearing capacity (Cox-Rogers et al. 2004), this system is considered to be limited by the number of spawners.

Atna Lake is a small (416 ha), glacial, lake located 10 m in elevation above Morice Lake. Its waters are extremely turbid due to glacial silt discharged from the Atna River. The outlet of Atna Lake is 2 km long, culminating in two waterfalls formed from bedrock ledges; sockeye can negotiate the lower falls near the south bank only, where the falls form a series of steps (Envirocon 1984). Atna Lake is ultra-oligotrophic; of 19 diatoms that occupy the lake, no dominant species could be identified. Only two copepod species (Cyclops bicuspidatus and Diaptomus franciscanus) were present in zooplankton samples collected in Atna Lake during June and August (Envirocon 1984). The smaller Cyclops species was generally more abundant and widely dispersed in the lake. Zooplankton biomass in August was within the range reported for other oligotrophic glacial lakes, including Morice Lake (Stockner & Shortreed 1978, 1979).

FISHERIES

Sockeye from the Morice Recovery Unit migrate through several mixed-stock fishing areas in southeast Alaska, northern British Columbia (Statistical Areas 1 through 5), and in First Nations food, social, and ceremonial fisheries (FSC) within the Skeena River.

Alaskan Commercial Fisheries

Sockeye from the Morice Recovery Unit migrate through southeast Alaska where they are caught in gillnet and seine fisheries. While Alaskan commercial fisheries do not exert large (5% average) exploitation pressure on these populations because of their relatively early run-time, Alaskan exploitation in some years is high (up to 18%; English et al. 2019).

Canadian Commercial

Commercial fishing for Skeena sockeye began in 1877 with the first salmon cannery, expanding to 15 canneries by 1920. Annual commercial catch of sockeye averaged roughly one million during this early (1877-1920) period, reaching a peak catch of 2.5 million in 1910 (Argue & Shepard 2005).

Sockeye were harvested solely by oar and sail vessels and linen gill-nets in the Skeena River and estuary until 1924 – after which time, powered vessels and mechanical net-drums were permitted, which enabled more efficient capture of fish. The number of boat licences was restricted to 850 up to 1914, but then increased to 1,153 by 1919, and reached a peak of 1,218 in 1933 (Milne 1955). Nylon gill-nets replaced linen gill-nets in 1955, further increasing capture efficiency of sockeye by more than 2.5 times (Todd & Larkin 1971). A seine fishery also was introduced in the 1950s, and grew rapidly through the following two decades.

FISHERIES

Sockeye returning to the Bulkley River (including Morice Recovery Unit) are vulnerable to mortality in the Canadian mixed-stock ocean fishery because their run-timing at least partly overlaps with the abundant channel-enhanced sockeye from Babine Lake, which is the target population for the fishery. Annual exploitation rates on these populations averaged 52% during 1960-1999, but has declined to 27% since 2000 (Figure 2; English et al. 2019).

Indigenous Fisheries

Wet'suwet'en have harvested sockeye for at least 6,000 years in fisheries at Hagwilget and Witset Canyons, and at numerous locations throughout the Bulkley/Morice watershed. Prior to the collapse of sockeye in 1954, annual Wet'suwet'en catch averaged 9,000 fish (Price 2019). Dipnets and basket traps historically were the primary method for capture of sockeye at Hagwilget and Witset Canyons until 1935, at which time all fishing methods were replaced by gaffing as enforced by the Fisheries Department (Milne 1948). Based on estimates of sockeye escapement (Brett 1952) and catch (Milne 1948) in the Bulkley River for 1944-1948, historical harvest rates ranged from 8-27%.

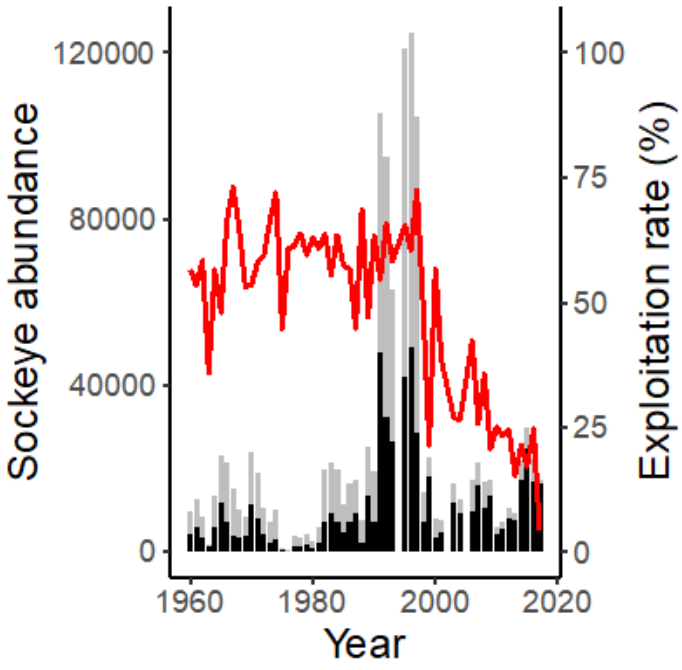

Figure 2. Morice sockeye abundance separated into annual escapement (black bars) and catch (grey bars) during 1960-2017; red line is total exploitation.

Recent-period reconstructions of in-river fisheries on the Skeena suggest that Indigenous exploitation of Bulkley sockeye averaged 23% during 1982-2017, which has been reduced to 13% since 2008. Indigenous fisheries on the Bulkley averaged 21% during 1982-2017, ranging from 0% (2011, 2014) to 64% (1988), with a recent decade average of 6% (English et al. 2019).

POPULATION ABUNDANCE

Sockeye spawning populations upstream of Witset Canyon are surveyed annually. Total sockeye numbers upstream of Witset Canyon are estimated using mark and recapture of tagged fish; escapements to Nanika River are estimated using aerial surveys and area under the curve. While sockeye that spawn on submerged beaches of Morice Lake and Atna Lake are estimated annually using aerial surveys, escapement estimates for these sites are limited.

Trends in total abundance

There exist quality records for annual Skeena sockeye catch (Argue & Shepard 2005) and exploitation (Shepard & Withler 1958) dating back to the onset of the commercial fishery in 1877. Reconstructions of historical abundance suggest that sockeye returning to the Bulkley/Morice once were the third largest population in the Skeena, averaging ~90,000 annually during 1913-1947 (Price et al. 2019, 2021). Over the recent (1960-2017) time-series, sockeye from the Morice CU have averaged ~23,000 annually. The 1990s were the peak decade of abundance during the modern era, when an average of ~75,000 fish were produced, which compares to ~15,000 produced during 2000-2017 (Figure 3).

