Product Sustainability Standard: Seafood

Chinook Fishery Evaluations

Version 2.0: April 2022

The following evaluation reports were researched and composed by experts at the National Fisheries Conservation Center (NFCC) to identify acceptable sources of Chinook salmon for PCC Community Markets. Depending upon the season, availability, and quality of product you may find Chinook salmon from one of more of these fisheries in our Meat and Seafood Department.

To meet the purchasing requirements for PCC, Chinook salmon must come from a fishery that earns an A or B in the stock and knowledge risk categories, and an A for interception risk.

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Chinook Salmon Fishery Evaluation

Bristol Bay Nushagak

May 26, 2020

2020 Evaluation: Passed Overall Rating: A

Fishery Overview:

The Nushagak fishery produces about 80% of Bristol Bay's annual Chinook harvest. This fishery is actively managed to conserve Chinook while these fish are running, enabling high confidence in management science supporting sustainability in the Nushagak harvest. Detailed findings on this fishery's performance against each relevant standard and indicator are contained in the attached supplemental evaluation report, along with full references.

Evaluation Summary:

The Nushagak Chinook fishery on Bristol Bay earns the A rating based on findings that: 1) prey interception risk, exploitation risk, and biomass risk are managed at levels that satisfy standards and indicators underpinning this rating for each category; and 2) knowledge risk for each standard and indicator is constrained sufficiently to produce the necessary confidence in data.

Note that no hatcheries operate on Bristol Bay, so hatchery risk and knowledge of hatchery risk are inapplicable in this case.

Evaluation Chart

	Findings	Rating	Notes
1. Prey Interception Risk		**A**	
1.1 No Overlap	All indicators met.	A	Fishery is remote from SRKW prey range. Data indicate no sign that Chinook from Southern U.S. or B.C. are caught in Bristol Bay's salmon fisheries.
Indicator 1.1.1			
Indicator 1.1.2			
1.2 Post-Prey			
Indicator 1.2.1			
Indicator 1.2.2			
1.3 Negligible Effect			
Indicator 1.3.1			
2. Stock Risk		**A**	
2.1 Exploitation	All indicators met.	A	Allowing enough fish to escape harvest and swim up to spawning grounds is the primary tool for ensuring control of exploitation rate and protection of spawning biomass. Bristol Bay salmon managers use multiple tools and practices to detect and quickly respond to variations in run strength and catch in order to protect escapement.
Indicator 2.1.1: Exploitation Rate			
Indicator 2.1.2: Reference Points			
Indicator 2.1.3: ETP Species			
Indicator 2.1.4: Uncertainty → Precaution			
Indicator 2.1.5: Compliance			
Indicator 2.1.6: Timely Action			
2.2 Biomass		A	
Indicator 2.2.1: Reference Points			
Indicator 2.2.2: Uncertainty → Precaution			
Indicator 2.2.3: Compliance			
Indicator 2.2.4: Timely Action			
2.3 Hatcheries			
Indicator 2.3.1: Hatchery Management			
Indicator 2.3.2: All-H Integration			
Indicator 2.3.3: Uncertainty → Precaution			
3. Knowledge Risk		**A**	
3.1 Knowledge Risk for Interception			
3.1.1 No Overlap	Indicators met.	A	
Indicator 3.1.1.1			Risk of intercepting SRKW prey is well documented to approximate zero.
Indicator 3.1.1.2			

		3.1.2 Post Prey			
		Indicator 3.1.2.1			
		Indicator 3.1.2.2			
		3.1.3 Negligible Effect			
		Indicator 3.1.3.1			
	3.2 Knowledge of Stock Risk				
		3.2.1 Exploitation	All indicators met with moderate to high confidence.	A	Management of fishery incorporates: 1) multiple data sources to monitor run size, harvest, escapement and other management parameters; 2) review of monitoring methods (includes focus on reducing errors/uncertainty); 3) regular and publicly available reviews of escapement goals.
		Indicator 3.2.1.1: Exploitation rate			
		Indicator 3.2.1.2: Reference points			
		Indicator 3.2.1.3: Uncertainty and Error			
		Indicator 3.2.1.4: Compliance			
		Indicator 3.2.1.5: Timely Action			
		Indicator 3.2.1.6: ETP Species			
		3.2.2 Biomass	All indicators met with moderate to high confidence.	A	
		Indicator 3.2.2.1: Monitoring			
		Indicator 3.2.2.2: Reference Points			
		Indicator 3.2.2.3: Uncertainty → Precaution			
		Indicator 3.2.2.4: Compliance			
		Indicator 3.2.2.5: Timely Action			
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		Indicator 3.2.3.3: Hatchery Marking and Tagging			
		Indicator 3.2.3.4: Uncertainty → Precaution			

Note: Any lines or sections left blank with greyed text are considered not applicable to the specific fishery under evaluation.

Full Evaluation Details

1. Prey Interception Risk (No Overlap)

Bristol Bay is remote from the range of SRKW and their known Chinook prey, and data from multiple sources indicate no sign that Chinook salmon from the Southern U.S. or British Columbia are caught in Bristol Bay's salmon fisheries.

Salmon tags collected over decades and two fishery-independent studies indicate that Chinook salmon from the range of SRKW do pass into the Bering Sea, but they pass far to the west of the Bristol Bay salmon fisheries. Future climate change could alter this migratory pattern, but for now it is a refuge from SRKW concerns.

2. Stock Risk: Exploitation and Biomass

Allowing enough fish to escape harvest and swim up to spawning grounds is the primary tool for ensuring adequate control of exploitation rate and protection of adequate spawning biomass.

Nushagak Chinook escapement met or exceeded its goal in all but one year from 1975 to 2017**.** That amounts to a record of compliance with limits on exploitation in more than 97.3% of years. (Source: ADFG website, http://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative_nushagak.historical

Reference points for catch and spawning biomass, precautionary response, and terminal harvest adjustments are satisfied by Alaska Department of Fish and Game's (ADFG) use of maximum-sustained-yield (MSY)-based escapement goals, regular scientific review of those goals, and cautious in-season harvest management.

Notes on Rating and Conditions:

- Potential future increases in harvest rates on Nushagak River Chinook salmon could introduce greater risks to the stock, especially if the population continues to trend downward. Further shortfalls in spawning escapement may become more likely as more complete enumeration of fish swimming upriver leads to the reduction or elimination of a "buffer" of adult Chinook that previously swam undetected past sonar counting stations.
- The lack of systematic scientific observations of fishery interactions with protected species (especially seabirds and cetaceans) has posed little risk in the past. This risk may rise in future as warming alters the distribution and behavior of many species.
- The harvest is managed to achieve escapement at 90-100% of MSY. A target that can dip below MSY places increased burdens on managers' ability to predict stock productivity, protect spawners when a run falls short of expectations, and resist political pressure to increase harvest rates. To date managers have met these challenges with multiple precautionary measures to protect the health of the stock, so we recommend a pass on this point for now. However, performance of this fishery should be closely monitored in the future, especially in light of the long-term decline of Chinook throughout their range.

3. Knowledge Risk

Knowledge of Prey Interception Risk

Strong evidence indicates near-zero probability of catching Chinook prey of SRKW in the Nushagak fishery. Decades of Coded Wire Tag (CWT) data and two independent satellite-tagging studies show no record of southern Chinook stocks entering this fishery or nearby waters.

Note on Rating: Warming oceans and increasing incidence of hot water "Blob" events in the North Pacific are shifting the distribution of many species. Although no interactions have been documented in this fishery, we recommend that future evaluations review available data on southern Chinook movements in the Bering Sea, especially during periods of unusually high temperature.

Knowledge of Stock Risk (Exploitation and Biomass)

Management of Bristol Bay's Nushagak Chinook fishery incorporates: 1) multiple data sources to monitor run size, harvest, escapement and other management parameters; 2) regular and rigorous reviews of monitoring methods, including systematic research to identify and reduce errors and uncertainties; 3) regular and publicly available reviews of escapement goals that incorporate lessons from the reviews and research described above.

ADFG managers and scientists conduct regular and rigorous review of escapement goals and uncertainties and errors in data. Escapement goals are based on standard S/R model estimates of escapement sufficient to achieve long-term MSY. Escapement targets effectively govern exploitation and guide conservation of spawning biomass.

> *Note on exploitation and spawning biomass reference points:* The policy setting the escapement goal range at 90-100% of MSY level may result in increased risk during periods of declining abundance— a trend that is visible in recent data for this fishery. Risk to the stock may also be elevated by improving escapement estimates, reducing an inadvertent but longstanding "buffer" of undercounted escapement. Climate change may also elevate risk to the stock.

Managers have access to multiple data sources to forecast and track changes in run size, track harvest rates based on rapid and accurate catch reports, and assess escapement during the annual fishing season, enabling timely management action and achieving escapement goals in 43 out of the 44 years ending in 2017.

Entanglement of seabirds and cetaceans is believed to be rare, based on credible but anecdotal reports from experienced managers who have overseen the fishery for decades. Multiple measures including spatial closures are in place to limit potential disturbance of vulnerable walrus at summer haulouts.

> *Note on ETP species impacts*: Systematic, scientific documentation of interactions with seabirds and cetaceans have been a low priority because interactions have been rare. If interactions increase in the future, systematic data collection may become necessary.

Reliable, timely data from multiple sources give harvest managers a strong toolkit to identify and reduce uncertainties and errors and rapidly constrain harvests to protect or increase escapement. Well-documented measures to avoid disturbing walrus and the apparent rarity of interactions with cetaceans and seabirds indicate that risk to protected species is currently low.

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Chinook Salmon Fishery Evaluation

Columbia River fisheries below Bonneville Dam

Original August 16, 2020. Revised November 17, 2020

2020 Evaluation: Passed **Overall Rating:** A/B

Fishery Overview:

This evaluation covers two of the three Columbia River fisheries that provide Chinook salmon to retail consumers: the mainstem river fishery below Bonneville Dam, and the small "Select Area" fishery, which operates in side-channels and bays near the rivermouth. In addition, tribal fisheries operate upstream, between Bonneville Dam and McNary Dam. All three fisheries primarily use gillnets, fishing selectively under rigorous rules that control the times, locations, mesh sizes, and other practices to target healthy runs of wild[1] or hatchery fish while tightly limiting incidental catch from weak stocks. For the two downstream fisheries, sufficient data were found to assess all three categories of risk in the PCC Chinook standard: interception risk, stock risk, and knowledge risk. We are still gathering data to evaluate elements of knowledge risk in the upriver tribal fisheries.

The Columbia River is the largest historic producer of Chinook salmon in the world (NMFS 1991). Despite profound losses and harm to habitat over the last 150 years, the river, and its vast network of tributaries—a watershed larger than France—still yields some of the largest salmon runs. In early 2020, biologists forecast that for the year 2020, 1.2 million adult salmon of all species would swim home to the river after feeding in the ocean. Chinook make up the largest share of the return, swimming home in all four seasons. Among Chinook, the fall runs have been the most productive recently, returning an average of more than 737,000 fish annually between 2008 and 2018 (WDFW and ODFW 2019a).

The Endangered Species Act (ESA) has played a major role in rebuilding salmon populations in the Columbia, as it has elsewhere along the West Coast. Since the early 1990s, 13 groups of Columbia Basin salmon and steelhead stocks have been listed as threatened or endangered under the ESA. Federal, state, and tribal resource management agencies have responded by tightening catch limits, regulating fishing and hatchery operations, and investing in habitat restoration and population enhancement efforts. They have made substantial headway in rebuilding many depleted populations despite rising mortalities that appear to be linked to climate change and other environmental pressures. Notably, sockeye and fall Chinook returning to the Columbia's largest tributary, the Snake River, have been salvaged from the brink of extinction, despite continuing threats from dams and other stressors.

The majority of Columbia Chinook originate from hatcheries, which proliferated as modern development ravaged the basin's natural spawning and rearing habitats (NMFS 2018). Hatchery management has improved greatly in recent decades. The first hatcheries built on the Columbia during the late 19th Century were a haphazard attempt to offset damage from overfishing, unchecked development, and habitat degradation. Fish were transplanted and released with little awareness of local adaptation or the risks of ecological and genetic harm to wild populations. Though hatchery science is still evolving, NOAA's National Marine Fisheries Service (NMFS), along with state and tribal co-managers, has used its authorities under the ESA to drive comprehensive, ongoing scrutiny and improvement in hatchery practices.

[1] For the purposes of this evaluation, the term "wild" refers to salmon populations that are not reared in and released by hatcheries. In a point-of-sale/retail context, the terms "wild" or "wild-caught" are often used interchangeably to differentiate between fish caught in oceans, rivers, or lakes and those raised in aquaculture operations. In the evaluation, we also use a variety of terms that are common in salmon management that recognize a spectrum of hatchery and native-fish influence on populations that spawn in streams and rivers.

Fishery Location Maps: The fisheries covered in this evaluation occur in zones 1-5 in the Columbia River. This includes Select Area fisheries near the rivermouth (see map below) and mainstem fisheries west of Bonneville Dam.

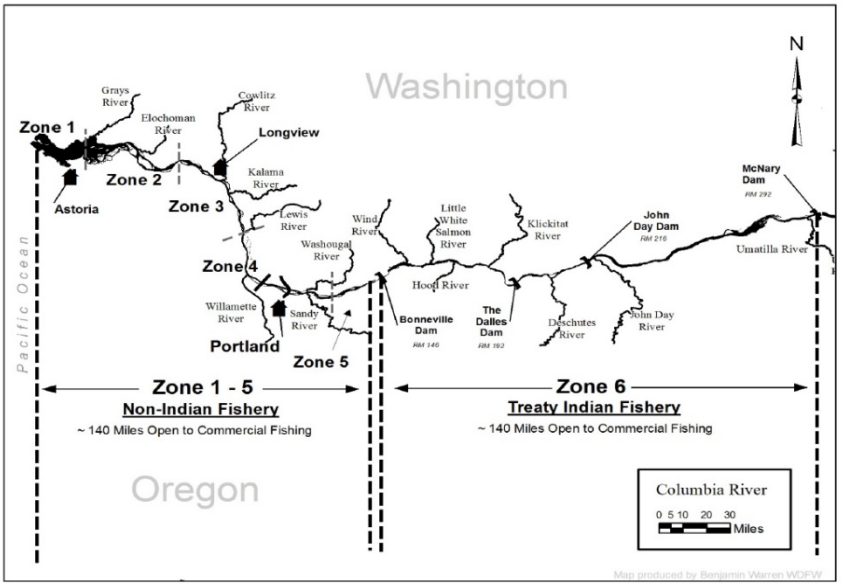

Figure 2. Map of the Columbia River downstream of McNary Dam showing areas open to commercial fishing.

SOURCES: Upper panel map of mainstem Columbia fishing areas from Spring 2020 Joint Staff Report, WDFW and ODFW. Lower panel map: Scott Smeltz/NFCC.

Evaluation Summary:

Continuous public debate and review are built into management systems for the Columbia River, its fisheries, and the science informing them. The 20th Century conversion of North America's largest salmon producing river into its largest hydropower system left a legacy of contention among multiple, competing institutions and people. One result is that many of them now have a vested interest in the effectiveness of actions to restore and conserve fisheries. This makes for complex and cumbersome discourse, creating many decentralized sources of data and analysis. It also helps to ensure a degree of rigor and transparency. Tribes, state and federal fisheries agencies, dam operators, industrial water and power users, utilities, irrigators, multiple fisheries stakeholders, and scientific experts now scrutinize and check each other's work on salmon in the Columbia Basin.

Spring Chinook salmon returning to the Columbia River constitute an important source of prey for Southern Resident Killer Whales, which are known to feed on returning adult fish off the coast of Oregon and Washington, notably targeting fish returning to the river during late winter and spring (NMFS 2018). However, fisheries in the Columbia River target Chinook that have already escaped from the whales' ocean foraging grounds, so they are no longer accessible to the Whales. Nor do they deplete the supply of Chinook. The catch in the river is tightly restricted to stay below natural replacement levels, on average taking less than 10% of adult natural-origin Chinook returning to the Columbia Basin (computed from data in NMFS 2018).

Three facts stand out about the Columbia's Chinook populations today:

- The majority of Columbia Chinook originate from hatcheries, which proliferated in response to modern development ravaging the basin's natural spawning and rearing habitats (NMFS 2018). However, the overall proportion from hatcheries has recently declined with reduced hatchery production, due to strict policies designed to protect wild salmon from potential genetic and ecological impacts of large hatchery runs.
- In the Columbia River, fishing effort is carefully controlled. On average an estimated 90.4% of all natural-origin (non-hatchery) Chinook that return to the river are protected from fishing (NMFS 2018). Precautionary, abundance-based rules curtail harvest rates when fish return to the river in low numbers, and fishing is regulated under strict impact limits that protect the weakest runs. Additional rules protect upriver tribal fishing rights and escapement. In-river run size and harvest rates are closely monitored, and managers can and do quickly curtail fishing when necessary to meet conservation targets. Taken together, these rules and practices ensure that enough fish escape from fisheries to swim home, spawn, and rebuild natural populations. These restraints on harvest sometimes provide a buffer against other sources of mortality that are harder to control, such as poor ocean survival and increasing fish kills in an overheated river and tributaries (courtesy of climate change, dams, and water withdrawals).
- Productivity of salmon populations in the Columbia —both hatchery and wild—is limited primarily by climate-related ocean conditions and by habitat constraints, not by fishing in the river. Columbia Basin hatcheries operated to support fisheries also increase the number of Chinook salmon available as prey to Southern Resident Killer Whales in the ocean (NMFS 2018).

Several layers of precautionary policies limit catches to protect salmon populations in the Columbia. Abundance-based rules curtail harvest rates when fish return in low numbers. Under the ESA, strict impact limits on the weakest populations constrain harvests on abundant runs. Additional rules protect upriver tribal fishing rights and escapement.

Uncertainties and knowledge risks persist, but overall**,** Chinook fisheries in the Columbia River operate under precautionary, adaptive management. Fishing is carefully limited, and spawning potential is protected from excessive fishing pressure. Hatcheries now operate under rules that are intended to complement and support recovery efforts. Risks from climate change are increasing, and important areas of spawning and rearing habitat are still closed to fish passage by dams and other obstructions. Nonetheless, in the Columbia below Bonneville the commercial catch of Chinook salmon and the hatcheries that support it are managed to support recovery of Chinook salmon.

Evaluation Chart

	Findings	Rating	Notes
1. Prey Interception Risk		**A**	
1.1 No Overlap			
Indicator 1.1.1			
Indicator 1.1.2			
1.2 Post-Prey	Target Chinook are fish entering the Columbia River from the ocean.		Chinook harvested from in-river fisheries have escaped from ocean feeding grounds of SRKW. Chinook die after spawning, so they don't return to the ocean feeding grounds.
Indicator 1.2.1	Indicator met.		
Indicator 1.2.2			
1.3 Negligible Effect			
Indicator 1.3.1			
2. Stock Risk		**A / B**	
2.1 Exploitation	All indicators satisfied with moderate to high confidence.	A	With minor caveats, these in-river fisheries meet the central goal of our stock risk standards: to avoid depleting the salmon populations that provide the main prey supply for SRKW.
Indicator 2.1.1: Exploitation Rate			
Indicator 2.1.2: Reference Points			
Indicator 2.1.3: ETP Species			
Indicator 2.1.4: Uncertainty → Precaution			
Indicator 2.1.5: Compliance			
Indicator 2.1.6: Timely Action			
2.2 Biomass	All indicators satisfied with moderate to high confidence.	A	
Indicator 2.2.1: Reference Points			
Indicator 2.2.2: Uncertainty → Precaution			
Indicator 2.2.3: Compliance			
Indicator 2.2.4: Timely Action			
2.3 Hatcheries	Indicators satisfied with moderate confidence.	B	Hatchery management practices for Chinook have improved significantly since the early 1900s. Many changes are a result of federal actions to protect the 13 groups of Columbia River salmon and steelhead
Indicator 2.3.1: Hatchery Management			
Indicator 2.3.2: All-H Integration			
Indicator 2.3.3: Uncertainty → Precaution			

					populations listed under the Endangered Species Act.
3. Knowledge Risk				**A / B**	
	3.1 Knowledge Risk for Interception			A	
		3.1.1 No Overlap			
		Indicator 3.1.1.1			
		Indicator 3.1.1.2			
		3.1.2 Post Prey	In-river fisheries target fish that have passed SRKW feeding grounds in the ocean and close to the river mouth.		Whales travel along the coast and feed on fish in marine waters near the river mouth, but NOAA reports no confirmed sightings of SRKW in the river. Some transient killer whales do enter the lower river to hunt seals and sea lions, but the fish-eating Southern Residents are believed to stay in marine waters.
		Indicator 3.1.2.1	Met with high confidence.		
		Indicator 3.1.2.2			
		3.1.3 Negligible Effect			
		Indicator 3.1.3.1			
	3.2 Knowledge of Stock Risk				
		3.2.1 Exploitation	All indicators satisfied.	A	Estimates of run size, exploitation rate, and stock composition are subject to uncertainties that are recognized, evaluated, and mitigated through harvest control rules that result in very precautionary escapement levels.
		Indicator 3.2.1.1: Exploitation rate			
		Indicator 3.2.1.2: Reference points			
		Indicator 3.2.1.3: Uncertainty and Error			
		Indicator 3.2.1.4: Compliance			
		Indicator 3.2.1.5: Timely Action			
		Indicator 3.2.1.6: ETP Species			
		3.2.2 Biomass	All indicators satisfied.	A	
		Indicator 3.2.2.1: Monitoring			
		Indicator 3.2.2.2: Reference Points			
		Indicator 3.2.2.3: Uncertainty → Precaution			
		Indicator 3.2.2.4: Compliance			
		Indicator 3.2.2.5: Timely Action			
		3.2.3 Hatcheries	Indicators are satisfied with moderate confidence through compliance with hatchery management requirements.	B	NMFS Biological Opinions set conditions and requirements for hatchery operations. These constitute a far-reaching system of oversight and ongoing improvement in hatchery practice
		Indicator 3.2.3.1: Hatchery management			
		Indicator 3.2.3.2: Monitoring			

			Indicator 3.2.3.3: Hatchery Marking and Tagging			and policy. Uncertainties and scientific debate about long-term effects of hatchery and wild fish interactions remain, but hatcheries now are managed to contribute to harvest, salmon recovery, and ecosystem needs, to limit potential risks, and to support adaptive potential (e.g. preserving gene banks for wild fish, preventing extinction of critically depleted runs such as Snake River sockeye and fall Chinook).
			Indicator 3.2.3.4: Uncertainty → Precaution			

Note: Any lines or sections left blank with greyed text are considered not applicable to the specific fishery under evaluation.

Full Evaluation Details

1. Prey Interception Risk (Post-Prey)

Chinook salmon are believed to escape from the hunting grounds of Southern Resident Killer Whales when they enter the fresh waters of the Columbia River. The whales do range along the coast and feed on these fish in marine waters near the river mouth.

Applicable approach and indicator: The relevant approach for this fishery is to assess whether it selectively targets fish that have already escaped from Southern Resident feeding grounds, qualifying the catch for "post-prey" status.

Details of this pathway for evaluation are:

Standard 1.2: Post-Prey. Chinook salmon caught in the fishery must have already passed through the feeding grounds of Southern Residents, caught in waters where the fish are approaching their home streams or hatcheries

> **Indicator 1.2.1:** Fishery occurs within SRKW range in a terminal or near-terminal area, and managers estimate with ≥ 80% confidence that at least 90% of Chinook encountered have already escaped from SRKW foraging waters en route to upstream spawning grounds or hatcheries.

FINDINGS

Indicator 1.2.1 is satisfied. NOAA reports that there have been no confirmed sightings of SRKW in the Columbia River. Harvest from in-river fisheries therefore consists of fish that are "no longer available to the whales in the ocean," according to NOAA's 2018 Biological Opinion on ESA compliance of Columbia River fisheries (NOAA 2018). Chinook salmon die after spawning (NOAA Species Directory, undated), so they do not return to the ocean feeding grounds.

Rating: A for Interception Risk

2. Stock Risk

Exploitation and Biomass Risk

Fisheries targeting Chinook salmon in the Columbia River today are tightly controlled, but external factors—notably climate change, reduced marine survival, impaired fish passage and degraded habitats—constitute ongoing constraints on recovery. Fishery managers have warned repeatedly that even the most precautionary harvest controls cannot countermand such habitat and climate impacts that erode productivity and survival in many salmon stocks.

Degradation or damming of habitat often limits potential spawning populations in watersheds. Variable ocean conditions such as the Pacific Decadal Oscillation and El Nino are well-known drivers of changes in abundance. Many scientists and managers also see an increasing influence from climate change, noting that heat spells, floods, and droughts are reducing productivity of both hatchery and wild salmon stocks.

FINDINGS

The following details the data and information gathered for indicators. For analysis, exploitation and biomass are grouped together.

Indicators 2.1.1 – Exploitation:

In-river fisheries operate under rules that keep exploitation rates well below levels that could deplete populations of naturally spawning fish (see discussion and tables below, under Reference Points). Low exploitation rates are primarily driven by measures to limit impacts on 13 groups of salmon populations that are listed under the Endangered Species Act (ESA).

Salmon hatcheries currently supply a majority of Chinook salmon returning to the river. Some 80 artificial propagation facilities—mostly run by states, federal agencies, and tribes—release salmon and steelhead to help offset loss of spawning and nursery grounds caused by dams, developments, and other human activities. Hatcheries can pose their own risks, but fish supplied by hatcheries now play an integral role in reducing fishery exploitation rates on wild Chinook in the Columbia, and they increase prey supply for SRKW in the ocean (NMFS 2018).

Hatcheries greatly reduce the normally high mortality that young salmon and steelhead face in the wild, especially in severely altered river systems such as the Columbia. They protect young fish in a controlled environment—providing favorable temperatures, stable waterflow, and protection from predators —until the fish are big enough to swim downriver and fatten up in their ocean pastures. However, hatchery fish are not exempt from high mortality caused by poor ocean conditions, overheated river waters, and other environmental threats such as climate-intensified droughts and floods. Poor survival in recent years has eroded returns of both hatchery and wild Chinook.

The combined effects of hatcheries and harvest in the Columbia now are scrutinized and regulated tightly under the Endangered Species Act (ESA). In a Biological Opinion (BiOp) evaluating tribal and non-tribal Columbia River fisheries (NMFS 2018), NOAA scientists considered potential effects of fishing on prey available to SRKW and potential for fishery-induced depletion of ESA-listed salmon populations in the basin. The BiOp authors stated that "we do not anticipate an effect on the Southern Resident killer whales' prey base from in-river harvest on hatchery Chinook salmon (i.e., the substantial majority of the catch)." Similarly, they noted that the in-river harvest of wild Chinook amounts to only a fraction of the adult fish hatcheries provide annually: about 81,000 per year. Hatchery production "more than offsets the reduction from harvest," the BiOp authors wrote.

The 2018 BiOp authors observed that 75% of upriver spring Chinook returning to the Columbia during 2008-2016 were returning to hatcheries. Managing in-river fisheries to target mainly hatchery fish is one approach used by state and tribal fisheries agencies to keep the impact on wild stocks well within low exploitation limits. The BiOp reports that during the 2008-2016 period, an average of 72,000 "natural origin[2]" Chinook salmon returned to the Columbia during spring, summer and fall runs each year, but in-river fisheries took an average of 6,900 annually. That amounts to less than 9.6% of the naturally spawned Chinook returning to the river. Thus, on average, 90.4% of wild Chinook returning to the river are protected from fishing, leaving a large buffer against other sources of mortality (which are increasing, e.g. due to climate change).

The percentage of each run allowed for harvest is limited by abundance-based control rules, which are described under Indicator 2.1.2 (Reference Points) below.

Indicators 2.1.2 and 2.2.2 – Reference Points for Exploitation and Biomass:

It should be noted that salmon fisheries generally use escapement goals to preserve spawning potential, so escapement goals (and measures to achieve them) serve as the proxy here for biomass reference points.

Management of Columbia River salmon, geared towards protection of weak stocks and ESA-listed populations, has resulted in several layers of reference points that are substantially more conservative than benchmarks based on Maximum Sustainable Yield (MSY). The NMFS 2018 Biological Opinion notes one exception in which MSY is used, but in practice limiting factors on harvest supersede it, resulting in escapement far above the MSY level (see discussion of North Fork Lewis River fall Chinook, below).

Harvest managers use several layers of reference points. These include: 1) impact limits designed to protect threatened and endangered fish under ESA; 2) abundance-based harvest rate schedules that constrain exploitation rates in fisheries, mostly to protect listed fish; 3) escapement goals at counting stations in the basin, which serve both to protect harvest for upstream treaty tribes and to leave enough fish to spawn; and 4) rebuilding goals, which seek to increase depleted populations.

