Product Sustainability Standard: Seafood

Chinook Fishery Evaluations

Version 1.0: August 2020

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.

Table of Contents

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			
		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.

Evaluation Details and Notes:

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

[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.

tribal co-managers, has used its authorities under the ESA to drive comprehensive, ongoing scrutiny and improvement in hatchery practices.

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.

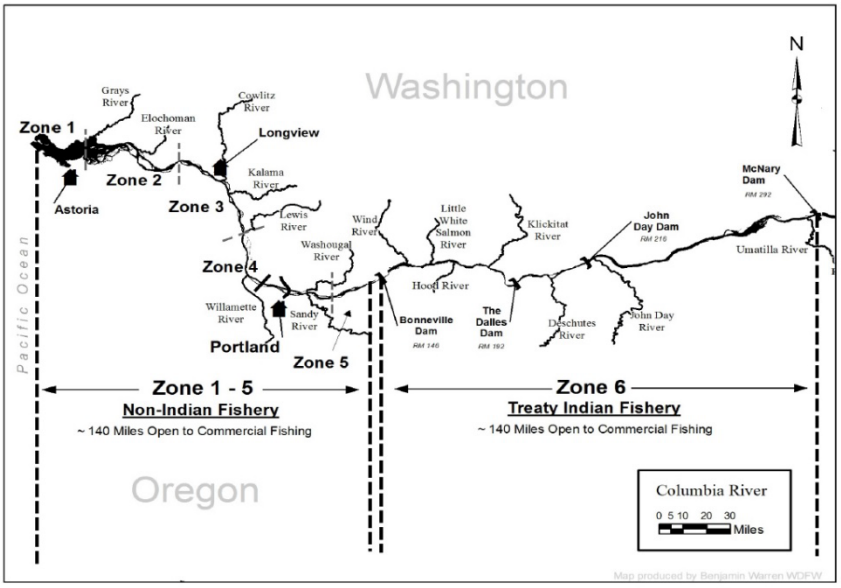

Figure 2. Map of the Columbia River downstream of McNary Dam showing areas open to commercial fishing.

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.

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).

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

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 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	LRH - Lower River	Hatchery	63,910	52,963	55,100
Chinook	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	Upriver Skamania Index	**Total**	**7,950**	**6,483**	**8,750**
Summer		N-O	*3,000*	*2,595*	*3,200*
Steelhead	A-Index	**Total**	**158,000**	**69,338**	**110,200**
(to Bonneville		N-O	*44,800*	*21,725*	*33,900*
Dam)	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	LRH - Lower River	Hatchery	55,100	48,914	50,200
Chinook	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	Upriver Skamania Index	**Total**	**8,800**	**3,134**	**4,400**
Summer		N-O	*3,200*	*1,522*	*1,800*
Steelhead	A-Index	**Total**	**110,200**	**66,174**	**85,900**
(to Bonneville		N-O	*33,900*	*30,300*	*33,300*
Dam)	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)

References

Anderson et al 2020. Anderson, JH, K Warheit, BE Craig, TR Seamons and AH Haukenes, A review of hatchery reform science in Washington State, WDFW, January 23, 2020. https://wdfw.wa.gov/sites/default/files/publications/02121/wdfw02121_0.pdf

BPA 2010. Columbia River hatcheries: an evolving role. Article published online by Bonneville Power Administration, September 2010. https://www.bpa.gov/news/pubs/GeneralPublications/fish-Columbia%20River%20hatcheries%20an%20evolving%20role.pdf

Carter et al 1995: Carter, HR, MLC McAllister and ME Isleib, Mortality of Marbled Murrelets in Gill Nets, USDA Forest Service Gen Tech Rep. PSW-152. https://www.fs.fed.us/psw/publications/documents/psw_gtr152/psw_gtr152_chap27.pdf

Connelly et al 2018. Connelly, KA, JR Gardner, MM Gambe, JW Chamberlin, A Winans, J Keister, DA Beauchamp, Marine Survival of Puget Sound Chinook: Size-Selective Mortality Growth Limitation and Bioenergetics of Sub-Yearling Chinook Salmon in Puget Sound, Washington, Final Technical Report #LLTK-SSMSP-9 for Long Live the Kings. https://marinesurvivalproject.com/wp-content/uploads/LLTK-SSMSP-9-Final-Report-Chinook-Size-Selective-Mort-Crit-GrowthEnergetics-June-2018.pdf