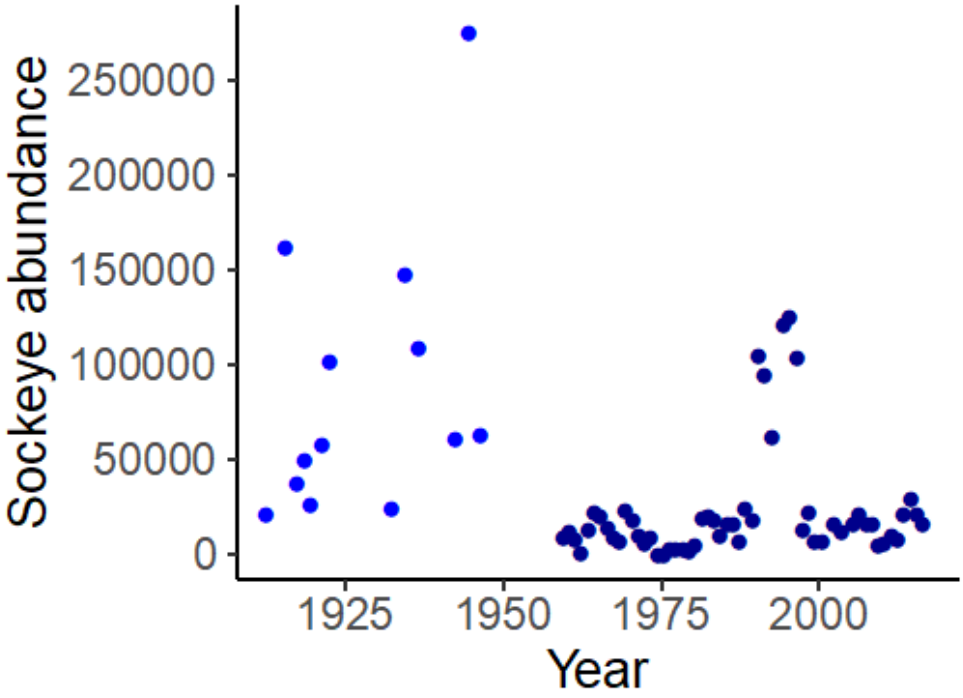

Figure 3. Abundance of sockeye produced throughout the Bulkley/Morice watershed reconstructed for 1913-1947 period (light blue; Price et al. 2019, 2021) and 1960-2017 (dark blue; English et al. 2019).

POPULATION ABUNDANCE

Trends in escapement

An estimated 70,000 sockeye spawned annually during 1944 to 1948; in 1945 specifically, an estimated 65,000 spawned in Nanika River (5,000 in Morice River; Brett 1952). The number of sockeye estimated to have spawned in the Nanika River during 1944-1982 ranged from 70,000 (1949) to 25 (1958; Hancock et al. 1983). Sockeye spawners in the Morice River averaged 1,200 over this same period, and annual lake-shore spawners averaged 235; annual lake-shore spawners in the Atna CU during 1944-1982 averaged <400. The records indicate that Morice/Atna sockeye annual escapements were generally below 5,000 during the 1950s and 1970s, and below 10,000 in all decades except the 1990s, where an average 29,000 fish returned to spawn. Combined, recent (1960-2017) spawning estimates for sockeye range from 240 (1976) to 49,600 (1996), and average 10,745 annually (English et al. 2019). There has been an increasing trend in spawners over the full time-series, as well as the most recent (last three generations; 18 years) period. Recent escapement estimates based on mark-recapture survey data are reported in Appendix B.

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PRODUCTIVITY

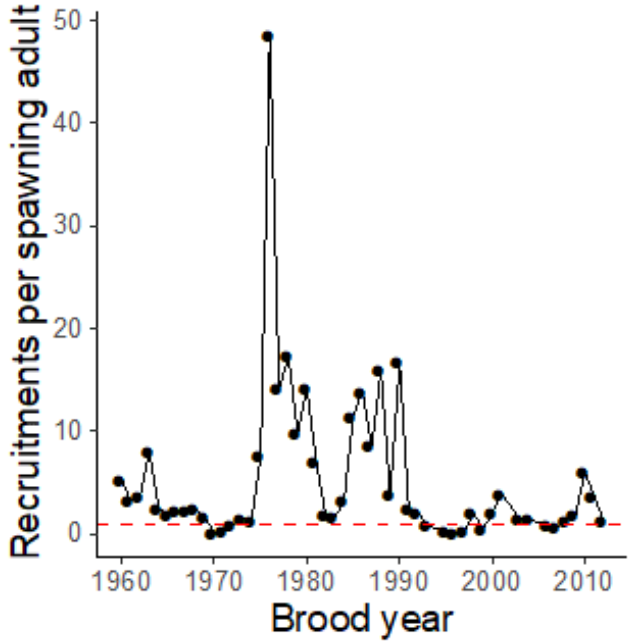


Figure 4. Estimated number of adults produced per spawning adult for each sockeye brood year with corresponding data to 2012; dashed line indicates replacement.

Estimates of escapement and average age composition can be used to estimate the total production of adult sockeye in the Morice Recovery Unit from a given brood year (i.e., the year that a cohort of salmon spawned). The number of sockeye recruits produced per spawner has been variable over the 50+ year time-series - averaging 5.3 adults per spawner - but ranging from a low of 0.1 (1970) to a high of 48.5 (1976; Figure 4).

BIOLOGICAL STATUS

Canada's Wild Salmon Policy (WSP; DFO 2005) provides a framework to assess the conservation and biological status of sockeye from the Morice Recovery Unit. Three metrics (percentile, habitat capacity, and trends in abundance) were compared against benchmarks that have been proposed to delineate levels of conservation and management concern in Pacific salmon (e.g., Holt et al. 2009) to quantify the current conservation status. These benchmarks have been identified based on simulations that have quantified extinction and recovery probabilities (Holt & Bradford 2011; Holt & Folkes 2015; Table 1). Canada's WSP uses a "stoplight" approach to communicate status of a population where green is healthy, amber is of concern, and red is threatened; we follow this approach below.

While stock-recruitment based metrics often are used to assess the status of populations, they are sensitive to assumptions about temporal variation in productivity (Holt & Bradford 2011), and are most reliable when quantified with annual age-composition data. Because these data generally have not been collected, and due to various other uncertainties, we have not used a stock-recruitment based metric here. Three metrics used to assess biological status include:

1. For historic spawner-based benchmarks, we used the 25th and 75th percentile of historic spawners (1913-2017) as lower and upper benchmarks, respectively. Recent decade (2008-2017) average spawning escapement (12,266) is above the lower (4,287) but not upper (18,843) benchmark, and suggests amber status (Figure 5a).

