

The decline of salmon adds to the struggle of Puget Sound's orcas


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The crew of the Bell M. Shimada hauled in the net, long as a football field and teeming with life. Scientists, off the coast of Washington for a week on this June research trip, crowded in for a look.

Each tow of the net revealed a changing world for Chinook [salmon](#), the Pacific Northwest's most famous fish—and the most important prey for the killer whales that frequent Puget Sound.

There were salmon the scientists expected, although fewer of them. But, weirdly, there were also pompano  [tropical fish](#) with pink highlights that were not supposed to be there.

What the scientists see each year on this survey, which began in 1998, has taken on new importance as oceans warm in the era of climate change.

Decadelong cycles of more and less productive ocean conditions for salmon and other sea life are breaking down. The cycles of change are quicker. Novel conditions in the Pacific are the new normal.

"It used to be up, or down. Now, it is sideways," said physiological ecologist Brian Beckman of the National Oceanic and Atmospheric Administration's Northwest Fisheries Science Center in Seattle.

That's bad news for endangered orcas that rely on salmon for food. When salmon decline, orcas suffer.

The search to understand why Puget Sound's orcas are in decline continues, as scientists investigate threats like inbreeding, disease pollution and vessel noise. But a key area of investigation is the primal necessity of regularly available, adequate quality food.

Across the Pacific Northwest, 40 percent of Chinook runs already are locally extinct, and a large proportion of the rest that remain are threatened or endangered. Meanwhile, most other marine mammals are surging in population, adding to the competition that the whales and fishermen face.

Now, even the water itself has turned hostile.

The southern-resident orcas evolved to take fish out of a vast area on the outer coast of North America, from California to British Columbia, and throughout the inland waters of the Salish Sea, connecting the U.S. and Canada. They even come all the way to Seattle's Elliott Bay.

The whales, which are top predators, can travel 75 miles a day, following the salmon they eat nearly exclusively, since the fish were always so big, so fat, and so plentiful.

But in the past 150 years all that has changed. Humans have altered everything from the climate and the ocean food web to the estuaries and freshwater rivers where salmon begin their perilous yearslong journey to sea and back.

Despite being listed as a threatened species 20 years ago, the prospects of Puget Sound Chinook remain unimproved.

How much Chinook do southern residents need?

Scientists in the Cetacean Research Program at Fisheries and Oceans Canada estimate that it takes the equivalent of at least 723 Chinook to feed the entire population of southern residents every day—but it could be as many as 868, depending on the age, body size and condition of the whales and the fish. A recovered population of killer whales would need perhaps as much as 75 percent more fish, said Rob Williams of Oceans Initiative, a Seattle-based science nonprofit.

Without more food, the whales will be extinct within 100 years, Williams and other colleagues said in a 2017 paper.

"Let's not kid ourselves," Williams said. "We have a long way to go."

Back aboard the Bell M. Shimada, nighttime for some of the scientists was prime time for towing a net alongside the ship to gather samples of zooplankton to assess the ocean's food supply for salmon.

The crews got up twice each night, the ship ablaze with lights, to capture tiny animals migrating upward in the water to feed on plankton—the great green pastures of the sea, each individual tiny green life feeding these animals that feed everything else.

Held to the light, a jar of seawater comes alive with a sampling of animals caught in the net. These are the tiny lives that feed the forage fish that baby salmon eat—and eat they must, to fatten and grow, before they get eaten by something else.

Most juvenile salmon that leave the freshwater river where they hatched don't survive to return as an adult to spawn, because they get eaten first by a predator. If a baby salmon doesn't get bigger than a bird's beak—and fast—it will never live to feed an orca.

Scientists want to see four times as many juvenile fish survive as they do in the sea. But ocean conditions hadn't been that good in decades. Then, they got even worse.

"When The Blob hit, everything changed," Beckman said.

The Blob, a gigantic mass of warmer-than-normal water off the Pacific Coast, began forming in late 2013. It depleted the ocean's food supply and killed an uncounted multitude of animals, including sea birds and marine mammals.

In June 2017, scientists caught so few juvenile Chinook they thought there might be holes in the net. Freakish numbers of species, such as pyrosomes, a firm, plastic-like tubular animal of subtropical seas,

covered the decks.

Those influences of The Blob are dissipating, said Brian Burke, a supervisory research fish biologist at NOAA's science center and chief scientist on the 2018 survey.

Still, in some places where juvenile Chinook in past years had been most abundant, very few were caught.

So powerful are the effects of ocean conditions, they can swing even abundant runs of salmon into significant downturns—or provide a bonanza of spectacular bounty. After decades of little change, more than a million Chinook came back to the Columbia River system from 2013 to 2015, capping 15 years of greatly improved returns. Yet as the full effects of The Blob developed, the runs crashed again.

