RECOVERY POTENTIAL ASSESSMENT FOR WHITE STURGEON

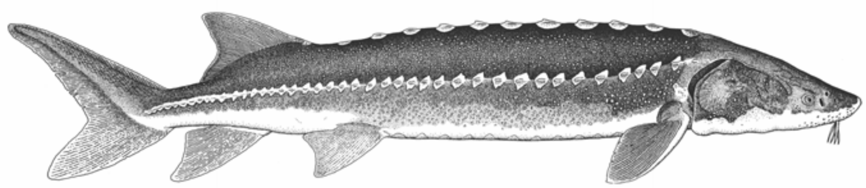

Figure 1. The white sturgeon, Acipenser transmontanus.
(Drawing by Paul Vecsei provided courtesy of Golder Associates Ltd.)

Context:

In November 2003, the white sturgeon was designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The species comprises six populations in Canada. In 2006, four of these populations (the upper Fraser, Nechako, Kootenay, and Columbia river) were added to Schedule 1 of the Species at Risk Act (SARA). A recovery potential analysis (RPA) was undertaken by DFO to provide science-based advice on current status, the likely impact of human activities on the potential for recovery, and options to mitigate human threats to achieve recovery objectives. This advice is intended to inform decisions about recovery planning and possible exemptions from the automatic prohibitions as required by SARA.

SUMMARY

- As of 2006, only about 11,000 mature white sturgeon remain in Canada. Most of these (75%) occur in the lower Fraser River population.
- The number of mature fish remaining in the four populations protected under SARA is estimated at 185 in the Upper Fraser River, 305 in the Nechako River, 455 in the Kootenay River and 1000 in the Canadian portion of the Columbia River.
- The Nechako, Kootenay, and Columbia populations are declining following decades of recruitment failure related to extensive habitat changes, primarily associated with dams and river regulation.
- Potential critical habitats (but not residences) have been identified for all populations and include key areas for spawning, larval and juvenile rearing, adult feeding and staging prior to spawning migration.
- Specific sources of harm or mortality to individual white sturgeon include targeted or incidental capture in recreational fisheries, bycatch in salmon gillnet fisheries, passage through dams, and sampling for research and hatchery broodstock.
- Best estimates for total annual mortality directly induced by humans range from 0.01% in the Upper Fraser to 0.07% in the Columbia population for small sturgeon (ages 2 to 10); and from 0.02% in the Upper Fraser to 0.3% in the Nechako population for large sturgeon (ages >10).
- The recovery goal specified in the draft national recovery strategy for white sturgeon is to ensure the long-term viability of naturally-reproducing populations throughout the species' natural range, and restore opportunities for beneficial use, if and when feasible.

- Specified quantitative recovery objectives that could be assessed in simulation scenarios include (1) to ensure no net loss of reproductive potential, (2) to achieve within 50 years (a) 1000 mature individuals, (d) ongoing natural recruitment, and (e) population growth when below the abundance target [2(b) and 2(C) not addressed].
- For the Upper Fraser population, simulation model projections suggest that all recovery objectives except 2a can be achieved if total human-induced mortality does not exceed twice the estimated status quo level. Simulation results based on assumptions about historic abundance raise doubts about the necessity of achieving 1000 mature fish (recovery objective 2a) and continued population growth (recovery objective 2e).
- For the Nechako, Kootenay, and Columbia populations, simulation model projections indicate that:
    - o extinction in the wild is inevitable, even in the absence of further human-induced mortality unless human intervention can restore natural recruitment.
    - o natural recruitment must be restored almost fully to historic rates to achieve recovery objectives.
    - o restoration of historic rates of natural recruitment would be sufficient to achieve abundance objectives within 100 years, but not within 50 years.
    - o hatchery supplementation will also be necessary to achieve abundance objectives, but would not be sufficient by itself.
- Scenarios with habitat restoration to fully restore historic rates of natural recruitment combined with low level, short-term hatchery releases, indicate that recovery objectives could likely be achieved in the face of continuing incidental mortality not exceeding twice the estimated current level in each of the three non-recruiting populations.