2. For habitat capacity, 15% and 55% of SMAX were used as the lower and upper benchmarks, where SMAX is the spawner abundance expected to produce the maximum number of juveniles that rearing habitat can support, based on models of habitat capacity (Cox-Rogers 2012) - though a weakness of this metric is that Morice Lake is limited by spawning (not rearing) habitat. SMAX estimate for Morice Lake is 191,362, with lower and upper benchmarks of 28,704 and 105,249, respectively. The average spawning escapement (12,266) during 2008-2017 is below the lower benchmark, and suggests "red" status (Figure 5b).

3. A 15% and 25% decline over 3 generations (18 years) was used as upper and lower benchmarks, respectively, for the trends in abundance indicator (Holt et al. 2009). Spawner abundance has increased by 8% over the last 18 years, driven largely by above-average returns since 2014, and suggests "green" status (Figure 5c).

BIOLOGICAL STATUS

Sockeye have averaged 12,266 spawners since 2008. While the quantified status of sockeye across the three metrics was not consistent (i.e., 1 red, 1 amber, 1 green), there is unanimous consensus among the recovery team and Wet'suwet'en Nation that this population is of conservation concern, and in need of rebuilding.

Indicator	Metric	Lower benchmark	Upper benchmark
Spawner abundance	Historic spawners	4,287	18,843
	Habitat capacity	28,704	105,249
Trends in abundance	Rate of change over recent generation	25% decline	15% decline

Table 1. Current values for a range of status metrics and their corresponding lower and upper benchmarks for sockeye from the Morice Recovery Unit.

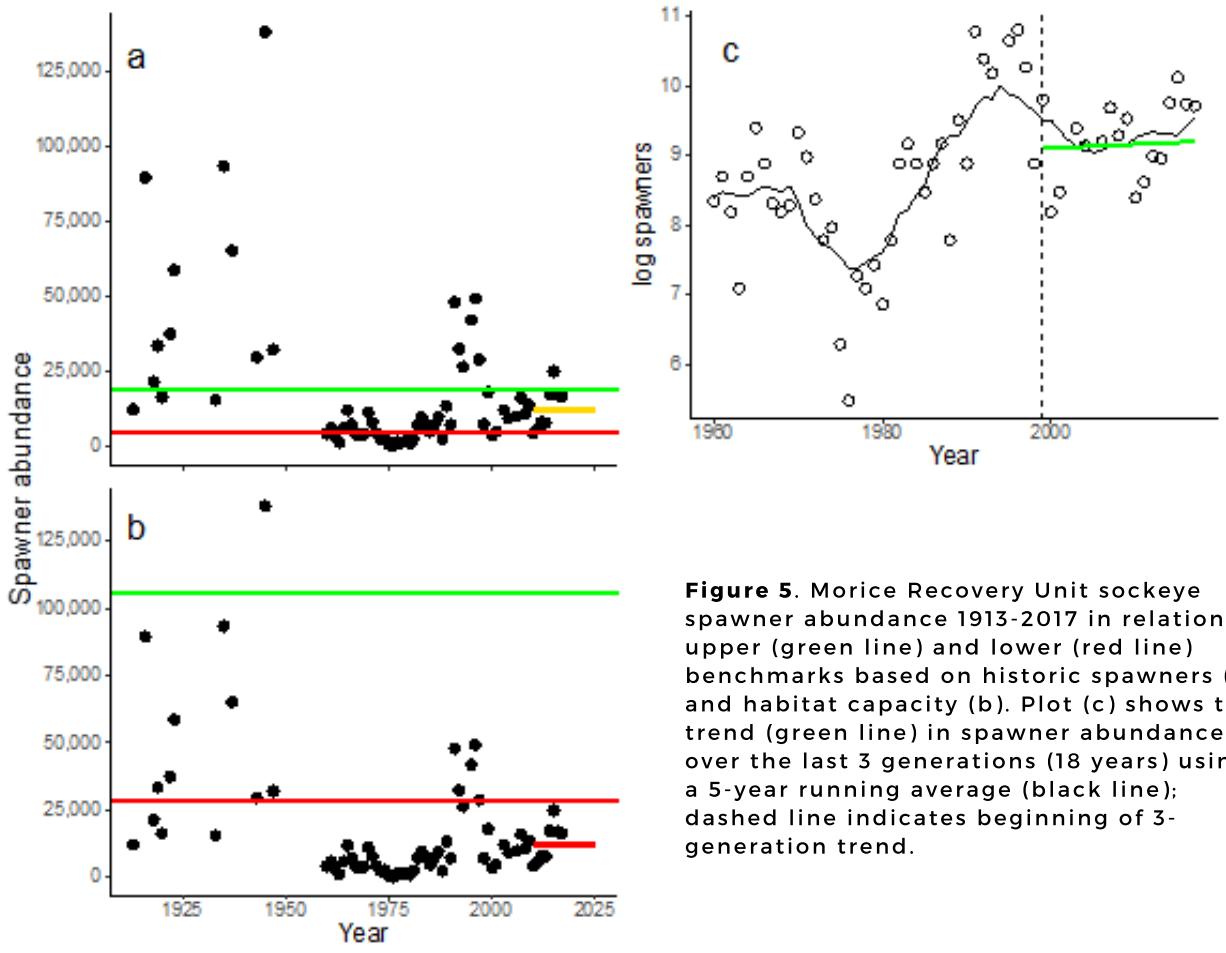


Figure 5. Morice Recovery Unit sockeye spawner abundance 1913-2017 in relation to upper (green line) and lower (red line) benchmarks based on historic spawners (a) and habitat capacity (b). Plot (c) shows the trend (green line) in spawner abundance over the last 3 generations (18 years) using a 5-year running average (black line); dashed line indicates beginning of 3-generation trend.

