Alaska Longline
FISHERMEN'S ASSOCIATION

ALASKA TROLLERS ASSOCIATION

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Executive Summary

The following report prepared by the **Alaska Longline Fishermen's Association** (ALFA) and **the Alaska Trollers Association** (ATA) addresses factors that affect the Southern Resident orca and responds to the campaign waged by the Wild Fish Conservancy, a Washington State organization, to link orca decline to the Southeast Alaska troll fishery. This report is based on extensive review of the research, data, and published literature.

Pollution, industrial toxins, urbanization, habitat loss and human-caused disturbance are the primary factors limiting the recovery of the Southern Resident orcas. Any one factor – acoustic disturbances from vessel traffic, the orca observing industry, chemical contaminants, or habitat harms specific to Chinook, chum and coho salmon – may in itself be a significant cause of nutritional stress, higher death rates or failed pregnancies. In short, Southern Resident orcas are threatened primarily because of their prolonged residence each year in Puget Sound and inland Southern British Columbia waters, all areas that are heavily used and contaminated by a growing human population.

ALFA and ATA are Southeast Alaska-based commercial fishing organizations that represent community-based, small commercial fishing businesses. Their members support science-based fisheries management and work to safeguard the health of the marine and freshwater environments that support salmon and other marine life. ALFA markets wild, sustainably caught Alaska seafood under the Alaskans Own label throughout Alaska and the U.S. to fund its Seafood Donation Program and Fishery Conservation Network. Alaskans Own is a leader in the sustainable seafood movement and has helped address food insecurity issues throughout Alaska and the Northwest, delivering more than 640,000 donated Alaska seafood meals in 2020-2021.

Chinook salmon produced by Southeast Alaska's troll fishery are the culinary world's salmon of choice, prized for their color, high oil content, firm texture, and succulent flesh. Trollers fish with hook and line gear on the open ocean and target individual adult salmon when they are "bright," or at their peak quality. Careful individual handling helps maintain this quality. No fish is treated with more care from the time it leaves the water until it arrives on a plate.

Troll fishery harvests are managed under the Pacific Salmon Treaty using annual catch limits based on the aggregate abundance of mixed, multiple Chinook stocks that feed in the Gulf of Alaska. Treaty harvest regimes are abundance-based and designed to be sustainable. Each year fishery managers develop annual abundance indices that respond to changes in stock productivity to meet biologically based escapement goals and exploitation rate objectives. Fishery managers have been successful at keeping catches below pre-season catch limits, consistent with Treaty obligations. Each year there is a post-season analysis of the fisheries and re-evaluation of harvest objectives. The Alaska troll fishery is one of the most carefully monitored fisheries in the world, with in season reporting and extensive dockside sampling. This management system ensures compliance with major seafood sustainability standards that require the harvest of sustainable fish stocks, minimal environmental impact on the marine ecosystem biodiversity, and an effective management system capable of responding quickly to environmental changes.

The Wild Fish Conservancy seeks to eliminate Southeast Alaska's troll fishery - a fleet of small fishing vessels operated by independent fishing families. Although there are many conservation groups concerned about orcas, the Wild Fish Conservancy acted alone to sue NMFS two years ago as part of its effort to eliminate the troll fishery. The court narrowly ruled NMFS needed to revise an incomplete plan to increase hatchery Chinook production that would provide additional prey for Southern Resident orcas.

The Wild Fish Conservancy is now misusing the court's decision in its campaign by targeting retailers, restaurants and seafood sustainability certifiers with misleading media materials that falsely fault a small and distant salmon fishery

for the decline of the Southern Resident orca population. Their theory is that Southeast Alaska troll fishery catches of Chinook salmon are the primary cause of downward population trends for the Southern Resident orcas. This theory ignores a massive body of literature detailing the role of habitat degradation and human pressure on orca population viability. The theory also ignores decades of harvest and stock composition data establishing that the troll fishery's impact on coastwide Chinook abundance is small and more importantly, its impact on stocks of importance to the Southern Resident orcas is low.

Southern Resident orcas move through the Salish Sea (Puget Sound and southern British Columbia inland marine waters) and outer Washington coast during May through October in pursuit of Chinook, coho, and chum salmon. After October they move to the outer coasts of Washington and southern Vancouver Island and forage for Chinook and groundfish such as ling cod, dover sole and halibut. By March and April, they frequent areas near the mouth of the Columbia River, which is the peak return time for Columbia River Spring Chinook.

There is a massive body of research investigating the decline of the Southern Resident orca. The causes are simple but multiple, with current research focused on habitat loss, vessel traffic and contaminants. Salmon abundance has varied considerably over the past 40 years, and it is either a non-factor or the least significant factor affecting long-term trends for Southern Resident orca population.

Vessel traffic impacts to Southern Resident orcas

The Salish Sea has become one of the busiest areas of marine traffic in the world, generating unprecedented levels of noise pollution. Vessels collide with orcas or draw them into propellers and are a significant and frequent cause of injury or death. The traffic increases have degraded habitat used by the orca for foraging, socializing and reproduction and are likely a major limiting factor for the population. The noise pollution is chronic in key foraging areas and makes it difficult for orcas to find and capture prey. Major increases in noise pollution occurred concurrently with ongoing and past periods of population decline. There are also clear correlations between the increasing intensity of orca observation and Southern Resident population declines. The number of commercial orca observing vessels alone that concentrate around foraging orcas has more than quintupled since the 1980s and disrupts orca foraging success. Researchers have identified each one of these factors – collisions, noise pollution and orca observers – as a potential primary cause of the population decline.

Contaminant cocktail impacts to Southern Resident orcas and Pacific Northwest salmon

Southern Resident orcas are among the world's most contaminated marine mammals. One of the main threats to Southern Resident orca survival - and salmon population recovery - is the high toxic contaminant burden borne by both species which forage in urban and industrial areas. Contaminated forage fish cycle toxic chemicals throughout the food web which bioaccumulate in salmon and orcas. Commonly consumed contaminant cocktails consist of PCBs (polychlorinated byphenyls), PBDEs (polybrominated diphenyl ethers), DDT (dichlorodiphenyltrichloroethane, an insecticide) and PAHs (polycyclic aromatic hydrocarbons - chemicals found in stormwater run-off from roadways). These contaminants – even if banned years ago - persist at high levels today in the Salish Sea marine environment.

Female orcas transfer contaminants to calves during pregnancy and while nursing. Exposure at this young age makes calves and juvenile orcas susceptible to severe consequences: disrupted growth and development, impaired future foraging capacity and lower chances of reproductive success. The contaminants increase the number of failed pregnancies and the post-birth calf mortality rates. All the major chemicals compromise orca immune systems and shorten life expectancies by increasing susceptibility to the infectious diseases that are large sources of marine mammal mortality. Southern Resident orcas mature differently, are less fertile, and produce fewer healthy surviving calves than Northern and Alaska Resident orcas – populations that avoid the Salish Sea and have much lower contaminant

concentrations. The contaminants have the same effects on salmon, particularly salmon species that spend the most time in the Salish Sea, particularly Chinook.

Marine mammal predation on salmon exceeds fishery impacts

Southern Resident orcas are the only orca population that preys on Chinook in the northeastern Pacific that is declining. Northern and Alaska Resident population levels have at least doubled since 1980. The Northern Resident population grew from 120 individual orcas in 1975 to over 300 orcas today, potentially consuming nearly a million more Chinook salmon each year than they did fifty years ago. Overall, the three resident populations *consume between 1.6 and 2.3 million Chinook each year, exceeding harvest in all marine, terminal, and freshwater fisheries.*

Degradation of Salish Sea habitat for Southern Resident orcas rather than salmon abundance is the main factor that distinguishes their population trends from those of their near northerly neighbors. Also, between 1970 and 2015, Chinook consumption by harbor seals and California and Steller sea lions increased over ninety percent and is another source that may limit the number of Chinook available to Southern Resident orcas during years of lower abundance. Pinnipeds eat twice as much Chinook salmon as the orcas and 6 times as much as harvested in commercial and recreational fisheries.

Southern Resident orcas may be sick or unable to forage in a degraded Salish Sea, but they are not starving for lack of Chinook salmon

Numerous studies of orca diet composition and other available evidence contradict the theory that occasional downward fluctuations in Chinook abundance causes the orcas to starve or suffer nutritional stress. There are healthy orcas within the Southern Resident population, and cases of nutritional stress in all northeastern Pacific orca populations that have access to abundant prey. Factors other than a lack of food, such as individual health issues or external disturbances from noise and vessels may be causing nutritional stress for some orcas. Some of them may simply be too sick to eat. The most common causes of death for recovered orcas are not starvation but rather disease, vessel strikes and accidental stranding. If the orcas are not eating enough Chinook during their Salish Sea summer the problem is more likely factors that limit accessibility to Chinook rather than Chinook abundance. Injuries caused by or interactions with vessels and chronic noise pollution impairs the ability to catch or consume prey - and disproportionately impacts pregnant or lactating females.

Fishery interactions with Chinook stocks important to Southern Resident orcas

While numerous habitat conditions have deteriorated for both Southern Resident orcas and their prey, Chinook, coho and chum salmon, ocean fisheries have borne substantial cuts to harvests of healthy Chinook stocks for decades to enable higher escapements of infrequently caught weaker stocks. Despite the cuts, there has been no meaningful improvement in Southern Resident orca population productivity, likely because of the failure to address other much more significant impacts. The Pacific Salmon Treaty has reduced Alaska troll fishery catch by over 30 percent since 1985; over the same time period the Southern Resident orca population fluctuated up and down but overall *grew* by two percent. The cuts to ocean fishery harvests *increased* Chinook terminal run sizes (numbers of fish returning to areas near their natal rivers) in the Salish Sea by over a third since the 1990s. Multiple analyses conclude that additional cuts to already low ocean fishery exploitation rates would be unlikely to help recover the Southern Resident orca population.

To the extent that a focus on fisheries would be meaningful to the orcas, that focus would need to be on fisheries that exclusively harvest stocks that occur in the orcas range off the Washington Coast in winter and inland Salish Sea in summer. In general, ocean fisheries have negligible impacts on these stocks. Alaska's troll fishery harvests stocks that may migrate for six to eight hundred miles from harvest locations in Alaska before reaching the Washington

coast or mouth of the Columbia River and nearly a thousand miles before reaching the Bonneville Dam. Any Chinook not harvested by the distant troll fishery still have to evade capture by other fisheries and marine mammals for hundreds of miles to provide any benefit to Southern Resident orca.

The largest proportion of Chinook harvested in the Alaska troll fishery are non-Puget Sound stocks migrating to or through the Washington or British Columbia coasts during summer when the Southern Resident orcas frequent the Salish Sea. Most Puget Sound Chinook spend their entire life in the Salish Sea and Coastal British Columbia, where 85 to 90 percent of the summer and fall run harvest occurs. Canadian and southern U.S. sport and commercial Chinook harvests vastly exceed the annual Alaska troll fishery catch of 400 to 700 Puget Sound Chinook. Canadian and Puget Sound harvest overlaps extensively with Southern Resident orca priority stocks. Most of the Canadian sport harvest – 154,000 Chinook – occurs off the West Coast of Vancouver Island and in the Salish Sea, where Puget Sound Chinook comprise between ten and seventeen percent of the catch. The 2021 Salish Sea Chinook harvest in Washington State was roughly 122,000 Chinook, including an estimated 48,000 Chinook in the sport fishery – two-thirds of them in Puget Sound.

During the winter, Southern Resident orcas target a broader range of Chinook stocks but Columbia Spring runs are the most important, comprising over half of the Chinook consumed by Southern Resident orca in winter and spring. These runs vary in abundance but overall returns are much higher than they were during the 1980s and 1990s. *Because most of the Columbia Spring runs have a non-coastal ocean distribution, marine fishery impacts on these stocks are negligible*. The biggest harvest impact on these stocks is sport fishing downstream from the Bonneville dam; however dams are the main limiting factor overall for Columbia Basin stocks. Immediate increases in spill levels at Snake and Columbia River dams and the removal of lower Snake River dams are essential for the recovery of Spring Chinook and therefore the orcas as well.

Columbia and Snake River summer and fall populations harvested in the Alaska troll fishery migrate past the Washington coast during the summer when the orcas are in the Salish Sea. These stocks have been resilient during the 21st century, with total annual runs exceeding a million Chinook. Long-term annual escapement rates have improved dramatically, vastly exceeding escapement goals. Five of the highest Snake River returns of the 21st century occurred over the past decade. Summer Chinook run sizes over the past decade are three to four times as high as during the 1980s and 1990s. The most abundant stock, Columbia River Brights, contributes to numerous fisheries. These healthy stocks are the far-north migrating stocks from the Columbia River that benefit from feeding in the Gulf of Alaska where they may be harvested in the Alaska troll fishery.