The tables below show performance of 2018 and 2019 fall in-river fisheries in meeting ESA impact limits and exploitation rate goals on target and non-target fish. These data come from state fisheries agencies' regular post-season evaluation of catches and final estimated run sizes, published in the 2019 and 2020 fall Joint Staff Reports (WDFW & ODFW 2019b and WDFW & ODFW 2020b). The 2018 and 2019 fall fisheries targeted Upriver Bright (URB) Chinook and Lower River Hatchery (LRH) Chinook. Incidental catch impacts on Snake River natural-origin

[2] *Note on terminology: In this case, "naturally spawned" may have been the intended meaning for "natural origin."*

Chinook were carefully controlled to keep the exploitation rate below guideline levels. Impacts on steelhead, chum, and coho salmon were held to single-digit rates well below the guidelines in both years. The final lines of each table show that managers kept catches well below the estimated "harvestable surplus" of upriver Chinook. Restraints on harvest ensured that escapement of fish into the upper river above McNary Dam exceeded the agreed minimum of 60,000 fish by 66% in 2018 and more than doubled this requirement in 2019.

2018 Management	Total	Goal/ Guideline
Total URB HR	**29.57%**	**31.25%**
Non-Treaty	9.35%	8.25%
Treaty Indian	20.22%	23%
Snake River Natural-origin HR	**29.57%**	**31.25%**
Non-Treaty	9.35%	8.25%
Treaty Indian	20.22%	23%
LRH Ocean/Inriver ER	**34.5%**	**38%**
In-River ER	*8.9%*	
Non-Treaty Natural-origin A-Index Steelhead	**1.4%**	**2.0%**
Non-Treaty Natural-origin B-Index Steelhead	**1.0%**	**2.0%**
Treaty Total B-Index Steelhead	**5.3%**	**13.0%**
Lower Columbia Chum	**0.03%**	**5.0%**
Percent of Upriver Chinook Harvestable Surplus		
Non-Treaty	37%	50%
Treaty Indian	42%	50%
McNary Escapement	100,030	60,000
Percent Upriver Coho to Bonneville Dam	71%	50%

2019 Management	Total	Preseason Goal/ Guideline
Total URB HR	**26.58%**	**31.25%**
Non-Treaty	7.37%	8.25%
Treaty Indian	19.21%	23%
Snake River Natural-origin HR	**26.58%**	**31.25%**
Non-Treaty	7.37%	8.25%
Treaty Indian	19.21%	23%
LRH Ocean/Inriver ER	**31.3%**	**38%**
In-River ER	*10.3%*	
Non-Treaty Natural-origin A-Index Steelhead	**0.61%**	**2.0%**
Non-Treaty Natural-origin B-Index Steelhead	**1.19%**	**2.0%**
Treaty Total B-Index Steelhead	**6.94%**	**13.0%**
LCN Coho	**19.45%**	**23.0%**
Lower Columbia Chum	**0.20%**	**5.0%**
Percent of Upriver Chinook Harvestable Surplus		
Non-Treaty	26%	50%
Treaty Indian	29%	50%
McNary Escapement	128,862	60,000
Percent Upriver Coho to Bonneville Dam	60%	50%

Source: Fall 2019 and 2020 Joint Staff Reports, WDFW & ODFW

This performance in protecting escapement is especially notable for 2018, when fewer fall Chinook than expected returned to the Columbia: the total run fell about 22% below its forecast numbers (calculated from data reported in Table 2 of Fall 2019 Joint Staff Report, ibid). The 2019 fall Chinook return, estimated at 375,769 fish, was about 7.5 percent above forecast (calculated from Table 2, fall 2020 Joint Staff Report, ibid). Both tables are reproduced below.

Table 2. Columbia River fall salmonid returns, forecasts and actual, 2018-2019. [1,2]

			2018		2019
			Forecast	Return	Forecast
Fall Chinook	LRH - Lower River	Hatchery	63,910	52,963	55,100
	LRW - Lower River	N-O	7,860	8,270	14,100
	BPH - Bonneville Pool	Hatchery	51,420	28,861	48,400
	URB - Upriver Bright		205,060	149,043	159,300
	Snake River	N-O	*9,600*	*10,642*	*8,600*
	LRB - L. River Brights	N-O	3,760	14,235	7,900
	PUB - Pool Upr. Br.	Hatchery	38,200	36,009	61,800
	SAB - Select Area Br.	Hatchery	5,300	4,043	3,100
	Total Fall Chinook		**375,510**	**293,424**	**349,700**
Coho	Early stock		127,200	78,913	388,000
	Late stock		86,400	59,467	223,300
	Total Coho		**213,600**	**138,380**	**611,300**
Upriver Summer Steelhead (to Bonneville Dam)	Upriver Skamania Index	**Total**	**7,950**	**6,483**	**8,750**
		N-O	*3,000*	*2,595*	*3,200*
	A-Index	**Total**	**158,000**	**69,338**	**110,200**
		N-O	*44,800*	*21,725*	*33,900*
	B-Index	**Total**	**24,400**	**24,662**	**8,000**
		N-O	*3,400*	*2,382*	*950*
	Total Upriver Steelhead	**Total**	**190,350**	**100,483**	**126,950**
		N-O	*51,200*	*26,702*	*38,050*

[1] *Columbia River mouth return, except summer steelhead is Bonneville Dam return. Numbers may not sum due to rounding.*

[2] *Natural origin (N-O)*

SOURCE: Fall 2019 JSR

Table 2. Columbia River fall salmonid forecasts and actual returns, 2019-2020. [1,2]

Species/Stock			2019		2020
			Forecast	Return	Forecast
Fall Chinook	LRH - Lower River	Hatchery	55,100	48,914	50,200
	LRW - Lower River	N-O	14,100	16,661	19,200
	BPH - Bonneville Pool	Hatchery	48,400	28,954	45,500
	URB - Upriver Bright		159,300	212,238	227,600
	Snake River	N-O	*8,600*	*15,231*	*10,900*
	LRB - L. River Brights	N-O	7,900	9,925	7,700
	PUB - Pool Upr. Br.	Hatchery	61,800	58,140	69,300
	SAB - Select Area Br.	Hatchery	3,100	937	1,000
	Total Fall Chinook		**349,700**	**375,769**	**420,500**
Coho	Early stock		388,000	144,933	103,000
	Late stock		223,300	67,400	37,100
	Total Coho		**611,300**	**212,333**	**140,100**
Upriver Summer Steelhead (to Bonneville Dam)	Upriver Skamania Index	**Total**	**8,800**	**3,134**	**4,400**
		N-O	*3,200*	*1,522*	*1,800*
	A-Index	**Total**	**110,200**	**66,174**	**85,900**
		N-O	*33,900*	*30,300*	*33,300*
	B-Index	**Total**	**8,000**	**6,292**	**9,600**
		N-O	*950*	*899*	*1,400*
	Total Upriver Steelhead	**Total**	**127,000**	**75,600**	**99,900**
		N-O	*38,050*	*32,721*	*36,500*

[1] *Columbia River mouth return, except summer steelhead is Bonneville Dam return. Numbers may not sum due to rounding.*

[2] *Natural origin (N-O)*

SOURCE: Fall 2020 JSR.

Abundance-based harvest rate schedules are a central mechanism of harvest policy in the Columbia river. These schedules adjust the allowable catch based on indicators of abundance, setting thresholds for reducing or halting fishing. These schedules also apply "weak stock management," a key tool of modern conservation practice in salmon fisheries where different runs of salmon mingle in the water. Abundance of the most depleted natural runs (especially ESA-listed populations) effectively sets the brakes on exploitation rates for other fish that migrate up the river at the same time. This requires foregoing potential catch of healthier stocks in order to ensure enough fish from small runs escape from fisheries to rebuild those populations.

A time series of upriver spring Chinook harvest and escapement in the Columbia illustrates the effect of abundance-based management in this fishery. Since the 1980s, the upriver spring Chinook run has fluctuated in size, with a low return of 12,792 fish in 1995 and a high of 439,885 in 2001. The data below are excerpted from Table 5 in the Spring 2020 Joint Staff Report (WDFW & ODFW 2020a). The two columns on the right, "Escapement past Zone 6," and "Escapement % of run," represent fish that have escaped past the major nontribal and tribal fisheries. Escapement has been at least 80% of the run in all but one year since 2009.

Columbia River Spring Chinook harvest and Escapement

Year	***Upriver run***	***Nontreaty harvest***	***Treaty harvest***	***Escapement past zone 6 fisheries***	***Escapement % of run***
2009	169,296	21,807	11,727	135,762	80%
2010	315,346	37,956	41,507	235,883	75%
2011	221,158	15,727	15,806	189,626	86%
2012	203,090	16,642	17,584	168,865	83%
2013	123,136	10,202	7,368	105,566	86%
2014	242,635	17,689	28,892	196,054	81%
2015	288,994	23,436	31,899	233,660	81%
2016	187,816	15,202	17,019	155,596	83%
2017	115,821	8,297	8,111	99,413	86%
2018	115,081	7,036	11,027	97,018	84%
2019	73,101	1,866	4,896	66,339	91%

Non-treaty harvest in this table includes both recreational and commercial catch; recreational catch constitutes the majority, and accounts for 100% of this harvest after 2016.
SOURCE: Table 5, Spring 2020 Joint Staff Report (WDFW & ODFW 2020a)

The combined operation of abundance-based and weak-stock management approaches can be seen in the harvest rate schedule and recent catches for the fall Upriver Bright (URB) Chinook (below). This is one of the most abundant Chinook stock groups in the Columbia, with an average run size of 427,440 fish from 2009-2018. Seven wild and hatchery-origin stocks comprise the Columbia River fall Chinook return. Upriver Brights constitute about 51% of the total return (WDFW & ODFW 2020a). Harvest rates are restrained both by the recent low overall abundance of URB fish and by measures designed to protect the weakest stock in the group, the ESA-listed Snake River fall Chinook population.

The Snake River fall Chinook population collapsed after a series of dams closed off about 80% of its spawning habitat. This run once produced an annual return of half a million adult Chinook. By 1990 it had dwindled so far that only 78 fish reached the Lower Granite Dam on the Lower Snake River (CRITFC 2020). The run was listed as threatened in 1992. Since then tribes and state and federal fisheries agencies have labored to rebuild Snake River wild Chinook.

They have made headway despite continuing mortalities at sea, continuing effects of dams, and dangerously high river temperatures that can weaken and kill both young fish and returning adult fish during the summer and fall when flows are low (Martins et al 2011, Haskell et al 2017, Maier 2015). Partly by invoking ESA authorities, the co-managers have substantially increased adult abundance since the mid-1990s, according to the 2018 NMFS BiOp. In the decade prior to 2018, an average of 11,084 natural-origin adult Chinook escaped past Lower Granite Dam, well above the minimum threshold of 4,200. Stock productivity was quantified at 1.5 for fish spawned during the 20 years ending in 2009—indicating that with each generation, about 50% more fish survived to reproduce (NMFS 2018). A Nez Perce tribal hatchery program launched in 2003 seeks both to preserve genetic integrity of the Snake

River fall Chinook and to rebuild the run for harvest and reproduction, raising fish "to behave like their natural counterparts" (CRITFC 2020).

Nevertheless, the Snake River fall Chinook still need protection. While habitat and climate threats remain largely unchecked, tight limits on harvest have enabled the co-managers to get more fish to the spawning grounds. As noted above, abundance-based exploitation and escapement rules that protect this stock continue to constrain the fall fisheries on the other Chinook swimming up through the Columbia.

In the table below, expected size of the Upriver Bright run entering the Columbia River (left column) brackets the allowable exploitation rate. Expected size of the ESA-listed Snake River run further restrains harvest rates for fall Chinook fisheries in the Columbia.

Harvest rates allowed to both treaty tribal and non-treaty (all-citizens) fisheries are adjusted as the run size fluctuates. Protections for Snake River stocks frequently limit harvests of other fish. At the low end, total harvest rate would be capped at 21.5% on all Upriver Bright (URB) Chinook stocks, if the fall wild Chinook run entering the Snake River declines below 1,000 fish. At the high end, a run expected to exceed 8,000 fish at the mouth of the Snake could allow a catch of as much as 45% of returning URB fish. In practice, precautionary harvest management in recent years has kept the exploitation rate well below that maximum allowable level, even when escapement exceeds the threshold of 8,000. In 2019, for example, total harvest rates on URB fish were restrained to 26.58%, although abundance as high enough that 45% was technically allowable (data from Table 37, fall 2020 JSR). Total impacts of 2019 in-river commercial Chinook fisheries on the ESA-listed Snake River fall Chinook amounted to 1.8% of the run size estimated at the Columbia River mouth (ODFW 2020).

Below, Table A3 from the Fall 2019 Joint Staff Report (WDFW and ODFW 2019b) describes the abundance control rule in this case.

Table A3. Chinook harvest rate schedule for fall management period.

Expected URB River Mouth Run Size	Expected River Mouth Snake River Natural-origin Run Size [1]	Treaty Total Harvest Rate	Non-Treaty Harvest Rate	Total Harvest Rate	Expected Escapement of Snake R. Natural-origin Past Fisheries
<60,000	<1,000	20%	1.50%	21.50%	784
60,000	1,000	23%	4%	27.00%	730
120,000	2,000	23%	8.25%	31.25%	1,375
>200,000	5,000	25%	8.25%	33.25%	3,338
	6,000	27%	11%	38.00%	3,720
	8,000	30%	15%	45.00%	4,400

1. If the Snake River natural fall Chinook forecast is less than the level corresponding to an aggregate URB run size, the allowable mortality rate will be based on the Snake River natural fall Chinook run size.
2. Treaty Fisheries include; Zone 6 Ceremonial, subsistence, and commercial fisheries from Aug 1-Dec 31.
3. Non-Treaty Fisheries include: Commercial and recreational fisheries in Zones 1-5 and mainstem recreational fisheries from Bonneville Dam upstream to the confluence of the Snake River and commercial and recreational SAFE (Selective Areas Fisheries Evaluation) fisheries from August 1-December 31.
4. The Treaty Tribes and the States of Oregon and Washington may agree to a fishery for the Treaty Tribes below Bonneville Dam not to exceed the harvest rates provided for in this Agreement.
5. Fishery impacts in Hanford sport fisheries count in calculations of the percent of harvestable surplus achieved.
6. When expected river-mouth run sizes of naturally produced Snake River Fall Chinook equal or exceed 6,000, the states reserve the option to allocate some proportion of the non-treaty harvest rate to supplement fall Chinook directed fisheries in the Snake River.

SOURCE: Fall 2019 Joint Staff Report, WDFW & ODFW 2019b. Note: numbering of copied tables and graphs is from source documents.

Abundance-based harvest control rules govern exploitation rates for multiple salmon runs in the Columbia. The table to the right describes the harvest guideline for Lower Columbia tule Chinook, a naturally spawning group whose run size is estimated based on returns of hatchery-marked fish in the Lower River Hatchery (LRH) group, which is considered a valid indicator of the abundance of tules. As abundance fluctuates, harvests both in the ocean and in the river are adjusted to meet the exploitation rate schedule. Since 2018, abundance of LRH Chinook has fallen well below the recent average returns.

Exploitation Rate Schedule for LCR Tule Chinook	
LRH Abundance	Exploitation Rate
0-30,000	0.30
30,000 -40,000	0.35
40,000 -85,000	0.38
> 85,000	0.41

SOURCE: Fall 2019 Joint Staff Report WDFW & ODFW 2019b

The seven hatcheries in the LRH group saw a return of just 48,914 fish in 2019, which is 54% of the 2009-2018 average of 90,870 fish (WDFW & ODFW 2020b).

The table below shows allowable exploitation rates for in-river fisheries under ESA take limits for listed salmon in the Columbia Basin, as described in a 2017 NMFS BiOp evaluating several upriver hatchery programs. Note that steelhead are targeted only by recreational and tribal fishers.

ESU or DPS	Take Limits (%)	Treaty Indian (%)	Non-Indian (%)
Snake River fall-run Chinook Salmon	21.5 – 45.0 [1]	20.0 – 30.0	1.5 – 15.0
Snake River spring/summer-run Chinook Salmon	5.5 – 17.0 [2]	5.0 – 14.3 [2]	0.5 – 2.7
LCR Chinook Salmon	Managed by components listed below		
spring-run component	Managed For Hatchery Escapement Goals	0	[3]
tule component (early-fall run)	41% Exploitation Rate[4]	0	41% exploitation rate[4]
bright component (late-fall run)	Managed For Escapement Goal	0	5,700 escapement goal
UWR Chinook Salmon	15.0	0	15.0
Snake River Basin Steelhead	Managed by components listed below		
A-Run Component	4.0 [5]	[6]	4.0
B-Run Component	15 – 22 [7]	13 – 20 [7]	2.0 [7]
LCR Steelhead	Managed by components listed below		
winter component	2.0	[6]	2.0
summer component	4.0 [5]	[6]	4.0
UWR Steelhead	2.0 [5]	0	2.0
MCR Steelhead	Managed by components listed below		
winter component	2.0	[6]	2.0
summer component	4.0 [5]	[6]	4.0
UCR spring-run Chinook Salmon	5.5 – 17.0 [2]	5.0 – 14.3 [2]	0.5 – 2.7
CR Chum Salmon	5.0	0	5.0
UCR Steelhead	Managed by components listed below		
Natural-Origin Component	4.0 [5]	[6]	4.0
Hatchery- Origin Component	[8]	[8]	[8]
Snake River Sockeye Salmon	6.0 – 8.0 [1]	5.0 – 7.0	1.0
LCR Coho Salmon	10 – 30 [9]	0	10 – 30 [9]
Monitoring, Evaluation, and Research	0.1 - 0.5 [10]		

[1] Allowable take depends on run size.
[2] Impacts in treaty fisheries on listed wild fish can be up to 0.8% higher than the river mouth runsize harvest rates (indicated in table above) due to the potential for changes in the proportion wild between the river mouth and Bonneville Dam.
[3] NMFS (2012c) determined fisheries have ranged from exploitation rates of 2% to 28% over the last ten years, and are expected to remain within this range through managing for hatchery escapement until other actions concerning terminal fish passage in the LCR are addressed.
[4] Total exploitation rate limits include ocean and mainstem Columbia River fisheries. NMFS (2012c) evaluated the PFMC's harvest matrix for total exploitation, including ocean and mainstem Columbia River fisheries, tiered on abundance.
[5] Applies to non-Indian fisheries only; 2% in winter/spring/summer seasons and 2% in fall season.
[6] There is no specific harvest rate limit proposed for treaty fisheries on winter steelhead above Bonneville Dam or on A-run summer steelhead.
[7] For fall fisheries only.
[8] There is no take prohibition on ad-clipped hatchery fish even if they are part of a threatened ESA-listed group.

SOURCE: NMFS 2017a: BiOp on hatcheries in upper Columbia River basin.

Court rulings that uphold tribal treaty rights have led to management agreements that drive some of the management reference points for Columbia River salmon and steelhead. These policies generally are designed to ensure that enough fish reach their upriver tribal fishing locations and spawning grounds. As sovereign nations, tribes retained their fishing rights when they signed treaties in 1855 allowing the United States to take over and populate most of their lands. A multi-year joint management agreement between tribes and U.S. and state governments restrains fishing on all salmon stocks returning to waters above Bonneville Dam, including the Upriver Bright Chinook, the main target of fall Chinook fishing on the mainstem Columbia. Two sequential escapement requirements apply: first to allow 50% of the run to escape past Bonneville, second to deliver escapement of at least 60,000 returning adult fish to waters above McNary Dam, (WDFW & ODFW 2019a). That sets the floor for escapement past McNary 50% above the MSY-based escapement level of 40,000 fish, as specified in the federal fishery management plan for West Coast salmon fisheries (PFMC 2016).

Escapement goals and recovery goals for listed stocks provide additional layers of protection for spawning capacity. In the Columbia as elsewhere, salmon returns are challenged by severe impacts of habitat degradation in watersheds and, more recently, high temperatures that are believed to reduce survival at sea and in rivers, e.g. by reducing feed quality in the ocean, especially during the warm "Blob" years in 2015 and 2016 (NMFS 2018). These impaired habitat conditions have eroded Chinook populations coastwide, making spawning escapement goals and recovery goals harder to attain. Nonetheless, state and tribal co-managers in the Columbia Basin and authors of the 2018 NMFS BiOp noted that many runs and hatcheries in the basin were meeting or exceeding these goals, in part due to major efforts to restore habitat and rebuild depleted runs.

Fishery managers have warned repeatedly that even the most precautionary harvest controls cannot countermand climate impacts that erode productivity and survival in many salmon stocks. The peak years of the "Blob" in 2015 and 2016 produced "some of the poorest outmigration years for juvenile salmon survival in the 20-year time series" (NMFS 2018). Many salmon managers believe this event set the table for poor survival in fish swimming home in 2019 and 2020.

Management to protect weak stocks, especially ESA-listed populations, has resulted in layers of reference points that protect spawning potential of salmon and steelhead well beyond requirements of any MSY-based escapement goal. The single example of an MSY-based escapement goal noted in the 2018 NMFS BiOp for Columbia River fisheries applies to adult salmon returning to the North Fork Lewis River population of late-fall Chinook, on the Washington side of the lower Columbia River. This is a natural-origin population with little or no hatchery influence, according to the 2018 NMFS BiOp. For this stock, managers have set an MSY-based escapement goal of 5,700 fish. However, once again, superseding constraints on harvest have resulted in much higher escapement. The 2018 BiOp authors note that "escapement has averaged 9,000 over the last ten years and has generally exceeded the goal by a wide margin since at least 1980" (NMFS 2018). That margin widened further during the decade to 2018 when escapement averaged 12,400. At that level, the stock was "exceeding the delisting abundance goal for the North Fork Lewis River population," the BiOP authors noted.

Recovery goals represent another set of reference points for conservation and restoration. Achieving these goals often requires more than merely restricting harvests, because the resource suffers from multiple insults that are more difficult to restrain. For ESA-listed salmon species, NMFS BiOp authors (NMFS 2018) apply "viable salmonid population" (VSP) criteria, built on four parameters for assessing the viability of populations: abundance, productivity, spatial structure, and diversity. One example of this approach is Lower Columbia River Chinook. This group of stocks were listed as a single "threatened" Evolutionarily Significant Unit (ESU) under ESA in 1999, encompassing both natural spawning and hatchery fish that share common ecological and genetic characteristics and inhabit the river and its tributaries downstream of Celilo Falls (a historic waterfall just east of the Cascade Mountains; Celilo was inundated by a dam at The Dalles in 1957). Degradation and destruction of habitat by multiple human actions over the last 150 years has whittled down these stocks and continues to limit populations of salmon and steelhead in the Lower Columbia (NMFS 2018). Despite some recent increases in fall-run populations, NMFS BiOp authors judged that "the majority of the populations in this ESU remain at high risk," and noted that "most are still far from their recovery plan goals" (NMFS 2018).

Indicators 2.1.3 – ETP Species:

Southern Resident Killer Whales, 13 listed assemblages of salmon and steelhead, and two listed populations of sturgeon and eulachon are considered in recent NMFS Biological Opinions evaluating fishery effects on endangered, threatened and protected (ETP) species under the ESA.

NMFS evaluated effects of Columbia River fisheries on all these stocks in its 2018 BiOp on the formal management agreement for Columbia River fisheries between tribes, states, and federal agencies. The U.S. Fish and Wildlife Service also prepared a Biological Opinion on listed freshwater species that could be affected by fisheries under that management agreement.

As noted above, authors of the 2018 NMFS BiOp judged that any effect of Columbia River salmon fisheries on prey available to the endangered SRKW is "more than offset" by hatchery production. They concluded that fisheries in the river are not likely to adversely impact SRKW, a standard that requires zero to near-zero effect. Having found no discernible impact on prey abundance, they noted that the Columbia River fisheries are not likely to jeopardize the Southern Residents.

While fisheries in the river target healthy stocks, they do incidentally take some fish from populations that are protected under the ESA. These impacts are acknowledged and regulated under the ESA to support recovery. Following standard practice, the 2018 BiOp authors evaluated and quantified fishery impacts, imposed incidental take limits on fishery-induced mortalities, and set requirements to support recovery through multiple controls on the fishery, including both harvest management and hatchery operations. Required measures include: use of best available monitoring methods to track incidental impacts on listed fish species; use of in-season management actions and monitoring to ensure compliance with impact limits for incidental catch of ESA-listed fish; monitoring for competition and predation effects of hatchery programs that support fish populations and harvests in the Columbia basin; annual reporting to NMFS of take limits and research, monitoring and evaluation activities associated with the fisheries, and more.

Two other species of concern along the Columbia are the freshwater bull trout and the Bliss Rapids snails. The U.S. Fish and Wildlife Service in 2018 issued a Biological Opinion evaluating potential impacts of the Columbia River salmon fisheries on freshwater bull trout and Bliss Rapids snails (USFWS 2018). The USFWS authors concluded that the planned harvests are "not likely to appreciably reduce reproduction, numbers, and distribution of the bull trout at the local population, core area, or range-wide scales." The USFWS BiOp authors noted that the hatcheries do not jeopardize bull trout and may provide them with useful marine nutrients and even prey in the form of salmon eggs from hatchery-origin spawners. The agency also found no jeopardy to the Bliss Rapids snail, noting that adverse impacts of hatchery operations "are not expected to appreciably reduce the likelihood of survival and recovery" of the species.

While some seabird entanglement has been documented in many fisheries that use gillnets (Wiedenfeld et al 2012), studies of these encounters in Columbia River fisheries suggested that impacts were small. A 1995 U.S. Forest Service report (Carter et al 1995) noted that observer programs in Columbia River gillnet fisheries during 1991, 1992, and 1993 recorded no killing of marbled murrelets. The marbled murrelet is listed as threatened. This diving, fish-eating bird has suffered steep population declines in the Pacific Northwest, mainly due to logging of coastal old-growth forests where it nests. However, the USFWS describes gillnet entanglement as one of several marine environmental threats to the species, along with harmful algal blooms, prey availability, oil spills, and impacts of climate change on the birds' prey supply (USFWS 2020).

On the lower Columbia River, a more commonly raised concern about seabirds is predation on out-migrating salmon smolts by Caspian terns, a trend linked to human actions that dramatically altered their habitat. Already widely distributed, these fish-eating birds colonized an artificial dredge-spoil island in the river and grew into a large, hungry breeding population accounting for about 25% of the total North American population of this species (Roby et al 2005). Caspian terns nesting on Rice Island were estimated to consume 11 to 12 million smolts annually, and some estimates ranged as high as 25 million (Harrison 2018a). In 2000, the NMFS concluded that predation by terns hindered recovery of threatened and endangered salmonids in the Columbia Basin. The terns were thought to be killing 5–30% of juvenile steelhead from some upriver populations. Finally, in 2007 most of the Rice Island tern colony was relocated to another island closer to the river mouth (where birds could forage on more plentiful marine fish); alternative nesting sites also were provided at six locations along the West Coast as far south as Northern California. These interventions reduced tern predation on smolts by 50% or more (Harrison 2018a).

The Columbia River salmon fisheries also interact with marine mammals in the Columbia River, but studies and policy initiatives on this issue focus mainly on predation, not entanglement. Concern about seals and sea lions feeding on salmon populations has increased in recent years as the mammal populations have grown. Sea lions may have taken 11% of the spring Chinook returning to the Columbia in 2010, and as much as 43% in 2014

(Harrison 2018b). Historically, the state of Oregon's Fish Commission paid a bounty on seals starting in 1936. From 1959 to 1970 the Commission also hired a seal hunter. The professional hunter's job was "to actively harass seals during the open commercial seasons," and "drive seals out of the Columbia River" with the aim of reducing predation on salmon held in fishermen's nets (Fish Commission of Oregon, 1972). As with most predator control programs, effectiveness of the effort was difficult to document. Officials doubted it worked and recommended ending the contract with the hunter and reducing the bounty (ibid).

