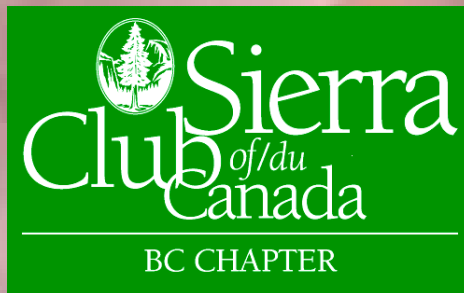


BC Sockeye Salmon Population Declines: Probable Causes and Recommended Response Strategies

February, 2006

Prepared for:

The Sierra Club of Canada – BC Chapter
P.O. Box 8202
Victoria, BC
V8W 3R8



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Executive Summary

This report was prepared for the Sierra Club of Canada, BC Chapter to evaluate sockeye salmon biodiversity conservation in BC. Numerous BC sockeye populations are declining in abundance and many small populations have unknown status due to the absence of stock assessment information. Sockeye returning to Cultus and Sakinaw Lakes have been designated as “endangered” by COSEWIC and many other populations are potential candidates for listing. In Northern and Central BC, approximately 75% of sockeye populations are either depressed, declining or unknown status and at least 38 populations coast-wide are below 25% of their historical baseline level. Better stock assessment information is required to determine the actual number of depressed stocks and to inform management decisions.

Factors that influence sockeye abundance include natural environmental variations and those induced by global warming. Sockeye in BC are captured in commercial, recreational and aboriginal fisheries and fishing is implicated in the declines of many smaller populations. Sockeye fisheries need to be structured so they do not endanger the persistence of small sockeye stocks.

Recommended actions to protect sockeye include:

- Preparation of coastal conservation strategies
- Shift to terminal fisheries that target specific stocks
- Intensified stock assessments
- Expanded involvement of First Nations
- Adopt a new conservation benchmark to represent the level of population abundance that triggers COSEWIC listing
- Petition COSEWIC for listings of endangered populations

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Introduction

There is growing awareness that salmon populations in BC are declining and that the present system of fisheries management does not protect weak stocks. A number of salmon stocks have been listed as “endangered” under COSEWIC, and others have declined to low levels of abundance. The Sierra Club of Canada, BC Chapter is deeply concerned that some smaller sockeye stocks may be endangered and vulnerable to local extinction (also called extirpation).

Protection of biodiversity of sockeye salmon is challenged by the high degree of genetic isolation and differentiation between stocks. While other salmon species are genetically similar over relatively large areas (e.g., coastal pink and chum salmon populations), sockeye within a single lake watershed are usually genetically distinct. Two sockeye stocks in BC, Cultus Lake and Sakinaw Lake, are endangered and DFO recovery programs are presently underway to stabilize and reverse the declines.

In view of the vulnerability of sockeye salmon populations to extirpation, the Sierra Club commissioned the present study to examine the declining sockeye populations, evaluate the causes of declines, and recommend a set of response strategies. This report summarizes the main results.



Figure 1. Sockeye salmon, *Oncorhynchus nerka*

Inventory of Declining Sockeye Populations

Northern and Central BC Summary

Riddell (2004) evaluated the status of Northern and Central Coast salmon populations for the Pacific Fisheries Resource Conservation Council by comparing recent salmon escapements with historical baseline levels. Data contained in Appendices A through G of Riddell's report were summarized and the results are compiled in Table 1.

The database compiles estimates of the numbers of salmon returning to spawn between 1950 – 2002 (53 years of observation). Most of the estimates were derived by visual surveys which are frequently imprecise and/or inaccurate; a cautious approach to their interpretation is required. The data are best used to determine long-term trends that recognize the uncertainty in the data.

The following criteria were utilized by Riddell to classify stock status:

Status	Criteria
Unknown	Sockeye present but annual surveys have been stopped or too fragmented to assess population status
Depressed	Present escapements less than 25% of historical base period
Decreased	Present escapements between 25 - 75% of historical base period
Stable	Present escapement within \pm 25% of historical base period
Increased	Present escapement at least 25% larger than base period

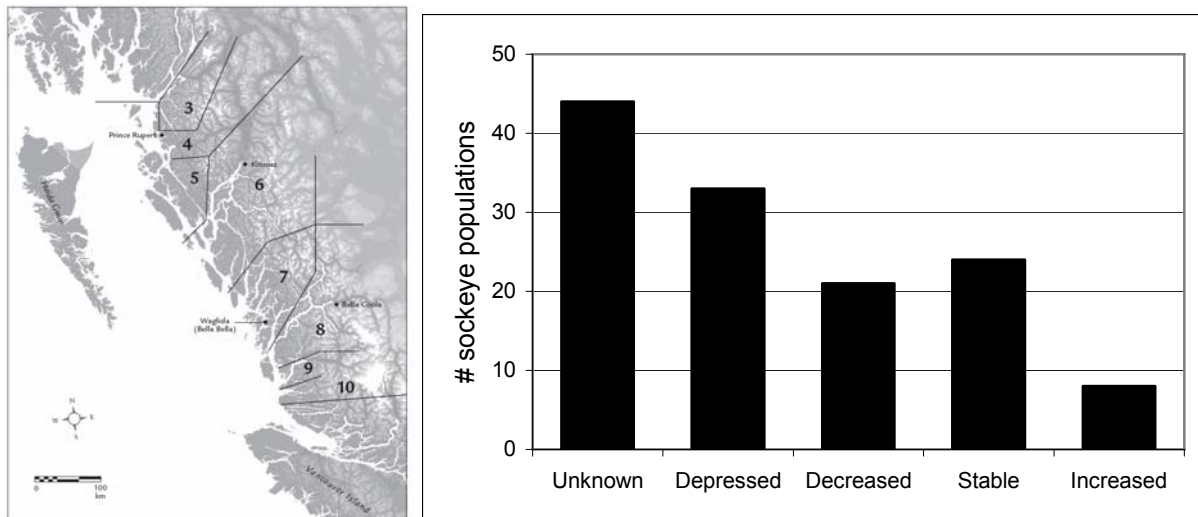
Table 1. Status of sockeye populations in Northern and Central BC.

Area	Location	Sockeye System	Status	Area	Location	Sockeye System	Status
1	QCI, Graham I.	Yakoun Lake and River	Stable	4	Skeena River	Sustut River	Decreased
1	QCI, Graham I.	Julian Lake and River	Depressed	4	Skeena River	Bulkley River	Decreased
1	QCI, Graham I.	Ian Lake and Ain River	Depressed	4	Skeena River	Morice	Increased
1	QCI, Graham I.	Mercer Lake and River	Depressed	4	Skeena River	Babine	Increased
1	QCI, Graham I.	Eden Lake and Naden River	Stable	4	Skeena River	Morrison	Stable
1	QCI, Graham I.	Awun Lake and River	Increased	5	Banks Island	Bolton Creek	Unknown
1	QCI, Graham I.	Mamin River, Masset Inlet	Unknown	5	Pitt Island	Devon Lake	Stable
2W	QCI, Moresby I.	Fairfax Creek and Lake,	Stable	5	Pitt Island	Curtis Lake	Decreased
2E	QCI, Louise I.	Mathers Lake and Creek	Decreased	5	Pitt Island	Mikado Lakes	Stable
2E	QCI, Moresby I.	Skidegate Lake	Decreased	5	Pitt Island	Hevenor Inlet Creek	Depressed
2E	QCI, Moresby I.	Mosquito Lake	Unknown	5	Pitt Island	Monckton Inlet Creek	Depressed
3	Portland Canal	Strohn Lake	Depressed	5	Pitt Island	Cridge Inlet Creek	Depressed
3	Work Channel	Several small lakes	Unknown	5	Banks Island	Bonilla Lake	Stable
3	Nass River	Meziadin Lake	Increased	5	Banks Island	Banks Lakes	Stable
3	Nass River	Bowser Lake	Stable	5	Banks Island	Kooryet Lake	Stable
3	Nass River	Fred Wright Lake	Stable	5	Banks Island	Keecha Lake	Stable
3	Nass River	Brown Bear Lake	Unknown	5	Banks Island	Deer Lake	Decreased
3	Nass River	Damdochaux Lake	Decreased	5	Pitt Island	Tsimtack/Moore Lakes	Stable
3	Nass River	Tseax River and Gingit Ck	Decreased	5	Banks Island	Kenzuwash Creek	Unknown
3	Nass River	Seaskinnish Creek	Unknown	5	Lowe Inlet	Lowe, Simpson & Weare Lakes	Decreased
3	Nass River	Zolzap River	Depressed	5	Banks Island	Waller Lakes	Depressed
4A	Coastal	Shawatlan River	Decreased	5	Principe Channel	Kumealon Lake	Unknown
4A	Coastal	Prudhomme Lakes	Stable	5	Ogden Channel	Captain Cove Creek	Depressed
4A	Coastal	Johnston Lake	Stable	5	Principe Channel	Ryan Creek	Depressed
4	Skeena River	Alastair Lake	Decreased	5	Principe Channel	Keswar Creek	Unknown
4	Skeena River	Lakelse Lake	Decreased	5	Banks Island	End Hill Creek	Depressed
4	Skeena River	Kitsumkalum Lake	Increased	5	Principe Channel	Sheeneza Creek	Decreased
4	Skeena River	Zymoetz River	Stable	5	Grenville Channel	Salter Lake Creek	Unknown
4	Skeena River	Kispiox River	Increased	5	Principe Channel	Spencer Creek	Stable
4	Skeena River	Kitwanga River	Unknown	5	Grenville Channel	Brodie Lake	Increased
4	Skeena River	Kluatantan River	Unknown				
4	Skeena River	Sicintine River	Unknown				
4	Skeena River	Slamgeesh River	Unknown				

Table 1. (cont'd)

