Recovering Chum Salmon in the Lower Columbia River Basin

By Kristen Homel

Chum Salmon (*Oncorhynchus keta*) were once abundant in the Columbia Basin but are now listed as threatened under the Endangered Species Act. This decline has had substantial ecological and economic impacts in the basin. In this article, I examine the causes for decline, how they relate to the life cycle of chum salmon, and collaborative efforts to recover populations.

Chum salmon are an iconic species in the Northwest, with their distinct purple and green spawning colors and the pronounced kype on the males. They grow to an average of 8-15 pounds, and up to 3.6 feet in length, making them the second largest species of salmon. Globally, chum salmon have the largest historical distribution of all the Pacific salmon, extending from the Sacramento River in California, north to Alaska, east to Russia, and south to the Korean peninsula. In the northern portion of their range — places like Washington, British Columbia, Alaska, Russia, and Japan — they are extremely abundant. As a result, they are an important component of commercial and subsistence fisheries, and also have substantial economic value. Chum were abundant in the Columbia Basin, too, until the 1940s, when the populations suddenly collapsed.

Unlike northern populations, chum salmon in the Columbia Basin predominantly exhibit a fall- run life cycle. Adults return to spawn at ages 3-5 and enter the lower Columbia River in October. They remain in the river until the first fall rains cue upstream migration. Spawning peaks around mid- to late November. Eggs incubate over the winter and fry outmigrate in early spring. After a short estuary residence of a few weeks to months, the smolts enter the ocean. Similar to pink salmon, the majority of the life cycle occurs in the ocean.

In the Columbia Basin, chum salmon historically spawned upstream to at least Celilo Falls at river kilometer (RKM) 309. This was a substantial waterfall before construction of The Dalles Dam was completed in 1957 and the falls were inundated. Other anecdotal data suggest chum salmon may have migrated upstream as far as Little Goose Dam on the Snake River, a migration of 638 RKM. Within this historical distribution, chum salmon would have spawned in most tributaries of all sizes and in portions of the Columbia River where large gravel and cobble beds existed. The spawning populations were quite large. In fact, in 1928, it is estimated that over a million chum salmon returned to the Columbia Basin. This estimate comes from commercial fishing records showing over 8 million pounds of chum salmon harvested that year.

Beginning in the 1930s and extending into the 1940s, chum salmon experienced precipitous declines in abundance and distribution. Causes for decline included loss of spawning habitat and access to habitat, altered hydrology, changes to the function of the estuary, predation, and over-harvest. By the 1950s, only hundreds or thousands of chum salmon returned each year. Of the 16 historical populations in the basin, 90% were extirpated (that is, lost). Remaining populations now primarily occur on the Washington side of the lower Columbia River, and returns on the Oregon side are so low that they are considered functionally extirpated. Moreover, the historical distribution up to Celilo Falls was reduced to isolated populations below Bonneville Dam. In response to these declines, chum salmon were listed as threatened under the Endangered Species Act in 1999.

Background

To understand how these populations

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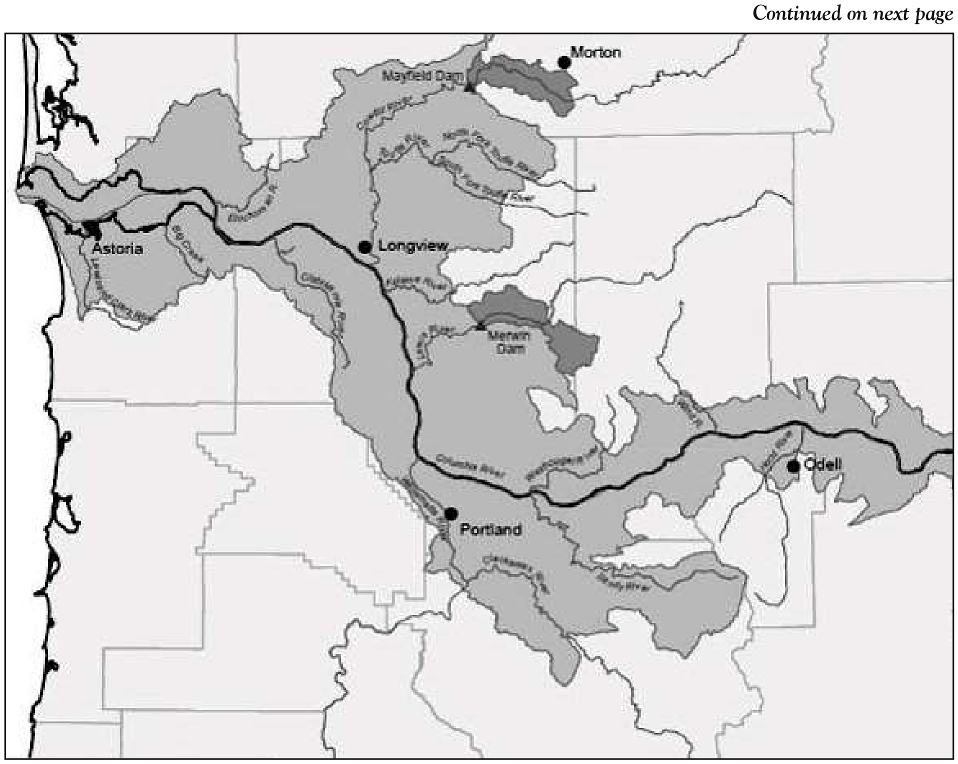

Chum salmon Evolutionarily Significant Unit in Oregon and Washington. Map by National Atmospheric and Oceanic Administration.