Indicators 2.1.4 & 2.2.2 – Uncertainty → Precaution:

State and tribal managers of Columbia River fisheries incorporate multiple precautionary measures to minimize risks arising from uncertainties in critical management data. A few examples of these measures:

- 30% buffer on run forecasts: To protect listed spring Chinook runs from inadvertent overharvest, a 30% buffer is reserved during the early season non-treaty fisheries in the mainstem Columbia (WDFW& ODFW 2020a). This translates into a 30% reduction in allowable harvest rates for spring Chinook. This buffer of extra fish can be released for harvest later if enough fish show up to confirm the forecast. Meanwhile the set-aside fish are effectively reserved to ensure spawning escapement and upriver tribal harvests, in case a run shows up smaller than expected. This policy is built into the formal, multi-year management agreement between tribes, states and federal agencies that govern in-river fisheries.
- Weekly in-season updates on catch and run size indicators: Resource managers meet roughly once a week during the fishing seasons to evaluate incoming data and adjust fishery regulations as needed.
- Localized abundance indicators: As fish migrate upstream, managers assess run strength and stock composition from a succession of data sources that provide increasing resolution and reliability. Counts and estimates of run strength from dams, in-river fisheries, tag and marking data, and other sources follow the fish upriver. Fish counts at Bonneville Dam, for example, inform management of tribal fisheries above the dam (NMFS 2018 p272).
- Monitoring survival in transit: Passive Integrated Transponder (PIT) tags and Coded Wire Tags have helped to clarify run timing and adjust harvest rules for more precise targeting, notably since the mid-2000s, (see discussion of PIT tags in upriver Chinook in NMFS 2018, p264-268). These data have improved understanding of survival in transit through the multitude of dams on the rivers. One important result is that these data show the influence of temperature on survival (NMFS 2018 p268). Among Snake River summer Chinook, survival en route to Lower Granite Dam is much higher (76%) among fish that pass Bonneville in temperatures <16°C (60.8°F). Survival drops to 41% in fish passing Bonneville at >16°C (and these fish amount to 71% of the run). High spill rates also affect survival: the second lowest survival of late timed Snake Chinook occurred in 2011 when flows were 50% above normal.

Indicators 2.1.5 & 2.2.3 – Compliance:

Columbia River resource managers have a track record of keeping harvest rates within conservation limits, both for the major target stocks and for populations that are depleted. Overages do occur, but they are rare, generally minor, and rapidly corrected.

Compliance with harvest-rate limits is documented in multiple data sets. One example is the time series of actual and allowed harvest rates for Upriver Brights (URB) and Snake River fall Chinook. Combined harvest rates for treaty and non-treaty fisheries in the river were kept below the limits in 11 out of most recent 12 years; that amounts to a compliance rate of 91.7%. The single exceedance in this time series occurred in 2009, yet even in that year managers were able to deliver escapement of 80% of the run (see excerpt from Table A3 above, under Exploitation). Managers' performance in restraining URB Chinook harvests to protect Snake River fall Chinook is shown in the time series of actual versus allowed harvest rates in Table 37 from the Fall 2020 Joint Staff Report (WDFW & ODFW 2020b), reproduced below.

Performance in achieving escapement goals is strong for many runs, but in some instances (e.g., Lewis River late fall Chinook) escapement fell short during a period of poor ocean survival from 2006 to 2008. Authors of the NMFS Biological Opinion (NMFS 2018) note that escapement improved in 2009 and has been "well above goal since," with variability in returns resulting in escapements that ranged from a low of 6,283 in 2009 to a high of 23,614 in 2015.

As noted above, recovery goals for ESA listed stocks provide another metric. Here, management performance has been mixed, primarily due to variations in abundance that are not driven by fishing. Ocean survival has been a major determinant of abundance, generally linked to climatic influences. Within the Columbia Basin, degradation or damming of habitat often limits potential spawning populations. In the Snake River, the current benchmark for recovery of spring/summer Chinook salmon is 25,500 fish reaching Lower Granite Dam; variable ocean conditions such as the Pacific Decadal Oscillation and El Niño are well-known drivers of changes in abundance. Many scientists and managers also see an increasing influence from climate change, noting that heat spells, floods, and droughts are reducing productivity of both hatchery and wild salmon stocks.

Table 37. Upriver Bright and Snake River natural-origin fall Chinook in-river harvest rates, 2007-2019.

Upriver Bright Harvest Rates				
Year	Treaty	Non-Treaty	Total	Post-Season Allowed
2007	16.02%	6.60%	22.62%	31.29%
2008	19.91%	7.63%	27.54%	31.25%
2009 [1]	27.35%	10.59%	37.94%	31.25%
2010	18.02%	7.95%	25.97%	33.25%
2011	19.55%	13.40%	32.95%	45.00%
2012	20.53%	14.22%	34.75%	45.00%
2013	20.60%	11.03%	31.63%	45.00%
2014	22.42%	12.47%	34.90%	45.00%
2015	20.07%	11.46%	31.53%	45.00%
2016	23.30%	14.80%	38.10%	45.00%
2017	26.30%	16.10%	42.40%	45.00%
2018	20.22%	9.35%	29.57%	31.25%
2019 [2]	19.21%	7.37%	26.58%	45.00%
Snake River Natural Origin Harvest Rates				
Year	Treaty	Non-Treaty	Total	Post-Season Allowed
2007	16.02%	6.60%	22.62%	31.29%
2008	19.91%	7.63%	27.54%	31.25%
2009 [1]	27.35%	10.59%	37.94%	31.25%
2010	18.02%	7.95%	25.97%	33.25%
2011	19.55%	13.40%	32.95%	45.00%
2012	20.53%	14.22%	34.75%	45.00%
2013	20.70%	10.58%	31.29%	45.00%
2014	22.37%	12.23%	34.60%	45.00%
2015	20.12%	11.21%	31.33%	45.00%
2016	23.30%	14.60%	37.90%	45.00%
2017	26.30%	15.95%	42.25%	45.00%
2018	20.22%	9.35%	29.57%	31.25%
2019 [2]	19.21%	7.37%	26.58%	45.00%

[1] Due to the final SRW abundance, post-season allowed harvest rates were reduced from 27% and 11% for treaty and non-treaty fisheries, respectively.

[2] Due to the URB abundance exceeding 200,000 based on the final run-reconstruction, post-season allowed harvest rates increased from preseason rates of 23% and 8.25% for treaty and non-treaty fisheries, respectively.

SOURCE: Fall 2020 Joint Staff Report (WDFW & ODFW 2020b)

Indicators 2.1.6 & 2.2.4 – Timely Action:

Managers receive data on catch volumes daily when fishing is underway and quickly adjust fishing limits, sometimes within hours. Allowable harvests are adjusted based on updates to estimated run-sizes as data come in from catches, fish counts at dams, data on recoveries of tagged and fin-clipped fish (which can be traced to specific runs), and visual stock identification, among other sources. In one example, managers met on a Tuesday in August 2019 and noticed a higher-than-expected catch of Upriver Brights in fish samples delivered to buying stations that morning. The following day they shut down the mainstem Columbia commercial fishery to keep the fleet within its

1.9% early-season exploitation rate limit. The fleet had used about 60% of its allowed percentage of Upriver Brights, and managers concluded another day of fishing might lead to an exceedance of the exploitation rate.

Ratings: A for Exploitation Risk, A for Biomass Risk

Hatchery Risk

FINDINGS

Indicators 2.3.1 to 2.3.3 (hatchery management, all-H integration—referring to hatchery, harvest, habitat, and hydroelectric operations—and precautionary responses to uncertainty) are satisfied with moderate confidence by multiple measures taken since the early 1990s to improve hatchery practices for salmon throughout the Columbia River Basin. Most of these changes result from federal actions to protect the 13 groups of Columbia River salmon and steelhead populations listed under the Endangered Species Act.

Hatchery production has been reduced significantly the last few years, but at one point, it was estimated that as much as 90% of all Chinook returning to the Columbia River were released from hatcheries scattered throughout this vast watershed, which extends from the Rocky Mountains to the Pacific. By 2010, 208 hatchery programs were reported to be producing salmon and steelhead in the Columbia basin (BPA 2010), many of them intended to mitigate losses of habitat and fish caused by dams. Some hatchery programs have since been closed. At least 281 hydroelectric dams of various sizes and "about 200 more dams built for other purposes, such as irrigation and flood control" exist in the Columbia basin today (NWPCC 2020b). Dozens of hatchery programs are intended to mitigate impacts of hydroelectric dams, a task funded by Congress under the Mitchell Act since the 1940s. Hatcheries serve many other purposes, including but not limited to preserving remnant gene pools, providing fish to repopulate sub-basins, meeting treaty obligations to protect upriver tribes' fisheries, and mitigating fishery losses from industrial activities and developments that degrade habitat.

Since the first ESA listing of fish in the Columbia River Basin (Snake River sockeye salmon in 1991), a series of federal reviews of hatchery operations have spurred changes in hatchery practices. These efforts are believed to be reducing hatchery risks to wild fish populations while increasing their compatibility with salmon recovery goals, according to a NMFS BiOp evaluating Columbia River salmon fisheries and hatcheries that support them (NMFS 2018).

A separate NMFS BiOp in 2017 examined effects of Mitchell Act hatcheries on listed salmon and other species (NMFS 2017b). Authors of the Mitchell Act hatchery BiOp noted that some adverse effects would likely continue, but they concluded that recent modifications in hatchery management "are likely to reduce effects such as competition and predation on natural-origin salmon and steelhead." The authors of the 2017 BiOp also state: "Where needed, reductions in effects on listed salmon and steelhead are likely to occur through changes in:

- Hatchery monitoring information and best available science,
- Times and locations of fish releases to reduce risks of competition and predation,
- Management of overlap in hatchery- and natural-origin spawners to meet gene flow objectives,
- Decreased use of isolated hatchery programs,
- Increased use of integrated hatchery programs for conservation purposes,
- Incorporation of new research results and improved best management practices for hatchery operations,
- Creation of wild fish only areas,
- Changes in the species propagated and released into streams and rivers and in hatchery production levels,
- Termination of programs,
- Increased use of marking of hatchery-origin fish,
- More accurate estimates of natural-origin salmon and steelhead abundance for abundance-based fishery management approaches."

Hatcheries have a long and mixed record on the Columbia River. The first salmon hatchery in the basin was built in 1877 by cannery operators hoping to reverse the decline of valuable spring Chinook. It faltered within four years but was later revived with federal government support. Overfishing, unchecked development, and irrigation soon made hatcheries look like an answer too easy to ignore. One promoter, Washington Fish Commissioner A.C. Little, contended that the state's fisheries were out of room to grow "unless radical measures are taken towards keeping up supply. In no way can this be done successfully but by artificial propagation." This quote from Little comes from

a history of hatcheries published by the Northwest Power and Conservation Council, a body established by Congress in 1980 to plan comprehensive salmon restoration and electric power production. With a wry note, the unnamed author of the Council's hatchery report writes of Little: "In effect, he argued that the way to beat the salmon decline was to ignore its obvious causes and simply produce more fish."

Early hatcheries built to mitigate fish loss at dams didn't always work as intended. The 2018 NMFS BiOp authors note that these early facilities "were operated without a clear understanding of population genetics," transferring fish to hatcheries "without consideration of their actual origin." Although hatcheries were increasing the number of fish returning to the basin there was no evidence that they were increasing the abundance of natural populations and it is considered likely that they were decreasing the diversity of populations they intended to supplement."

Over time, many fisheries biologists came to believe that hatcheries, if not carefully managed, could harm wild salmon populations in multiple ways. Transferring hatchery fish to distant watersheds could lead to interbreeding and dilution of genetic fitness in nearby salmon populations. If released in the wrong places or times, hatchery fish could cause ecological risks to wild fish, for example by preying on them or competing with them for food and space. Without careful management, hatcheries could also become vectors for diseases, could degrade stream water quality with their effluent, and could even dewater streams that neighboring wild fish needed for spawning and migration. Such concerns grew into the basis of a countermovement among fisheries scientists and advocacy groups who have worked to improve or shut down hatchery activities that could weaken wild salmon populations.

Under the Endangered Species Act, scientists from NMFS evaluate these and other potential effects of hatcheries on ESA-listed species. They routinely consider potential risks not only to threatened or endangered salmon populations, but also to Southern Resident Killer Whales, and other listed fish and marine animals. In Biological Opinions prepared under the ESA, they set requirements that hatchery operators must meet in order to get operating permits and funding. NMFS also conducts separate Environmental Impact Statements (EIS) on hatcheries under the National Environmental Policy Act. The agency has linked these two statutory review processes to drive changes in hatchery policies in the Columbia River.

The 2018 NMFS BiOp addresses the 2018-2027 management agreement that governs Columbia River fisheries under federal court rulings upholding treaty fishing rights of tribes in the basin (TAC 2018). That agreement is a primary framework for fishery management in the river, including both harvest and hatchery programs. The hatchery evaluation in the NMFS 2018 BiOp relied on a series of earlier NMFS BiOps and other federal reports that systematically reviewed hatcheries in the basin. One important source for that analysis was the 2017 NMFS BiOp on hatcheries funded under the Mitchell Act (NMFS 2017b), which formalized and expanded the agency's overall policy approach of seeking to minimize risks to wild stocks, shape hatchery programs to support salmon recovery, and maximize their beneficial effects.

As noted earlier in this report, the 2018 BiOP authors found that the management agreement for Columbia River fisheries (including hatchery programs supporting the fisheries) "is not likely to adversely affect Southern Resident killer whales."

Addressing hatchery impacts on listed fish, the 2018 BiOp authors reviewed findings from earlier BiOps that covered "the vast majority of hatchery programs in the Columbia River basin." They concluded that hatchery programs are "not likely to jeopardize" listed fish populations.

While affirming that some hatchery impacts on listed fish stocks were likely to occur, the BiOp authors noted that these impacts were already decreasing and would likely continue to decline under the requirements set by NMFS. They note that hatchery operators are implementing the array of changes listed two pages above this text.

Beyond broad programmatic guidance provided in its BiOp and EIS reports, NMFS provides detailed oversight of hatchery practices through Hatchery and Genetic Management Plans that operators must submit to the agency in order to obtain permits. Site-specific requirements cover all aspects of hatchery management—integration of hatchery practices to align harvest, habitat, and hydropower programs in a coordinated effort to recover salmon populations, and stipulations on monitoring and research to fill gaps in knowledge and constrain important areas of uncertainty about potential hatchery impacts.

Taken together, these actions and requirements by NMFS constitute a far-reaching system of oversight and ongoing improvement in hatchery practice and policy. They satisfy the three indicators for this standard with moderate confidence.

Some current concepts of best practice for hatcheries rest on science that is still evolving or that require balancing competing risk-management strategies. Any simple, unilinear measure of performance is thus incomplete at best. In a system as complex as the Columbia River Basin, with scores of distinct hatchery programs, some degree of uncertainty about hatchery effects is unavoidable. However, this uncertainty itself can be recognized and used to fuel research and debate over how best to drive improvements. Such a discourse is visible in multiple publications and forums organized by federal, state, tribal and other actors in the Columbia Basin. For example, the Washington Department of Fish and Wildlife in 2019 initiated a review of hatchery reform science (Anderson et al 2020). "Long-term empirical studies of hatchery reform principles are absent in Washington state," the authors note. "Thus, it is difficult to know with any degree of accuracy if management actions based on these reforms are achieving their intended goals."

In February 2020, WDFW released a draft assessment of hatchery and fishery reform within its own operations, which include 81 fish hatcheries, the largest "fleet" of such enhancement facilities in North America. The authors (Murdoch and Marsten 2020) took note of one practice that NMFS requires for most hatcheries in the Columbia basin: reducing the proportion of Hatchery-Origin Spawners (pHOS) that stray into nearby streams. In their draft report, Murdoch and Marsten wrote: "Understandably, given the uncertainty (i.e., lack of empirical studies) associated with some hatchery reform actions (e.g., pHOS goals), an evaluation of the policy and subsequent actions taken warrant a quantitative assessment of the effectiveness in achieving the policy goals." However, they also noted that such a quantitative assessment cannot yet be conducted because it would require data from multiple generations of fish. Current changes in hatchery practice have been implemented for only a decade at most, too short a time to detect genetic effects attributable to any reduction in straying hatchery fish.

Reducing straying by hatchery fish is intended mainly to protect naturally spawning populations from genetic risks, e.g., dilution of locally adapted genetic traits, or spreading of "domesticated" traits from fish that are raised in a hatchery during early life.

Hatcheries sometimes play a vital role in rebuilding threatened and endangered runs that have reached the brink of extinction. So, an urgent risk of extinction can sometimes take precedence over long-term genetic concerns. Co-managers have intervened to save vanishing stocks, such as Redfish Lake sockeye, by raising some of the fish in hatcheries and then "out-planting" them to bolster the wild population (NMFS 2018). With careful controls—such as ensuring out-planted fish are from local rivers, not distant basins—this approach is considered an important tool for preserving and rebuilding stocks that otherwise face extinction.

How to balance long-term genetic risks against short-term extinction risks is an area of continuous, dynamic learning as resource managers throughout North America's salmon-producing western river systems adapt to a changing environment.

Rating: B for Hatchery Risk

3. Knowledge Risk

Knowledge of Prey Interception Risk

FINDINGS

All requirements of this indicator are satisfied.

1. Southern residents from K and L pods have been documented feeding on salmon in marine waters off the mouth of the Columbia River, a finding that contributed to NMFS' decision to propose an expansion of SRKW critical habitat under the ESA from the prior designation within the Salish Sea to encompass waters along much of the U.S. West Coast (NMFS 2019a, NMFS 2019b).
2. NMFS excludes waters inside the Columbia River (and other rivers) from its proposed expansion of critical habitat for SRKW along the West Coast (NMFS 2019a, NMFS 2019b).
3. Columbia River fisheries encounter Chinook salmon "after the fish have returned to the river and are no longer available to the whales in the ocean," according to the 2018 NMFS Biological Opinion on in-river fisheries contemplated under the 2018-2027 Management Agreement (NMFS 2018). This finding is supported by recent field research from NMFS scientists investigating habitat use by SRKW along the West Coast. The Draft Biological Report for the agency's 2019 proposal to expand critical habitat of SRKW

outside the Salish Sea notes that "there are no data from sightings or satellite tags to indicate that Southern Residents enter river mouths or semi-enclosed bays and estuaries along the outer coast, although data indicate the whales do use the open embayment of Monterey Bay in California."

A longstanding behavioral difference appears to distinguish seal-eating transient killer whales from fish-eating Southern Residents. Some transient killer whales occasionally enter rivers. In 2018, a group of transient whales were observed and one of the transients was photo-identified inside the Columbia River just east of the Astoria Bridge, where thousands of seals and sea lions congregate (Frankowicz 2018).

It is not known why pinniped-hunting transient whales enter rivers while fish-eating Southern Residents avoid them. One speculation is that seals and sea lions that frequent some river mouths are larger, and therefore easier for whales to locate, track, and capture than salmon in freshwater areas where high-frequency noise from small boat traffic is prevalent. Southern Residents are known to rely on high-frequency echolocation clicks to detect and capture salmon, so some researchers have suggested that noise from "small, outboard vessels" may impair their foraging ability more than "low-frequency background noise from commercial shipping" (Lacy et al 2017).

Rating: A for Knowledge of Interception Risk

Knowledge of Stock Risk (Exploitation & Biomass)

For fisheries below Bonneville Dam, applicable standards and indicators for exploitation and biomass are evaluated together.

FINDINGS

Indicators 3.2.1.1, 3.2.1.6 & 3.2.2.1 – Knowledge of Exploitation Rate; ETP species; Monitoring:

These indicators are satisfied. Time series from multiple sources document high rates of compliance with exploitation limits. Allowed vs actual harvest rates on ESA-listed salmon and abundant stocks over time are documented in published Joint Staff Reports by WDFW and ODFW, NMFS Biological Opinions, and other sources. Protection of endangered, threatened, and protected species is closely monitored and controlled, driving increased levels of precaution in fishery harvest management throughout the Basin. In general, the denominator for in-river exploitation rates is derived from model estimates of run sizes entering the Columbia. The run size estimates are back-calculated in-season and post-season by using the latest dam passage projections and adding back harvest and mortalities from all potential sources. Data from multiple sources collected during the upriver migration (landings, fish counts at dams, visual identification of fish from specific stocks, tag recoveries, tallies of hatchery marked fish, etc.) progressively increase the expected precision and reliability of estimates of run size and catch composition as fish progress upriver.

Indicators 3.2.1.1 & 3.2.2.2 – Reference Points:

For most Chinook stocks, tribal, state, and federal co-managers have evolved a system of reference points that are substantially more conservative than MSY, largely eliminating the risk of unknowingly setting limits that could allow Columbia River fisheries to deplete Chinook stocks. Impact limits on 13 ESA-listed salmon populations (shown in evaluation of exploitation and biomass risk), abundance-based harvest control rules, and sequential escapement goals for upriver dams provide reference points for in-river harvests that result in very precautionary levels of escapement. As noted above, for upriver bright fall Chinook, MSY escapement above McNary Dam has been estimated at 40,000 (PFMC 2016) but the current *U.S. v Oregon* management agreement requires minimum escapement of 60,000 beyond McNary. In addition, the agreement reserves fish for tribal harvests and spawning further upriver by requiring minimum escapement of 43,500 adult fish past Priest Rapids Dam. In practice these rules commonly result in escapement larger than required. At McNary, for example, actual escapements recently have roughly doubled the required 60,000 fish. Time series data for 2008-2016 show that an estimated 90.4% of all wild Chinook entering the Columbia are allowed to escape from fisheries.

The NMFS Biological Opinion evaluating the current management agreement (NMFS 2018) notes one instance of an MSY-based escapement goal, for fall bright Chinook returning to the North Fork Lewis River in Washington, part of an ESA-listed group of Mid-Columbia Chinook stocks. In this case too, other constraints on harvest result in escapement that more than doubles the goal. This naturally spawning population has an MSY escapement goal of 5,700 fish, but "escapements over the last 10 years averaged 12,400," the NMFS BiOp authors note (NMFS 2018).

The BiOp authors note that current levels of escapement are expected to continue, exceeding the delisting criteria for this stock.

Practices and policies governing commercial fisheries in the Columbia River below Bonneville Dam are sufficient to satisfy the relevant indicators for references points.

3.2.1.3 & 3.2.2.3 – Uncertainty, Error and Precaution:

Commercial fisheries harvesting Chinook salmon in the Columbia River below Bonneville Dam satisfy these indicators. Estimates of run size, exploitation rate, and stock composition are subject to uncertainties that are recognized, evaluated, and mitigated through harvest control rules that commonly result in very precautionary escapement levels.

Routinely collected data from coded wire tags, fin-clipped hatchery-marked fish, visual stock identification, and landings reports, among other data sources, enable informed and precautionary responses to changes. Data collection practices in the middle and upper basin vary by sub basin. As an example, in the Snake River fall run, incidence of fish with adipose-fin clips is "used to construct daily estimates of hatchery proportions in the run," the NMFS BiOp authors note. Use of passive-integrated transponder (PIT) tags has improved understanding of variations in migration timing, plus mortality rates associated with warm river waters and large water spills affecting these fish, the authors report (NMFS 2018).

In addition, the BiOp authors note that Parentage Based Tagging (PBT), a genetic method for tracing offspring of genotyped fish (usually from hatcheries), is being used in a program on the Snake River that will soon enable "a more direct assessment of natural returns and ESU abundance risk" (ESU stands for Evolutionarily Significant Unit, a term used to define populations for protection under the ESA). Development of PBT methods has been hailed as a significant addition to the toolkit for conserving and managing salmon in the Columbia Basin. "Rarely does a technological approach come along that has the potential to simultaneously advance management, research, and conservation in fisheries," note authors of a 2019 report on this method (Steele et al 2019). The 13 ESA listings of salmon stocks in the Columbia Basin intensified the need for such tools. Steele and co-authors note "increased demand from fisheries managers for precise information on stock contributions to mixed-stock fisheries." The use of PBT techniques could help to narrow knowledge gaps and uncertainties that older, established methods (Coded Wire Tags, fin-clipping) do not resolve.

Continuous public debate and review are built into management systems for the Columbia River, its fisheries, and the science informing them. The 20th Century conversion of North America's largest salmon producing river into its largest hydropower system left a legacy of contention among multiple, competing institutions and people. One result is that many of them now have a vested interest in the effectiveness of actions to restore and conserve fisheries. This contention makes for complex and cumbersome discourse, for example, creating many decentralized sources of data and analysis. It also helps to ensure a degree of rigor and transparency. Tribes, state, and federal fisheries agencies, dam operators, industrial water and power users, utilities, irrigators, multiple fisheries stakeholders, and scientific experts now scrutinize and check each other's work on salmon in the Columbia Basin. Regular, formal evaluations of fishery management and conservation actions are conducted by NMFS and USFWS via ESA Biological Opinions, NEPA Environmental Impact Assessments, and permitting processes.

3.2.1.4, 3.2.1.5, 3.2.2.4 & 2.2.2.5 Compliance & Timely Action:

For fisheries below Bonneville Dam, these indicators are satisfied. Publicly available time series clearly document the performance of managers and fishers in meeting both exploitation and escapement policies. Timely action to control fishing effort is evident in the high rates of compliance (and outperformance) achieved in both exploitation and escapement, as shown above. As discussed, in-season response to changes in catch rates and run size can result in closure of mainstem fisheries within hours after landings data are collected. Monitoring and research on fish survival and underlying physical conditions in the ocean and the river, including climate impacts, inform both management and formal evaluations of management and policy.

Ratings: A for Knowledge of Stock Risk (Exploitation) and A for Knowledge of Stock Risk (Biomass)

Contemporary commercial fisheries in the Columbia River below Bonneville Dam are confidently known to restrain exploitation and protect spawning potential of target and non-target fish, preventing harvest-induced stock depletion. Impacts on other protected, threatened, and endangered species are minor.

Knowledge of Stock Risk (Hatchery Risk)

Overview:

As of 2014, more than 80 hatcheries were running 177 distinct programs to produce salmon and steelhead in the Columbia River basin (NMFS 2014). Since the 1990s, ESA listings of 13 population groups of salmon and steelhead in the Columbia Basin have spurred increased scrutiny of hatcheries to ensure that they contribute to recovery, efficiently produce fish, and minimize genetic and ecological impacts on nearby wild salmonids. NMFS has responded to the listings by driving far-reaching changes, both in hatchery operations and in research, monitoring and evaluation conducted to show how they are performing.

The federal marine fisheries agency wields broad authority over salmon hatcheries, both as a funder and a regulator. Under the Mitchell Act, NMFS provides funds for about a third of all Columbia Basin hatchery programs (NMFS 2014). Under the National Environmental Policy Act (NEPA), NMFS evaluates hatchery programs and establishes broad guidelines for assessing and limiting the risks they can pose to wild stocks. Under the ESA, the agency sets performance standards for hatcheries, mandates allowable levels of production, imposes limits on straying to protect wild fish, and specifies monitoring and research requirements.

The agency's permit authorities under the ESA help to put teeth in its requirements, especially where hatcheries interact with ESA-listed wild fish. To receive permits to collect broodstock, among other tasks, hatchery operators in the Columbia Basin (and other regions where fish are listed) need NMFS approval of their Hatchery and Genetic Management Plans (HGMPs). Those plans provide detailed guidance for production, operations, and monitoring and research at each facility. Similarly, access to Mitchell Act funds is also contingent on documenting compliance with NMFS requirements through annual reporting on these activities.

The agency's 2017 Biological Opinion (BiOp) on hatcheries funded by the Mitchell Act (NMFS 2017b) codified a detailed list of requirements for oversight and operation of hatcheries in the Columbia River Basin. It mandated measures for all covered hatchery programs and actions at specific facilities in order to reduce potential for harm to listed species, or (in the phrase used in ESA documents) "to minimize incidental take." These requirements echo and consolidate similar rules the agency has instituted through BiOps on hatchery programs throughout the basin. They include multiple required steps to reduce potentially risky interactions with wild fish, protect water quality and quantity, control diseases, and mitigate other potential impacts. The 2017 BiOP also requires annual reporting on results and specifies detailed approaches to measure impacts through research, monitoring, and evaluation. It incorporates many additional NMFS specifications for impact reduction and regulatory compliance, which must be documented in the hatchery's regular reports to NMFS and their HGMPs.

FINDINGS

Indicators 3.2.3.1, 3.2.3.2, 3.2.3.3 & 3.2.3.4 – Hatchery Management, Monitoring, Marking and Tagging, & Uncertainty and Precaution

These indicators are satisfied with moderate confidence by the detailed requirements imposed by NMFS in its 2017 BiOp on Mitchell Act hatcheries, as well as multiple earlier BiOps that set conditions on hatchery operations throughout the basin. Regular reviews under the ESA and NEPA have provided a framework for careful scrutiny and improvement of required research and monitoring to document performance of hatcheries. Increasing use of Parentage-Based Tagging, notably by tribes, is helping to clarify relationships and influences between hatchery-origin and naturally spawning populations (Steele et al 2019).