Now forecasts for Chinook in 2019 all over the West Coast are even worse.

The southern-resident orcas eat only fish, mostly salmon. In winter, as much as half their diet is coho and chum, a little steelhead and some lingcod, skate or flatfish. What these predators need the most, however, is Chinook. As the ocean becomes even more unpredictable, what will it mean for salmon?

"What if the frequency of these events increases, even if they don't get worse?" Ritchie Graves, chief of the hydropower division for NOAA's Northwest Region, said of The Blob. "We lost 20 years of investment in improving the status of stocks. We are almost back down to where we were in the bad times of the late 1990s," years of record-low salmon returns.

And as Chinook heading back to the Columbia crash, salmon already

have been struggling in Puget Sound and its rivers.

The Nisqually River slid toward Puget Sound, whirling and sparkling when suddenly, a sleek brown head popped up.

The sea lion surfaced with a big chum salmon clamped in its jaws, shaking its head violently, sending chunks of the fish flying. It dived underwater to retrieve the pieces. Back up in minutes, the sea lion tipped its head back like a sword swallower and downed the rest of its meal.

Sea lions never used to come up the river, said Willie Frank III, a member of the Nisqually Tribal Council. Today, seals and sea lions travel more than 20 miles up the Nisqually after chum. These are not just any fish. These chum are unique among the latest winter salmon runs in the state.

They are the prime fish the southern-resident orcas are hunting when they come to Central Puget Sound in winter.

But this chum run has declined so much, tribal members barely get a fishing season anymore, said Frank, whose late father, Billy Frank Jr., was repeatedly arrested in the 1960s and '70s defending the tribe's fishing rights.

Frank sees a parallel in the tribal elders and the southern residents, both struggling to find enough fish.

"To see the little ones out there, and their moms, it breaks your heart," Frank said of the whales.

A population boom in marine mammals—other than southern-resident orcas—may be complicating the picture, as seals, sea lions and Alaskan and northern-resident killer whales beat the southern residents and

fishermen to the catch.

A paper published in 2017 by Brandon Chasco and other researchers showed that the resurgent population of marine mammals, because of the ban on hunting enacted in the federal Marine Mammal Protection Act in 1972, may have had unintended consequences.

Today, the Chinook catch by marine mammals on the West Coast is up 150 percent from 1975 to 2015, and down 41 percent by anglers.

Whether to cull marine mammals is under regionwide debate. But the whales salmon also confront much bigger problems.

The salmon decline began with non-Indian settlement of the Northwest around 1880. It's not been a unilateral slide. Some runs are in better shape today than during the heyday of unregulated logging, irrigation, mining and industrial discharges to Puget Sound and rivers throughout the Northwest.

But overfishing took its toll. So do hatcheries releasing hundreds of millions of fish that can compete with wild fish for food and habitat, and spread disease. Dams impede, and some even wholly block, the rivers in which salmon spawn. Bulkheads harden shorelines. Estuaries and tide flats have been filled. Rivers have been straightened and walled off with dikes and levees. Thousands of inadequate highway culverts block access to miles of spawning habitat. Water withdrawals for irrigation and other uses diminish river flows. A warming climate is raising summer water temperatures above safe levels for salmon in rivers.

Preliminary findings by 60 nonprofits, universities, tribes, state and federal agencies on both sides of the border in a marine survival study begun by Long Live the Kings and the Pacific Salmon Foundation are revealing devastating trends in the Salish Sea.

While coastal stocks of Chinook have cycled up and down with ocean conditions, Chinook, coho and steelhead in the Strait of Georgia and Puget Sound have declined by as much as tenfold since the 1980s and have remained depressed, the research project is finding. Many salmon die in Puget Sound, victims of everything from pollution to predators to habitat destruction and changes in the food web, long before they ever make it to the open sea.

From the orcas' perspective, their food supply cratered in just a few generations, compared with the historic numbers of fish, their availability across the seasons, and even their size.

Brad Hanson, a research wildlife biologist with NOAA's science center, said people forget about how much the baseline for salmon and orcas has shifted, and how fast.

"If you look at all the areas the whales take fish out of, it's a huge swath of North America, all the way to (British Columbia). These animals evolved to depend on all these different stocks," Hanson said. Today, scientists are concerned about what they call seasonal serial failures: when, from one season to the next, in one river after another, there is not enough food regularly available for the whales.

"If California is bad, and the Columbia is bad, and the Fraser is bad, that takes out six or eight months of the year," Hanson said. "You are not going to make it. You are potentially losing calves, or individuals, and that is what we are seeing."

British Columbian salmon stocks in general are at just 36 percent of runs in the 1800s, and Puget Sound stocks are also at far down from their historic abundance, Oceans Initiative's Williams and his co-authors reported in a 2011 PlosOne paper.

