Puget Sound Recreational Advisor Meeting

October 17, 2018 9am, Teleconference

Natural Resources Building, Room 537 Olympia, WA

Conference line: (360) 407-3780 PIN: 550999 #

Draft Agenda:

1. **Welcome / roll call / introductions**

2. **Puget Sound Chinook Resource Management Plan Update**
   a. **Overall process update**
   b. **Pacific Salmon Treaty tentative agreement**
   c. **Modeling work – validation runs, exploitation rate work group**
   d. **Management Unit Profiles**
   e. **Discussion / next steps**

3. **Southern Resident Killer Whales**
   a. **Brood year 2018 hatchery production increases**
   b. **Task Force discussion**

4. **Winter recreational fishery overview**

5. **Other issues**

JAY INSLEE
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Agreement to boost salmon returning to Pacific Northwest waters

Pacific Salmon Treaty agreement finalized; agreement will support improved salmon recovery to benefit orcas

Gov. Jay Inslee announced today that representatives from the United States and Canada have agreed to recommend their governments approve new coast-wide fishing agreements under the Pacific Salmon Treaty.

The agreement outlines each nation's fishery management plans for chinook, coho and chum stocks from 2019 to 2028. If approved, the treaty will result in more salmon returning to Washington and Oregon waters, where many populations are listed for protection under the federal Endangered Species Act.

"This step comes at a crucial time as we continue to see declines in chinook salmon populations around Puget Sound," Inslee said. "As we work with our international partners to send more fish into our waters, it becomes even more crucial that state leaders do what's necessary to protect and restore habitat and address the dire needs of these fish."

Principles of the treaty, originally agreed upon in 1985, define the obligation of Canada and the United States to conduct their fisheries in a manner that prevents overfishing and allows each country to receive benefits equivalent to the production of salmon originating in each nation's waters.

"I praise the efforts of the joint U.S. - Canada Pacific Salmon Commission for approving strong recommendations to the Pacific Salmon Treaty. Successful updates to the Treaty through 2028 will help ensure long term sustainable and healthy salmon populations that are vital to the people of the Pacific Northwest, and to the entire ecosystem," Oregon Governor Kate Brown said.

The governments of Canada and the United States must approve the recommendations of the Pacific Salmon Commission before implementation can occur in 2019. The U.S. commissioners include representatives from Washington state, Oregon, Alaska and Northwest and Columbia

River Treaty Tribes. Phil Anderson, former director of the Washington state Department of Fish and Wildlife, is the lead negotiator for the United States.

"We faced some very challenging issues in these negotiations," Anderson said. "I appreciate everyone's willingness to work together to come up with a plan that will create a better future for salmon in Washington."

The most significant changes in the treaty involve chinook salmon, which migrate from Washington's rivers and streams north to the marine waters of British Columbia and southeast Alaska. While feeding in those waters, the fish are vulnerable to fisheries in British Columbia and Alaska.

Under the new terms, Canada will reduce its chinook fisheries by as much as 12.5 percent from 2009–2015 levels while Alaska will cut fisheries to reduce impacts to chinook by as much as 7.5 percent from 2009 levels during years when poor salmon runs are expected. Fisheries in Washington will remain tightly constrained unless runs exceed management objectives.

"This agreement corresponds with the efforts I asked state agencies to take earlier this year to benefit southern resident killer whales and salmon," Inslee said. "Additional federal funding is essential in order to make the key conservation work possible to recover salmon, and in turn, our orcas."

The governor established a task force to address threats to killer whales such as the lack of salmon and toxic contaminants in the water. More information can be found here.

As part of the agreement, U.S. commissioners will seek additional federal funding for salmon habitat improvement, habitat protection, and hatchery conservation programs within Puget Sound.

Details about the federal funding are expected to be finalized within the next month. U.S. commissioners anticipate a funding request that is equal to or more than the 2009 one-time request of $50 million.

Agenda

Pacific Salmon Treaty Briefing

Date: Sept. 28, 2018

Time: 9AM – Noon

Location: Rooms 175 A&B, Natural Resource Building, Olympia

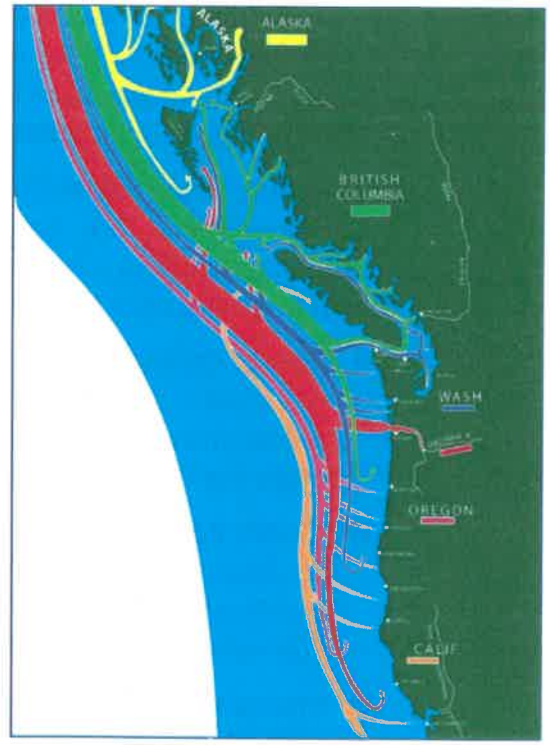
1) Fishery and Stock Context for Pacific Salmon Treaty
2) Chapter Updates for 2019-2028
    - Chinook
    - Coho
    - Chum
3) Federal Funding Request
    - One-time Funding
        - Puget Sound Chinook Habitat Restoration
        - Mark-Selective Fishery Implementation
        - Improved Access to Southeast Alaska Hatchery-Origin Chinook
    - Annual Funding
        - Southern Resident Killer Whale Prey
        - Hatchery Conservation Programs
        - Habitat Protection
        - Improved Scientific Basis for Management
        - State and Tribal Implementation
4) Future Coordination – We Need Your Help

Pacific Salmon Treaty 2019 – 2028

September 26, 2018

Summary

Chinook Salmon Migration



1) **Problem of Interceptions.** The majority of salmon originating in Washington rivers and streams migrate north and are vulnerable to fisheries north of our border.

2) **Last in Line Bears Conservation Burden.** Absent an agreement with Canada and Alaska that limits the interceptions of Washington-origin fish, the entire conservation burden falls on Washington. Conversely, stocks originating in Canada can be vulnerable to Washington and Alaska fisheries.

3) **Management Failure.** Uncontrolled interceptions will result in conservation and allocation concerns and the collapse of our management structure. That is where we found ourselves in the early 1980's.

4) **1985 Pacific Salmon Treaty** (PST) provides a coordinated management framework based on two underlying principles:

    - "prevent overfishing and provide for optimum production"; and
    - "provide for each Party to receive benefits equivalent to the production of salmon originating in its waters".

    Specific management obligations are identified in seven species-fishery chapters that are regularly updated (often at 10-year intervals).

5) **All species-fishery chapters (except Fraser sockeye and pink salmon) are expiring** at the end of 2018. Successful negotiation of chapters essential to:

    - Limit interceptions in southeast Alaskan (SEAK) and Canadian fisheries;
    - Provide certainty regarding fishery levels;
    - Maintain North-South sharing agreement stipulated in Yakima v. Baldrige; and
    - Allow disbursement of funds from the PST Northern and Southern endowment funds.

6) **The Pacific Salmon Commission completed negotiations** in early July, and the proposed chapter updates have been transmitted to the U.S. and Canadian governments.

7) **Substantial work remains** to secure approval by the U.S., Canadian, and tribal governments, complete the biological opinion, and obtain implementation funding.

8) **Next 10-years Critical for Puget Sound Chinook.** Habitat protection, substantive habitat restoration, and reduced pinniped predation are essential to complement the fishery actions, stop the decline in spawners, and promote rebuilding.

What did we achieve?

1) **Responsive to Climate Change: Yes.** Chinook provisions require annual Pacific Salmon Commission (Commission) engagement to adaptively manage Treaty implementation. Coho provisions take into account data uncertainty and changing environmental conditions.

2) **Reduce Puget Sound Chinook Interceptions: Yes.** Approximately a 12.5% reduction is required in fisheries where Puget Sound (PS) Chinook are most heavily impacted (southern Canadian fisheries).

3) **Reduce Coastal/Columbia R. Chinook Interceptions: Yes.** In addition to the 12.5% reduction in southern Canadian fisheries, the updated chapter requires up to a 7.5% reduction in SEAK fisheries, further reducing fishery exploitation rates on far north migrating Washington coastal and Columbia River stocks.

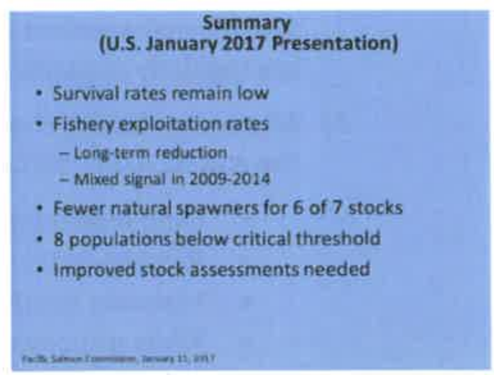
4) **Modify Review Process for Management Objectives: Yes.** Chapter 3 now identifies the abundance triggers for fishery actions in southern U.S. (SUS) fisheries for Skagit Spring and Skagit Summer/Fall Chinook salmon. A new protocol for the Chinook Technical Committee (CTC) facilitates Commission consideration of triggers for other stocks.

5) **Maintain Limits on Canadian Coho Fisheries: Yes.** Fishery provisions were maintained with substantive process improvements.

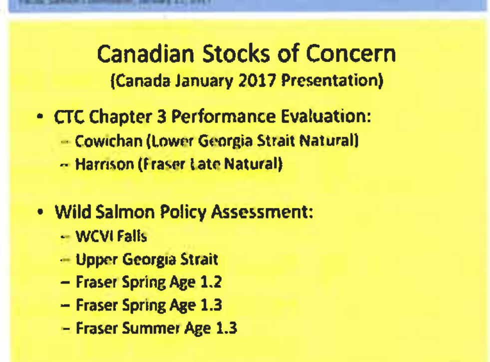
6) **Simplify: Yes.** Chinook and coho chapters were significantly simplified and clarified.

Chinook Salmon (Chapter 3)

1) **Puget Sound Chinook Focus of Negotiations.** NOAA Fisheries set a sideboard for the U.S. position by stating "a simple roll over of the current agreement would be problematic" due to the declining status of PS Chinook salmon. Presentations by the Parties in January 2017 highlighted concerns regarding the status of Salish Sea stocks south and north of the U.S.-Canada border as well as the West Coast of Vancouver Island (WCVI) stock.



2) **U.S. Objective – PS Rebuilding Exploitation Rates.** A Rebuilding Exploitation Rate (RER) is a population-specific exploitation rate metric used by NOAA Fisheries as a guidepost to evaluate proposed management regimes. Not all RERs need to be achieved for a fishery regime to be consistent with ESA requirements. A U.S. objective was to reduce exploitation rates so that RERs were achieved, on average, for PS populations.



3) **2019 – 2028 Canadian Fishery Obligations.** Fishery impacts to PS stocks occur primarily in southern British Columbia fisheries (WCVI troll and sport, Georgia Strait and Juan de Fuca sport). Washington coastal and Columbia River stocks are also exploited in the WCVI sport and troll fisheries.

   The WCVI troll and outside sport fishery is managed based on the aggregate abundance of stocks, referred to as Aggregate Abundance Based Management (AABM). The negotiated agreement requires a 12.5% reduction in the allowable catch relative to the current agreement at the abundance levels that have generally occurred in recent years. Reductions of 2.4% - 4.8% are required at higher abundance levels:

Abundance Index (AI)	Reduction in Allowable Catch From Current Chapter
AI < 0.93	12.5%
0.93 < AI ≤ 1.12	4.8%
1.12 < AI	2.4%

   The remainder of southern British Columbia fisheries have PST exploitation rate limits on individual stocks (Individual Stock Based Management or ISBM). For U.S. stocks not meeting agreed management objectives, the allowable exploitation rate is 87.5% of the 2009-2015 average (12.5% reduction from recent levels).

4) **2019 – 2028 SEAK Fishery Obligations.** The SEAK fishery is managed as an AABM fishery and impacts far north migrating Washington Coastal and Columbia stocks. The negotiated reductions in the allowable catch relative to the current agreement range from 7.5% at low to moderate abundance to 1.5% at high abundance:

Abundance Index (AI)	Reduction in Allowable Catch From Current Chapter
AI < 1.805	7.5%
1.805 < AI ≤ 2.2	3.25%
2.2 < AI	1.5%

5) **2019 - 2028 Southern U.S. Fishery Obligations.** The PST identifies stock-specific fishery exploitation rate limits in SUS ISBM fishery for stocks not meeting agreed management objectives. In general, the limits are the 2009-2015 average rate with reductions from that level for some stocks to account for fisheries that occurred during that period. Several examples are provided below:

Stock	US ISBM Limit Relative to 2009-2015 Exploitation Rates	Management Objective
Nooksack Spring	100% 2009-15 Average	To be Determined
Skagit Spring	95% 2009-15 Average	690
Skagit Summer/Fall	95% 2009-15 Average	9,202
Stillaguamish	100% 2009-15 Average	To be Determined
Snohomish	100% 2009-15 Average	To be Determined
Grays Harbor	85% 2009-15 Average	13,326
Queets Fall	85% 2009-15 Average	2,500

Quillayute Fall	85% 2009-15 Average	3,000
Hoh Fall	85% 2009-15 Average	1,200
Upriver Brights	85% 2009-15 Average	40,000
Coweeman	100% 2009-15 Average	To be Determined
Mid-Columbia Summers	85% 2009-15 Average	12,143
Cowichan (Canada)	95% of 2009-15 Average	6,500
Nicola (Canada)	95% of 2009-15 Average	To be Determined
Harrison (Canada)	95% of 2009-15 Average	75,100

6) **Benefits to PS Stocks**. Preliminary analysis indicates that the negotiated agreement will significantly reduce fishery exploitation rates on PS Chinook relative to the 2009 agreement. The analysis projects that RERs will be achieved for 67% of the PS populations, versus 17% for the 2009 agreement as negotiated, and 42% as implemented (the Parties did not always fish up to the fishery limits).

			Projected Exploitation Rate		
Stock Group	**Population**	**RER**	**2009 As Negotiated**	**2009 As Implemented**	**2019 Negotiated**
NPS Natural Spr	Suiattle R.	0.53	0.42	0.38	0.34
NPS Natural Spr	Upper Cascade R.	0.49	0.42	0.38	0.34
PS Natural S/F	Skykomish R.	0.31	0.76	0.25	0.21
NPS Natural Spr	Upper Sauk R.	0.39	0.42	0.38	0.35
PS Natural S/F	Upper Skagit R.	0.47	0.57	0.46	0.42
PS Natural S/F	Lower Sauk R.	0.44	0.57	0.46	0.42
PS Natural S/F	NF Stillaguamish R.	0.39	0.90	0.44	0.38
PS Natural S/F	Snoqualmie R.	0.22	0.76	0.25	0.21
PS Natural S/F	SF Stillaguamish R.	0.28	0.90	0.44	0.38
PS Natural S/F	Lower Skagit R.	0.27	0.57	0.46	0.42
NPS Natural Spr	NF Nooksack R.	0.05	0.59	0.50	0.43
NPS Natural Spr	SF Nooksack R.	0.05	0.59	0.50	0.43

7) **ISBM Accountability Provisions.** The performance of ISBM fisheries will receive more scrutiny in 2019-2028 than under the current agreement. If the running three-year average exceeds the limit by more than 10%, the management entity is required to provide the Commission with the actions that will be taken to minimize the deviations in subsequent years. To assist in those discussions, the PSC Chinook Technical Committee (CTC) will recommend improvements to pre-season, in-season, and other management tools.

8) **AABM Accountability Provisions.** The performance of AABM fisheries will also be monitored by the Commission. Accountability measures include:

- If the actual catch exceeds the pre-season catch limit, the overage shall be paid back in the subsequent fishing year.
- If in two consecutive years, the North British Columbia (NBC) or WCVI AABM fishery catches exceed the post-season limit by more than 10%, or in the SEAK AABM fishery the pre-season tier and catches exceed the post-season tier, the

management entity is required to provide the Commission with the actions that will be taken to minimize the deviations in subsequent years. To assist in those discussions, the CTC will recommend improvements to pre-season, in-season, and other management tools.

9) **SEAK Abundance Index.** The abundance index for the SEAK fishery will be predicted based upon catch-per-unit-effort in the winter troll fishery. The expectation is that this will be more effective in predicting the significant variation in survival rates that has been occurring. The performance of this method will be monitored and in 2022 (and 2025) the Commission will determine if the CPUE-based method should be maintained, use of the PSC Chinook Model resumed, or if an alternative method should be implemented.

10) **Incidental Mortality Limits.** For the first time, the Chinook Chapter places limits on the incidental mortality in AABM fisheries. The limit is 59,400 Chinook salmon in the SEAK AABM fishery and 38,600 for the combined aggregate of the WCVI and NBC AABM fisheries.

Coho Salmon (Chapter 5)

Summary – the Coho Chapter has been simplified and clarified, but the fishery provisions remain similar.

1) **Interior Fraser Coho.** The Interior Fraser Coho Management Unit (IFMU) will remain in *low status* (with existing exploitation rate (ER) caps) until such a time as Canada develops and adopts scientifically-reviewed status determination methods for the IFMU. Additionally:
    - There will be opportunities for U.S. technical and policy review regarding Canada's status determination methods, through meetings of the bilateral Coho Technical Committee and Coho Working Group.
    - Until such a time as status determination methodologies have been developed for other Canadian management units (MUs), Chapter 5 provisions will be implemented based on the status of IFMU and US MUs.
    - Management to MUs, other than IFMU and existing US MUs, requires bilateral discussion, and will occur consistent with the provisions of Chapter 5. Further, timing of bringing on other Canadian MUs for management purposes in the Southern Coho Agreement will be included in the bilateral discussions.