As noted earlier, some practices currently mandated by NMFS are based upon science that is still evolving. One example is the NMFS policy to reduce the proportion of Hatchery-Origin Spawners in streams (pHOS), discussed above in the section on hatchery-related stock risk. Required annual reports to NMFS and independent reviews demonstrate that most hatcheries in the basin are applying the required practices. However, there is still little clear empirical evidence that these practices will achieve their intended results, e.g., increased diversity and resilience in naturally spawning population, nor is this evidence likely to be quickly obtainable (Anderson et al 2020, Murdoch and Marston 2020). Conversely, the Columbia River salmon populations carry a legacy of consequences from early hatchery operations that swapped populations among distant basins with little attention to local adaptation, genetic effects, ecological impacts, or even whether the effort succeeded in increasing naturally spawning stocks. The results of that legacy and of modern efforts to do better are both subject to continuing research and discussion.

Meanwhile, the role of hatcheries is evolving and subject to ongoing debate. Co-managers in the Columbia Basin and elsewhere use hatcheries to help restore some depleted populations of salmon and steelhead. Dynamic environmental challenges such as climate change complicate the balancing of conservation priorities for hatcheries. In recent years, reduced survival from smolt to adult stages in many West Coast salmonid populations—both hatchery and wild—has fueled vigorous research and contention among fisheries scientists about potential causes. One such topic is whether hatchery fish may be overgrazing marine foodwebs, or merely experiencing the same environmental changes as wild fish. Furthermore, recent reductions in hatchery production are themselves a subject of debate, and agencies and tribes are gearing up to boost production strategically to provide Chinook as prey for Southern Resident Killer Whales.

In this dynamic context, the Columbia's network of hatcheries benefits from strong oversight and robust, transparent systems for monitoring, research, and policy evaluation. Uncertainty and errors in knowledge of potential hatchery risks may be ineradicable, but they are recognized, regularly reviewed, and adaptively managed.

Rating: B for Knowledge of Stock Risk (Hatcheries)

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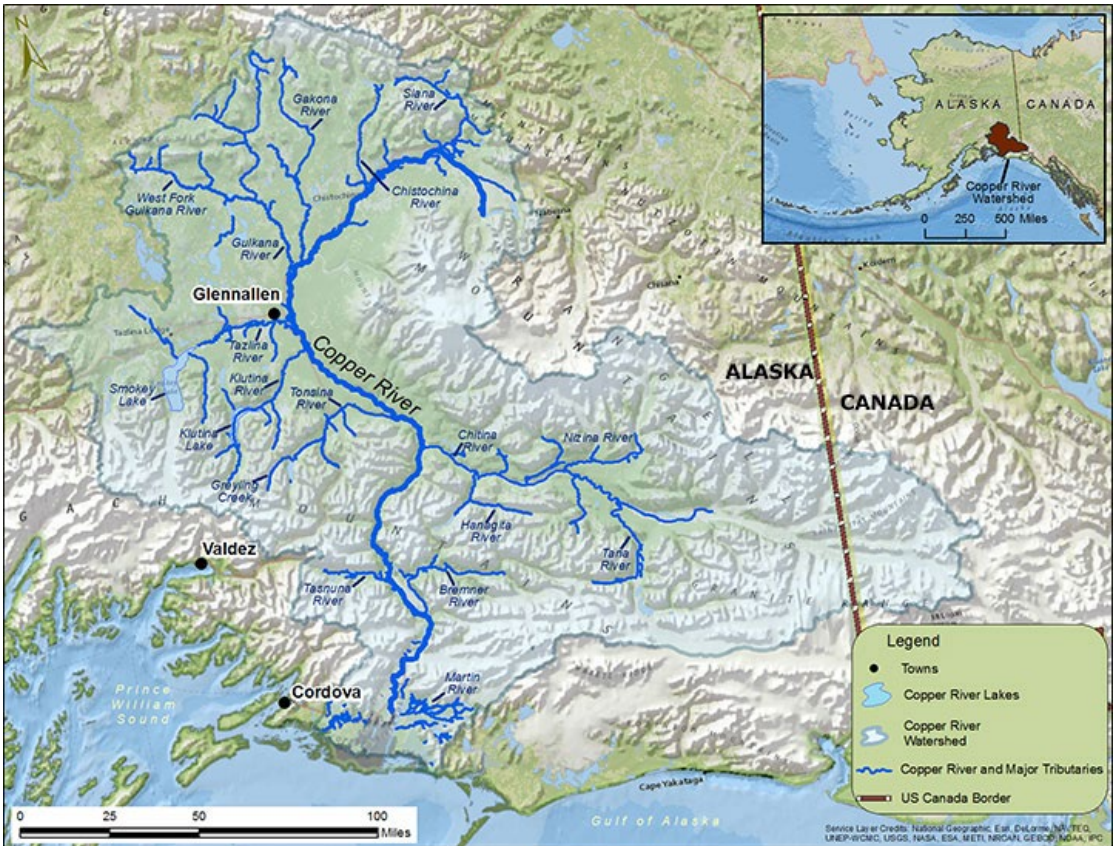
Chinook Salmon Fishery Evaluation

Copper River

January 18, 2022

2022 Evaluation: Passed **Overall Rating:** A/B

Fishery Overview:



Fishery Location in Alaska

The Copper River commercial salmon fishery has operated since the early 1900s. It currently has about 500 active permits, targets all species of salmon, and occurs in the Prince William Sound management area—just off the river mouth near Cordova, Alaska—between Hook Point and Point Martin. Sockeye salmon generally provide the bulk of the harvest. Chinook and sockeye are co-mingled in the waters, so targeting occurs by season timing and area restrictions, and through gear regulations (e.g., mesh-size limits) that minimize gillnet interception of larger species such as Chinook during fishing for sockeye and coho. There are no Chinook hatcheries in the Copper River basin, but there is one sockeye hatchery.

Commercial fleets use gillnets to catch Chinook salmon in the nearshore marine waters just outside the Copper River Delta (at the mouth) as they return to spawn in the Copper River. The fishery also intercepts some Chinook originating from other rivers in the Gulf of Alaska, British Columbia, and the U.S. West Coast. The catch of Chinook salmon returning to hunting grounds of Southern Resident Killer Whales (SRKW) is normally small—meeting PCC's sourcing standard—but during unusually warm years these interceptions may increase.

The Alaska Department of Fish and Game (ADF&G) manages the Copper River salmon fishery, with policy oversight and direction from the Alaska Board of Fisheries (BOF). It has received sustainability certification from the Marine Stewardship Council (MSC) and the Alaska Responsible Fisheries Management (RFM) program.

Three primary strategies are used to ensure the fishery is managed responsibly. First, commercial fleets are regulated to allow enough fish to escape their nets and proceed upriver to spawn and to support sport and subsistence harvesters. Legally the subsistence harvesters have the highest priority for fishing opportunity, so substantial escapement is required as fish first pass through commercial fleets at the river mouth. Over the past decade, the Copper River Chinook fishery has been successful at meeting or surpassing those escapement goals. This is essential to ensure there are enough fish to sustain the population and to allow for up-river sport and subsistence harvesters.

Second, the Copper River commercial fishery is closed by default and fishing seasons are opened by Emergency Order.

Third, an area around a chain of islands at the river mouth referred to as the "Chinook salmon inside closure area," is off-limits to commercial fisheries, unless permitted by the ADF&G (this has not occurred for many years). The commercial fishery operates around the islands and south of the closure. This restriction on fishing inshore of the barrier islands is intended to ensure that enough Chinook pass through to support fisheries upstream and achieve the annual escapement goal.

Management of the fishery is intense and requires effective coordination and constant communication as fishery biologists and managers collect data and assess information to ensure fishery goals and objectives are achieved. The BOF adopts policies and regulations for this fishery on a biennial basis. Harvest data and other management tools, including in-river sonar, aerial surveys, and mark-recapture estimates, provide indices of abundance and allow fishery managers to manage fisheries in-season.

Evaluation Summary:

The Copper River Chinook fishery earns an A/B rating based on findings that: 1) prey interception risk, exploitation risk, biomass risk and risk to protected species are managed at levels that satisfy the PCC Chinook Standard's indicators for each category; 2) knowledge risk for each standard and indicator is constrained sufficiently to produce the necessary confidence in data; and 3) under biomass risk, some concerns over escapement are noted, and at this writing they drive the B portion of the grade. Escapement goals recently became a subject of some concern and debate, mainly over a proposal to reduce the escapement goal (which would forego some of the precaution historically provided by ensuring more fish escape to spawning grounds). A related potential risk arises from the lack of separate spawning escapement goals for the six major Chinook stocks in the Copper River basin. With respect to hatchery risks, no Chinook hatcheries operate in the Copper River basin; thus, hatchery risk and knowledge of hatchery risk are inapplicable in this case.

Recommendations for the Copper River Chinook Fishery:

These recommendations are designed to offer options for PCC to advance two aims:
a) To protect the Copper River Chinook salmon resource (one of the few sources that meet the PCC Chinook standard) by advocating precautionary management of harvests and habitats; and b) To uphold the value of PCC's Chinook sourcing standard in the future.

1. Regularly assess interception risk via genetic analysis. At present, genetic stock identification (GSI) data provide the only accurate method for estimating stock composition of the commercial harvest of wild stocks and untagged stocks from areas outside of the Copper River. A preliminary analysis suggests a correlation between sea surface temperature (SST) and intercept rates of Chinook originating from

southern waters in the range of the Southern Resident Killer Whales (SRKW). During winter, the phase of the Pacific Decadal Oscillation (PDO)—warm or cool—may offer a forecasting tool for identifying periods of elevated interception risk. If this approach proves reliable, it could enable purchasing managers to avoid sourcing fish from the Copper River fishery in years when higher levels of the preferred prey of SRKW may be caught. Therefore, we recommend that PCC consider advocating for a retrospective analysis of Chinook GSI samples on a four- or five-year cycle. This work may be most efficiently conducted by staff at ADF&G's GSI program.

2. Encourage ADF&G to conduct a periodic evaluation on two-year or three-year intervals of (a) the risks of using an aggregated escapement goal for all six major Chinook stocks in the Copper River; and (b) the technical feasibility of methods for surveying these individual stocks, in light of evolving survey technologies and stock-estimation tools. ADF&G scientists report that major obstacles in the Copper River system frustrate current survey methods, which might otherwise be used to track escapement and reproductive success for these populations. Individuated stock management of salmon populations is common in other large river systems, and risks of aggregated management are well-recognized; individual stocks may differ in productivity or mortality rates (e.g., due to localized environmental changes, development or habitat alteration, upriver subsistence fishing, etc.), so an aggregate goal can mask problems that affect a faltering subpopulation within the group. The biomass reference point provisions in PCC's Chinook standard include a requirement for disaggregated escapement goals in salmon stocks (Indicator 2.2.1.4). Fisheries that fall short on one or more of these indicators are graded accordingly.

3. Support use of precautionary (high) goals for escapement, until and unless reliable assessments show that productivity of Copper River Chinook stocks is sufficient to sustain and rebuild populations even at a reduced escapement level.

Evaluation Chart

	Findings	Rating	Notes
1. Prey Interception Risk		**A**	
1.1 No Overlap	All indicators met.	A	Fishery is remote from SRKW prey range. Data indicate that West Coast Chinook are rarely caught in the fishery (10% or less of the catch), except in years with warmer waters. Genetic analysis and monitoring will help predict such events to avoid sourcing when risk of catching SRKW prey is too high.
Indicator 1.1.1			
Indicator 1.1.2			
1.2 Post-Prey			
Indicator 1.2.1			
Indicator 1.2.2			
1.3 Negligible Effect			
Indicator 1.3.1			
2. Stock Risk		**B**	
2.1 Exploitation		B	Allowing adequate fish to escape harvest and swim up to spawning grounds is the primary tool for ensuring control of exploitation rate and protection of spawning biomass. However, the pre-season run forecasts for Chinook err both high and low, and lately they have tended toward overestimating run size. Due to geographic impediments, managers rely on a basin-wide aggregated escapement goal, which may pose some risk to sub-stocks. Copper River salmon fishery managers use multiple tools and practices to detect and quickly respond to variations in run strength and catch to protect escapement. Balancing subsistence fisheries needs has presented some challenges for protecting escapement and taking timely action, because those subsistence fisheries have priority over commercial harvesting, but are catching fish later on further up the river. A continued precautionary approach toward proposed reductions to the escapement goal is advised.
Indicator 2.1.1: Exploitation Rate	All indicators met.		
Indicator 2.1.2: Reference Points			
Indicator 2.1.3: ETP Species			
Indicator 2.1.4: Uncertainty → Precaution			
Indicator 2.1.5: Compliance			
Indicator 2.1.6: Timely Action			
2.2 Biomass		B	
Indicator 2.2.1: Reference Points	All indicators met.		
Indicator 2.2.2: Uncertainty → Precaution			
Indicator 2.2.3: Compliance			
Indicator 2.2.4: Timely Action			
2.3 Hatcheries			

		Indicator 2.3.1: Hatchery Management			
		Indicator 2.3.2: All-H Integration			
		Indicator 2.3.3: Uncertainty → Precaution			
3. Knowledge Risk				**A/B**	
	3.1 Knowledge Risk for Interception				
		3.1.1 No Overlap	All indicators met.	A	Risk of intercepting priority prey of SRKW is well-documented to be low during historically normal thermal conditions. Knowledge of interception risk could be improved with a retrospective analysis of data to help improve tools for pre-season prediction on risk of more SRKW prey being in the fishery.
		Indicator 3.1.1.1			
		Indicator 3.1.1.2			
		3.1.2 Post Prey			
		Indicator 3.1.2.1			
		Indicator 3.1.2.2			
		3.1.3 Negligible Effect			
		Indicator 3.1.3.1			
	3.2 Knowledge of Stock Risk				
		3.2.1 Exploitation	All indicators met with moderate to high confidence.	B	Management of the fishery incorporates: 1) multiple data sources to monitor run size, harvest, escapement, and other management parameters; 2) review of monitoring methods (includes focus on reducing errors and uncertainty); and 3) regular, rigorous, and publicly available reviews of escapement goals. Knowledge of stock risk could be improved by incorporating new sonar-based survey methods into a future stock assessment and carefully evaluating trends in stock productivity, which has mostly been declining until recently. As survey methods evolve, disaggregating the escapement goal may be feasible in the future, which would constrain risk by differentiating between the six major Chinook stocks. Stock risk could be further controlled by taking a precautionary approach in revising the escapement goal, especially in the context of accelerating environmental change and a rising
		Indicator 3.2.1.1: Exploitation rate			
		Indicator 3.2.1.2: Reference points			
		Indicator 3.2.1.3: Uncertainty and Error			
		Indicator 3.2.1.4: Compliance			
		Indicator 3.2.1.5: Timely Action			
		Indicator 3.2.1.6: ETP Species			
		3.2.2 Biomass	All indicators met with moderate to high confidence.	B	
		Indicator 3.2.2.1: Monitoring			
		Indicator 3.2.2.2: Reference Points			
		Indicator 3.2.2.3: Uncertainty → Precaution			
		Indicator 3.2.2.4: Compliance			
		Indicator 3.2.2.5: Timely Action			

						share of the harvest taken in upriver subsistence fisheries.
		3.2.3 Hatcheries				
			Indicator 3.2.3.1: Hatchery management			
			Indicator 3.2.3.2: Monitoring			
			Indicator 3.2.3.3: Hatchery Marking and Tagging			
			Indicator 3.2.3.4: Uncertainty → Precaution			

Note: Any lines or sections left blank with greyed text are considered not applicable to the specific fishery under evaluation.

Full Evaluation Details

Note: All tables and figures mentioned in the text below are located in Appendix B.

Fishery Background Information:

A directed commercial fishery for Copper River salmon has occurred since the early 1900s. It has about 500 active permits, uses drift gillnet gear, and targets all species of salmon. Chinook and sockeye are co-mingled and targeting occurs by season timing and area restrictions. There is one sockeye salmon hatchery in the Copper River, but no Chinook hatcheries.

The Copper River commercial salmon fishery occurs in the Prince William Sound management area—just off the river mouth near Cordova, Alaska—between Hook Point and Point Martin. In recent years, it has been shifted further offshore to the nearshore marine waters just outside of the Copper River Delta. The commercial fleets are intercepting salmon returning to spawn in the Copper River. They also intercept some fish originating from other rivers of the Gulf of Alaska (GOA), British Columbia, and the U.S. West Coast.

Commercial, sport, and subsistence salmon fisheries are all managed by the Alaska Department of Fish and Game (ADF&G) with policy oversight and direction from the Alaska Board of Fisheries (BOF). These fisheries occur sequentially as the salmon migrate into the river and move upstream: first the commercial fleet encounters fish at the river mouth, and later the upriver harvesters, which are subject to a patchwork of both state and federal regulations, take their share in subsistence and personal use fisheries in the Copper River District, Chitina Subdistrict, and Glenallen Subdistrict. Management is intense and requires effective coordination and constant communication as fishery biologists and managers collect data and assess information to ensure fishery goals and objectives are achieved. Legally, the in-river subsistence fishery has the highest priority for fishing opportunity, and they have successfully pursued an increased share of the harvest in recent years, reducing the share available for commercial and sport catch. As such, the commercial fishery must be managed both to allow adequate spawning escapement and to provide for allocations for in-river subsistence, personal use, and sport fisheries.

The commercial fishery can quickly harvest its Chinook limit, so to control the catch during the fast-paced in-season, the Copper River commercial fishery is closed by default and fishing seasons are opened by Emergency Order. The commercial fishery opens in mid-May and typically consists of two 12-hour open periods per week, on Mondays and Thursdays, with period lengths established in-season through emergency regulations. Chinook harvest is concentrated in the early season and usually concludes by the end of June, with a few Chinook being caught throughout the summer fishing season as late as August. Beginning in early or mid-August, the main run of sockeye has largely passed, Chinook have largely passed through the fishery, and the harvest is managed for coho, which continue returning into the fall.

Another strategy to manage the commercial salmon fishery is the establishment of an area closure around the barrier islands in the Copper River District (Figure 2), referred to as the "Chinook salmon inside closure area." The commercial fishery occurs around these islands and seaward (i.e., south) of the closure. Since 2012, by regulation, the "Chinook salmon inside closure area" has been off limits to the commercial fishery. ADF&G is permitted to open this inside closure area for up to one fishing period per week in Statistical Weeks 20 and 21 (for 2021, these are weeks beginning May 17th and 24th, respectively). However, in recent years, the area has remained closed throughout the commercial season. In 2021, the "inside closure" was expanded northwesterly and easterly. This restriction on fishing inshore of the barrier islands is intended to ensure that enough Chinook pass through to support fisheries upstream and achieve the annual escapement goal.

Commercial harvest varied substantially from 1980 through 2007 with a peak in 1998 of 68,827 Chinook. The catch dropped significantly in 2008, has stayed at relatively low levels since, and dropped again in 2018 (Figure 1). Notably, the 2018 commercial harvest was about 62% of the 2008-2018 average. The sport fishery peaked at around the same time (1996-1998) with a harvest of 9,116 Chinook in 1996 compared to 1,278 fish in 2018, which was 91% of its 2008-2018 average of 1,408.

Collectively, the subsistence fisheries harvested more Chinook in 2018 than the commercial and sport fisheries combined. The subsistence fishery in the Copper River District has been a steady, but fairly low component of the harvest. The Chitina Subdistrict subsistence fishery also peaked in 1998 with a harvest of 6,723 Chinook, showing a similar trend to the commercial and sport fisheries. On the other hand, the Glenallen Subdistrict subsistence fishery peaked in 2018 harvesting 6,960 Chinook, which is 225% of its 2008-2018 average catch. For annual harvest levels by fishery and district, total run size, and escapement, see Appendix A.

The commercial salmon fishery has received sustainability certification from the Marine Stewardship Council (MSC) and the Alaska Responsible Fisheries Management (RFM) program. The RFM certification includes a Fisheries Standard and a Chain of Custody standard that provides traceability through the supply chain back to its origin. Both the MSC and RFM certification programs have been recognized by the Global Sustainable Seafood Initiative for their applied wild-capture fisheries audit standards.

Risk Assessment:

1. Prey Interception Risk (No Overlap)

The Copper River Chinook fishery qualifies as "No Overlap" as the fishery location is remote from SRKW range in waters where the whales' priority prey—Chinook salmon from the western United States and British Columbia—are rare (<10%) in the catch. However, during years of prolonged marine heatwaves (i.e., "the warm blob"), those priority prey Chinook will swim further north, increasing the risk of being in the fishery. The Copper River District is outside the range of SRKW and catches of West Coast Chinook in the fishery are typically < 5%, except in years of prolonged marine heatwaves when catches could be in the 10-15% range.

Genetic studies of the composition of the commercial harvest in 2011 and 2017 delineate three reporting groups within the Copper River (Upper Copper River, Gulkana River, and Lower Copper River) and five large-scale groups in the GOA and areas to the south (Northwest GOA, Northeast GOA, Coastal Southeast Alaska, British Columbia, and the West Coast). For the purposes of this evaluation, these groupings preclude stock-specific assessment of catch composition, but they permit a precautionary screening for potential effects on Chinook stocks that are recognized as priority prey for Southern Resident Killer Whales. The BC and West Coast groupings provide a basis for us to formulate a biologically conservative estimate (i.e., likely to exceed actual effects) of the fishery's potential to intercept preferred prey for SRKW.

For monitoring and predicting climate and associated environmental effects on fisheries, the NOAA Alaska Fisheries Science Center (AFSC) has determined that the best available science currently employs the Pacific Decadal Oscillation (PDO), an index of ocean regimes driven primarily by sea surface temperature (SST) (NPFMC 2020). Changes in the PDO, SST, and key ecosystem indicators form the basis of NOAA's Alaska Marine Ecosystem Status Reports, which are updated annually by the AFSC. These reports are presented to the North Pacific Fishery Management Council (NPFMC) to inform its deliberations on each year's harvest limits and other conservation measures.

NOAA's SST data and PDO data for the Gulf of Alaska (GOA) indicated prolonged marine heatwaves in 2015-2016, and again in 2019-2020. An anomalous marine heatwave occurred in 2014-2016 throughout the GOA (commonly referred to as the "warm blob"), and then sea surface temperatures returned to the typical range for about two years (2017-2018).

Starting in the fall of 2018 and continuing through December 2019, the GOA returned to a period of heatwave conditions. The winter of 2018-2019 was not as warm as 2014-2015 or 2015-2016, but summer SSTs exceeded those of the 2014-2016 heatwave. In spring (May) 2019, SSTs were warmer than average, but not as warm as those from 2015 and 2016.

ADF&G collects Genetic Stock Identification (GSI) data in the Copper River commercial fishery each year for Chinook and Sockeye. GSI data for Sockeye are, as a matter of priority, collected and analyzed every year and, in most cases, they are available for in-season management. However, ADF&G scientist have analyzed Chinook GSI data only for two timeframes, 2005-2008 and 2013-2017, not making annual analysis of data an ongoing priority. For the 2005-2008 GSI analysis, the U.S. West Coast and British Columbia were grouped together, whereas the 2013-2017 GSI analysis separated these geographic areas. As noted earlier, these groupings preclude evaluating interception rates on a stock-specific basis (e.g., for each of the 31 preferred SRKW Chinook stocks). However, the

cumulative total catch of all U.S. West Coast and British Columbia Chinook stocks remained below the "No Overlap" risk threshold of < 10% (Table 1), except for 2014 and 2015 when the anomalous marine heatwave occurred. Any one stock from these regions to the south is likely to incur only a fraction of the total impact from any interceptions in the Copper River fishery. This means the interception risk estimate is conservative, providing a wide buffer for protection against any potential errors.

Similar patterns of interception—low except in warm years—emerge from coded wire tag (CWT) data for Chinook. These data were collected sporadically through dedicated sampling projects in 2000-2002 and 2015-2020. Those sampling efforts were aimed at recovering tags from an in-river project that tagged out-migrating adipose fin-clipped Chinook smolts (J. Morella, personal communication, May 18, 2021). Most adipose fin-clipped ("marked") fish are of hatchery origin, but not all hatchery fish are "marked" and tagged. In most cases, naturally spawned (or "wild") salmon are neither marked nor CWT-tagged. Thus, the recovered CWT-tags offer a partial index of potential fishery removals from hatchery stocks.

GSI data are more precise and cover both wild and hatchery stocks because all fish are sampled, regardless of whether their adipose fins have been clipped. For purposes of this evaluation, CWT data may under-sample interception, for two reasons: (1) the tiny wire tags are generally implanted in hatchery fish, not wild fish; and (2) the data come only when tags are detected by samplers in the field using wands that are passed over the fish's snout. If a CWT is detected, then the head of the fish is removed and sent to scientists who remove the tag, read the data, and compile the coastwide CWT database. Even with this caveat, however, CWT data provide a supporting index of interception risk. Tags collected and analyzed affirm that catches of West Coast hatchery Chinook were notably high during the mid-decade heat wave but were low in other years. However, data from recovered CWTs detected significantly fewer interceptions in the Copper River fishery than did GSI analysis. If taken at face value, the CWT data would suggest that interception in the fishery remained below the threshold of < 10% in all years examined (Table 2).

The timing of the two recent heatwaves (and the associated PDO "warm" phase) also correlates with lower abundance of Copper River Chinook overall and above-normal interceptions of U.S. West Coast and British Columbia Chinook in this fishery (Figure 3). It appears that the PDO trend from December through February may provide a means to predict the likelihood of elevated interception rates of West Coast Chinook in the Copper River fishery before it opens in May. This approach would be consistent with NFCC's guidance for "No Overlap" stocks under PCC's interception risk standard, and it may provide purchasing managers with a pre-season preview that could be used to inform sourcing decisions. PDO trends can indicate whether cooler or warmer temperatures are expected to prevail during the harvest season. If previously observed correlations continue, cooler temperatures will measurably reduce the likelihood of catches of the southern Chinook stocks that known to be consumed by SRKW. Research is recommended to understand this predictive pattern more precisely and to periodically assess whether rising temperatures in the North Pacific may increase the incursion of potential SRKW prey into this fishery in the future.

2. Stock Risk (Exploitation and Biomass)

Alaska state regulations set sustainability standards for state-managed fisheries such as salmon. The Alaska Administrative Code (5 AAC 39.222 *Policy for the management of sustainable salmon fisheries)*, directs ADF&G to manage Alaska's salmon fisheries for "maximum sustained yield" (MSY), which is "the greatest average annual yield from a salmon stock." The code stipulates that this benchmark "is achieved when a level of escapement is maintained within a specific range on an annual basis, regardless of annual run strength." Under this policy, the Copper River Chinook fishery has been managed to achieve a "sustainable escapement goal" (SEG), which is defined as the escapement estimate "that is known to provide for sustained yield over a 5-to-10-year period," The SEG for Copper River Chinook has remained at 24,000 or more Chinook basin-wide since 2003. The latest SEG assessment (Joy et al 2021) estimates MSY for Copper River Chinook to be 22,844 fish. The 2014-2018 average escapement was 27,305 Chinook, so the fishery has a track record of achieving or exceeding MSY.

In reviewing, recommending, and revising a Sustainable Escapement Goal (SEG), ADF&G is guided by two policies in the Alaska Administrative Code:

5 AAC 39.222 *Policy for the management of sustainable salmon fisheries*, and
5 AAC 39.223 *Policy for statewide salmon escapement goals*.

The former is an overarching guidance document that incorporates management principles into general direction for developing and implementing long-term management plans. The latter policy is designed "to establish the concepts, criteria, and procedures for establishing and modifying salmon escapement goals." While the general guidance is to take "a precautionary approach," the escapement goal policy lacks specific criteria regarding when revisions to an SEG may be warranted. This absence of criteria could have increased consequences when managers are contemplating a reduction in the goal (lowering the escapement goal and allowing a higher harvest rate), as ADF&G authors recently recommended for Copper River Chinook.

An ADF&G memorandum (2020) indicates that the SEG goal has been on the conservative side and that escapements in the range of 21,000-31,000 Chinook "have a high probability (64-85%) of achieving 80% of MSY." However, reducing the lower bound of the SEG to 21,000- 24,000 may permit escapement in some years to drop below the estimated MSY of 22,844.