Southeast Alaska harvests of Columbia River salmon may range between 30,000 and 50,000 fish in any given year and are a small proportion of the harvest compared to other fisheries. Columbia River net and sport fisheries alone harvested nearly 220,000 Columbia River Chinook in 2021 – more than the troll fishery's total mixed stock harvest. Angler effort on the mainstem Columbia increased rapidly over the last thirty years. Typically, Columbia River sport harvests exceeded 100,000 Chinook over the past decade – with most of harvest coming from the thriving Columbia River Bright stocks.

Puget Salmon habitat

NMFS approved continued implementation of the Puget Sound fisheries in a 2021 BiOp, further raising questions about why the Wild Fish Conservancy would target a distant fishery that harvests a small fraction of the total harvest of Puget Sound Chinook. The 2021 BiOp, multiple scientific analyses, and government reports all point to other factors that harm Salish Sea salmon targeted by the orcas – in particular, deteriorating habitat conditions. The increasing human population undermines both Chinook and Southern Resident orca population recovery. Fishery managers recognize that continued destruction and degradation of habitat, not fisheries, is the primary problem limiting the viability of Puget Sound Chinook. Indeed, more Puget Sound Chinook - 2,500 - died in one event in the Nooksack River's

South Fork in 2021 than Southeast Alaska trollers harvest in three or four years. These events recur across many Puget Sound rivers and returning Chinook, coho, and chum salmon that are primary prey for the orcas.

Washington state's population tripled to over seven million people between 1950 and 2018 and over two-thirds of the still growing population live in 12 counties adjacent to Puget Sound. The length of time salmon spend rearing in freshwater or nearshore Salish Sea marine habitats significantly influences regional salmon stock productivity patterns. Habitat quality at early life stages is critical to salmon survival, and the lengthy freshwater rearing stage and delayed ocean entry are a disadvantage for wild Puget Sound salmon. Dams are prevalent throughout Puget Sound watersheds, blocking access to habitat in many of the largest rivers and degrading downstream spawning and rearing habitat. Barrier culverts block access to thousands of miles of spawning habitat and prevent juvenile salmon from migrating within a watershed to rearing or overwintering habitat or moving to find food or refuge from adverse environmental conditions.

Logging and timber road construction has had significant impacts on upstream habitats – particularly the loss of riparian forests that maintain water quality and regulate stream temperatures and flows. Downstream agricultural and urban development removed riparian vegetation and trees, leaving unshaded watersheds with higher stream temperatures. Urban and highway runoff, wastewater treatment, failing septic systems and agriculture or livestock impacts further degrade water quality. Various developments, water diversions and high contaminant concentrations and other intensive uses degraded or destroyed Puget Sound estuaries where juvenile Chinook salmon rear extensively and continue to threaten these highly productive but vulnerable ecosystems. The degradation or loss of these habitats reduces salmon survival rates and drastically diminishes salmon returns. In sum, at-risk Chinook populations will continue to decline until the condition of Puget Sound watershed improves.

Conclusion

The Alaska troll fishery is sustainably managed under the Pacific Salmon Treaty based on the abundance of far-north migrating Chinook salmon that spend most of their lives feeding in the Gulf of Alaska. None of the Puget Sound Chinook populations are far north migrating, making impacts from Southeast Alaska marine fisheries extremely low. While Canadian fisheries off of Vancouver Island and the Strait of Juan de Fuca and Washington and Oregon fisheries in or near Puget Sound and the Columbia River take far more Chinook than the Southeast troll fishery, the primary threats to Southern Resident orca are associated with human-caused pollution and disturbance.

Increases in pollution of various types from vessels, vehicles, industrialization and urbanization, residential, agricultural, and timber management sources are the primary factors limiting the recovery of the Southern Resident orcas. Any one factor – acoustic disturbances from vessel traffic, the orca observing industry, chemical contaminants, or habitat harms specific to naturally spawning Chinook, chum and coho salmon – may be a cause of significant nutritional stress, higher death rates or failed pregnancies, but more than likely a combination of these factors are driving Southern Resident orca population trends.

The Wild Fish Conservancy's theory that commercial fishing alone, particularly fishing occurring hundreds of miles away in Alaska, is causing orca mortality and impeding growth is not supported by the numerous recent scientific analyses that track salmon abundance and Southern Resident orca diet composition and/or evaluate actual primary causes of population decline. Cuts to ocean fisheries have been the primary means of improving Chinook escapements over the past three decades. The significant sacrifices of harvest opportunities on the most abundant stocks by ocean fishermen have increased the numbers of Chinook available to the orcas but the orca population has not recovered. As other habitat harms have continued and worsened, so too has the plight of Southern Resident orcas.

Southern Resident orca face significant and worsening threats to their survival from population pressure in the Puget Sound area. The Southeast Alaska troll fleet is of little consequence to the survival of this species. **Seafood consumers, retailers and restaurants should feel confident that the Alaska troll fishery is not depleting the prey of Southern Resident orcas nor contributing to their ongoing decline.**

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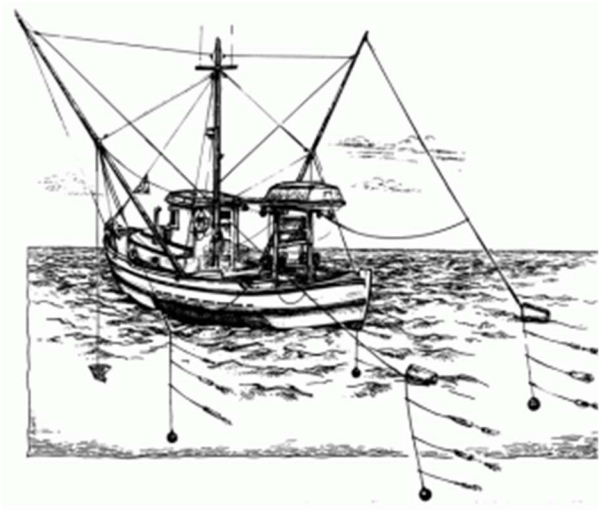
1. Introduction

The troll fishery is a small boat fishery and one of the most important fisheries in Southeast Alaska, a region with more full-time fishery workers than any region in Alaska other than the Bering Sea.[1] In any given year, seven of the top

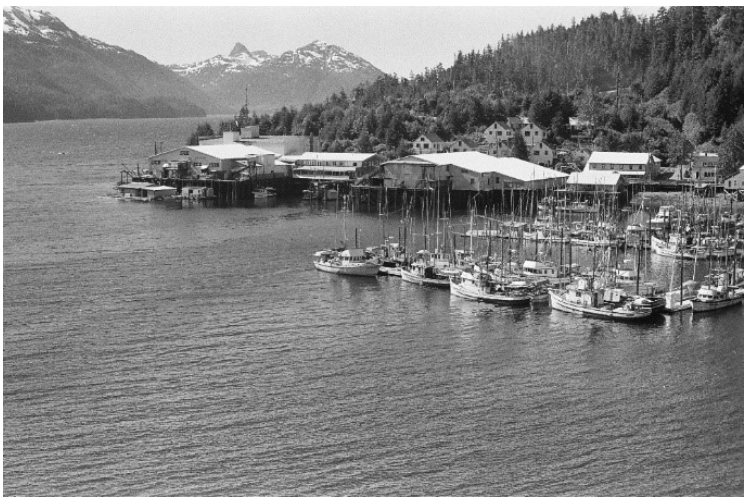
100 fishing ports by value in the entire country are likely to be Southeast Alaskan ports.[2] The top competitive strength is the high quality of Southeast Alaska seafood products, which include most of the Alaska harvest of high value Chinook salmon by the troll fleet.[3] Troll-caught Chinook are by far the highest valued salmon species harvested in Southeast Alaska and typically comprise 44 percent of troll harvest value.[4] In general troll fleet Chinook harvests averaged 199,000 fish per year over the past decade.[5]



Trolling is a unique, environmentally responsible fishery in large part because it is a low volume fishery in which fishers selectively target individual adult salmon with hook and line fishing gear. Fishing lines with lures are drawn through the water behind a moving boat. Fishers catch, clean and ice or freeze each fish.

Because of the special care and prompt processing, Southeast Alaska troll-caught Chinook are some of the highest quality seafood products in the world, harvested by fishers who are committed to quality, traceability and sustainability. Fishers respect the resource and adhere to science-based fisheries management. The low impact fishing gear is deployed from a fleet of individually owned and operated small fishing boats.

Southeast Alaska's troll fishery has the highest level of local ownership of any major Alaska fishery, making its survival critical to nearly all of Southeast Alaska's 33 communities. 85 percent of the fleet is local to Southeast Alaska.[6] Between 900 and 1,100 trollers actively fish each year and Alaska residents earn roughly eighty percent of the fleet's annual ex-vessel value, which typically ranges from $29 million to $52 million.[7]



The scenic Southeast Alaska fishing port of Pelican Alaska is one of many communities that depend on the troll fishery.

Many of the more remote communities, such as Edna Bay, Meyers Chuck, Point Baker, Port Protection, Port Alexander and Pelican, are historical fishing villages that rely almost exclusively on the troll fishery. Alaska Native villages such as Hoonah and Yakutat also depend on fishing and processing salmon caught in the troll fishery. The region's three largest communities – Juneau, Ketchikan and Sitka, and mid-sized communities of Haines, Petersburg and Wrangell – also rely on the troll fishery because of the large number of resident fishermen and contribution of the troll fishery to regional processing capacity and local economies.

Southeast Alaska resident harvests, as well as harvests by non-resident fishermen who function as locals during the extended troll season, significantly benefit local economies through higher local expenditures on fuel, groceries, vessel repair and maintenance sectors and gear suppliers, generating induced economic effects that include more indirect employment and wage income circulating in the economy.[8] Studies show that the value of high quality seafood such as salmon multiplies by a factor of four as harvested fish transit the economy from a hook to plates served to consumers in the Pacific Northwest and throughout the country.[9] A typical troll fishery value of $37 million per year generates $148 million annually in economic outputs when adding in restaurant sales, consumer

purchases, transportation jobs and other benefits accruing throughout the west coast of the U.S. and beyond.[10] The troll fleet is diverse, including hand trollers (who use hand-powered gurdies or fishing rods), power trollers who use hydraulic powered gurdies and sell iced fish to shore based processing plants and tenders, and 50 catcher-processors (freezer trollers which harvest fish and freeze them while at sea).[11]

Southeast Alaska's troll fleet is a diverse, small boat fishery.
Photo credit: F/V Patience.

1.1 The Pacific Salmon Treaty

Southeast Alaska troll fisheries are part of a larger, international Chinook fishery regime managed pursuant to the Pacific Salmon Treaty ("Treaty"), which assigns conservation obligations and harvest sharing for Chinook stocks that migrate through U.S. and Canadian waters[12] There are roughly thirty-four distinctly managed marine net, troll and sport and freshwater sport and net fisheries that harvest substantial numbers of Chinook off the coast of British Columbia, in Georgia Strait, the Strait of Juan de Fuca (both Canada and the U.S.), in south and north Puget Sound, the Washington coast, and in Oregon and Idaho.[13] In general, Canadian ocean fisheries in northern British Columbia and off of the West Coast of Vancouver Island catch twice as many Chinook as Alaska ocean fisheries.[14]

Annex IV to the Treaty governs Treaty Chinook fisheries management with the objective of providing healthy, productive Chinook populations that support sustainable fisheries, other social, economic and cultural benefits and ecosystem benefits for multiple species.[15] The U.S. and Canada share a comprehensive, coordinated program that uses science-based management to allow for sustainable, targeted harvests of natural and hatchery produced Chinook stocks based on abundance.[16] Scientific teams evaluate and report annually on harvests, exploitation rates, escapement objectives and productivity trends for all stocks.[17] They develop abundance indices each year, including the index used to set the Alaska fishery pre-season catch limit each year.[18]

Treaty management measures sustain or recover and protect different Chinook stocks and respond to changing environmental conditions identified through monitoring of stock abundances and changes in distribution or marine survival rates.[19] Many Chinook stocks managed pursuant to the Treaty are healthy and show long-term positive productivity trends.[20] The Treaty recognizes and provides for stocks that have conservation concerns caused by the long-term cumulative effects of chronic habitat degradation.[21] Fishery managers work to preserve Chinook biodiversity and conserve, protect and rebuild those stocks.[22]