2) **Reduce Number of Canadian MUs**. The four Canadian MUs in the previous Coho Chapter (Lower Fraser, Interior Fraser, Strait of Georgia Mainland, and Strait of Georgia Vancouver Island) will be reduced to three MUs. The two Strait of Georgia (SoG) MUs (SoG Mainland and SoG Vancouver Island) have been combined into one Strait of Georgia MU.

3) **Reliable Preseason Information.** To provide a reliable basis for fishery planning, in any given year, the Parties shall not change the status or associated ER caps for an MU after March 31st (typically two weeks following the mid-March manager-to-manager pre-

season information exchange). The other elements of the mid-March information exchange currently described in Paragraph 8(g) within Chapter 5 will be carried forward.

- When methodologies to establish status benchmarks and associated ER caps have been established for other Canadian MUs (other than IFMU), the US shall provide estimates of its impacts on these MUs by April 30th in addition to the IFMU.
- By June 30th of each year, Canada shall provide the US with projected exploitation rates for its fisheries on US MUs specified in Paragraph 8(a) for the coming season. Likewise, by April 30th of each year, the US will provide Canada with projected exploitation rates for its fisheries on IFMU for the coming season.

4) **Exploitation Rate Trends.** If a producing country identifies concerns about increasing trends in ERs on the producing country's MU by the intercepting country over two or more years, bilateral discussions of the appropriate response will be initiated for implementation in the following year.

5) **Limited flexibility:** The US and Canada agreed to include chapter language committing the parties to work together in developing bilateral guidance on the approach to implementing paragraphs 11(b) and 11(c) of the current chapter – requesting decreases or increases in allowable ERs, respectively.

Chum Salmon (Chapter 6)

Summary – the updated chapter adds a second fishing tier that allows a catch of up to 160,000 chum salmon (increase of 30,000) in commercial fisheries in the San Juans. However, in the lower tier, the allowable catch was reduced to 125,000 (decrease of 5,000), and the abundance breakpoint was increased from 900,000 to 1,050,000 Fraser chum salmon.

Table 1. Summary of U.S.-Canada bilaterally agreed breakpoints and allocations for U.S. Area 7/7A Chum Fisheries (in numbers of Chum) within the newly negotiated Chapter 6 of the PST (Chum Chapter; years 2019-2028) and compared to the current Chum Chapter (years 2009-2018).

Item	Current Chum Chapter		NEW Chum Chapter [1/]	
	Breakpoints and Allocations	Payback Trigger [2/]	Breakpoints and Allocations	Payback Trigger [2/]
1st Fraser Chum run size breakpoint	900,000		1,050,000	
Resulting US 7/7A Allocation (ceiling)	130,000	+5,000	125,000	+10,000
2nd Fraser Chum run size breakpoint	n/a		1,600,000	
Resulting US 7/7A Allocation (ceiling)	n/a		160,000	+10,000

[1/] Bilateral Southern Panel final agreement, January 11, 2018.

[2/] Number of fish over catch ceiling triggering payback calculation

1) **Two Tiered Management.** A second management tier was added to allow a higher level of harvest in the U.S. Area 7/7A Chum Fishery in years of relatively higher Fraser Chum

abundance. Lower harvest levels are expected in years of lower Fraser chum run size. Table 1 provides a summary of this two-tiered management approach.

- For aggregate chum run sizes (through Johnstone Strait) above the *Inside Southern Chum Critical Threshold* of 1.0 million, the catch ceiling for the U.S. chum salmon fishery in Areas 7 and 7A will be 125,000 chum salmon. This ceiling of 125,000 could be subsequently revised based on Fraser Chum terminal run size updates as specified below. U.S. chum fisheries in Areas 7 and 7A may not occur prior to October 10th in any given year.

- For Fraser Chum terminal run sizes above 1.05 million, the catch ceiling for the U.S. chum salmon fishery in Areas 7 and 7A will remain at 125,000 chum salmon. The current agreement allows a catch of 130,000 when the Fraser Chum run size exceeds 900,000.

- For Fraser Chum terminal run sizes above 1.6 million, the catch ceiling for the Areas 7 and 7A fishery will be 160,000 chum salmon. The current agreement does not provide for an increase in allowable catch at higher Fraser Chum run sizes.

Next Steps

1) **NOAA Fisheries Section 7 Consultation**. NOAA Fisheries must complete a biological opinion to assess the consistency of updated chapters with ESA requirements for listed salmon, Southern Resident Killer Whales (SRKW), and other ESA-listed species.

2) **Approval by U.S. and Canada**. Approval by the U.S. and Canada of the updates proposed by the Pacific Salmon Commission will occur through a series of internal processes and the exchange of diplomatic notes. The Canadian process includes a period of Parliamentary consideration which may be challenging to complete by January 2019. In the U.S., since we are only amending an annex to the Treaty, as envisioned in the Treaty itself, the amendments do not require advice and consent from the Senate and will instead be concluded as an executive agreement. In the event that all of these steps cannot be completed by January 2019, the Parties have agreed to abide by the updated chapters until the approval process has been completed.

3) **Implementation Funding**. Substantial new funding is needed to implement the PST and ensure consistency with ESA requirements. Securing this funding will require broad stakeholder support and substantial work with the Congressional delegations of Alaska, Washington, and Oregon. Package elements under consideration include:

    - Puget Sound Critical Stock Program. Funding will be requested for habitat restoration, habitat protection, and hatchery conservation programs for the South Fork Nooksack, South Fork Stillaguamish, Dungeness, and Mid-Hood Canal populations.

    - SRKW Prey. Funding will be requested to increase hatchery production of Chinook salmon to increase the prey base for SRKW.

    - Improve Access to Southeast Alaska Hatchery Production. Funding will be requested to mark all Chinook salmon released from hatcheries in southeast

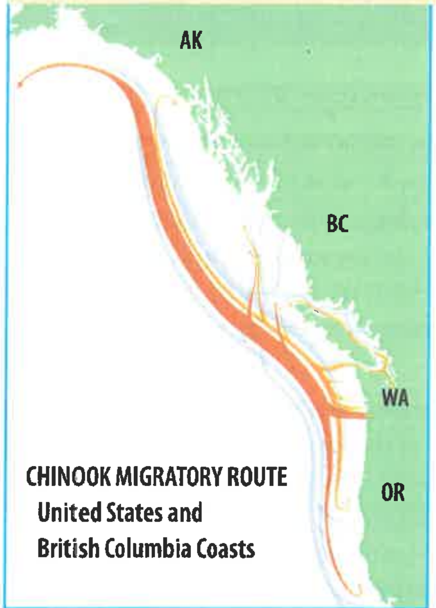
Alaska, pay for ongoing hatchery programs, and maintain production at the Little Port Walter Hatchery.

- Improved Stock Assessment. Funding will be requested to improve the scientific basis of fishery management.
- Mass Marking and Selective Fisheries. Funding will be requested to support bilateral investments in mass marking and improved assessment of mark-selective fisheries.
- Agency Implementation Funding. Funding will be requested to facilitate implementation of the PST by each of the management entities, including a $7.3 million increase in federal funding to WDFW.

4) **Fishery Implementation.** At WDFW, it will be important to update and document the preseason fishery planning process (North of Falcon) to address the new ISBM obligations for SUS fisheries. SUS fisheries will be scrutinized more intensely than under the current PST.

Pacific Salmon Treaty 2019 - 2028

A shared commitment to a better future for salmon



Revamped treaty provides hope for salmon, but successful launch requires one-time funding of $57.1 million

- Restore Puget Sound habitat
- Maintain & improve hatchery production of Southeast Alaska Chinook
- Mark 100% of hatchery production of Southeast Alaska Chinook
- Establish funding to support mark-selective fisheries

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Photo Oregon State University

Background on Pacific Salmon Treaty

The Pacific Salmon Treaty is critical to meeting the provisions of the federal Endangered Species Act (ESA), addressing tribal fishing rights, and maintaining sustainable U.S. fisheries that provide 26,700 full time equivalent jobs and $3.4 billion in economic value annually.

The treaty, signed by United States and Canada in 1985, provides a framework for the two countries to cooperate on the management of Pacific salmon. The treaty is revisited roughly every 10 years to reflect current conditions and address new challenges.

Pacific salmon are highly-migratory, often spending years at sea and travelling thousands of miles before returning to their native rivers to spawn.

A high degree of cooperation is required between the nations to prevent overfishing, provide optimum production and ensure that each country receives benefits that are equivalent to the production of salmon in its waters.

Revamped Treaty for a Dynamic New Decade

Representatives from the United States and Canada agreed in September 2018 to recommend their governments approve new coast-wide fishing agreements under the Pacific Salmon Treaty.

During talks to revise the treaty, commissioners were confronted with dynamic environmental conditions such as wide swings in salmon survival rates, changes in salmon migration patterns, and continued declines in the productivity of wild Chinook salmon in the Salish Sea. The plight of southern resident killer whales, which depend on Chinook salmon for prey, has provided an eye-opening example of the challenges.

Commissioners are recommending fishery reductions for both nations, new conservation objectives for several salmon populations, enhanced stock assessments to inform decision-makers in both countries, and the resources to ensure the effective implementation of fisheries that target marked hatchery-origin salmon.

Investing in the Future

Securing the benefits from our international commitment to a better future for salmon and southern resident killer whales requires investing in the revamped Treaty – an initial one-time investment to ensure a successful start, and an ongoing investment to fund the complex implementation of an international treaty.

The updated treaty addresses conservation needs of the stocks and the PST's objectives to prevent overfishing, provide for optimum production, and for each party to receive benefits equal to the production of salmon originating in their waters.

Initial funding

The request of $57.1 million in short-term funding (fiscal years 2020-2021) is similar to the amount sought for the 2009 update to the treaty and about 40 percent of the funding provided for the 1999 update. The funding will provide:

- $31.2 million for habitat restoration projects for at-risk Puget Sound Chinook salmon stocks. These habitat improvements are designed to help increase the number of salmon returning to Puget Sound and are essential in offsetting impacts to Chinook through fisheries. Although a number of projects have been identified, such as providing fish passage on the South Fork Nooksack River in the north Sound, the specific projects will vary based on when federal funding is available.
- $22.4 million for both marking and production of Southeast Alaska hatchery-origin Chinook.
- $3.5 million for equipment and short-term studies to ensure effective implementation of mark-selective fisheries.

Photo by Ken Rea

Fiscal Years 2020 through 2029

The 30-year history of the Pacific Salmon Treaty is impressive. Both nations have worked hard to put the "fish wars," including blockage of marine traffic, in the past. But for most of the last decade, the level of annual federal funding to implement the treaty has not kept up with inflation or rising costs. Recent year funding has been slightly higher.

Commissioners are requesting an increase in annual funding to fulfill the obligations of the revised treaty and associated ESA-consultation. A portion of the request will go toward filling existing gaps in fishery sampling and monitoring, estimating spawners, assessing fishery exploitation rates, and other activities essential to effectively implementing the treaty:

+ $14.3 million for states
+ $900,000 for tribes
+ $150,000 for the Pacific States Marine Fisheries Commission

Additionally, beyond the FY18 base funding, new funding is needed to implement these complementary actions:

+ $1.49 million to preserve at-risk Puget Sound Chinook salmon stocks through hatchery conservation programs. The programs target stocks that are at high risk of going extinct, such as South Fork Nooksack, South Fork Stillaguamish, Mid-Hood Canal, and Dungeness populations.
+ $2.33 million to aid local efforts to protect habitat and promote public support for salmon and killer whale-friendly environmental conditions.
+ $5.6 million to increase hatchery production to provide increased prey for southern resident killer whales. The state of Washington will also seek state funding for increases in hatchery production for this purpose.
+ $5.44 million to provide a sound scientific basis for management through improved estimates of Chinook salmon catch, spawners, and fishery exploitation rates.

Draft Proposal for SRKW Increases of Chinook Brood Year 2018 (FY19)

Facility Name	Operator	Species	Current Program	Max Production	FPP	Brood source	Rearing Facility	Release Facility	Production Increase for SRKW
Skookum .Cr	Lummi Nation	Late Spring Chinook	0	500,000	200	South Fork Nooksack	Skookum Cr.	Upper South fork Nooksack	500,000
Skookum .Cr	Lummi Nation	Late Spring Chinook	1,000,000	1,500,000	80	South Fork Nooksack	Skookum Cr.	Skookum Cr.	500,000
Kendall	WDFW	Spring Chinook	200,000	700,000	80	Kendall	Kendall	Kendall	500,000
Whatcom Cr.	WDFW/Bellingham Tech College	Fall Chinook	0	500,000	80	Samish	Whatcom Cr.	Whatcom Cr.	500,000
Samish	WDFW	Fall Chinook	4,000,000	5,000,000	80	Samish	Samish	Samish	1,000,000
Wallace River	WDFW	Summer Chinook	1,000,000	1,400,000	70	Wallace River	Wallace River	Wallace River	400,000
Wallace River	WDFW	Summer Chinook	500,000	600,000	8	Wallace River	Wallace River	Wallace River	100,000
Bernie Gobin	Tulalip	Summer Chinook	2,400,000	4,400,000	80	Wallace River	Bernie Gobin	Tulalip Bay	625,000
Soos/Palmer	WDFW	Fall Chinook	4,200,000	6,200,000	80	Green River	Palmer	Palmer	2,000,000
Marblemount	WDFW	Spring Chinook	787,500	2,000,000	8	Marblemount	Marblemount	Marblemount	400,000
Lewis River	WDFW	Spring Chinook	1,350,000	1,750,000	80	Lewis River	Speelyai	Lewis River	400,000
Forks Creek	WDFW	Spring Chinook	0	1,000,000	80	Kalama	Forks Creek	Forks Creek	1,000,000
Minter/Hupp	WDFW	Spring Chinook	400,000	500,000	80	Minter	Hupp	Hupp	100,000
Sol Duc	WDFW	Summer Chinook	70,000	1,320,000	50	Sol Duc	Sol Duc/Bear Springs	Sol Duc	500,000
Sol Duc	WDFW	Summer Chinook	250,000	325,000	8	Sol Duc	Sol Duc/Bear Springs	Sol Duc	75,000
Bear Springs	Quileute Tribe	Summer Chinook	60,000	140,000	8	Sol Duc	Sol Duc/Bear Springs	Sol Duc/Bear Springs	75,000
Chinook Total			**16,217,500**	**27,835,000**					**8,675,000**

<u>2018/2019 salmon winter sport fishing season:</u>

Marine Area 5:
- Dates = **February 16 through April 30, 2019**.
- Daily limit of up to two salmon. Hatchery Chinook – min. size = 22”. No min. size on other salmon species. Release all wild Chinook and wild coho.
- Managed as a season, beginning and ending at the above dates.

Marine Area 6:
- Dates = **February 1 through April 15, 2019**.
- Daily limit of up to two salmon. Hatchery Chinook – min. size = 22”. No min. size on other salmon species. Release all wild Chinook and wild coho.
- Dungeness Bay Fishery closure is in effect.
- The preseason prediction of total Chinook salmon encounters in Area 6 is **5,473**. WDFW plans to manage this fishery as a season, beginning and ending at the dates above. However, if in-season estimates indicate that total Chinook salmon encounters are projected to be at 80% of the preseason modeled encounters, WDFW will initiate co-manager discussion regarding potential fishery actions. WDFW will ensure that the fishery does not exceed **6,413** predicted total Chinook salmon encounters.

Marine Area 7:
- Dates = **January 1, 2019 through April 15, 2019.**
- Daily limit of one hatchery Chinook salmon (min. size = 22”). Release all coho and wild Chinook.
- The preseason prediction of total Chinook salmon encounters in Area 7 is **10,734** and total unmarked encounters (legal-unmarked plus sublegal-unmarked) is **3,634**. WDFW plans to manage this fishery as a season, beginning and ending on the dates above. However, if in-season estimates indicate that total Chinook salmon encounters are projected to be at 80% of the preseason modeled encounters. WDFW will initiate co-manager discussion regarding potential fishery actions. WDFW will ensure the fishery does not exceed 3,176 total unmarked encounters and/or exceed **11,867** total encounters.
- WDFW will begin providing in-season catch estimates on **January 11, 2019.**
- Season may close early if Chinook guideline is attained.
- See sport fishing rules pamphlet for special sub-area rules and closures.

Marine Area 8-1 and 8-2:
- Dates = **December 1, 2018 through April 30, 2019**.
- Daily limit of up to two hatchery Chinook salmon (min. size = 22”). Release all coho and wild Chinook.
- The preseason prediction of total Chinook salmon encounters in Area 8-1 and 8-2 is **5,473.** WDFW plans to manage this fishery as a season, beginning and ending on the dates above. However, if in-season estimates indicate that total Chinook salmon encounters are projected to be at 80% of the preseason modeled encounters, WDFW will initiate co-manager discussion regarding potential fishery actions. WDFW will ensure that the fishery does not exceed **6,568** predicted total Chinook salmon encounters.
- WDFW will begin providing in-season catch estimates on **December 21, 2019.**
- Season may close early if Chinook guideline is attained.
- See sport fishing rules pamphlet for special sub-area rules and closures.

Marine Area 9

- Dates = **January 1 through April 15, 2019**.
- Daily limit of up to two salmon; one may be a hatchery Chinook (min. size = 22”). Release coho and wild Chinook.
- The preseason prediction of total encounters in Area 9 is **8,337**. WDFW plans to manage this fishery as a season, beginning and ending on the dates above. However, if in-season estimates indicate that total Chinook salmon encounters are projected to be at 80% of the preseason modeled encounters, WDFW will initiate co-manager discussion regarding potential fishery actions. WDFW will ensure that the fishery does not exceed **10,004** predicted total Chinook salmon encounters.
- WDFW will begin providing in-season catch estimates on **January 18, 2019**
- Season may close early if Chinook guideline is attained.