Area	Location	Sockeye System	Status	Area	Location	Sockeye System	Status
6	Laredo Inlet	Bloomfield Creek	Stable	7		Choke Pass Creeks	Unknown
6	Hecate Strait	Borrowman Creek	Depressed	7	Roscoe Inlet	Clatse Creek	Unknown
6	Laredo Inlet	Busey Creek	Unknown	7	Lama Passage	Cooper Inlet Creeks	Depressed
6	Fraser-Graham Reach	Canoona Creek	Stable	7		Deer Pass Lagoon	Unknown
6	Hecate Strait	Clifford Creek	Unknown	7	Kynock Inlet	Kainet Creek	Increased
6	Laredo Channel	Dallain Creek	Unknown	7	Seaforth Channel	Kakushdish River	Depressed
6	Laredo Sound	Don Creek	Unknown	7		Kildidt Creek	Unknown
6	Chapple Inlet	Douglas Creek	Unknown	7		Kwakusdis River	Depressed
6	Hecate Strait	Duffey Creek	Depressed	7	Finlayson Channel	Lagoon Creek	Decreased
6	Hecate Strait	Eagle Creek	Depressed	7		Mary Cove Creek	Depressed
6	Douglas Channel	Evelyn Creek	Stable	7		McLoughlin Bay Creek	Decreased
6	Laredo Channel	Evinrude Creek	Decreased	7	Mussel Inlet	Mussel River	Unknown
6	Hecate Strait	Flux Creek	Depressed	7		Pine River	Depressed
6	Laredo Channel	Fury Creek	Unknown	7		Ship Point Creek	Depressed
6	Laredo Inlet	Quigley Creek	Depressed	7	Spiller Channel	Tankeeah River	Depressed
6	Graham Reach	Green Inlet Creek	Unknown	7		Tuno Creeks	Depressed
6	Higgins Passage	Gull Creek	Unknown	7	Milbank Sound	Yaaklele Lagoon	Unknown
6	Douglas Channel	Hartley Bay Creek	Decreased	8	Bentinck Arm S.	Asseek River	Unknown
6	Hecate Strait	Kdelmashan Creek	Decreased	8	Dean Channel	Cascade River	Unknown
6	Gardner Channel	Kemano River	Unknown	8	Dean Channel	Dean River	Depressed
6	Kitimat Arm	Kitimat River	Increasing	8	Dean Channel	Elcho Creek	Unknown
6	Douglas Channel	Kitkiata Creek	Depressed	8	Fitz Hugh Sound	Elizabeth Lake	Unknown
6	Gardner Canal	Kitlope River	Stable	8	Fisher Channel	Port John Lake	Depressed
6	Kitasu Bay	Kwakwa Creek	Decreased	8	Dean Channel	Kimsquit Lake	Stable
6	Laredo Channel	Limestone Creek	Depressed	8	Fisher Channel	Kisameet River	Depressed
6	Hecate Strait	McDonald Creek	Unknown	8	Fitz Hugh Sound	Koeys Lake	Stable
6	Laredo Channel	Nias Creek	Unknown	8	Fitz Hugh Sound	Namu Lake	Stable
6	Hecate Strait	Noble Creek	Unknown	9	Rivers Inlet	Owikeno Lake	Depressed
6	Laredo Channel	Powles Creek	Depressed	9	Fitz Hugh Sound	Elsie Lake	Unknown
6	Laredo Sound	Price Creek	Decreased	10	Smith Inlet	Long Lake	Depressed
6	Douglas Channel	Quaal River	Unknown	10	Smith Inlet	Walkum Creek	Unknown
6	Hecate Strait	Salmon Creek	Unknown	10	Smith Inlet	Nekite River	Unknown
6	Hecate Strait	Sentinel Creek	Unknown				
6	Laredo Channel	Talamoosa Creek	Decreased				
6	Surf Inlet	Wale Creek	Unknown				
6	Douglas Channel	Weewanie Creek	Unknown				
6	Beauchemin Channel	West Creek	Decreased				

Numerous salmon populations in Northern and Central BC are reduced from historical levels of abundance, and many are less than 25% of their former abundance. Results are shown in Figure 2.



Status	Number of Sockeye Populations	Percent
Unknown	44	34%
Depressed	33	25%
Decreased	21	16%
Stable	24	18%
Increased	8	6%
Total	130	100%

Figure 2. Status of sockeye populations in Northern and Central BC. Source: Riddell (2004).

Around 75% of these sockeye populations have either unknown, decreased or depressed status. There are 33 populations in the depressed category (escapements <25% of historical baseline) for which urgent action is required. The unknown category likely contains many small populations which are depressed, however, the information is inadequate for assessment. The 44 populations in the unknown category form the most numerous category of sockeye populations in Northern and Central BC.

Nass River Watershed

A recent Sierra Club review evaluated the effectiveness of salmon fisheries management in the Nass Watershed (Levy 2006). In the Nass, the Meziadin Lake population and the Gingit River populations are stable or increasing, however, the status of six of the smaller sockeye populations is poorly known due to inadequate assessment information. Figure 3 shows the distribution of sockeye populations in the Nass; under the Wild Salmon Policy there will likely be five sockeye Conservation Units.

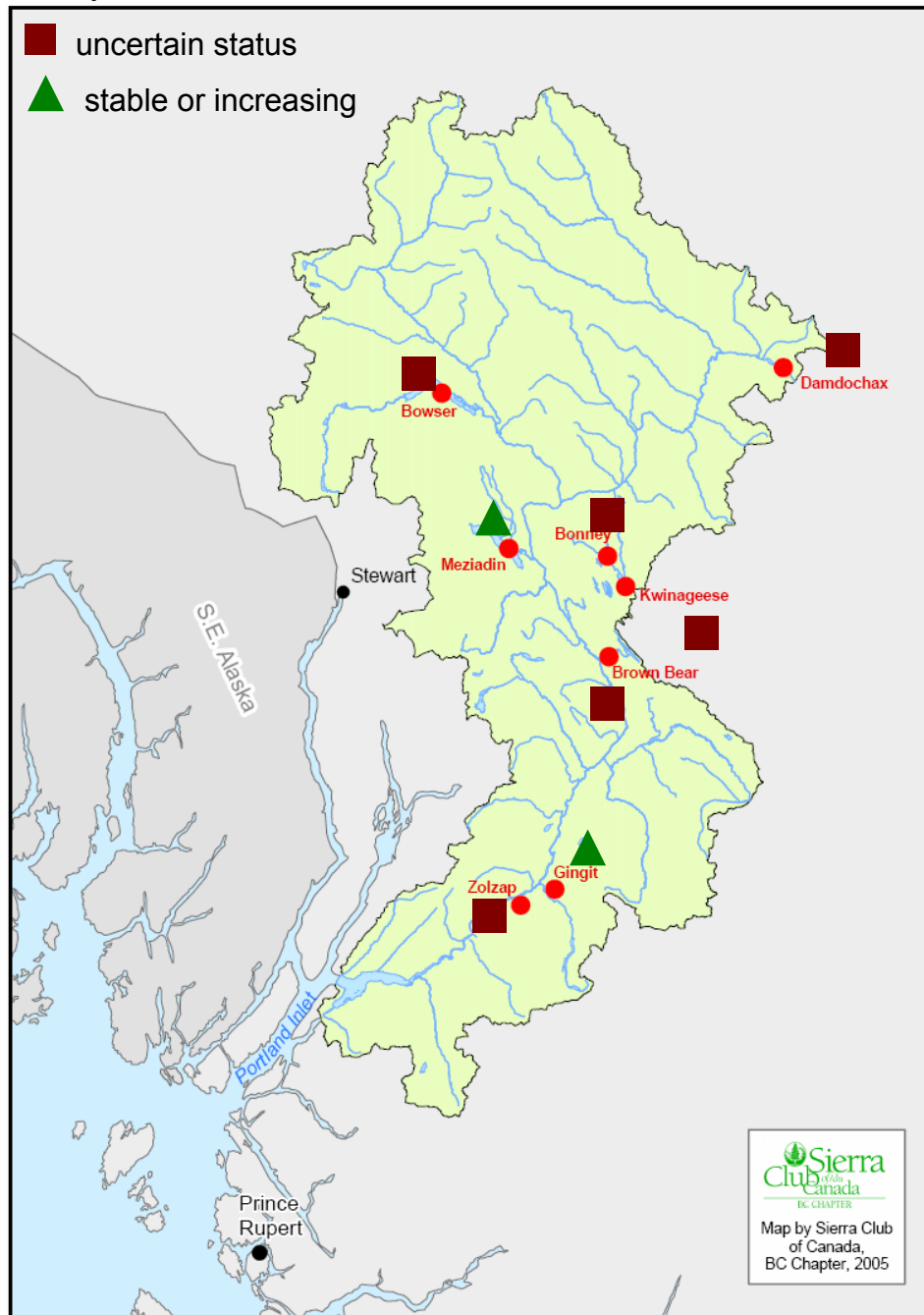
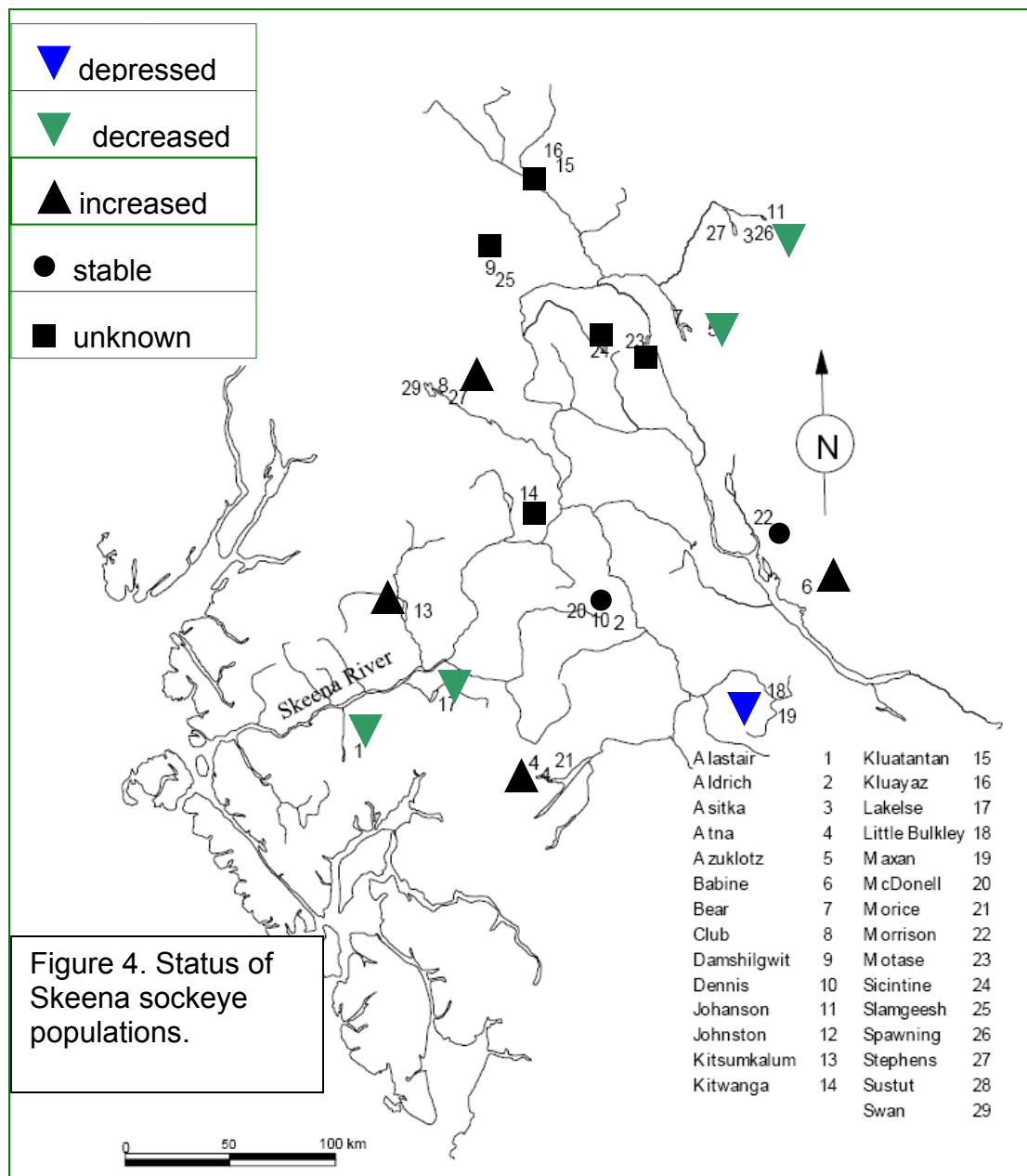


Figure 3. Status of eight sockeye populations in the Nass Watershed.

