Fisheries and Oceans Canada | Pêches et Océans Canada
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Pacific Region
Canadian Science Advisory Secretariat
Science Advisory Report 2010/056

ASSESSMENT OF CULTUS LAKE SOCKEYE SALMON IN BRITISH COLUMBIA IN 2009 AND EVALUATION OF RECENT RECOVERY ACTIVITIES

Photograph 1. Sockeye salmon spawning on submerged talus slopes in Cultus Lake (DFO).

Photograph 2: Cultus Lake, BC (DFO)

Context :

The Cultus Lake sockeye salmon Conservation Unit is one of three salmon populations that were designated as endangered by the Committee on the Status of Endangered Wildlife in Canada. The Cultus Lake population is part of the late-run aggregate of Fraser River sockeye salmon stocks and their status can impact fishery management planning for the stock aggregate. A suite of recovery actions have been implemented since 2000 and this assessment is a review of the status of the population, the efficacy of recovery actions, and the long-term prospects for the population.

SUMMARY

- The abundance of adult sockeye salmon (*Oncorhynchus nerka*) returning to Cultus Lake has been monitored since 1921, and has been slowly declining since the 1970s. The recent generational (4-year) average is about 1,000 spawners, 5% of historical values.
- The decline appears to have been halted but the population has not met any of the recovery objectives set by the Cultus Sockeye Recovery Team, nor a lower benchmark proposed under the Wild Salmon Policy.
- Poor survival after smolts leave Cultus Lake is a major contributor to the recent status of the population.
- Recovery actions include reductions in harvest, predator control in Cultus Lake, and a captive broodstock/supplementation program.

- Concerns over Cultus Lake sockeye salmon have resulted in the 2000-2009 harvest rates being reduced to an average of 20% for the late-run complex of stocks.
- The removal of predators from the lake has coincided with an increase in the in-lake survival of juvenile sockeye salmon.
- Hatchery fry releases to the lake have resulted in increasing numbers of returning hatchery adults. The majority of adult sockeye that returned to Cultus Lake in 2008 and 2009 were hatchery-origin fish.
- The reproductive success of hatchery fish in the wild is unknown and the apparent failure of the 2008 brood, which consisted of >90% hatchery fish, is cause for concern.
- The prospects for the Cultus Lake sockeye population are highly uncertain as they are tied to future trends in smolt-recruit survival.
- Recovery actions should be considered experimental and need to be monitored carefully and managed adaptively.

INTRODUCTION

Cultus Lake is a small (6.4 km^2) coastal lake in the lower Fraser River watershed that is the natal home to a unique population of sockeye salmon (Withler et al. 2000). The population is significant to local First Nations and has contributed to non-native fisheries since the late 1800s. The abundance of adult returning to this lake has been monitored continuously since 1921 (Figure 1). While highly variable, the historical generational (4-year) average abundance of spawners entering the lake was about 20,000 spawners. The population began to decline in the 1970s and the current generational average is about 1,000 spawners.

The Cultus Lake population is part of the late-run aggregate of sockeye stocks that historically entered the Fraser River and began their upstream migration in September of each year. Cultus sockeye salmon are caught in fisheries directed primarily at large, more productive late-run populations, which results in higher rates of exploitation for Cultus Lake salmon. Exploitation rates, particularly in the 1980s, contributed to the decline in abundance. Since 1996, the timing of migration of late-run sockeye has advanced by more than a month earlier and the stresses associated with early migration have contributed to a loss in productivity (Cooke et al. 2004). Since 1988, Management actions have been taken to constrain exploitation rates on the late-run aggregate.

The status of Cultus Lake sockeye salmon was reviewed by Schubert et al. (2002) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), which assessed the population as "*endangered*" (COSEWIC 2003). Just prior to the COSEWIC analysis there had been two successive years of premature mortality of >80% of the adult spawners in the lake (called "pre-spawning mortality", PSM). Low abundance and uncertainty about the reoccurrence of PSM contributed to the COSEWIC determination.