Marine Area 10

- Dates = **January 1, 2018 through March 31, 2019.**
- Daily limit of up to two hatchery Chinook (min. size = 22”). No min. size on other salmon species. Release all wild Chinook.
- The preseason prediction of total Chinook salmon encounters in Area 10 is **2,997**. WDFW plans to manage this fishery as a season, beginning and ending on the dates above. However, if in-season estimates indicate that total Chinook salmon encounters are projected to be at 80% of the preseason modeled encounters, WDFW will initiate co-manager discussion regarding potential fishery actions. WDFW will ensure that the fishery does not exceed **3,596** predicted total Chinook salmon encounters.
- WDFW will begin providing in-season catch estimates on **January 18, 2019**
- See sport fishing rules pamphlet for special sub-area rules and closures.

Marine Area 11

- Dates = **October 1, 2018 through April 30, 2019.**
- Daily limit = 2 salmon. Hatchery Chinook – min. size = 22”. No min. size on other salmon species. Release wild Chinook.
- Managed as a season, beginning and ending at the above dates.
- See sport fishing rules pamphlet for special sub-area rules and closures.

Marine Area 12

- Dates = **October 1, 2018 through April 30, 2019.**
    - **October 1, 2018 through December 31, 2018** - Daily limit = 4 salmon; up to 2 may be hatchery Chinook. Hatchery Chinook – min. size = 22”. No min. size on other salmon species. Release wild Chinook.
    - **January 1, 2019 through April 30** – Daily limit = 2 salmon; Hatchery Chinook – min. size = 22”. No min. size on other salmon species. Release wild Chinook.
- Managed as a season, beginning and ending at the above dates.
- See sport fishing rules pamphlet for special sub-area rules and closures.

Marine Area 13

- Dates = **October 1, 2018 through April 30, 2019.**
- Daily limit = 2 salmon. Hatchery Chinook – min. size = 22”. No min. size on other salmon species.
- Managed as a season, beginning and ending at the above dates.
- See the sport fishing rules pamphlet for specific sub-area rules and closures

From:	Jones, Rob
To:	US v WA Mediation -- Combined Groups
Subject:	[US v WA Mediation Communication] Nooksack MUP
Date:	Friday, September 14, 2018 1:53:35 PM
Attachments:	Nooksack River Management Unit Profile 090618.docx

All,
With this email, I am transmitting the Nooksack MUP, which has undergone full comanager review, to NOAA.

Rob

Nooksack River Management Unit Status Profile

Component Populations

Commented [S1]: Is this consistent with US position in PST in terms of the CYER for southern US ISBM fisheries?

North/Middle Fork Nooksack early Chinook
South Fork Nooksack early Chinook

This profile has been prepared and submitted to obtain coverage for a process that does not align with the harvest and recovery objectives of the Lummi Nation and the Nooksack Tribe. The Nooksack River early Chinook populations have been decimated as a result of decades of habitat loss and degradation, and a failure to reverse this damaging progression. Despite the tribes' commitment to rebuilding the early Chinook populations, including no directed fisheries on natural-origin Nooksack early Chinook since 1978, things are no better today than they were 40 years ago. The fact that habitat preservation and restoration have not outpaced continued habitat decline, or led to higher Chinook productivity, is of great concern to the tribes. Adhering to the harvest management objectives within this profile will not lead to the recovery of meaningful and sustainable harvestable surpluses of natural Chinook populations without significant actions to protect and restore habitat and water quality and quantity within the basin, which is the real cause of salmon decline. Additionally, as long as fisheries outside the jurisdiction of this plan continue to account for 80% of the exploitation rate on Nooksack early Chinook populations, restrictions on fisheries in the southern US will have little effect on "recovery". At this time, the co-managers reluctantly endorse the management objectives described in this plan, based on the anticipated support and flexibility of NOAA to work with the co-managers on the implementation of a strategic regional hatchery production plan that will contribute to the co-managers' interim harvest goals and begin to address the harvest needs of Lummi and Nooksack tribal communities.

Geographic description

The Nooksack River Chinook management unit is comprised of two early-returning, native Chinook populations that are genetically distinct, and exhibit different migration and spawn timing from one another (SSDC 2007).

Commented [S2]: Cite source ADDED

The North and Middle Forks drain high altitude, glacier-fed streams. North Fork/Middle Fork Nooksack early Chinook (NF/MF Chinook) spawn in the North Fork and Middle Fork, including tributaries, from the confluence of the South Fork (RM 36.6) up to Nooksack Falls at RM 65, and in the Middle Fork downstream of the diversion dam, located at RM 7.2. A diversion dam on the Middle Fork, installed in 1960-1961, creates a fish passage barrier and cuts off 17 miles of former Chinook habitat. According to an Ecosystem Diagnosis and Treatment model run in 2003, restoring passage at this site would yield a 31% increase in natural origin (NOR) Chinook abundance, 12% increase in NOR productivity, and 48% increase in diversity index for the North/Middle Fork Nooksack NOR early Chinook population (SSDC 2007).

Commented [S3]: Do you know how much this would increase production if access to habitat was opened up? ADDED

The South Fork drains a lower-elevation watershed that is fed by snowmelt and rainfall, but not by glaciers. Consequently, river discharge is relatively lower and water temperature relatively higher in the South Fork mainstem than the North and Middle Forks during summer and early fall. South Fork Nooksack early Chinook (SF Chinook) spawn in the South Fork and South Fork tributaries from the confluence with the North Fork to the cascades at RM 30.8, although use is much lower upstream of Sylvester's Falls at RM 25 in recent decades.

Commented [S4]: Does this reflect historic distribution?

PER NED: this is the best description of spawning distribution. Yes, to the best of our knowledge, this represents historic distribution.

For both the NF/MF and SF populations, the amount of tributary spawning varies considerably from year to year depending on whether discharge is sufficient to allow entry to the spawning grounds. Climate induced changes in watershed flow regimes have likely altered spawning distributions. Spawning ground survey data appears to confirm a recent decline in tributary habitat use, coinciding with dry late summers.

Life History Traits

River Entry
Previous studies indicate that Nooksack early Chinook populations are characterized by entry into freshwater beginning in March, slow upstream migration and lengthy holding periods in the river prior to spawning (Barclay 1980, Barclay 1981). However, this early work never extended lower river tagging beyond June, included very few Chinook that went up the South Fork, and it does not provide a solid basis for river entry distribution or timing, leading to the hypothesis that the SF population may exhibit slightly later run timing than the NF/MF population.

Restrictions on sampling the migration between mid-June and the end of July have diminished the ability to clearly establish river entry timing for SF Chinook. Recent CWT recoveries from the Skookum Creek early Chinook population recovery program in the August terminal area fisheries appear to support the hypothesis that the behavior of the SF population is different than of the NF/MF population. South Fork Chinook river entry timing appears to continue longer than for the NF/MF population.

Spawning
Beginning in the late 1970s, spawning ground survey effort started increasing in the North Fork and South Fork. For the Middle Fork, survey effort did not increase until the mid-1990s, after Chinook were detected there. By the late 1990s, survey effort in all forks, increased 2 to 4 fold over previous decades.

In the North and Middle Forks, spawning is estimated to occur from July through September, peaking in August. South Fork Chinook begin spawning in August and continue through September, with peak spawn timing in September and at least 2-3 weeks after NF/MF Chinook. However, the increased incidence of storms and high flows during early fall diminishes the ability to make observations and collect carcasses after early October that would allow a more accurate determination of the spawn timing and distribution, especially in the South Fork.

Outmigration

Nooksack Chinook exhibit all three out-migrant life history patterns (ocean-type fry, ocean-type parr and stream-type yearlings) as evidenced by adult scale pattern analysis, sampling and analyzing catches of juvenile out-migrants at a lower river screwtrap, and beach seine sampling through the lower river, delta and nearby estuaries (Beamer et al. 2016; Lummi Natural Resource juvenile salmon database and analyses). Ocean-type age 0 Chinook fry migrate out early from late winter through March rearing in the river delta or pocket estuaries until they are large enough to undergo the physiological shift to salt water. Ocean-type age 0 parr rear for a few months in freshwater before migrating out directly to estuaries and near-shore regions; outmigration peaks in May and June. Yearlings rear over summer and overwinter in freshwater and outmigration occurs over two main periods. One period occurs in April through May preceding the main parr outmigration. The second period starts in late fall and extends through the winter ending in February prior to the out-migrant fry peak.

Analysis of juvenile salmon captured at a rotary screw trap, operated in the lower main stem of the Nooksack River, confirms that, from 2005-2015, fry comprised 5.5%, parr 90% and yearling 4.5% of the total natural-origin Chinook out-migrant population (Beamer et al. 2016). The outmigration of yearlings is likely an underestimate at 4.5%, due to the lack of sampling during some of the outmigration and lower catchability of yearlings compared to parr. Scales collected from natural-origin spawners show the NF/MF spawning population to consist of 29% yearlings while the SF spawning population consists of 38% yearlings (SSDC 2007).

Age Composition

Available information on the age composition of adults returning to the NF/MF and the SF suggest a predominance of age-4 returns. The NF/MF population age data were derived from natural origin adults sampled on the spawning grounds from 1999 through 2014. There is less confidence in estimates of SF age structure, due to the low number of carcasses sampled on the spawning grounds. Estimated age composition for natural origin returns for both populations are shown in Table 1.

Table 1. Estimates of the age composition of returning adult natural origin Nooksack early Chinook by population 1999-2014 (co-manager unpublished data).

Population	Age 2	Age 3	Age 4	Age 5	Age 6
NF/MF NOR	<1%	20%	54%	16%	0%
SF NOR	1%	11%	74%	14%	0%

Hatchery Recovery Programs

Two hatcheries in the Nooksack River watershed operate early Chinook programs; the Kendall Creek Hatchery and the Skookum Creek Hatchery. Both the Kendall and Skookum programs are key components in the recovery of native Nooksack Chinook populations and are operated to buffer demographic and genetic risks while improvements to habitat quantity and quality occur. The Kendall Creek and Skookum Creek hatcheries are intended to assist in recovery of the NF/MF and SF populations by significantly increasing population abundances and natural production.

Kendall Creek Hatchery – North Fork/Middle Fork Chinook Program

A population recovery program for the NF/MF Chinook population has operated at the Kendall Creek Hatchery since 1981. At peak production, up to 2.3 million fingerlings, 142,500 unfed fry and 348,000 yearlings were released into the North Fork, or at various acclimation sites. The yearling release program was discontinued after the 1996 brood because survival rates were lower than those of sub-yearling release groups. In 2001, fingerling releases into the Middle Fork were initiated. Since 1992, all Kendall Chinook have received thermal otolith marks and 200,000 (single index) or 400,000 (double index) have received coded-wire tags to evaluate release strategies, estimate contribution to natural production, and estimate contribution to fisheries. A portion of the Kendall Hatchery NF/MF Chinook releases have been coded wire tagged since 1983.

The production strategy for the NF/MF program was adjusted in 2003 to reduce straying into the South Fork. On-station releases, which exhibited the highest stray rate into the South Fork, were reduced from 900,000 in 1998, ranging from 630,000 to 424,000 in 1999-2002, and were further reduced to 200,000 in 2003, which remains the current on-station release goal. The total off-station release was reduced in 2003 from a peak of approximately 1,730,000 fingerlings in 1999 (all in the North Fork or its tributaries) to 400,000 fingerlings in the North Fork, 200,000 in the Middle Fork, and 50,000 fry to remote site incubators in the North Fork. The remote site incubator releases were discontinued after the 2004 release. The current total NF/MF program release objective is 800,000 sub-yearlings; 100% of these are adipose-clipped.

Commented [S5]: What proportion are ad-clipped? **TC: Addressed**

Skookum Creek Hatchery – South Fork Chinook Program

A captive brood South Fork population recovery program was initiated in 2007 using natural-origin juveniles captured from the South Fork and reared at Kendall Creek and Manchester facilities. Since the program was initiated, there has been extensive genetic stock identification of captive brood and returning adults from captive brood progeny released from the hatchery. Key priorities for the program are to maintain genetic diversity of the population and expand the effective population size. In 2017, all of the program broodstock came from Hatchery Origin Broodstock (HOB) adult returns from the program (Table 2.). The current total Skookum hatchery release objective is 1,000,000 sub-yearling smolts.

Table 2. Captive South Fork Chinook brood spawned and total adult Chinook recruits to Skookum Creek Hatchery Brood Years 2010-2017 (unpublished data).

Brood Year	Captive Females Spawned	Captive Males Spawned	Total Returned Females	Total Returned Males
2010	2	10	0	0
2011	15	15	0	0
2012	91	91	0	0
2013	285	171	0	0
2014	194	160	0	23
2015	144	123	12	949
2016	175	108	114	1,547
2017	0	0	482	1,123

All juvenile Chinook released from the Skookum Creek Hatchery have been coded-wire tagged to improve evaluation of the program. The co-managers will likely propose that the coded wire tag program transition to an indicator stock program with a planned release of 200,000 CWT-adipose clipped fish; this is 20% of the current program size. The remaining 800,000 will not be clipped. Beginning in 2017, all release groups will be thermally otolith marked annually to improve estimation of returning adult abundance, particularly from spawning ground surveys.

Commented [S6]: The remaining 600K would not be clipped, correct?
TC: Addressed.

Habitat

Habitat loss and degradation have resulted in substantially reduced spawning and rearing habitat capacity and quality, which in turn limits the potential abundance and productivity of Nooksack Chinook populations. At present, reduced capacity of and survival in freshwater habitat are considered key factors limiting recovery. The last estimate of current capacity is 2,723 in the North Fork and 1,215 in the South Fork. In 2005, the productivity was estimated to be 1.8 in the North Fork and 1.4 in the South Fork (SSDC 2007). In 2017, a NOAA produced RER analysis suggested the capacity of the management unit was 1,529 (Ricker) and 457 (Beverton Holt) (NWFSC 2017).

Land uses contributing to habitat degradation include agriculture throughout much of the lowlands, timber harvest in the upper watershed, rural residential development in the valleys, and urban and industrial development in the lower watershed and along the shoreline south of the Nooksack River delta (SSDC 2007). Climate change will exacerbate the negative effects of habitat loss and degradation by increasing summer temperatures, sediment loads, the frequency and magnitude of peak flows, and by reducing summer flows (Dickerson-Lange and Mitchell 2013; Murphy 2015; EPA 2016; Kuhlman et al. 2016).

Habitat degradation in the Nooksack River Forks, which contains the majority of Nooksack early Chinook spawning and rearing habitat, substantially limits both populations (SSDC 2007). In the North Fork, high channel instability, which is associated with frequent channel shifting, reduces egg-to-emergence survival due to increased scour or burial of redds (Hyatt and Rabang 2003). Reduced channel stability has been linked to the loss of forested islands and associated stable side channels for spawning and rearing in the North and Middle Forks (Hyatt 2007). The Middle Fork Diversion Dam, built in 1960-1961 to divert water to Lake Whatcom to augment the City of Bellingham's water supply, blocks at least 10.2 miles of habitat in the Middle Fork and 6.9 miles in its tributaries (Currence 2000).

In the South Fork, Chinook are limited by low habitat diversity and lack of deep holding pools, along with higher water temperatures and lower instream flows (compared to the other forks), due to instream wood loss and removals and degraded riparian conditions coupled with extensive bank hardening and wetland loss through the South Fork valley (Maudlin et al. 2002; Soicher et al. 2006). Pathology analysis of Chinook prespawn mortalities in the South Fork in 2003, 2006, 2009 and 2013 confirmed the presence of Flavobacterium columnare (Columnaris), a pathogen associated with high temperatures; corresponding 7-day average of the daily maximum temperature in the lower South Fork for those years were 23.1°C, 23.0, 23.8, and 22.1, respectively (EPA 2016). Temperatures in the South Fork have continued to exceed 20 °C but there have not been pathologist confirmed reports of Columnaris. The respective fisheries passed

Commented [S7]: Has this continued into recent years or is it different?

these fish through, but they did not survive to reproduce. There have also been management-induced increases in fine sediments relative to natural conditions, due to past and ongoing forest practices, riparian forest clearing, and floodplain disconnection (Brown and Maudlin 2007).

Commented [S8]: Do you have estimates of in-river mortality resulting from the temperatures and pathogens? Would help to emphasize the impact of the conditions on survival.

Rearing habitat in the main stem Nooksack River and associated floodplain and tributary habitats is limited by extensive bank hardening and levees, especially through the lower 25 miles, clearing of the floodplain forest, and ditching and draining of floodplain wetlands (SSDC 2007). An instream flow rule was established for the Nooksack watershed in 1985, and much of the watershed was either fully closed (lower Nooksack watershed) or seasonally closed (much of the North and South Fork watersheds) to further appropriation at that time (WAC 173-501). Nonetheless, established instream flows are frequently not met in many areas of the watershed, and there is no mechanism to ensure that instream flow needs can be met (Blake and Peterson 2005). Finally, the impacts of pollution from agricultural and household chemical use, as well as urban stormwater runoff, on Nooksack Chinook have not been fully evaluated.

Estuarine habitat connectivity in the Nooksack is limited by fish passage barriers, floodplain disconnection, and lack of forested cover (Brown et al. 2005; Beamer et al. 2016). The Lummi River, formerly the primary distributary channel of the Nooksack River, was cut off in the late 1800s and remains largely disconnected except at the highest flows. The Nooksack River delta has prograded significantly into Bellingham Bay since the 1930s, creating diverse and productive estuarine environments. Much of the near-shore to the south of the delta is urbanized, and legacy industrial uses on the waterfront have contaminated sediments and water quality in Bellingham Bay (SSDC 2007). Stormwater runoff associated with Bellingham also negatively impacts water quality in the Bay and in independent tributaries that can provide non-natal rearing habitat.