In this fishery, ensuring that an adequate number of spawners escape upriver is the primary management approach to govern harvest and achieve stock sustainability. The lower bound "sustainable escapement goal" (SEG) for Copper River Chinook of 24,000 or more spawners was established in 2003; no upper bound or escapement goal range was set. Escapement is typically above the goal, although five instances of under-escapement have occurred since the goal was adopted (Figure 4). The SEG has been reviewed during each cycle of Board of Fish (BOF) meetings since 2002 and various methods have been used to set the goal, but the goal has remained the same. Although the SEG has undergone regular reviews and periodically been recalculated, in recent years (2018 and 2020), ADF&G staff have twice recommended lowering the SEG. This would mean reducing the current SEG (minimum escapement of 24,000 Chinook) and could permit escapement to drop below the model estimated MSY. The rationale for recommending an SEG that could authorize escapement below MSY is unclear, particularly in light of long-term declines in productivity and the agency's guiding policies for escapement goals in the administrative code, which imply that the lower bound should not be below MSY. In December 2021, the Board of Fish rejected the proposal to lower the escapement goal.

Thus, the current escapement goal remains 24,000 or more Chinook. Based on the Joy et al. (2021) SEG review, ADF&G had recommended a reduced SEG of 21,000-31,000 Copper River Chinook salmon.

The PCC Chinook standard demands rigor in limiting catch and protecting spawning biomass, and precautionary response to shortfalls in escapement or to unforeseen pulses of elevated harvest rates. These requirements are met by ADF&G's use of MSY-based SEGs, regular scientific review of those goals, and rigorous in-season monitoring and management. Under the policies referenced above, the scientific assessment and staff- recommended changes to SEGs are required to be publicly reviewed with an opportunity for comment. The SEGs are set and modified through the BOF process, which includes stakeholder engagement opportunities.

The Copper River salmon fishery occurs both around the barrier islands and further offshore. Regulations have shifted the commercial fishery outside the islands, to slow the commercial fleet's harvest rate on Chinook and send more of these fish upriver to other harvest groups. ADF&G's 2019-2021 Prince William Sound Area Commercial Salmon Fishing Regulations, 5 AAC 24.350. Closed waters, Section (1)(B) provides a description with coordinates for the "Chinook inside closure area," which is always closed to commercial salmon fishing, except as provided in 5 AAC 24.361(b). 5 AAC 24.361 Copper River King Salmon Management Plan, subsection (b) allows the ADF&G commissioner to open the commercial fishery "no more than one 12-hour fishing period within the inside closure area of the Copper River District" during statistical weeks 20 and 21 (i.e., roughly the second half of May). While Chinook and sockeye salmon are mixed in the fishery, higher densities of Copper River Chinook are found in the inshore area (J. Botz, personal communication, May 12, 2021).

In recent years with lower Copper River Chinook pre-season run-size projections, the "Chinook inside closure area" has remained closed to the commercial fishery. In 2021, this closure was expanded to encompass more area to the northwest and east. The "inside area closure" has reduced the commercial fleet's access to Chinook (its intended purpose), but the fishery has also foregone some Sockeye harvest as well. ADF&G staff recently proposed to keep the "inside area closure" in place, so it would still be effectively used when Chinook harvest needs to be curtailed, but they may allow the fishery to access more Chinook (i.e., catch its commercial allocation more quickly) at the beginning of the season when Chinook are more abundant in the area. This regulatory change may further reduce the likelihood of the fishery intercepting Chinook that are considered "priority prey" stocks for SRKW, as Chinook stocks from areas outside the Copper River tend to be encountered more in the offshore area (J. Botz, personal communication, May 12, 2021).

ADF&G staff collect GSI samples throughout the season for both Chinook and Sockeye. While the Sockeye samples are readily processed, the Chinook samples are stored indefinitely and available for potential future analysis. Analysis of these samples could allow an evaluation of the predictive power of the PDO phase as a pre-season indicator of interception risk. If confirmed, this approach may provide a basis both for pre-season buying decisions and for adaptive management in salmon fisheries.

The Copper River salmon fishery is intensively managed with all available fishery biologists and managers in the Cordova area actively monitoring and sampling in the field on opening day and throughout most of the season. The process requires rapid coordination among enforcement, port samplers, fishery biologists, and managers in the marine area and upriver. Acting fast is essential to respond to rapid changes in the influx of migrating fish and catch rates. The commercial harvest is managed in-season through multiple openings and closures. These conservation measures are implemented quickly via emergency rules to ensure that enough fish pass through for escapement and to accommodate in-river fisheries.

Managers face multiple challenges in regulating the commercial fishery in a timely manner to accommodate fisheries upstream and ensure that escapement meets or exceeds the SEG. Many factors are considered in the process, including the pre-season forecast (i.e., how many Chinook are expected to return, and how many the commercial fishery is expected to harvest), the actual commercial effort and early season harvest rates, the estimated effort of the in-river fisheries (i.e., how many permits have been issued and, of those, how many typically participate), and the average in-river harvest in recent years.

In addition to tracking multiple moving pieces, in-season decisions are complicated by inaccurate forecasts, variable harvest rates, and recent increases in subsistence harvest levels. While multiple forecast methods are examined each year, they all rely on recent levels of total run size—either averages (2-, 3-, and 5-year) or annual observed. These have been highly variable. The resulting forecasts have often erred in both directions—overestimating and underestimating the run. Until recently these errors showed no trend in either direction (Table 3). However, in recent years (2009-2020), nearly two-thirds of the time the forecast commercial harvests have exceeded actual harvest levels by 40 percent or more.

Overall, the Copper River commercial Chinook fishery earned a B in the Stock Risk category, despite multiple strengths in harvest management. Potential risk factors include an aggregated escapement goal for all six sub-stocks, proposals to reduce the escapement goal, and a long-term decline in stock productivity (which fortunately shows recent signs of abatement). However, intensive in-season monitoring, coordinated communication, timely action taken in response to elevated harvest levels (particularly in recent years) and public and precautionary review of changes in. escapement goals support the B grade rather than a lower grade for Stock Risk.

3. Knowledge Risk

Knowledge of Prey Interception Risk

Strong evidence indicates that the probability of catching Chinook prey of SRKW in the Copper River fishery is low. Genetic sampling (GSI) data show that catches of West Coast-origin Chinook in the Copper River fishery are below the 10% threshold except in 2014 and 2015 when the anomalous marine heatwave occurred, and CWT data support this finding, indicating catches of hatchery Chinook from the south are below the threshold as well.

> *Note on prey interception risk:* Knowledge of SRKW prey interception rates relies upon the analysis of GSI data. To date, such analysis has been conducted only sporadically. Fortunately, Chinook GSI data are collected in the commercial fishery every year and are available for future analysis, which may be warranted as climate shifts become more frequent and extreme.

Knowledge of Stock Risk (Exploitation & Biomass)

Management of the Copper River Chinook fishery uses: 1) multiple data sources to monitor harvest, escapement, and other management parameters, including sonar data and apportionment data from dip net fisheries, Gulkana River aerial indices and tower counts, and mark-recapture estimates; 2) regular reviews of monitoring methods, including systematic research to identify and reduce errors and uncertainty; and 3) regular and rigorous reviews of the sustainable escapement goal (SEG) that are improved by the research and reviews described in the knowledge of prey interception risk section above.

Genetic studies have identified six major spawning populations (Upper Copper, Gulkana, Tazlina, Klutina, Tonsina, and Chitina; Templin et al 2011) that comprise the Copper River Chinook salmon stock. However, the SEG applies to all Copper River Chinook salmon in the aggregate. Managers at AF&G report that there is insufficient data to estimate escapement goals at the sub-stock level and that multiple physical challenges constrain the agency's ability to conduct spawning surveys, which would be necessary to measure performance against such goals.

An age-structured assessment model was initially used to estimate the abundance and escapement of Chinook salmon (Savereide 2001) and the number of spawners estimated to produce MSY (SMSY) was about 19,700 Chinook (Savereide and Quinn 2004). During the SEG review in 2017, a state-space model was used to estimate run size, escapement, and recruitment of Copper River Chinook. The model assumed a Ricker spawner-recruit (S/R) relationship and was fitted to multiple data sources for run reconstruction, and uncertainty was passed through the S/R analysis and subsequent reference points, such as SMSY. The 2017 review produced an SMSY of 18,595 fish, a recommended goal of 18,500-33,000 (Savereide et al. 2018). ADF&G initially proposed reducing the SEG accordingly. However, the modeled abundance estimates were imprecise and uncertain, and stakeholders were concerned that the lower SEG was not sufficiently precautionary; in response, ADF&G subsequently withdrew the proposal.

The latest SEG review (Joy et al. 2021) is more robust and precise than the previous review. It uses the same state-space model (Savereide et al. 2018) with two additional years of run size and escapement data and five more years of GSI data from commercial harvests (Gilk-Baumer et al. 2017). Joy et al. (2021) integrates two state-space models and only includes higher quality data sources comprised of harvest records, genetic makeup of the harvest, and mark-recapture estimates of escapement. Additionally, the mark-recapture dataset now includes a time series of sufficient length to calculate abundance estimates with quantified error estimates without the use of indices. This is a more precise method. This review produced an SMSY of 22,844 and a recommended SEG of 21,000-31,000 Copper River Chinook (Joy et al. 2021).

As indicated in the assessment, productivity and harvest have trended downward since the mid-1990s and the total run size of Copper River Chinook sharply declined in 2008 (Figure 4) and has remained relatively low since. Of particular note, the two state-space models in Joy et al. (2021) use different time series—one uses the full time-series of 1980-2018 and the other uses a subset of 1999-2018. The year 1999 marked a notable drop in stock productivity (Savereide et al. 2018) and using the two models allowed for a more focused examination of how productivity has changed. Median productivity in the full time series (1980-2018) was high (5.58 recruits per spawner), but so is the uncertainty of this estimate. The 1999-2018 model indicates lower productivity in the most recent 20 years (3.44 recruits per spawner), but with even greater uncertainty in the estimate (Joy et al. 2021).

The ADF&G Chinook Research Team (2013) and the latest assessment both note that productivity has been below average for all cohorts. Similar declines have been observed in many other Alaska Chinook stocks. Even though the reduction in productivity is thoroughly discussed in Joy et al. (2021), ADF&G staff are recommending reducing the lower bound of the SEG from 24,000 to 21,000 Chinook. Following the guidance in policies referenced above, they provided an opportunity for stakeholder review and public comment on their recommendation through the BOF process. The board rejected the lower escapement goal.

To improve the precision of escapement estimates and produce more accurate estimates of escapement in-season, ADF&G intends to manage the fishery in the future using Miles Lake sonar counts. ADF&G began differentiating Chinook using sonar at Miles Lake in 2018 with the long-term goal of pairing sonar counts with the mark-recapture estimates and switching to a sonar-based escapement goal. However, it will likely take one or more management cycles (i.e., two to four years) before these new methods can be incorporated into the stock assessment.

Multiple physical obstacles complicate in-stream surveys of salmon abundance in this river system. The Copper River mainstem is very braided down near the river mouth, which is over ten miles wide, and it does not narrow into a single channel until Miles Lake, about 33 miles up the river. The Copper River basin encompasses more than 24,200 square miles, about the size of West Virginia. ADF&G does not have the staff resources to cover the area, and many tributaries are extremely difficult to access with a boat, much less a plane. Visibility for surveys is poor as the water is glacial and very turbid throughout much of the basin. In considering alternatives to manage escapement, ADF&G officials have concluded that installing weirs and conducting mark-recapture studies for each spawning tributary would be very expensive, not feasible, and would have a high degree of uncertainty; counting fish using sonar is too expensive and needs a stable, deep channel (R. Brenner, personal communication, May 17, 2021). Haught et al. (2017) note that from 1980 to 1998, Chinook escapements were indexed in some spawning

tributaries using aerial surveys, but the current SEG of 24,000 was set based on "very few direct estimates of escapement," with the aim of keeping escapements "near the historical average" estimated for 1980-1998.

Three factors support a cautious approach to the idea of lowering the escapement goal: the downward trends in productivity and harvest over the past twenty-plus years (Figure 5), the uncertainty in using the mark-recapture data set to quantify abundance, and the ongoing need to confirm the reliability of sonar counts as a new and (hopefully) improved method to set future escapement goals. One precautionary approach would be to keep the current SEG until 1) new methods for estimating escapement and abundance, (e.g., using Miles Lake sonar), are confirmed to be more reliable; and 2) stock assessment scientists can carefully evaluate whether any improvement in such data collection methods actually justifies a lower escapement goal.

Endangered, Threatened, and Protected (ETP) Species:

Protected species include animals, such as marine mammals and seabirds, which are protected under the federal Marine Mammal Protection Act and Migratory Bird Treaty Act. Additional protective measures apply to species or stocks in decline that have been listed under the Endangered Species Act (ESA) as threatened or endangered. These may include marine mammals and seabirds, but can also include other animals, such as sea turtles.

Entanglement in fishing gear is the most consequential potential impact of salmon gillnet fisheries on protected species. For the Copper River Chinook fishery specifically, entanglement of seabirds or marine mammals is thought to be relatively rare, based on credible, but anecdotal, reports from experienced ADF&G staff who have managed and observed the fishery for decades.

> *Note on endangered, threatened, and protected (ETP) species impacts:* Systematic, scientific observations and documentation of interactions with seabirds and marine mammals have been a low priority because interactions have been relatively rare. If interactions increase in the future, systematic data collection may become advisable.

The apparent rarity of interactions with seabirds and marine mammals indicates that risk to protected species is likely low.

Marine Mammals:

Documented at-sea fishery observations from the National Marine Fisheries Service (NMFS) Alaska Marine Mammal Observation Program (AMMOP) are available for the Prince William Sound gillnet fishery for 1990-1991. The Prince William Sound gillnet fishery was not observed from 1992-2005, and the AMMOP was discontinued in 2006 (NOAA 2019a). Additional observations in other Alaska gillnet fisheries (e.g., in Cook Inlet and around Kodiak Island) may also provide useful information on potential for seabird bycatch.

Observer coverage is measured by the percentage of estimated sets observed. Observer coverage was 4% and 5% in 1990 and 1991, respectively, for the Prince William Sound gillnet fishery, which includes the Copper River drift gillnet fishery and other fisheries. The estimated total number of marine mammal interactions for the fishery was expanded based on the percentage observed (NOAA 2019a).

The Prince William Sound salmon drift gillnet fishery is currently classified as a Category II fishery under the Marine Mammal Protection Act (MMPA), which means that occasional interactions with marine mammals occur. There are approximately 537 participants in the fishery throughout Prince William Sound and the marine mammal species (and stocks) that are killed or injured are:

- Dall's porpoise (Alaska)
- Harbor porpoise (Gulf of Alaska)
- Harbor seal (Gulf of Alaska)
- Northern fur seal (North Pacific)
- Pacific white-sided dolphin (Central North Pacific)
- Sea otter (Alaska)
- Steller sea lion (Western U.S.)

The basis for the categorical classification is the total annual mortality and serious injury of marine mammals in this fishery is greater than 1% and less than 50% of the stocks' Potential Biological Removal (PBR) level. PBR is defined in the MMPA as "the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable

population" (NOAA 2019a). PBR is a calculation that takes into account the minimum population estimate of the stock, the estimated net productivity rate of the stock at a small population size, and a stock-specific recovery factor, which ranges in value from 0.1 for endangered stocks to 1.0 for healthy stocks (Wade and Angliss 1997).

Because Southern Residents are not found near the Copper River, the fishery is believed to have no entanglement impacts on them. However, as an example of how PBR is calculated and the factors considered, the PBR for SRKW is 0.13, which is approximately one animal every seven years. This PBR was calculated using the minimum population size (for SRKW, this is the direct count of individually identifiable animals, which is 75) multiplied by the estimated net productivity rate (for SRKW, this is one-half the maximum net growth rate for Alaska resident killer whales or 0.5 of 3.5%) multiplied by the recovery factor of 0.1 as SRKW are endangered (NOAA 2019b).

The two stocks driving the classification of the Prince William Sound salmon drift gillnet fishery are harbor porpoise and Steller sea lion. This fishery was listed as a Category II based on observer data that showed the level of harbor porpoise mortality and serious injury was 20 animals/year or 8.1% of PBR (PBR=247) and serious injury and mortality of Stellar sea lions was 14.5 animals/year or 6.2% of PBR (PBR=234) (NOAA 2019a).

More recent reports from the NOAA Alaska Fisheries Science Center on human-caused mortality or serious injury (2012-2016 and 2013-2017) indicated that ADF&G staff documented observations of Steller sea lion entanglements and fishery gear interactions during their standardized annual sea lion haul-out and rookery summer surveys. These surveys occur in Southeast Alaska, Prince William Sound, the Barren Islands, and Bristol Bay. From these observations, there were 228 incidents of seriously injured Steller sea lions in Prince William Sound that were determined to be unique animals. Additional observations specific to Prince William Sound include a Dall's porpoise that had been caught and killed in salmon drift gillnet gear (2013), seven harbor seals were killed with firearms (1 in 2015; 3 in 2016; and 3 in 2017), and a Steller sea lion had suffered a serious injury from an arrow in its muzzle (2013) (Helker et al. 2019, Delean et al. 2020).

There is a track record of enforcement of protected species rules in the Copper River salmon gillnet fishery. In 2015, two men participating in the fishery pled guilty and were convicted of killing 15 sea lions—one was the captain of the F/V Iron Hide and the other was a member of his crew. The captain admitted to regularly directing his crew to shoot the sea lions and driving the boat toward the animals to give his crew member a better shot, and at times using a shotgun to shoot the animals himself. Both men were placed under house arrest and ordered to provide community service and pay fines for their actions.

Seabirds:

The U.S. Fish and Wildlife Service (USFWS) periodically assesses the status of seabird populations in Alaska and identifies the major threats and conservation concerns. Their status reports also include information on seabird interactions in fisheries based on at-sea observer data collected through the NMFS Alaska Marine Mammal Observation Program, and other human-induced sources of mortality. Table 4 summarizes the most recent USFWS seabird reports for Alaska.

Summary of Knowledge Risk Assessment

To summarize knowledge risk and its management in this fishery, ADF&G managers have timely access to multiple data sources to develop preseason run-size forecasts, monitor run size and harvest rates in-season, and respond rapidly to changing conditions. Fishery managers and scientists have a robust toolkit to restrict harvest in order to protect or increase escapement and reduce consequences of any errors and uncertainties in run-size estimates (which have frequently been high in recent years). However, the BOF policies lack specific criteria and direction for when revisions to an SEG may be warranted, particularly if the proposed modification is a reduction. Recently developed sonar monitoring at Miles Lake may permit greater precision in estimating run size and escapement. However, a rising subsistence harvest occurring upriver from the lake has potential to complicate these tasks. Meanwhile, acknowledging the impediments to developing and monitoring stock-specific escapement goals, the absence of disaggregated goals for the six substocks of Chinook in the basin could present both knowledge and stock risks. These risks appear likely to increase with climate change and reduced productivity.

Recommendation

Genetic stock identification (GSI) data provide the only accurate method for estimating stock composition of the commercial harvest of wild stocks and untagged stocks from areas outside of the Copper River. A preliminary

analysis suggests that there may be a correlation between sea surface temperature (SST) and intercept rates of Chinook from areas outside the Copper River and that the Pacific Decadal Oscillation (PDO) may be a viable indicator for use in PCC sourcing and potentially in fishery management. To validate this approach and serve PCC's objective to protect prey supply for SRKW, we recommend research to retrospectively analyze existing Chinook GSI samples on a four- or five-year basis to assess the potential for use of the PDO's warm phase as a forecasting tool to identify periods of elevated SRKW prey interception risk.

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Appendix

Appendix A: Chinook Harvest

Table A-1. Estimates of Chinook salmon harvest from the Copper River District for the commercial and subsistence fisheries, by sector and harvest type (1980-2018).

Year	Copper River District					
	Commercial	Subsistence	Homepack	Donated	Educational	Total District Harvest
1980	8,454	19				8,473
1981	20,178	48				20,226
1982	47,362	60				47,422
1983	52,500	79				52,579
1984	38,957	68				39,025
1985	42,214	88				42,302
1986	40,670	86				40,756
1987	41,001	49				41,050
1988	30,741	59				30,800
1989	30,863	56				30,919
1990	21,702	60				21,762
1991	34,787	136				34,923
1992	39,810	142				39,952
1993	29,727	120				29,847
1994	47,061	164	751			47,976
1995	65,675	154	1,688			67,517
1996	55,646	276	2,169	0	0	58,091
1997	51,273	200	1,243	0	0	52,716
1998	68,827	295	1,411	0	0	70,533
1999	62,337	353	1,115	0	14	63,819
2000	31,259	689	740	6	8	32,702
2001	39,524	826	935	0	16	41,301
2002	38,734	549	773	4	27	40,087

2003	47,721	710	1,073	3	0	49,507
2004	38,191	1,106	539	5	0	39,841
2005	34,624	260	760	11	92	35,747
2006	30,278	779	779	3	11	31,850
2007	39,095	1,145	1,019	0	70	41,329
2008	11,437	470	537	4	47	12,495
2009	9,457	212	876	0	50	10,595
2010	9,645	276	906	0	31	10,858
2011	18,500	212	1,282	0	6	20,000
2012	11,764	237	853	0	6	12,860
2013	8,826	854	564	0	55	10,299
2014	10,207	153	768	0	36	11,164
2015	22,506	167	1,145	0	50	23,868
2016	12,348	73	727	0	86	13,234
2017	13,834	778	744	0	50	15,406
2018	7,618	1,356	85	0	40	9,099

Source: Reproduced from Joy et al. 2021, Appendices A.1 and A.2

Table A-2. Estimates of Chinook harvest from the Copper River District commercial and subsistence fisheries, federal subsistence and state personal use fisheries in the Chitina and Glenallen Subdistricts, sport fishery, and combined total subsistence and total harvest for Copper River District (1980-2018), and (when available) estimates of inriver abundance, total run, harvest rate, and escapement (1999-2018).

Year	Copper River District Commercial & Subsistence	Federal Subsistence & State Personal Use		Sport	Total Subsistence (All Areas)	Total Harvest (All Areas)	Inriver Abundance	Total Run Size	Harvest Rate	Total Escapement
		Chitina Subdistrict	Glenallen Subdistrict							
1980	10,453	1,767	3,035	2,101	4,802	17,356				
1981	22,207	1,410	2,410	1,717	3,820	27,744				
1982	49,404	1,900	2,764	1,802	4,664	55,870				
1983	54,562	4,255	5,950	2,579	10,205	67,346				
1984	41,009	1,760	509	2,787	2,269	46,065				
1985	44,287	1,329	1,958	1,939	3,287	49,513				
1986	42,742	2,367	686	3,663	3,053	49,458				
1987	43,037	2,968	813	2,301	3,781	49,119				
1988	32,788	2,994	992	1,562	3,986	38,336				
1989	32,908	2,251	787	2,356	3,038	38,302				
1990	23,752	2,708	647	2,302	3,355	29,409				
1991	36,914	4,056	1,328	4,884	5,384	47,182				
1992	41,944	3,405	1,449	4,412	4,854	51,210				
1993	31,840	2,846	1,434	8,217	4,280	44,337				
1994	49,970	3,743	1989	6,431	5,732	62,133				
1995	69,512	4,707	1,892	6,709	6,599	82,820				
1996	60,087	3,584	1,482	9,116	5,066	74,269				
1997	54,713	5,447	2,583	8,346	8,030	71,089				
1998	72,531	6,723	1,842	8,245	8,565	89,341				
1999	65,832	5,913	3,278	6,742	9,205	81,765	32,090	95,909	85%	14,144
2000	34,716	3,168	4,856	5,531	8,032	48,271	38,047	70,749	68%	22,478
2001	43,318	3,113	3,553	4,904	6,682	54,888	39,778	81,079	68%	26,191

Source: Reproduced from Joy et al. 2021, Appendices A.1 and A.2

Continued on next page

Table A-2. *Continued from previous page*

Year	Copper River District Commercial & Subsistence	Federal Subsistence & State Personal Use		Sport	Total Subsistence (All Areas)	Total Harvest (All Areas)	Inriver Abundance	Total Run Size	Harvest Rate	Total Escapement
		Chitina Subdistrict	Glenallen Subdistrict							
2002	40,118	2,056	4,217	5,098	6,300	51,489	32,873	72,960	71%	21,471
2003	49,510	1,921	3,092	5,717	5,013	60,240	44,764	94,271	64%	34,031
2004	39,846	2,502	3,982	3,435	6,484	49,765	40,564	80,405	62%	30,640
2005	35,850	2,094	2,618	4,093	4,804	44,655	30,333	66,080	68%	21,425
2006	31,864	2,681	3,229	3,425	5,921	41,199	67,789	99,639	41%	58,440
2007	41,399	2,722	3,939	5,123	6,731	53,183	46,349	87,678	61%	34,495
2008	12,546	2,022	3,218	3,618	5,287	21,404	41,343	53,838	40%	32,434
2009	10,645	223	3,036	1,355	3,309	15,259	32,401	42,996	35%	27,737
2010	10,889	718	2,425	2,409	3,174	16,441	22,323	33,181	50%	16,740
2011	20,006	1,080	3,062	1,753	4,148	25,901	33,889	53,889	48%	27,988
2012	12,866	572	2,510	459	3,088	16,407	31,452	44,312	37%	27,905
2013	10,354	762	2,522	285	3,339	13,923	32,581	42,880	32%	28,957
2014	11,200	733	1,785	931	2,554	14,649	24,158	35,322	41%	20,673
2015	23,918	1,585	2,614	1,343	4,249	29,460	32,306	56,174	52%	26,714
2016	13,320	726	2,471	327	3,283	16,844	16,009	29,243	58%	12,399
2017	15,456	1,973	3,366	1,731	5,389	22,526	40,725	56,131	40%	33,605
2018	9,139	1,374	6,960	1,278	8,374	18,751	52,524	61,623	30%	42,872

Source: Reproduced from Joy et al. 2021, Appendices A.1 and A.2

Appendix B: Tables & Figures

Year	*Estimated U.S. West Coast Chinook[1]*	*Total Commercial Chinook Sampled*	*U.S. West Coast Chinook Intercept Rate*
2005	409	30,703	1.33%
2006	1299	26,484	4.90%
2007	77	33,759	0.23%
2008	480	11,387	4.22%
2013	68	4,336	1.57%
2014	969	9,364	10.35%
2015	3003	19,340	15.53%
2016	426	10,181	4.18%
2017	106	12,782	0.83%

[1]Note: GSI data for 2005-2008 includes British Columbia and West Coast.

Table 1. Chinook GSI estimates (numbers of fish) caught in the Copper River commercial fishery.

Year	*Estimated U.S. West Coast Chinook*	*Total Commercial Chinook Harvest*	*U.S. West Coast Chinook Intercept Rate*
2000	92	31,259	0.30%
2001	278	39,524	0.70%
2002	361	38,734	0.93%
2015	1,804	22,506	8.01%
2016	132	12,348	1.07%
2017	21	13,834	0.15%
2018	3	7,618	0.05%
2019	221	19,890	1.11%
2020	152	6,105	2.50%

Table 2. CWT estimates of Chinook (numbers of fish) caught in the Copper River commercial fishery.

Year	Preseason Forecast			Actual			Actual in Relation to Forecast		
	Commercial Harvest	*All Harvest*	*Total Run*	*Commercial Harvest*	*All Harvest*	*Total Run*	*Commercial Harvest*	*All Harvest*	*Total Run*
2009	30,700	53,000	77,000	9,457	15,209	42,996	-69%	-71%	-44%
2010	17,000	25,000	49,000	9,645	16,410	33,181	-43%	-34%	-32%
2011	9,000	14,000	38,000	18,500	25,895	53,889	206%	185%	42%
2012	19,800	27,000	54,000	11,764	16,401	44,312	-41%	-39%	-18%
2013	14,000	19,800	46,000	8,826	13,868	42,880	-37%	-30%	-7%
2014	22,000	33,000	62,000	10,207	14,613	35,322	-54%	-56%	-43%
2015	5,500	*9,185*	36,000	22,506	29,410	56,174	409%	320%	156%
2016	21,000	40,000	64,000	12,348	16,758	29,243	-41%	-58%	-54%
2017	4,000	*6,680*	29,000	13,834	22,476	56,131	346%	336%	194%
2018	13,000	19,000	43,000	7,618	18,711	61,623	-41%	-2%	143%
2019	*20,770*	31,000	55,000	19,000			-9%		
2020	*24,120*	36,000	60,000	6,878			-71%		

Note: Italicized forecast values were estimated using the average commercial proportion of total harvest for 2009-2014 (67%). Blank cells indicate data are not available.

Table 3. Comparison of preseason forecast vs. estimated actual commercial harvest, all-sector harvest, and total run size and the differences expressed as a percentage of the forecast amount, 2009-2020.

