4.0 Indicators

What are Indicators?

Environmental indicators are tools used to help citizens and decision-makers better understand the health of the environment and whether we are reaching our environmental goals. Indicators may be specific organisms, specific media such as water or sediment, or a specific sampling location or contaminant. The indicators used in this report are animal species living in the Columbia River Basin or dependent on food from the River. Studying these species over time will help scientists track changes in the Basin's ecosystem.

Which Indicator Species are Used in this Report?

For this report, the following indicator species were selected to help assess the health of the Basin ecosystem: juvenile salmon; resident fish, both native and introduced (e.g., sucker, bass, and mountain whitefish); sturgeon; predatory birds (osprey and bald eagle); aquatic mammals (mink and otter), and sediment-dwelling shellfish (Asian clam).

Why were These Species Selected as Indicators for the Columbia River Basin?

The indicator species listed above were chosen for this report because they have some or most of the following characteristics:

- The species has a clear connection with important aspects of the Basin's ecosystem.
- Information is available to describe contaminant status and/or trend information for the species.
- The species can be used to track progress on toxics reduction activities.
- The species represents an important functional level (e.g. predator, prey) of the Basin's food web.
- The species may be compared with the same species living in other aquatic ecosystems.

Juvenile salmon

There are five species of salmon in the Basin: Chinook, coho, sockeye, chum, and pink salmon. Salmon are *anadromous*, meaning their eggs are laid and hatch in freshwater, and their young spend part of their early lives in freshwater before swimming to the ocean to grow and mature (Figure 4.1). Upon returning to their native stream, the adults spawn and then die. Cutthroat trout and steelhead are closely related to salmon. These two species can exhibit both anadromous and resident fish behaviors and are capable of spawning. In the 1990s, the federal fish and wildlife agencies listed several of the anadromous salmon species as threatened and/or endangered.

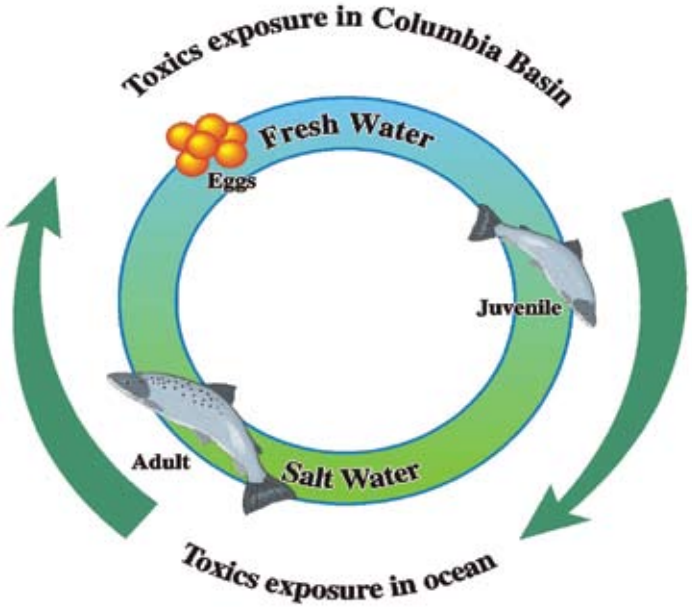

Figure 4.1: Salmon spend a significant part of their adult lives in the ocean. Therefore, it is primarily in their juvenile stages that they are exposed to contaminants in the Columbia River Basin.

Salmon as a Food Source

Because adult salmon spend the majority of their lives in the ocean, the percentage of contaminant accumulation in their tissue from sources in the Columbia River Basin cannot be determined. Regardless of the source, contaminants in adult salmon could pose a threat to people who consume large amounts of salmon, especially Columbia River Basin tribal people for whom the salmon is an important part of their culture and a major food source. In addition, some recreational anglers and their families may consume large amounts of salmon. Given this, it is important to ensure that both tribes and anglers have the most up-to-date information to make informed decisions on how much salmon can be safely consumed.

Pacific salmon die within days of digging their nests, or "redds," and mating. Their remains decompose, releasing nutrients for plants and other animals. Live and dead salmon are also important food for birds and mammals such as bald eagles, otters, and bears. In this way, salmon contribute to the health of freshwater ecosystems.

Juvenile salmon are an important indicator of ecosystem health in the Basin because: (1) they are relatively widespread throughout the Basin; (2) they both forage in the River system and serve as a major food source for larger fish, birds, and mammals; (3) they use many habitat types and therefore provide a means of assessing environmental conditions throughout the River system and estuary; (4) they go through physiological changes from juvenile to adult and therefore can be more susceptible to toxic contaminants; and (5) currently, 13 species of salmon and steelhead in the Basin are listed as either threatened or endangered under the Endangered Species Act.

The National Oceanic and Atmospheric Administration (NOAA) Fisheries and the University of California (UC) Davis are investigating how chemical contaminants affect juvenile salmon health and survival in the Lower Columbia River. In a recently published paper, they concluded that the adverse health effects of chemical contaminant exposure are similar to adverse health effects associated with passage through the hydropower system in the Columbia River. [1]

Resident fish

There are many native and nonnative resident fish species in the Basin, including rainbow trout, cutthroat trout, mountain whitefish, large scale sucker, bass, walleye, and northern pikeminnow. They are a common source of food for people and wildlife and are widely distributed throughout the Basin. Resident fish live their entire lives in the Basin and thus are exposed to contaminants present in the water and sediments through their food, by breathing in oxygenated water through their gills, and by continuous contact with the water and sediments. In many of the Basin's water bodies, these resident species have accumulated levels of some contaminants that are harmful to predators and to people.