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initially collapsed, it is important to get a sense of the history of the Columbia Basin with respect to canneries and the early commercial fishing industry. The first canneries were constructed in the lower Columbia River in 1866, and represented a significant technological advance in the ability to preserve fish and supply it to the East Coast or abroad. Canned salmon was a cheap protein, and there was a huge demand for it. In "Salmon Fishers of the Columbia", Courtland Smith reports that by 1885, there were 40 canneries processing over 3 million pounds of fish per year. During this time, salmon returns to the Columbia basin (of all species) ranged from 10 to 16 million fish a year. Chinook salmon were the main target for the fisheries and were worth more per pound than chum salmon. However, by the late 1800s and early 1900s, Chinook salmon runs began to collapse from over-fishing. At this point, fishing pressure shifted to Chum Salmon. Numerous techniques were used, but purse seines, gill nets, and fish wheels were highly effective. In fact, according to the Northwest Power and Conservation Council, by 1889 there were 57 fish wheels and 156 salmon traps operating on the Columbia River. Harvest of chum salmon during this time period was substantial — estimated at over 70% of returns to the Columbia Basin.

As the overall abundance of chum salmon decreased, the deteriorated condition of spawning and estuary rearing habitats exacerbated declines. In particular, chum salmon spawn in the most downstream, low gradient, portions of tributaries. These are also the locations where sediment tends to accumulate when land use impacts result in increased erosion upstream. Because salmon deposit their eggs in the gravel, if sediment covers the gravel, it results in suffocation and increased mortality of the eggs. In systems with increased sediment, it takes a large number of spawners to flush out the sediment and expose the spawning gravels below. When populations decline, fewer adults return to spawn and they have a reduced ability to clean the gravel. In this way, an initial reduction in the abundance of spawners from one cause (here, the historical fisheries), results in perpetual depression of populations because the habitat is degraded. This combination of historical harvest and habitat degradation represents just one of the interactions between environmental factors that has resulted in a lack of recovery. Other specific relationships are being actively investigated.

The loss of chum salmon has had important ecological effects in the Columbia River. Of the 10 to 16 million salmon and steelhead that historically returned annually to the Columbia Basin, chum salmon may have comprised 7 to 10% of the return. At an average of 8-15 pounds each, those chum salmon returns represented a significant input of nutrients into the Columbia River basin. As mentioned above, the loss of chum salmon has negatively affected the quality of lower gradient spawning habitats, but not just for the survival of chum salmon eggs. Cleaner streams are more suitable for all species of salmon. In addition, chum salmon are a vital part of the food web in the stream, estuary, and ocean phases of the life cycle. For example, in streams, carcasses are consumed by mammals, such as bears and coyotes, and eggs may be consumed by other fish species, including sculpin and crayfish. In the estuary, chum salmon smolts contribute to the diet of coho salmon, cutthroat trout, gulls, double-crested cormorants, harbor seals, and more. And in the northeast Pacific Ocean, chum salmon adults are the second-most preferred food item of another iconic species — the resident killer whale, following their preferred diet of Chinook salmon. As John Muir wrote, "When we try to pick out anything by itself, we find it hitched to everything else in the Universe." This is true of the relationship between chum salmon and the food web of the Pacific Northwest and why chum salmon could be considered a keystone species.

There have also been substantial economic losses resulting from the decline of chum salmon. Globally, salmon harvest is a 2 to 3 billion dollar industry. In data aggregated for 2005-2007, the Wild Salmon Center reported that global chum salmon harvest for both roe and meat was valued at between 789 million and 1.073 billion dollars. In the United States, that value ranged from 119 to 269 million dollars. Although the economic value of harvest varies annually due to many factors, the value of chum salmon harvest is consistently a substantial portion of the global salmon market. Indeed, in 2017, chum salmon harvest in Alaska alone was valued at 128.3 million dollars, according to the Alaska Department of Fish and Game.

Kristen Homel with a chum salmon during broodstock collection.
Photo courtesy Oregon Department of Fish and Wildlife

Recovery in action

Given the importance of chum salmon, it is a major priority of the Oregon Department of Fish and Wildlife (ODFW) to rebuild populations on the Oregon side of the lower Columbia River. To this end, ODFW developed a four-pronged recovery approach, entailing (1) habitat restoration to promote natural recolonization, (2) development of a conservation brood-

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stock (3) supplementation and reintroduction, and (4) researching and addressing limiting factors. Ultimately, these steps are designed to re-establish self-sustaining, naturally reproducing chum populations.