HABITAT STATUS


Photo Credit: Walter Joseph

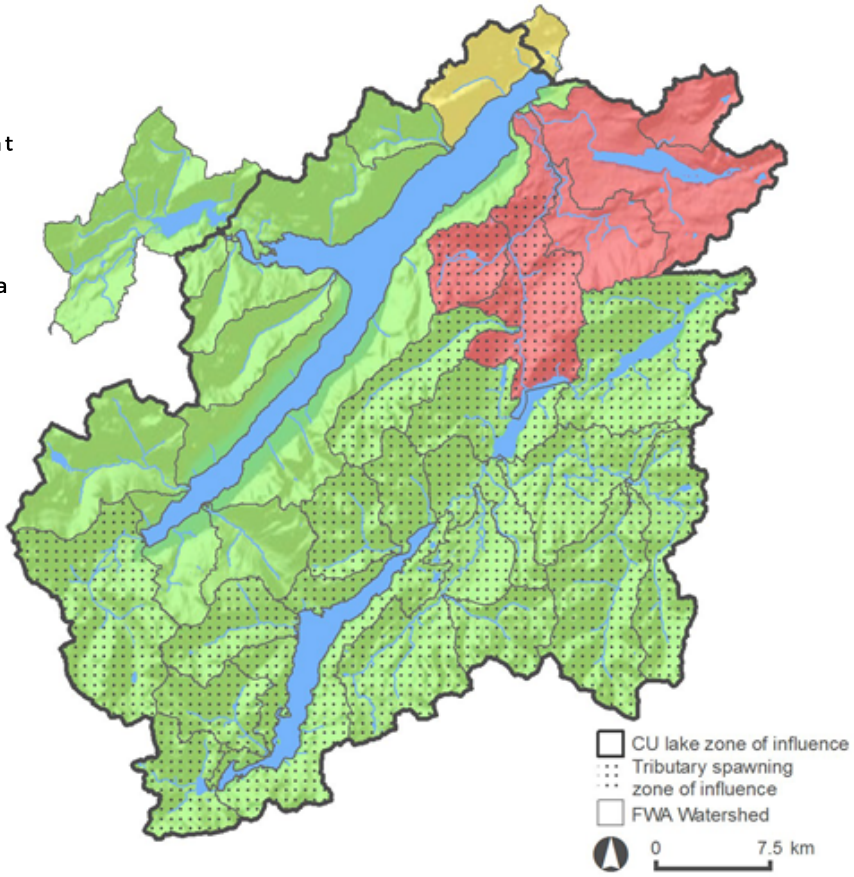
Land-use development in the Morice Recovery Unit over the previous century is well described by Rabnett (2005). What began with tie hackers, who cut small amounts of lodgepole pine for railroad ties at the lower end of the catchment through the 1920s and 1930s, developed into clear-cut logging operations by the 1960s. A complex road-network has been built, and sizable tracts of forest have since been felled by clear-cut logging in the area between Owen Creek and Nanika River (Office of the Wet'suwet'en 2013).

An associated activity related to forestry is road development, where total road length in the watershed is estimated at 2,020 km, and road density is 0.46 km/km^2. Approximately 8.0% of the riparian area across the Morice watershed has been altered by logging or road development, and there are 1,043 known stream crossings; the total human development footprint comprises ~17% (772 km^2) of the land-area (Office of the Wet'suwet'en 2013). The Atna watershed remains pristine.

While the total human development footprint in the Morice watershed is relatively low, activity in the lower Nanika River sub-basin below Kidprice Lake – where the majority of sockeye spawn – has been extensive. Cumulative pressure scores are considered high for sockeye (Porter et al. 2013; Figure 7). Specifically, spawning and rearing Morice sockeye are considered at high risk in the lower Nanika River for the following metrics: Hydrologic processes, Equivalent clear-cut area, Vegetation quality, Fish passage, and overall Human development footprint (Porter et al. 2013; Figure 8), and at moderate risk to Riparian disturbance (9.4%) and Road density (0.93 km/km^2). While much of the forest removal occurred a decade or more ago (at times involving salvage of beetle-killed trees), there is urgent need for a detailed habitat assessment. Regardless of restoration needs, priority recovery activities should either seek full protection for the lower Nanika River sub-basin, or improve all red- or amber-status habitat pressure metrics to green-status given the overwhelming importance of this area as sockeye spawning grounds.

HABITAT STATUS

Figure 6. Cumulative pressure habitat vulnerability assessment based on various metrics for spawning and rearing sockeye in the Morice Sockeye Recovery Unit (black outline); grey lines identify sub basins. Red (Nanika and Lamprey sub basins) denotes high risk, amber is moderate risk, and green is low risk. From Porter et al. (2013).



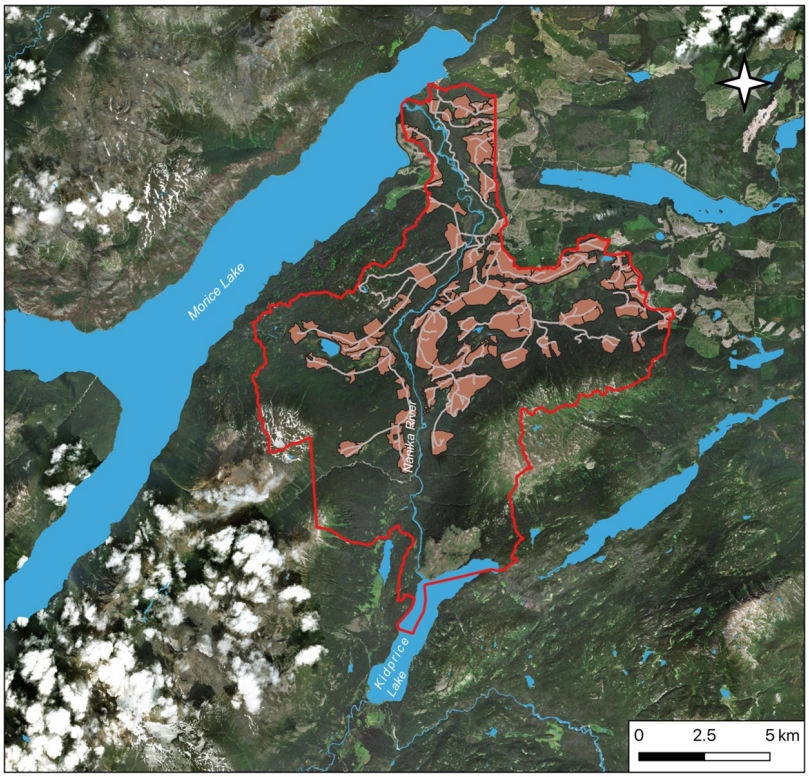


Figure 7. Human development footprint within the lower Nanika River sub-basin (red outline; 22.5%); pink shade denotes forest removal, and grey lines are roads.

HABITAT REQUIREMENTS

The habitat requirements of sockeye in the Morice Recovery Unit are ecologically and geographically extensive. As with most salmonids, their life-cycle spans both freshwater (for spawning, egg incubation, fry rearing, and smolt migration) and marine (ocean rearing and return migration to spawn); each of these stages has different habitat requirements.

Migratory route with appropriate flow and temperature

Morice and Atna sockeye ascend the lower Skeena River and the Bulkley River before migrating up the Morice River into Morice Lake. Historically, these fish were challenged by natural rock obstacles at Hagwilget and Witset Canyons. However, the Department of Fisheries blasted rock out of the Witset Canyon waterfalls in 1929, and built fishways in subsequent years; similarly, a large rock outcrop at Hagwilget Canyon was removed in 1959. While these remedies indeed improved fish passage, they eliminated Wet'suwet'en fisheries at Hagwilget, and greatly reduced catchability at Witset Canyon. Reduced flow and elevated water temperatures have been reported in the Bulkley River and Morice River (Oliver 2018, 2020) during recent years, which may become a concern for sockeye under future projections of climate change. Such habitat requirements currently are met. Importantly, a natural gas pipeline corridor is proposed to cross Morice River near the confluence with Gosnell Creek, which will alter habitat during construction, and present a threat to migrating fish during operation.