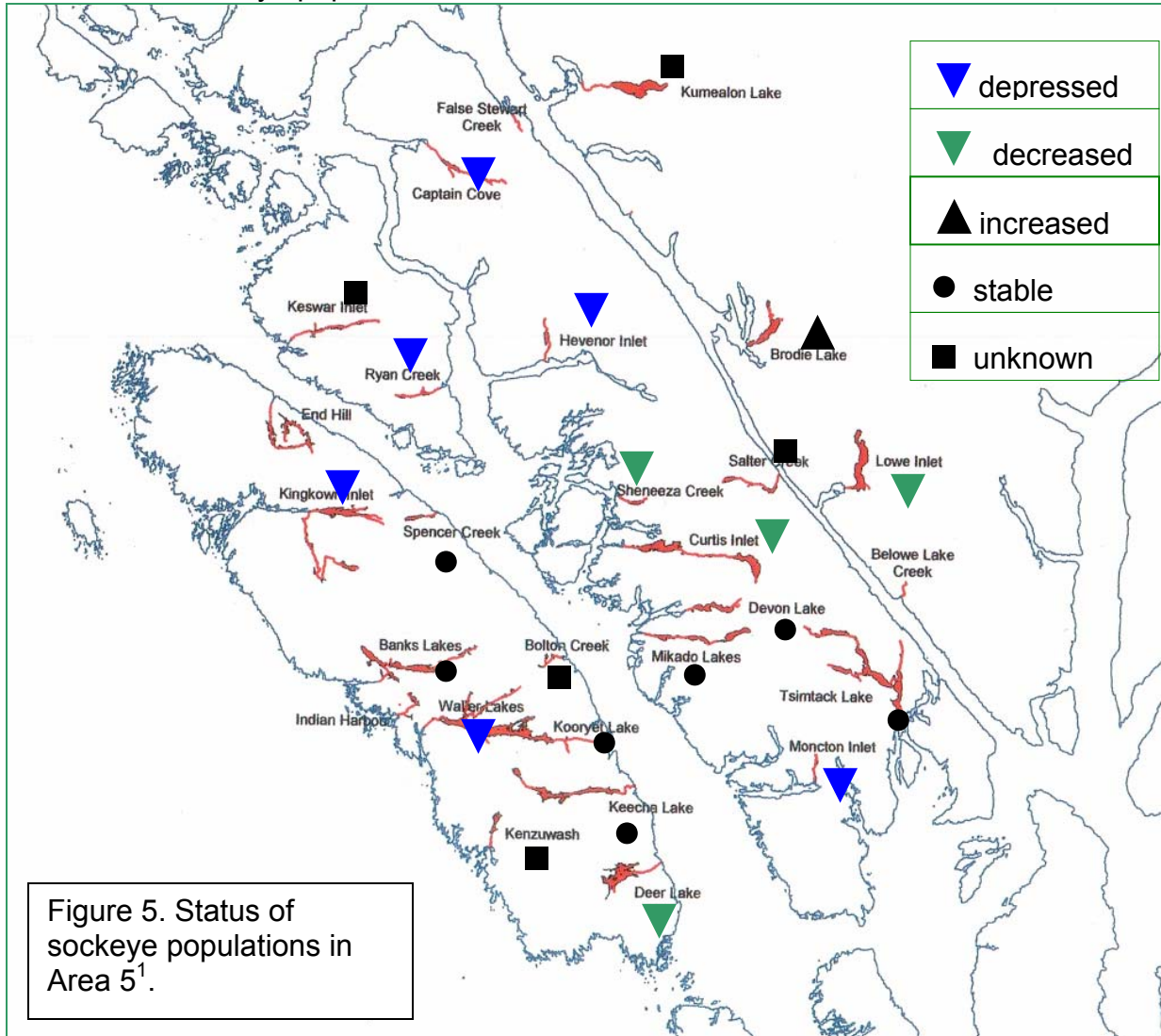
Skeena River Watershed

There are 29 sockeye lakes in the Skeena drainage (Figure 4), the largest of which is Babine Lake. Table 1 only identifies 14 Skeena sockeye populations; some of the adjacent populations below have been lumped together for assessment purposes. Fisheries target the enhanced (via spawning channels) Babine Lake runs which comprise 90% of the Skeena sockeye population. Due to enhancement, the Babine Lake stock can withstand higher harvest rates than the un-enhanced wild stocks. Cox-Rogers et al. (2004) evaluated Skeena sockeye and found that wild stock escapements are below the levels to fully utilize lake rearing habitat and maximize smolt production.



Area 5

Both Watkinson and Watkinson (2002) and Riddell (2004) have summarized the status of the sockeye populations in Area 5. Results are shown below.



Following is the breakdown of Area 5 sockeye populations into the 5 categories:

Status	Number of Sockeye Populations	Percent
Unknown	5	22%
Depressed	6	26%
Decreased	4	17%
Stable	7	30%
Increased	1	4%
Total	23	100

Around 65% of Area 5 sockeye populations are either depressed, decreased or unknown status.

¹ There are several additional populations which are not shown in the figure, and have not been included in the subsequent analysis.

Rivers and Smith Inlets

Along the Central Coast, there were formerly large sockeye runs that returned to Areas 9 (Rivers Inlet/Owikeeno Lake) and 10 (Smith Inlet/Long Lake). The Owikeeno Lake population showed a steady decline for about 50 years before crashing during the 1990's. The Long Lake population had variable returns until the 1990's when it too crashed fairly abruptly.

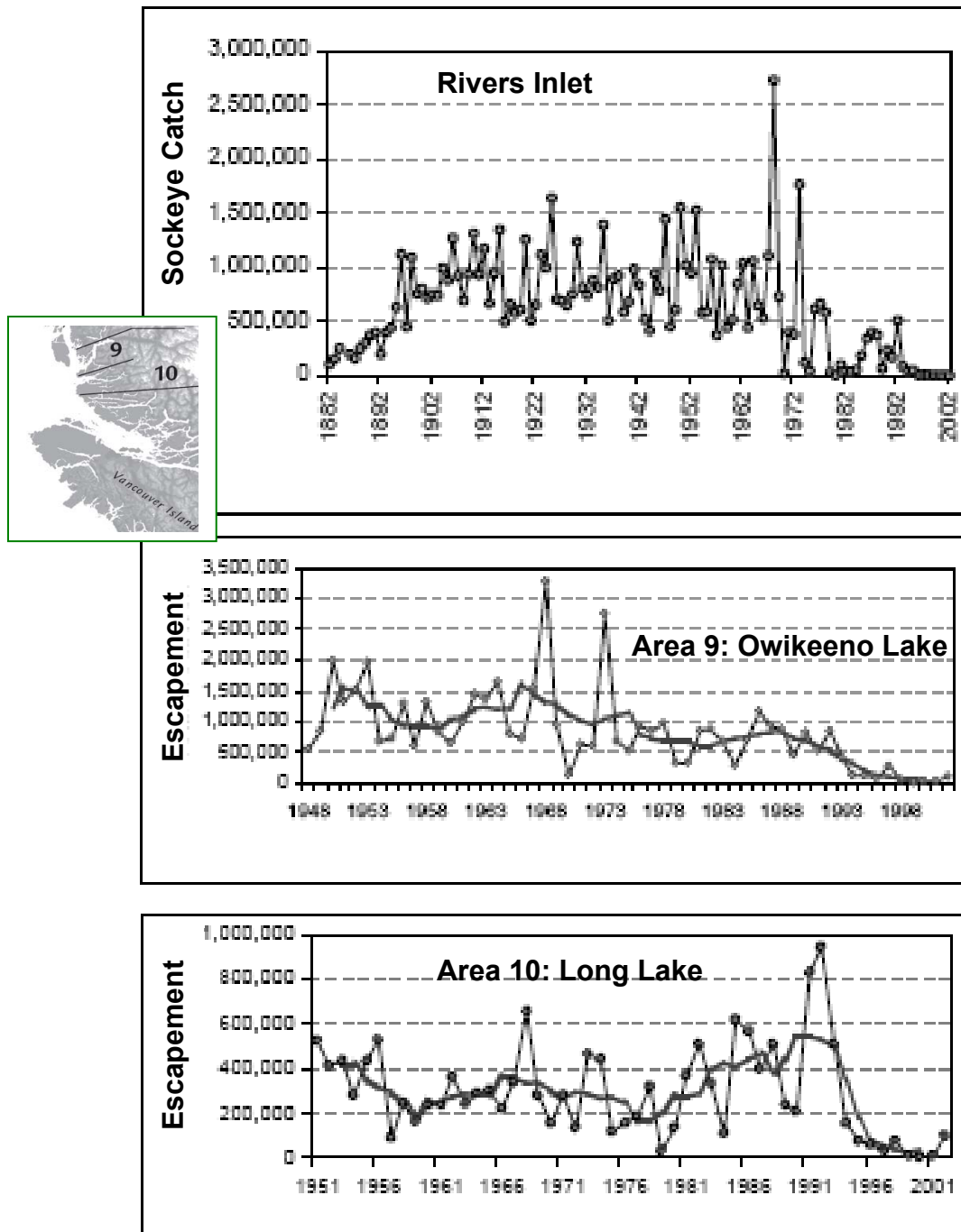


Figure 7. Sockeye production time series for Rivers Inlet and Smith Inlet. Upper: Commercial catch of sockeye in Rivers Inlet. Total production of sockeye (catch plus spawning escapement) is shown for Owikeeno Lake (middle graph) and Long Lake (lower graph). Smoothed lines on the two lower graphs represent 5-year moving averages. Source: Riddell (2004).