Beginning in 2000, a number of recovery actions were implemented to increase the abundance of Cultus Lake sockeye salmon, including a predator control program in the lake and a captive broodstock/enhancement program, under the guidance of the Cultus Sockeye Recovery Team (CSRT). A conservation plan for the population was published in 2009 (CSRT 2009) that has the following Conservation Goal:

"..to halt the decline of the Cultus Lake sockeye population and return it to the status of a viable self-sustaining and genetically robust wild population that will contribute to ecosystems and have the potential to support sustainable use."

A series of recovery objectives were established towards meeting this goal. In addition, the implementation of the Wild Salmon Policy requires specification of 2 abundance-based benchmarks to which the Cultus population can be compared.

ASSESSMENT

The purpose of this assessment is to update the status of Cultus Lake sockeye salmon and review the recovery actions that have been put in place.

The primary indicator for the status of Cultus Lake sockeye salmon is the 4-year average number of successful spawners (the generational average). Based on this status indicator, the decline in the generational average has been halted in the last few years (Figure 1). This has occurred largely as a result of large returns of hatchery-born fish in 2008 and 2009, but this conclusion depends on the untested assumption that the reproductive success of hatchery fish is equivalent to that of wild spawners). Regarding recovery of Cultus Lake sockeye, CSRT (2009) Recovery Objective 1 specifies a generational average of at least 1,000 successful adult spawners and no single year less than 500; this objective has not been met, as 2 of 4 years within a generation remain below 500 fish. Objective 2 calls for continuous population growth, and this objective has also not been achieved.

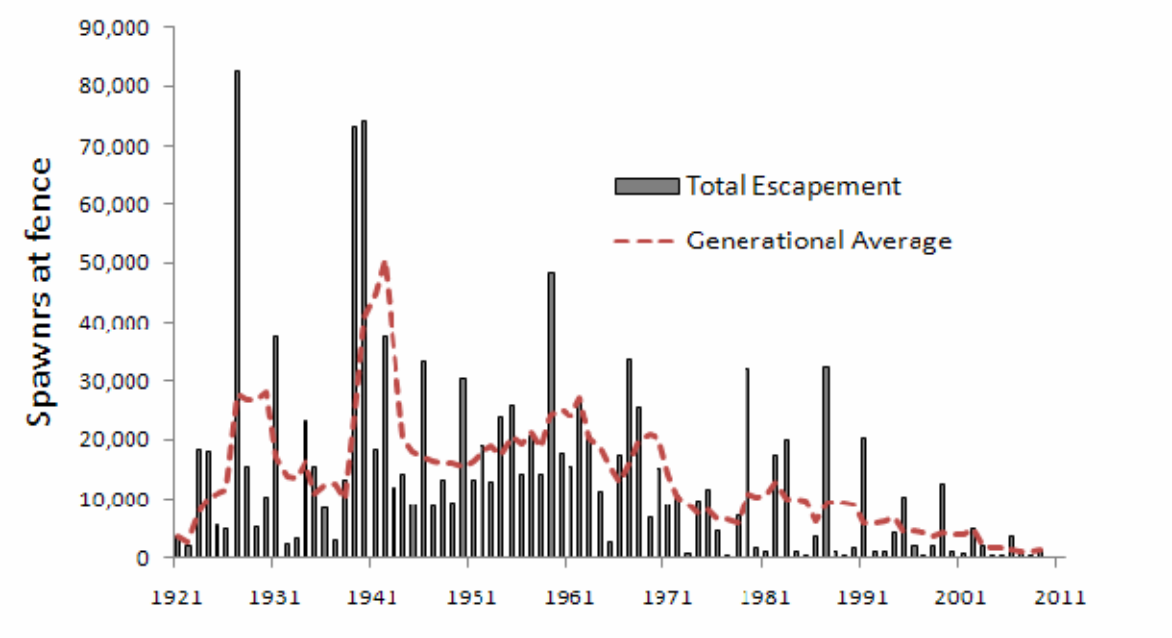

Figure 1. The number of adult sockeye salmon entering Cultus Lake each year, and the 4-year running average of abundance.

A provisional estimate of the lower WSP benchmark for Cultus Lake sockeye salmon is 10,200 wild spawners; the current abundance of wild spawners is <10% of that level.