Climate change impacts to the hydrologic regime (Nooksack River watershed) and stream temperature (South Fork Nooksack River watershed) have been modeled, and vulnerability of salmon in the South Fork assessed. Hydrologic modeling indicates that, by 2025, median August flows are estimated to drop 25%, 14%, and 40% relative to the historic average (1950-2010) for the North, Middle, and South Forks, respectively (Murphy 2015). Projected changes in flood frequency are more challenging to model, but increase in annual flood peak is projected, such that the magnitude of the historical 10-year flood in the main stem Nooksack River is projected to have a return interval of 3 years by 2050 (Dickerson-Lange and Mitchell 2013). Critical condition temperatures (i.e. those experienced during hot, dry summers) in the South Fork are expected to increase 2.5-3.6°C by the 2040s, and 3.4-5.9°C by the 2080s (Butcher et al. 2016). Sediment loads are likely to increase under climate change due to loss of snowpack and increased intensity of precipitation events (EPA 2016). Potential impacts of sea level rise, wave-generated erosion, and sediment load increases on tidal and near-shore habitats are being evaluated (USGS 2017).

Habitat status has been updated through development of the Nooksack Chinook monitoring and adaptive management framework (PSP and WRIA 1 SRB 2014; Coe 2015). Watershed-wide, status of floodplain connectivity, channel migration, floodplain forest, riparian forest stand age, main stem habitat connectivity, and turbidity (South Fork) is considered fair. Status of instream large wood, pool frequency, forested islands, forest road density, and summer water temperature (South Fork) are considered poor. While restoration has improved habitat conditions in some reaches of the Forks, watershed-wide habitat condition continues to decline (NWIFC 2016). Between 2012 and 2016, floodplain status, tributary habitat connectivity, shoreline hardening and South Fork water temperature conditions all declined. Recent habitat declines include 350 feet of new marine shoreline added (since 2011), 99 additional fish passage barriers identified (since 2010), 1.5% loss in wetlands (2006-2011), and 565 new permit-exempt wells (2008-2014; NWIFC 2016).

Population Status

The current status of both Nooksack early Chinook populations is critical (SSCD 2007), with significantly degraded habitat contributing to consistently poor returns of natural-origin Chinook and low productivity. For the most recently completed brood years, 2006-2010, productivity was 0.30 and no year exceeded a productivity of 1 for the management unit.

Commented [S9]: What is the standard for this (i.e., CET, LAT)?

Between 1999 and 2015, escapement of NF/MF natural-origin spawners (including NF/MF spawners in the South Fork) ranged from a low of 85 to a high of 453, with an average of 281. During this time period, two of the highest and two of the lowest natural-origin escapements occurred in the most recent four years, 2012-2015. The escapement of NF/MF hatchery-origin Chinook to the spawning grounds in all forks ranged from a low of 556 to a high of 3,806 (Figure 1). There has been no indication that years of above average escapements lead to above average natural-origin returns in the subsequent three to five years. For the most recently completed brood years, 2006-2010, the average productivity was well below replacement, 0.27 and none of the years exceeded 1 (NMFS 2017; NWFSC 2017).

Between 1999 and 2015, SF Chinook natural-origin escapement ranged from a low of 7 to a high of 159, averaging just 60 spawners per year. The estimated 10 natural-origin spawners in 2013 and 7 in 2015 are considered minimum estimates due to a large return of pink salmon spawning concurrently with SF Chinook and the difficulties associated with identifying Chinook redds during these conditions (Figure 1). For the most recently completed brood years, 2006-2010, the average productivity was 2.83, but was below replacement in 2 of 5 years (NMFS 2017; NWFSC 2017). This high degree of variability is primarily a result of consistently low abundance. Although the number of SF natural-origin spawners has consistently been below 200, the total number of spawners in the SF is expected to increase significantly in coming years as the SF recovery program operating from the Skookum Creek hatchery continues to develop and progress according to program objectives.

The very low NOR escapements from 2013-2015 in Figure 1 can be explained, at least partially, by the survey conditions in those years. Pink salmon spawn concurrently with South Fork Chinook, and the 2013 and 2015 Nooksack pink escapement estimates (224,000 and 247,000 respectively) were the highest and third highest since 1959, when the methodology was developed. Consequently, the South Fork Chinook estimates for those years were reported as minimum estimates due to redd superimposition. In 2014 we had an unusual high flow event that coincided with peak population spawn timing, where discharge rose from a low of 133 cfs September 23rd to a high of 3,830 cfs September 24th at the South Fork USGS Saxon Gauge. This freshet obscured redds and also flushed carcasses which would skew the stock assignment results to under represent the population. Similar situations occurred in 2013 and 2015, with a minimum discharge September 27, 2013 of 226 cfs rising to a peak of 13,300 cfs September 28. In 2015 the minimum discharge was 163 cfs on September 18 but that rose to 9,480 cfs by September 20th. This is a very flashy river and visibility rarely recovers after the first strong fall freshet.

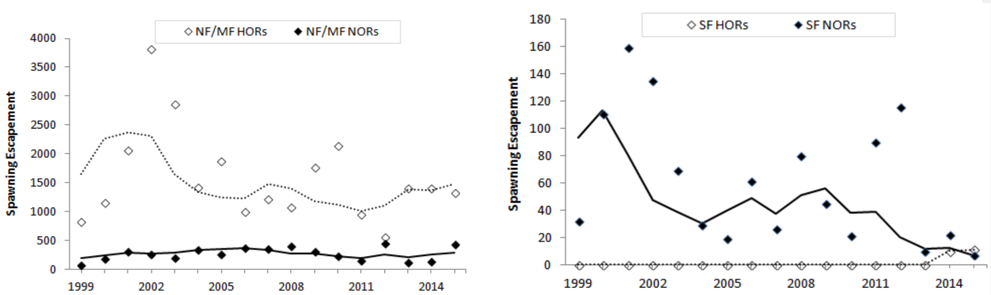

Figure 1. Spawning ground escapement estimates for the NF/MF (left graph) and SF (right graph) Nooksack early Chinook populations (1999-2015). Left graph includes NF/MF Chinook that spawned in the South Fork. The filled and unfilled diamonds represent point estimates, while the solid and dashed lines represent the four-year geometric means.

Commented [S10]: Is there something in particular starting in 2011 that has influence the decline in the SF? Looked like it had stabilized until that point.
NED: See added narrative above

Table 3. Spawning ground escapement estimates for the NF/MF and SF Nooksack natural origin and hatchery origin early Chinook populations (1999-2015). NF/MF NOR and HOR totals include Chinook that spawned in the South Fork.

Return Year	NF/MF Natural Origin Spawners	NF/MF Hatchery Origin Spawners	SF Natural Origin Spawners	SF Hatchery Origin Spawners
1999	85	828	32	0
2000	202	1156	111	0
2001	315	2059	159	0
2002	279	3806	135	0
2003	210	2857	69	0
2004	347	1419	29	0
2005	266	1869	19	0
2006	377	993	61	0
2007	372	1216	26	0
2008	412	1068	80	0
2009	327	1762	45	0
2010	247	2137	21	0
2011	160	942	90	0
2012	453	556	116	0
2013	139	1409	10	0
2014	147	1406	22	10
2015	440	1325	7	11

Enumeration Methods

Current escapement estimate methodologies for the South Fork are redd-based, calculated by multiplying the total number of redds by the standard 2.5 adults per redd. The methodology assumes all redds are accurately counted in all geographic areas utilized by spawners, that no spawning Chinook after September 30th are early Chinook and that all Chinook that spawn through September 30 die within a week (October 7).

In the North/Middle Forks, a predominance of unfavorable viewing conditions support utilizing a carcass-based methodology for estimating the number of natural origin and Kendall Creek Hatchery origin early Chinook in the North/Middle Forks and their tributaries. A methodology was developed using redd data from five years (1991, 1992, 1995, 1996, and 2000) considered to have good viewing conditions. Redd counts from these five years were multiplied by 2.5 fish to estimate total population abundances. The total carcass counts in each of these five years was expanded to match the respective redd based total population abundance estimates. The individual year results ranged from a low of 3.22 to a high of 3.95, and the averaged expansion was 3.48 fish per recovered carcass to match redd-based estimates. As such, a 3.48 expansion factor for carcasses was adopted.

Beginning in 2010, carcasses observed in proximity to the Kendall Creek Hatchery were not expanded, and instead were considered the total counts. Unexpanded counts from Kendall Creek and Kendall Slough, areas of high carcass density and frequent surveys, were considered to more accurately reflect total abundance in this area. Prior escapement estimates were not recalculated with this more conservative methodology.

Commented [S11]: Were previously expanded counts in this area recalculated, i.e., are the estimates before and after 2010 comparable? Can't remember from our data discussions but important to know when looking at the trends in Figure 1.

In the Middle Fork, the escapement methodology has shifted between carcass-based methodology in years with poor survey viewing conditions (with a carcass expansion factor initially being 3.48, but later adjusted to 1.91) and a redd-based methodology in years with good survey viewing conditions. For select years, unexpanded carcass counts from low-flow, clear-water, and frequently surveyed Middle Fork tributaries were considered to more accurately reflect total Chinook spawners in those areas.

Stock Allocation

Commented [S12]: Please include table of results for years since samples were reliably estimated. This is important work.
Addressed

In the South Fork, DNA extracted from tissue samples from carcasses is used to determine a primary, secondary, and tertiary stock assignment with a posterior probability assigned to each level. The three stocks with unique genetic baselines that have been used are the NF/MF baseline, the SF baseline, and a Nooksack/Samish Fall stock baseline. Population of origin for each carcass is determined by simple majority (posterior probability of individual assignment >50%). The posterior assignments are generally very high for the Nooksack stocks averaging over 80% for all stocks and with a low percentage of ambiguous results.

In the South Fork, hatchery origin fish were identified based on adipose fin clip marks, otolith marks and/or CWT presence and subsequently assigned to their respective hatchery origin stock. These data are used to estimate respective hatchery contributions to the estimated total number of spawners through Sept. 30, as determined by multiplying the total redd count by 2.5. The DNA results for the sampled natural origin carcasses are proportionally applied to the total estimate of wild Chinook (those without marks indicating hatchery origin) as expanded from the total number of redds in the South Fork.

Harvest Distribution and Exploitation Rate Trends

In the Fishery Regulation Assessment Model (FRAM), the NF/MF and SF populations are managed as a single unit as an indicator stock, based on coded wire tags from Kendall Creek Hatchery. Kendall Creek Hatchery represents both the NF/MF and SF populations because the Skookum Hatchery Spring Chinook program was not operational during the new FRAM base period.

Northern fisheries, conducted in Alaska and British Columbia, have consistently accounted for a majority of fishing-related mortality on Nooksack early Chinook, averaging an exploitation rate (ER) of 36% from 1992-2014. Pre-terminal and terminal fisheries conducted in the southern US averaged 6.9% and 1.4% ER, respectively, for the same time period (Figure 2). Viewed another way, northern fisheries averaged 81.3% of the total annual exploitation rate between 1992 and 2014, while pre-terminal and terminal fisheries averaged 15.1% and 3.6% of the total annual exploitation rate on Nooksack early Chinook, respectively (Figure 2).

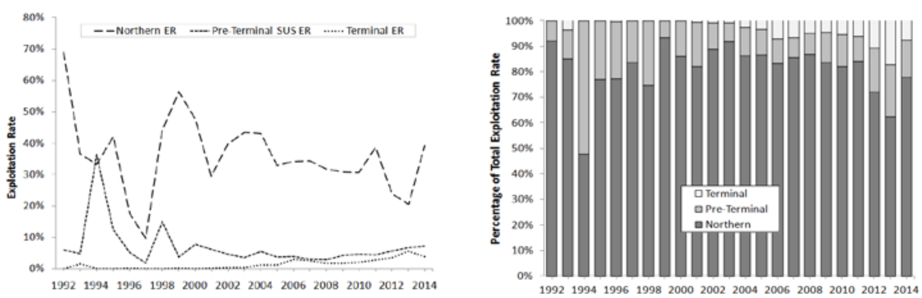

Figure 2. Northern, Pre-Terminal and Terminal exploitation rates on natural-origin Nooksack early Chinook from 1992-2014 (left graph), and the percentage of the total annual exploitation rate attributed to the Northern, Pre-Terminal and Terminal fisheries (right graph). Both graphs are based on post-season model runs using the new FRAM base period.

Management Objectives

The Kendall Creek and Skookum Creek hatchery programs are key components in the recovery of native Nooksack Chinook populations, playing a critical role in sustaining and increasing population abundances and buffering demographic and genetic risks while improvements to habitat quantity and quality occur.

The management objectives for Nooksack early Chinook were developed to ensure that Southern US harvests do not impede recovery or jeopardize the genomes of the NM/MF and SF populations, to maintain supplementation production from the Kendall and Skookum hatcheries until habitat capacity might be restored to a level that will sustain viable populations and to allow the exercise of treaty-reserved tribal fishing rights and non-tribal fishing opportunities on harvestable salmon. Both the NF/MF and SF Nooksack early Chinook populations will be managed for escapement of natural origin spawners.

The Nooksack management unit has been managed under a critical exploitation rate ceiling (CERC) under past management plans, with Upper Management Thresholds (UMTs) of 2,000 and Low Abundance Thresholds (LATs) of 1,000 for both populations, and with no allowable exploitation rate ceiling higher than the CERC identified. The comanagers will continue to manage using a CERC response at the onset of this plan regardless of expected abundance, but have attempted to define UMTs and LATs more representative of the current status of the populations and their habitat. In recent analyses of Nooksack early Chinook populations' abundance and productivity, a rebuilding threshold of 500 adult spawners was identified for the combined NF/MF and SF populations (NMFS 2003; NMFS 2017; NWFSC 2017). Because the SF population generally represents less than 5% of total spawners returning to the Nooksack River, 400 natural origin spawners is a reasonable reference point for establishing a conservative LAT for the NF/MF population. The UMT for the NF/MF population will be set at 1,000 natural spawners (Table 4). Although an allowable exploitation rate higher than the CERC at higher abundances is not identified in this plan, setting the UMT for the NF/MF population at a level that is twice the rebuilding threshold of 500 is a very conservative approach to defining escapement thresholds.

For the SF population, chronically low natural-origin abundance estimates and highly uncertain productivity estimates limit the ability to produce a recruit-per-spawner curve or establish escapement reference points. Because of low confidence in biologically-based population metrics for the SF population, a LAT was established utilizing a habitat-based model (Parken et al. 2006) that estimates spawners at MSY based on watershed area and dominant life history type (ocean-type, stream-type). For the South Fork watershed, 25% of the watershed is considered inaccessible due to natural falls and cascades, and based on previous EDT model-based estimates the current capacity of accessible spawning habitat is 7.5% of historic levels (WRIA 1 SRB 2005). Using the method established by Parken et al. (2006) results in 157 spawners at MSY. Following logic for taking a conservative approach similar to that used for the NF/MF population, a LAT for the SF population is set at 200 natural origin spawners, and the UMT is set at 500 natural origin spawners (Table 4). Setting both thresholds at levels higher than the best available estimate of MSY escapement is a very conservative approach to defining escapement thresholds. These escapement thresholds are consistent with the goals of the Skookum Creek SF early Chinook program of increasing natural-origin spawner abundance and preserving genetic diversity of the SF population.

When pre-season FRAM outputs of projected natural spawning escapement for one or both Nooksack early Chinook populations are below the LAT, fisheries in the Southern US will be planned so as not to exceed the CERC. The CERC will be 10.5% SUS ER on the natural-origin components of the combined populations. However, to allow some flexibility in conducting directed fisheries on harvestable surplus of healthy stocks, the SUS ER ceiling may increase to 13.5% in one out of five years. These ceilings are not viewed as targets, but rather as ceilings within which tribal C&S fisheries, and fisheries on abundant Nooksack/Samish Fall Chinook and other species will be prosecuted. Northern fisheries continue to account for the majority of harvest-related mortality on Nooksack early Chinook (Figure 2), and further reductions of fishery impacts in Washington waters below the CERC limits used for management in the past would not materially influence spawning escapement, while further reductions would have large impacts on tribal and non-tribal fisheries. The limited amounts of SUS harvest permitted under the CERC limits will not appreciably reduce the likelihood of survival and recovery of the Nooksack early Chinook populations, or the Puget Sound Chinook ESU, consistent with criteria C for FMEPs in the 4(d) rule.

Until escapement objectives for Nooksack early Chinook are approved by the Pacific Salmon Commission's Chinook Technical Committee (CTC), fisheries will be planned and managed such that the SUS ER on Nooksack early Chinook will not exceed the CERC levels as described above. Once CTC-approved escapement estimates are established, it will be necessary to re-visit management objectives identified in this plan.

The CERC was developed by converting the previous CERC, used through 2016 (7% SUS ER, with 9% SUS ER once every 5 years), into new base-period FRAM terms. For each year from 1995-2014, a conversion factor was calculated by dividing the new-FRAM post season estimates by the old-FRAM post season estimates. The mean conversion factor across years was 1.5, so 7% SUS ER in the old model equates to 10.5% SUS ER in the new model, and 9% SUS ER in the old model equates to 13.5% SUS ER in the new model.

Table 4. Upper Management Thresholds (UMT) and Low Abundance Thresholds (LATs) of natural origin spawners for the NF/MF and SF Nooksack early Chinook populations. The Critical Exploitation Rate Ceiling (CERC) and Exploitation Rate Ceiling (ERC) are applied to the two populations combined.

Population	ER Ceiling	UMT	LAT	Critical ER Ceiling
NF/MF	N/A	1,000	400	10.5% SUS ER; 13.5% 1 out of 5 years
SF		500	200	

Achieving hatchery rack goals for the Kendall and Skookum hatcheries are an essential component of realizing recovery goals for the Nooksack management unit. However, hatchery rack goals were not incorporated into the LATs and UMTs for each population. Instead, the co-managers will meet pre-season to discuss and agree upon appropriate hatchery rack goals to use for the upcoming season. Hatchery rack and release goals are expected to increase over the term of this plan as the status of terminal hatchery programs move towards production goals developed by the co-managers.

As hatchery production in the Nooksack watershed continues to progress, particularly for the Skookum program, the abundance of natural origin spawners is expected to grow relative to recent escapements. For the Nooksack management unit, it will be particularly important to have the ability to revisit established management objectives over the term of this plan to ensure they remain relevant in light of harvest and recovery objectives.