Resident fish are useful indicators because: (1) they are widely distributed throughout the Basin; (2) most of the existing data on contaminants in the Basin are from resident fish species; (3) many species of resident fish spend their lives in relatively small areas, so their tissue concentrations are indicative of the contaminant loads in those areas; and (4) they occupy a central place in the food web, are exposed to contaminants through their diet, and in turn expose those who eat them, including people, to any accumulated contaminants.

VISIT THE WEB For more information about salmon in the Columbia River Basin, go to: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Draft-Plans.cfm.

Sturgeon

White sturgeon are the largest freshwater fish in North America, occurring in Pacific Coast rivers from central California to Alaska's Aleutian Islands. Some white sturgeon spend their entire life cycle in freshwater, while others use estuarine or coastal saltwater resources for growth and food, only entering freshwater to reproduce.

White Sturgeon (photo courtesy of Gretchen Kruse, Free Run Aquatic Research)

White sturgeon inhabit the Columbia River and its larger tributaries, such as the Snake and Kootenai Rivers. Sturgeon can live 100 years and grow up to 1,500 pounds and 15 feet long. Sturgeon are primarily bottom-dwelling fish. Juvenile sturgeon feed primarily on plankton and aquatic insects, whereas adults feed mainly on live or decaying fish, aquatic insects, and shellfish (e.g., Asian clams).

Sturgeon are not reproducing successfully throughout the Columbia River system. In Canada's portion of the River, there has been no successful reproduction recorded in the wild over the last decade. For similar reasons, the Kootenai River population of white sturgeon has been listed on the federal endangered species list since 1994.

White sturgeon are a good Columbia River indicator species for several reasons: (1) they are widely distributed in large rivers of the Basin; (2) they are long-lived and thus have prolonged exposure to toxic contaminants; (3) sturgeon migration is curtailed by dams in some portions of the Basin, allowing for evaluation of local toxics effects; (4) they are near the top of the food web; and (5) effects of contaminants on sturgeon are likely similar for other benthic, bottom-dwelling species.

Predatory birds—osprey and bald eagle in the Lower Columbia River

Osprey and bald eagle are large birds of prey that live in much of the Basin, but they are concentrated in the Lower Columbia River. While the bald eagle is found exclusively in North America, the osprey has a nearly world-wide distribution. Bald eagles feed primarily on live or scavenged fish and aquatic birds, while the osprey has a diet almost exclusively of live fish captured near the nest.

Osprey and bald eagles are useful indicators for evaluating the health of an aquatic ecosystem for several reasons: (1) they are widely distributed; (2) they are long-lived (bald eagles, for instance, can live up to 28 years in the wild); (3) they primarily prey on fish and other aquatic predators, usually near their nests; and (4) they are at the top of the food web and are therefore exposed to high concentrations of contaminants through their diet.

Osprey

Bald Eagle

(photos courtesy of NOAA/Dept. of Commerce)

Aquatic mammals—mink and river otter

Mink and river otter are members of the weasel family. They are excellent swimmers and are active predators that feed on fish, frogs, crayfish, and sometimes small mammals and waterfowl. The average lifespan of mink in the

Mink (photo courtesy of U.S. Forest Service)

North American River Otter (photo courtesy of USGS)

wild is three to six years, whereas river otter average over eight years. Both are found throughout the Basin in appropriate habitat; however, mink populations have not recovered from a decline in the 1950s and 1960s, even though suitable habitat is available for them in the Lower Columbia River.

Mink and otter are useful indicators of ecosystem health in the Basin because they: (1) prey on other aquatic species; (2) are particularly sensitive to contaminants which accumulate and can impact their reproduction; (3) have smaller home ranges compared to osprey and bald eagles; and (4) occur throughout the Basin.

Sediment-dwelling shellfish—Asian clam

First found in North America at Vancouver Island, British Columbia, in 1924, the nonnative, freshwater Asian clam is a small, light-colored bivalve now abundant throughout North America. It is widely distributed throughout a large portion of the Basin and has an average life span of three to five years. Located primarily in flat-bottom sand or clay areas, Asian clams feed by filtering particles from the surrounding water. They also routinely bury in the sediment for extended periods and filter sediment pore water.

Asian clams are a good indicator species for several reasons: (1) they are filter feeders and, like other freshwater shellfish, can collect and concentrate contaminants in their bodies; (2) they are not very mobile, so data on clams can be more useful to pinpoint the location where they were exposed to the contaminants than similar or more mobile species; (3) because of their distribution and feeding habits, they are a useful indicator of sediment and water quality conditions in the Basin; and (4) they occupy a lower position in the food web than other indicator species.

Lamprey

Pacific lamprey are scaleless, jawless fish that are culturally important to the Columbia River tribes. Lamprey have declined drastically in the past 20 years and are no longer found in many streams in their traditional range. Pacific lamprey spawn in freshwater streams. Juvenile lamprey (ammocoetes) spend their first five to seven years in the sediment as filter feeders. Adult lamprey migrate to the ocean, where they feed parasitically on other fish for up to three years before returning to freshwater streams to spawn.

Because lamprey spend their developing years in the Basin's streams, there are concerns that toxics may be a contributing factor in their declining numbers. Studies in locations outside the Columbia River Basin have documented the sensitivity of juvenile lamprey to toxics in their environment. [2,3] The unique life cycle of the lamprey with its potential for exposure to Basin contaminants distinguishes it as a potential indicator of ecosystem health. However, very little data have been collected on toxics in lamprey in the Columbia Basin. Because of this lack of data, lamprey are not discussed as an environmental indicator in this report. Given the cultural importance of lamprey to the Columbia River tribes, however, we will evaluate whether lamprey should be added as an indicator species after additional data on toxics in lamprey are collected and evaluated.