The recovery of the population is constrained by continued poor smolt-recruit survival (Figure 2). Historically, an average of 6% of smolts returned as adults, but that average has fallen to 2.6% for the 1999-2005 broods, with the most recent broods being in the 1-2% range. At these rates the population is not self-sustaining, even in the complete absence of fishing. The decline in survival is similar to that observed in Chilko Lake sockeye, another Fraser River sockeye salmon population (Figure 2).

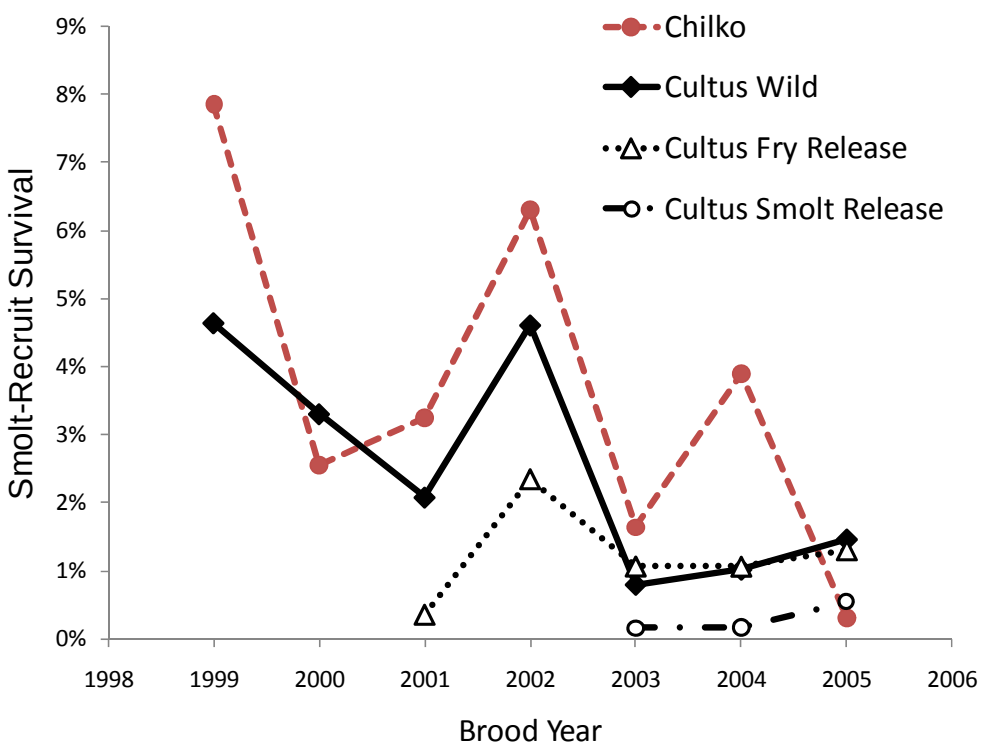

Figure 2. Recent smolt-recruit survival for Cultus Lake sockeye salmon, for wild smolts, smolts resulting from summer and fall fry releases to the lake, and from yearling smolt releases made in Sweltzer Creek, the outlet of Cultus Lake. Also shown are survival rates for Chilko Lake sockeye salmon, located in upper Fraser River basin.

Beginning in 2004, a program to reduce the northern pikeminnow *Ptychocheilus oregonensis* (a large predatory fish) population was initiated, following indications of the success of similar efforts conducted in the 1930s (Forester and Ricker 1941). In 2004, the pikeminnow population was estimated to be about 60,000 adult fish (Bradford et al. 2007) and since then over 40,000 adults have been removed from the lake, mainly by purse seine. Coincident with the removals, the survival of juvenile sockeye has increased. Considering all of the available data that extends back to the early 1920s, predator control appears to eliminate depensatory mortality in the lake, which results in an increase in sockeye smolt production for smaller broods. Thus, the predator control program may be contributing to recovery by increasing freshwater survival of juveniles, although the longer-term impact reducing one of the lake's top predators on the lake ecosystem remains unknown.

In response to the threat of large losses of adult spawners, similar to the pre-spawn mortality that occurred in 1999 and 2000, a captive broodstock program was initiated in 2000. The goal of this program was to maintain at least 500 spawners in captivity using a breeding design that would maintain genetic diversity in the captive population. This captive broodstock program results in considerable numbers of excess fish being produced. Those fish are released to the lake as fed fry or yearling smolts, supplementing the wild population. Large-scale releases of up to 1 million juvenile sockeye have occurred annually since 2003.