Inside Sockeye Stocks

Inside sockeye stocks (Figure 8) include coastal populations in watersheds adjacent to the Strait of Georgia, Johnstone Strait and the southern Mainland Inlets (Dobson and Wood MS 2006). Sakinaw Lake sockeye have declined precipitously and have been designated as endangered by COSEWIC. The population is presently the focus of a major DFO recovery effort. The status of Inside sockeye stocks is shown below:

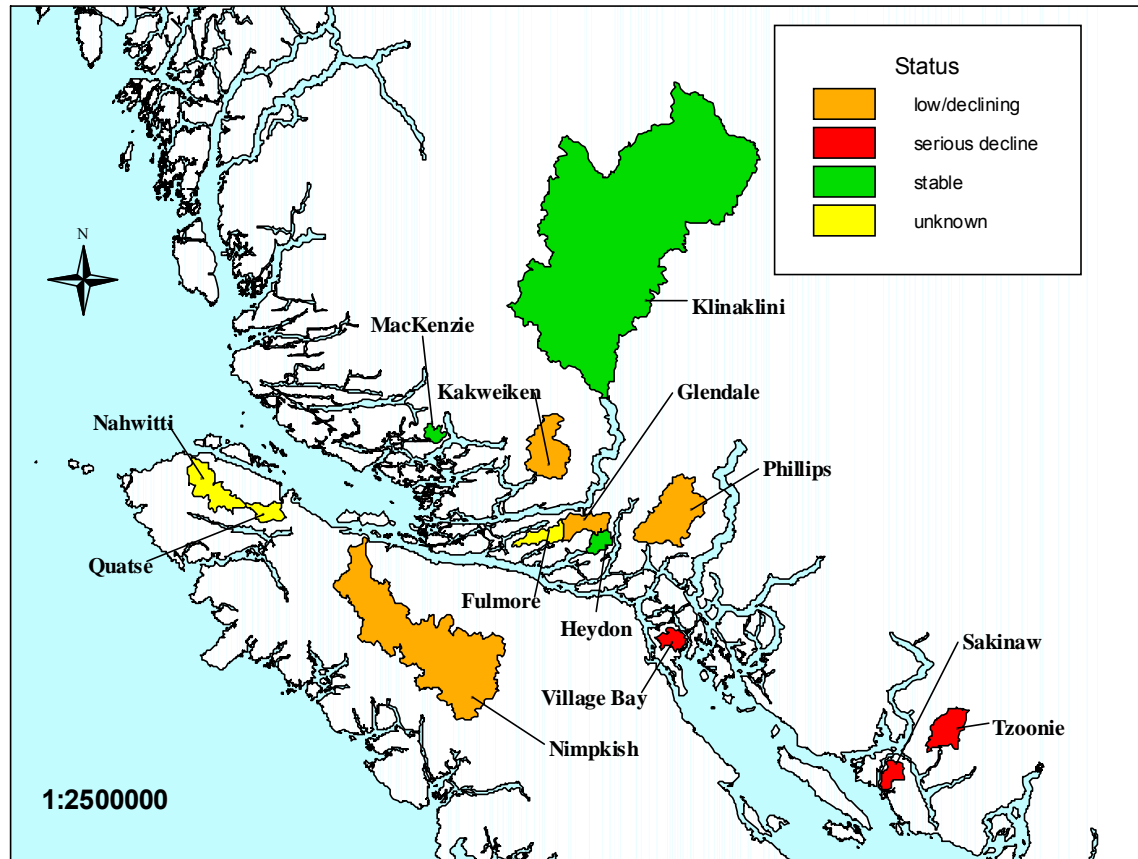


Figure 8. Status of Inside sockeye stocks. Source: Dobson and Wood (MS 2006)

Of the thirteen populations examined by Dobson and Wood (MS 2006), three are in serious decline and are now at critically low abundance (<100 spawners); four are at low abundance relative to historical levels and/or declining; three appear to be stable; and three cannot be assessed because of inconsistent data.

The three stocks that are in serious decline include Sakinaw, Tzoonie and Village Bay sockeye. While Sakinaw sockeye have been designated by COSEWIC and there is now a recovery plan in place for this population, there are no recovery plans for Tzoonie and Village Bay sockeye. These latter stocks have not been designated because no petition for listing has been filed with COSEWIC. Escapement time series for Sakinaw and Village Bay sockeye are shown below.

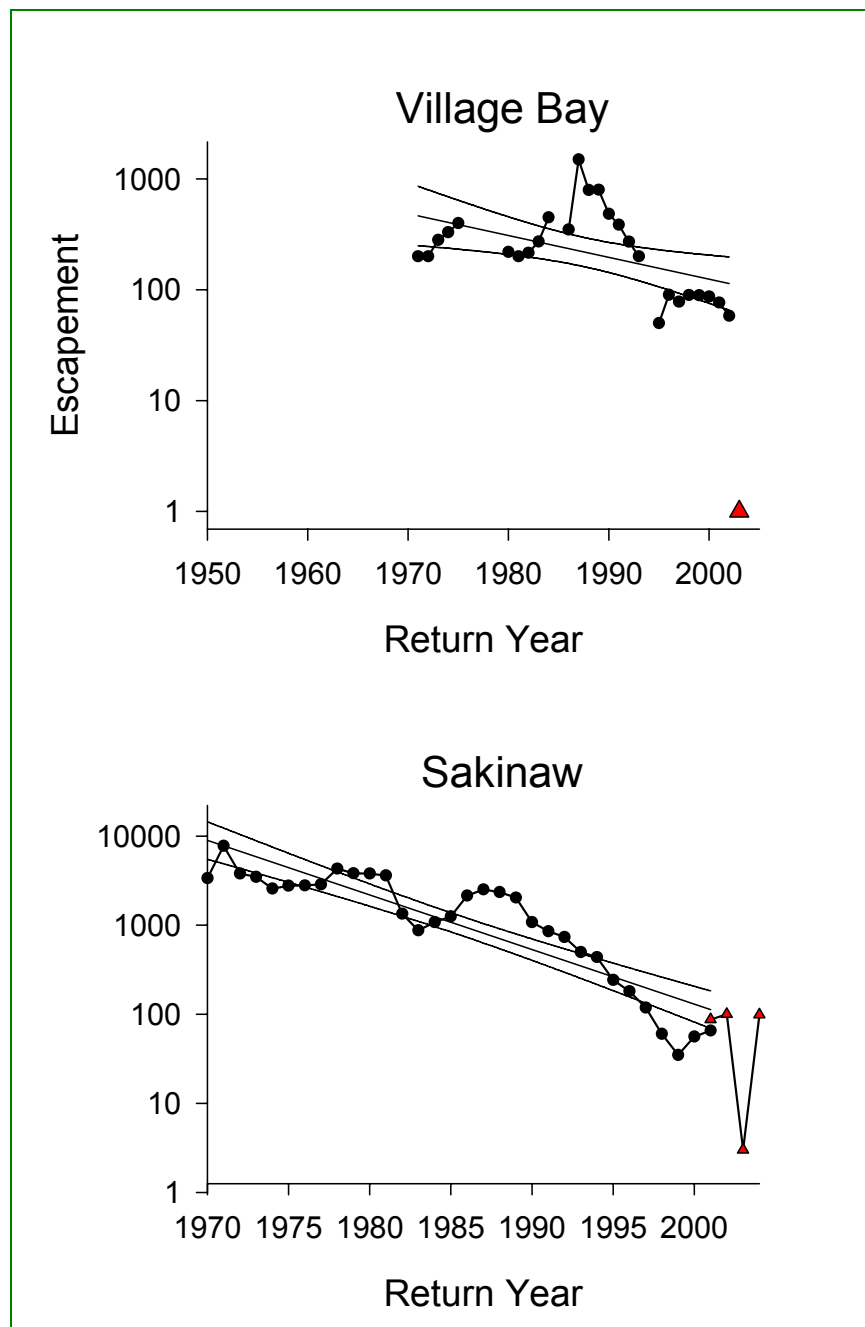


Figure 9. Escapement time series for Village Bay and Sakinaw sockeye populations. Note logarithmic y-axis. While both populations are at critically low levels, only the Sakinaw Lake population has been designated by COSEWIC. Source: Dobson and Wood (2006; in press).

Barclay Sound

There are three sockeye runs to Great Central, Sprout and Henderson Lakes adjacent to Barclay Sound. Escapement to Henderson Lake has fallen below 5000 fish in some years, but was as high as 120,000 in 1993 (Figure 10). This background variability makes it difficult to classify the status of Henderson Lake sockeye.

