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ASSESSMENT OF HABITAT USE AND HABITAT QUALITY FOR SARA-LISTED POPULATIONS OF WHITE STURGEON IN BRITISH COLUMBIA

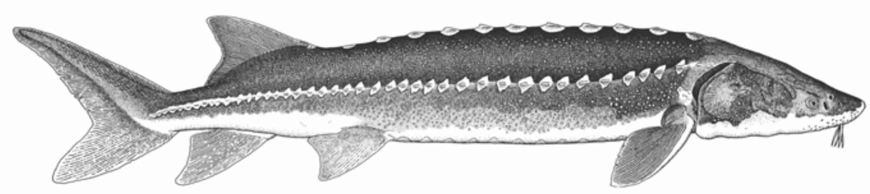

Figure 1. The white sturgeon, Acipenser transmontanus.
(Drawing by Paul Vecsei provided courtesy of Golder Associates Ltd.)

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 assessment (RPA) was undertaken by DFO in 2007 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. The RPA included an assessment of habitat use and quality and provided advice on potential critical habitat necessary for persistence of white sturgeon populations in Canada. New information to support critical habitat identification for the populations listed under SARA has become available since the original RPA was developed and was the subject of a science peer review by the Pacific Scientific Advice Review Committee (PSARC) in June 2009. The advice from that review will be used to complete of the Recovery Strategy and to develop Recovery Action Plans.

SUMMARY

- New information to support critical habitat identification of SARA-listed populations of white sturgeon (Upper Fraser, Nechako, Columbia, Kootenay) has become available since a 2007 recovery potential assessment was completed. This information was the subject of science peer-review by the Pacific Scientific Advice Review Committee (PSARC) in June 2009.
- Natural populations in the Nechako, Kootenay, and Columbia rivers are declining as a result of recruitment failure or unsustainable recruitment declines related to extensive changes in habitat, many of which are believed to be associated with several factors including dams and river flow regulation.
- Participants at the June 2009 PSARC meeting agreed that recovery efforts should focus primarily on improving natural recruitment in each of the dam-affected populations.
- Identifying critical habitat requires judgments about the extent to which habitat contributes to a species' survival or recovery. Habitat was also classified as "important" in cases where

existing knowledge was insufficient to meet a reasonable burden of proof in delineating boundaries for critical habitat, but where a subset of the habitat might yet qualify as critical habitat given further study. The purpose of identifying important habitat is, first, to emphasize that the full recovery of white sturgeon will require management of a larger set of geographic locations than can be designated as critical habitat at this time, and second, to highlight the specific geographic locations that are most likely to require additional protection in the future.

- Areas of present high use were recommended *de facto* as a partial specification of critical habitat. To meet recovery targets, additional critical habitat will likely have to be identified in the future as research and recovery efforts proceed. Measures may be necessary for some populations on both sides of the Canada-US border to recover trasboundary components of Canadian populations.
- Where detailed studies were lacking or inconclusive, expert opinion was used to identify important and critical habitats.
- Most participants at the June 2009 PSARC meeting agreed with the geographic locations identified as critical and important habitats. Details, source information, risk evaluation and maps with boundaries demarking potential critical habitats are documented by Hatfield et al. (2009).

Figure 2. Approximate ranges for the four white sturgeon populations in the Fraser River basin (from Hatfield et al. 2009).

Figure 3. Approximate ranges for the two white sturgeon populations in the Columbia River basin (from Hatfield et al. 2009).

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 typically 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 fast water velocities, over coarse substrates during the late spring and early summer, typically following the highest water levels of freshet as water temperatures are rising. 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). In 2003, COSEWIC designated the white sturgeon as endangered in Canada for the following reasons: [white sturgeon] *a long-lived species with a 30-40 year generation time and late maturity that has suffered over a 50% decline in the last three generations. Three of six populations in Canada are in imminent threat of extirpation. Extant populations are subject to threats of habitat degradation and loss through dams, impoundments, channelization, diking and pollution. Illegal fishing (poaching) and incidental catches are also limiting. In addition, a developing commercial aquaculture industry may also impose additional genetic, health and ecological risks to wild populations.*

Natural populations in the Nechako, Kootenay, and Columbia rivers are declining as a result of recruitment failure or unsustainable recruitment declines related to extensive changes in habitat, many of which are associated with dams and river regulation. Potential critical habitat was identified for all populations and included 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.