The captive broodstock program has been successful, as over 600 adults have been raised to maturity in captivity annually. However, an increasing incidence of Bacterial Kidney Disease

(BKD) outbreaks in the captive population has been observed. The survival of juveniles released in the lake to the smolt stage has averaged 14% and consequently the production of hatchery smolts has exceeded wild production since 2005. The smolt-recruit survival for smolts resulting from fry releases to the lake is similar to wild smolt survival; however, the survival of hatchery smolts released directly as yearlings is much lower (Figure 4).

Relatively large numbers of hatchery-born adults returned in 2008 and 2009 and the majority of returning adults are expected to be of hatchery origin for next few broods. The reproductive success of hatchery fish in the wild is currently unknown. Of concern is the 2008 brood for which > 90% of the spawners were hatchery born; very few age-1 smolts from natural spawning left the lake from this brood in 2010. The cause of the failure of this brood is currently unknown and is under investigation. The ability of hatchery fish to effectively contribute to the spawning population is a key component if the hatchery program is to increase the abundance of fish in the wild, and in some other studies a significant decline in fitness of hatchery fish has been observed (Araki et al. 2007). Genetic sampling and parental analysis will be used to evaluate this component of the supplementation program.

Forward projections using a revised version of the Population Viability Analysis (PVA) model of Korman and Grout (2008) highlight that the recovery of the Cultus population rests largely on the return of smolt-recruit survival rates to values more similar to those observed historically. The reproductive success of hatchery fish is also critical because most of the adults expected to return to the lake in the next few years are of hatchery origin. The continued regulation of fishing mortality, and successful implementation of other recovery measures, are all needed to maximize the likelihood of persistence of Cultus sockeye salmon. The model results suggest that the population is not likely to reach the lower WSP benchmark in the next 20 years, except under the most favorable environmental and management circumstances.

CONCLUSIONS AND ADVICE

The Cultus Lake sockeye salmon population is still small, and recovery hinges on an improvement in the survival of smolts once they leave the lake (the so-called “marine survival”). As most of the smolts and returning adults are now hatchery-born, the short-term trajectory will also depend on the untested assumption that hatchery fish will be able to reproduce successfully in the wild. Given the uncertainty about future survival rates, short and long-term effects of the hatchery program, and the potential changes to the Cultus Lake food web from predator manipulation, the prognosis for the Cultus Lake sockeye population remains highly uncertain.

Specific recommendations resulting from this assessment include:

- Attempts to recover endangered salmon populations through the manipulation of the population or its environment are both risky and experimental and thus require a thorough monitoring program to ensure benefits are being accrued as expected or to allow timely modifications to the recovery protocols as required. These programs should comprise a significant proportion of the overall recovery program.

- Given that the severe pre-spawn mortality of 1999-2000 has not re-occurred, the apparent lower survival of hatchery raised smolts compared to the wild stock supplementation program, and the risks associated with continuing the captive broodstock program from both a genetic and fish culture perspective, it is recommended that the captive breeding program be phased out of the recovery strategy.

- Long term supplementation may be an alternative to a captive broodstock program, but this will depend on the relative reproductive success of hatchery fish in the wild. Assessing the reproductive success of hatchery fish in the lake is a high priority information need. Depending on the outcome of this assessment, significant changes to the enhancement program may be warranted.

- Predator control appears to be increasing juvenile sockeye survival, and efforts to suppress the pikeminnow population are recommended. However, monitoring of the predator population and other components of the lake ecosystem is needed to ensure undesirable side-effects of the predator control program do not occur.

- To ensure the Cultus population will persist for a decade or longer of poor smolt-recruit survival, continuation of the current recovery measures (harvest management, predator control, and supplementation) is recommended, but the exact nature of those activities should be continually reviewed to take advantage of the findings of the ongoing assessment program.

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E-Mail: csap@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs
ISSN 1919-5079 (Print)
ISSN 1919-5087 (Online)

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION

DFO. 2010. Assessment of Cultus Lake Sockeye Salmon in British Columbia in 2009 and Evaluation of Recent Recovery Activities. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/056.