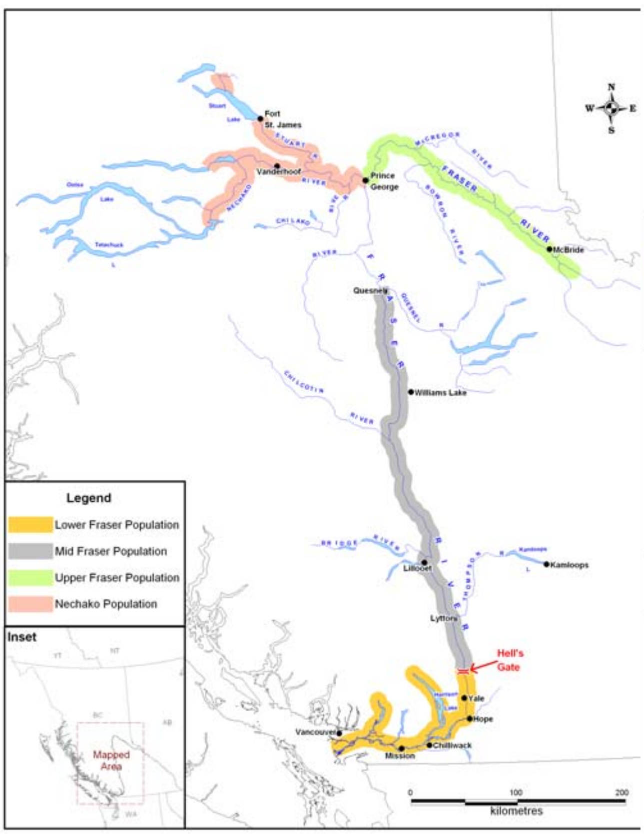

Figure 2. Approximate ranges for the four white sturgeon populations in the Fraser River basin (from Wood et al. 2007).

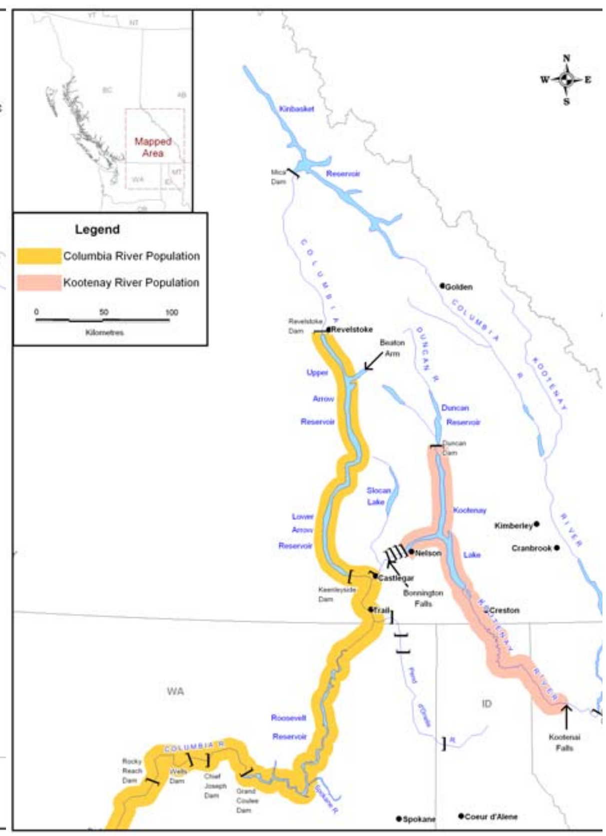

Figure 3. Approximate ranges for the two white sturgeon populations in the Columbia River basin (from Wood et al. 2007).

BACKGROUND

The white sturgeon is the largest, longest-lived freshwater fish species in North America with a maximum length of over 6 m and maximum age of over 100 years (Figure 1). Females spawn for the first time at about 26 years of age, and spawn repeatedly but at intervals ranging from 4 to 11 years. White sturgeon are broadcast spawners, releasing large numbers of eggs and sperm into the water column of turbulent river habitats. Spawning occurs in the late spring and early summer, typically following the highest water levels of freshet, as water temperatures are rising, in fast water velocities, over coarse substrates. This life history makes the white sturgeon extremely vulnerable to human activities in freshwater habitats.

White sturgeon are found only in the mainstem and larger tributaries of three major drainages on the Pacific coast of North America: the Fraser, Columbia and Sacramento rivers. Six genetically distinct populations have been identified in Canada, all in British Columbia (Figures 2 and 3). A catch-and-release fishery targets white sturgeon in the mid- and lower Fraser river populations. There is no directed fishing for white sturgeon in the other four populations.