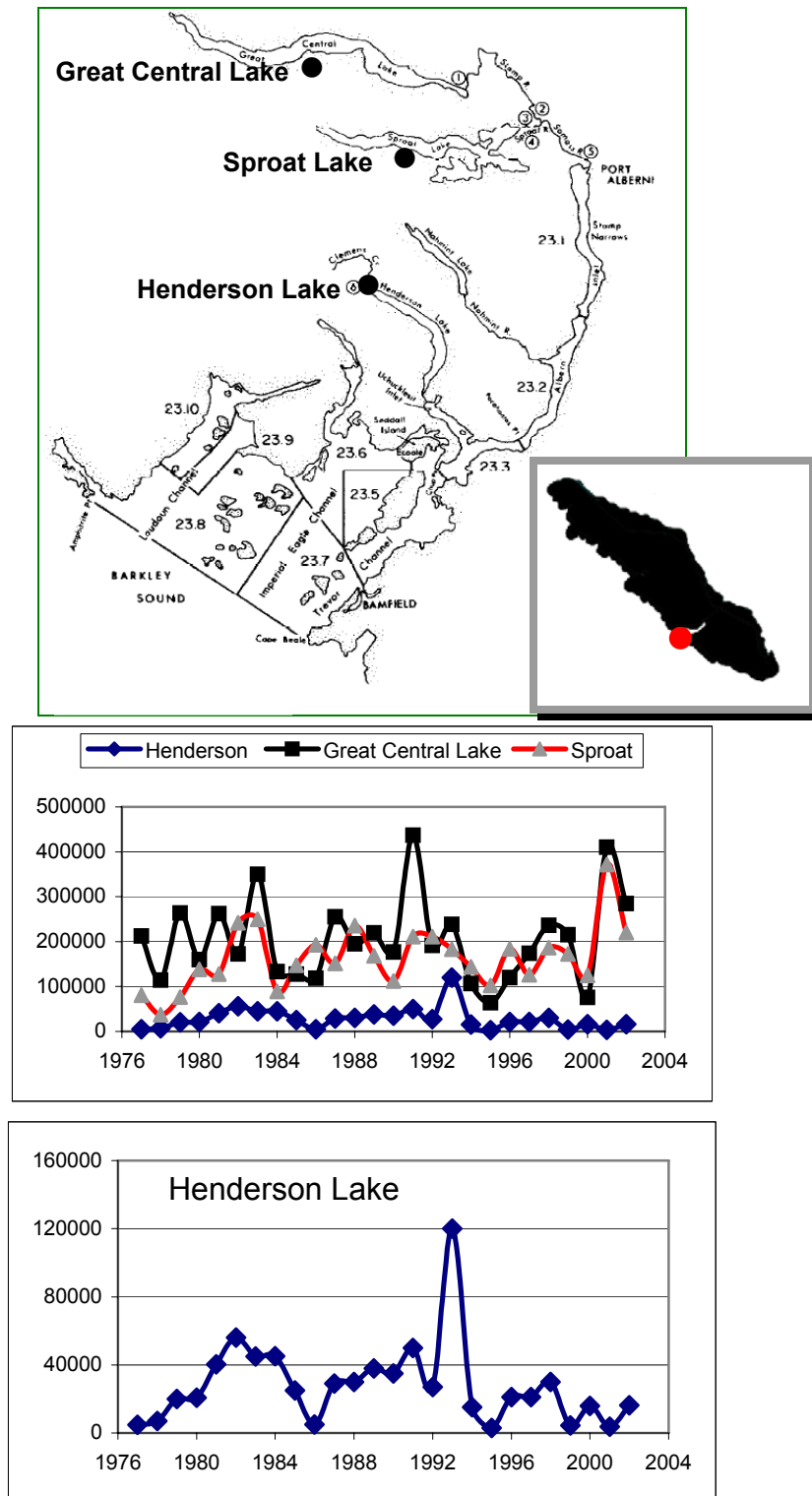


Figure 10. Sockeye escapements to Barclay Sound on different Y-axis scales.

Fraser River Watershed

The Fraser River (Figure 11) has world-renowned sockeye populations throughout the watershed. Several declining populations are discussed below (assessment of the status of all Fraser sockeye populations is beyond the scope of the present analysis).

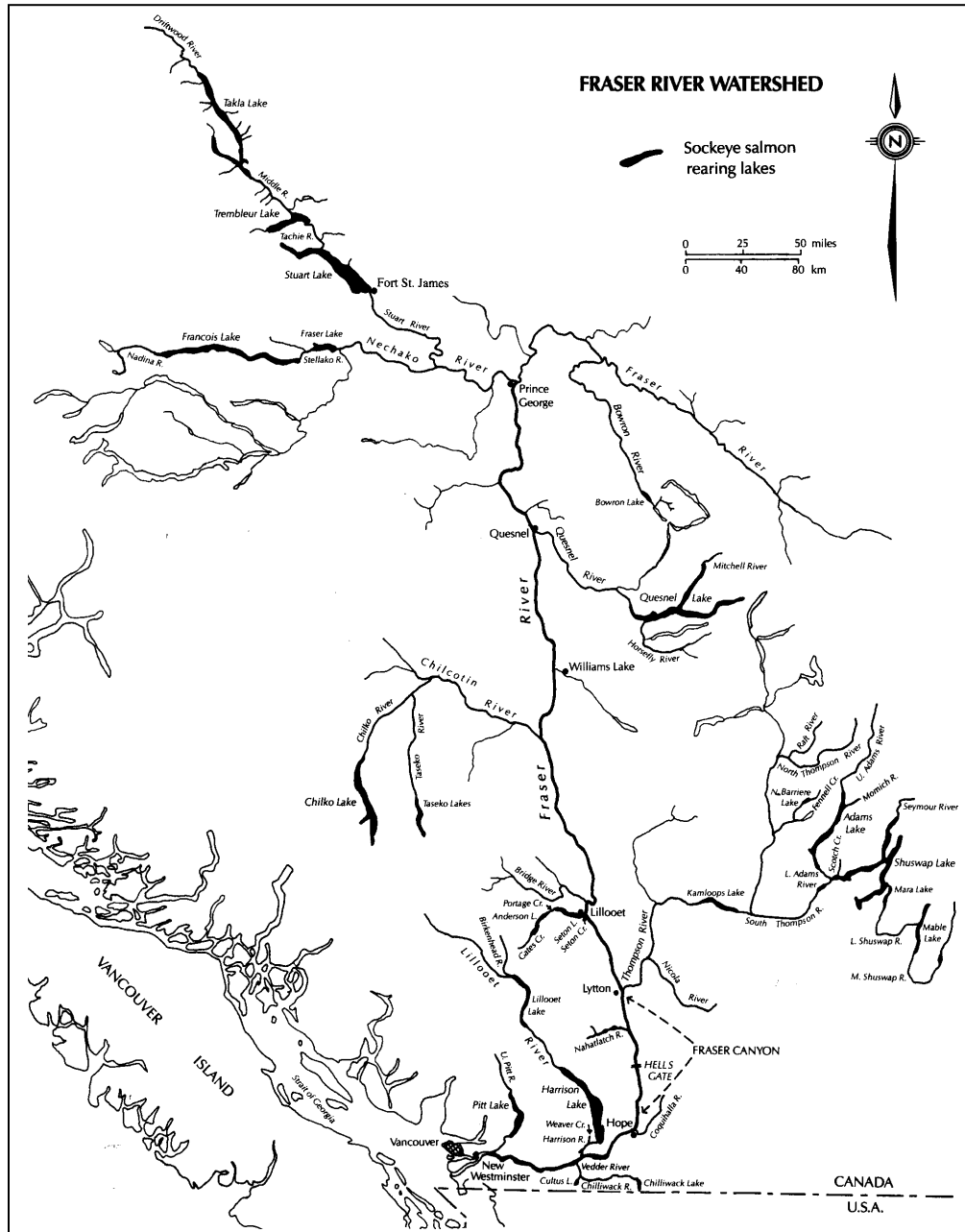


Figure 11. Locations of Fraser River sockeye populations.

Most Fraser sockeye populations have one dominant return over their 4-year cycles of abundance, one sub-dominant return, and two off-cycle returns.

Sockeye management recognizes the occurrence of cyclic dominance and treats each cycle line as a separate sub-population.

Sockeye returning to the tributaries of Stuart and Takla Lakes are a genetically related “complex” of smaller sub-populations, some of which cover over 1500 km between the mouth of the Fraser and their spawning grounds. There are two distinct run-timing groups: Early Stuart and Late Stuart. These fish are genetically similar but are segregated from each other by migration timing. Early Stuart fish spawn primarily in 35 small headwater tributaries of Takla and Trembleur Lakes, including the Driftwood River. Late Stuart fish spawn in larger lake-headed tributaries. Early Stuart fish are particularly susceptible to adverse high discharge conditions during migrations (>8000 cms at Hell’s Gate; T.Whitehouse, DFO, pers. commun.) and, in recent years, high water temperatures.

Spawning escapements are shown below:

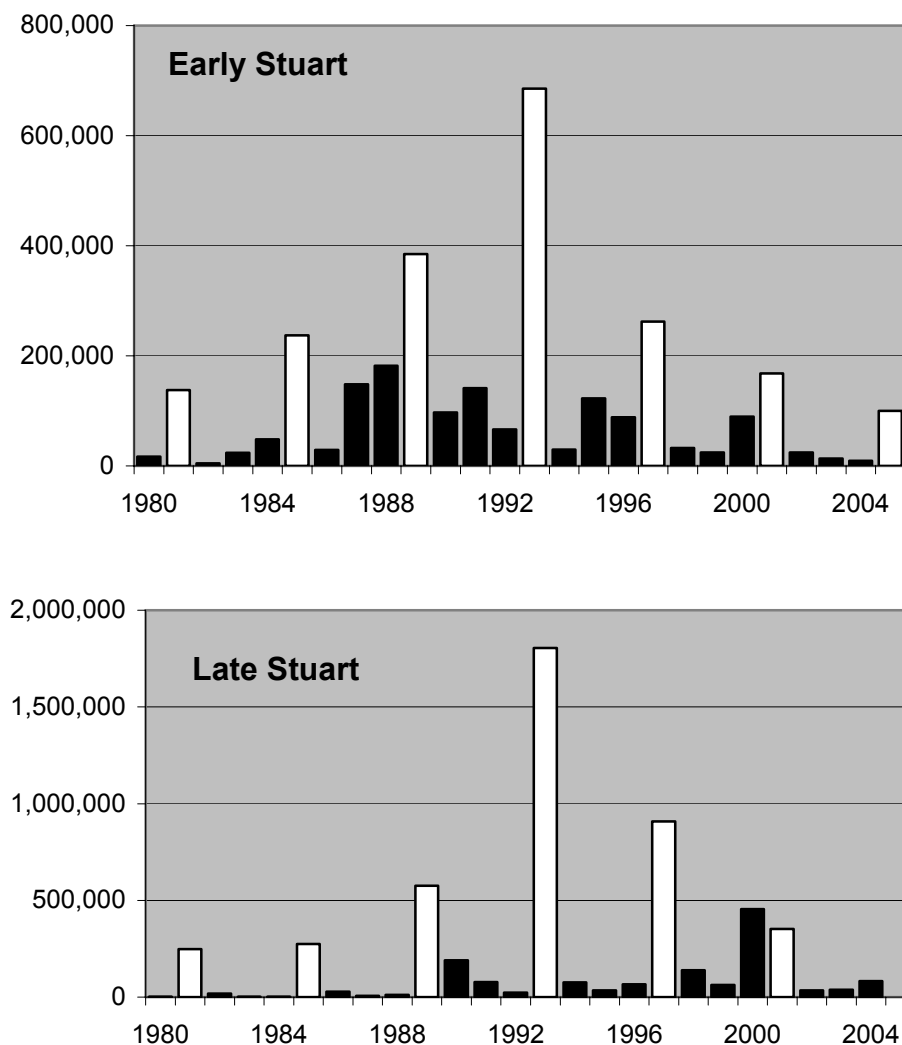


Figure 12. Early Stuart and Late Stuart sockeye escapements. White bars indicate dominant return years. Source: DFO unpublished data.

Until the early 1990's, these populations were increasing due to ocean survival and migration conditions. Since 1992, there has been a sharply decreasing trend, particularly for the dominant cycle lines. The decline in the Early Stuart population is primarily due to the reduction of the Driftwood River population. These declines trigger concerns about future production and also meet COSEWIC criteria for listing (>70% decline over three generations).

The decline in the Cultus Lake population triggered a COSEWIC designation of "endangered" and a DFO Recovery Plan. A time series of Cultus sockeye catch and escapement trends is shown in Figure 13.