Farther south, the Columbia River was once the mightiest salmon river in the world, with 4.5 million Chinook a year returning. Now even in a good year, typically less than a million Chinook come back. California's Sacramento River salmon runs—once an abundant source of vital winter food—have collapsed.

There have been fishing reforms, but fishing still takes a toll on the orcas' food supply.

Commercial, sport and tribal fishing in all marine waters in the U.S. and Canada reduces the amount of adult 4- and 5-year-old Chinook returning to Puget Sound rivers by about 20 percent, according to a 2012 study by the Washington Department of Fish and Wildlife. Fraser River Chinook are depleted by about 15 percent.

Even some Chinook marketed as abundant, sustainable wild Alaskan salmon may have started their life as a hatchery fish in the Columbia or elsewhere in Washington. That is because most fish leaving Washington waters, especially the Columbia, head northward in their migration, where many are later caught in mixed-stock ocean fisheries. They are never seen in Washington again—except on a plate.

Targeted fishing closings may help the southern residents, a panel of scientists concluded in 2017. But their confidence was not high, because whatever one angler doesn't catch may be caught somewhere else or eaten by another predator. The researchers put more confidence in reducing vessel disturbance to make fish easier for the whales to locate and catch. How best to quickly get more food to the whales is still under debate.

Salmon abundance is more than a numbers game; it's also about the size of individual fish, and seasonal variety of Chinook available for the whales. Over time, that diversity has become greatly reduced.

Of 396 populations of Chinook that used to be available to southern residents all over the Northwest, 159 today are gone, leaving gaps in the calendar year in which the orcas' preferred prey is no longer available. Chum also are depleted, with 23 of 112 populations no longer there, according to a scientific paper published in 2007.

With so much diversity lost, recovering the whale population isn't just a matter of pumping up existing stocks, said Mike Ford, director of the conservation biology division at NOAA's science center in Seattle.

For example, in the Columbia over the past 20 years, fall Chinook runs have mostly been doing better than in the previous 60 or 70 years. Yet the whales continue to decline.

That's because the southern residents need salmon year-round, throughout their home range. And spring Chinook—the biggest, fattiest prize—throughout the Northwest are among the most depleted, including in the Columbia and its largest tributary, the Snake River.

Size matters, too. For Chinook, also called king salmon, big isn't what it used to be.

The giants that used to lumber up and down the Columbia and cruise the North Pacific from California to Western Alaska have shrunk, Jan Ohlberger of the University of Washington's School of Aquatic and Fishery Sciences, and other authors found in a 2018 paper published in the journal *Fish and Fisheries*.

The researchers documented a widespread trend in both wild and hatchery fish. All are smaller and younger today, researchers have found, examining 85 Chinook populations along the West Coast.

Coast-wide, the weight of 4-year-old Chinook on average dropped 20

percent from 1975 to 2005, Ohlberger found. Giant salmon such as the legendary June Hogs of the Columbia, weighing 80 pounds as recently as the 1920s, today exist only in historic photos.

A sampling of Chinook caught in Washington from 1970 to the present by purse seine and troll gear indicates puny average weights, ranging from around 10 to 15 pounds.

That's just a snack for a 6-ton killer whale.

It comes suddenly: sharp, and unmistakable. A foul, sour, sewer-gas stench. The smell of death.

"That is J50," said Deborah Giles, resident scientist at the University of Washington Friday Harbor Labs and the science and research director for the nonprofit Wild Orca.

It was Giles who last summer was among the first to alert NOAA scientists to the declining condition of the J-pod whale, just 3 years old. What Giles smelled that July day, while out on a research survey offshore of San Juan Island with the southern residents, was the foul breath of an animal in compromised health.

Over the course of the summer, researchers worried as J50 continued to decline, eventually developing a deformed, emaciated shape known as "peanut head."

By August, NOAA had developed an elaborate, unprecedented rescue plan. For the public, the plight of the young whale had new urgency after watching another southern resident, Tahlequah, swim for more than 1,000 miles carrying her dead calf, which had died shortly after birth. But before J50 could be helped, the whale sank forever out of sight. It was the third death among the southern residents last summer.

Why she died is still unknown, and why Tahlequah's mother, J17, now also is failing is a puzzle. Why are some members of the pods so extremely affected? Is it disease? Starvation is not seen throughout the population. But malnutrition is occurring.

Researchers began a health assessment of the southern residents using drone photography in 2008, tracking the orcas' body condition in spring and fall.

"There is this growing recognition they are in poor condition presently," said John Durban of NOAA's Southwest Fisheries Science Center in La Jolla, Calif.

Drone photos taken by Durban and Holly Fearnbach of the Seattle-based nonprofit SR3 are telling, when compared with the orcas' northern neighbors in British Columbia and the waters of southeast Alaska.