Following the model established by Washington Department of Fish and Wildlife, habitat restoration has been broken up into long term and short term strategies. The long term strategy is to recover spawning and estuary rearing habitat. This will involve restoring the processes (for example, sediment transport and a natural hydrograph) that create habitat through large-scale integrated projects. By focusing on restoring the ability of streams to function naturally, we expect to see long term benefit from specific restoration efforts. For example, process-based restoration might involve replanting a significant riparian buffer around a large extent of a stream while also placing large wood in the stream to trap sediment. Ideally, large wood could be placed in the stream over time until the trees in the riparian zone were large enough to begin recruiting to (falling into) the stream and functioning as habitat.

The short term strategy has a very different objective — to create artificial spawning channels to increase population abundance as a buffer against catastrophic loss. These artificial spawning channels are constructed to contain a suitable composition of gravel and small cobble, and sufficient depth, flow, and temperature to maximize the survival of chum salmon eggs. Estimates of egg to fry survival in these channels may exceed 50%, making them a high production area with the potential to serve as a source for recolonizing adjacent, restored habitats. Ultimately, the goal is to construct several of these spawning channels throughout the recovery area. By including both short term strategies to increase abundance in each recovery population, and long term strategies to restore functioning habitat throughout the recovery populations, we hope to achieve improvement in freshwater survival rates, distribution of spawners, and overall abundance of chum salmon in the Columbia Basin.

With current abundance at such a low level, natural recolonization into restored (or soon-to-be restored habitats) is thought to be insufficient to re-establish functioning populations. The spatial extent where spawners could go is so large that there is a high probability that recolonizing spawners may not find each other. Therefore, the second part of the recovery strategy is to develop a conservation broodstock to serve as a source for supplementation and reintroduction efforts. To this end, ODFW has been operating a conservation broodstock program since 2010 at Big Creek Hatchery in Oregon. From 2010-2014, eggs were collected from the Grays River, a large, genetically similar population in Washington. Each year, wild-origin adults were collected from the Grays River basin and brought to the Grays River Hatchery to be spawned. Eggs were held on site at the hatchery until they had reach the eyed stage. At that point, approximately 100,000 eyed eggs were transferred to Big Creek Hatchery in Oregon where they were reared, marked with tags or other types of markings, and eventually released at the fed-fry stage, when the fry have absorbed their yolk sacs and eat on their own. Once adults began to return to Big Creek from these releases, we shifted to using those returns for our egg collection.

Beginning in 2013, adult returns to Big Creek Hatchery were sufficient to meet broodstock collection goals and also to conduct experimental supplementation and reintroduction efforts. Supplementation involves releasing chum salmon into a population where they exist at a very low abundance and have not been able to recover naturally; reintroduction occurs in streams where chum salmon were historically present but no longer occur. The experimental phase of reintroductions was designed to determine which streams might be targeted for reintroduction, which stages (fry, adults, etc.) should be released, when those releases should occur, and how release strategies related to survival rates in freshwater, estuary, and marine environments.

Experimental reintroductions of adults were conducted from 2010-2015 and release of eyed-eggs from remote site incubators (RSIs) occurred in 2014 and 2015. From adult reintroductions, we determined that egg to fry survival rates range from 0.38 – 27.4%. These survival rates vary among sites and among years at a single site. In contrast, eyed-egg to fry survival rates in RSIs consistently exceed 95%. Each type of reintroduction satisfies a different component of the recovery strategy. Eyed-egg release is a good technique for rapidly increasing abundance, whereas adult outplanting is useful for identifying the condition of the habitat and freshwater survival and also for identifying where habitat restoration may be needed

Along with this restoration and reintroduction work, we have also been researching limiting factors. Previous work has focused on identifying habitat availability and quality throughout the historical distribution for four populations. Another recent study focused on identifying fry migration patterns through the estuary as a first step in understanding which habitats they occupy and what potential threats they might encounter during the estuary phase of their life cycle (e.g., predators, lack of food, disease, etc.). Additional research is focused on understanding climate change impacts, particularly as they relate to the variation of behavioral (or life history) strategies expressed in the Columbia Basin.

Future

The Columbia River chum salmon story has a lot of moving parts. The path forward is certainly challenging. But we also have the opportunity to write a positive ending to the story, and it is not a story that will be written by scientists alone. Although research and recovery planning have identified the specific actions that need to be completed to achieve recovery, it is the community and stakeholder involvement that will allow salmon recovery to be successful. As Margaret Mead said, "Never doubt that a small group of thoughtful, committed, citizens can change the world. Indeed, it is the only thing that ever has." In the Columbia Basin, we have seen this in action. Multiple groups are working to implement restoration projects; volunteers assist with broodstock collection or research projects; and outreach events result in big turnouts of interested community members. This collective stewardship over salmon recovery is powerful and effective and absolutely critical to the success of these efforts.

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