CRITFC 2020. Snake River Fall Chinook Recovery: A Tribal Success Story, published online by the Columbia River Inter-Tribal Fish Commission. https://www.critfc.org/fish-and-watersheds/fish-and-habitat-restoration/restoration-successes/snake-river-fall-chinook/

Fish Commission of Oregon 1972. Columbia River Seal Control Program. Commission staff report, March 9, 1972, in online collection of Oregon State University. https://ir.library.oregonstate.edu

Frankowicz 2018. Frankowicz, K. Orcas make rare appearance near Astoria Bridge, published May 10, 2018 in *The Daily Astorian*, republished by KGW.com. https://www.kgw.com/article/news/local/north-coast/orcas-make-rare-appearance-near-astoria-bridge/283-551103905

Harrison 2018a. Harrison, J, Management Actions Have Reduced Predation on Fish by Caspian Terns in the Columbia River Estuary, article published by Northwest Power and Conservation Council, September 14, 2018.

Harrison 2018b. Harrison, J, Freshwater Slaughter, article published by Northwest Power and Conservation Council, June 2018, https://www.nwcouncil.org/fish-and-wildlife/topics/sealions

Harrison 2020. Harrison, J, 2020 Columbia River Salmon and Steelhead Forecast: Low, Again, article published by Northwest Power and Conservation Council, April 17, 2020. https://www.nwcouncil.org/news/2020-columbia-river-salmon-and-steelhead-forecast-low-again

Haskell et al 2018. Haskell, C, DA Beauchamp, SM Bollens, Linking functional response and bioenergetics to estimate juvenile salmon growth in a reservoir food web, published PLOS One, Oct 11, 2017. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0185933

Kendall et al 2017. Kendall, NA, GW Marston, MM Klungle, Declining patterns of Pacific Northwest steelhead trout (*Oncorhynchus mykiss*) adult abundance and smolt survival in the ocean, Canadian Journal of Fisheries and Aquatic Sciences, June 26, 2017. https://www.nrcresearchpress.com/doi/pdf/10.1139/cjfas-2016-0486

Lacey et al 2017. Lacy, RC, R Williams, E Ashe, KC Balcomb III, LJN Brent, CW Clark, DP Croft, DA Giles, M MacDuffee, PC Pacquet, Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans, Nature, October 26, 2017. https://www.nature.com/articles/s41598-017-14471-0

Martins et al 2011. Martins, EG, SG Hinch, DA Patterson, MJ Hague, SJ Cooke, KM Miller, MF Lapointe, KL English, and AP Farrell, Effects of river temperature and climate warming on stock-specific survival of adult migrating Fraser River sockeye salmon (*Oncorhynchus nerka*), Global Change Biology, 2011. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.892.2994&rep=rep1&type=pdf

Maier 2015. Maier, G, Low Water + high temperatures = drastic effects on fish? article published by Upper Columbia Salmon Recovery Board, September 2, 2015. https://www.ucsrb.org/low-water-high-temperatures-drastic-effects-on-fish/

Murdoch and Marston 2020. Murdoch, A and G Marston, WDFW Hatchery and Fishery Reform Policy Implementation Assessment, Draft Progress report, 2009-2019, WDFW February 27, 2020. https://wdfw.wa.gov/sites/default/files/publications/02133/wdfw02133.pdf

NMFS 1991. Waples, RS, RP Jones, BR Beckman and GA Swan, Status Review for Snake River Fall Chinook Salmon, NOAA Technical Memorandum NMFS/F/NWF-201, June 1991, National Marine Fisheries Service, Portland OR. https://www.nwfsc.noaa.gov/publications/scipubs/techmemos/tm201/body2.htm

NMFS 2014. Final Environmental Impact Statement to Inform Columbia River Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs. https://archive.fisheries.noaa.gov/wcr/publications/nepa/hatchery/mitchell_act_hatcheries_feis_final.pdf

NMFS 2017a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation: Four Summer/Fall Chinook Salmon and Two Fall Chinook Salmon Hatchery Programs in the Upper Columbia River Basin. NMFS Consultation Number: WCR-2015-3607.