In 2003, COSEWIC designated the white sturgeon as endangered in Canada. In 2006, the four populations without directed fisheries (the upper Fraser River, Nechako River, Columbia River, and Kootenay River populations) were added to Schedule 1 of SARA. Designation under SARA has triggered a requirement for scientific assessment of current status, critical habitat, recovery objectives, the likely impact of human activities on the potential for recovery, and options to mitigate human threats to achieve recovery objectives. This detailed recovery potential assessment is provided by Wood et al. (2007).

ASSESSMENT

Trends and Current Status

The upper Fraser population in 2001 was estimated at 815 fish of 50 cm or larger based on a mark-recapture study (Yarmish and Toth 2002). No trend data are available. Abundance is believed to be naturally low in this region and to be within the historic range based on the apparent absence of significant threats both historically and currently, and evidence that age composition is as expected for a population at equilibrium.

The Nechako population in 1999 was estimated at 571 fish (300 were likely mature) based on information from radio telemetry, recreational catch statistics, mark-recapture estimates and life history studies (RL&L 2000). Age composition is dominated by older individuals indicating that little or no juvenile recruitment has occurred since 1967. Applying an annual survival rate of 92.3% (or M=0.08), the total population in 2006 is estimated at only 318 fish of which 286 are likely mature.

The Kootenay population (including the transboundary reach from Libby Dam to Bonnington Falls) was estimated at 760 fish in 2000 based on radio telemetry, recreational catch statistics, mark-recapture estimates and life history studies (Paragamian et al. 2005). Age composition data indicate that natural recruitment began to decline in the mid-1960s and has been negligible since 1974. Thus, the (projected) natural population in 2006 is an ageing cohort of <450 large, mature fish.

The Columbia population was estimated by mark-recapture studies to comprise 52 fish (95% CI was 37-92) above Keenleyside Dam in 2006, 1157 fish (95% CI was 414-1899) from

Keenleyside Dam to the border in 2003, and 2295 fish (95% CI was 1528-3574) downstream of the Canada-US border to the Grand Coulee Dam (including the Roosevelt Reservoir) (Golder 2005). Age composition indicates that natural recruitment began to decline in 1969, and has failed almost entirely since 1985, so that the remaining natural population is at least 90% mature fish. Assuming an annual survival rate of 97%, abundance in 2006 is estimated at 3000 mature fish, of which 1000 are in Canadian habitat.

Natural populations in the Nechako, Kootenay, and Columbia rivers are declining as a result of recruitment failure related to extensive changes in habitat, many of which are associated with dams and river regulation (McAdam et al. 2005). Conservation aquaculture programs have been initiated to prevent extinction of these populations, beginning in 1990 for the Kootenay population, 2001 for the Columbia population, and 2006 for the Nechako population.

Critical habitat and threats

Potential critical habitats (but not residences) have been identified for all populations and include key areas for spawning, larval and juvenile rearing, adult feeding and staging prior to spawning migration (Appendix 1 of Wood et al. 2007). Threats to habitat include river regulation; instream activities such as dredging for gravel or sand; linear development; alterations or development of riparian, foreshore, or floodplain areas; upstream use of land and water; and effluent discharge from both point and non-point sources.

Specific sources of harm or mortality to individual white sturgeon include targeted or incidental capture in recreational fisheries, bycatch in salmon gillnet fisheries, passage through dams, and sampling for research and hatchery broodstock. Best estimates for total annual mortality directly induced by humans range from 0.01% in the Upper Fraser to 0.07% in the Columbia population for small sturgeon (ages 2 to 10); and from 0.02% in the Upper Fraser to 0.3% in the Nechako population for large sturgeon (ages >10).

Recovery objectives

The recovery goal specified in the draft National Recovery Strategy for white sturgeon is to ensure the long-term viability of naturally-reproducing populations throughout the species' natural range, and restore opportunities for beneficial use, if and when feasible. Specified quantitative recovery objectives include (1) to ensure no net loss of reproductive potential, (2) to achieve within 50 years (a) 1000 mature individuals, (b) approximately 1:1 sex ratio at maturity, (c) distribution over the natural range, (d) ongoing natural recruitment, and (e) population growth when below the abundance target.

Performance measures and simulations

Recovery potential was assessed in Monte Carlo simulations with an age-structured, stochastic population model (details in Appendix 2 of Wood et al. 2007). Recovery objectives were re-expressed as numerical or probabilistic performance measures to evaluate recovery success under various scenarios. Feasibility of achieving recovery objective 1 (no loss of reproductive potential) was evaluated by keeping track of both the number of mature fish and the total potential egg deposition. The latter index takes into account that older fish are larger and can produce more eggs.