NMFS is responsible for analyzing the impacts of ocean fisheries on at-risk species. After listing a number of Chinook populations under the Endangered Species Act during the 1990s, NMFS prepared a Biological Opinion, or "BiOp" focused on four Chinook populations (Evolutionarily Significant Units, or ESUs) most frequently harvested in the ocean fisheries managed under the Pacific Salmon Treaty.[23] The first BiOp concluded that the fisheries would not jeopardize the listed Chinook species.[24] In 2008 the agency prepared another BiOp evaluating changes to the fisheries under the proposed 2009 Treaty agreement.[25] The 2008 BiOp also considered effects to the Southern Resident orcas and concluded that the fisheries would not jeopardize the orcas or harm their critical habitat. [26] The 2009 Treaty agreement cut Southeast Alaska and some Canadian Chinook fisheries by 15 and 30 percent, respectively.[27] The most recent 2019 Treaty reduced Southeast Alaska's catch by another 7.5 percent and the West Coast of Vancouver Island fishery by another 12.5 percent.[28]

1.2 The Wild Fish Conservancy's lawsuit

NMFS prepared a new analysis of the Southeast Alaska salmon fisheries following adoption of the 2019-2028 Pacific Salmon Treaty Agreement and an associated conservation program. One component of that program would increase hatchery Chinook production, and thus Southern Resident orca prey availability, by four to five percent in their seasonal foraging areas.[29] The new BiOp evaluated the fisheries and a conservation program intended to benefit Puget Sound Chinook and Southern Resident orcas.[30] The BiOp concluded that Alaska salmon fisheries as managed under the Pacific Salmon Treaty would neither harm the orcas nor several at-risk Chinook stocks.[31]

A Washington State non-profit corporation, the Wild Fish Conservancy, sued NMFS, alleging that the analysis in the BiOp violated U.S. environmental laws. The Wild Fish Conservancy argued that NMFS failed to fully describe how it would fund and implement the conservation program and further that NMFS needed to analyze the impacts of additional hatchery releases on at-risk Chinook populations.[32] The court agreed, and ruled that NMFS would need to develop a more specific conservation plan with clear deadlines and prepare additional analysis under the National Environmental Policy Act (NEPA). [33]

The court held a hearing in October 2022 after briefing by all parties on the appropriate remedy for the case and has not yet issued a final decision regarding whether or not to vacate the BiOp. NMFS has requested that the court remand the BiOp and Incidental Take Statement to the agency to undertake further analysis without vacating any portion of those documents.[34] The court's ruling did not change NMFS' conclusions regarding the low impacts of the Southeast Alaska troll fishery. The agency's most recent filings in the case recognize that troll fishery impacts on Chinook stocks of importance to the Southern Resident orcas are small and will not jeopardize their survival or recovery.[35] Indeed, NMFS successfully implemented the prey increase program as anticipated in the BiOp, releasing more than 19 million juvenile Chinook in 2022.[36] NMFS staff in charge of orca recovery and Chinook enhancement have explained the vacating the BiOp will be harmful rather than beneficial to the orcas in large part because of the successful salmon enhancement program.[37]

1.3 Southern Resident orca population trends and range

There are ten orca populations in the northeastern Pacific Ocean: four resident populations, five transients and one offshore population.[38] These populations neither interact nor interbreed with one another.[39] They also have very different and specialized fisheries - residents are piscivorous (fish eaters); transients eat harbor seals and other marine mammals and offshore orcas mostly eat sharks.[40] Resident populations have known home ranges but travel considerable distances at times. [41] Southern Resident orcas are the southernmost of the northeastern Pacific piscivorous populations.[42]

The largest known Southern Resident population size was 96 orcas in 1967.[43] Between 1962 and 1974, demand from aquariums and marine parks incentivized the formation of orca capture companies in the Pacific Northwest that

took 68 orcas – mostly Southern Residents.[44] The population dropped to its lowest level, 67 orcas, by 1971.[45] The population then fluctuated.[46] Growth occurred at normal rates during the late 1980s and peaked at 98 orcas in 1995 before a 20 percent decline from 1996-2001.[47] The decline led to the listing of the species as endangered in both Canada and the U.S.[48] The causes of that decline are uncertain; most scientists attribute it to combination of factors, including the small size of the population, contaminants, vessel traffic disturbances and reduced access to prey.[49] By 2010 the population rebounded to 86 orcas.[50] Another decline then occurred after 2010 when the population dropped to 74 by 2018, the lowest level since the late 1980s.[51]

The U.S. and Canada designated critical habitat for Southern Resident orcas throughout the "Salish Sea" which contains the Strait of Juan de Fuca, Puget Sound and Georgia Strait. [52] Southern Resident orcas move through the Salish Sea and outer Washington coast seasonally in pursuit of prey and particularly to areas where salmon congregate in the late stages of making final migration to natal rivers.[53] Most of the Chinook they eat originate from the Columbia River and rivers flowing into the Salish Sea.[54] In the early spring, they commonly forage for Columbia and upper Fraser River spring run Chinook in western Juan de Fuca Strait and off the coasts of southern Vancouver Island and northern Washington state.[55] They spend most of May through October in the Straits of Georgia and Juan de Fuca, and Puget Sound.[56] By June, they occur mostly in the southern Salish Sea, targeting summer and fall Chinook runs migrating to rivers that flow into the Salish Sea.[57] They typically concentrate in specific areas, particularly the San Juan Islands.[58] In recent years they are spending more time at the western portion of their summer range near the southern end of Vancouver Island.[59] Beginning in September the Southern Resident orcas move throughout Puget Sound when returning coho and chum runs salmon comprise an increasing proportion of their diet - up to half their food.[60]

Winter distribution and diet differs from summer.[61] The proportion of Chinook salmon in their diet decreases in fall and winter.[62] Southern Resident orcas mostly eat chum when in Puget Sound between October and December but there is little available diet data for other areas.[63] After October the orcas leave the Salish Sea and move to the outer coasts of Washington, Oregon and southern Vancouver Island, sometimes moving as far south as central California.[64] During this time they eat groundfish such as ling cod, dover sole and halibut but considerable uncertainty remains regarding their winter diet because of insufficient data.[65] The mouth of the Columbia River and Westport are favorite fishing spots in March and April during the peak return time for Columbia River spring Chinook.[66]

Different salmon stocks may be more important in some years than others and the importance of specific stocks to Southern Resident orca diet changes over time.[67] The overall coast-wide Chinook abundance is more important than smaller aggregations or specific stocks.[68] In recent years, the Southern Resident orcas are spending less time in the Salish Sea, and consuming a more diverse range of Chinook stocks in other areas. [69]

1.4 Current threats to the Southern Resident Orca: pollution, people, traffic, marine mammals and Chinook habitat loss

The Southern Resident orca is one of the most intensively studied marine mammals, and the most studied resident orca population in the world.[70] Numerous studies identify multiple and interacting causes of downward population fluctuations including high contaminant concentrations increase disturbances from vessel traffic, noise pollution, and commercial and recreational whale watchers, the small population size, and the effects of traffic, noise pollution, and orca observers on orcas seeking to capture salmon.[71] Current research focuses on habitat loss, vessel traffic and contaminants.[72] Researchers have found it challenging to assess which threats are most significant.[73] Researcher M. Scott Taylor of the University of Calgary explains that:

> …no research has been able to quantify the impact of any one (or combination) of channels given the extreme difficulty of observing and then measuring potential causal effects on population that ranges over thousands of square miles of habitat and is, for the majority of the time, below the surface. Despite

literally tens of millions of dollars of research, the debate over what to do with or for, the Southern Resident is going nowhere fast.[74]

Salmon abundance has varied considerably since 1980 and does not explain the long-term decline in the Southern Resident orca population.[75] Southern Resident and Northern resident orca populations grew at similar rates of nearly three percent from 1974-1987. [76] During the mid-1990s, Northern Resident and Southern Resident orca populations declined by seven and eighteen percent, respectively, coinciding with low Chinook abundance throughout the Pacific coast.[77] But the Southern Resident population continued to shrink even with extended, positive periods of higher Chinook abundance after 2000. [78] Meanwhile, the Northern Resident orca population again increased after 2000, casting considerable doubt on the theory that Chinook abundance is a sole or even primary driver of the Southern Resident orca population decline.[79]

Numerous factors have degraded Southern Resident orca foraging habitat in the Salish Sea and the various habitats used by Chinook salmon for spawning, foraging and rearing.[80] Since 1970 there has been a dramatic increase in human population, development and industrialization.[81] These changes have impacted the Southern Resident orcas in various ways that have reduced their population productivity while the Northern Resident orcas have thrived by avoiding the Salish Sea.

The Salish Sea has become one of the busiest areas of marine traffic in the world.[82] The traffic generated unprecedented levels of acoustic disturbances for the Southern Resident orcas.[83] Noise pollution is prevalent, intense and long lasting and interferes with both orca communication and foraging which rely on the production of sounds and ability to detect echoes.[84] The noise pollution likely has a significant impact on population productivity and may have been a significant factor in the population decline during the mid-1990s by reducing foraging efficiency, particularly for pregnant females during the summer. [85] The commercial orca observing fleet in the Salish Sea increased from 20 boats in the 1980s to 100 by 2017.[86] Other vessels normally used for other charter or recreational purposes also concentrate around the orcas in key foraging areas.[87] Orca observers have likely caused significant disturbance to orca foraging, reducing the accessibility of Chinook salmon.

Industrial and urban development of Puget Sound and southern British Columbia exposed Southern Resident orcas to multiple contaminants that enter the marine environment through various pathways, notably PCBs (polychlorinated byphenyls used as lubricants in electrical transformers), PBDEs (polybrominated diphenyl ethers used as flame retardants) and DDT (dichlorodiphenyltrichloroethane once used in agriculture as an insecticide).[88] These contaminants persist at high levels today in the Salish Sea marine environment and enter the aquatic food web and bioaccumulate up the food chain, becoming very concentrated in long-lived apex predators such as the orcas.[89] As a result, Southern resident orcas are among the world's most contaminated marine mammals, particularly with high concentrations of PCBs, DDTs, PBDEs that routinely exceed toxicity thresholds for marine mammals.[90]

Population growth and industrial development have degraded spawning and rearing habitat for the orcas preferred prey, salmon, throughout Puget Sound and southern British Columbia. [91] Various land uses – whether for urbanization, logging, farming or other developments, have significantly degraded habitat conditions throughout regional watersheds, wetlands and estuaries.[92] Impacts include reduced watershed connectivity, quality, complexity and function, loss of riparian areas, disturbances to stream substrates, impaired fish passage conditions and losses of genetic diversity. [93] Developments near floodplains and shorelines converted salmon habitat to residential and industrial areas and added contaminants to aquatic ecosystems through run-off from roads.[94] Dams and flood control infrastructure have cut off significant portions of the rivers that once provided habitat for Chinook and other salmon; new projects may continue to increase these impacts.[95] There is a smaller amount of functioning nearshore and estuarine habitat for salmon rearing and migration after decades of dredging and filling estuarine areas, altering marine shorelines, causing a loss of habitat features critical for salmon, particularly juveniles. [96] These impacts have reduced ecosystem resilience, increasing salmon susceptibility to habitat disturbances such as floods, landslides and droughts.[97]

The habitat loss continues to reduce carrying capacity for spawning salmon in Puget Sound rivers, causing ongoing declines in Chinook abundance.[98] While there have been efforts to improve habitat, regulate whale watchers and other measures, the increasing human population undermines both Chinook and Southern Resident orca population recovery.[99] The Southern Resident orca population continues to fluctuate at lower levels even though cuts to ocean fisheries such as those imposed through the Pacific Salmon Treaty process have increased the abundance of Chinook returning to terminal areas (near their freshwater streams) by over a third.[100] The inability to improve conditions for the Southern Resident orcas through changes to ocean fishery management is why fishery managers from both Canada and the U.S. emphasize actions to reduce disturbances to the orcas rather than broad scale coast-wide reductions in fisheries.[101]

Non-anthropogenic factors also affect the distribution and accessibility of Chinook. Marine mammal predation on Chinook, particularly by pinnipeds in the Salish Sea and Columbia River, vastly exceeds commercial fishery harvests. The Northern Resident population grew from 120 orcas in individuals in 1975 to over 300 orcas today and is still steadily growing, potentially consuming nearly a million more Chinook salmon each year than they did fifty years ago. [102] Over the same time period the harbor seal population increased 700 percent in Georgia Strait and Puget Sound, accompanied by significant growth in the coastal sea lion population. [103] Pinnipeds consume twice as many Chinook salmon as orcas and six times as many as harvested by all coastwide and freshwater fisheries. [104]

2. Salish Sea Traffic and Toxins

2.1 Salish Sea Vessel Traffic impacts to orcas: noise pollution and orca watching

Vessel traffic is likely to increase in the Salish Sea which is already one of the busiest seaways in the Pacific.[105] Existing high levels of vessel traffic degrade Southern Resident orca habitat through their presence, activity and chronic noise pollution.[106] The role of rising vessel traffic impacts on the decline of the Southern Resident orca is now a primary hypothesis explaining the failure of the Southern Resident orca population to recover.[107] It is likely that the traffic has had significantly influenced recent declines by increasing collision risks by reducing or eliminating foraging success through noise pollution and other disturbances.[108]

The west side of San Juan Island in Haro Strait is the orca's most important summer foraging habitat.[109] Today, nineteen large ships transit adjacent to or in orca critical habitat in Haro Strait near San Juan Island each day, or nearly one large ship nearly every hour all year.[110] The globalization of the economy significantly increased the volume and variety of vessels transiting the Salish Sea to or from ports outside North America beginning in the late 1990s.[111] Most of the vessels driving the increase are container ships which generate the loudest sounds.[112] Between 1998 and 2019 the number of large vessel trips increased by 46 percent, for a total of 175,000 more trips.[113] Vessels travel 1.8 million miles in orca critical habitat each year, an increase of half a million miles a year compared to the late 20th century.[114] The massive underwater noise generated by these traffic increases is chronic and has degraded habitat used for foraging, socializing and reproduction, and is likely a major limiting factor for the population.[115]

The orcas are also a "principal target species" for a rapidly growing marine mammal watching industry.[116] San Juan Island is one of the most popular recreational boating and orca watching destinations in the U.S. and Canada.[117] Orcas react to obstruction or disturbances from vessels by swimming faster and further, changing travel direction or diving differently.[118] These impacts, along with acoustic disturbances, affect communication, reduce foraging time by at least several hours a day and increase energy expenditures.[119] The impacts of noise pollution are so large that some researchers believe it would require unprecedented abundances of salmon to offset the energetic costs incurred by orcas.