NMFS 2017b. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation, NMFS consultation number NWR-2014-697, January 15, 2017. https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/mitchell-act-hatchery-programs

NMFS 2018. Biological Opinion on 2018-2027 US v Oregon Management Agreement for Columbia River salmon fisheries, NOAA National Marine Fisheries Service, Feb 23, 2018. https://www.westcoast.fisheries.noaa.gov/publications/fishery_management/salmon_steelhead/s7-_usvoregon_2018-2027_mgmagmnt__final_signed.pdf

NMFS 2019a. Draft Biological Report, Sept 2019, as part of NMFS 2019 proposal to expand SRKW Critical Habitat. https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/critical-habitat-southern-resident-killer-whales

NMFS 2019b. Proposed Revision of the Critical Habitat Designation for Southern Resident Killer Whales: Draft ESA Section 4(b)(2) Report, September 2019. https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/critical-habitat-southern-resident-killer-whales

NOAA Species Directory, undated. Species Directory: Chinook Salmon. https://www.fisheries.noaa.gov/species/chinook-salmon

NWPCC 2020a. Fish Passage at Dams, Northwest Power and Conservation Council, https://www.nwcouncil.org/reports/columbia-river-history/fishpassage

NWPCC 2020b. Dams: history and purpose, article published online by the Northwest Power and Conservation Council. https://www.nwcouncil.org/reports/columbia-river-history/damshistory

NWPCC 2020c. Hatcheries. Article published online by the Northwest Power and Conservation Council. https://www.nwcouncil.org/reports/columbia-river-history/hatcheries#:~:text=In%201877%20Columbia%20River%20cannery,in%20the%20Columbia%20River%20Basin

ODFW 2020. Estimated Snake River wild fall Chinook mortalities in fisheries, data provided per NFCC request, Oregon Department of Fish and Wildlife, Sept. 30, 2020.

PFMC 2016. Pacific Coast Salmon Fishery Management Plan, Pacific Fishery Management Council, Portland, March 2016. https://www.pcouncil.org/documents/2016/03/salmon-fmp-through-amendment-19.pdf/

Roby et al 2005. Roby, DD, K Collis, and DE Lyons, Conservation and Management of Fish-eating Birds and Endangered Salmon, USDA Forest Service Gen Tech Rep PSW-GTR-191. 2005. https://www.fs.fed.us/psw/publications/documents/psw_gtr191/psw_gtr191_0161-0165_roby.pdf

Siegel & Crozier 2019. Siegel J and L Crozier, Impacts of Climate Change on Salmon of the Pacific Northwest: A review of the scientific literature published in 2018, Fish Ecology Division, Northwest Fisheries Science Center, NMFS, NOAA, December 2019. https://www.webapps.nwfsc.noaa.gov/assets/11/9835_03132020_140127_BIOP-Lit-Rev-2018.pdf

Steele et al 2019. Steele, CA, M Hess, S Narum, and M Campbell, Parentage Based Tagging: Reviewing the Implementation of a New Tool for an Old Problem, published in Fisheries, Journal of the American Fisheries Society. https://collaboration.idfg.idaho.gov/FisheriesTechnicalReports/FisheriesSteele2019%20Reviewing%20the%20Implementation%20of%20a%20New%20Tool%20for%20an%20Old%20Problem.pdf

TAC 2018. 2018-2027 United States v. Oregon Management Agreement, February 26, 2018.

USFWS 2018. Biological Opinion addressing Implementation of the U.S. v Oregon Management Agreement for Non-Treaty and Treaty Indian Fisheries in the Columbia River Basin from 2018 to 2028, US Fish and Wildlife Service, Feb 23, 2018. https://www.fws.gov/lsnakecomplan/Reports/USvOregon/2018USvOR_ManagementAgreement_FWS_BO_FinalSigned.pdf

USFWS 2020. Marbled Murrelet, article published online by the Oregon Fish and Wildlife Office, US Fish and Wildlife Service, last updated January 6, 2020. https://www.fws.gov/oregonfwo/articles.cfm?id=149489445

WDFW & ODFW 2019a. 2019 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, Joint Columbia River Management Staff, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, February 8, 2019. https://wdfw.wa.gov/publications/02043

WDFW & ODFW 2019b. 2019 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon, Joint Columbia River Management Staff, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, July 22, 2019. https://wdfw.wa.gov/publications/02085

WDFW & ODFW 2020a. 2020 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, Joint Columbia River Management Staff, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, February 7, 2020. https://wdfw.wa.gov/sites/default/files/2020-02/2020_or_wa_spring_joint_staff_report.pdf

WDFW & ODFW 2020b. 2020 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon, Joint Columbia River Management Staff, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, July 22, 2020. https://wdfw.wa.gov/fishing/management/columbia-river/reports

Wiedenfeld et al 2012. Wiedenfeld, DA, S Iudicello, N Atkins, EC Bricklemyer, B Gentner and A Johnson, Analyses of Seabird Bycatch in Fisheries Selling Seafood in the US Market. American Bird Conservancy, The Plains, VA 2012.

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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.