"The northern residents are not that far away and even feed on some of the same salmon runs, but they also have access to different fish," Durban said. "It is very different with the southern residents, to look at the shifting baseline. You have to remind yourself what robust looks like."

Transient killer whales that feed on seals are flourishing as well. "They are very, very robust, fat [killer whales](#)," Durban said.

And while both the transients and the northern residents have been steadily reproducing, the southern residents have a high rate of failed pregnancies. In 69 percent of pregnancies tracked from 2008 to 2014, no live calf was produced, according to a 2017 study led by Sam Wasser, director of the Center for Conservation Biology at the University of Washington. Wasser documented a connection between failed pregnancies and stress hormones in the whales' scat and periods of low

salmon abundance in the Columbia and Fraser rivers.

Starving whales also burn fat to survive, releasing toxics into their blood where they can do damage to the whales' immune system and reproductive capacity.

So hunger hurts. Even kills.

Giles, the researcher who detected J50's peril, led the field team of researchers on Wasser's multiyear survey of killer-whale scat.

On a trip last July, she followed the whales' fluke prints—large glassy patches on the surface created by the movement of the orcas' tails as they swim along—guided also by the acute nose of Dio, a blue-heeler mix at the bow.

Handled by trainer Collette Yee, Dio is one of the dogs, all of them rescues, in Wasser's Conservation Canines program, crack environmental detectives trained to track such things as invasive plants, polychlorinated biphenyls (PCBs) and grizzly-bear scat.

Before long, Dio found a particle that looked like a bloated, wet dog kibble.

Giles set the scat spinning in a vial in the shipboard centrifuge, for analysis back at the lab. This sample would tell researchers everything, from what the whales were eating, to the orcas' condition and, using DNA analysis, the species of fish.

"Within four days we see the impact if they are not getting enough nutrition," Giles said. "Any animal goes through feast and famine; that is normal. But their periods between feast and famine are bigger."

It used to be the whales showed up in the San Juan Islands in May, and they were around nearly every day, even in large gatherings known as superpods, with J, K, and L pods all present at once.

More typically today, as some of the salmon runs in the Fraser River the orcas feed on have declined, the southern residents arrive much later, and are split up and spread out, with only a few of the families together in any one location. They socialize and rest less, and travel more. Looking for food.

On a stretch of the Elwha River outside Port Angeles, great clouds of insects hummed over spawned-out salmon carcasses. A kingfisher clattered from a branch, and diving ducks flew upriver. Eagles cruised overhead, and a big juicy dragonfly hawked after bugs.

Fins cut the water: Chinook, battling upriver. Back home from their great journey to the sea.

A big male zipped across the channel, chasing off a rival. As the river sang over the clean, graveled bottom, other fish held steady in the current: females, guarding their redds, the telltale pale patches on the river bottom where they had turned over the stones with their tails, digging their nests.

While recovery is slow on the Elwha after the largest dam removal ever, all five species of Pacific salmon are recolonizing every reach of the river.

Salmon and orcas are tough survivors, weedy even, surging to reclaim most any place returned to them.

After a generation of the southern residents was trapped for aquariums, they battled back to a recent population peak of 98 in 1995. Their deaths

at times correlate with Chinook salmon declines. Today, only 75 southern residents survive.

But Chinook come back. Replacing highway culverts, ripping out dikes to restore estuaries, improving flows in streams—restoration work is going on all over Washington.

Dam removal is on the table. Washington Gov. Jay Inslee is seeking funding from the state Legislature to study the effects of breaching the four Lower Snake River Dams.

It will take a wide variety of strategies all over the state to rebuild salmon runs. Some of the region's efforts already have been historic.

Beginning in 2011, people did the once unthinkable, and in a grand experiment took out both dams on the Elwha. That opened 70 miles of unspoiled habitat to salmon for the first time in a century. There were doubters of the \$350 million investment in the salmon, but the fish are proving them wrong.

Last summer, about 7,500 Chinook returned to the Elwha, the most in more than a generation.

Mel Elofson, Lower Elwha Klallam Tribal member and assistant habitat manager for the tribal fisheries department, picked up an eagle feather from the ground as he watched the fish go upriver last August. With the return of the salmon have come the animals, with tribal members seeing more eagles along the river than anyone could remember.

Elofson recently saw a bear eating salmon on the bank of the Elwha. "It was great to see that bear feeding in broad daylight," Elofson said.

The eagles and the bears aren't the only ones to notice the big kings are

back.

In August, researcher Ken Balcomb, founding director of the Center for Whale Research, got a call to come document dark dorsals cutting the water offshore of the mouth of the Elwha.

Twin monarchs of the Northwest, Puget Sound's orcas and king salmon, were back in their home waters.

At the river's mouth, J pod was hunting.

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