Spawning and egg incubation habitat

Egg and alevin survival depend on clean gravel and sufficient flow of well-oxygenated water. While the majority of sockeye from the Morice Management Unit spawn in the Nanika River, a small proportion spawn along submerged beaches of Morice Lake - to our knowledge, all Atna sockeye spawn on submerged beaches of Atna Lake - these locations likely are where upwelling groundwater exists. Such habitat requirements currently are considered met, although there are water quality concerns for Nanika River if further road-building and logging occurs, and metal mines currently proposed become active, in the sub-basin.

HABITAT REQUIREMENTS

Juvenile freshwater rearing habitat

Sockeye fry rear in Morice Lake and Atna Lake for one to two years (and occasionally, three years). Juveniles utilize deep waters during the day - where cooler water slows metabolic rates, which allows more food energy to go into growth – and shallow surface waters at night to feed. Morice Lake and Atna Lake are of low productivity, which appears to be phosphorus limited. Average zooplankton biomass was relatively high (648 mg wt/m^3) when last assessed (2004) considering its low-productivity status, and juvenile abundance in Morice Lake when last assessed (2004) was estimated to be 2% of its rearing capacity (Cox-Rogers et al. 2004).

Ocean rearing habitat

Juveniles require unrestricted marine corridors and feeding grounds of appropriate temperature and productivity (Foerster 1968; Burgner 1991). Several human activities currently challenge ocean rearing habitat for Morice and Atna sockeye. For example, the Skeena estuary is one such feeding ground that has been altered by previous industrial development (26 salmon canneries operated at various times since 1877, as well as a pulp mill, export grain terminal, and container port), and several industrial projects currently are proposed. Additionally, phenology is changing due to climate warming: Spring is tending to be earlier and Autumn is later, which is reshuffling species interactions. There is concern that the arrival of juvenile sockeye in the estuary is becoming out of sync with peak prey availability (Carr-Harris et al. 2018). Finally, while climate-driven variability in ocean productivity has, and will continue to, influence the survival of sockeye, habitat requirements at the ocean basin-scale currently are challenged by the large production of fish from hatcheries, mostly in Alaska (Ruggerone & Irvine 2018).

RECOVERY POTENTIAL

Several red-flags of impaired recovery for depressed populations have been reported (e.g., Hutchings et al. 2012), and many of these apply to sockeye from the Morice Recovery Unit: i) numerical decline in excess of 50% from historical abundance, ii) life-history trait combinations of slow freshwater growth and older age at maturity compared to other sockeye populations, and iii) slow implementation of conservation interventions.

Given the recent (2009-2017) return of sockeye to the Morice Recovery Unit, and based on the average productivity over the time series 1960 to 2017 (English et al. 2019), it is predicted to take an estimated 15 years to produce a spawning escapement above 40,000 in the absence of any fishing mortality (Figure 8). Even at 20% ER, which is less than the recent decade average of 26%, the probability of recovery does not exceed 80% at any time over the next 20 years.

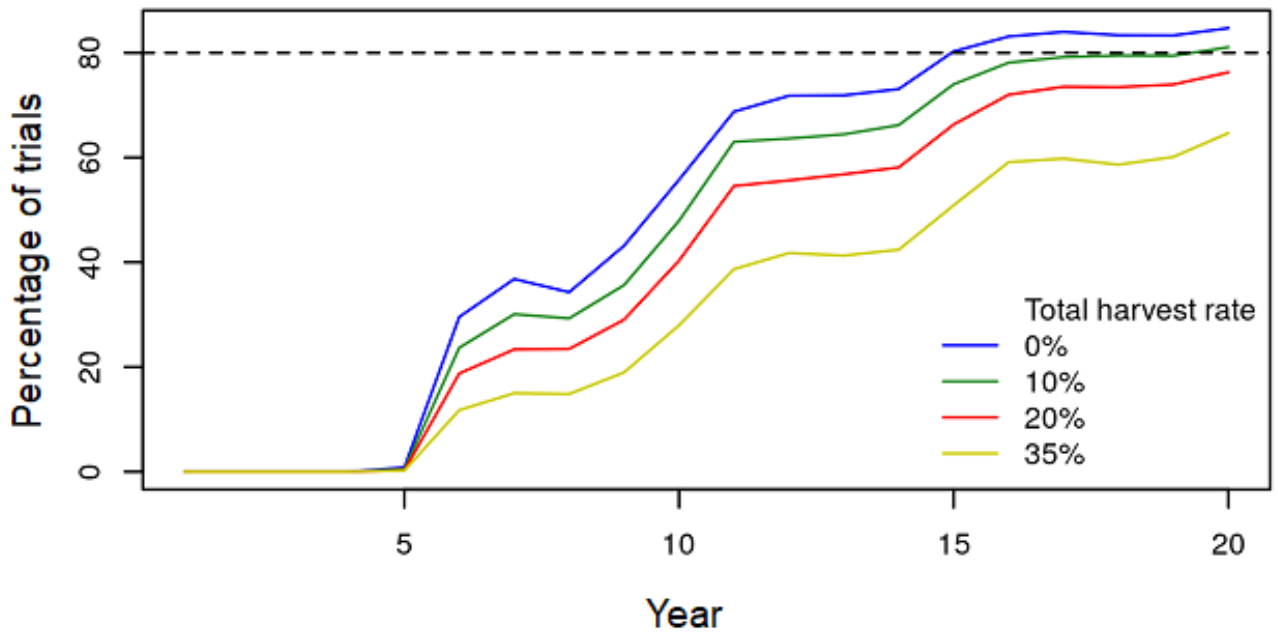


Figure 8. The potential time in years and related probability (percentage of trials) for sockeye from the Morice Recovery Unit to "recover" (i.e., 40,000 spawners) in relation to various rates of fisheries exploitation.

THREATS TO POPULATION VIABILITY & RECOVERY

Sockeye from the Morice Recovery Unit are largely diminished, but recovery appears biologically possible if particular threats to their viability can be addressed. The available information suggests that the long-term and recent decline of sockeye can be attributed to at least two primary causes:

1. Historic overexploitation in mixed-stock fisheries, particularly during the 1940s and early 1950s when Babine sockeye returns were low, has increased susceptibility to other sources of natural mortality.