2.1.1 Noise Pollution impacts

The first study to fully examine the relationship between acoustic disturbances to the Southern Resident orcas identified noise pollution as a likely factor in the 20 percent population decline between 1996 and 2001.[120] Ongoing research emphasizes the impacts of underwater noise pollution because it impairs foraging and communication.[121] Significant and long lasting vessel noise spreads through propeller cavitation and engines.[122] Large commercial vessels, ferries, tugboats and container ships and smaller recreational vessels emit noises throughout the Salish Sea via propeller cavitation and engines.[123] Additional sources of underwater noise include military sonar, seismic surveys and marine construction.[124] Both high and low frequencies are impactful.[125] Widely used low frequency depth sounders and sonars also interfere with the orcas' ability to navigate and capture prey.[126] High frequencies generated by large ship propellers are unavoidable due the overlap between Southern Resident orca foraging areas and shipping lanes.[127]

Hearing is critical for orcas because sound travels much farther underwater than light.[128] The noise pollution occurs at the same frequencies used by orcas for both communication and echolocation.[129] Echolocation is the act of producing sound and using the resulting echo to perceive surroundings and is the primary means used by orcas for navigation and to locate salmon or other prey.[130] Orcas also rely on quieter acoustic habitat to communicate through calls, clicks and whistles.[131] Noise pollution impairs echolocation and can temporarily or permanently damage hearing sensitivity.[132]

Smaller whale watching vessels (<65') and recreational vessels also produce intermittent noise that makes it more difficult for orcas to find and capture fish.[133] They spend less time foraging in the presence of these vessels, reducing amount of prey captured.[134] Other recreational vessels also are increasing noise pollution levels.[135] This noise is difficult to mitigate because high speeds increase the intensity of the noise but slower speeds keep the noise around for longer periods of time.[136]

There are numerous documented responsive behavioral changes such as altering swimming paths, diving rates and surface activity, increasing travel time and increasing calling amplitude.[137] The additional energy expenditures and lost foraging opportunities are most troubling in years when Salish Sea Chinook salmon stocks are at lower abundances and/or during spring and summer months when pregnancies begin.[138] The increased traffic likely has a significant impact on population productivity, lower birth rates and increasing mortality rates.[139]

2.1.2 Orca observing in critical habitat

The number of tour boats focused on observing the Southern Resident orcas increased rapidly during the mid-1990s.[140] The number of hours per day and number of days per year also increased.[141] By 2001, orca observers were operating from April through October: six months per year, and 12 hours per day.[142] The substantial increase in commercial orca watching vessels correlates with the rapid population decline during the late 1990s.[143] Because of this correlation, some researchers have identified a need to reduce the fleet to pre 1990s levels.[144]

By 2015, the orca watching fleet had quintupled in size relative to the 1980s, to nearly 100 vessels accompanied by another approximately 150 multi-purpose charter vessels.[145] There has also been a massive increase in the numbers of kayakers in these areas.[146] Other recreational and research vessels, cruise ships, fishing vessels and freight ships pass by throughout the day, causing a cumulative effect.[147]

An average of 15 to 22 vessels and sometimes over fifty vessels concentrate within a half mile of the orcas during the day in their most important foraging habitat.[148] Violations of regulations and guidelines are chronic – over four incidents per hour.[149] Vessels approach within 200 yards or park in the orca's pathways.[150] Private boaters in particular are frequent violators.[151] The number of incidents or violations, particularly intrusions of foraging areas or impediments to movements, rose from 398 in 1998 to 2,621 in 2012.[152] Efforts to reduce impacts have occurred but the disturbances continue.[153]

Orca observers impact the orca's ability to capture prey.[154] Multiple studies show feeding disruptions when vessels are around and other energy costs associated with vessel avoidance.[155] The orcas spend more time swimming than resting, increasing energy expenditures by thirteen percent.[156] Noise pollution alone produced by orca observing vessels can reduce the accessibility to salmon by as much as 80 percent, adding to the impacts of noise from other traffic off San Juan Island.[157] Even the presence of kayakers can reduce foraging time by 20 percent, reducing prey intake and increasing energy expenditures.[158]

The concentration of orca observing vessels and their noise may be displacing the Southern Resident orcas.[159] The obstruction of accessibility to prey and energy expenditure costs may be affecting population growth and increasing mortality.[160] *There is a clear correlation between the intensity of orca observation and changes in Southern Resident population size, leading researchers focused on impacts from orca observers to suspect that disturbances from these vessels, particularly their impacts on prey accessibility, may be the most important factor in the population's decline*.[161]

2.1.3 Vessel collisions

Vessel strikes are likely one of the multiple mechanisms contributing to the population decline - collisions occur occasionally, causing injury or death.[162] The extent of vessel strikes is unknown as very few deceased killer whales are found and necropsied.[163] Any Southern Resident orca killed by a vessel strike is a significant loss because of the small population size.[164] A 2020 analysis of vessel strikes explained that:

> Historically, vessel strike has not been considered an important anthropogenic cause of morbidity or mortality in killer whales; however, based on findings from this pathology review and other observations of vessel strike, this risk factor may be an underappreciated but important threat to the population status of endangered killer whales in the eastern Pacific.[165]

Vessel strikes are a particular threat for Southern Resident orcas because of the their proximity to population centers and shipping lanes.[166] The amount of vessel traffic in the Salish Sea increases the risk of vessel strikes or orcas being drawn into ship propellers.[167] Recent studies of stranded orcas throughout the northeastern Pacific are identifying vessel strikes as a significant and frequently occurring cause of death.[168] Between 1995 and 2005 in British Columbia there were five non-fatal and two fatal strikes.[169] Two of the non-fatal strikes caused serious injury and one of the injured orcas died a year later.[170] A recent study of stranded orcas throughout the northeastern Pacific identified six suffering traumatic injuries likely caused by vessel strikes, including two Southern Resident orcas.[171] Recreational vessels speeding toward or away from the orcas also increase risks of vessel strikes.[172]

Because of the various risks – reduced accessibility to salmon, collisions, disturbances and increased energetic costs, researchers are identifying a need to minimize the impacts of vessel traffic.[173] It is the one threat to Southern Resident orcas that further regulation can mitigate expeditiously.[174] Regulators could reduce the number of orca observing vessels, increase spatial and temporal closures, and, as recommended by Washington State's Southern Resident Orca Task Force, prohibit orca viewing for three to five years.[175] For larger vessels there may be a need to alter shipping lanes further away from critical habitat, more carefully control vessel traffic to avoid long periods of overlap, change ship designs and reduce speeds below thirteen knots.[176] Indeed, there were observations of increased orca foraging following efforts in British Columbia during the summer of 2019 to slow down vessel traffic.[177]

2.1.4 Oil Spill risks

Washington State is a shipping and refining hub and major oil spills occur at times.[178] The Southern Resident orca population is highly vulnerable to a major oil spill because their primary foraging areas overlap with international shipping lanes that have the highest oil spill risks in the Salish Sea.[179] Although improved prevention measures have reduced the number of spills, large oil spill risks remain.[180] Additional growth in container ship traffic as well as tanker

traffic from increased oil and natural gas production in interior North America and coastal British Columbia are likely to increase major oil spill risks. [181]

Marine mammals can handle some pollution from oil spills but intense or persistent exposure is severely toxic.[182] Orcas do not avoid oil spills and can intake oil or vapors at the surface or while feeding.[183] The Exxon Valdez spill caused an unprecedented loss of up to 20 orcas suspected to have inhaled too many petroleum vapors. [184] As with other pollutants, oil spills also can be destructive to prey populations. [185] A major oil spill in key Southern Resident orca foraging areas could cover between roughly one to three-fourths their critical habitat and a catastrophic spill of two to four million gallons would be fatal to between nine and 36 orcas.[186]

2.2 Salish Sea toxic pollution

One of the main threats to Southern Resident orca survival - and salmon population recovery - is the high toxic contaminant burden borne by both species.[187] Southern Resident orcas forage in some of the most urbanized and industrialized areas on the Pacific west coast, including Puget Sound, a toxic contaminant "hot spot."[188] Contaminated forage fish cycle toxic chemicals throughout the food web which bioaccumulate in salmon and orcas.[189] Orcas and multiple salmon species, particulary wild Chinook, species constantly consume contaminant cocktails comprised of PCBs, PBDEs, DDT, PAHs (polycyclic aromatic hydrocarbons found in stormwater run-off from roadways) and other pesticides, herbicides, trace metals, and contaminants of emerging concern. [190]

The contaminants enter the marine environment through the atmosphere, run-off, spills and direct discharge.[191] PCBs are entering the marine environment more than forty years after being banned in the U.S. and levels have remained high in orcas since the 1990s.[192] In parts of Puget Sound PCB levels in the food web are as high as they were twenty years ago.[193] DDT continues to enter the marine environment through terrestrial run off and persists in aquatic sediments throughout the Columbia River Basin and central California even though banned over forty years ago.[194] Many consumer products contain PBDEs: furniture, mattresses, hard plastics such as television casings and computers, gym mats and car seats.[195] They concentrate in residential dust and end up in Puget Sound through wastewater discharge.[196] Although the use of PBDEs stopped in North America in 2005, the chemical is so prevalent in homes and offices that it will continue to enter the marine food web at potentially increasing levels for years.[197]

PCBs and PBDEs are the top two contaminants detected in sediments throughout the Salish Sea.[198] The highest concentrations are near large urban areas, harbors, municipal wastewater treatment plants, landfills and industrial areas such as ship building and repair facilities, pulp and paper mills and paper recycling plants.[199] PCBs and PBDEs commonly occur in the orcas' designated critical habitat at levels that exceed regulatory thresholds for marine mammals.[200]

The most significant source of Southern Resident orca exposure to contaminants is their prey.[201] The orcas frequently feed on fall run Chinook and coho from rivers originating in Puget Sound and other industrialized portions of the Salish Sea.[202] These particular runs spend extended time rearing in a marine environment where they accumulate high concentrations of PCBs and PBDEs via contaminated forage fish such as herring and sand lance.[203] Maturing Chinook from Puget Sound have 3 to 5 times higher PCB levels than Chinook from other portions of the Pacific Coast.[204]

As stated above, Southern resident orcas are among the world's most contaminated marine mammals with concentrations of PCBs, DDTs and PBDEs routinely exceeding toxicity thresholds for marine mammals.[205] They have some of the highest PCB concentrations of any marine mammal on the planet, and higher PBDE concentrations than all northeastern Pacific orca populations and worldwide whale populations. [206] Both contaminants bioaccumulate, meaning their concentration in orcas increases over time as they continually consume toxic prey. [207]