Recovery objective 2a was evaluated by computing the proportion of Monte Carlo simulation trials in which mature abundance exceeded 1000 in simulation year 50. The *minimum* number of spawners over the course of each simulation period was also recorded to monitor the risk of genetic bottlenecks and the expected availability of broodstock for hatchery supplementation.

Recovery objectives 2b (equal sex ratio) and 2c (distribution over the natural range) were not evaluated. Instead, demographic stochasticity was introduced explicitly in computing the number of fish older than age 1 that survived each year, and an equal sex ratio was assumed. For scenarios that allowed natural recruitment, recovery objective 2d (continuing natural recruitment) was typically achieved whenever mature fish remained in the simulated population; this is because natural recruitment to age 1 in each year was computed with a stock-recruitment function based on potential egg deposition, subject to environmental stochasticity. However, status quo scenarios for populations that lack natural recruitment were simulated by adjusting a natural recruitment scaling parameter designed to model habitat suitability.

Feasibility of achieving recovery objective 2e was evaluated by computing population growth rate based on population size at the beginning and end of each simulation trial, and then averaging over all trials. For hatchery supplementation scenarios, the proportion of mature fish that originated from natural spawning was computed at the end of each trial.

Feasibility of achieving recovery objective 3 was not evaluated because targets for beneficial use have not been discussed by the national recovery team. However, the performance statistics were also computed in simulation year 100 to provide a longer term perspective. For most populations, recovery objective 2a could be achieved only within this longer time frame.

Sources of uncertainty

To determine whether simulated outcomes were particularly sensitive to uncertainty in the parameter values used in the population model, key parameters were systematically manipulated one at a time. This sensitivity analysis suggested that conclusions were robust (i.e., performance measures within ± 30%) over a plausible range of parameter values and levels of annual variability.

It should be noted that simulation scenarios were selected to demonstrate the necessary and sufficient conditions for achieving recovery objectives, not to determine the best options for recovery. Other scenarios involving different trade-offs might achieve recovery objectives with better socio-economic outcomes.

CONCLUSIONS AND ADVICE

For the Upper Fraser population, simulation model projections suggest that all recovery objectives except 2a can be achieved if total human-induced mortality does not exceed twice the estimated status quo level. Simulation results based on assumptions about historic abundance raise doubts about the necessity of achieving 1000 mature fish (recovery objective 2a) and continued population growth (recovery objective 2e). An alternative approach is to recognize that the naturally small size of the Upper Fraser population makes it inherently vulnerable to extinction, and to seek to maintain its current viability by preventing further deleterious impacts. Concerns about the potential loss of genetic diversity over the longer term that motivate recovery objective 2a might be addressed by intervention to manage gene flow with other populations.

For the Nechako, Kootenay, and Columbia populations, simulation model projections indicate that unless human intervention can restore natural recruitment, extinction in the wild is inevitable, even in the absence of further human-induced mortality. The simulation results indicate first, that (almost full) restoration of the historic rates of natural recruitment will be necessary to achieve recovery objectives, and second, that restoration of historic rates of natural recruitment would be sufficient to achieve abundance objectives within 100 years, but not within 50 years. Hatchery supplementation will also be necessary to achieve abundance objectives, but would not be sufficient by itself. Hatchery supplementation should be viewed as experimental, but supported as a calculated risk to reduce the serious risk of genetic bottlenecks in natural spawning expected over the next 30 years.

Recovery potential for the three declining populations depends entirely upon successful human interventions to increase natural recruitment. Given a commitment to engage in habitat restoration that is deemed sufficient to increase natural recruitment to historic levels, and to hatchery supplementation that is deemed sufficient to avoid future genetic bottlenecks, some level of continuing incidental harm might be exempted without jeopardizing the survival or recovery of these populations. Simulated scenarios with habitat restoration to fully restore historic rates of natural recruitment combined with low level, short-term hatchery releases, indicate that recovery objectives could likely be achieved in the face of continuing incidental mortality not exceeding twice the estimated current level in each of the three non-recruiting populations.

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ISSN 1480-4913 (Printed)

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

CORRECT CITATION FOR THIS PUBLICATION

DFO, 2007. Recovery potential assessment for white sturgeon. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/014.