2. Poor overall survival since the 1993 brood year, which has further reduced abundance in the recent term.

Other threats, such as low lake productivity, altered density dependence, increased ocean-rearing competition, reduced marine productivity, and loss of genetic variation will require further evaluation. Fisheries exploitation - while currently considered low, but not insignificant - also should be further evaluated. The list of threats potentially affecting the recovery of sockeye from the Morice Recovery Unit include:

Life-stage: Egg to alevin

- Loss of genetic variation due to low spawning abundance (known threat; high risk)
- Past, current, and continued habitat degradation due to logging in the Nanika sub-basin below Kid-Price Lake (known threat; moderate risk)

Life-stage: Fry

- Low lake productivity, resulting in fry that rear for up to 2 to 3 years (known threat; moderate risk)
- In-lake predation (known threat; moderate risk)
- Decreased density-dependence due to low spawning abundance, resulting in decreased marine survival for fry that rear for 1 year (potential threat; moderate risk)

THREATS TO POPULATION VIABILITY & RECOVERY

Life-stage: Smolt

- In-river predation (presumed threat; low risk)
- Phenological changes due to increasing climate variability, resulting in a mis-match between arrival in the Skeena estuary and peak prey availability (potential threat; moderate risk)
- Estuarine predation (presumed threat; low risk)
- Current and continued industrial development in the Skeena estuary (potential threat; moderate risk)

Life-stage: Marine growth

- Competition with pink salmon in the north Pacific (known threat; high risk)
- Reduced ocean productivity (potential threat; moderate risk)
- Predation (presumed threat; low risk)
- Fisheries mortality (known threat; moderate risk)

Life-stage: Spawner

- In-river fisheries mortality (known threat; moderate risk)
- Elevated water temperatures in the Bulkley River and Morice River during low water years (known threat; moderate risk)

RECOVERY GOAL

Reverse the decline in abundance of sockeye from the Morice Recovery Unit, re-establish numbers and production equivalent to best estimates of long-term capacity and historical levels, and maximize the net sustainable ecological, cultural, and economic benefits for the Morice/Atna ecosystem.

RECOVERY OBJECTIVES

The objectives to meet the recovery goal need to consider the various threats affecting sockeye production in the Morice Recovery Unit, as well as the watershed's current and future capacity to support increased production.

1. Inform the local community and other stakeholders about the recovery planning process for sockeye from the Morice Recovery Unit, and encourage them to participate in the stewardship of the Morice/Atna watershed.

2. Achieve continued growth in the generational average by increasing spawner abundance relative to the brood year (5 and 6 years prior) for at least 3 out of 4 consecutive years.

3. Increase annual number of naturally produced spawners to 30,000 by the year 2025.

4. Ensure that by the year 2030, the mean population abundance exceeds 40,000 naturally produced spawners in the Nanika River during any five-year period, with no fewer than 30,000 spawners in a year.

5. Increase the population to a level where food needs can be met (see Wet'suwet'en Fishing Plan – Appendix C).

6. Ensure that once the population is deemed to have recovered, and the Nation's food needs are met, that sustainable economic/trade opportunities are resumed.

7. Identify the level of abundance required to support ecosystem function and sustainable use, as a longer-term target for recovery.

8. Implement habitat protection measures, or improve all red- or amber-status habitat pressure metrics to green-status for the lower Nanika River sub-basin to ensure environmental flow and water quality needs are met for sockeye in the Morice Recovery Unit.

RECOVERY APPROACHES

Rebuilding of sockeye in the Morice Recovery Unit will focus on the following recovery approaches to achieve the above objectives:

1. Engage and consult stakeholders.

2. Develop and implement watershed stewardship initiatives.

3. Reduce natural and fishing mortality on Morice/Atna sockeye.

4. Evaluate, maintain, restore, and protect critical habitat.

5. Enumerate and collect biological and genetic information on juveniles and adults.

6. Evaluate, and (if beneficial, which may be difficult to quantify) strategically enhance sockeye.

The only project associated with a recovery approach that will support population recovery in the short-term is the reduction of fisheries-induced mortality of sockeye returning to the Morice Recovery Unit. The remainder of projects inevitably will produce results over the long-term. Because financial resources are limited, and the time and effort required to implement some projects is substantial, the recovery team has established priorities.

PRIORITIZED PROJECTS

Appendix D outlines the prioritized projects designed to recover sockeye in the Morice Recovery Unit. Recovery of this population will be a learning process that begins with smaller, ongoing, projects and moves over time towards the larger, more costly, and challenging projects. To meet the most immediate objective of increasing the number of spawning sockeye, it is strongly recommended that projects aimed at improving existing information on spawner estimates (such as stream counts and other monitoring effort), age-at-return (scale sampling), and genetic characterization (tissue and environmental-DNA sampling) be implemented beginning in 2021.

Several of the longer-term projects (such as habitat protection or restoration, radio-tagging adults and identifying spawning locations, and smolt-sampling at the outlet of Morice Lake) also could begin in 2021 if funding were in place. Two projects considered by the recovery team as of high priority and moderate priority: i) Nanika River habitat evaluation and protection, and ii) Witset Canyon fishway impact, should be considered for immediate discussion and planning.

A final, yet important, component of recovery implementation identified by the recovery team is to inform the local community and other stakeholders about the recovery planning process, and encourage them to participate in the stewardship of the Morice/Atna watershed.

IMPLEMENTATION & EVALUATION

The next step in the recovery planning process should include the development of an implementation plan, jointly crafted by the Wet'suwet'en Nation and Fisheries and Oceans Canada. Such a plan must focus on the priority rebuilding programs identified in Appendix D, identify potential sources of funding, ensure collaboration with ongoing programs, and include a periodic review (e.g., every 5 years) of progress. Ideally, the implementation plan would include specific time-lines, project leads, roles and responsibilities, and details of monitoring and evaluation for recovery actions in the short-term. Finally, we advise that the periodic review include results of the implementation of recovery actions, an updated assessment of biological status for the Morice Sockeye Recovery Unit, and a formal assessment of escapement goals (an escapement goal process for Morice sockeye currently is in development) as a high-priority activity.