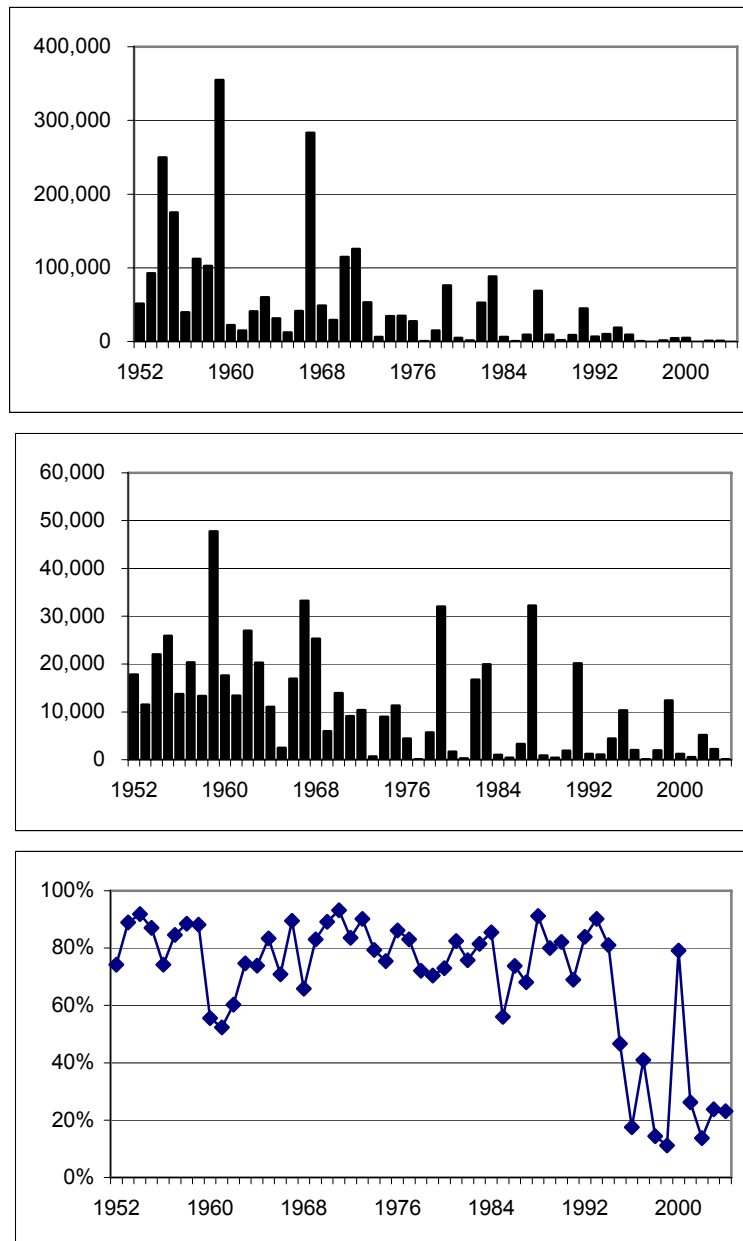


Figure 13. Time series of Cultus Lake sockeye catches (upper), escapement (middle) and exploitation rates in the commercial fishery (lower).

Conclusions

In BC, there is a large number (at least 38) sockeye populations that are below 25% of their baseline levels, making them potential candidates for COSEWIC and/or SARA listing. There is an even larger number of stocks for which we have little or no information available to judge their status. There is a critical need for better data to diagnose the status and to serve as the foundation for recovery planning for affected sockeye populations. In view of the large number of sockeye populations to monitor, new approaches for population assessment are required to provide expanded monitoring coverage for all BC sockeye populations.

Causes for Declines

Reduced Marine Survival

Several of the sockeye stocks identified in the Inventory, including Long Lake and Owikeeno Lake, have declined as a result of reduced marine survival. Time series of returns per spawner (Figure 14) provide evidence for a change in marine survival.

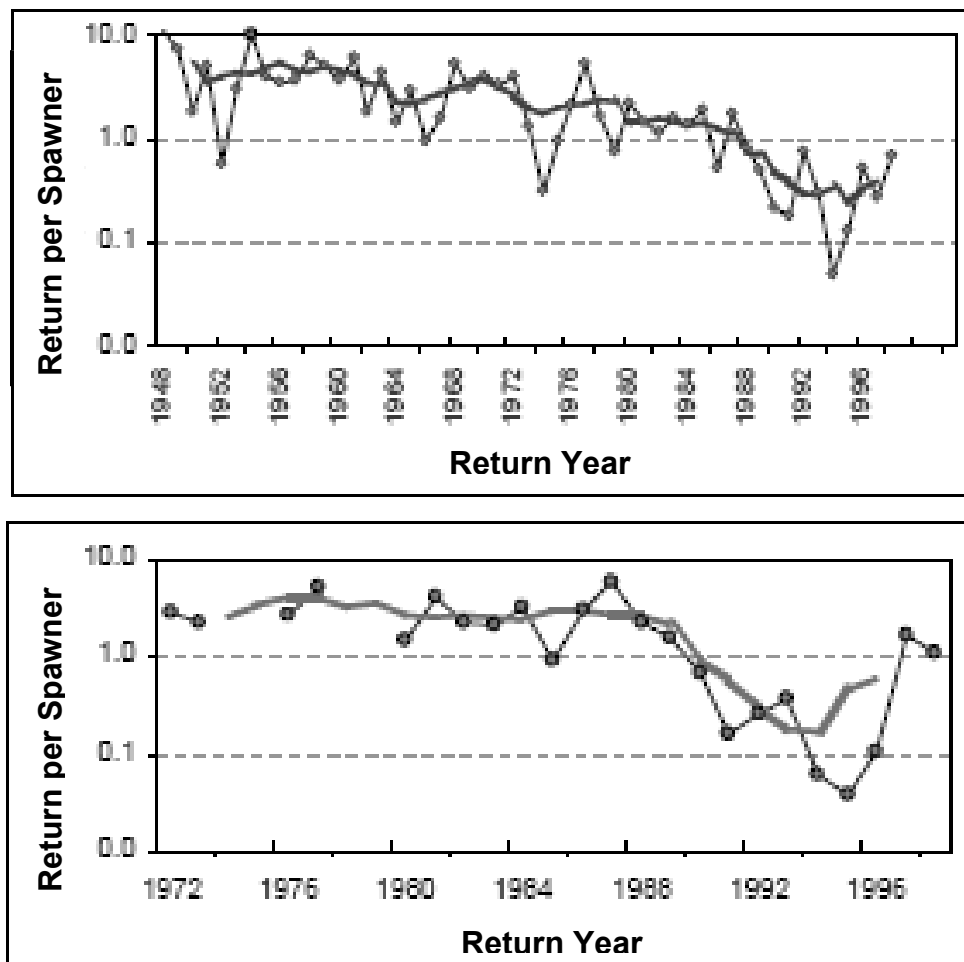


Figure 14. Return of adult recruits per spawner in the parent generation for Owikeeno Lake (upper) and Long Lake (lower) sockeye. Note logarithmic y-axes. The smoothed line is a 5-year running average to indicate trends in productivity. Source: Riddell (2004).

After about 1982, there was a pronounced decrease in the return per spawner in both populations that was likely due to decreased marine survival rates. These reductions have reversed themselves and the productivity of the runs, measured as return per spawner, is now increasing towards baseline levels. Because the absolute population numbers in Owikeeno and Long Lakes are so low (Figure 7), it will take many decades of favourable marine survival conditions for complete population recovery.

Other sockeye stocks that are sensitive to marine survival variations are the three Barclay Sound populations (Figure 10). These populations appear to fluctuate synchronously with each other, most likely in response to marine survival variations.

Marine environmental conditions can fluctuate on a cyclic basis, so sockeye declines can be reversible. Until 1953, escapements to Morice Lake in the Skeena River were in excess of 70,000. The sockeye population then crashed abruptly and escapements were in the 3,000 to 5,000 range until the 1990s when they rose to 20,000 to 40,000. The population has since declined again to the low thousands (Joseph 2005).

Climate Change

There is growing evidence that climate change is affecting sockeye migration timing and migration patterns. During 2005, sockeye returned to the mouth of the Fraser River 2-6 weeks later than usual. A model of sockeye return timing (Blackbourn 1987) provides an explanation for the delayed timing (Figure 15).

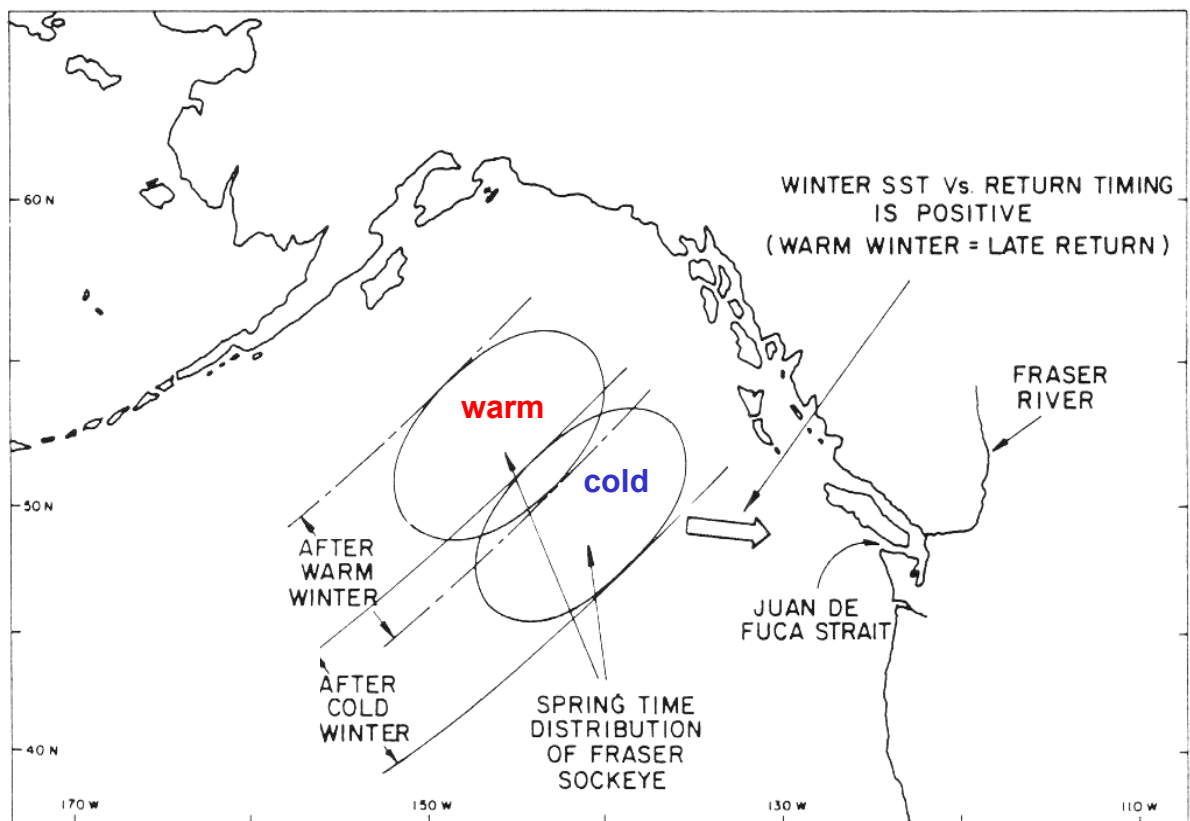


Figure 15. Model of sockeye return timing to the mouth of the Fraser River. SST= sea surface temperature. Source: Blackbourn (1987).