There have been no directed commercial fisheries on Nooksack spring Chinook in Bellingham Bay and the Nooksack River since the late 1970s. Incidental harvest of Nooksack early Chinook in fisheries directed at fall hatchery-origin Chinook in Bellingham Bay and the lower Nooksack River was reduced in the late 1980s by significantly restricting fisheries in July. In addition, release, marking and acclimation strategies on fall hatchery Chinook further reduced incidental impacts on early Chinook and reduced straying into early Chinook spawning areas. Beginning in

2008, fisheries in July were discontinued entirely. Since 2010, there have been very limited C&S fisheries in the Nooksack River from April into June.

The tribal treaty right fishery on Nooksack early Chinook in the Nooksack River is the highest priority in the tribal terminal area fishing regime. Under this plan a majority of tribal fishing impacts on early timed Chinook stocks in the Nooksack River will occur between mid-March and mid-June. These fisheries will target Kendall Creek and Skookum Creek Hatchery returns, and may utilize selective gear, to enable the release of natural-origin Chinook. These fisheries will take place in the lower river below Slater Road Bridge and in the upriver area of the mainstem located from ¼ mile downstream of the Nugent's Corner Bridge up to no higher than the lowest ¼ mile of the North Fork. A small proportion of impacts on early timed Chinook may occur between mid-June and mid-July, but only after an assessment of expected impacts to SF Chinook and steelhead during this fishing time, and a review of Chinook escapement estimates from the most recent years. This fishery is initially intended to fill a gap in knowledge on the migration characteristics of Chinook returning to the Nooksack River.

Commented [bas13]: **FROM SUSAN:** Given the declining status of SF Nooksack fish, the Skookum program is not yet established and the later run timing of SF Nooksack returns, this pattern would likely increase impacts to SF returns. Effects on the Skookum program are unclear. Why would fishing on the SF returns not appreciably reduce the likelihood of survival and recovery of the population?

Starting in 2019, a radio tag study will commence, tagging and releasing Chinook, with the intent of utilizing up to 1% ER for this research fishery, as described in Section 7 of this plan. Tissue samples will be collected from natural origin Chinook and summer run steelhead caught in this fishery and will be used to assess fishery impacts and migration timing. The projected total harvest of early Chinook by in-river tribal fisheries will be determined during preseason planning, with reference to forecasted abundance of natural-origin and hatchery-origin returns.

A limited commercial fishery targeting HOR early Chinook returning to the Lummi Bay hatchery facility will occur in Salmon Management Area 7D. This fishery will be structured to minimize interceptions and/or mortalities of NOR Chinook and will be closely monitored and sampled. Because of the location of Lummi Bay in relation to the Nooksack River, very few (if any) NORs are expected to be encountered in this fishery directed at hatchery Chinook.

Under this plan, fisheries in Bellingham Bay and the Nooksack River directed at Nooksack/Samish fall Chinook will not open prior to August 1. Subsequent fishing in the Nooksack River will occur in progressively more upstream zones to enable early Chinook stocks to clear these areas. The first week the river is open from Marine Drive Bridge to Slater Road Bridge. The following week the zone up to Hannegan Bridge is added, and the third week the zone up to Nugent's Corner (located ¼ mile up-river of Nugent's Corner Bridge) is added to those downstream. The fourth week also includes the area from ¼ mile above Nugent's Corner Bridge (RM 30.9) to a line coinciding with the Nooksack Tribe blue colored Automotive shop, approximately 1.3 miles downstream from the South Fork confluence. The uppermost 1.3 mile portion of the mainstem will also not open during the early portion of the Tribal coho management period, remaining closed prior to statistical week 39. The intent is to protect holding adult South Fork Chinook in the upper mainstem where temperatures are cooler than the South Fork.

Commented [S14]: How is this determined? ADDRESSED

Commented [S15]: Why change from 2010 which was 1.8 miles from confluence?
NED: Boundary did not change. The changes are a more accurate description of the closure area.

Commented [S16]: But the July fishery would primarily impact SF Nooksack fish, yes?

In recent years, the portions of the mainstem Nooksack from the confluence of the North and South forks to the yellow boundary marker approximately 1.3 miles downstream, and of the South Fork Nooksack from the confluence to the mouth of Wanlick Creek have been closed to all recreational fishing during much of the trout season (through September 30th) to protect holding and spawning chinook. Similar closures are expected to remain in place given the status of the Chinook population and environmental conditions likely to persist in the near future.

Data Gaps

- Evaluate and potentially modify escapement estimate methodologies to improve abundance and productivity estimates
- Improve understanding of NF/MF and SF Chinook freshwater entry and migration
- Chinook life history model
    - The Chinook life history model will identify, prioritize and estimate the temporal and spatial aspects of factors limiting recovery. The life history model would also provide survival information for forecasting. There is currently no funding for this work.
- Smolt to Adult Survival
    - Improvements in the outmigrant population estimates from the smolt trap will provide the information to calculate smolt to adult return survival estimates.
    - Combined with the Chinook life history model, the smolt to adult survival will identify freshwater and marine survival factors limiting recovery.
    - Skookum Creek Hatchery early Chinook survival
        - Metrics are being developed to evaluate this new program

From:	James Dixon - NOAA Federal
To:	jason.schaffler@muckleshoot.nsn.us
Cc:	Mike Mahovlich; Isabel Tinoco; Adicks, Kyle K (DFW); Warren, Ron R (DFW); Andy Rankis (arankis@suquamish.nsn.us); Rob Purser; Christina Iverson - NOAA Federal; Rob Jones; Susan Bishop
Subject:	NOAA comments on the Lake WA MUP and responses
Date:	Monday, July 23, 2018 5:15:08 PM
Attachments:	Lake Washington Management Unit Status Profile_Changes_comanager_070318_NOAAF comments_07-23-2018.docx Lake Washington_MUP_Questions_comanager_070318_NOAAF comments_07-23-2018.docx

Jason, All,

Please find NOAA Fisheries' comments on the latest draft of the Lake WA MUP and to the responses to NOAA's early questions, provided by the Co-managers earlier this month. We have highlighted the new comments in yellow to more easily separate them from older comments you've already reviewed.

Please forward to any recipients I may have missed.

Look forward to productive discussions on August 1st.

Thank you,

--

James Dixon
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Lake Washington Management Unit Status Profile

Component Populations

Cedar River Fall
Sammamish River Fall[1]

Geographic Distribution

The Lake Washington basin is one of the most altered and degraded basins in Washington State. Lake Washington lies within King County Washington which has over 2.0 million residents. Historically, the basin drained through the Black River into the Duwamish River. Chinook had access to the Cedar River from the confluence of the Black and Duwamish rivers upstream to Cedar Falls at RM 34.5. In 1901 Landsburg Dam was constructed at RM 21.8 and blocked access to the upper Cedar River watershed. In 1916, the Cedar River was diverted away from the Black River and into Lake Washington when the Hiram M. Chittenden Locks and Ship Canal was completed. These actions resulted in the lake elevation being lowered 9 feet and all discharge from the basin exiting through the newly constructed locks.

Cedar River

Fish passage facilities were completed at Landsburg Dam in 2003, and Chinook may now access suitable spawning areas upstream to Cedar Falls. The majority of spawning still occurs in the mainstem Cedar River upstream of RM 5 to Landsburg Dam. Chinook also spawn in two Cedar River tributaries, Rock Creek and Taylor Creek.

Sammamish River

The Sammamish River flows from Lake Sammamish into Lake Washington. In the Sammamish River, Chinook primarily spawn in Bear Creek with intermittent spawning in Little Bear Creek. Approximately 10.0 of the 12.4 miles of Bear Creek are accessible to Chinook, most spawning occurs between RM 4.3 and 8.8. Spawning occurs in the lower 3.5 miles of Cottage Lake Creek, a tributary to Bear Creek. In Little Bear Creek, there is 3.8 miles of spawning habitat. No Chinook spawning occurs in the Sammamish River mainstem due to a lack of suitable habitat in the low-gradient, heavily silted channel.

Additional spawning occurs in Issaquah Creek, which flows directly into Lake Sammamish. Spawning in Issaquah Creek occurs predominately in the reach between RM 1.0 and the Issaquah Hatchery at RM 3.2. Surplus adults are passed above the Issaquah Creek Hatchery weir to access additional spawning habitat (approximately 4-12 river miles, depending on flow), but are not part of the spawning escapement calculations in Issaquah Creek. Limited spawning occurs in the first 1.0 miles of the East Fork Issaquah Creek.

[1] TRT defined population. Co-managers believe that recent data indicates that this is not a viable population.

Life History

Adult salmonid counts are conducted at the Hiram M. Chittenden Locks from June 12 – October 2 and adult Chinook have been observed throughout this period. After a variable migration through the lakes, Chinook begin entering spawning tributaries from mid-August through early November and most spawning is complete by mid- November. The average age composition of adult natural-origin returns between 2003 and 2016 was 36% age-3, 60% age-4, and 4% age-5. The age composition is a composite between the Cedar River and Sammamish River returns due to the limited number of natural origin recruits collected in Sammamish River (average 19 per year) versus the Cedar River (average 163 per year).

Juvenile Chinook trapping occurs in both the Cedar River and Bear Creek (Kiyohara 2015). From 1998-2013, the proportion of juveniles emigrating as fry averaged 79% in the Cedar River but ranged from 34-98%. Conversely, fry emigration in Bear Creek averaged 19% and ranged from 4-56%. The remainder of emigrants were parr in both systems as no yearlings were encountered. The early emigrating fry rear in lacustrine habitat, with an unknown survival rate to smolt. Smolt emigration through the locks is protracted, beginning in May and continuing up to September when environmental (e.g. temperature and flow) conditions allow.

Hatchery Production

The first recorded plants of juvenile Chinook into the Lake Washington basin occurred in 1901, and intermittent plants continued for decades. Chinook were first released into Issaquah Creek from the Issaquah Creek Hatchery in 1936 and Portage Bay from the University of Washington (UW) Hatchery in 1950. Beginning in 1952 when standardized records began, Chinook have been periodically released into many of the tributaries in the basin, primarily from Issaquah Creek and Green River hatchery production. Hatchery stocks at both Issaquah Creek Hatchery and the UW Hatchery were both principally derived from Green River hatchery stock. Since 1994, the Issaquah hatchery has exclusively used local broodstock from Issaquah Creek.

The only current hatchery production of Chinook in the Lake Washington basin occurs at Issaquah Creek Hatchery. The University of Washington Hatchery program was discontinued after release of the 2009 brood year. Issaquah Creek Hatchery production averaged 1.7 million sub-yearling smolts for brood year 2011-2015, while the current production objective is 3.0 million sub-yearling smolts. The co-managers are continuing to evaluate options for increasing salmon productivity in Lake Washington, consistent with the joint urban watershed management strategy currently being developed by the Muckleshoot Indian Tribe and the Washington Department of Fish and Wildlife and the agreed to Hatchery and Genetic Management Plans (HGMP) for the basin. Lake Washington (and other Puget Sound) Chinook are well below the planning ranges for recovery escapement, as well as below spawner recruit levels identified as consistent with recovery. Until habitat function is restored, hatchery production will be essential to harvest opportunity in highly urbanized watersheds like Lake Washington.

Genetic Information

Commented [S1]: Same for both Cedar and North Lake tribs?

Commented [JD2R1]: Comment addressed.

Commented [S3]: What was the life history of the remainder? Looks like they are holding longer than those in the Cedar? Is this influenced by the hatchery?

Commented [JD4R3]: Comment addressed. Inclusion of some of the additional info from the MUP Questions doc, S2 response section would be informative.

Commented [JD5]: Is the production shortcoming a product of not meeting broodstock objective or a product of in-hatchery mortality issues?

A comprehensive review of the available genetic data from naturally-spawning and hatchery produced Chinook in the Lake Washington basin found no evidence to support a conclusion that the naturally-spawning aggregations of Chinook in the Lake Washington basin are anything other than a single genetic population nor are different than other Green River derived populations (Warheit and Bettles 2005; Ruckelshaus et al. 2006).

Status

The Cedar River Chinook population is managed for total natural spawners by an escapement goal that is assumed to provide protection for the Sammamish River population. Spawners have ranged from 135 to 2,247 on the Cedar River (Figure 1A) and from 182 to 2,303 in the Sammamish River (Figure 1B) basin from 1988-2016 (Figure 1; Table 1). Total spawners on the Cedar and Sammamish River declined throughout the 1990s but began a rapid increase to levels seen today. The NOR component of the Cedar River population is moderately productive compared to other Puget Sound populations. Total spawners in both systems have been higher and more variable since the early 2000s. Since 2001, the average NOR return to the Cedar River has been 938. There have been 12 complete broods produced during this time (2001-2012), 6 have observed productivities >1 and 6 have observed productivities <1. The average productivity was 1.33 recruits/spawner, but not significantly different than 1 meaning the population is stable. This would indicate that the Cedar River NOR population is at the current capacity of the habitat. NORs made up about 80% of the spawning population on the Cedar River across the time series while making up less than 20% of adults on the spawning grounds in the Sammamish River population (Figure 1C). Due to the long history of hatchery production and habitat degradation in the basin, hatchery produced Chinook are an important component of natural spawning escapement. Protecting and ensuring hatchery production meets program goals are vital in urban systems (Figure 1D).

Commented [S6]: What is the supporting information/data for this assumption?

Commented [JD7R6]: Partially addressed. Should add the language regarding the rational for this statement from the MUP Questions doc, section responding to S3. See additional comments in the MUP Questions doc, section responding to S3.

Commented [S8]: Include a table of the escapement information in Figure 1? What does that tell you about the status of the NOR component for the Cedar (covered for the Sammamish) consistent with criteria B of the 4d Rule.

Commented [JD9R8]: Mostly addressed.

If the average NOR return to the Cedar has been 938, what would the proposed harvest mgmt. mean for this average? Would we expect an increase in the NOR return to the Cedar? From the recruitment modeling below, it looks like the updated SMSY (282) would only be expected to only produce 853 total NORs, correct?

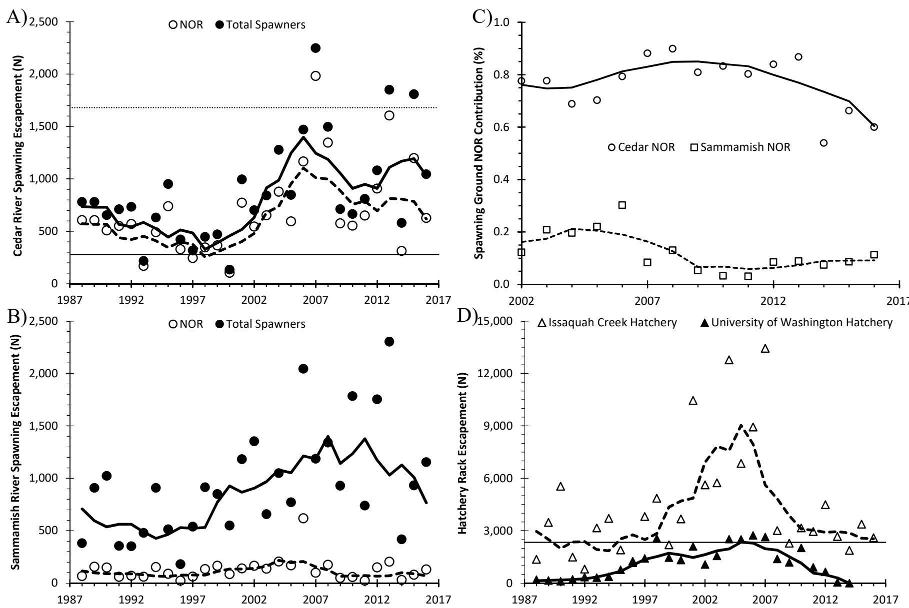

Figure 1. Observed NOR (open circle) and total (filled circle) escapement on the Cedar River (panel A) and Sammamish River (panel B) from 1988-2016. A 5-year running geometric mean for total escapement (solid line) and NOR escapement (dashed line) is fit to each data series. The Cedar River interim escapement goal of 1,680 spawners (lite dashed line) is contrasted with the MSY escapement goal of 280 (108-389 95%CI) natural spawners (lite solid line) which is based on current habitat conditions. There is no historic or MSY based escapement goal on the Sammamish River population. Observed NOR Chinook contribution (panel C) to the Cedar River (open circle) and Sammamish River (open square) spawning grounds from 2002-2016 with a 5-year running geometric mean. Observed hatchery rack escapement (panel D) at Issaquah Creek Hatchery (open triangle) from 1988-2014 and University of Washington Hatchery (closed triangle) from 1988-2014 is shown with a 5-year running geometric mean. The hatchery escapement goal of 2,337 adult Chinook needed to make current program goals at Issaquah Creek Hatchery is shown (lite solid line).

Commented [JD10]: 282?

Table 1. Natural origin recruits from the Cedar River and Sammamish River populations and hatchery origin recruits from Issaquah Creek hatchery (ICH) and University of Washington hatchery (UWH) that escaped pre-terminal and terminal fisheries. Recruits/Spawner (R/S) includes all adult NORs caught in pre-terminal and terminal fisheries or counted on the spawning grounds in the Cedar or Sammamish rivers. Pre-terminal mortalities from the 1988-2009 brood years are based on post season FRAM validations while data for 2010-2013 brood years includes estimates from pre-season FRAM.