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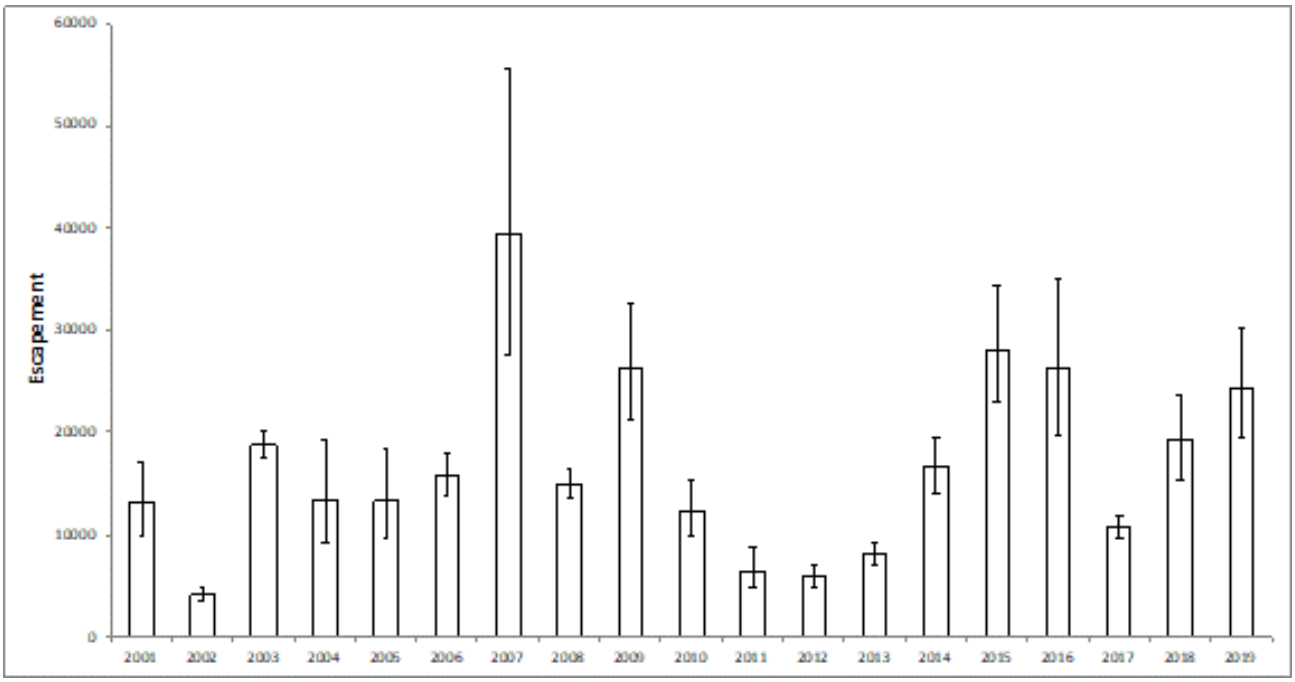
APPENDIX A

Morice sockeye age data based on circulicounts of scales collected either from commercial fisheries in the Skeena River and estuary (pre-1950), Tyee Test Fishery (post-1950), or at various locations in the Bulkley/Morice; 1.x fish emigrated to the ocean after one year in freshwater, and 2.x fish reared in freshwater for two years.

Year	Sampling location	1.1	1.2	1.3	1.4	2.1	2.2	2.3	Other	Total	%1.x	%2.x	% Other
1916	Skeena	0	0	1	0	0	0	0	0	1	100	0	0
1918	Skeena	0	0	1	0	0	0	1	0	2	50	50	0
1919	Skeena	0	0	0	0	0	0	1	0	1	0	100	0
1920	Skeena	0	0	0	0	0	1	1	0	2	0	100	0
1921	Skeena	0	1	0	0	0	1	0	0	2	50	50	0
1922	Skeena	0	1	3	0	0	7	0	0	11	36	64	0
1923	Skeena	0	0	2	0	0	3	5	0	10	20	80	0
1933	Skeena	0	3	3	0	0	1	1	0	8	75	25	0
1935	Skeena	0	2	8	0	0	27	5	0	42	24	76	0
1937	Skeena	0	1	1	0	0	1	12	0	15	13	87	0
1943	Skeena	0	2	0	0	0	6	9	0	17	12	88	0
1944	Witset	0	10	74	74	0	86	42	0	286	55	45	0
1945	Skeena & Witset	0	30	85	1	0	233	187	0	536	22	78	0
1946	Witset	1	137	79	0	5	120	124	0	466	46	53	0
1947	Skeena & Witset	3	17	83	0	13	45	57	0	218	47	53	0
1951	Witset	0	0	20	0	0	184	168	53	425	5	83	12
1961	Witset	0	11	4	0	1	157	36	2	211	7	92	1
1962	Witset	0	14	24	0	4	106	68	3	219	17	81	1
1963	Witset	0	14	2	0	1	145	36	0	198	8	92	0
1964	Witset	0	30	32	0	1	128	19	1	211	29	70	0
1965	Witset	0	125	42	0	12	259	132	8	578	29	70	1
1965	Nanika	0	12	13	0	3	114	129	3	274	9	90	1
1966	Witset	0	7	19	0	0	160	25	0	211	12	88	0
1966	Nanika	0	2	2	0	2	186	27	2	221	2	97	1
1967	Witset	0	7	2	0	0	15	87	1	112	8	91	1
1967	Nanika	0	4	4	0	0	72	312	8	400	2	96	2
1968	Nanika	0	16	24	0	0	521	241	0	802	5	95	0
1969	Nanika	0	20	50	0	10	707	212	10	1009	7	92	1
1970	Nanika	59	59	197	0	157	1103	335	59	1969	13	81	3
1971	Nanika	0	0	58	0	0	278	823	0	1159	5	95	0
1972	Nanika	12	89	10	0	4	79	4	0	198	50	44	0
1996	Nanika	0	2	12	0	0	44	40	0	98	14	86	0
2000	Skeena	0	1	1	0	0	2	0	0	4	50	50	0
2002	Skeena	0	3	6	0	0	0	0	0	9	100	0	0
2003	Skeena	0	3	4	0	0	8	0	0	15	47	53	0
2004	Bulkley Fence	0	4	1	0	0	0	0	0	5	100	0	0
2005	Bulkley Fence	1	40	6	0	0	2	0	0	49	94	4	0
2006	Skeena	0	0	0	0	0	0	2	0	2	0	100	0
2007	Skeena	0	2	5	0	0	0	4	2	13	54	46	0
2008	Skeena	0	0	2	0	0	3	5	0	10	20	80	0
2009	Skeena & Witset	0	9	16	0	0	8	25	0	58	43	57	0
2010	Skeena	0	1	2	0	0	5	2	0	10	30	70	0
2011	Skeena	0	0	4	0	0	3	0	0	7	57	43	0
2012	Skeena	0	1	0	0	0	1	0	0	2	50	50	0
2013	Skeena	0	0	1	0	0	0	2	0	3	33	67	0
2015	Atna Lake	0	1	1	0	0	2	1	0	5	40	60	0
2017	Skeena & Atna Lake	0	3	5	0	0	5	7	0	20	40	60	0
2018	Witset	0	15	1	0	0	20	2	0	38	42	58	0
2019	Witset	0	4	41	0	0	13	7	0	65	69	31	0

APPENDIX B

Estimates of annual sockeye escapement upstream of Witset Canyon based on mark recapture surveys.