Blackbourn's model correlates Fraser sockeye return timing with sea surface temperature in the winter prior to migration. When winter sea surface temperature is warmer, sockeye are displaced northwards, creating a longer migration distance and longer duration migration than in cooler years. Future warming of the North Pacific can be expected to delay the sockeye return timing to the BC coast and also to reduce sockeye body size, since additional energetic expenditures are required to cover a longer migration distance.

Sockeye migratory pathways are changing over time, most likely in response to climate change. Sockeye can migrate to the mouth of the Fraser River via one of two marine approaches, a northern route through Johnstone Strait, and a southern route through Juan de Fuca Strait (Figure 16).

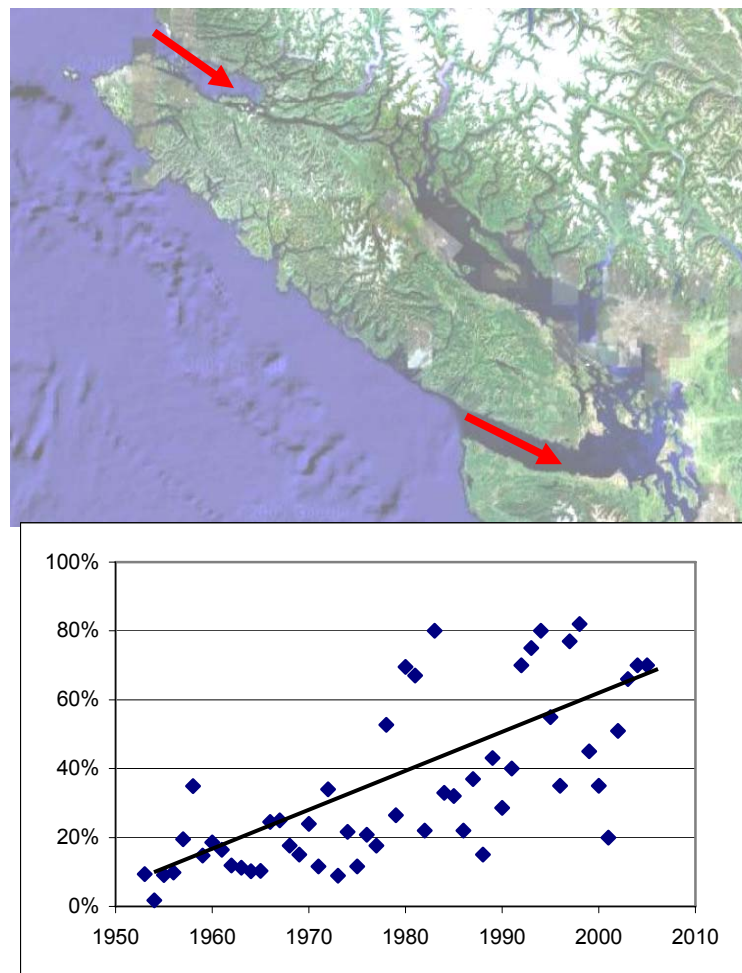


Figure 16. Time series of the percentage of Fraser sockeye which migrate via the Northern Diversion (Johnstone Strait). Source: Pacific Salmon Commission unpublished data.

The Pacific Salmon Commission data indicates that sockeye are making their Pacific landfall further northward than previously. This is likely due to warmer sea surface temperatures, particularly during the final winter at sea. A northern

landfall leads sockeye into Johnstone Strait, while a more southerly landfall in the vicinity of Washington State or Vancouver Island leads the fish towards Juan de Fuca Straits. The increasing percentage of fish migrating via Johnstone Straits implies a progressive warming of surface temperatures in the North Pacific in the marine areas where salmon concentrate.

In freshwater, there are indications that climate change is adversely affecting Fraser sockeye. The Fraser River has been warming and this is causing increased migratory stress and pre-spawning mortality for Early Stuart sockeye. The magnitude of pre-spawning mortality is (weakly) related to temperature (Figure 17) although water discharge conditions also play a key role.

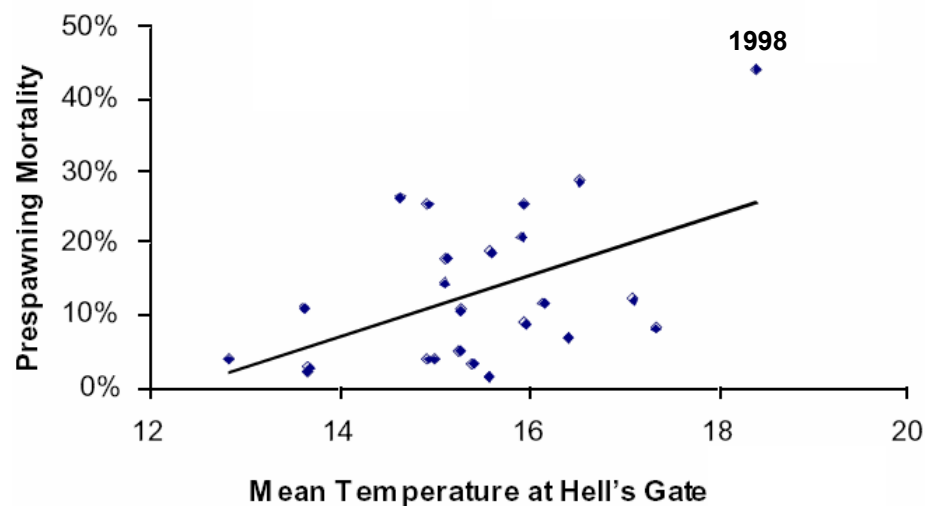


Figure 17. Pre-spawning mortality of Early Stuart sockeye as a function of water temperature at Hell's Gate. Source: DFO, unpublished data.

In summary, it is evident that climate change is affecting sockeye populations. Sockeye in BC are situated along the southern edge of the sockeye geographical distribution (Figure 18) making them vulnerable to the degradation of freshwater and marine habitat quality due to warming. Further impacts on sockeye can be anticipated as the BC climate and the North Pacific continues to warm.



Figure 18. Geographical distribution of sockeye salmon. Red shading indicates extinct sockeye populations.

- Current
- Limited
- Extirpated
- Ocean

Source: http://www.stateofthesalmon.org/images/map_dist_sockeye.jpg

Logging Impacts

Sockeye are partially buffered from logging impacts due to their lake life history which minimizes their exposure to stream habitat impacts. Logging can affect sockeye spawning environments and create stream blockages from logging debris. It is unlikely, however, that the declines described in the previous Inventory section of the report are related to logging impacts. Logging is more likely to affect species of salmon that rear in streams as juveniles, e.g. coho, and which are more directly exposed to logging impacts.

Mixed Stock Fisheries Interceptions

Most sockeye are harvested in mixed-stock fisheries that are directed towards the abundant stocks. Current fisheries management attempts to focus harvest efforts towards locations and times where the bycatch of non-target stocks is minimized. Due to their co-migration with the more numerous runs, there are only limited opportunities to protect weaker stocks by invoking spatial or temporal fishery closures. Return timing of the larger stocks that can withstand high harvest rates usually overlaps with less-productive stocks.

Harvest rates of most BC sockeye populations are generally high. Between 1952-1994, exploitation rates of Cultus sockeye were around 80% (Figure 13) just prior to the population crash. Exploitation rates of the Sakinaw population are between 21-59% (Murray and Wood 2002) and this was sufficient to trigger a collapse of this population.

The declines in the Area 5 sockeye populations (Figure 5) are most likely the result of mixed stock fisheries interceptions. Most of the fish are taken in fisheries directed at co-migrating stocks in the marine approaches to Area 5.

Adverse Effects of Enhancement

DFO sockeye enhancement projects for sockeye include construction and operation of spawning channels in the Fraser and Skeena River systems. Spawning channels have been implicated in the harvest of weaker sockeye stocks by fisheries targeting the enhancement fish. Two areas where this occurs are: 1) fisheries that harvest spawning channel sockeye from the Fulton and Pinkut River Spawning Channels, and 2) fisheries that target salmon from the Weaver Creek Spawning Channel which also intercept Cultus Lake sockeye.

Conclusion

The five factors identified that provide causal explanations for the declines in BC sockeye populations are:

- Reduced marine survival
- Climate change
- Logging impacts
- Mixed stock fisheries interceptions
- Adverse effects of enhancement

Logging is rejected as an explanation due to the limited exposure of sockeye to logging-related impacts. Climate change and reduced marine survival are closely coupled, as are mixed stock fisheries interceptions and adverse effects of enhancement.

Two of the formerly large Central Coast sockeye populations in Owikeeno Lake and Long Lake (Figure 7) declined in response to reduced marine survival rates (Figure 14). These populations were also subject to intensive fisheries through the latter part of 20th Century.

The Inventory section of the report identified a large number of sockeye stocks that are depressed to various degrees. It would be simplistic to conclude that any single influence on sockeye provides an adequate explanation for the depressed status of the populations described in the Inventory. Rather, it is the synergistic influence of several factors that threatens the long-term viability of many of the weaker sockeye stocks.

The Inventory section lists out 38 depressed sockeye stocks, some of which are critically depressed (<100 spawners). In view of the large number of stocks, a regional conservation strategy is required for the protection of sockeye biodiversity.

Recommended Responses

Conservation Benchmarks

When sockeye are abundant, the risk of extirpation is low and conversely, when numbers are depressed, the risk is high. To understand the status of a sockeye population¹ it is necessary to define criteria or benchmarks for population monitoring. Figure 18 provides a classification scheme developed by DFO under the Wild Salmon Policy, which includes Upper and Lower Benchmarks relative to spawner population size.