Return Year	Cedar	Sammamish	ICH	UWH	R/S C[a]	R/S S[a]
1988	781	381	1,359	207	1.69	0.43
1989	780	909	3,473	148	1.10	0.17
1990	655	1,023	5,541	106	1.20	0.18
1991	710	356	1,489	223	1.53	0.47
1992	734	353	796	346	0.84	0.20
1993	218	479	3,159	321	1.70	0.17
1994	632	909	3,703	360	0.86	0.17
1995	952	513	1,907	767	0.58	0.34
1996	423	182	1,246	1,167	0.72	0.81
1997	317	540	3,815	1,417	1.91	0.38
1998	447	988	4,855	2,560	2.58	0.28
1999	470	998	2,189	1,461	1.33	0.23
2000	135	642	3,676	1,326	9.99	0.42
2001	995	1,690	10,451	2,094	0.65	0.20
2002	702	1,478	5,620	1,067	1.94	0.54
2003	842	650	5,742	1,563	2.13	0.43
2004	1,277	1,012	12,771	2,520	2.07	0.10
2005	847	866	6,852	2,513	0.94	0.04
2006	1,470	2,223	8,934	2,738	0.46	0.02
2007	2,247	1,300	13,431	2,637	0.61	0.09
2008	1,497	1,301	3,007	1,386	0.23	0.24
2009	712	924	2,280	1,187	4.22	0.93
2010	665	1,831	3,156	2,014	0.66	0.72
2011	810	733	2,954	906	1.49	0.38
2012	1,082	2,034	4,492	651	1.09	0.16
2013	1,850	2,333	2,670	46	0.83	0.31
2014	580	482	1,872	0	--	--
2015	1,807	988	3,373	NA	--	--
2016	1,045	1,247	2,596	NA	--	--
2017	2,048	1,673	3,321	NA	--	--

a The 1988 R/S estimate does not include Age-3 pre-terminal or terminal freshwater sport mortalities and the 2013 R/S estimate does not include recruits from the Age-5 portion of the cohort.

An interim escapement goal (i.e. Upper Management Threshold) for the Cedar River was set in 1993 at 1,200 Chinook for the river downstream of Landsburg Dam based on average escapements observed from 1965-1969. This value was updated to 1,680 based on a conversion associated with changing the escapement methodology from area under the curve to a redd based methodology. In 2003, a new fish ladder allowed Chinook to pass above Landsburg Dam, increasing the complexity in determining an appropriate escapement goal for the entire sub-basin. Chinook passed above the dam have counted toward the interim escapement goal and is reflected in the lower productivity associated with current habitat conditions based on an MSY approach. Update of the Fishery Regulation Assessment Model (FRAM) base period to brood years 2005-2008 necessitated updating natural and hatchery escapements back to 1988 for calibration. These data were used to fit a Beverton-Holt stock recruit curve (Beverton and Holt

1957) to brood years 1988-2013 (Figure 2). For this model, a=0.1092 and b=0.0007848 which resulted in a spawning stock size at equilibrium of 1,135 and a theoretical maximum recruitment of 1,274. The spawning stock size MSY is 282 (139-384 95%CI) which is expected to result in 853 (796-924 95%CI) recruits. Due to uncertainty in stock dynamics at population sizes this small and the potential for negative genetic impacts, an escapement goal of 500 spawning adults will be the management goal.

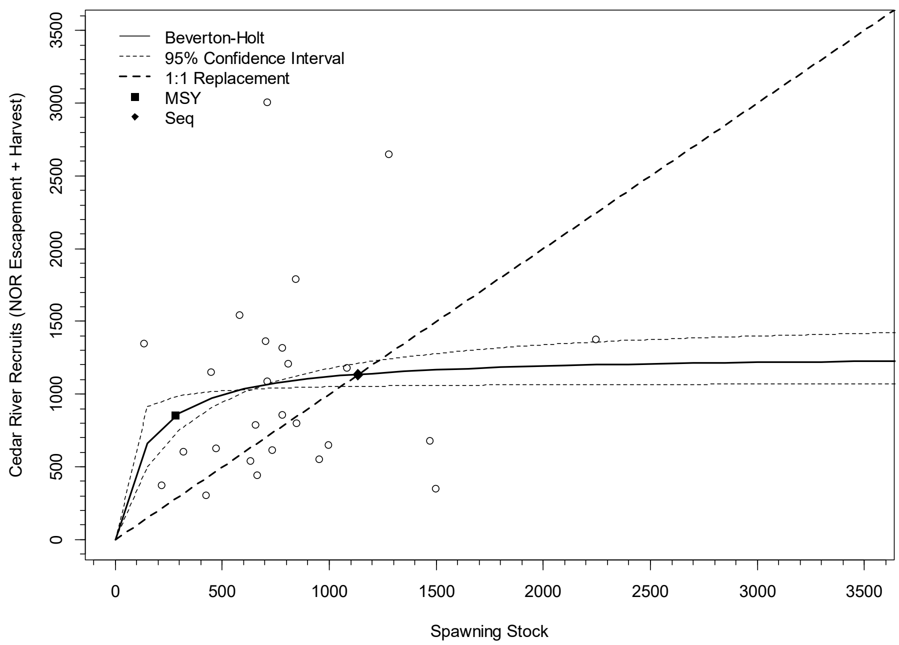

Figure 2. Beverton-Holt stock-recruit curve for Cedar River Chinook based on brood years 1989-2009. The spawning stock size at MSY is 282 (139-384 95%CI) which results in 853 (796-924 95%CI) recruits. The spawning stock size at equilibrium is 1,135 (1,027-1,224 95%CI) Chinook.

Uncertainty exists about the historical presence of a Chinook population in the Sammamish River sub-basin. The TRT concluded that one did exist (Ruckelshaus et al. 2006), although there is uncertainty about this conclusion due to a lack of documentation that Chinook were consistently produced in the Sammamish River sub-basin prior to the establishment of hatchery programs (RITT 2008).

No biologically based escapement goal has been or can be established for the Sammamish River Chinook population. Protection of the Cedar River population was assumed to provide sufficient protection for the Sammamish River population. As previously alluded to, update of the FRAM

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Commented [S13]: What is the expected outcome re: Sammamish with the new management framework?

Commented [JD14R13]: Comment addressed.

base period necessitated reconstruction of the data necessary to fit a Beverton-Holt stock recruit curve (Beverton and Holt 1957) to brood years 1989-2009 (Figure 3). For this model, a=1.0505 and b=0.004099 which did not result in an equilibrium stock size or spawning stock size at MSY. Recruits to the Sammamish River population never reached replacement. Based on current habitat conditions, the Sammamish River population is not viable and should not be included in the 22 extant independent populations of the Puget Sound Chinook evolutionary significant unit.

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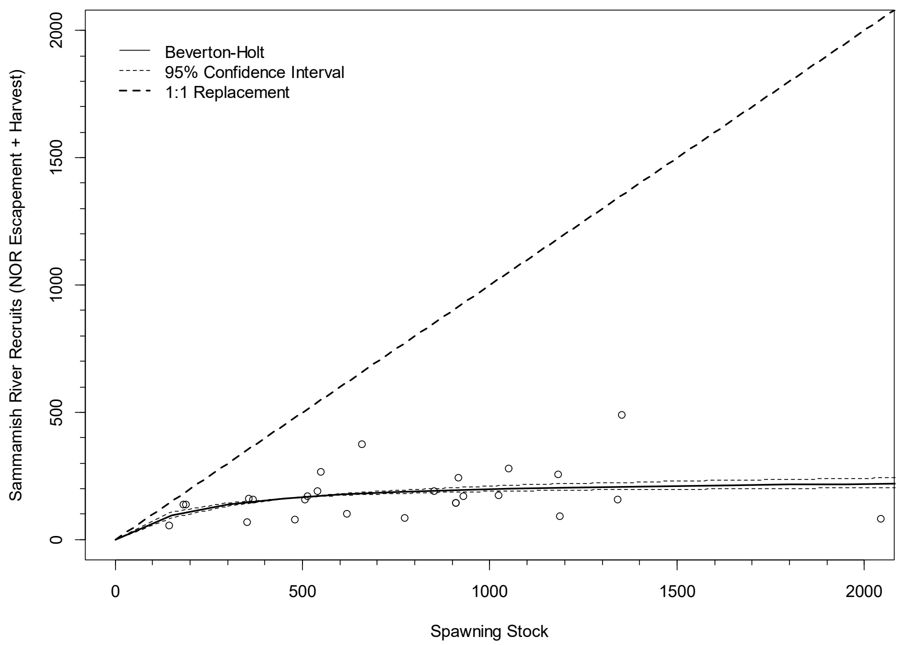

Figure 3. Beverton-Holt stock-recruit curve for Sammamish River Chinook based on brood years 1988-2013. There is no MSY for this population because recruits never reach replacement under current habitat conditions.

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Recruits per spawner have been highly variable in the Cedar River population while the Sammamish River population has been consistent and poor (Figure 4). The 2000 brood year was the most productive brood with 10.0 recruits per spawner produced in the Cedar River. No brood year was greater than 0.7 recruits per spawner in the Sammamish River. The 2005-2008 brood years were the longest set of years where recruits per spawner fell below 1.0 in the Cedar River. Escapement during these years averaged 1,515, which is well above the 812 average in the Cedar River across the available years. Following the streak of poor recruitment years, recruits per spawner was 4.2 for the 2009 brood year and was produced by a stock size of 712. There is a weak correlation between Cedar River and Green River (r = 0.39) Chinook productivity. Within the Lake Washington basin, Cedar River and Sammamish River Chinook productivity is poorly

Commented [S15]: Please include a table with the productivity information

Commented [JD16R15]: Comment addressed.

Commented [S17]: ?? text missing here? So data indicating escapements at this level reached system capacity or any other contributing cause e.g., marine survival?

Commented [JD18R17]: Comment addressed. Please see response in MUP Question doc, response to S8.

correlated (r = 0.25). The average productivity for Cedar River Chinook across all brood years is 1.8 recruits per spawner whereas 3.0 recruits per spawner is the current productivity at MSY.

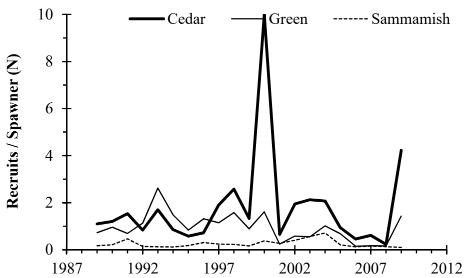

Figure 4. Trend in recruits per spawner for Cedar River (bold line), Green River (solid line), and Sammamish River (dashed line) management unit natural origin recruits from completed brood years (1989-2009).

Harvest Distribution and Exploitation Rate Trends

Lake Washington Chinook are part of the Mid-South Puget Sound fall fingerling FRAM stock aggregate. The FRAM base period for this stock aggregate is based upon coded wire tagged indicator groups from Issaquah Creek, Soos Creek, Voights Creek, and Grovers Creek hatcheries from the 2005-2008 brood years. The Cedar River population is the managed natural component of Lake Washington Chinook, which is modeled through terminal fisheries within the Terminal Area Management Module (TAMM).

As estimated by post-season FRAM/TAMM for Cedar River Chinook, Northern (British Columbia and Alaska) fisheries had a combined 13% average exploitation rate, the pre-terminal southern US (PT SUS) exploitation rate averaged 9% and the terminal exploitation rate averaged 5% from 2010-2014. Exploitation rates generally declined through the 1990s (Figure 5A). Beginning in the early 2000s northern exploitation rates began to increase to levels near where they were in the early 1990s. Terminal exploitation rates have remained low because of no directed terminal harvest. TAMM is not configured to estimate exploitation rates for the Sammamish River population.

Commented [JD19]: The avg total rate here is 27%. The only rate proposed here that produces a lower total ER is the LAT threshold?

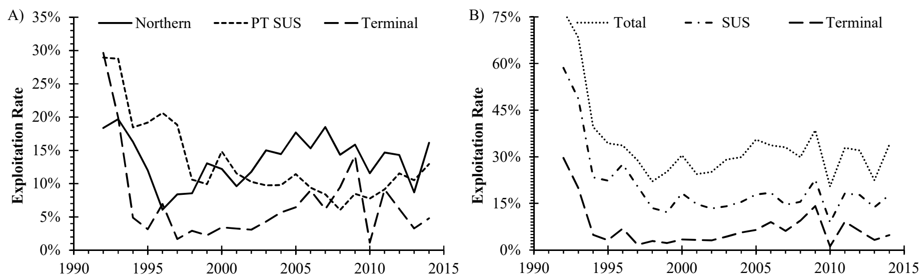

Figure 5. Trend in the A) northern (solid line), pre-terminal southern US (short dashed line), and terminal (long dashed line) exploitation rates and B) Total (dotted line), Southern US (dashed and dotted line), and terminal (long dashed line) exploitation rates on Cedar River natural origin Chinook from 1992-2014, based on the new FRAM base period (version 8/16/17).

Management Objectives

Lake Washington Chinook stocks will continue to be managed for total natural escapement that includes both natural and hatchery origin adults on the Cedar River spawning grounds; as well as hatchery rack escapement at Issaquah Creek Hatchery needed to achieve program goals[1]. Cedar River escapement goals will be consistent with escapement according to MSY under current habitat conditions. The Upper Management Threshold (UMT) will be set at a conservative trigger that aims to prevent demographic instability. Southern U.S. fisheries will be planned in the pre-season according to a tiered management regime that accounts for uncertainties in the pre-season forecast. Terminal directed fisheries will be planned in the pre-season when terminal run size meets the threshold abundance but will only go forward when in-season run size estimates project that natural and hatchery escapement goals will be met. The Low Abundance Threshold (LAT) is set at 40% of the escapement goal or no lower than 200 spawners to maintain genetic health.

MSY associated with current habitat condition is 282 (139-384 95%CI) naturally spawning adult Chinook, less than 25% of the 1,680 that were managed for under previous plans. The new UMT for Cedar River spawning escapement is 500 adults. This trigger will allow a pre-terminal exploitation rate of up to 12%. If both the Puyallup River MU and the Lake Washington MU have met their respective UMTs and the Green River MU meets its upper trigger for a 13% pre-terminal ER, then all Mid-Puget Sound aggregate MUs will be managed for a 13% pre-terminal SUS ER (Table 1).

Hatchery escapement will be managed for an approximate 2,337 adult escapement goal (Figure 1D); this may be a constraining factor for planning Puget Sound (sport and terminal) fisheries. Annual variations in abundance of hatchery and natural Chinook may require additional in-season terminal fishery management to ensure both the hatchery and Cedar River escapement

[1] However, among pre-terminal entities, the State has agreed to take responsibility for meeting hatchery escapement objectives.

Commented [S20]: What is the basis for this rule of 40%?

Commented [JD21R20]: See comment in MUP Questions doc, section responding to S9.

Commented [S22]: What is the MSY ER associated with this relationship?

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Commented [JD25R24]: Comment addressed.

Commented [JD26]: See earlier comment regarding the reason that the Issaquah hatchery has not, on average met the production objective. If the shortage is broodstock related, does this number build in the necessary buffer?

goals are met. The LAT, based on a calculation of 40% of MSY is 112 adult Chinook on the spawning grounds, however, the co-managers agree that an LAT of 200 adults to maintain genetic health is appropriate (McElhaney et al. 2000). The lowest observed natural spawning escapement on the Cedar River was 135 in 2000, which produced over 1,300 recruits from that cohort.

Consistent with Cedar River Chinook exceeding the UMT, the PT SUS fisheries will be planned not to exceed a 12% (13% if criteria in the Green River and Puyallup River MU are met; Table 2) exploitation rate, and directed Chinook fisheries will be planned in the terminal area (10F/Lake Washington Ship Canal, 10G/North Lake Washington, 10C/South Lake Washington, and 10D/Lake Sammamish). Combined terminal fisheries will be designed to achieve spawning and hatchery escapement at or above management objectives.

Table 2. Management thresholds and corresponding exploitation rate ceilings for stock components of the Mid-South Puget Sound FRAM stock aggregate. The MMT is triggered when natural spawning escapement is forecasted between the LAT and the UMT. In pre-terminal fisheries the aggregate is managed for its weakest component MU.

Management Unit	MSY	LAT (SUS)	MMT (SUS)	UMT – trigger 1 (PT SUS)	UMT – trigger 2 (PT SUS)
Lake Washington[1]	282	200 (12%)	18%	500 (12%)	500 (13%)
Green River	2,003	805 (12%)	18%	3,800 (12%)	6,000 (13%)
Puyallup River	797	319 (15%)	30%	1,300 (12%)	1,300 (13%)

[1] The Cedar River is the natural managed component of the Lake Washington MU

If FRAM/TAMM pre-season model output of natural spawning escapement falls between the UMT and LAT, the SUS fisheries will implement the moderate management threshold (MMT) where SUS fisheries will not exceed 18% (pre-terminal + terminal) ER. If FRAM/TAMM pre-season model output of natural spawning escapement falls below the LAT, a critical exploitation rate ceiling of 12% will be implemented for SUS fisheries (pre-terminal + terminal). Under this approach, terminal fisheries planned in the pre-season at the MMT or LAT will only have incidental impacts to Chinook as fisheries will be directed at other salmonids. Due to the use of in-season monitoring and management in the terminal area, abundance may be observed that is sufficiently greater than UMT such that a limited directed terminal fishery could be prosecuted which would result in higher exploitation rates in the terminal area than modeled in the pre-season but would result in meeting both natural spawning and hatchery escapement goals. The lowest SUS ER observed was 8.9% in 2010 and is the only time since 1992 the SUS ER has been below 12% according to post-season validation runs.

During the pre-season process, Puget Sound (sport and terminal) fisheries will be planned to meet the broodstock needs at Isssaquah Creek Hatchery. Even when expected abundance of Chinook returning to the Cedar River to spawn naturally is above the UMT, it is possible that additional fishery actions may be necessary to ensure broodstock needs at the hatchery are met. Broodstock needs at Issaquah Creek Hatchery will be calculated based on pre-spawn mortality in the adult holding ponds, fecundity, male to female ratio and egg to smolt survival rates, each of which the co-managers will discuss and agree upon during the pre-season planning process.

Commented [JD27]: See new comment in MUP Question doc, related to the response to S9.

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Commented [S28]: From the information presented, escapements have been above 500 pretty much every year recently so directed fisheries would be likely. How would the directed fishery occur? How would it be implemented to allow testing the habitat rather than harvesting down to the goal? What is the anticipated total ER under directed fisheries?