Species	ESA-Listed in Alaska	Conservation Status	Observed in Prince William Sound Gillnet Fisheries	Observed in Other Alaska Gillnet Fisheries	Other Human-Induced Sources of Mortality
Kittlitz's murrelet	No - Was a candidate species from 2004 to 2013	High Concern	Yes (1990-1991)	No	Oil spills; potential breeding area disturbance
Marbled murrelet	No - Listed as Threatened in WA, OR, and CA	High Concern	Yes (1990-1991)	Yes - Cook Inlet (2000) and Kodiak Island (2002)	Oil spills; potential loss of nesting habitat and forage fish
Common murre	No	Low Concern	Yes (1991)	Yes - Upper Cook Inlet (1999) and Kodiak Island (2002)	Native subsistence hunting and egg harvesting; oil spills; predation (introduced species)
Least auklet	No	Moderate Concern	No	Yes - Kodiak Island (2002)	Native subsistence hunting and egg harvesting; oil spills; nesting disturbance; predation (introduced species)
Rhinoceros auklet	No	Low Concern - Population likely increasing	No	No	Oil spills; disturbance and trampling of burrows and nests; predation (introduced species)
Horned puffin	No	Moderate Concern	No	Yes - Kodiak Island (2002)	Native subsistence hunting and egg harvesting; oil spills
Tufted puffin	No	Not at Risk - Population Increasing	Yes - in "small numbers"	Yes - Kodiak Island (2002)	Native subsistence hunting and egg harvesting; oil spills; predation (introduced species)
Pelagic cormorant	No	High Concern	No	Yes - Kodiak Island (2002)	Native subsistence hunting and egg harvesting; oil spills; nesting disturbance
Red-faced cormorant	No	High Concern	No	Yes - Kodiak Island (2002)	Native subsistence hunting and egg harvesting; oil spills; predation (introduced species)
Pigeon guillemot	No	Moderate Concern	No	Yes - Kodiak Island (2002)	Native subsistence hunting and egg harvesting; oil spills; predation (introduced species)

Table 4. Status of seabird populations in Alaska and observed seabird interactions in Alaska gillnet fisheries from USFWS reports[1].

[1]Source: USFWS online reports (2006) https://www.fws.gov/

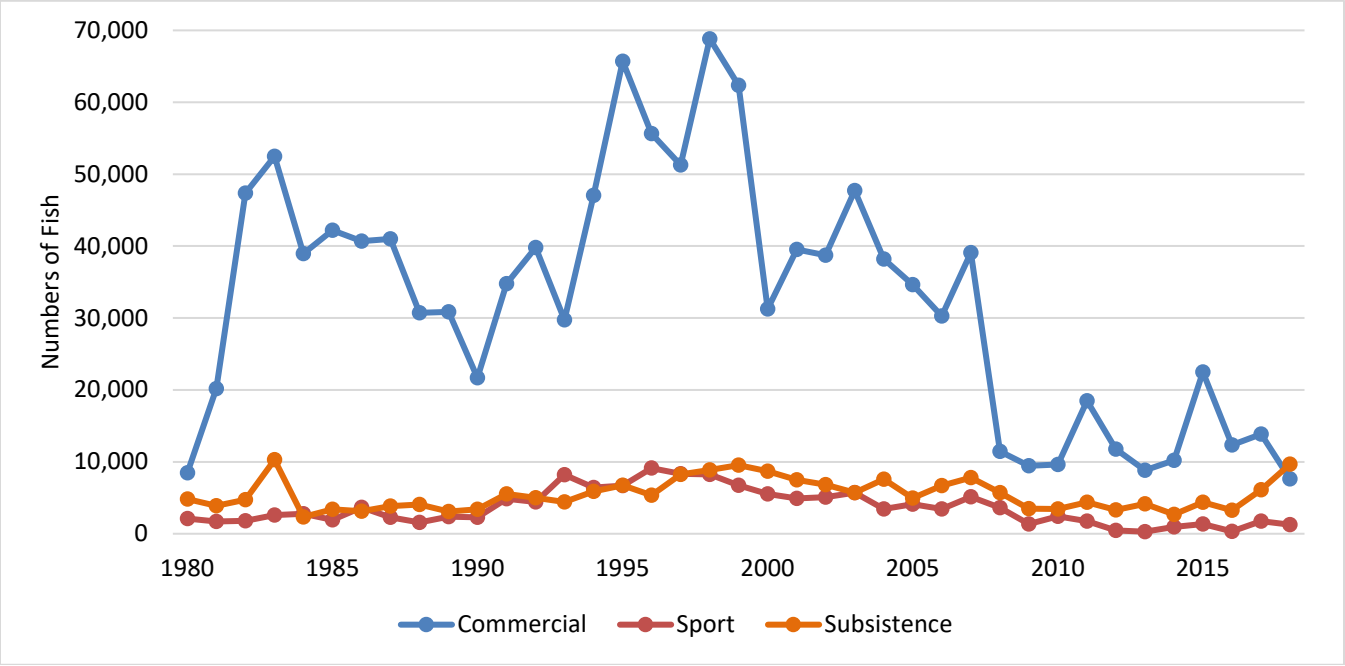

Figure 1. Estimates of Chinook harvest in the Copper River salmon fisheries, by sector, 1980-2018.

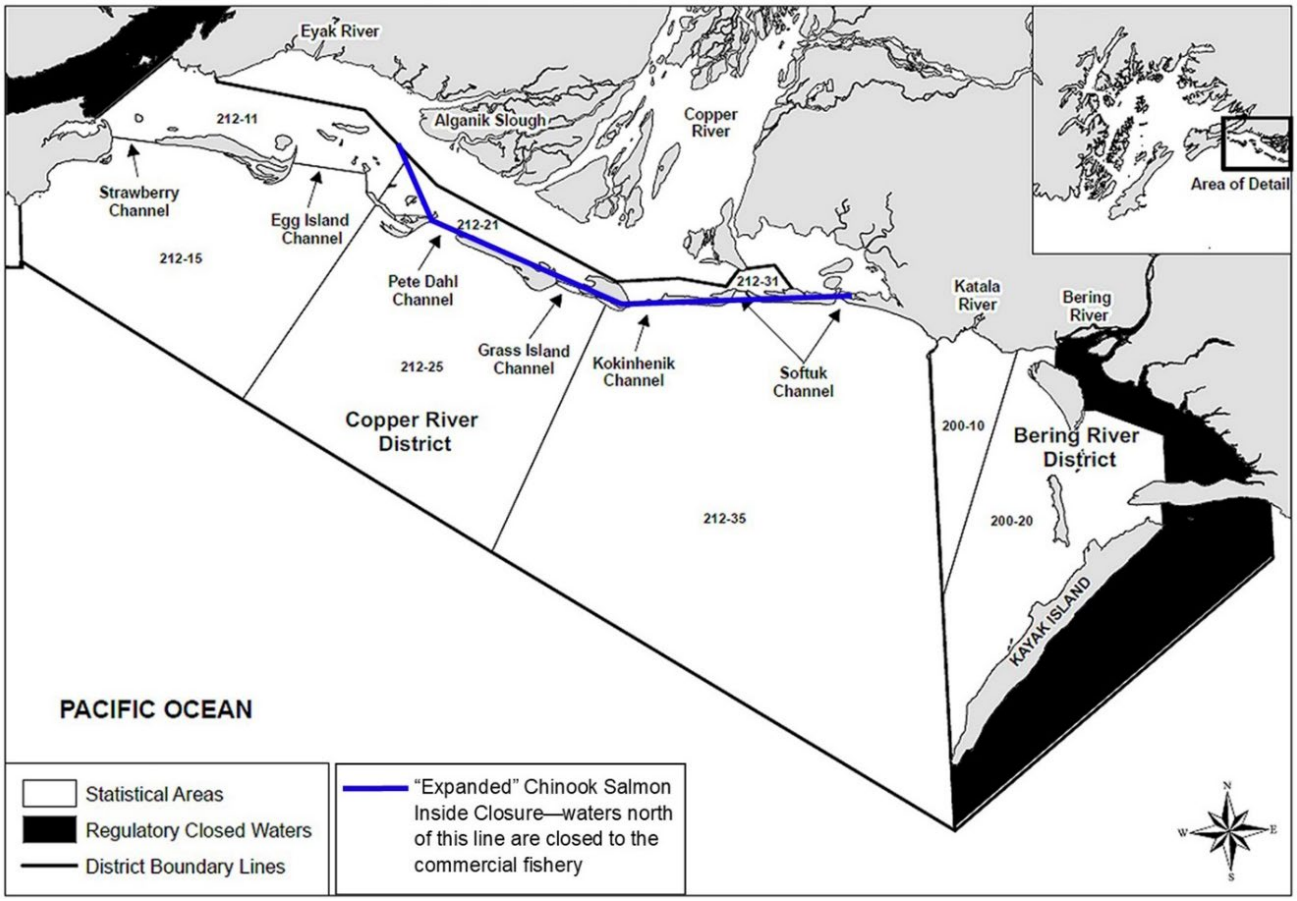

Figure 2. The Copper River commercial fishery occurs around the islands and seaward of the "Chinook salmon inside closure area," which was expanded in 2021 to include areas to the northwest and east.

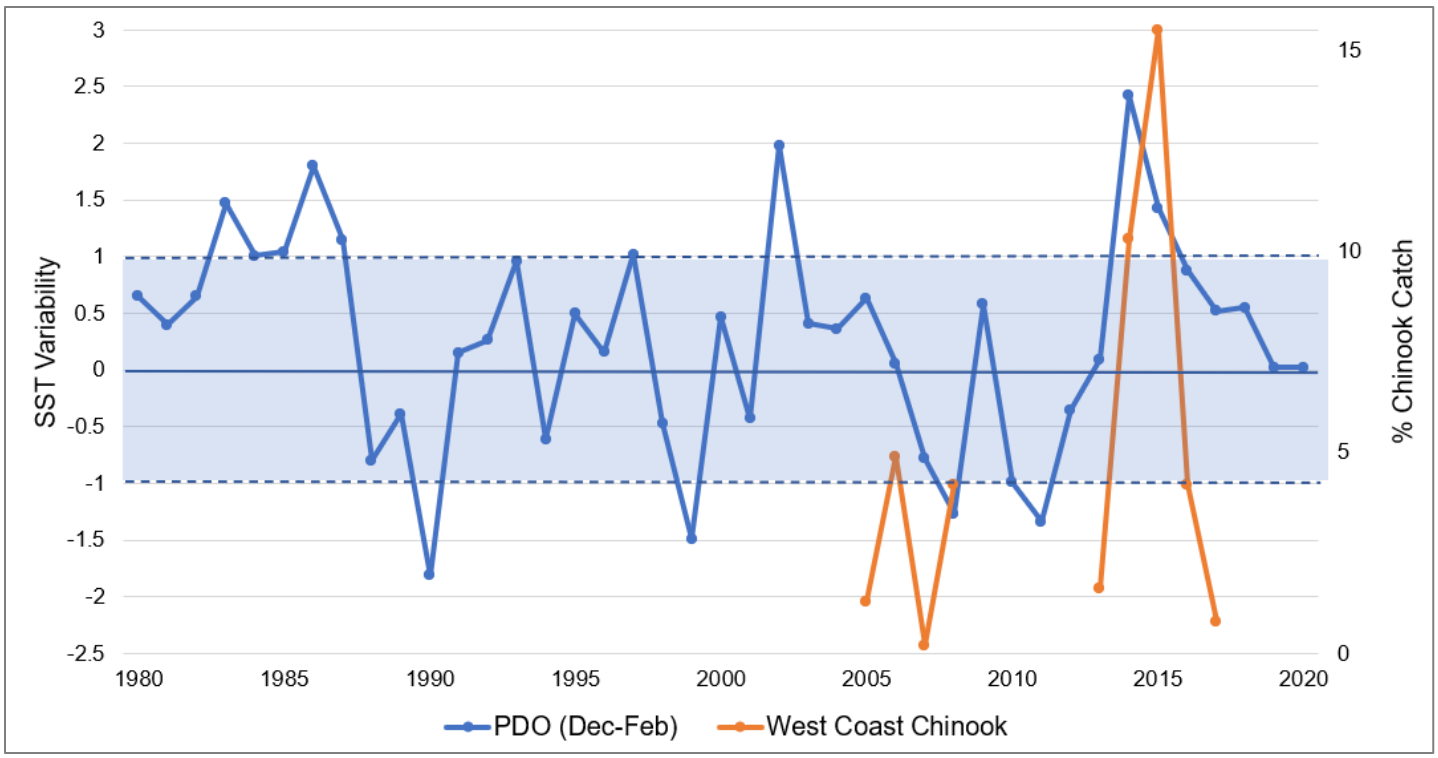

Figure 3. SST variability relative to the mean (PDO) and percent Chinook catch of West Coast-origin in the Copper River commercial fishery using GSI data, 1980-2020.

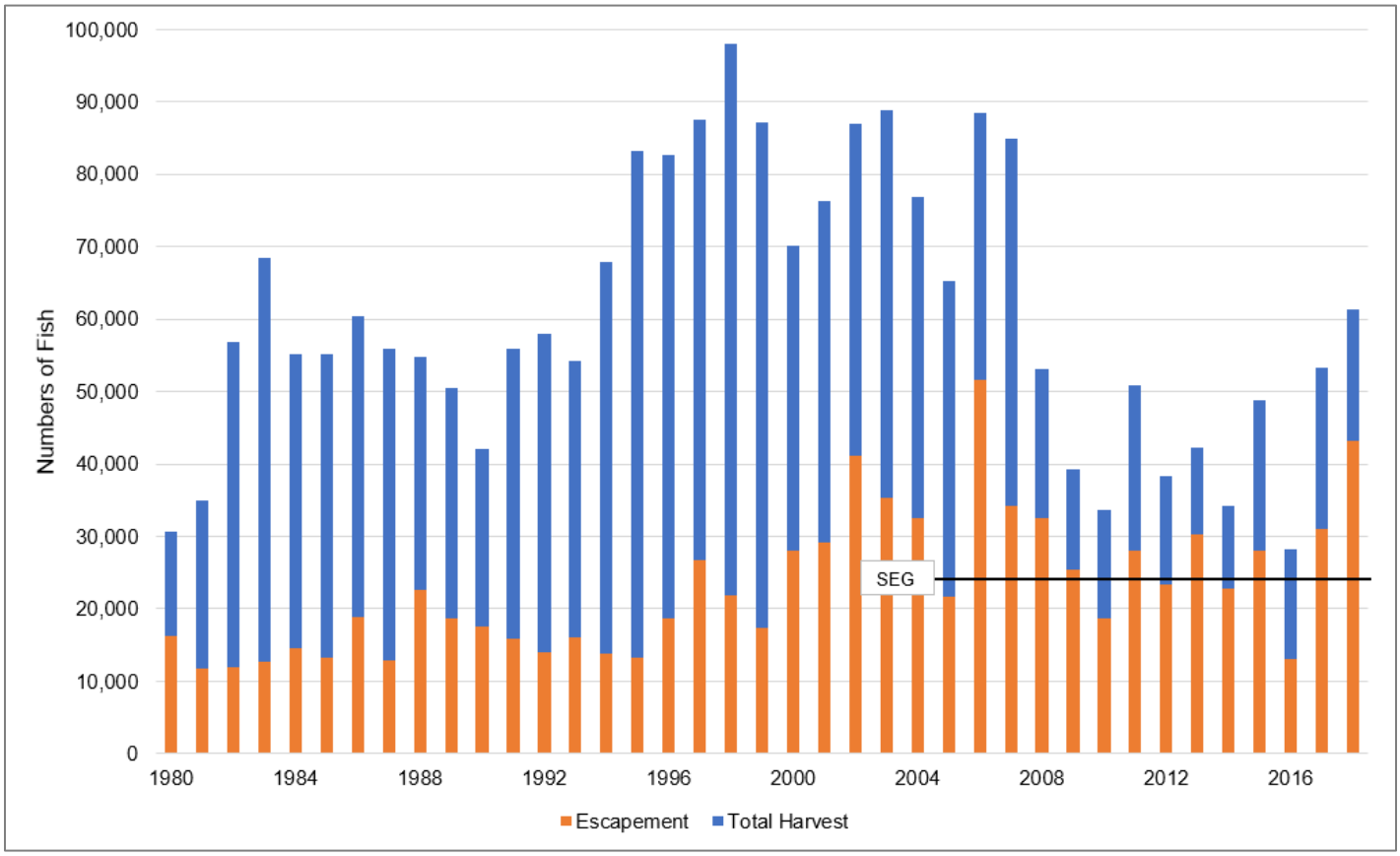

Figure 4. Copper River fishery Chinook harvest (all sources) and escapement (i.e., total run size, in combination), 1980-2018.

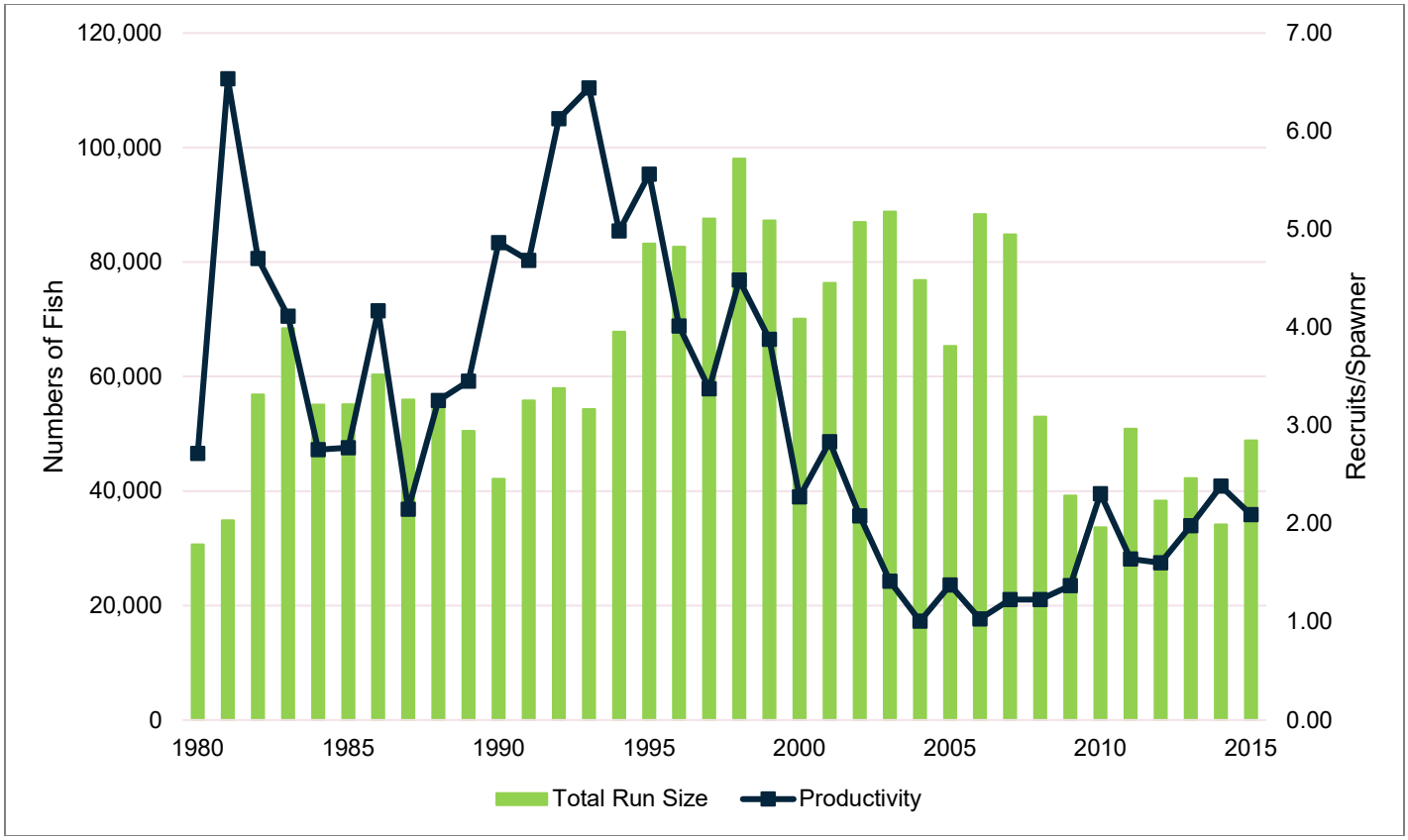

Figure 5. Copper River Chinook salmon run size and productivity, 1980-2015.

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Chinook Salmon Fishery Evaluation

Hoodsport Hatchery Terminal Fishery

August 4, 2020

2020 Evaluation: Passed **Overall Rating:** A

Fishery Overview:

The Chinook terminal fishery at Hoodsport Hatchery harvests fish in their final passage from the sea back to a state-run hatchery in the Southern end of Hood Canal, a fjord opening into Puget Sound.

The fishery is managed to target only hatchery fish, which can be identified by adipose fin clips. Chinook are caught with beach seines as they return to their 'natal' hatchery location at the mouth of Finch Creek. Therefore, the target catch consists of Chinook that have already escaped from foraging grounds of Southern Resident Killer Whales (SRKW).

The hatchery program follows best practices recommended for segregated broodstock management and for mitigating the risk of genetic and ecological impacts on neighboring stocks. To ensure complete clipping of hatchery fish, on a daily basis several checks are conducted as the Chinook are released. Records of those samples are kept ensuring a complete clipping rate. At the hatchery level, 100% of the adult Chinook catch is checked for fin clips and Coded Wire Tags (CWT). Additionally, timing and location help ensure low incidental catch of chum, steelhead, and non-salmonid species in the Hoodsport hatchery terminal fishery. The impacts on protected species are believed to be rare and minimal.

Evaluation Summary:

The Hoodsport hatchery Chinook fishery on Finch Creek earns the A rating based on findings that: 1) prey interception risk, exploitation risk, and biomass risk are managed at levels that satisfy standards and indicators underpinning this rating for each category; and 2) knowledge risk for each standard and indicator is constrained sufficiently to produce the necessary confidence in data.

At Hoodsport, indicators for hatchery management, All-H integration, and precautionary response to uncertainty are satisfied by careful and closely scrutinized practices under their Hatchery Genetic Management Plan.

Evaluation Chart

	Findings	Rating	Notes
1. Prey Interception Risk		**A**	
1.1 No Overlap			
Indicator 1.1.1			
Indicator 1.1.2			
1.2 Post-Prey	Strong evidence indicating near-zero probability of catching SRKW priority Chinook prey.	A	No documented sightings of SRKW in Hood Canal. Fishery is located at the hatchery and harvest targets returning adult fish that have escaped from foraging grounds of SRKW.
Indicator 1.2.1			
Indicator 1.2.2	Indicator met.		
1.3 Negligible Effect			
Indicator 1.3.1			
2. Stock Risk		**A**	
2.1 Exploitation		A	Fishery is managed on the basis of hatchery production. Any fish not needed for broodstock collection are harvested, so indicators for target-stock exploitation rate and protection of spawning biomass (applicable to wild stocks) do not apply. Exploitation rates and impact limits for non-target fisheries are observed, but for the targeted hatchery fish there is no cap on exploitation rate. Close observation of harvest levels and set reference points allow managers to reduce harvest rates as appropriate to meet broodstock needs.
Indicator 2.1.1: Exploitation Rate			
Indicator 2.1.2: Reference Points	Tight control over production and harvest allows for set reference points.		
Indicator 2.1.3: ETP Species	Satisfied provisionally by evidence that little mortality is attributed to the fishery for Chinook salmon returning to Hoodsport hatchery terminal fishing area.		
Indicator 2.1.4: Uncertainty → Precaution	Data and in-season changes ensure hatchery escapement goals are met.		
Indicator 2.1.5: Compliance	Satisfied to extent that exploitation rates and impact limits for non-target fisheries are observed.		
Indicator 2.1.6: Timely Action	Tight control and monitoring allow for in-season adjustments.		
2.2 Biomass		A	
Indicator 2.2.1: Reference Points			
Indicator 2.2.2: Uncertainty → Precaution	Data and in-season changes ensure hatchery escapement goals are met.		

		Indicator 2.2.3: Compliance	Satisfied by practice of adjusting fishing pressure as needed based on in-season data.		
		Indicator 2.2.4: Timely Action	Satisfied by practice of adjusting fishing pressure as needed based on in-season data.		
	2.3 Hatcheries		All indicators met.	A	Location, timing, and segregation from natural spawning populations reflect strong precaution against potential hatchery risks to wild stocks. Management objectives include All-H integration, seeking to integrate management of hatchery, habitat, and harvest according to recognized best practices. This is a segregated hatchery, meaning that only marked hatchery fish are used for broodstock, and no wild salmon inhabit the creek.
		Indicator 2.3.1: Hatchery Management			
		Indicator 2.3.2: All-H Integration			
		Indicator 2.3.3: Uncertainty → Precaution			
3. Knowledge Risk				**A**	
	3.1 Knowledge Risk for Interception			A	
		3.1.1 No Overlap			
		Indicator 3.1.1.1			
		Indicator 3.1.1.2			
		3.1.2 Post Prey		A	Hoodsport is an "extreme-terminal" fishery, and 97% of the harvest can be shown to originate from the hatchery through ongoing marking data. Thus, the fishery meets the relevant requirement to ensure that over 90% of Chinook encountered have escaped from SRKW foraging waters en route to upstream spawning grounds or hatcheries.
		Indicator 3.1.2.1			
		Indicator 3.1.2.2	1) Hood Canal is specifically excluded by NOAA as SRKW Critical Habitat Designation and there have been no sightings of SRKW in Hood Canal; and 2) Ten years of catch records show an average of ~97% of the catch originates with the hatchery. Hatchery origin fish are identified by adipose fin clipping.		
		3.1.3 Negligible Effect			
		Indicator 3.1.3.1			

	3.2 Knowledge of Stock Risk			A	
		3.2.1 Exploitation		A	Reliable, timely data from multiple sources give harvest managers a strong toolkit to identify and reduce errors and rapidly constrain harvests to protect or increase escapement. Monitoring, documentation, and data collection over 10 years provide sufficient confidence that nearly all fish harvested (~97%) are of hatchery origin. If broodstock levels aren't met, managers can take from neighboring hatcheries that use genetically identical broodstock.
			Indicator 3.2.1.1: Exploitation rate		
			Indicator 3.2.1.2: Reference points		
			Indicator 3.2.1.3: Uncertainty and Error	Satisfied with high confidence.	
			Indicator 3.2.1.4: Compliance		
			Indicator 3.2.1.5: Timely Action	Satisfied with high confidence.	
			Indicator 3.2.1.6: ETP Species	Satisfied with moderate to high confidence.	
		3.2.2 Biomass		A	
			Indicator 3.2.2.1: Monitoring	Satisfied with high confidence.	
			Indicator 3.2.2.2: Reference Points		
			Indicator 3.2.2.3: Uncertainty → Precaution	Satisfied with high confidence.	
			Indicator 3.2.2.4: Compliance	Satisfied with high confidence.	
			Indicator 3.2.2.5: Timely Action	Satisfied with high confidence.	
		3.2.3 Hatcheries		Indicators satisfied with high confidence.	A	Managers employ best practices in hatchery management, monitoring, marking, and precautionary response to uncertainties. Use of local broodstock, extensive marking, documentation, and efforts to minimize ecological and genetic impacts permit high confidence in determining that the hatchery meets the relevant standards and indicators.
			Indicator 3.2.3.1: Hatchery management		
			Indicator 3.2.3.2: Monitoring		
			Indicator 3.2.3.3: Hatchery Marking and Tagging		
			Indicator 3.2.3.4: Uncertainty → Precaution		

Note: Any lines or sections left blank are considered not applicable to the specific fishery under evaluation.

Full Evaluation Details

1. Prey Interception Risk (Post-Prey)

Hood Canal has no known sightings of SRKW (NOAA 2006, NOAA 2019). NOAA's 2019 *Proposed Rulemaking to Revise Critical Habitat for the Southern Resident Killer Whale Distinct Population Segment*, specifically excludes the waters of Hood Canal from the critical habitat designation, reaffirming the exclusion made by the agency's earlier designation of critical habitat (NOAA 2006, NOAA 2019).

Approximately 99% of released juvenile hatchery fish are marked (Addae 2020), which allows managers a very high degree of confidence in ensuring that harvested fish originated at the hatchery, and that there is little to no incidental catch of Chinook from either SRKW priority stocks or Endangered Species Act (ESA) listed Chinook stocks. Ten years of catch records indicate that 97% of harvested adult fish were marked and of Hoodsport origin.