The contaminants accumulate in orca's fatty tissues – *i.e.* their blubber.[208] Female orcas transfer contaminants to calves during pregnancy.[209] Calves then absorb even more contaminants during nursing when the contaminants break down and end up in milk. [210] As a result, there are lower contaminant concentrations found in lactating mothers, but higher concentrations in calves.[211] Concentrations in calves can be four to ten times as high than their mothers,

particularly the first-born calf.[212] Juveniles have higher PBDE concentrations than adults which can exceed tolerable effects thresholds for marine mammals by 200 to 350 percent. [213] In general males also have higher concentrations than females.[214] For all orcas, nutritional stress caused, for example, by noise pollution and orca observer vessels, worsens the effects because when orcas draw on blubber reserves for energy, there is a release of stored contaminants into the full body, impairing immune systems. [215]

The exposure to high contaminant concentrations at critical developmental stages and limited capacity to eliminate them makes calves and juvenile orcas particularly vulnerable.[216] Calves assimilate contaminants during early development stages when the effects to hormones such as endocrine disruption can have severe consequences by disrupting growth and development.[217] Impaired development can include cognitive development and memory, potentially affecting future foraging capacity.[218] Impacts can include delayed sexual maturity and reduced chances of future reproductive success.[219] Contaminants also may increase the likelihood of mortality prior to or shortly after birth.[220] During the 2015 "baby boom" of nine documented births in 13 months, only five calves survived.[221]

The contaminant concentrations cause chronic health effects.[222] Exposure to multiple contaminants is synergistic, multiplying the health risks.[223] PCBs can cause cancer and skeletal abnormalities.[224] PCBs and DDTs cause reproductive impairment. [225] All three chemicals interfere with the immune system and hormones – whether through endocrine disruption or thyroid effects.[226] Sublethal and lethal effects include premature or delayed physical or sexual maturity, reduced fertility, failed pregnancies and calf mortality. [227] Their compromised immune systems shorten their life expectancy by increasing susceptibility to infectious diseases that are large sources of chronic illnesses, or mortality in marine mammals, causing as many as a third of marine mammal deaths.[228]

Southern Resident orcas mature differently, are less fertile and produce fewer healthy surviving calves than Northern and Alaska Resident orcas.[229] Scientists have not identified a clear cause for the disparity. [230] However, both Northern and Alaska Resident orcas have lower concentrations of contaminants that affect reproductive success. [231] Male Southern Resident orcas have PCB concentrations four times as high as male Northern Resident orcas.[232] Current concentrations create twice the risk of population decline for Southern Resident compared to unexposed populations.[233] PCB exposures alone can be a factor in a population collapse even independently of other factors such as impacts of noise pollution and vessels on prey accessibility. [234] Some researchers project that only orca populations in less contaminated waters in Antarctica and the Arctic are likely to sustain growth, while others foraging in contaminated waters are at high risk of population collapse.[235]

These same contaminants - and other pollutants - are also major contributors to Chinook population declines.[236] Some Chinook are residents that spend their entire marine life in the Salish Sea instead of feeding offshore.[237] Contaminant exposure reduces growth and survival rates and increases susceptibility to disease.[238] A third of juvenile Chinook sampled from urbanized estuaries in Puget Sound and migrating near urban areas in the Columbia River Basin have PCB concentrations above adverse-effects thresholds. [239] These juvenile salmon are nearly twice as likely to die as salmon from uncontaminated estuaries. [240] High PBDE concentrations associated with urban river systems similarly increase juvenile Chinook susceptibility to disease and alter growth and development. [241]

Urban stormwater runoff is another major source of pollution that degrades water quality with toxic effects to fish that range from reproductive impairment to death.[242] Polycyclic aromatic hydrocarbons (PAHs) come from petroleum products that enter the aquatic environment directly though oil spills or indirectly from stormwater runoff.[243] PAHs are not as harmful to orcas as PBDEs, DDTs and PCBs but are toxic to Chinook salmon, slowing growth and increasing susceptibility to disease. [244] Juvenile Chinook ingest PAHs primarily through consumption of forage fish such as herring in urban estuaries in Puget Sound and Columbia River. [245]

Researchers have been studying "urban runoff mortality syndrome" for two decades because of severe impacts to coho salmon.[246] Coho returning to urban watersheds in the Pacific Northwest frequently die within four hours of exposure to stormwater run-off.[247] Mortality rates range from half to over 90 percent of an entire run.[248] The

susceptibility is even higher during storm events with cumulative mortality rates of 92 percent to 100 percent.[249] These high rates of pre-spawning mortality occur throughout Puget Sound. [250]

Road run-off contaminants cause the die-offs, which usually occur during the fall following rain events in urban areas with high road densities.[251] While vehicles also leak other contaminants, chemical concentrations from tire wear particles (TWPs) are the most prevalent. [252] Nearly all motor vehicle tires contain a chemical called 6PPD (N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine) that protects them against degradation and cracking.[253] As treads deteriorate over time, small rubber particles interact with oxidants, converting 6PPD to 6PPD-quinone which is the primary cause of urban runoff mortality phenomenon. [254] 6PPD-quinone concentrations, even at short-term exposures, are chronically lethal to adult and juvenile coho and also kill Chinook at lower rates, with unknown sublethal effects.[255]

There are many factors causing coho populations to decline, including loss and degradation of physical spawning and rearing habitat.[256] The high mortality rates are a significant immediate and long-term threat, particularly in lowland areas like the Puget Sound and Columbia River basins where road density and motor vehicle traffic density are highest.[257] Because of the high mortality rates in watersheds with heavily trafficked roadways, chemical habitat degradation may extinguish wild local coho populations within decades.[258] Chinook are also vulnerable to urban runoff mortality syndrome. [259] While cohos are the most susceptible salmon species, Chinook cumulative mortality rates can reach thirteen percent.[260] Chinook have a longer survival time after 6PPD quinone exposure, dying one or two days later.[261] Sublethal impacts to Chinook are unknown but potentially significant. [262]

There is a need to reduce contaminant inputs to Southern Resident orcas, their prey and forage fish. [263] Regulations phasing out some chemicals and reducing wastewater contaminant load of others have not prevented the ongoing transport of contaminants to the aquatic food web.[264] Existing regulations allow for continued discharges of high concentration of toxic chemicals from both stormwater and wastewater in industrial and high traffic areas.[265] There are projected increases in pollution from new government and private sources and current contaminated sites.[266] The continued failure to remove PBDEs from wastewater treatment plants through additional filtering is a significant concern. [267] Additional clean-up of sources beyond current slow and underfunded efforts will be necessary.[268]

3. Increases in predation

Southern Resident orcas are the southernmost orca population that preys on Chinook in the northeastern Pacific.[269] It is the only northeastern Pacific orca population showing a declining trend. [270] The growth of other resident orca and pinniped populations has had increasing impacts on coastal Chinook abundance.[271] Combined orca and pinniped Chinook consumption has nearly tripled since the mid-1970s.[272] The overall abundance of resident orcas has continuously increased since the 1970s. [273] Northern and Alaska Resident populations levels have at least doubled over the last 40 years, growing to a total resident population of 2,300 orcas in the Northeast Pacific.[274] The Northern Resident population grew from 120 to more than 250 orcas between 1975 and 2011.[275] Current population estimates range from 302 to 330 orcas and the population is still steadily growing. [276]

During the 20th century, both Northern and Southern resident populations responded in similar ways to fluctuations in Chinook abundance. [277] Population growth and declines occurred during the same time periods.[278] However, declines in the Southern Resident population were disproportionately higher, particularly during the late 1990s and early 2000s.[279] Over time, Southern Resident orcas have produced fewer offspring, had shorter life expectancies and higher mortality rates.[280] Nearly two decades have passed since Canada and U.S. began protecting them as a species at risk but the population has not recovered, instead declining to 73 orcas in 2021 – the smallest population since 1984.[281]

Southern Resident orcas compete for food and space with the two other resident populations, which may be limiting population recovery.[282] In particular, they overlap with Northern Residents and compete for prey, even if at some times they forage in different areas during summer months.[283] Recent research shows both populations currently

overlap at times during the summer at Swiftsure Bank, where Chinook bound for river systems that drain into the Salish Sea congregate at the southern tip of Vancouver Island.[284] This area may be a primary summer foraging location for Southern Resident orcas when outside of the Salish Sea.[285] In other words, both populations forage at the same time and in the same place for the same prey originating from the same rivers.[286]

Overall, the three resident orca populations consume between 1.6 and 2.3 million Chinook each year, exceeding human harvest in all marine, terminal and freshwater fisheries.[287] Large increases in consumption by the growing Northern Resident population has had a much more significant influence on coastal Chinook abundance than human fisheries, particularly at lower abundance levels when orca predation may reduce Chinook marine survival rates to between thirty and forty percent.[288] Recent research estimates that Southern Resident orcas consume between 190,000 and 260,000 Chinook each year, mostly between April and October.[289]

The Northern and Southern resident orca population trends began to diverge around the end of the 20th century. The Northern resident population declined between 1998 and 2001 and since has grown 2.9 percent each year since 2001.[290] The Southern Resident orca population's most recent peak was 99 orcas in 1995 and the population size has since declined one percent annually.[291] The different population trends for Northern Resident and Southern Resident orcas undermine the theory that there is a direct causal relationship between salmon abundance and Southern Resident orca population productivity.[292] When prey availability limits a predator population, either a larger amount of prey or a lower number of predators will enable the predator population to grow because of increased per capita prey consumption.[293] The different population responses to fluctuations in Chinook abundance indicate that other factors are driving Southern Resident orca population trends.[294]

In particular, habitat degradation in the Salish Sea may have exacerbated the impacts of competition for prey between a large growing population and a small diminishing population.[295] Between 1970 and 2015, Chinook consumption by harbor seals and California and Steller sea lions increased over ninety percent and is likely limiting the number of Chinook available to Southern Resident orcas during years of lower abundance.[296] The effect of pinniped predation on Chinook populations is severe. [297] Pinnipeds eat twice as much Chinook salmon as the orcas and 6 times as much as harvested in commercial and recreational fisheries.[298] Since the 1960s, the Georgia Strait seal population increased from 2,000 to 40,000 seals. [299] There was a similar, 700 percent increase in the Puget Sound seal population.[300] They congregate in areas such as the Hood Canal Bridge, which impedes salmon movements, and feast on Chinook and chum.[301] The harbor seals consume as many as 1,000 Chinook each day (as well other orca prey species such as coho and chum) and likely have a significant influence on Chinook populations.[302] A major recommendation of Washington State's Southern Resident Orca Task Force was to reduce harbor seals predation.[303]

Sea lion populations have also increased significantly. [304] The number of sea lions occupying areas between Southeast Alaska and Mexico has increased from 80,000 during the 1970s to 260,000 today.[305] Significant predation occurs in 145 river miles before the Bonneville Dam.[306] The predation is one of the top three factors affecting Chinook stocks of particular importance to the orcas such as Upper Columbia River spring Chinook. [307] Between 2010 and 2015, sources other than harvest caused the loss of an estimated 20 to 44 percent of spring Chinook originating above Bonneville - the 2015 estimated loss of 44 percent amounted to 224,000 spring Chinook. [308]

4. Marine Fishery Impacts and Southern Resident orca health

Despite the known impacts from predation, pollution, habitat loss and vessel traffic, mainstream news media frequently report that "a pod of orcas is starving to death" or "Orcas of the Pacific Northwest are Starving and Disappearing."[309] While some years of higher Chinook abundance have correlated with higher orca population productivity, the correlations occurred only during two time periods at a coarse, coast-wide scale and are not necessarily causative.[310] The Columbia River in particular has had record Chinook returns over the past decade while the Southern Resident orca population declined.[311] Broad correlations from the previous century that predated the large increase in

vessel traffic, growth of the orca observing industry and increasing contaminant concentrations simply do not inform relationships between Chinook fisheries and orca population trends in the way the Wild Fish Conservancy suggests in its media materials.[312] Ongoing data collection and analysis has weakened the strength of these correlative relationships.[313]

Lower numbers of Chinook may provide an overly simplified explanation for orcas observed in poor body condition and reduced productivity but there is very little evidence supporting the theory that occasional downward fluctuations in Chinook abundance are causing the orcas to starve or are even a main factor affecting the population.[314] Wildlife biologist Brad Hanson of NOAA's Northwest Fisheries Science Center started studying the Southern Resident orca declines 15 years ago.[315] In 2019, he explained that "I think there has been an effort to simplify the problem and so the default answer is the animals are starving. That's something in general people can easily wrap their heads around."[316]

4.1 Southern Resident Chinook consumption and causes of nutritional stress

Nutritional stress occurs when a species does not obtain adequate energy and nutrients and when chronic can reduce individual body sizes and lower reproductive or survival rates in a population.[317] In 2011-2012, U.S. and Canadian fishery managers convened a scientific review panel and conducted a series of workshops to assess whether salmon fisheries were affecting Southern Resident orca population productivity.[318] The panel questioned the theory that fisheries impact Southern Resident orca population trends because of other, more significant factors: industrial hazards, increased vessel traffic and rising predation by other marine mammals.[319]