NOAAF proxy FRAM RER for the population is 19%. If the total ER were say 30% under a directed fishing scenario, modelling indicates a substantial reduction in the probability of rebuilding for the Cedar population.

Commented [JD29R28]: Not fully addressed.

Commented [S30]: What is the basis for this rate and rationale for why it is higher than the 2010 RMP? Need to show that this rate would not impede growth back above LAT of NOR component.

Commented [JD31R30]: See new comment in MUP Questions, section responding to S13.

Further in-season actions consistent with the agreed to HGMP will guide actions that may be required to meet natural spawning and hatchery goals as additional information becomes available.

There is some uncertainty in annual ERs from northern fisheries (British Columbia and Alaska) on Lake Washington Chinook, but impact of those fisheries is unlikely to decrease significantly relative to recent years (Figure 5A). SUS fisheries will be constrained to the levels described above when natural spawning abundance is expected to be below the management objectives. Those constraints, coupled with the agreed to hatchery objectives, will ensure that fisheries do not reduce the likelihood of recovery of Cedar River Chinook, while allowing limited fisheries to continue in years when natural spawning abundance falls below the management objectives.

While directed terminal fisheries are planned when the FRAM/TAMM model output of terminal run size exceeds the spawning and hatchery objectives, terminal fisheries will only proceed when in-season information corroborates pre-season expectations. In the Lake Washington basin, in-season information from adult salmonid counts made at the Hiram M. Chittenden Locks is used. This methodology will be used to project harvestable surplus in-season to allow terminal fisheries when terminal run sizes are projected to exceed escapement objectives for the Cedar River spawning grounds and Issaquah Creek Hatchery, or to constrain those fisheries when escapements do not meet management objectives. Regardless of pre-season forecasts, in-season updates will be used to manage terminal area fisheries which may serve to open or close terminal fisheries. In the case where no directed terminal fisheries were modeled in the pre-season (i.e. management at the MMT or LAT), Chinook directed fisheries may be implemented in terminal areas by agreement of the terminal area co-managers (Muckleshoot Indian Tribe, Suquamish Indian Tribe, and Washington Department of Fish and Wildlife) when data indicate a harvestable surplus of both Cedar River natural spawners and Issaquah Creek Hatchery broodstock. In those instances, the total SUS ER may increase over pre-season expectations; but MSY and hatchery escapement goals will be met. It is understood that this will increase the total SUS ER over pre-season expectations. The in-season update method and terminal area fisheries that are based on this update will be agreed to by the terminal area co-managers prior to implementation. Any directed Chinook fisheries in the terminal area will be designed to result in spawning escapements that meet or exceed the Cedar River Chinook and Issaquah Creek Hatchery escapement objectives, 500 and approximately 2,337 respectively. As noted previously, hatchery escapement needs will be reviewed, updated, and agreed to annually by the co-managers and available during the pre-season planning process.

Commented [S32]: How does this framework allow abundance to vary to continue to test the productivity and capacity of the habitat, particularly as spawners continue to take advantage of the habitat in the upper Cedar watershed? As mentioned previously there is quite a bit of uncertainty in the information.

The recovery goal is 2,000 NOR at MSY so need to show how this framework will allow growth of NOR component to that level as habitat allows.

What is the anticipated impact to north LWA tribs?

Commented [JD33R32]: Partially addressed. Clarification request in MUP Question doc, section responding to S14.

Commented [S34]: How will you project abundance for Cedar and North Lake abundance separately?

Commented [JD35R34]: Comment addressed.

Commented [S36]: Is this the ISU model used now or is something additional in the works? What it its performance?

Commented [JD37R36]: Partially addressed, see additional comment in MUP Question doc, response to S16.

Data Gaps and Information Needs

Table 2. Data gaps in Lake Washington Chinook stock assessment and harvest management, and research required to address those data needs.

Data gap	Research needed
Estimates of return per spawner and egg to emigrant productivity	Juvenile emigrant trapping in Issaquah Creek.
Updated escapement estimates for Sammamish population	Stream life estimates for AUC validation in Bear/Cottage Creek, and assessment of fall-back rate from fish passed above the Issaquah Hatchery weir
Uncertainty in run size estimates at the Chittenden Locks relative to spawning ground surveys	Independent assessment of Chinook abundance and migration through large lock chamber
Temperature impacts on adult Chinook and eggs	Quantify pre-spawning mortality and sub-lethal effects. These include the viability and maturation rate of eggs exposed to high temperatures in vivo.
Outmigration survival by stock	Estimate mortality associated with juvenile passage at the Chittenden Locks, piscine and avian predation in the lake and canal, and other mortality factors.
Invasive piscivores	The diet composition of invasive piscivores has been characterized many times but the impact cannot be modeled until population sizes of piscivores are known.
Pre-terminal in-season update models	In partnership with terminal and pre-terminal Tribes and State, examine relevant fishery dependent or independent data to develop an in-season update model for pre-terminal SUS fisheries.
Refinements to terminal in-season runsize update model.	Develop methodology to estimate Cedar River NOR and Issaquah Hatchery Chinook in the Lake Washington terminal run.
Stock specific exploitation rates	The Lake Washington stock is a component of the Mid-South Puget Sound fall fingerling release group in FRAM. Each of the component stocks should be managed separately to better assess population level impacts.

The data gaps described above assume that the current annual monitoring in place will continue. This includes spawner surveys in the Cedar River, Bear and Issaquah creeks, including carcass sampling, outmigration estimation in the Cedar River and Bear Creek, hatchery sampling and Locks count estimation.

Lake Washington MUP Questions

S1: Same for both Cedar and North Lake tribs?

This is a composite age structure for the Sammamish River and Cedar River populations. Over the previous 10 years, an average of 19 unmarked carcasses are collected annually in the Sammamish River basin. On the Cedar River, an average of 163 unmarked carcasses are collected over the previous 10 year period.

S2: What was the life history of the remainder? Looks like they are holding longer than those in the Cedar? Is this influenced by the hatchery?

Fry make up 19% of emigrants and parr/smolt emigrants make up the remaining 81% of the juvenile Chinook indexed by the Bear Creek screw trap. This ratio of fry to parr/smolts is very different than on the Cedar River (79% fry and 21% parr/smolt). There is no information on egg to fry survival in either basin to be able to determine differences among populations. Chinook smolt releases from Issaquah Creek Hatchery are mass marked at a high rate and would not impact smolt estimates in the Bear Creek screw trap.

S3: What is the supporting information/data for this assumption?

The 2010 resource management plan stated "Management objectives for the Cedar population will also protect the Sammamish population. Cedar and Sammamish abundances are highly correlated." Protecting the Cedar River population would protect the Sammamish River population if productivities were similar or lower in the Cedar River population. This is not the case with the analysis of new data in this plan. All ocean, Puget Sound, and terminal fisheries could be closed and the NOR component of the Sammamish River population will not increase. The population spawning in the Sammamish River is primarily composed of hatchery origin recruits which typically produce fewer than 200 natural origin recruits, even at spawning abundances exceeding 1,000. The Sammamish River population is not viable and should not be included in the 22 extant independent populations of the PS Chinook ESU.

Commented [JD1]: So, the plan has moved from in 2010 stating (my summaries) that "the controls on the Cedar harvest should protect the Sammamish" to "No controls, anywhere, will have any effect on the status of the Sammamish"? It seems that the 2010 logic would still hold and at least provide a reference for the level of potential conservation the fisheries provide.

S4: Include a table of the escapement information in Figure 1? What does that tell you about the status of the NOR component for the Cedar (covered for the Sammamish) consistent with criteria B of the 4d Rule.

Table 1. Natural origin recruits from the Cedar River and Sammamish River populations and hatchery origin recruits from Issaquah Creek hatchery (ICH) and University of Washington hatchery (UWH) that escaped pre-terminal and terminal fisheries. Recruits/Spawner (R/S) includes all adult NORs caught in pre-terminal and terminal fisheries or counted on the spawning grounds in the Cedar or Sammamish rivers. Pre-terminal mortalities from the 1988-2009 brood years are based on post season FRAM validations while data for 2010-2013 brood years includes estimates from pre-season FRAM.

Return Year	Cedar	Sammamish	ICH	UWH	R/S C[a]	R/S S[a]
1988	781	381	1,359	207	1.69	0.43
1989	780	909	3,473	148	1.10	0.17

1990	655	1,023	5,541	106	1.20	0.18
1991	710	356	1,489	223	1.53	0.47
1992	734	353	796	346	0.84	0.20
1993	218	479	3,159	321	1.70	0.17
1994	632	909	3,703	360	0.86	0.17
1995	952	513	1,907	767	0.58	0.34
1996	423	182	1,246	1,167	0.72	0.81
1997	317	540	3,815	1,417	1.91	0.38
1998	447	988	4,855	2,560	2.58	0.28
1999	470	998	2,189	1,461	1.33	0.23
2000	135	642	3,676	1,326	9.99	0.42
2001	995	1,690	10,451	2,094	0.65	0.20
2002	702	1,478	5,620	1,067	1.94	0.54
2003	842	650	5,742	1,563	2.13	0.43
2004	1,277	1,012	12,771	2,520	2.07	0.10
2005	847	866	6,852	2,513	0.94	0.04
2006	1,470	2,223	8,934	2,738	0.46	0.02
2007	2,247	1,300	13,431	2,637	0.61	0.09
2008	1,497	1,301	3,007	1,386	0.23	0.24
2009	712	924	2,280	1,187	4.22	0.93
2010	665	1,831	3,156	2,014	0.66	0.72
2011	810	733	2,954	906	1.49	0.38
2012	1,082	2,034	4,492	651	1.09	0.16
2013	1,850	2,333	2,670	46	0.83	0.31
2014	580	482	1,872	0	--	--
2015	1,807	988	3,373	NA	--	--
2016	1,045	1,247	2,596	NA	--	--
2017	2,048	1,673	3,321	NA	--	--

a The 1988 R/S estimate does not include Age-3 pre-terminal or terminal freshwater sport mortalities and the 2013 R/S estimate does not include recruits from the Age-5 portion of the cohort.

The NOR component of the Cedar River population is moderately productive compared to other Puget Sound populations. This population would still be "critical" because the planning range for abundances is stated as 8,200-13,000 (NOAA 2006). Since 2001, the average NOR return to the Cedar River has been 938. There have been 12 complete broods produced during this time (2001-2012), 6 have observed productivities >1 and 6 have observed productivities <1. The average productivity was 1.33 recruits/spawner, but not significantly different than 1 meaning the population is stable. This would indicate that the Cedar River NOR population is at the current capacity of the habitat.

Commented [JD2]: "Critical" in the 4(d) Rule criteria is a reference for very low abundances, on the level of demographic risk and or QET. In the MUP you reference the 200 and 500 fish abundances of LAT and LAT-MMT as providing the function of protecting against genetic risk, i.e., protecting effective population levels. These could provide a reference to compare the current NOR spawner abundances and the likely abundances of the proposal against.

S5: Figure 1 indicates stable escapement at approximately 1,000 which is higher that I would expect if the MSY level was about 300. Do you see any density dependence reflected in the juvenile trapping data?

MSY is function of spawners and their recruits over the lifetime of the brood. Even though total spawners has been relatively constant (similar to that observed in the White River), there are broods with poor survival (2000, 2005, and 2009) from the most recent years. Broods from 2002 to the present seem to be more productive than broods from earlier years. As data are added and the older information is eliminated, MSY will be expected to increase.

Anderson et al. (In Press) has recently completed an analysis that demonstrated strong density dependence among juveniles in the Green River. A similar analysis has not been conducted for the Cedar River population but would be a valuable exercise.

Commented [JD3]: I believe this responds to Susan's original question. Has there been any work done looking at the juvenile Chinook production estimates, from the Cedar smolt trap, and the spawning abundances? Like the work done in the Green, it could certainly inform the density mechanism in your recruitment model and further support the resulting SMSY objective.

S6: What is the expected outcome re: Sammamish with the new management framework?

Based on the results of the stock-recruit modeling, there is not a management strategy available that will produce increases in the NOR component of the Sammamish River population. Under the new management framework, the co-managers expect similar total escapements to the Sammamish River spawning grounds with a similar ratio of HOR and NOR recruits as under previous plans.

S7: Please include a table with the productivity information.

Table 1 includes R/S for the Cedar River and Sammamish River populations.

S8: ?? text missing here? So data indicating escapements at this level reached system capacity or any other contributing cause e.g., marine survival?

This sentence should have read "which is well above the 812 average in the Cedar River across the available years." Data here indicate that escapements well above 1,000 spawners is over system capacity and could be due to freshwater or marine conditions.

Commented [JD4]: Please include in MUP section.

S9: What is the basis for this rule of 40%?

This is a built in rebuilding plan. If R/S is 2.5 (generally accepted as fully functioning habitat), and spawners were to fall to 40% of MSY, the population could be rebuilt in one complete brood cycle. This is designed to increase the probability of recovery in the MU by preventing dramatic declines in NOR. When combined with proposed ERs at this conservative LAT, we expect to maintain growth of the MU that tracks habitat recovery.

Commented [JD5]: The Cedar productivity is avg around 1.0 R/S. How does that change the % of MSY that would be necessary to maintain the 1 generation rebuilding rate? Shouldn't it be a higher % if the R/S is lower than the theoretical 2.5?

S10: What is the MSY ER associated with this relationship?

If this population were managed at the current MSY, 282 adult Chinook on the spawning grounds, we would expect 853 recruits over the lifetime of the cohort. There are 571 adults available for harvest which translates into a 66.9% total ER. Managing this population at 500 adult Chinook on the spawning grounds will produce 997 recruits over the lifetime of the cohort. Under this scenario, there are 497 adults available for harvest which translates into a 49.8% total ER.

Commented [JD6]: Is the proposal to manage the escapement to 282 or to 500, at a total ER% of 18% and 49.8%, respectively? Below 282, it would be a total ER of 25%? For reference the 2010-2014 avg was 27% TER.

S11: I don't understand the tie here and relevance to LWA MU. The previous sentence indicated the LWA data would allow for a 12% PT SUS rate. This says 13% based on data for other MUs which is higher.

Currently pre-terminal impacts for the Puyallup River MU, Green River MU, and Lake Washington MU are modeled together as an aggregate. This means that the status of the lowest MU will be applied to all other MUs. The Green River MU appears to have the most stochasticity associated with recruitment and as such will be the most likely to constrain pre-terminal fisheries for the mid-Puget Sound aggregate.

S12: From the information presented, escapements have been above 500 pretty much every year recently so directed fisheries would be likely. How would the directed fishery occur? How would it be implemented to allow testing the habitat rather than harvesting down to the goal? What is the anticipated total ER under directed fisheries?
NOAAF proxy FRAM RER for the population is 19%. If the total ER were say 30% under a directed fishing scenario, modelling indicates a substantial reduction in the probability of rebuilding for the Cedar population.

Spawning escapements have been above 500 since 2000 when total escapement in the Cedar River fell to 135 spawners. The co-managers are working on an urban salmon strategy that will increase hatchery production and potentially survival of both hatchery and natural smolts in the Lake Washington basin. There is optimism that a combination of research and increased production in the Lake Washington MU will result in terminal fisheries. Currently a lack of hatchery recruits prevents any directed terminal fisheries, a trend that is expected to continue for at least the next 5 years (a similar time frame was used to understand additional production from Palmer in the Green River MU). We expect to add at least 5 additional complete broods to the stock-recruit relationship in the Lake Washington MU which will continue to improve our understanding of stock dynamics and system capacity.

The NOAA RER proxy for the Cedar River population (Lake Washington managed component) appears to be the Upper Sauk population. This is a spring timed population that bears no similarities to the Lake Washington populations.

Based on the current productivity of the Cedar River population, managing for a ~50% total ER will not reduce the probability of rebuilding. The currently proposed management framework will result in a population that will track habitat recovery in the Cedar River.

Commented [JD7]: This is the ER% associated with the 500 NOR spawner Cedar goal?

S13: What is the basis for this rate and rationale for why it is higher than the 2010 RMP? Need to show that this rate would not impede growth back above LAT of NOR component.

The co-managers agreed on a rate that would provide protection for each component of the mid-Puget Sound aggregate. The 2010 Plan was for a PTSUS rate of 10%, plus a terminal minimum fishing regime. This plan is for 12% SUS which includes both terminal and pre-terminal fisheries. Developing a fishing for the Mid-Puget Sound aggregate at 12% SUS will severly constrain the co-managers agreed to fishing package by limiting impacts to other species throughout much of Puget Sound.

Commented [JD8]: Are you saying that, given the inclusion of a "terminal minimum fishing regime" in the last RMP, the proposed 12% total SUS limit is equivalently conservative? Looks like the rate avg ~14% total SUS, based on the rates stated in the MUP.

S14: How does this framework allow abundance to vary to continue to test the productivity and capacity of the habitat, particularly as spawners continue to take advantage of the habitat in the upper Cedar watershed? As mentioned previously there is quite a bit of uncertainty in the information. The recovery goal is 2,000 NOR at MSY so need to show how this framework will allow growth of NOR component to that level as habitat allows. What is the anticipated impact to north LWA tribs?

Total spawners in the Cedar River basin have been relatively constant since the early 2000s. Under the 2010 Chinook Harvest Plan the Cedar River was managed for 1,680 total spawners which was a translation from an escapement goal of 1,200 total spawners. The change was based on moving from a redd based escapement goal from an AUC based escapement goal. The 2,000 goal appears to be the planning target abundance under a high productivity scenario (NOAA 2006). The available habitat in the Cedar River does not support an average productivity of 3.1 R/S as assumed under high productivity.

Commented [JD9]: Current avg productivity in 1.8 and 3.0 at MSY.

The stock-recruit modeling in the new management unit profile indicates that maximum sustainable yield is substantially lower. Based on current habitat capacity MSY is 282 adult spawners. However, this value is sufficiently low that a small mistake in forecast could result in an escapement that falls below population sizes where genetic effects become sufficiently detrimental to cause negative population level impacts (McElhaney et al. 2000). Therefore, we have chosen a "buffered" MSY escapement level of 500. This value is large enough to prevent negative genetic impacts.