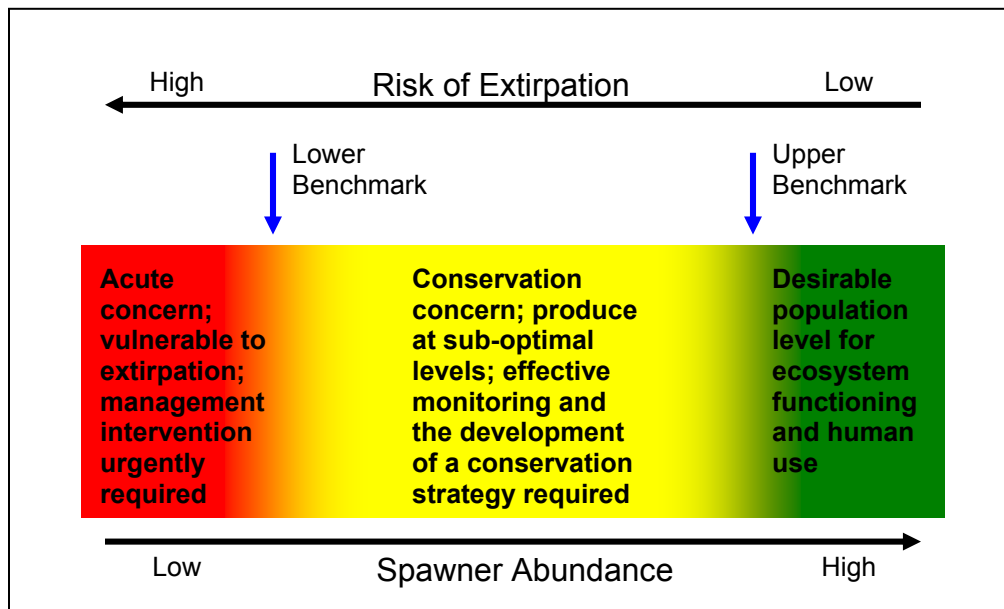


Figure 18. Diagram illustrating the inverse relationship between sockeye stock size and extirpation risk. Source: Adapted from the DFO Wild Salmon Policy.

Three colored zones on Figure 18 reflect a classification system for sockeye status based on spawner abundance (escapement) and distribution. Sockeye stocks in the green zone above the Upper Benchmark are at a desirable population level for ecosystem functioning and human use. Sockeye stocks in the red zone below the Lower Benchmark are at high risk of extirpation and could trigger a management response based on COSEWIC criteria, e.g. Cultus Lake Sockeye Recovery Strategy, or the Species at Risk Act. Sockeye stocks in the yellow zone are a source of concern, produce at sub-optimal levels, require both careful monitoring and the development of a conservation strategy to arrest any further population declines.

¹ In future the DFO Wild Salmon Policy will monitor the status of “Conservation Units” which for most sockeye populations will be based on discrete lake populations. In certain cases, e.g. sea-type populations in the Nass River, adjacent populations will cluster into a single CU.

For conservation and biodiversity protection, the Lower Benchmark is the reference point for determining whether a sockeye stock is depressed and requires management intervention. Various definitions that have been used to identify conservation triggers include:

- Slaney et al. (1996): **“High risk of extinction”** - small populations where the mean abundance in the current decade is less than 20% of the long-term mean and less than 200 fish.
- Riddell (2004): **“Depressed”** - present escapements less than 25% of historical base period.
- DFO Marine Stewardship Council Response (2004): **“Lower Reference Point”** - The state of a fishery and/or a resource, which is not considered desirable. A total abundance below the lower reference point implies a conservation concern, and urgently requires rebuilding.

The DFO Wild Salmon Policy (2005) presents a different concept for a Lower Benchmark that is above a critical conservation threshold. The Lower Benchmark under the WSP is a level of abundance:

“high enough to ensure there is a substantial buffer between it and any level of abundance that could lead to a CU being considered at risk of extinction by COSEWIC. The buffer will account for uncertainty in data and control of harvest management. There is no single rule to use for determination of the Lower Benchmark. Rather, it will be determined on a case-by-case basis, and depend on available information, and the risk tolerance applied.”

Below the Lower Benchmark as defined by the WSP is a population level that cannot sustain further mortalities due to fishing or habitat change. This level of abundance infers a high probability of extirpation. The WSP states that:

“determining this level of abundance is a continuing discussion in salmon assessment literature and is not specified in this policy. The Department will prepare and publish operational guidelines on the estimation of this level. The management response to this level will be determined on a case by case basis, in consultation with First Nations, and others affected by this determination.”

This definition is vague and open to interpretation. In effect the conservation of a salmon stock could be compromised to meet non-biological objectives. In order to protect stocks, biological realities need to supercede socioeconomic requirements and to adopt different priorities is to further endanger weak stocks. A meaningful biodiversity conservation strategy requires objective criteria and comparisons of present levels of abundance with a historical baseline.

For biodiversity conservation, it is recommended that a benchmark be defined to represent that level of population abundance which triggers COSEWIC listing (Figure 19). By explicitly adopting the COSEWIC criteria as a response threshold

and defining these benchmarks for every sockeye conservation unit, a more responsive system for biodiversity protection will be obtained.

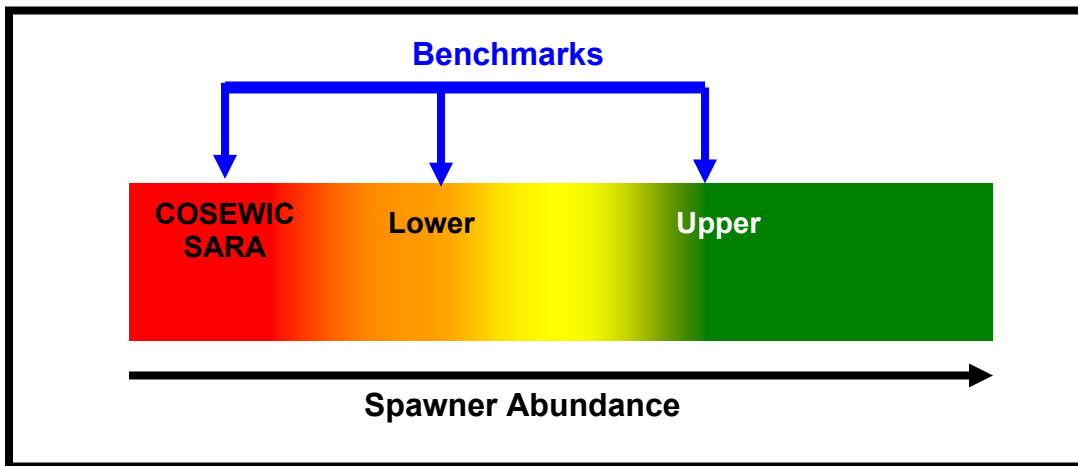


Figure 19. Three different benchmarks for sockeye biodiversity protection.

The COSEWIC/SARA benchmark is a (low) level of spawner abundance that is defined by COSEWIC criteria. For a COSEWIC-listed population to end up on the more stringent SARA list is a political determination that includes socio-economic considerations. The COSEWIC/SARA benchmark will vary for different CU's, e.g. Early Stuart benchmark would be different from a small coastal sockeye CU.

Coastal Biodiversity Conservation Strategies

In support of sockeye biodiversity protection, it is recommended that Coastal Biodiversity Conservation Strategies be prepared and preferentially target stocks that fall below the Lower Benchmark on Figure 19. The strategy would develop a proactive approach to ensure that all stocks within the watershed or coastal unit stay above the Lower Benchmark. Coastal or watershed conservation units would be defined by stocks which share similar migration patterns, production characteristics and exposure to fisheries.

Each of the large sockeye watersheds, e.g. Skeena, Nass, Fraser would provide the focus for a biodiversity conservation strategy, while coastal areas would be grouped into logical groupings e.g. DFO Areas 5 and 6, Inside sockeye stocks, Vancouver Island sockeye. These conservation strategies would need to be undertaken collaboratively by DFO, First Nations, commercial fishers and other stakeholders concerned about the status of sockeye stocks.

Restructuring of the Commercial Fishery

After conservation needs are met, and priority access is provided for First Nations as set out in the DFO Allocation Policy, the commercial sector harvests at least 95 per cent of combined commercial and recreational harvest of sockeye, pink and chum salmon. In order to reduce harvesting pressure on weak sockeye stocks, the commercial sector needs to become involved in sockeye biodiversity protection. Protection of biodiversity requires more conservative harvest rates and more effective precautionary approaches to fisheries management, which ultimately benefits all participants in the fishery.

The best opportunity for restructuring the fishery lies in the development of terminal fisheries. To protect sockeye biodiversity and the reduction of fishing pressure on weak stocks, this will require the development of commercial inland fisheries. There will be a reduction in the value of the fishery due to reduced fish quality. Nevertheless, a cannery grade product can usually be obtained at locations which permit the selective harvesting of abundant stocks.

Rotational Inventories and Annual Stock Assessments

Refined sockeye stock assessment strategies are required that provide the necessary data for monitoring weak stocks. For conservation purposes, it may be sufficient to undertake periodic rotational inventories over several years (3-5?) so as to distribute limited sampling effort over a wider geographical area. More sockeye populations could then be surveyed, albeit at a reduced frequency.

Sockeye weirs and counting fences provide accurate data but are expensive to build, maintain and operate. Other more cost-effective approaches may be applicable, including hydroacoustic surveys of juvenile, and DNA sampling for stock identification. Within large river systems such as the Nass River where there are annual tagging programs, DNA methods could be applied to generate stock-specific estimates of sockeye abundance (Levy 2006).

The absence of suitable quality stock assessment data is arguably the biggest constraint for effective sockeye biodiversity protection. Without data, there is no basis for a recovery response, extirpation risks cannot be properly evaluated, and sockeye populations could easily disappear without public knowledge.

First Nations Involvement

First Nations are frequently located adjacent to sockeye streams and play an essential role within "sockeye ecosystems". Traditional Knowledge and awareness can be integrated within an assessment framework to provide essential information for evaluating sockeye stock status. First Nations fisheries technicians can carry out essential stock assessment activities with available DFO funding programs (e.g. AAROM). First Nations involvement needs to extend

beyond field data collection; collaborative management approaches can be developed to ensure that First Nation values are integral components of future biodiversity protection strategies.

Conclusions

Sockeye restoration plans or regional strategies are required to stabilize and reverse the declines in BC sockeye stocks. Preparation of the required restoration plans must be the immediate priority. Sierra Club of Canada can play an important role in sockeye biodiversity conservation by petitioning COSEWIC to assess and list threatened sockeye stocks in BC, either under the unsolicited process, or by making the case for emergency designation, where required.

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