New information to support critical habitat identification has become available since the 2007 recovery potential assessment was completed (DFO 2007a). All existing information was the subject of review by the Pacific Scientific Advice Review Committee (PSARC) in June 2009.

ASSESSMENT

The details and source information for the assessment is provided by Hatfield et al. (2009). White sturgeon inhabit large rivers where they are associated with particular habitat features: slow, deep mainstem channels interspersed with a zone of swift and turbulent water, extensive floodplains with sloughs and side channels, and a snowmelt-driven hydrograph with prolonged spring floods. Most habitat use studies are recent and have come from regulated rivers, particularly the upper Columbia and Kootenay Rivers. The few studies completed on the Fraser River, which is the only unregulated system in the species' range, indicate that habitat use there may be quite different.

Habitat use by life stage

Spawning and incubation habitat

Extensive studies (mostly in regulated rivers) indicate that white sturgeon have strict spawning requirements for deep, swift water and coarse substrates. Spawning habitat in the Columbia River below McNary Dam is characterized as having a 0.8 to 2.8 m sec^{-1} mean water column velocity, and boulder and bedrock substrates. Mean water column velocities typically range from 0.5 to 2.5 m sec^{-1} at most sites studied. Spawning habitat has recently been identified in the Columbia River just south of the US border at Northport, Washington, with conditions such as high turbulent flows, and coarse substrates.

Spawning has occurred in the Kootenai River[1] in an area characterized by large mobile sand deposits, but this area is not considered to be good spawning habitat because eggs collected there have been coated in sand, and only one surviving wild sturgeon larvae has ever been collected there despite significant collection effort. Spawning was observed in 2004 in the Nechako River over substrates dominated by gravel and fines, a condition that appears to be one of the causes of ongoing recruitment failure.

Evidence from the lower Fraser River indicates that white sturgeon use large side channels for spawning as well as more turbulent areas downstream of the Fraser canyon. Physical characteristics of the side channels included gravel, cobble and sand substrates, and mostly laminar flows with near-bed velocities averaging 1.7 m s^{-1}. Boulder and cobble predominated in the mainstem study site. All sites were within a portion of the lower Fraser that is unconfined and largely unaffected by floodplain development. Successful spawning is most often associated with turbulent or turbid river sections areas upstream of floodplains.

Incubation success is thought to be greatest when discharges are high and steady. High velocities in egg deposition areas may exclude some predators and provide high turbidity, which may limit some predators. Substrate condition may also influence free-embryo survival. Recent research has indicated a preference by 48 hour-old white sturgeon free embryos for gravel sizes between 12 and 22 mm.

Juvenile habitat

Habitat for white sturgeon juveniles (<2 years old) varies considerably with stage of development. Little is known about habitat use by natural juveniles in BC populations, and most information comes from studies in laboratories or other river systems. Physical habitat for juveniles in the lower Columbia River has been described as 2 to 58 m depth, 0.1 to 1.2 m s^{-1} mean column velocity, and near-substrate velocity of 0.1 to 0.8 m s^{-1}. Note that the study was conducted downstream of McNary Dam, and the upper end of this depth range rarely exists in natural rivers. Nevertheless, the observation suggests that juvenile white sturgeon may be found at a range of depths, but that they prefer slow to moderate water velocities. Observations and traditional ecological knowledge in a number of locations within the Canadian range show that juveniles are often associated with the lower reaches or confluences of tributaries, large backwaters, side channels and sloughs. Sampling of side channel and slough habitat on the

[1] Portions of the Kootenay River that occur within the US are referred to as the “Kootenai.” We use the American spelling to refer to American portions of the river, and to the “Recovery Plan for the Kootenai River Population of the White Sturgeon (*Acipenser transmontanus*).” The plan was developed by the US Fish and Wildlife Service, with input from Canadian agencies, and refers to white sturgeon recovery in both Canadian and American portions of the river.