2. Stock Risk

Exploitation and Biomass Risk

Some stock risk indicators, except those detailed below, are inapplicable to the Hoodsport terminal Chinook fishery because it targets hatchery fish and harvest occurs directly at the hatchery grounds. The fishery is managed on the basis of hatchery production, which allows for in-season harvest decisions as necessary to meet sustainable hatchery production goals for escapement/broodstock collection. Meeting broodstock goals acts as a proxy for exploitation rate and biomass protection. When goals are expected to be met, the run is open to harvest.

As a terminal hatchery-based fishery, Hoodsport has tight controls over escapement and harvest that have allowed the fishery to be reasonably successful in meeting seasonal escapement goals. Through careful management, the fishery removes a high proportion of returning adult hatchery fish while providing sufficient escapement to perpetuate the hatchery program. Additionally, the fishery is successful in avoiding incidental catch of non-hatchery fish; ten years of catch records indicate that an average of 97% of fish caught have clipped adipose fins indicating hatchery origin.

For this fishery, indicators 2.1.1 and 2.2.1 are satisfied by managers' practice of ensuring that sufficient broodstock are collected (including following the recommended hatchery practice of collecting broodstock throughout the run to ensure diversity), and making in-season decisions about needed closures or reductions in harvest when broodstock collection goals are not being met. As noted above, no exploitation rate limit exists for the target catch. Fish not needed for broodstock are harvested, and protections of biomass are not applicable to a terminal, segregated-broodstock, hatchery fishery.

Indicators: Reference Points, Uncertainty, & Timely Action

To set appropriate harvest limits, managers need access to reliable data to track harvest and return size accurately. Current practices in Washington Department of Fish and Wildlife (WDFW) management of the Hoodsport Chinook fishery meet these requirements.

This terminal fishery is believed to have little to no impact on wild stocks. The number of young hatchery Chinook released is managed to allow for best possible forecasting and desired harvest size. The terminal location of the fishery enables managers to adjust harvest for actual run size and ensure appropriate escapement for hatchery broodstock. Since all hatchery fish are marked and the fishery is mark-selective, managers can have a high degree of confidence that over 95% of harvest originate with Hoodsport Hatchery, with about 3% originating from unmarked stock, believed by managers to be mostly other Hood Canal hatchery Chinook that spawned in the wild (WDFW 2019b, Downen 2019).

State and tribal co-managers of Hoodsport fisheries demonstrate a precautionary response to uncertainty in the fishery by revising harvest limits to ensure adequate broodstock. Harvest is contingent upon abundance and sustainability of the hatchery program. In 2019, the fishery was closed, and a release from managers stated: "Hatchery returns are below projections. This conservation measure is necessary to ensure that hatchery broodstock goals are met" (WDFW 2019f).

Indicator: Endangered, Threatened and Protected (ETP) Species

WDFW managers report little to no indication that the Hoodsport terminal Chinook fishery is responsible for mortality of any endangered, threatened, or protected species. Entanglement with seabirds, pinnipeds, and cetaceans is believed to be rare, with no documented entanglements, based on reports from tribal and WDFW managers overseeing the fishery. This fishery is conducted in a small "extreme terminal area" in waters within a 2,000-foot arc seaward of the yellow marker buoys at the mouth of Finch Creek, using only beach seine gear. While reports note the presence of certain ETP species such as the marbled murrelet (USFWS 2012), migratory birds, and bald eagles (SBE 2015), managers and published scientific articles collected on seabird entanglement do not report any encounters between the Hoodsport terminal beach seine fishery and these species. The risk of such entanglement is considered to be very low (Addae 2020).

Chinook fisheries in Hood Canal are restricted to protect summer chum salmon and other ETP fish species. Finally, use of beach seines enables live release of incidentally caught fish, one of several well-known approaches to achieve selective harvest.

Hatchery Risk

The Hoodsport hatchery is believed to pose minimal risk to wild salmon stocks and surrounding ecosystems, and is managed through a precautionary All-H integration framework, seeking to responsibly align hatchery, habitat, and harvest according to recognized best practices. The latest Hatchery Genetic Management Plan found a negligible risk of genetic or ecological impacts on neighboring stocks (HMGP 2016).

Location, timing, and segregation from natural spawning populations, coupled with the absence of a natural Chinook population, results in minimal impact from any hatchery strays and minimizes bycatch risk during harvest. Timing, location and use of beach seines for harvest allows for easy and immediate release of any bycatch of non-Chinook species, such as chum, steelhead or non-salmonid species. Hoodsport Chinook are expected to migrate quickly through Hood Canal and minimize potential ecological interactions and any adverse effects to listed Chinook.

At Hoodsport, WDFW annually monitors size, age class, number, date of release, location and release type, and records them in the WDFW Hatcheries Headquarters Database. Additionally, staff annually coded-wire tag a portion of the releases to enable evaluation of contribution to fisheries, survival rates, possible straying to other watersheds, and identification at release site (HGMP 2016).

Broodstock selection, marking practices, and disease control practices provide ongoing checks to maintain a high level of precaution. Pathologists from WDFW's Fish Health Section monitor the program monthly. Exams performed at each life stage may include tests for virus, bacteria, parasites and/or pathological changes, as needed, and smolts are always inspected in the weeks before release to prevent carrying of disease into outside waters. Returning adult broodstock are inspected for pathogens, and a fish health database is maintained. Flow and discharge from the hatchery are reported monthly and monitored to prevent effluent from detrimentally affecting natural populations and habitat.

Fishery managers and organizations that oversee the recovery of local wild stocks of other species report that the Hoodsport fishery does not interfere with the recovery plans or abundance of those species (Downen 2019, HGMP 2016, HCCC 2020). Endangered summer chum are considered extirpated from Finch Creek (WDFW and PNPTT 2000).

ESA salmonids in the area include the George Adams Hatchery fall Chinook, Skokomish Fall Chinook, Hamma Hamma fall Chinook, Mid Hood Canal Fall Chinook, Puget Sound Chinook, Hood Canal summer chum, and Puget Sound Steelhead. The most recent Hatchery Genetic Management Plan for Hoodsport hatchery finds that none of the listed species are directly affected by the program, but some may be incidentally affected (HGMP 2016). To mitigate the potential of the hatchery program and fishery to harm these listed species, timing, geography of the fishery, and smolt size at release are managed to minimize impacts on other salmonid and non-salmonid wild stocks. Juvenile releases are made at an age to ensure swift migration out of the area, reducing the potential for predation by hatchery fish. In addition, on-site release enhances homing sense, reducing the potential for straying (HGMP 2016).

3. Knowledge Risk

Knowledge of Prey Interception Risk (Post-Prey)

While the area is within the range of SRKW, no known sightings of SRKW have occurred near Hoodsport Chinook fishery, and Hood Canal is specifically excluded from critical habitat of these whales. According to NOAA, there have been no confirmed sightings of Southern Residents in Hood Canal. Additionally, tag recovery data indicates that within the past several decades, no migrating Chinook from British Columbia or the U.S. West Coast have been found in Hoodsport.

All hatchery fish are marked and counted, and records show that over 95% of fish caught in the Hoodsport terminal fishery originated from Hoodsport, with the remainder originating from what managers believe to be primarily other Hood Canal hatchery stocks (Downen 2019). No priority SRKW stocks or non-hatchery fish have been found in the harvest (WDFW 2019b).

Knowledge of Stock Risk (Exploitation & Biomass)

For this hatchery-stock-based terminal harvest, exploitation and biomass indicators are largely inapplicable, but we assessed practices used to meet hatchery broodstock needs. Exploitation rate is managed by first ensuring that broodstock needs are met and making any necessary in-season changes to harvest to meet those needs; what remains determines exploitation (harvest). In a hatchery-based terminal fishery, knowledge and management of exploitation can be carefully overseen and documented. Hoodsport Terminal Chinook escapement (with broodstock egg-take as proxy) met or exceeded its goal for providing hatchery broodstock in 75% of years documented in WDFW's 1999-2019 escapement reports (WDFW 2020b).

Managers report that any shortfall is made up by obtaining broodstock from neighboring hatcheries that have exceeded their needs for that year (neighboring hatcheries use broodstock of identical genetic origin). The fishery isn't opened until managers are confident that returns of adult fish are on track to meet broodstock needs, and harvest is adjusted if it appears that broodstock needs may not be met. Best practice for genetic management of stock requires that broodstock be taken throughout the return period in proportions approximating the timing and age distribution of the population from which broodstock is taken (HGMP 2016). Hoodsport follows this practice.

Harvest of non-hatchery Chinook is avoided, and an ongoing, annual marking program affirms the fishery's performance in this task. To ensure all hatchery fish are clipped, on a daily basis several checks are conducted as the young Chinook are released. Records of those samples are kept ensuring as near to 100% clipping rate as possible (average over 10 years is 99.7%, per WDFW 2019b). At the hatchery level, 100% of the adult Chinook catch is checked for fin clips and Coded Wire Tags (Villarreal 2020).

The streams entering the Hoodsport fishery area do not support native wild stocks (HGMP 2016), and the method of fishing (beach seine) ensures that any bycatch of non-Chinook species can be immediately released alive. Fishery managers and organizations that oversee the recovery of local wild stocks of other species report that the Hoodsport fishery does not interfere with the recovery plans or abundance of those species (Downen 2019, HGMP 2019, HCCC 2020). Further, endangered summer chum are considered extirpated from Finch Creek (WDFW and PNPTT 2000).

Indicators: Compliance & Timely Action

Managers have access to multiple data sources to forecast and track changes in run size, track harvest rates based on current and accurate catch reports, and assess escapement during fishery openings, enabling timely management action and achieving escapement goals needed for broodstock according to hatchery management guidelines.

Finch Creek currently supports no local natural Chinook stock (NOAA 2005, HGMP 2016). Daily checks ensure that juvenile fish from the hatchery are marked before they are released, and all harvested fish are checked to determine the proportion of marked and unmarked fish. Of the Chinook harvested in the Hoodsport Hatchery Zone, approximately 97% of the catch is documented to be hatchery marked. This shows that exploitation of any naturally spawning Chinook is 3% or less (WDFW 2019b).

Indicator: Endangered, Threatened and Protected (ETP) Species

Entanglement of seabirds, cetaceans, and pinnipeds is believed to be rare, based on credible but anecdotal reports from experienced managers who have overseen the fishery for decades. The fishery uses beach seines only, a method of fishing that is less prone than many others to harmful interactions with ETP species; the risk of entanglement is considered very low. Chinook harvest and broodstock collection are conducted using timing and methods that minimize impacts on and interactions with any naturally spawning population or ETP fish species. Use of beach seines permits live release of any non-target fish, which are visually identified by the absence of adipose fin clips.

The apparent rarity of interactions with cetaceans, pinnipeds, and seabirds indicates that risk to protected species is currently low. As elsewhere, the incidence of these interactions may change in the future as climate change alters the distribution and behavior of many species.

The 2005 NOAA Endangered and Threatened Species Listing Determinations (NOAA 2005) states: "In the proposed ESU determination for the Puget Sound Chinook ESU… we conclude that the Hoodsport Hatchery program is not part of the ESU. Finch Creek, where the Hoodsport Hatchery program is located, historically and currently lacks an extant local natural Chinook salmon population."

Knowledge of Stock Risk (Hatchery Risk)

Hoodsport managers employ best practices in hatchery management, monitoring, marking, and precautionary response to uncertainties. The hatchery actively participates in coordinated multi-sector work to achieve "all-H" risk management. As noted above (under Hatchery component of Stock Risk), Hoodsport applies best practices for control of potential hatchery impacts. Hoodsport hatchery's fin-clipping marking system generates adequate and reliable data on catch composition in this terminal Chinook fishery. Use of local broodstock and extensive monitoring of the percentage of marked harvest and the hatchery release clipping program, as well as efforts to mitigate any potential detrimental effects on other Hood Canal fish, permit high confidence in evaluation of potential ecological and genetic impacts.

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Chinook Salmon Fishery Evaluation

Tulalip Bay

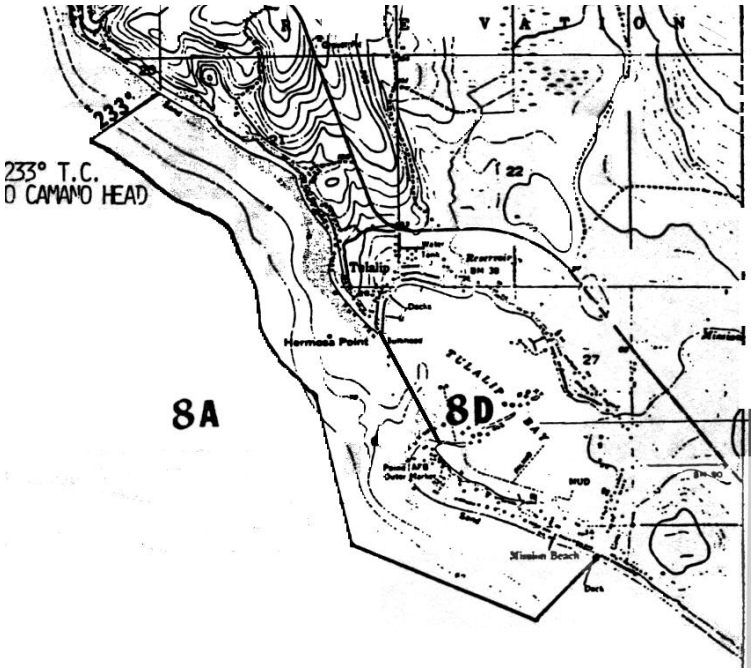
August 29, 2020

2020 Evaluation: Passed **Overall Rating:** A

Fishery Overview:

Tulalip Bay is located about 40 miles north of Seattle, near the mouth of the Snohomish River, where the tribe plays a leading role in salmon restoration work. Approximately 77% of tribal Chinook catch occurs inside Tulalip Bay, and the rest is taken just off the beach along the Tulalip reservation. In most years, the tribal Tulalip Bay Chinook fishery harvests a few thousand Chinook salmon, caught selectively as they return to the Tulalip tribal hatchery in the bay. The target catch consists of Chinook that have escaped from foraging grounds of Southern Resident Killer Whales. The tribes' setnet fishers operate inside the bay, and a few tribal gillnet, beach seine, and roundhaul fishers operate just outside the bay along the reservation shore, targeting the same hatchery fish. The Tulalip fishery accounts for a fraction of the 3% incidental mortality on Snohomish wild Chinook collectively attributed to all treaty tribal fisheries. Impacts on non-salmonid protected species are believed to be rare and minimal. Risks of intercepting SRKW prey or depleting Chinook stocks are low to non-existent. Available data and research support the tribes' precautionary, adaptive management.

Map of Tulalip Bay, Area 8D shown in red on the left. 8A marks open water offshore.



Above: Map of Tulalip Bay (red) and nearby waters of Puget Sound, about 40 miles north of Seattle: MAP SOURCES: Left: Scott Smeltz. Right: Tulalip Tribes.

Evaluation Summary:

The Tulalip Chinook fishery earns the A rating based on findings that: (1) prey interception risk, exploitation risk, and biomass risk are managed at levels that satisfy standards and indicators underpinning this rating for each category; and (2) knowledge risk for each standard and indicator is constrained sufficiently to produce the necessary confidence in data. At Tulalip's hatchery facility, "All-H" integration and precautionary response to uncertainty satisfy the relevant standards and indicators with careful and closely scrutinized practices under a federal permit issued by NOAA.

The evaluation for this particular fishery examines exploitation and biomass jointly; any identically named indicators within the two sections are combined for analysis.

Evaluation Chart

	Findings	Rating	Notes
1. Prey Interception Risk		**A**	
1.1 No Overlap			
Indicator 1.1.1			
Indicator 1.1.2			
1.2 Post-Prey	Fishery is in enclosed terminal area, where fish-eating SRKW have not been documented in recent decades (though mammal-eating transient orcas have visited the bay in the past).	A	Using small, shallow, closely tended setnets, the Tulalip Tribes' Chinook fishery in Tulalip Bay selectively harvests fish returning from the ocean to the tribal hatchery where they originated.
Indicator 1.2.1	Satisfied by careful tribal management practices and the fishery's geographic isolation from known feeding grounds of SRKW.		
Indicator 1.2.2			
1.3 Negligible Effect			
Indicator 1.3.1			
2. Stock Risk		**A**	
2.1 Exploitation		A	The Tulalip fishery avoids ESA-listed wild Chinook, targeting fish from a hatchery that the tribe built in the 1980s (long before Puget Sound Chinook were listed) to support its fishery while protecting depleted local wild stocks. Incidental impacts on wild Chinook returning to the Snohomish River Basin amount to a fraction of the 3% incidental mortality attributed to all treaty tribal fisheries. Entanglement of marine mammals and birds is believed to be rare to non-existent, and no takes of these species were identified. One
Indicator 2.1.1: Exploitation Rate	Satisfied with moderate to high confidence.		
Indicator 2.1.2: Reference Points	Satisfied by managers' use of Rebuilding Exploitation Rates.		
Indicator 2.1.3: ETP Species	Satisfied Tulalip Tribe & co-manager precautions to limit hatchery impact on wild species, including Chinook.		
Indicator 2.1.4: Uncertainty → Precaution	Satisfied by managers' use of Rebuilding Exploitation Rates.		
Indicator 2.1.5: Compliance	Satisfied with moderate to high confidence.		
Indicator 2.1.6: Timely Action	Satisfied with moderate to high confidence.		
2.2 Biomass		A	
Indicator 2.2.1: Reference Points	Satisfied by managers' use of Rebuilding Exploitation Rates.		
Indicator 2.2.2: Uncertainty → Precaution			

		Indicator 2.2.3: Compliance	Satisfied with moderate to high confidence.		manager noted that tribal fishers actively tend their small, shallow nets in the bay to collect fish before agile seals and sea lions grab them. The tribes' hatchery program may supply prey for a variety of marine mammals that feed in the estuary and adjacent marine waters, according to a 2017 NOAA report.
		Indicator 2.2.4: Timely Action			
	2.3 Hatcheries		All indicators satisfied with high confidence. Known and potential impacts of Tulalip's hatchery and state hatchery programs in the Snohomish basin are recognized, carefully monitored, and managed using precautionary best practices.	A	The hatchery program supporting this harvest operates under close scrutiny through NMFS permitting, using recognized best practices for hatchery management and protection of neighboring wild stocks. Use of local broodstock, extensive monitoring and marking of hatchery fish helps to limit potential hatchery risks to neighboring natural stocks of salmon.
		Indicator 2.3.1: Hatchery Management			
		Indicator 2.3.2: All-H Integration			
		Indicator 2.3.3: Uncertainty → Precaution			
3. Knowledge Risk				**A**	
	3.1 Knowledge Risk for Interception			A	
		3.1.1 No Overlap			
		Indicator 3.1.1.1			
		Indicator 3.1.1.2			
		3.1.2 Post Prey	The Tulalip Tribes' carefully documented selective harvest of hatchery Chinook, and the absence of documented SRKW sightings in Tulalip Bay during recent decades provides high confidence that this fishery meets the criteria for "post-prey" status.		Otolith thermal marking of all hatchery-released Chinook shows that an average of 91.5% of the catch taken in the tribe's Tulalip Bay Chinook fishery during 2007-2018 originated from the tribal hatchery. No SRKW have been documented in the bay during recent decades.
		Indicator 3.1.2.1	Satisfied with high confidence.		
		Indicator 3.1.2.2			
		3.1.3 Negligible Effect			
		Indicator 3.1.3.1			

	3.2 Knowledge of Stock Risk				
		3.2.1 Exploitation	Indicators satisfied with high confidence, unless noted otherwise.	A	Carefully documented harvest data and marking of hatchery fish provide high confidence that the tribal fishery selectively avoids wild Chinook and targets fish from Tulalip's hatchery, protecting escapement and spawning capacity in adjacent wild stocks. Available monitoring shows with high confidence that the fishery's incidental impacts on wild Chinook are kept safely below fishery exploitation limits designed to rebuild wild populations of Snohomish basin Chinook. Increasing evidence suggests that non-fishing impacts—habitat degradation and climate change—now constrain recovery.
			Indicator 3.2.1.1: Exploitation rate		
			Indicator 3.2.1.2: Reference points		
			Indicator 3.2.1.3: Uncertainty and Error		
			Indicator 3.2.1.4: Compliance		
			Indicator 3.2.1.5: Timely Action		
			Indicator 3.2.1.6: ETP Species	This indicator is satisfied with moderate confidence.	
		3.2.2 Biomass	All indicators satisfied with high confidence.	A	
			Indicator 3.2.2.1: Monitoring		
			Indicator 3.2.2.2: Reference Points		
			Indicator 3.2.2.3: Uncertainty → Precaution		
			Indicator 3.2.2.4: Compliance		
			Indicator 3.2.2.5: Timely Action		
		3.2.3 Hatcheries	All indicators satisfied with high confidence.	A	Tulalip managers employ best practices in hatchery management, monitoring, marking, and precautionary response to uncertainties.
			Indicator 3.2.3.1: Hatchery management		
			Indicator 3.2.3.2: Monitoring		
			Indicator 3.2.3.3: Hatchery Marking and Tagging		
			Indicator 3.2.3.4: Uncertainty → Precaution		

Note: Any lines or sections left blank with greyed text are considered not applicable to the specific fishery under evaluation.

Full Evaluation Details

1. Prey Interception Risk (Post Prey)

The fishery operates mainly in Tulalip Bay, a shallow, semi-enclosed body of water covering nine square miles, located just north of the Snohomish River mouth at the Tulalip Reservation. A small portion of the catch is taken in waters outside to the bay along the reservation shore.

Selectivity is achieved by tribal fishing rules and rigorously verified by data from the tribes' salmon-marking program. All Chinook from the tribes' hatchery are marked. The hatchery releases fish into the bay when they are ready to begin their ocean migration, feeding in the North Pacific for several years before returning to spawn. Tribal hatchery managers adjust the water temperature while young fish are rearing in the facility. This places a thermal mark on the otoliths (ear bones) of all hatchery Chinook raised by the tribe. When the fish return, the marked otoliths are collected and examined in a Tulalip laboratory.

These marking data show affirmatively that an average of 91.5% of the catch taken in the tribe's fishery during 2007-2018 originated from the Tulalip Bay hatchery (Mike Crewson pers. comm. 2020).

No documented sightings of Southern Residents in Tulalip Bay in recent decades were identified in reports designating critical habitat for SRKW (NMFS 2006) or the recent National Marine Fisheries Service (NMFS) proposal to expand critical habitat (NMFS 2019). Killer whales of unknown origin reportedly frequented Tulalip Bay and nearby open waters during salmon and herring runs in the early 20th Century (when both fish species were more abundant), according to the federal 2008 Recovery Plan for Southern Resident Killer Whales (NMFS 2008).

Not all killer whales in this region are Southern Residents, which rely on fish for food. Seal-eating killer whales were believed to visit waters near Tulalip in ancient times. Tulalip oral history and legends suggest a historical and cultural connection to seal-eating killer whales that are regarded as ancestors and benefactors to the tribes. These whales are credited with saving the Tulalip people from famine. According to one story shared by the tribes, one year strange climate conditions led to a shortage of game on land, and after a hungry winter the spring salmon run was consumed by seals: "Hordes of seals invaded the waters near Priest Point, chasing the salmon and devouring them before the people could catch any" (Tulalip Tribes website, undated). In despair, the starving people called out to their ancestors, two brothers who had been skilled seal hunters who "went to live in the ocean and became killer whales." In one version of this story, "the people called out to them for help, remembering that the two brothers had been expert at getting food for the people. The killer whales heard the peoples' call. They arrived and caught every seal. They ate the seal heads and tossed the seal bodies on the beach for the people. In that way, they saved the people from starvation and preserved the salmon run for coming generations." Another version of this story shared by the tribe reports that "the seals used to come frequently in the spring, and that the killer whales were called many times, not just once" (Tulalip, undated). Either way, the Tulalip's reverence for these seal-eating whales still resonates among tribal members today.

It is not known if the whales visiting the Tulalip area in the early 20th Century were fish-eaters such as SRKW or transient whales that eat predators of the fish, such as pinnipeds. Terry Williams, a tribal elder and longstanding Commissioner of Fisheries and Natural Resources for Tulalip Tribes (full disclosure: also a board member of NFCC), noted that the recent steep decline in local Chinook salmon populations (mainly due to habitat degradation) has depleted the main food source that might have had potential to attract fish-eating Southern Residents to waters near the Tulalip reservation in the past (Terry Williams pers. comm. 2019).

Marine biologists have noted a distinction in use of habitat by different killer whale populations, which informed NMFS's determination that SRKW avoid shallow inshore waters such as Tulalip Bay. The federal fisheries agency excluded waters shallower than 20 feet from designated critical habitat for SRKW inside Puget Sound (NMFS 2006), while noting that other killer whale populations do use these areas. "We do not consider extremely shallow waters of Puget Sound to be within the geographical area occupied by the species," states the agency's 2006 critical habitat report for the SRKW population. "This is in contrast to transient killer whales, which enter shallow water to capture seals and sea lions, and Northern Residents, which spend time in shallow water at rubbing beaches," the 2006 report authors noted.

2. Stock Risk

Exploitation and Biomass Risk

Note on Evaluation Method: Indicators are listed separately for exploitation and biomass, but they are combined for purposes of this evaluation because management practices address these forms of risk jointly. In practice, in salmon fisheries, exploitation and biomass standards are addressed by evaluating numbers of fish, not their weight, even though biomass remains a common and broadly applied term. Similarly, reference points based on Maximum Sustainable Yield (MSY) are still widely applied in policies such as the Magnuson-Stevens Fishery Conservation and Management Act, but in many salmon fisheries they have been supplanted by more precautionary metrics.

Indicators: Exploitation Rate, Compliance, & Timely Actions

Exploitation rate in this fishery meets all applicable limits on harvest, indicating that both managers and fishers are complying with policies governing exploitation rate and conservation of spawning potential. Timely action is reflected both in policies and in management actions that have reduced harvests to protect wild stocks.

Fisheries in Alaska and British Columbia get "first crack" at Snohomish basin Chinook while the adult fish return from ocean pastures to their natal waters. Recreational catches in British Columbia and Washington accounted for "the bulk of the harvest" (46.9% and 45.1% respectively) on WDFW's Wallace River hatchery Chinook, a key indicator stock for natural-origin Chinook returning to the Skykomish tributary of the Snohomish, according to the 2017 regional Chinook management plan (Puget Sound Indian Tribes and WDFW 2017).

The Tulalip Bay treaty tribal Chinook fishery selectively targets hatchery fish, which are produced according to best practices (see *Hatchery Risk* below). The fishery has no direct take of fish from natural spawning Chinook, which are now listed under the ESA. Because the fishery selectively targets hatchery fish in terminal waters within the bay, it has only incidental and minor impact on naturally spawning Chinook returning to the adjacent Snohomish River.

Incidental impacts from the Tulalip Bay fishery are kept safely below the 2017 harvest limits developed jointly by the Puget Sound Indian Tribes and Washington Department of Fish and Wildlife (WDFW). This plan sets exploitation rates to allow for rebuilding and reduces those rates, declining to 15% or more, when abundance is critically low (Puget Sound Indian Tribes and WDFW 2017).

In recent decades, declining stock productivity (linked to climate change impacts and habitat degradation) has required extraordinary action to reduce exploitation rates on wild stocks (see Figure 1, in Appendix A). To protect Snohomish wild Chinook stocks, total exploitation rates from coastwide fisheries were whittled down from over 60% in 1985 to less than 20% during 2010-2016. Tulalip's Chinook fishery's impact on these fish accounts for a fraction of the small (<3%) incidental mortality attributed to all treaty tribal fisheries, based on model analyses summarized by the Snohomish Basin Salmon Recovery Forum in 2019, originally from FRAM model runs.

Tribal and nontribal fisheries in the region have a strong record of compliance with exploitation limits. Even in the face of severe habitat damage and increasing climate impacts, state and tribal co-managers were able to keep coastwide fishery exploitation rates below the planned limits in all but one year in the decade from 2004-2014 (see Figure 2, "pre-post column, Total ER" in Appendix A).

Managers also were able to modestly increase Snohomish River Chinook escapement during the decade to 2018 (see Figure 3, in Appendix A). However, managers reported that escapement dropped sharply in 2019. Some biologists attribute this decline largely to the hot, fish-killing conditions experienced during 2015, the year much of the 2019 return was spawned. That year, large numbers of returning adult salmon died in their final passage toward spawning grounds in overheated Northwest rivers, resulting in a small year-class of fish returning in 2019.