Evaluation Details and Notes:

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.

References

Addae 2020. Pers comm. Kwasi Addae, WDFW Hoodsport Commercial Biologist, via email on 7/14/20.

Commonly Found Marine Mammals of Puget Sound, Orca Network. http://www.orcanetwork.org/marinemammals/webpage3marmams.pdf

Downen 2019. pers. comm. Mark Downen, WDFW Hood Canal Fish Program Biologist, via phone on 12/17/19.

Hagen-Breaux 2019. Pers comm. Angelika Hagen-Breaux, WDFW analyst and Chair of the PFMC Salmon Model Evaluation Workgroup, via email on 12/18/19.

HCCC 2020. Pers comm Scott Brewer, Executive Director of the Hood Canal Coordinating Council, via email on 7/10/20.

HGMP 2014. Hatchery and Genetic Management Plan, Hoodsport Hatchery Fall Chinook Program, Washington Department of Fish & Wildlife, May 2014.

NMFS 2005. Policy on the consideration of hatchery-origin fish in endangered species act listing determinations for Pacific salmon and steelhead. National Marine Fisheries Service, U.S. Department of Commerce, NOAA. Docket No. 040511148–5151–02; I.D. 050304B.

NOAA 2005. NOAA Endangered and Threatened Species; Final Listing Determinations; Final Rules and Proposed Rules. Federal Register, Part III, Department of Commerce, June 20th, 2005. https://www.govinfo.gov/content/pkg/FR-2005-06-28/pdf/05-12351.pdf

NOAA 2006, Designation of Critical Habitat for Southern Resident Killer Whales, Biological Report, October 2006, NMFS Northwest Region. https://repository.library.noaa.gov/view/noaa/18693

NOAA 2019. Endangered and Threatened Wildlife and Plants; Proposed Rulemaking to Revise Critical Habitat for the Southern Resident Killer Whale Distinct Population Segment. https://www.govinfo.gov/content/pkg/FR-2019-09-19/pdf/2019-20166.pdf

SBE 2015. Seattle Biological Evaluation, Appendix C, Bald and Golden Eagle Protection Act, May 2015 Revision. https://www.seattle.gov/Documents/Departments/SPU/Documents/SBEAppendixCBaldandGoldenEagleProtectionAct.pdf

USFWS 2012. Marbled Murrelet Biology, Habitat Use and Abundance in Washington, US Fish and Wildlife Service, Spring 2012. https://www.dnr.wa.gov/publications/amp_sepa_nonpro_mm_1_fws_murrelet.pdf?ko7ffe

Villarreal 2020. Pers comm. Jorge Villarreal WDFW Hoodsport Hatchery Manager, via email 7/16/20.

WDFW and PNPTT 2000. Summer Chum Salmon Conservation Initiative - An Implementation Plan to Recover Summer Chum in the Hood Canal and Strait of Juan de Fuca Region. Washington Department of Fish and Wildlife and Point No Point Treaty Tribes. Olympia, WA. 800 p. http://wdfw.wa.gov/conservation/fisheries/chum/

WDFW 2019a. 2019 Puget Sound Commercial Salmon Regulations, WDFW. (https://wdfw.wa.gov/sites/default/files/publications/02091/wdfw02091.pdf)

WDFW 2019b. Catch Database via Angelika Hagen-Breaux, WDFW, accessed 5/26/20.

WDFW 2019c. FRAM model accessed 12/17/19.

WDFW 2019d. Concise Explanation of Puget Sound Commercial Salmon Regulations for 2019, WDFW. https://wdfw.wa.gov/sites/default/files/2019-07/2019_ps_comm_ces_final_12_july_1233pmkmh.pdf

WDFW 2019e. Co-Managers List of Agreed Fisheries 2019-2020. https://wdfw.wa.gov/sites/default/files/publications/02067/2019-20agreement.pdf

WDFW 2019f. Salmon Fishing to Close at Hoodsport Hatchery. WDFW Regulations 2019, in-season announcement. https://www.tedssportscenter.com/reports/2019/11/15/SALMON-FISHING-TO-CLOSE-AT-HOODSPORT-HATCHERY

WDFW 2020a. WDFW Conservation website, Mid Hood Canal Chinook Recovery Goals, accessed 7/17/20. https://fortress.wa.gov/dfw/score/score/species/population_details.jsp?stockId=1236

WDFW 2020b. WDFW Annual Escapement Reports, 1999-2019. Accessed 7/17/20. https://wdfw.wa.gov/fishing/management/hatcheries/escapement#annual-reports

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