Kootenay has, however, shown little use of such habitats in comparison to the mainstem. Extensive use of deep, low velocity mainstem habitats also occurs, especially as fish grow larger. Substrates at collection sites have varied from finer particles through to boulder and hard clay. Feeding juveniles showed a slight preference for sand substrates, but occupied other substrates if food was present. In the Kootenay system, and perhaps in other systems, there is use of lake habitat by juveniles.

Immature and mature adult habitat

Habitat use by immature (> 2 years) and mature fish varies seasonally with feeding, overwintering, and migration behaviours. In general, white sturgeon adults are found in deep areas, adjacent to heavy flows, defined by deposits of sand and fine gravels with backwater and eddy flow characteristics. Adults in the upper Fraser may be widely dispersed, use tributary habitat, and may require long migrations to reach feeding and spawning habitats. Most studies of habitat use by adults have focused on the physical features of spawning habitat. Considerably less attention has been given to habitat required for other life history events including overwintering, feeding, holding, or migration. Large lakes and rivers, where available, are used extensively at all times of the year.

Summer residency

From July to September, the movements of white sturgeon in most populations tend to be more localized than in the spring to early summer or in fall. In the Columbia and Kootenay rivers, white sturgeon were reported to use shallower depths during the spring to summer period and exhibited frequent, short distance forays between shallow and deep-water areas to feed. Information on summer residency of Fraser white sturgeon is sparse, but movements appear to be localized and associated with summer feeding activity. Sturgeon in the upper Columbia (i.e., above Hugh Keenleyside Dam (HLK)) may be an exception to the patterns described here, since their movements may be most restricted by their isolation.

High-use areas in the upper Columbia River are generally depositional areas where food items settle out. These areas also support higher densities of other fish species which likely provide a primary food source. In Kootenay Lake, adults undertake an annual migration from the south end of the lake to the outlet of the Duncan River at the north end, where large numbers of spawning kokanee provide an excellent food source. Summer residency in other populations is not as well understood, but is likely also linked to food availability. In the upper Fraser, summer habitat is associated with spawning events, but potentially is also linked to opportunities to feed on spawning cyprinids, and the upstream migration of mature salmon, especially sockeye.

Overwintering

Sturgeon activity is generally lowest during winter months. Telemetry data for mature adults in the Fraser indicated that few individuals move more than 5 km during the winter. Individuals in all populations tend to utilize deeper, lower-velocity areas during this period. Large lakes and rivers are extensively used, where available.

Migration movements

Migration is defined as sustained, unidirectional movements unrelated to displacement by human activities, either upstream or downstream but not both, likely for feeding, spawning or overwintering. Migration patterns are being studied in many populations, but are not well understood for BC populations. Migrations in the spring are associated with staging, spawning, and feeding activities associated with the spring hatch of invertebrates and spawning in other fish species. Fall movements are also associated with feeding opportunities, particularly at the confluence of creeks in which kokanee spawn. Mature white sturgeon, especially females, do not usually spawn each year, so movements of individuals may vary among years and by sex. The extent of movements is related to proximity between overwintering areas and spawning and feeding areas.

Connectivity among habitats is necessary since fish must be able to move freely between feeding, holding and spawning areas to complete their life cycle. At present, connectivity is maintained throughout much of the species' Canadian range, but the variable is acknowledged as key for conservation planning of this species.

For the Arrow Lakes Reservoir (ALR) component of the Columbia River population, connectivity is required for the segment upstream from the Highway 1 Bridge to Big Eddy, and from Big Eddy to the spawning site at the golf course. Connectivity is identified specifically for those locations because flow releases from Revelstoke Dam (REV) may be a prerequisite for connectivity. The proposed minimum flow from REV may provide such connectivity but an evaluation is needed following implementation. Connectivity is also an issue in the transboundary component of the Columbia River. Preliminary genetic data suggest that HLK currently divides a formerly contiguous component of the Columbia population. Maintaining genetic diversity in the now-isolated ALR component of the population will be challenging given the limited ability to alter present levels of connectivity at HLK. At a minimum the present level of connectivity should be maintained within existing habitat in the transboundary reach downstream of HLK Dam.