Orcas from any population may show a poor body condition or experience nutritional stress for reasons other than reduced prey availability.[320] There were few observations of malnourished Southern Resident orcas during the 1990s population decline, suggesting external disturbances, contaminants or disease were responsible for observations of some orcas in poor body condition.[321] *Between 2005 and 2011 the only dead Southern Resident orca recovered died from a vessel strike.*[322] *There is no evidence since that time showing starvation as a cause of death*.[323] A recent study of stranded orcas throughout their range identified a number of orcas in poor body condition but only a few that were thin or emaciated.[324] Causes of death varied and included disease, blunt force trauma, and accidental stranding.[325]

Scientists continue to question the theory that Chinook abundance drives Southern Resident orca population trends.[326] University of Washingon fisheries scientist Ray Hilborn, who chaired the 2012 expert panel, identifies the small population size as the primary problem.[327] There is still a lack of data supporting the theory that low Chinook abundance is the main cause of the poor physical condition of some individual orcas.[328] Two recent studies, both published in 2021 focused on the orca's diet and again found a shortage of evidence linking prey depletion with nutritional stress.[329] The good physical condition of many Southern Resident orcas and absence of population-wide impacts suggests that factors other than a lack of food, such as individualized health issues, are causing nutritional stress in some Southern Resident orcas.[330] Cases of nutritional stress and poor body condition occur throughout the multiple healthy orca populations inhabiting the northeastern Pacific that have plentiful available prey, including in Alaska and Hawaii.[331]

Contaminants can cause higher rates of disease among Southern Resident orcas, making them too sick to eat.[332] High mortality rates also occurred during years of higher Chinook abundance, driven by factors unrelated to nutritional stress such as trauma or infection.[333] Other underlying health conditions can cause a loss of appetite or inability to absorb nutrients.[334] Wildlife biologist Hanson has observed this phenomenon when attempting to administer medicine contained in a Chinook salmon to a female orca that had no interest in eating.[335] For these reasons, while scientists identify cases of nutritional stress, starvation is not a direct cause of highly publicized orca deaths.[336]

Because of the combination of other factors that reduce foraging success one problem for Southern Resident orcas may be the accessibility, rather than abundance, of Chinook.[337] Even when fish are abundant, the orcas need to be able to forage for them.[338] Injuries caused by or interactions with commercial vessel traffic or whale watchers impairs

the ability to catch or consume prey and disproportionately impacts pregnant or lactating females.[339] Chinook densities have been relatively high in Southern Resident orca foraging areas in Juan de Fuca Strait during summer and four to six times as high as in Johnstone Strait, the key inland foraging area for Northern Resident orcas.[340] The high prey density suggests that there is not a prey limitation during summer months but rather greater difficulty accessing prey because of chronic interference caused by intensive vessel presence and noise.[341] Reduced accessibility due to traffic is likely more consequential than previously considered because interference with foraging affects orca energy intake and expenditures, growth, survival and reproduction.[342]

4.2 Fishery interactions with Chinook stocks important to Southern Resident orcas

As explained in the preceding discussion, numerous habitat conditions have deteriorated for both Southern Resident orcas and their prey, Chinook, coho and chum salmon. The only major mitigation action taken occurring over the time period of the orcas' decline is substantial cuts to ocean harvest of healthy Chinook stocks to enable higher escapements of weaker stocks. Those sacrifices have not resulted in salmon or orca recovery because of ongoing failures to address more serious threats to salmon and orca populations associated with habitat loss, pollution and other human-driven population pressures.

By the 2000s, average annual coastal Chinook abundance from British Columbia to California had declined modestly relative to the 1980s.[343] However, major cuts to ocean fishery harvests *increased* Chinook terminal run sizes (numbers of fish returning to rivers) and the number of Chinook available to Southern Resident orcas by over a third.[344] Terminal run sizes of Salish Sea stocks originating in Canada increased between 38 percent and 100 percent and remained the same in Puget Sound.[345]

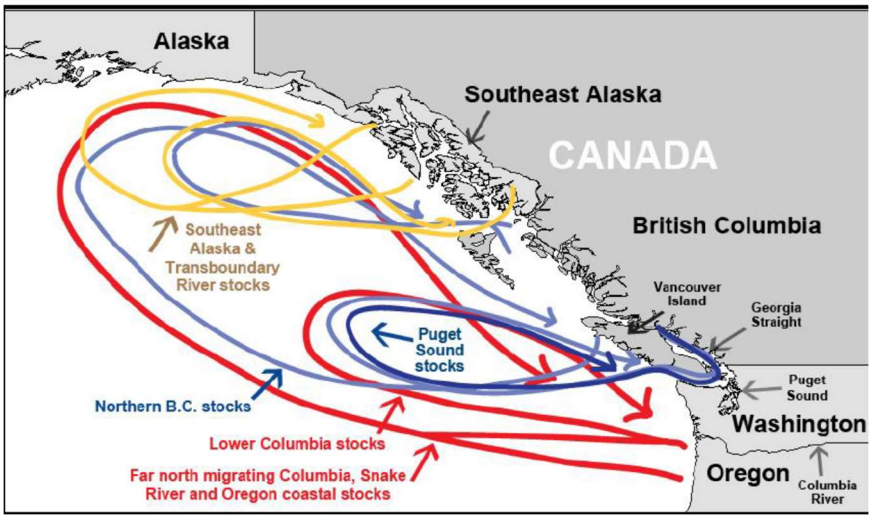
Because of lower ocean harvests, NMFS' 2012 expert review panel questioned whether additional reductions to Chinook harvest would meaningfully impact Southern Resident orcas.[346] It was more likely that larger spatial scale changes in Chinook abundance had much greater influence over orca populations than any one fishery.[347] In particular, increased terminal run sizes suggested factors other than Salish Sea summer Chinook abundance were driving orca population trends.[348] The panel recognized studies correlating Chinook abundance and orca population trends but cautioned against theories that confuse correlation with cause.[349]

A subsequent analysis in 2013 reiterated that additional cuts to already low ocean fishery exploitation rates would be unlikely to help recover the Southern Resident orca population, particularly in light of increases in terminal run sizes of stocks targeted by the orcas.[350] There could be short-term increases in prey availability that were unlikely to generate any detectible difference for the orcas.[351] Ocean fisheries have negligible impacts on most of Salish Sea resident and spring stocks, and stocks that were ocean migrators – those stocks harvested in the ocean fisheries - had tripled in terminal run sizes.[352]

NMFS' 2012 expert review panel identified several criteria for evaluating ocean fishery impacts, including: (1) foregone ocean fishery catch must be available to orcas rather than feed other predators and (2) fisheries would need to exclusively harvest from stocks targeted by orcas rather than from aggregate mixed-stocks.[353] Alaska's troll fishery harvests mixed Chinook stocks that may migrate for six to eight hundred miles from harvest locations in Alaska before reaching the Washington coast and mouth of the Columbia River and nearly a thousand miles before reaching the

Bonneville Dam.[354] Any Chinook not harvested in Southeast Alaska are highly susceptible to harvest by Canadians, sport fishermen, and other predators during this migration.

Chinook stocks or groups of stocks harvested in ocean fisheries, particularly in Alaska, are not the same stocks or groups of stocks targeted by Southern Resident orcas.[355] The top four priority stocks for these orcas are north and south Puget Sound fall stocks followed by fall stocks from Lower Columbia River and the Strait of Georgia. These stocks are not far-north migrators and appear rarely in the Alaska troll fishery. The effect of ocean fisheries in general on stocks targeted by orcas off the Washington Coast in winter and inland Salish Sea in summer is minimal.[356] Alaska troll harvests are extremely low in relation to the specific stocks targeted by Southern Resident orcas in inland waters from May to September and in coastal waters from October to May.[357]



Priority stocks for the Southern Resident orca such as Puget Sound and Lower Columbia stocks typically do not migrate through Southeast Alaska. Graphic: NMFS. 2018. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Act Fishery Conservation and Management Act Essential Fish Habitat Response. Consultation on the Delegation of Management Authority for Specific Salmon Fisheries to the State of Alaska. NMFS Consultation Number: WCR-2018-10660.

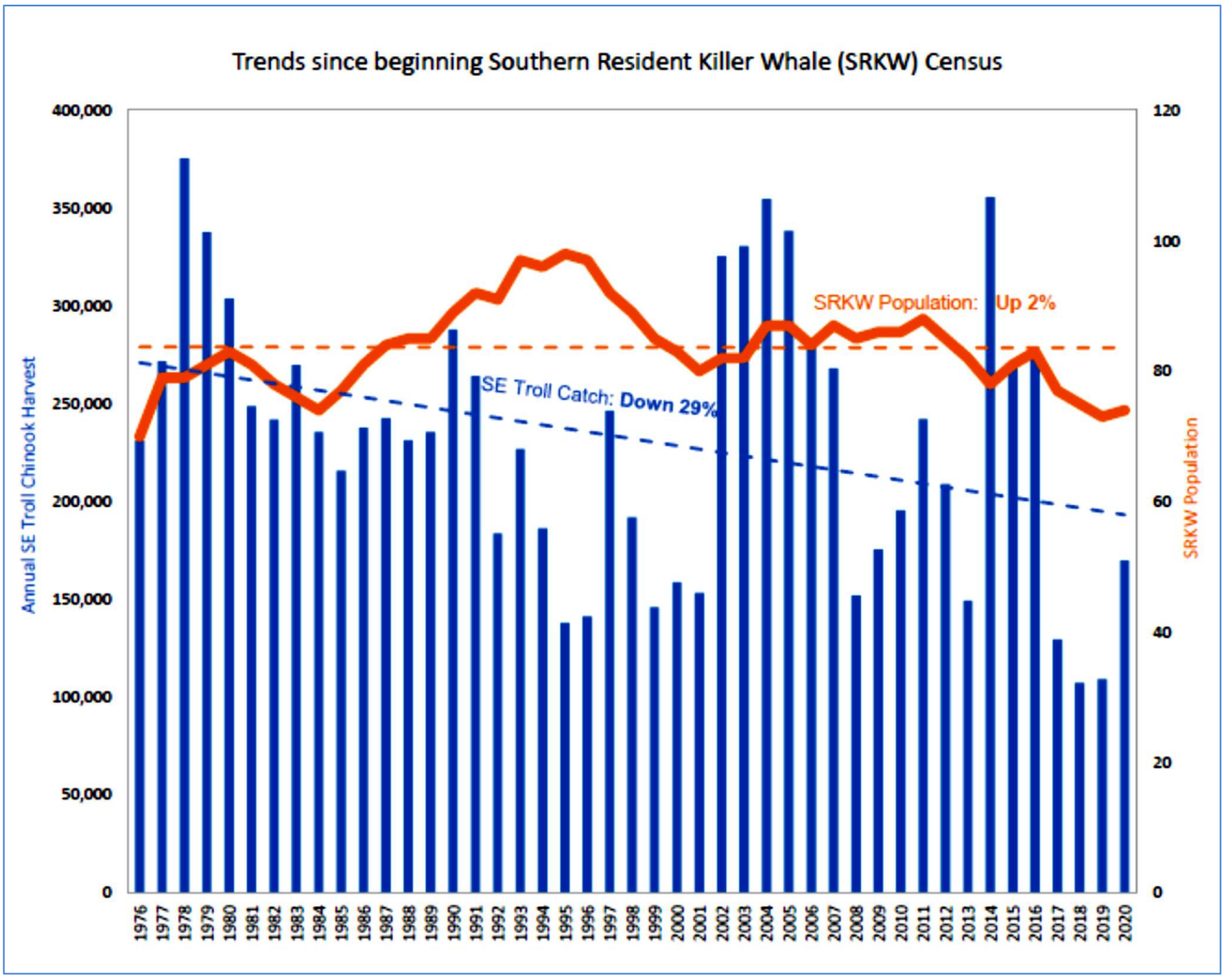
The Pacific Salmon Commission and the Alaska Department of Fish and Game maintain an extensive time series of stock composition data from the Alaska troll fishery and outer coast fisheries in British Columbia. The fisheries are managed based on the overall abundance of multiple stocks. The largest proportion of Chinook harvested in the Alaska troll fishery are stocks that migrate to or past the Washington or British Columbia coasts during the summer, when the Southern Resident orcas are most likely to be in the Salish Sea.[358] Columbia River Bright and West Coast Vancouver Island stocks typically are the most abundant stocks feeding in Southeast Alaska waters, along with stocks from Southeast Alaska, northern and southern British Columbia and the Oregon and Washington coasts that make up the bulk of the Southeast Alaska troll catch.[359]

Despite the low impact on winter coastal and summer Salish Sea stocks, the Wild Fish Conservancy claims that closing the Alaska troll fishery would increase the amount of Chinook available to Southern Resident orcas by nearly five percent - as many as 314,000 to 553,000 fish out of a total coastal Chinook abundance ranging between 6.5 to 11.5 million in any given year – two to three times as much as annually harvested.[360] To clarify, betewen 2017 and 2021, the Southeast Alaska troll fishery annually harvested between 108,000 and 170,00 Chinook. The Wild Fish Conservancy offers no justification for their wildly inflated numbers.