Recovery of Puget Sound's endangered wild Chinook remains in question, primarily due to ongoing threats to habitat. Tribal and state co-managers of the Puget Sound Chinook fishery state: "Recovery for most populations cannot be accomplished solely by constraint of harvest. For the immediate future, harvest constraint will assist in providing optimal escapement, suited to current habitat condition. Productivity is constrained by habitat conditions, and is not influenced by harvest, provided harvest does not reduce escapement to the point of demographic or genetic instability. The quality and quantity of freshwater and estuarine environment determines

embryonic and juvenile survival, and oceanic conditions influence survival up to the age of recruitment to fisheries. Physical or climatic factors, such as stream flow during the incubation period, will vary annually, and have been shown to markedly reduce smolt production in some years" (Puget Sound Indian Tribes & WDFW 2017).

The co-managers also noted that diminished productivity due to adverse habitat and climate conditions have kept the major Snohomish Chinook stock, the Skykomish, "at very low levels, while total natural escapement has either increased or held stable where hatchery supplementation programs exist…. It is evident that natural production has not increased under reduced harvest pressure and is constrained primarily by the condition of freshwater habitat. Therefore, the harvest rates governed by this plan are not impeding recovery."

In a 2019 Biological Opinion evaluating tribal and non-tribal fishery effects on ESA-listed stocks, NMFS affirmed that salmon fisheries in Southern U.S. waters (mainly Washington) have kept exploitation rates on Snohomish wild Chinook well below rebuilding rates in recent years, further indicating that harvests were not impairing recovery. The 2016 actual exploitation rate on Snohomish Chinook was 8%, well below the 15% management objective (NMFS 2019).

Indicators: Reference Points & Uncertainty → Precaution

Note: The exploitation rate limits described below are from the 2017 management plan, as the initial draft of this evaluation occurred prior to the release of the new 2020 management plan.

Rebuilding Exploitation Rates (RER) were initially developed by Tulalip biologists (working with peers at WDFW and NOAA) as a tool for rebuilding Puget Sound salmon runs. The runs became so depleted, mainly by habitat damage, that Puget Sound commercial fishers petitioned to protect them under the Endangered Species Act in 1999. The RER framework has been widely adopted as a primary harvest control tool by federal, state, and tribal resource managers in Puget Sound. The goal is to ensure that any salmon catch still permitted in Washington waters leaves enough fish in the water not just to reproduce at today's levels, but to rebuild healthy natural-spawning populations.

The RER and other reference points for harvest vary by run, incorporating data on abundance, productivity, and, in some basins (including the Snohomish), habitat condition. These benchmarks are more conservative than a maximum-sustained yield (MSY) policy. This higher level of precaution is evident in the fact that exploitation rate on the Snohomish basin's naturally spawning Chinook averaged 17.5% under the RER policy during 2010- 2016. The 2017 Puget Sound Chinook Management Plan incorporated stepped reductions in fishing pressure to be applied when abundance is low, and for some runs, tighter catch limits formally outlined in the most recent management plan were already being applied even before final publication in late 2020.

Among multiple precautionary restraints on fishing pressure, the 2017 management plan "prohibits directed harvest on natural origin populations of Puget Sound Chinook salmon unless they have a harvestable surplus," the plan authors noted. For the region's most depleted stocks, the plan drastically reduced exploitation rate ceilings—including any incidental catch—to protect spawning escapement. The thresholds stepping down exploitation are designed to keep spawner abundance well above the "point of instability," the level that represents high risk to populations.

Given these controls on exploitation, the plan authors affirmed that recovery of Puget Sound Chinook stocks in critical condition now hinges on improving habitat, not further cuts in harvest. "Improvement of these stocks' condition will not occur without significant actions to correct reductions in natural productivity and capacity due to loss and degradation of habitat," they stated. Even "complete closure of all fisheries is unlikely to improve the status of any critical MU" (management unit), the plan authors stated.

Tribal, state, and federal co-managers recognize and address uncertainty and its risks in multiple ways. The 2017 Puget Sound Chinook Management Plan noted that exploitation ceilings based on stock productivity (e.g., for naturally spawning Chinook in the Snohomish Basin) are subject to "uncertainty and bias, and harvest management is subject to imprecision." To address this, plan authors noted that the methodology for setting exploitation rate ceilings "considers specifically these sources of uncertainty and error and manages the consequent risk that harvest rates will exceed appropriate levels. The productivity of each management until will be periodically re-assessed, and harvest objectives modified as necessary."

Puget Sound Chinook fisheries are regulated with explicit recognition of uncertainties about impacts from interception fisheries that are outside the jurisdiction of state and tribal authorities. Authors of the Puget Sound

Chinook Management Plan noted that persistent high exploitation of Snohomish Chinook by Alaska and British Columbia fisheries recently pushed Washington managers to reduce planned harvest rates deeply and repeatedly in local fisheries to protect spawning capacity.

Additional Details on Benchmarks and Controls:

The Exploitation Rate Ceiling represents "the maximum level of fishing-related mortality allowed (Puget Sound Indian Tribes and WDFW 2017). This ceiling is "the principal mechanism for achieving spawning escapement objectives that are consistent with current habitat function," according to the 2017 management plan. This approach also provides a buffer against uncertainty: "a harvest strategy based on harvesting all surplus above a certain level (i.e., escapement goal management) maximizes the long-term yield assuming no uncertainty in the forecasted population size. When there is uncertainty in the forecasted abundance, a proportional threshold strategy, which attempts to harvest a constant fraction (i.e., ER management) of the forecasted abundance above a population threshold outperforms a pure threshold strategy (i.e., escapement goal management) both in long-term yield and variability in yield..." The plan adds: "The co-managers determined that management objectives based on exploitation rates were more averse to risk (e.g., overharvest, extinction probabilities, etc.) than objectives based on spawning escapements…because of uncertainties associated with forecasting abundance estimates and because exploitation rates can be verified by independent estimates derived from CWT recovery data."

The Critical Exploitation Rate (CER) ceiling in the 2017 plan set a more precautionary exploitation policy for salmonid stocks in very poor shape. The policy intended to minimize additional demographic and genetic risk to critical stocks while providing some opportunity for treaty tribes to harvest healthy, harvestable stocks, for example from hatcheries. Puget Sound's severely depleted naturally spawning Chinook are off-limits to any directed harvest; in Washington waters, only incidental catch is allowed. The CER limits often govern that incidental catch.

The 2017 plan specifically noted that habitat damage is the main driver of depletion in these stocks, so eliminating harvest alone cannot rebuild them. Even "complete closure of all fisheries," the plan authors state, "is unlikely to improve he status of any critical management unit." In most cases, the CER ceilings cap total exploitation rate in Southern US fisheries. The 2017 Puget Sound Chinook management plan notes that Southern US (SUS, mainly Washington) fisheries have taken the brunt of conservation restrictions on harvest because interception fisheries in Alaska and British Columbia are not subject to the same controls: "From 2004 to 2014, SUS (Southern US) fisheries were managed in most years under the critical ER ceilings because pre-season planning indicated the Rebuilding Exploitation Rate (RER) would be exceeded due to northern fisheries."

Biomass reference points under the 2017 plan included three thresholds for abundance that indicate different levels of precaution in harvest management. The Upper management threshold (UMT) is an escapement level associated with maximum sustainable harvest or (for the Snohomish), a level of escapement set somewhat higher (at 4,900 fish) based on quantitative modeling of stock productivity. The Low Abundance Threshold (LAT) triggers additional conservation measures when abundance drops below it. This threshold is generally a defined percentage of estimated MSY escapement, varying by stock. The Point of Instability (POI) is a low abundance level representing high risk to viability of populations, varying by run.

Under the 2017 plan, the CER limit of 15% for Southern US fisheries was designed to apply when escapement falls below 3,375 fish, but in practice managers recently have implemented lower limits than this, to be formalized in the next multi-year management plan. Both of the major Chinook-spawning tributaries in the Snohomish River system, the Skykomish and Snoqualmie, were assigned their own limits that constitute subcomponents of the Snohomish basin CER.

Indicator: Endangered, Threatened and Protected (ETP) Species

Precautions undertaken by Tulalip Tribes and co-managers ensure that the fishery and the hatchery supporting it limit any potential impacts. The primary protected species of concern for the Tulalip Bay Chinook salmon fishery are wild spawning Chinook returning to the Snoqualmie and Skykomish tributaries of the nearby Snohomish River, which the fishery selectively avoids.

Entanglement of marine mammals and birds in this fishery is believed to be rare, so (unsurprisingly) no formal studies were found on fishery interactions with these species in Tulalip Bay. The tribal fishery in Tulalip Bay uses shallow setnets (WDFW & NWIFC 2019) that are tended continuously and limited to 300 feet in length under tribal

fishing regulations. Continuous tending is necessary as a practical matter because agile seals and sea lions grab the catch from the net if fishers don't get there first. Bird bycatch is believed to be rare or nonexistent; one experienced tribal harvest manager reported that he had never heard of any bird entanglement in the Tulalip Bay fishery (Diego Holmgren, pers. comm. 6.2.2020).

In its 2017 Environmental Assessment of tribal and state hatchery programs in the Snohomish Basin, NOAA determined the risks to ESA listed Chinook salmon and steelhead were minimal, in terms of factors such as genetic diversity, competition, and disease transfer. The agency suggested that fish from the hatchery may benefit wild fish stocks by providing an alternative food source for salmon predators. Tulalip's hatchery program may supply additional prey for Southern Resident Killer Whales, harbor seals, sea lions, harbor porpoises, Dall's porpoises, and Pacific white-sided dolphins located in the bay or nearby marine waters, the authors noted (NOAA 2017). According to the Environmental Assessment, pinnipeds in Tulalip Bay eat about half of the fish moving through the Tulalip Bay tribal fishery's gillnets. It's estimated that about 50 seals and sealions use Tulalip Bay as feeding grounds between June and early January, corresponding to the beginning of the hatcher-origin Chinook return and the end of chum salmon run.

Hatchery Risk

The relevant indicators for hatchery management, All-H integration, and precautionary response to uncertainty are satisfied by careful and closely scrutinized practices of the tribe under federal permits issued by NOAA.

From the start in 1983, Chinook production at the Bernie Kai-Kai Gobin Salmon Hatchery ("Tulalip Hatchery") at Tulalip Bay enabled the tribe to shift tribal fishing efforts away from vulnerable wild Chinook (more than a decade before these fish were listed under the ESA). (See Figure 4, "Graph of Impacts on Wild Stocks" in Appendix A.)

The hatchery supporting this harvest uses multiple methods to protect neighboring natural stocks of salmon from potential ecological and genetic impacts. These risks and mitigating practices were evaluated by NOAA in a 2017 Environmental Assessment (EA) of Snohomish Basin hatchery programs, including production of Chinook at Tulalip's Bernie Kai-Kai Gobin Hatchery supporting the Tulalip Bay fishery. The NOAA EA's key findings include:

- Hatchery fish pose a negligible risk in terms of predation on wild salmon and competition for resources because they are released into tributaries in Tulalip Bay where wild salmon and steelhead are not present. Additionally, for the same reason, any impacts on wild stocks from the facility itself are not detectible.
- The risk of disease spreading either within the hatchery or being transmitted to wild stocks was considered negligible based on effective compliance with health protocols.
- The risk of negative genetic effects on wild salmon was determined to be low since the hatchery integrates natural origin broodstock from the Skykomish Chinook populations. Additionally, it was determined that the limited take of natural broodstock does not have a detrimental impact on wild stock populations.
- Tulalip hatchery supplementation in fisheries was found to have no substantial adverse impacts, and EA authors noted potential beneficial outcomes: reducing catch of wild stocks and helping to stabilize escapement trends of wild fish.
- Tulalip operates its hatchery with an All-H integrated approach, linking management of hatcheries, habitat, harvest, and hydropower in terms of their impacts on salmon recovery. (Note: The Environmental Assessment notes the tribes' limited powers to control habitat damage beyond the reservation, and acknowledges the tribal view that any assessment of hatchery performance must recognize the extent to which habitat loss now constrains the ability of wild salmon to repopulate the basin.)
- The hatchery mitigates uncertainties of potential impacts through effective monitoring, research, and management strategies.

3. Knowledge Risk

Knowledge of Prey Interception Risk

Thermal marking of 100% of hatchery-released Chinook show affirmatively that an average of 91.5% of the catch taken in the tribe's Tulalip Bay Chinook fishery during 2007-2018 originated from the tribal hatchery (Mike

Crewson pers. comm 2020). These data satisfy both the performance requirements and the confidence requirements of this standard.

No documented sightings of Southern Residents in Tulalip Bay in recent decades were identified. Federal reports designating critical habitat for SRKW (NMFS 2006) and a recently proposed significant expansion of habitat area (NMFS 2019) do note that orcas of unknown origin were observed in the area during the early 20th century. Killer whales that visited the tribes' shoreline in the distant past displayed hunting behaviors that identify them as transient, seal-eating killer whales, not fish-eating SRKW.

Knowledge of Stock Risk (Exploitation & Biomass)

Indicators: Exploitation Rate, Monitoring, & Compliance

Extensive, multi-method monitoring of exploitation rate and escapement allows managers to reliably gauge compliance with harvest policy, producing time series that document long-term performance against reference points and conservation limits.

Indicator: Reference Points

Reference points are derived from detailed historic and current understandings of stock productivity, reflecting expert judgment of tribal, state, and federal managers who carefully scrutinize each other's work to enforce both treaty and statutory obligations for conservation of Chinook stocks. Reference points incorporate stepped, abundance-based rules that protect spawning potential by restraining exploitation when abundance is low. Rebuilding exploitation rates generally limit harvest well below MSY levels. A critical exploitation rate limit at very low abundance serves a precautionary role similar to MSST, severely reducing fishing to preserve spawning capacity.

Indicator: ETP Species

Available data and known fishing practices suggest that interactions with protected species (e.g., birds and marine mammals) are limited. Federal evaluators noted (NOAA 2017) that the fishery and supporting hatchery may yield more benefit (via increased prey opportunity) than risk to protected predator species, including SRKW and pinnipeds. However, systematic observations (e.g., through a formal fishery observation program to document interactions with birds and pinnipeds) were not found.

Indicator: Timely Action

Monitoring of run-size, harvest, escapement, and other key parameters has produced time-series data showing compliance with conservation limits over decades. This compliance provides strong evidence that data and management systems enable managers to understand changing conditions and take timely actions when needed. The Tulalip Tribes' curtailment of fishing area and harvest in response to diminishing runs of salmon further confirm this evidence of timely action.

Indicator: Uncertainty and Error

The co-managers' policies and practices reflect recognition of uncertainties and errors that can increase risks to the resource, and commensurate measures to reduce that risk, both through advance planning and real-time precaution in response to changing conditions. Multi-method monitoring of key parameters and cross-checking by tribal, state, and federal managers produce a capable and cautious response to knowledge risks.

Knowledge of Stock Risk (Hatchery Risk)

Tulalip managers employ best practices in hatchery management, monitoring, marking, and precautionary response to uncertainties. The tribe actively drives coordinated multi-sector work to achieve true "all-H" risk management, in part by restoring and protecting habitat and, where possible, tightening controls on habitat degradation across the basin. As noted above (under the hatchery component of Stock Risk), the tribe applies best practices for control of potential hatchery impacts. Tulalip's thermal marking system generates adequate and reliable data on catch composition in the tribal hatchery-supported Chinook fishery in Tulalip Bay. Use of local broodstock and extensive monitoring of hatchery-origin fish in the Snohomish estuary and tributaries permits high confidence in evaluation of potential ecological and genetic impacts.

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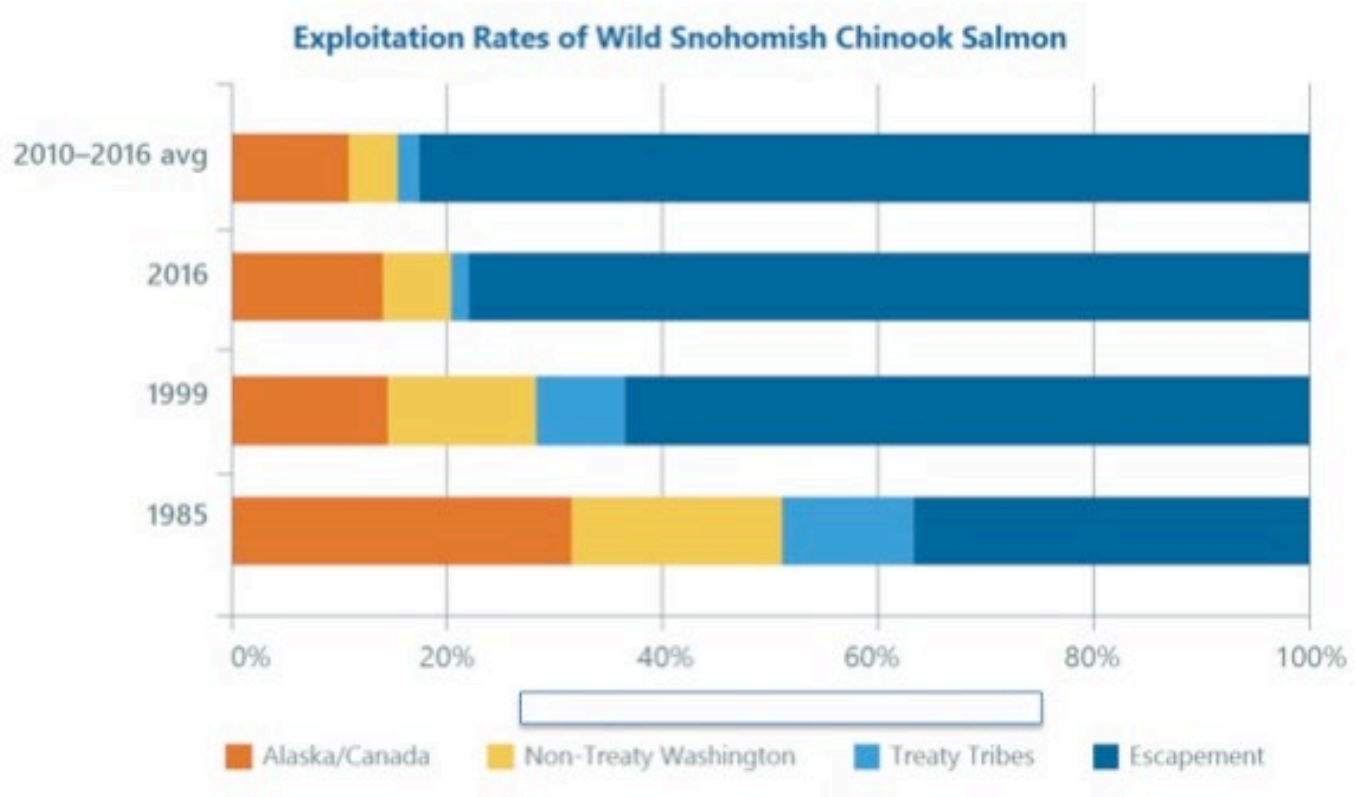
Appendix A: Graphs and Tables

Figure 1: Stock Risk, Exploitation and Biomass Risk



Reduction in exploitation rates on naturally spawning Snohomish Chinook salmon since 1985. Treaty tribal share of incidental mortality (pale blue) includes multiple tribes. Source: Adapted from Snohomish Basin Salmon Recovery Forum 2019.

Figure 2: Stock Risk, Exploitation & Biomass Risk

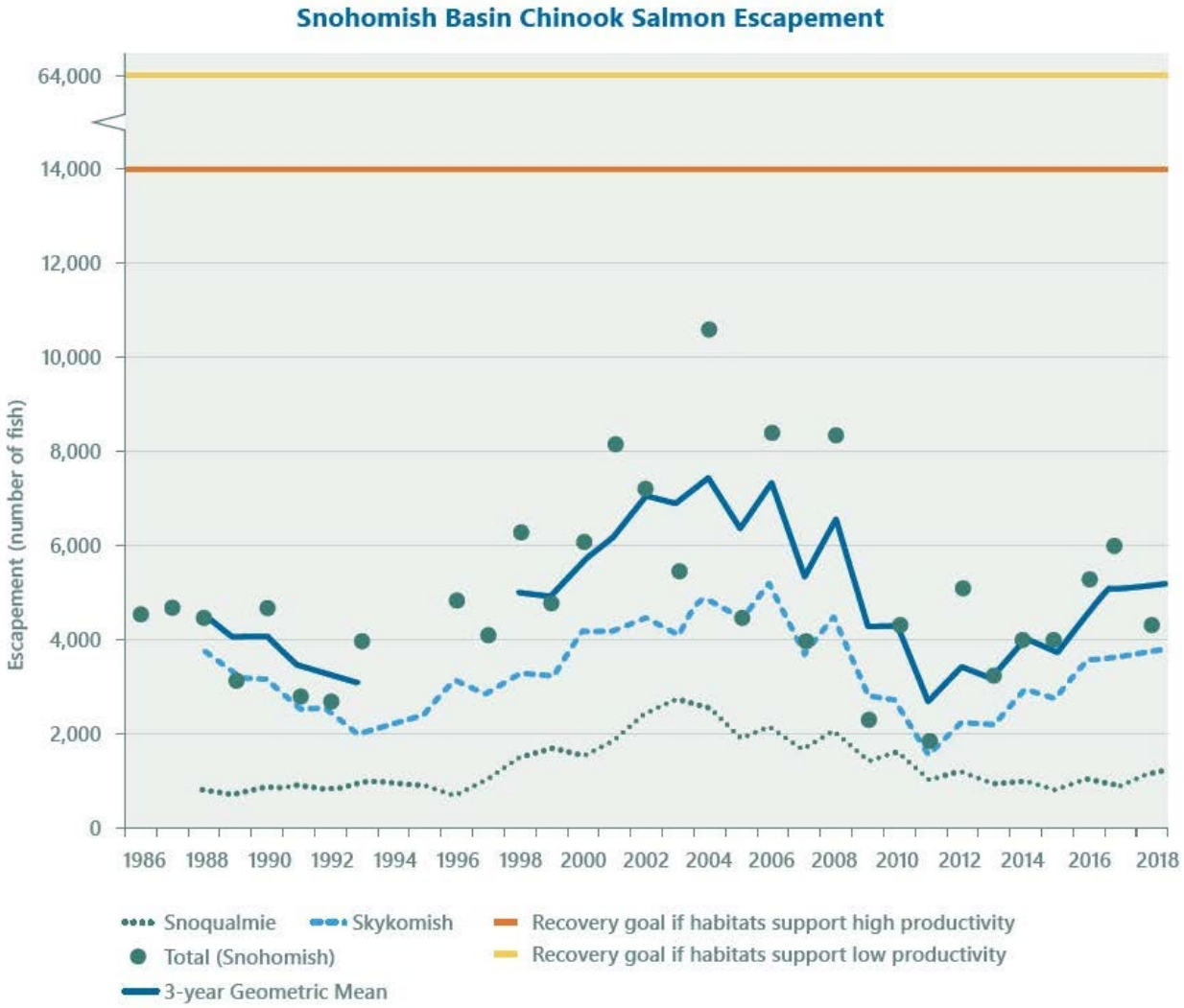
Table 3. Exploitation rates for Snohomish Chinook estimated by pre-season and post-season FRAM models.

	Total ER			SUS ER		
Year	Pre-season	Post-season	Pre-post	Pre-season	Post-season	Pre-post
2004	28.72%	17.05%	11.67%	12.74%	7.82%	4.93%
2005	32.67%	22.59%	10.09%	15.69%	10.99%	4.71%
2006	33.10%	12.72%	20.38%	16.38%	6.40%	9.98%
2007	35.32%	22.13%	13.19%	12.44%	11.44%	1.00%
2008	25.43%	10.87%	14.56%	12.63%	3.82%	8.81%
2009	26.43%	16.95%	9.49%	13.74%	6.69%	7.06%
2010	20.31%	12.66%	7.65%	10.74%	5.89%	4.85%
2011	22.29%	21.48%	0.81%	10.32%	13.39%	**-3.07%**
2012	16.44%	13.88%	2.55%	8.76%	5.86%	2.91%
2013	23.06%	20.23%	2.83%	11.23%	14.37%	**-3.14%**
2014	20.35%	22.95%	**-2.60%**	9.33%	13.27%	**-3.93%**

The table above is reproduced from the 2017 Puget Sound Chinook management plan.

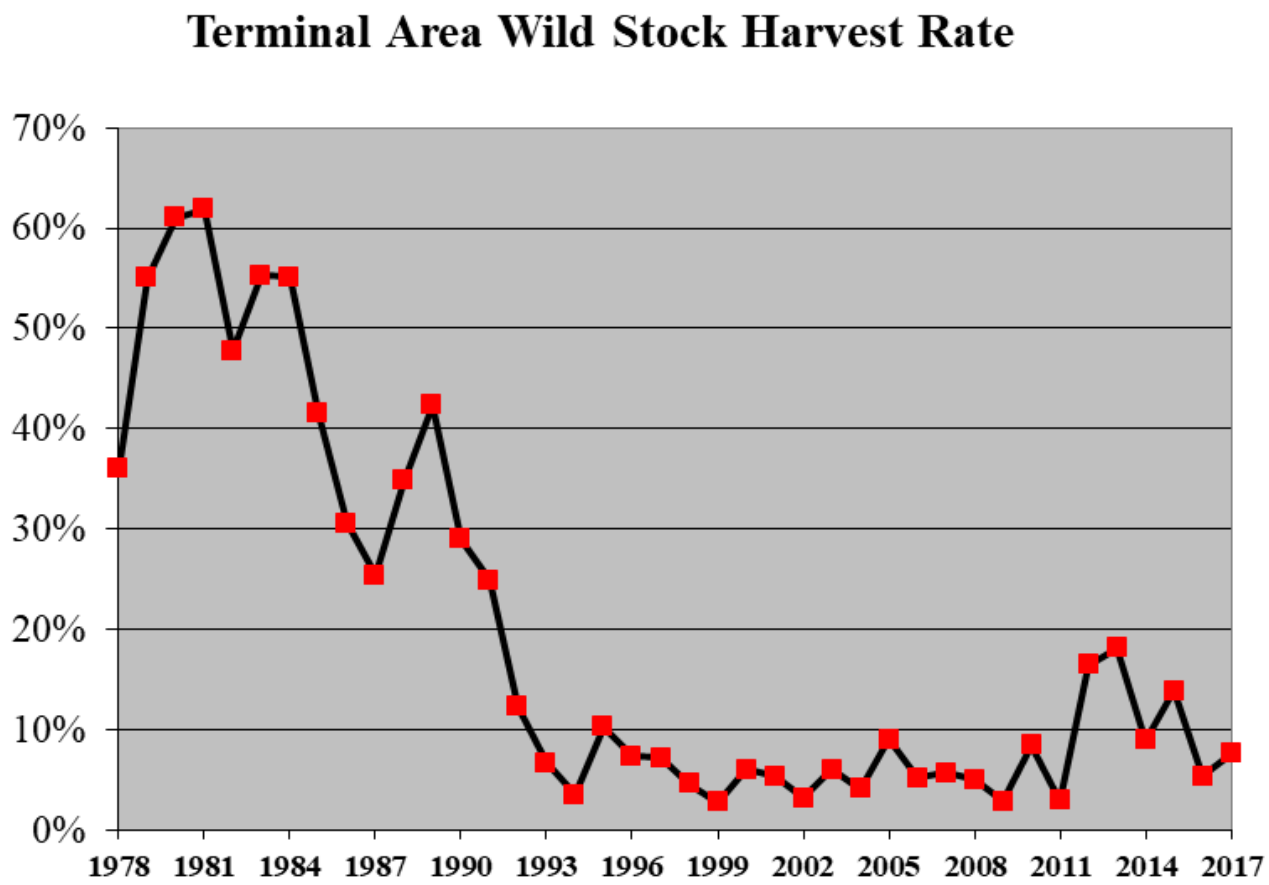
SOURCE: Puget Sound Indian Tribes and WDFW 2017. Note: Table numbering is from original source material.

Figure 3: Stock Risk, Exploitation & Biomass Risk



Chinook escapement time series in Snohomish Basin. SOURCE: Snohomish Basin Salmon Recovery Forum 2019.

Figure 4: Stock Risk, Hatchery Risk



The plot below reflects the reduction in wild stock impacts, which Tulalip fishery managers achieved by establishing a hatchery in the early 1980s and adjusting fishing effort to target the hatchery fish in the bay and adjacent nearshore waters.

Proportion of naturally spawning Chinook in Tulalip Chinook harvest, 1978- 2017. Note that in the title of the plot above, "harvest rate" on wild stocks is defined to mean the percentage of the catch that these fish constitute.
SOURCE: Tulalip Tribes Natural Resources Department.

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