Water Quality

Aquatic species may be at risk when water quality degrades beyond specific thresholds for oxygen, temperature, pH, or pollutants. In general, white sturgeon need cool, pollutant-free water. The current provincial water quality guidelines provide general direction for the protection of aquatic life (see http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html#approved for details) and are likely sufficient for describing the general boundaries of required water quality for white sturgeon. Additional research is needed to determine tolerance limits for other water quality factors affecting various white sturgeon life stages. Specific concerns include treated and untreated municipal and private sewage, and various other industrial and urban discharges, and non-point sources of pollution from agriculture, forestry, and urban areas.

Water temperature

Spawning appears to be initiated naturally when water temperature rises above a threshold value. While other factors may have a secondary influence on spawn timing (e.g., flow and photoperiod) temperature appears to have a dominant effect. Threshold temperatures of 14 ºC and 13 ºC have been reported for the Columbia River at Waneta and the Nechako River respectively. Spawning in the Kootenai River occurs at a lower temperature (8.5-12 ºC) as does spawning at the Revelstoke site (10-11 ºC). In these two latter cases it is challenging to identify such thresholds due to historic anthropogenic changes. For example, it is possible that the fish have a biological threshold that is not reached by the current thermal regime (e.g., Revelstoke spawning site) or are uniquely adapted to a cooler thermal regime (suggested for the Kootenai population). Maximum temperatures may also be a concern, particularly at the Waneta spawning site where spawning has occurred above the 20 ºC level which may cause abnormal development.

Alterations to thermal regimes are not considered to be a primary cause of recruitment failure in the Nechako, Columbia or Kootenay populations, but thermal changes may have secondary effects. Perhaps the best example is the Nechako River, in which thermal regime was affected by flow regulation for 15 years before recruitment failed (1967). Ongoing monitoring under the current thermal regime indicates that neither past nor present thermal regimes have been a primary cause of recruitment failure.

No general temperature criteria are proposed at this time given that temperature change is likely not the principal cause of historical recruitment failure, and that management for a single variable in a large river ecosystem might create unintended consequences. Future consideration of temperature criteria should be considered as part of a suite of measures to restore natural recruitment. In addition, temperature requirements for white sturgeon should be considered when reviewing new project proposals that have the potential to affect thermal regimes. Site-specific temperature criteria may be required given the natural differences in thermal regimes among basins and the potential for local adaptation within sturgeon populations.

Diet

Feeding behaviour of white sturgeon is specialized for dark, benthic habitats where prey are often located through direct contact, and facilitated by highly sensitive taste receptors on barbels near the mouth. Diet varies throughout the year and with location depending on prey availability. Juveniles reportedly eat a variety of aquatic insects, isopods, mysids, clams, snails, small fishes, and fish eggs. In the upper Columbia River (upstream of the border), *Mysis relicta*, a non-native pelagic crustacean, is the most common prey item of 1 – 2 year old juveniles. Adults feed predominantly on fish, particularly migratory salmonids where available, although crayfish and chironomids are also consumed.

Approach to identify potential critical habitat

Providing information on critical habitat is a discrete and obligatory task during development of the Recovery Strategy. The information base on habitat use and availability and the assessment of habitat requirements for recovery was provided by the Recovery Team for the DFO science peer review. The Recovery Team comprises a number of regional technical and community working groups, each with representation on the National Technical Coordinating Committee. In 2007, members of the Committee were tasked with leading the regional groups through a process to collate and evaluate relevant existing information on critical habitat. They were asked by DFO to document the sources of information, how the information was collected, the reliability of the information, and to describe data gaps. In 2008, this process was repeated to capture new information and analyses. It should be noted that the assessment was based on biological factors only and did not include non-biological (i.e., socio-economic) considerations.

During their assessment of information related to habitat use, each regional group was asked to categorize the degree of habitat use as high, medium, or low based on numbers of fish and the frequency of use, and to assess the level of certainty about use as confirmed, suspected, or unknown. The groups were not given definitions of these terms, but were able to categorize habitat use with these terms. In assessing habitat use, the relative size of the population or group of fish using the area was considered. Because different expert groups have assessed habitat use for each population using their own understanding of these terms, caution is warranted when making comparisons among watersheds.

The process used by the Recovery Team to identify important habitat for white sturgeon was identical to that used to identify critical habitat. The basin teams were asked to assign sturgeon habitats into one of three categories: critical, important, and other based on their ability to meet the burden of proof for delineating boundaries of potential critical habitat. The basin teams used available scientific information to define the boundaries of these habitats, but inevitably, this task involved some subjectivity. The elevational boundary of critical and important habitats was limited to the annual high water mark. All boundaries were demarcated on maps presented in Hatfield et al. (2009).