More importantly, the Wild Fish Conservancy ignored stock composition data showing that the Alaska troll fishery catches negligible proportions of the stocks ranked highest on the priority list for the orcas.[361] There is no harvest of most Puget Sound stocks; the few Puget Sound fish caught in the troll fishery comprise roughly 0.39 percent of the total harvest, meaning that in recent years trollers harvested at most, 400 to 700 Puget Sound Chinook salmon..[362] In the highly unlikely absence of any other fishing pressure or predation, closing the Alaska troll fishery would only increase Chinook availability by slightly more than a half percent in areas occupied by the Southern Resident orcas in coastal areas from October to April and Salish Sea areas from May through September.[363]

The Pacific Salmon Treaty reduced the Alaska troll fishery catch by over 30 percent over time while the Southern Resident orca population fluctuated up and down and actually grew by two percent since 1976. *There is no correlation*

between reducing the amount of Chinook harvested in the Alaska troll fishery and Southern Resident orca population trends.[364]



The Southeast Alaska troll Chinook harvest has declined by 29 percent since the first Southern Resident orca census, while the orca population grew over the same time period. Graphic: Alaska Trollers Association.

4.2.1 Human harvest of Puget Sound stocks: mostly sportfishing and Canadian commercial/sport

Chinook abundance trends in Puget Sound have been highly variable since 1970.[365] A typical range of Salish Sea summer Chinook abundance is .8 million to 1.0 million.[366] Between May and September, Southern Resident orcas feed on Puget Sound and British Columbia Chinook returning to rivers that drain into the Salish Sea.[367] The two top priority stocks for the orcas are the north and south Puget Sound fall run Chinook salmon.[368]

The Wild Fish Conservancy claims that Southeast Alaska troll harvests of these Chinook are a primary source of orca prey depletion.[369] There are 22 populations in five regions further subdivided into 14 stocks/ management units.[370] Half the harvest of seven of these stocks, or management units occurs primarily in Canadian waters.[371] A few populations in north and central Puget Sound support most of the overall abundance while the southern and westernmost stocks are at low levels.[372]

The stocks have distinct migration patterns, creating considerable variation in harvest locations.[373] Most Puget Sound ocean-migrating Chinook spend their entire life in Salish Sea and Coastal British Columbia, where 85 to 90 percent of summer and fall run harvest occurs.[374] None of the Puget Sound populations are far north migrating, making impacts from Southeast Alaska marine fisheries extremely low, especially when compared to other fisheries, whether individually or cumulatively.[375] The Alaska troll fishery has nearly no impacts to nine Chinook stocks - exploitation rates range between 0.1 percent and 0.3 percent and the troll percentage of marine harvest ranges from 0.1 to 1.6 percent.[376] From 1985 to 2019, Puget Sound Chinook comprised 0.39 percent of the Alaska catch.[377]

As shown below, higher exploitation rates in the Puget Sound and Canadian fisheries account for seven to ten times the impact on the two stocks that infrequently appear in Southeast Alaska waters, and at least several hundred times the impact on most stocks. Canadian fisheries take the highest proportions of the marine harvest of northern Puget Sound and Strait of Juan de Fuca stocks – between 45 and 75 percent.[378] Puget Sound marine fisheries are responsible for most of the remaining harvest, taking between 50 and 75 percent of central and southern Puget Sound stocks.[379] Exploitation by Puget Sound fisheries, particularly sport fisheries, put the most direct pressure on these stocks and, to the extent that these Chinook are accessible to orcas, sport fisheries have the greatest effect on prey availability by exclusively harvesting Puget Sound stocks (Table 1).[380]

Table 1: Regional Fishery Exploitation Rates for Puget Sound Chinook under the 2019 Pacific Salmon Treaty[381]

ESU	SEAK Troll	Canada	PFMC	Puget Sound	Marine Area
Elwha River	1.0%	7.6%	0.9%	1.6%	11.4%
Dungeness River	1.0%	7.4%	.9%	2.0%	11.5%
Mid-Hood Canal	0.3%	9.6%	6.2%	4.5%	20.7%
Skokomish River	0.3%	9.5%	6.1%	31.5%	47.6%
Nooksack River	2.8%	25.9%	2.9%	4.7%	37.2%
Skagit River Spring	0.3%	9.0%	0.8%	11.1%	21.2%
Skagit River Summer/Fall	5.4%	16.0%	1.2%	18.3%	42.6%
Stillaguamish River	1.3%	11.1%	1.6%	4.1%	18.6%
Snohomish River	0.3%	10.0%	1.7%	4.6%	16.6%
Lake Washington	0.1%	11.2%	4.9%	9.4%	25.6%
Green River	0.1%	11.2%	4.9%	27.3%	43.5%
White RIver	0.3%	7.2%	1.7%	10.6%	19.7%
Puyallup River	0.1%	11.2%	4.9%	32.7%	49.0%
Nisqually River	0.1%	7.8%	6.5%	32.6%	46.9%

Mixed stock ocean fisheries have borne the bulk of the burden of reducing Chinook harvests on healthy stocks for decades in order to contribute to escapements of small numbers of weaker stocks with no meaningful improvement in Southern Resident orca population productivity. Meanwhile, marine sport fishery effort in British Columbia and Puget Sound on the same stocks targeted by the orcas is increasing, with harvests typically exceeding 35,000 Chinook each

year.[382] Freshwater sport fishing effort on Puget Sound Chinook has increased since the 1980s, and harvests over the past decade have ranged from ten to twenty-five thousand Chinook each year. [383] Puget Sound marine and freshwater net fisheries harvested another twenty to sixty thousand Puget Sound Chinook in any given year over the past two decades.[384]

Washington State sport fisheries harvest mostly coho and Chinook, two of the main species eaten by orcas during summer and early fall months.[385] In 2020, Puget Sound marine sport fishers took nearly twenty thousand Chinook mostly during July and September.[386] Freshwater fishers that same year took over eleven thousand Chinook from Puget Sound rivers mostly between August and October – the summer and fall runs that are primary stocks for Southern Resident orcas. [387] Sport fishers took nearly one hundred thousand coho from Puget Sound in 2020 – nearly all of them during August and September when they would otherwise be or become accessible prey for orcas.[388]

The Wild Fish Conservancy's proposal to eliminate Alaska troll fishery is likely to have the perverse effect of increasing the take of Puget Sound Chinook, particularly by Canadian sport and troll fisheries.[389] Under the Pacific Salmon Treaty, most Canadian fisheries may harvest any portion of a domestic stock that is surplus to escapement needs.[390] In the absence of an Alaska troll fishery, this harvestable surplus is likely to occur because a variable but significant portion of Southeast Alaska catch originates in Canada, particularly West Coast of Vancouver Island stocks. [391] Increased fishing effort in Canada aimed at harvesting surplus West Coast of Vancouver Island stocks would significantly increase overall harvest of Puget Sound stocks which comprise 14.5 percent of the Canadian catch.[392] *Indeed, some estimates indicate that for every Puget Sound Chinook saved by closing Alaska's troll fishery, Canadian fisheries could harvest twenty Puget Sound Chinook*.[393]

4.2.2 Puget Sound habitat

The Wild Fish Conservancy did not file a lawsuit against NMFS for approving continued implementation of Puget Sound fisheries in 2021, raising questions about why the Conservancy is targeting a distant fishery that harvests a small fraction of the total harvest of Puget Sound Chinook. The 2021 BiOp, multiple scientific analyses and government reports all point to other factors that harm the salmon populations targeted by the orcas – in particular, deteriorating habitat conditions.

Rapid population growth in Puget Sound alone is a significant threat to Southern Resident orcas because significant changes will be necessary to protect and restore salmon habitat.[394] Washington state's population tripled from 2.4 million in 1950 to 7.4 million in 2018.[395] Over two-thirds of the population lives in 12 counties adjacent to Puget Sound.[396] The projected population in by 2030 in those counties is 5.7 million people.[397] According to the 2021 BiOp evaluating Puget Sound fishery impacts, the additional population growth and urbanization will worsen already degraded salmon habitat.[398] The 2021 BiOp recognized that habitat, not fisheries, is the primary problem and explained that ***"the continued destruction and modification of habitat is the principal factor limiting the viability of Puget Sound Chinook … into the foreseeable future."*** [399]

Overall, ocean fishery exploitation rates for Salish Sea salmon stocks declined so much since the 1990s that it should be obvious that other factors limit the salmon and the orcas' recovery.[400] For example, it is becoming increasingly apparent that the length of time spent rearing in freshwater or nearshore Salish Sea marine habitats significantly influences salmon stock productivity patterns.[401] Abundance, survival rates and productivity for stocks that rear briefly in freshwater and then quickly exit the Salish Sea and its rivers, including pink, chum and hatchery Chinook, are generally stable or increasing.[402]

In contrast, naturally spawning Chinook, coho and sockeye that rear for extended periods of time in freshwater are decreasing in abundance and have lower survival rates.[403] Ocean climate conditions and fishery impacts do not explain this phenomenon - there have been significant harvest cuts and periods of favorable climate patterns.[404] Habitat quality at early life stages is critical to salmon survival, and the lengthy freshwater rearing stage and delayed ocean entry

are a disadvantage for wild Chinook and coho stocks.[405] The impacts are most obvious in central and south Puget Sound due to the largest human population growth and most intensive freshwater and nearshore marine habitat degradation.[406]

The quality of all Puget Sound watersheds need to improve from current conditions in order to recover at-risk Chinook populations.[407] Stillaguamish stocks continue to decline because of poor freshwater habitat conditions.[408] Efforts to restore Nooksack stocks have been thwarted by long-term failures to protect and restore severely degraded riparian habitat that have left them susceptible to large die-offs during late summer high temperature and low flow events.[409] The ongoing development of Hood Canal has reduced water quality to the point of causing significant fish kills.[410] Dams built for hydropower, irrigation and flood control are prevalent throughout Puget Sound watersheds, blocking access to habitat in many of the largest Chinook producing systems.[411] The dams also changed flow patterns, increased temperatures, stranded juveniles and reduced downstream spawning and rearing habitat.[412]

Barrier culverts are prevalent throughout Puget Sound. Culverts are the most common method used by road builders to cross streams.[413] They cost less than bridges but it is difficult to maintain fish passage with constantly changing stream and debris flows.[414] Culverts eventually become blocked and impede or become complete barriers to fish movements.[415] There are over 10,000 culverts on anadromous salmon streams in Washington and Oregon.[416] Between half and sixty percent of these culverts are barriers to salmon migration, blocking literally thousands of miles of fish habitat.[417] Culverts also can become barriers by creating high velocity stream flows.[418] Floods magnify this impact.[419] Overflow that bypasses barrier culverts also increases sedimentation and stream temperatures.[420]

The impacts of barrier culverts are much more extensive than the obvious problem of eliminating adult salmon spawning habitat because they eliminate habitat connectivity.[421] Juvenile salmon move within a watershed to rearing or overwintering habitat or explore other habitats at times in pursuit of food.[422] They also move to seek refuge from adverse environmental conditions such as floods or debris flows from landslides.[423] Barrier culverts block those movements, cumulatively reducing population productivity by impairing foraging opportunities that slow growth and development and by blocking access to refugia.[424] When less habitat is accessible to salmon for spawning and rearing and other life cycle needs, there can be a significant loss of population productivity, to the point of local extirpations.[425]

Logging and timber road construction has had significant impacts on upstream habitats in Puget Sound – particularly the loss of riparian forests that maintain water quality, regulate stream temperatures and contribute in multiple other ways to salmon rearing and spawning habitat.[426] Some studies found stream temperatures to be up to 7 to 11°F warmer in logged areas in Western Washington.[427] The warmer temperatures alter fish behavior and the timing of life cycle events and can cause population declines or even collapses.[428] Timber roads, particularly widespread unpaved roads in upper stream reaches cause ongoing, chronic sediment delivery that goes downstream and degrades salmon spawning and rearing habitat.[429] Sedimentation of stream beds is a principal cause of declining salmon populations throughout their range.[430] Salmon abundance in forested watersheds with high road densities typically declines by over fifty percent.[431]