APPENDIX C: WET'SUWET'EN FISHING PLAN

The Morice River is located entirely within Wet'suwet'en traditional territory. The sockeye fishery is an integral part of the Wet'suwet'en Aboriginal fishing rights, constitutionally protected by s. 35 of the Constitution Act ("Aboriginal Rights"). However, over 20 years ago, Wet'suwet'en had no choice but cease this practice because of concerns regarding the conservation of the population, and the ability of future generations of Wet'suwet'en members to exercise their Aboriginal Right to fish. While this decision was made voluntarily, it has not been without adverse impacts to Wet'suwet'en. It has always been Wet'suwet'en's intentions to resume the Morice sockeye fishery as soon as the population could sustain a food fishery harvest without putting them at risk of extirpation.

Currently, there are no official biological production benchmarks set for Morice sockeye. However, the mean biological threshold of spawning escapement (i.e., lower management benchmark) through work funded by the Pacific Salmon Foundation has been estimated at 49,441 (lower and upper 95% confidence intervals of 25,015 and 89,522, respectively; Korman & English 2013). Importantly, Morice sockeye spawner abundance has not reached the estimated lower biological threshold since 1997. Fishing mortality of Morice sockeye has occurred in all years post-1997, with a Canadian annual average harvest rate of 27%, and a total (which includes harvest by Alaska) average annual harvest rate of 30%.

In the interim, the professional recommendation from the Wet'suwet'en Fisheries is that fishery managers strive to achieve an overall annual escapement goal for the stock in the order of 30,000 to 40,000. In some years, it may be permissible to fish the population below this level to satisfy important food needs - for example, the Aboriginal Rights of the Wet'suwet'en to fish in their traditional territory. However, it should be noted that fishing the population below optimum production levels annually may slow rebuilding and place small spawning populations such as Atna, Morice lake-shore, Morice River, and Upper Bulkley) at risk of extirpation (depending on how low the escapements become).

Given that Section 35 right-based fisheries take precedent over all other fisheries, it is believed that the Morice sockeye Recovery Unit could support a small Wet'suwet'en sustenance fishery of 1,000, provided that commercial and in-river exploitation remain at a relatively low level (10% or less), and that the sockeye numbers estimated at Witset Canyon exceed 20,000. However, it is important to note that this level of harvest does not satisfy their Aboriginal Right to fish on the Bulkley. The Wet'suwet'en harvest of sockeye from the Morice Recovery Unit should then increase, as (hopefully) the escapement numbers increase. As Aboriginal fisheries have priority over commercial fisheries, the rebuilding of the Morice sockeye Recovery Unit and the ability of Wet'suwet'en to fully exercise their Aboriginal Right to fish on the Bulkley is the constitutionally protected priority after conservation.

APPENDIX C: WET'SUWET'EN FISHING PLAN

Accordingly, Wet'suwet'en Fisheries have prepared the following list of technical recommendations for the declaration and implementation of the Section 35 harvest of sockeye from the Morice Recovery Unit in the future. They are as follows:

1. Total sockeye escapement estimated at Witset Canyon should exceed 20,000 before any fishery is declared.

2. It is recommended that in-river Section 35 harvest of sockeye proceed according to the following schedule:.

SOCKEYE ESCAPEMENT TO WITSET CANYON	TOTAL RECOMMENDED MAXIMUM MORICE SOCKEYE SECTION 35 HARVEST
20,000	1,000
25,000	2,000
30,000	3,000
35,000	4,000
40,000	5,000
45,000	7,500
50,000	10,000

3. Harvest allocation numbers are based on the assumption that female sockeye compose approximately 50% (+/- 10%) of the return. If the ratio of females-to-males is less than 50%, harvest allocations and triggers should be reduced accordingly.

4. Harvesting of sockeye at Witset Canyon should be done in a selective manner, prioritizing a higher proportion retention of males, and care to not adversely affect the migration and/or spawning success of other non-target species of salmon frequenting the Bulkley River.

5. Annual sockeye escapement estimates are performed via mark-recapture methods at Witset Canyon by Wet'suwet'en Fisheries, and will be the basis for deciding whether a food fishery for sockeye is to proceed in any given year.

APPENDIX D

Prioritized list of projects and associated costs aimed at rebuilding sockeye returning to the Morice Recovery Unit.

Project description and priority	Status	Annual $	One-time $
Highest Priority			
Spawner enumeration *Increased annual effort for minor spawning locations (Atna, Morice Lake beaches)*	Underway	$50,000	
Monitoring of adult spawning locations to increase spawner estimates *Radio-tag adults at Witset Canyon and quantify proportions of specific spawning locations*	Proposed	$40,000 x 3 years	
Adult age-at-maturiy sampling *Increaed scale-collection effort for adults at Witset Canyon and spawning locations*	Underway	$20,000	
Smolt capture program *Trap out-migrating smolts from Morice Lake to quantify age/size distributions*	Proposed	$100,000 x 6 years	
Genetic sampling of spawning adults *Increased tissue sampling to characterize genetic distribution of populations (including river-type)*	Underway		$20,000
Nanika River habitat evaluation and protection *Determine what restoration efforts are required for Lower Nanika River, and implement*	Proposed		$30,000
Moderate Priority			
Assessment of loss in genetic diversity *Quantify the change in genetic diversity over century & millenial time-scales*	Proposed		$100,000
Quantify Skeena in-river exploitation of Bulkley sockeye *Coordinate collection of tissue from sockeye caught in Indigenous fisheries*	Proposed		$50,000
Assess limnology of Morice & Atna Lake *Undertake limnological surveys of Morice & Atna Lake*	Proposed		$75,000
Quantify changes in glacial input to Morice & Atna Lake *Undertake assessments to determine glacial loss and potential affects on receiving lakes*	Underway		$30,000
Witset Canyon fishway impact on Wet'suwet'en fishery *Assess whether fishways are influencing Wet'suwet'en's capture efficiency*	Proposed	DFO responsibility	
Update enhancement & lake fertilization options report *Write an update to the 2006 Rabnett report on enhancement & lake fertilization*	Proposed		$20,000
Quantify historical salmon nutrients in Morice & Atna Lake *Extract sedminent cores from Morice & Atna Lake*	Proposed		$150,000
Lower Priority			
Assess water quality within Morice Management Unit *Increase water quality surveys opportunistically*	Underway	$30,000	
Inclusion of CABIN sampling throughout Morice Management Unit *Increase Cabin sampling surveys opportunistically*	Underway	$30,000	
Assess limnology of Nanika & Kid Price Lake *Undertake limnological surveys of Nanika & Kid Price Lake*	Proposed	$100,000 x 2 years	