The Recovery Team sought consensus throughout the process of identifying important and critical habitats, and in almost all cases was able to reach consensus on recommendations. However, consensus was not reached on five locations for the Columbia population, specifically the spawning site adjacent to the Revelstoke Golf Course and related staging habitats downstream (Big Eddy and Salmon Rocks), and two rearing/feeding areas in the lower Kootenay River downstream of Brilliant Dam, the Brilliant Tailrace and Bridge Hole.

The Recovery Team considered the amount and type of habitat that would be required to achieve and maintain each population at the recovery target, an approach supported by existing guidance including Rosenfeld and Hatfield (2006) and recent DFO guidance documents (DFO 2007b), draft DFO policy). However, empirical data are insufficient to estimate a quantitative relationship between habitat and sturgeon population size. The Recovery Team also recognized that currently utilized habitat might not be adequate to achieve recovery targets in populations that have declined to low abundance.

Instead, areas of present high use were recommended *de facto* as a partial specification of critical habitat. To meet recovery targets, additional critical habitat will likely have to be identified in the future as research and recovery efforts proceed. Where detailed studies were lacking or inconclusive, the Team relied on expert opinion to identify important and critical habitat. This approach allowed definitions of potential critical habitat to be developed for less-well studied populations such as the Upper Fraser River and for early life stages in areas where reproduction continues to fail.

The Recovery Team and participants at the June 2009 PSARC meeting agreed that recovery efforts should focus primarily on improving natural recruitment in each of the dam-affected populations

Critical versus important habitat

Identifying critical habitat requires judgments about the extent to which habitat contributes to a species' survival or recovery. The Recovery Team also classified habitat as “important” in cases where existing knowledge was insufficient to meet a reasonable burden of proof in delineating boundaries for critical habitat, but where the Recovery Team suspected that a subset of the habitat might yet qualify as critical habitat given further study. The purpose of identifying important habitat is, first, to emphasize that the full recovery of white sturgeon will require management of a larger set of geographic locations than can be designated as critical habitat at this time, and second, to highlight the specific geographic locations that are most likely to require additional protection in the future.

Hatfield et al. (2009) provides a compilation of all geographic locations that are proposed as potential critical and important habitat and the attributes of these areas that make them critical to white sturgeon. Also provided is the time of year that different life stages use the habitat. In addition, activities that could impact critical habitat are tabulated in terms of their qualitative risk and level of uncertainty. Habitat risk factors include river regulation, instream activities such as gravel or sand dredging, linear developments, riparian, alterations or developments to instream or adjacent habitats, upstream land and water uses, and point and non-point source effluent discharges.

Sources of uncertainty

Although there remains some uncertainty regarding the precise timing and spatial location of critical habitat, the greatest threat to recovery are uncertainties about the cause of persistent recruitment failure and feasible means of restoration. Additional studies of the species' biology and movements will no doubt improve the delineation of critical habitat, but such studies should not supersede investigation of the reasons for recruitment failure and development of effective strategies for restoration. Causal agents of recruitment failure may be interactive and cumulative, and investigators should be careful to avoid selecting one over a suite of hypotheses in the absence of clear population relationships.

CONCLUSIONS AND ADVICE

Despite the foregoing emphasis on the need to determine the cause of recruitment failure and to find a feasible means for restoration, two knowledge gaps stand out with respect to critical habitat. The first gap concerns the ALR component of Columbia white sturgeon, because a decision about the feasibility of recovering this component of the Columbia River population either separately or within the larger population will influence the designation of critical habitat in this area. Current studies to examine the historic and contemporary genetic population structure of the Columbia River population, historic patterns of movement, and how thermal regime influences the development, survival and growth of white sturgeon, will help to evaluate the necessity and feasibility for recovery options for the ALR component. These and other studies should provide information about the possibility of unique characteristics and behaviour in sturgeon that are seen regularly at low density in the lower Kootenay River. The presence of unique characters within partially isolated components within the Columbia population could influence future decisions about critical habitat in this and other portions of the species' range.

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