Downstream, agricultural and urban development also removed riparian vegetation and trees, leaving unshaded watersheds with higher stream temperatures.[432] Water diversions in the lower stream reaches are a major habitat problem and eliminated many smaller channels, causing significant loss of juvenile salmon rearing and refuge habitat.[433] The massive loss of wetlands has disrupted natural hydrological processes that maintain water quality for salmon.[434] Urban and highway runoff, wastewater treatment, failing septic systems and agriculture or livestock impacts further degrade water quality throughout Puget Sound.[435]

The degradation and loss of freshwater and estuary habitat at river mouths has weakened salmon populations throughout the region.[436] Various developments, water diversions and high contaminant concentrations and other intensive uses have heavily degraded or destroyed Pacific Northwest estuaries and continue to threaten these highly productive but vulnerable ecosystems.[437] By the mid-1990s there was a loss of 70 percent of estuarine habitat in Puget

Sound – the second largest estuary in the U.S. - and 50 percent or more in Salish Sea estuarine habitat in British Columbia.[438] The numerous rivers that flow into Puget Sound form many local estuaries that are adjacent to major shipping ports, industrial sites and waste treatment plants.[439]

Salmon production often corresponds to productive estuaries and estuarine vegetation such as seagrasses.[440] The degradation of these estuarine habitats reduceses prey densities and salmon survival rates and drastically diminishes salmon returns.[441] Salmon pass through estuaries twice, during outmigration as smolts and then when returning to spawn as they transition between freshwater and the marine environment.[442] Chinook in particular rear extensively in estuaries as juveniles.[443] Multiple studies of juvenile salmon show that their initial growth and survival depend on the capacity of these systems to produce forage and protection from predators.[444] Coastal wetlands that contribute to the productivity of Pacific west coast and Puget Sound estuaries are disappearing rapidly.[445]

Contaminants from industrial waste, stormwater, chemical spills, and run-off significantly degrade estuaries and the combined contaminant cocktails reduce juvenile Chinook survival.[446] Legacy contaminants such as PCBs and DDTs remain at elevated levels in sediment and fish.[447] Estuarine concentrations of other contaminants such as PAHs, PBDEs, pharmaceuticals, personal care products are increasing.[448] These contaminants accumulate quickly in juvenile Chinook because of they consume large amounts of prey in estuaries in order to grow rapidly before migrating to the ocean.[449]

Juvenile Chinook that rear in uncontaminated estuaries are nearly twice as likely to survive to adulthood than juvenile Chinook transiting contaminated estuaries.[450] Wild juvenile ocean-type Chinook spend twice as much time in estuaries than hatchery Chinook or other salmon species causing more dramatic impairment and large changes in population abundance.[451] The toxic exposure over longer periods of time impairs growth, alters behavior, increases susceptibility to disease and results in higher mortality rates.[452]

4.2.3 Impacts to Coastal Chinook abundance

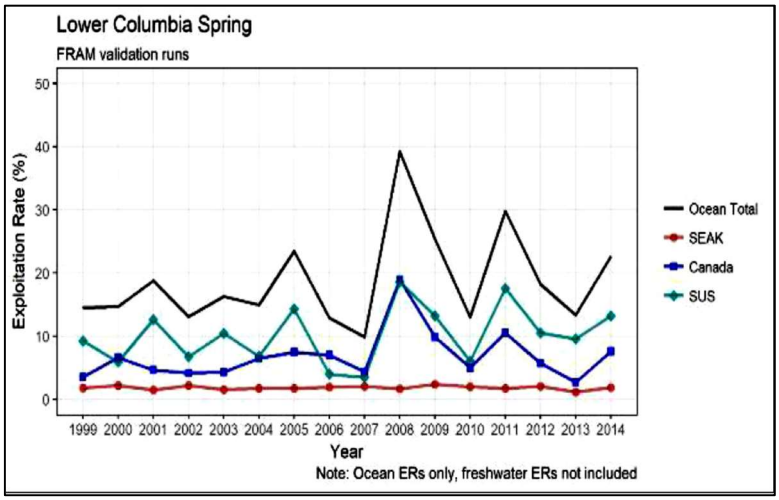
The Wild Fish Conservancy alleges that the Southeast Alaska troll fishery is a primary source of prey depletion for lower Columbia River and Snake River Chinook, contributing to orca starvation. The estimated impact of the Southeast Alaska troll fisheries on Southern Resident orca prey availability under the Pacific Salmon Treaty is very small – less than half a percent.[453] Other ocean salmon fisheries that overlap spatially with the range of the Southern Resident orcas also cause minimal or no prey reduction during October to April time period regardless of year or region.[454] Typically Chinook abundance during these months when Southern Resident orcas feed on coastal stocks is 2.7 million to 4.7 million.[455] The small amount of coastal Chinook abundance that may increase through further cuts to the Alaska troll fishery would be negligible because Alaska fishers catch Chinook returning to coastal river systems between July and October when the Southern Resident orcas occupy the Salish Sea.[456] Harvests of Columbia River Chinook consist mostly of summer and fall Chinook stocks, particularly Columbia Brights and some Columbia River Summer stocks.[457]

Despite the 1990s decline, Columbia River Chinook runs have proven to be resilient, with total annual runs exceeding a million Chinook.[458] The most abundant stock, Columbia River Brights, supports numerous fisheries, including ocean harvests by southern U.S., Canadian and Alaska troll and sport fisheries and by several Columbia River sport and gillnet fisheries.[459] Columbia River bright stocks are generally healthy and meeting or exceeding escapement goals.[460] On average, over 700,000 fall Chinook have returned each year over the past decade with Columbia River Brights comprising up to two-thirds of the return.[461] There were three 3 straight years of total returns of over a million fall Chinook from 2013-2015.[462] Snake River fall returns have also improved considerably over the past decade, including five of the highest returns of the 21st century from 2011 through 2015.[463] Summer Chinook returns have also steadily increased, with run sizes over the past decade three to four times as high as the 1980s and 1990s.[464]

Columbia River summer and Upriver bright fall stocks are the most important of the Columbia River stocks harvested in the Alaska troll fishery.[465] Overall, Southeast Alaska harvests of Columbia River salmon are lower than other fisheries. In particular, there has been a massive increase in angler effort on the mainstem Columbia River, nearly

tripling to over 118,000 angler trips since the 1980s.[466] Columbia River sport harvests were at the highest levels since 1980 over the past decade, exceeding well over 100,000 Chinook each year between 2010 and 2017, and peaking at over 150,000 Chinook in 2015.[467] Columbia River net fisheries have typically harvested between one to two hundred thousand Chinook over the past decade with a peak of nearly four hundred thousand Chinook.[468] Columbia River brights comprise most of the in-river sport and net harvests.[469] These stocks have significantly exceeded escapement goals since 2009 and would actually support higher harvests.[470]

During the winter Southern Resident orcas target a broader range of Chinook stocks than during the summer in the Salish Sea, including some of the abundant Columbia River Brights.[471] Columbia Spring runs, however, are probably the most important stocks for Southern Resident orcas during this time of year, comprising over half of the Chinook consumed by the orcas in winter and spring.[472] Spring Chinook historically were the most available stocks during winter and early spring months, returning in large numbers of bigger, fatter fish.[473] Spring Chinook migrate early, entering the river between February and June and spawn during August through October.[474] Southern Resident orcas frequently gather at the mouth of the Columbia River in pursuit of these fish.[475]



Graphic: NMFS. 2018 BiOp

The Columbia River Basin alone has 22 major and 353 minor dams.[476] The greatest reductions from historical population levels occurred for Columbia River Spring Chinook most important to the Southern Resident orcas.[477] The declines have been the most severe because these fish typically spawned in areas that are now upstream from impassable dams.[478] Impacts to Spring Chinook were widespread, most notably in the Columbia River but affecting all spring runs.[479] Dams, failed culverts, logging, mining and urbanization have severely degraded the cold, clear tributary streams used by spring Chinook, leaving few Pacific Northwest watersheds in good enough condition to support Spring Chinook.[480] These Chinook stocks are highly vulnerable to habitat degradation in the Columbia Basin because they spend up to a year in freshwater before entering the marine environment.[481] There has been considerable recent variability in abundance, with record high and record low returns occurring during the 21st century driven by increases or decreases in hatchery returns.[482] **Because most Columbia River Spring runs have a non-coastal ocean distribution, marine fishery impacts on spring Chinook stocks are negligible and lower in the Alaska troll fishery than in any other marine fishery.[483]**

NMFS recently evaluated Southeast Alaska fishery impacts on three specific Chinook populations from the Lower Columbia River, Willamette River, and Snake River. The effects of ocean harvest on all of these stocks were declining by the late 1990s.[484] Most Lower Columbia River Chinook stocks are not far-north migrating and rarely encountered in Alaska troll fisheries.[485] The few Lower Columbia stocks that are far north migrators are a small proportion of Alaska troll fishery catch which is a very small proportion of total run size.[486] Southern U.S. fisheries and Canadian fisheries harvest over a half and over a third of the Lower Columbia River stock, respectively.[487]

Harvest has not been a limiting factor for either the Upper Willamette River or Snake River fall-run since the early 1990s.[488] Other factors are currently impeding recovery.[489] The overall marine exploitation rate for Upper Willamette River Chinook is exceptionally low so that ocean fishery harvest is not a primary or limiting factor for the stock.[490] These stocks comprise a small portion of Southeast Alaska fishery harvests.[491] Freshwater sport and commercial fisheries in the lower mainstem Columbia River, mainstem Willamette River and Willamette tributaries take

a higher proportion of the Willamette Chinook than ocean fisheries.[492] As with other analyzed Chinook stocks, Alaska troll harvest is a very small fraction of the Snake fall harvest - harvests from in-river fisheries and other marine fisheries in Canada and the U.S. all have exploitation rates ten to twenty times as high.[493] There have been harvest cuts throughout the range of Snake River salmon and the population is improving significantly.[494] Spawner abundance is increasing with average escapements over four times as high in the 2010s as in the early 2000s.[495]

Because dams are the main limiting factor for Columbia Basin stocks, orca researchers recommend immediate increases in spill levels at Snake and Columbia River dams and the removal of lower Snake River dams.[496] They believe that improving habitat conditions in the Columbia Basin are essential for the recovery and likely the survival of Southern Resident orca populations.[497] The current recovery plan for Lower Columbia River Chinook focuses on fixing problems with tributary and estuary habitat and dams.[498] Tributary dams that block over 400 miles of habitat are a primary limiting factor for Willamette River Chinook.[499] The dams also reduce flows and increase downstream temperatures.[500] The cumulative impacts of agriculture, urbanization, logging and other developments have eliminated or degraded spawning and rearing habitat, ruined riparian areas, impaired water quality and increased water temperatures.[501] Introduced species have increased predation and competition.[502] Dams, predation, degraded estuary and mainstem and tributary habitat continue to impede recovery for Snake River fall Chinook.[503]

5. Conclusion

Pollution, industrial toxins, urbanization, habitat loss and human-caused disturbance are the primary factors limiting the recovery of the Southern Resident orcas. Any one factor – acoustic disturbances from vessel traffic, the orca observing industry, chemical contaminants or habitat harms specific to naturally spawning Chinook, chum and coho salmon – may in itself be a significant cause of nutritional stress, higher death rates or failed pregnancies. More than likely a combination of factors are driving Southern Resident orca population trends.

The Alaska troll fishery is managed under the Pacific Salmon Treaty based on the abundance of Alaskan resident and far-north migrating Chinook salmon that spend most of their lives feeding in the Gulf of Alaska. Very few of the fall Chinook from Puget Sound, Lower Columbia River or the Strait of Georgia the stocks that are most critical to SRKWs migrate to Alaska and thus are not susceptible to being caught by Alaskan trollers. Less than half of one percent of to the Alaska troll catch is from the top priority Puget Sound fall stocks. Far more Puget Sound Chinook are taken in Puget Sound and British Columbia sport fisheries or during the Chinook's migration by other predators than in the distant Alaska troll fishery. The readily available stock composition data renders bizarre the Wild Fish Conservancy's marketing campaign against Alaska's small boat fishing families.

To restate, the Wild Fish Conservancy's theory that commercial fishing is a primary cause of Southern Resident orca population trends is contradicted by the numerous recent scientific analyses that track salmon abundance and Southern Resident orca diet composition. Indeed, cuts to ocean fisheries have been the primary means of improving Chinook escapements over the past three decades, and these harvest sacrifices by ocean fishermen have failed to recover the orcas because other habitat harms have continued and worsened. Sadly, the decline of the Southern Resident orcas is likely to continue until habitat damage, pollution and other human-related pressure on the orca is reduced. The Wild Fish Conservancy might look to their own sport fishing and orca observing constituency if saving the orcas is the true objective of their action.

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