Commented [JD10]: This objective is for NOR spawners, correct?

We do not expect directed terminal fisheries in the Lake Washington basin during at least the next 5 years due to constraints at Issaquah Creek Hatchery. This will result in at least 5 additional broods that will test the habitat in the Cedar River and continue to allow us to evaluate the productivity of this watershed.

Examining the stock-recruit relationship with just the brood years since 2000 when passage at Landsburg Dam was opened, MSY does not substantially change. We would still be at a "buffered" 500 escapement goal.

S15: How will you project abundance for Cedar and North Lake abundance separately?

The ISU is currently configured to project total adult abundance which is split based on pre-season forecasts or historical splits. This model could be configured to project Cedar/Sammamish spawning abundance and Issaquah Creek hatchery returns separately. This change would only require a few lines of additional code to complete.

S16: Is this the ISU model used now or is something additional in the works? What it its performance?

Commented [JD11]: What has the post-season performance looked like relative to prediction.

This ISU model has been used for the past 3 years in its current configuration. The ISU is able to project escapements by the first week of August when less than 25% of the run has migrated through the Ballard Locks.

From:	James Dixon - NOAA Federal
To:	jason.schaffler@muckleshoot.nsn.us
Cc:	Mike Mahovlich; Isabel Tinoco; Adicks, Kyle K (DFW); Warren, Ron R (DFW); Andy Rankis (arankis@suquamish.nsn.us); Rob Purser; Christina Iverson - NOAA Federal; Rob Jones; Susan Bishop
Subject:	NOAA comments on the Green River MUP and responses
Date:	Friday, July 20, 2018 6:22:56 PM
Attachments:	Green River_MUP_Questions_comanager_070318_NOAAF comments_7-20-2018.docx Green River Management Unit Status Profile_Changes_comanager_070318_NOAAF comments_7-20-2018.docx

Jason, All,

Please find NOAA Fisheries' comments on the latest draft of the Green River MUP and to the responses to early questions, provided by the Co-managers earlier this month. We have highlighted the new comments in yellow to more easily separate them from older comments you've already reviewed.

Please anticipate the Lake WA documents on Monday, July 23rd.

We look forward to our meeting on August 1st.

Thank you,

--
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Green River Management Unit Status Profile

Component Populations

Green River Fall Chinook

Geographic Distribution

The Green River basin has been dramatically altered by hydro modification. The White River was permanently diverted into the Puyallup River Basin in 1906. The Cedar River was diverted into Lake Washington basin in 1916 with the completion of the Ship Canal and Hiram M. Chittenden Locks. These two actions reduced the watershed to approximately 30% of its historic size. The lower Duwamish River basin and estuary (Elliott Bay) have been extensively modified by urbanization and industrial uses. The lower 5.5 river miles are routinely dredged for commercial shipping. Access to the upper Green River watershed was limited by construction of the Tacoma Diversion Dam in 1911 and Howard Hanson Dam in 1961.

Fall Chinook spawning occurs in the mainstem Green River and in two major tributaries, Soos Creek and Newaukum Creek. Spawning in the mainstem Green River occurs from RM 25.4 to RM 61. An adult trap and haul facility was constructed in 2005 at the Tacoma Diversion Dam (RM 61), however, spawning access is currently restricted to downstream areas because no juvenile fish passage facilities exist at Howard Hanson Dam (RM 64). Spawning occurs in the lower 4.5 miles of Newaukum Creek and the lower 5.0 miles of Soos Creek. Spawning in Soos Creek occurs below the Soos Creek Hatchery at RM 0.7 and adults surplus to hatchery program needs are passed upstream to spawn. Neither group of spawners in Soos Creek are a part of the escapement goals for the Green River basin.

Life History Traits

Fall Chinook begin entering the Duwamish River in July, and spawn from mid-September through early November. The average age composition of adult natural-origin returns between 2003 and 2016 was 27% age-3, 66% age-4 fish, and 7% age-5. Ninety nine percent of juveniles emigrate from freshwater in their first year with emigration as fry as the dominant strategy (Topping and Anderson 2015). From 2000-2014, fry emigration averaged 59% of the sub-yearling component but was as low as 10% and as high as 92%. Fry begin emigrating during January and peak during February or March. The peak in parr/smolt occurs during May.

Commented [S1]: What is emigration timing?

Commented [JD2R1]: Comment addressed.

Hatchery Production

Shortly after 1900, the first hatchery in the basin was constructed on Soos Creek. Current hatchery production involves three programs: production of 3.2 million sub-yearlings released on-station from the Soos Creek Hatchery, 1.6 million sub-yearlings which are acclimated and released from Palmer Ponds, and 0.3 million yearlings released from the Icy Creek Hatchery. The Palmer Pond release program began in 2011 and was designed to provide increased adult returns to the upper anadromous accessible reach of the Green River. The yearling program at

Icy Creek was initiated in 1983. Broodstock for both the Icy Creek and Palmer Pond programs is collected at Soos Creek Hatchery.

Chinook hatchery operations in the Green River Basin are explained in detail in the co-manager's Hatchery and Genetic Management Plan (HGMP) for the Soos Creek Fall Chinook Hatchery Program, and reflect the joint urban salmon management strategy currently being developed by the Muckleshoot Indian Tribe and the Washington Department of Fish and Wildlife for this and other highly urbanized watersheds. The HGMP acknowledges that Green River (and other Puget Sound) Chinook are well below the planning ranges for recovery escapement, as well as below spawner recruit levels identified as consistent with recovery. Until habitat function is restored, hatchery production will be essential to harvest opportunity and to maintaining abundances of naturally-spawning Chinook, particularly in highly urbanized watersheds like the Green and Duwamish rivers.

Genetic Information

Genetic analyses have shown no significant difference between mainstem and Newaukum Creek natural spawners and Soos Creek Hatchery Chinook. (Marshall et al.1995; Ruckelshaus et al. 2006). The hatchery broodstock program is operated as an integrated program with the natural origin Green River Chinook population. There is significant genetic interchange between natural- and hatchery-origin Chinook on the spawning grounds (WDFW et al. 2002).

Status

The Green River Chinook population is managed for total natural spawners on the spawning grounds, which has varied from 688 to 10,263 since 1988 (Figure 1A; Table 1). Through the early 2000s, spawning escapement was relatively steady with a 5-year geometric mean that remained close to the escapement goal of 5,800. However, from 2009-2015 total spawning escapements were consistently below the historic escapement goal. NOR spawners have declined across the time series of available data. From 1988-2016, the average NOR contribution to the spawning grounds is 44% but the most recent 5-year average has fallen to less than 30% (Figure 1B). Due in part to the long history of hatchery production and habitat degradation in the basin, hatchery produced Chinook are an important component of natural spawning escapement. Protecting and ensuring hatchery production levels meet program goals are vital in urban systems (Figure 1C).

Commented [S3]: Include a table of the escapement information in Figure 1. What does that tell you about the status of the NOR component consistent with criteria B of the 4d Rule. You introduce the topic here, but should comment on its status relative to the magnitude of the component and the trends compared with overall spawners.

Commented [JD4R3]: Partially addressed. See additional comments in MUP Questions doc, in the response to S2 section.

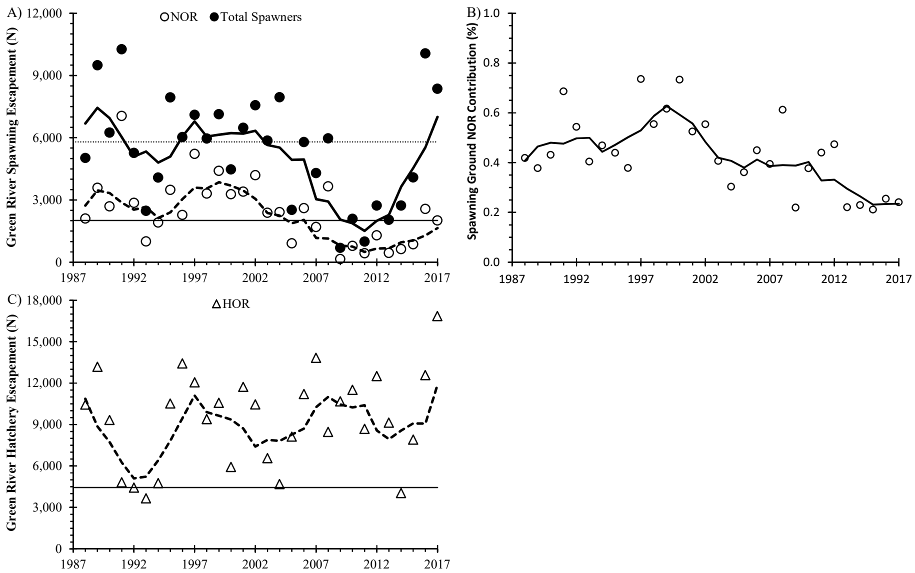

Figure 1. Observed NOR (open circle) and total (filled circle) escapement on the Green River Chinook spawning grounds (panel A) from 1988-2017. A 5-year running geometric mean for total escapement (solid line) and NOR escapement (dashed line) is fit to each data series. The historic escapement goal of 5,800 natural spawners (lite dashed line) and MSY escapement goal of 2,003 (1,525-2,232 95%CI) natural spawners (lite solid line) based on current habitat conditions are shown. Observed NOR Chinook contribution to the Green River spawning grounds (panel B) from 1988-2017 (open circles) with a 5-year running geometric mean (solid line). Observed hatchery rack escapement (open triangle) at Soos Creek Hatchery (panel C) from 1988-2017 is shown with a 5-year running geometric mean. The hatchery rack escapement goal of 4,452 adult Chinook needed to make current program goals is shown (lite solid line).

Table 1. Natural origin recruits and hatchery origin recruits (from the fingerling and yearling programs) that escaped pre-terminal and terminal fisheries. Recruits/Spawner (R/S) includes all adult NORs caught in pre-terminal and terminal fisheries or counted on the spawning grounds in the Puyallup or White rivers. Pre-terminal mortalities from the 1988-2009 brood years are based on post season FRAM validations while data for 2010-2013 brood years includes estimates from pre-season FRAM.

Commented [JD5]: Green River?

Return Year	NOR	Fingerling	Yearling	Spawners	R/S[a]
1988	1,809	12,807	846	5,026	1.85
1989	3,383	17,792	1,498	9,495	0.65
1990	2,198	12,376	996	6,247	0.83
1991	3,580	10,022	1,474	10,263	0.61
1992	1,869	7,039	787	5,267	1.02
1993	887	4,851	394	2,476	1.76

1994	1,442	6,771	630	4,078	1.00
1995	2,782	14,430	1,245	7,939	0.57
1996	2,111	16,301	1,028	6,026	0.84
1997	2,494	15,506	1,154	7,101	0.81
1998	2,103	12,299	958	5,963	0.99
1999	2,522	14,054	1,136	7,135	0.58
2000	1,577	8,124	701	4,473	0.87
2001	2,263	14,875	1,063	6,473	0.24
2002	2,153	14,665	1,193	7,564	0.27
2003	1,056	10,474	901	5,864	0.34
2004	1,230	10,253	1,156	7,947	0.31
2005	389	9,785	469	2,523	0.41
2006	917	15,128	962	5,790	0.08
2007	687	16,639	799	4,301	0.09
2008	944	12,547	945	5,971	0.10
2009	107	11,002	258	688	0.87
2010	327	12,809	462	2,092	0.26
2011	157	9,245	269	993	0.84
2012	478	14,509	614	3,090	0.65
2013	319	10,437	419	2,041	1.06
2014	428	5,937	435	2,730	--
2015	634	10,683	679	4,087	--
2016	1,882	19,187	1,566	10,063	--
2017	1,900	21,905	1,399	8,357	--

a The 1988 R/S estimate does not include Age-3 pre-terminal or terminal freshwater sport mortalities and the 2013 R/S estimate does not include recruits from the Age-5 portion of the cohort.

The historic escapement goal (i.e. Upper Management Threshold) was established in 1977 (Ames and Phinney 1977) as the average of estimated natural spawning escapements from 1965-1974. This goal does not reflect the lower productivity associated with the current condition of habitat. Update of the Fishery Regulation Assessment Model (FRAM) base period to brood years 2005-2008 necessitated updating natural and hatchery escapements back to 1988 for calibration. These data were used to fit a Beverton-Holt stock recruit curve (Beverton and Holt 1957) to brood years 1988-2013 (Figure 2). For this model, a=0.5766 and b=0.0000908 which resulted in a spawning stock size at equilibrium of 4,423 and a theoretical maximum recruitment of 11,014. The spawning stock size MSY is 2,003 which is expected to result in 2,466 recruits.

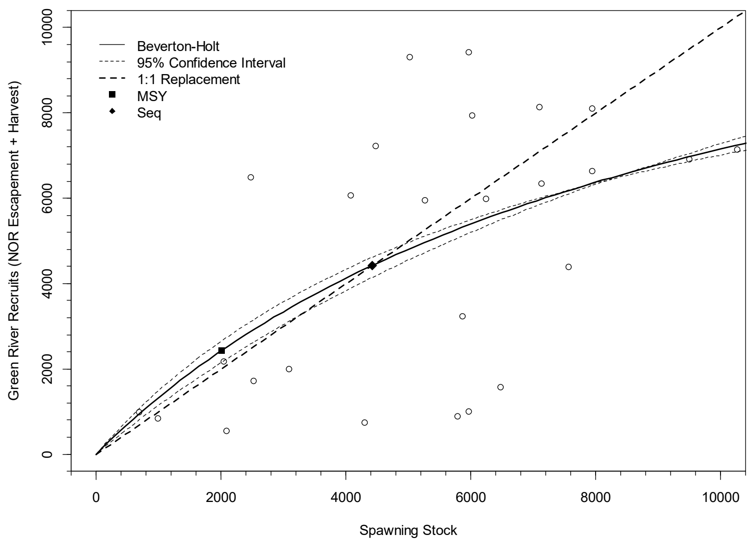

Figure 2. Beverton-Holt stock-recruit curve for Green River Chinook based on brood years 1988-2013. The spawning stock size at MSY is 2,003 (1,525-2,232 95%CI) which results in 2,466 (1,681-2,834 95%CI) recruits. The spawning stock size at equilibrium is 4,423 (3,207-4,906 95%CI) Chinook.

An independent assessment of optimal spawning escapement based on smolt production was recently completed (Anderson and Topping, in prep). That assessment showed that smolt production was affected by both spawner abundance and environmental conditions (river flow), and spawner escapements greater than 3,000 "typically yield few additional parr due to density dependence." Although increased fry emigrants may result from higher escapement, emigrating fry are presumed to survive and contribute to future adult abundance at a very reduced rate relative to parr, due to degraded habitat conditions in the lower Duwamish River and Elliot Bay. This is consistent with the conclusion from the spawner recruit analysis that the productivity of the watershed has declined and the equivalent optimal escapement is much less than 5,800 spawners used as a goal in the past.

An analysis of the Rebuilding Exploitation Rates (RER) was recently completed (NWFSC 2017). The RER analysis used data from the abundance and productivity tables that NOAA maintains and covered brood years 1987-2011, a slightly wider timeframe than the stock-recruit analysis considered here. The RER analysis based on a Ricker stock-recruit model indicated an MSY spawning escapement of 2,527 while a Beverton-Holt stock-recruit model indicated an MSY spawning escapement of 1,813 adult Chinook. The RERs associated with these spawning escapements are 20% and 31% for the Ricker and Beverton-Holt models, respectively. Assuming the two spawner-recruit functions were equally plausible, the results were combined for a 26%

(19-31% CI) RER with a target spawning escapement of 2,200 adults. These conclusions are consistent with analyses in this document as well as an independent assessment of escapement based on smolt production.

Commented [JD6]: This would be updated based on RER workgroup work.

Recruits per spawner have been moderately variable in the Green River population (Figure 3). The 1993 brood year was the most productive brood with 2.6 recruits per spawner produced. The least productive brood years were 2006-2008 which produced fewer than 0.2 recruits per spawner. Escapement during these years averaged 5,354, which is about average in the Green River basin. Recruits per spawner was 1.4 for the 2009 brood year, the largest observed since the 2000 brood year which occurred at the end of a stable period where recruits per spawner was consistently greater than 1.0. There is a weak correlation between Green River and Puyallup River (r = 0.41) or Cedar River (r = 0.39) Chinook productivity. The average productivity across all brood years is 1.0 recruits per spawner whereas 1.3 recruits per spawner is the current productivity at MSY.

Commented [JD7]: This doesn't seem to match the value in table 1, above – 0.87 R/S?

Commented [S8]: It looks like productivity has declined over this period for the Green, except for the most recent BY.

Commented [JD9R8]: See additional comments in the MUP Questions doc, response to S4 section.

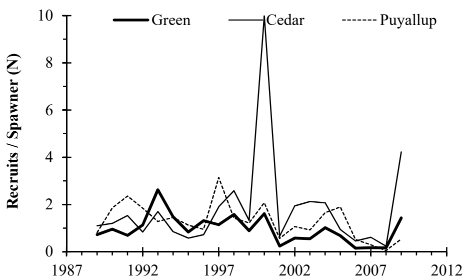

Figure 3. Trend in recruits per spawner for Green River (bold line) and adjacent management unit natural origin recruits from completed brood years (1989-2009).

Harvest Distribution and Exploitation Rate Trends

Green River Chinook are part of the Mid-South Puget Sound fall fingerling FRAM stock aggregate. The FRAM base period for this stock aggregate is based upon coded wire tagged indicator groups from Issaquah Creek, Soos Creek, Voights Creek, and Grovers Creek hatcheries from the 2005-2008 brood years. Natural spawners in the mainstem Green River and Newaukum Creek are the managed natural components of the Green River Chinook population, which is modeled through terminal fisheries within the Terminal Area Management Module (TAMM).

As estimated by post-season FRAM/TAMM for Green River Chinook, northern (British Columbia and Alaska) fisheries had a combined 13% average exploitation rate, the pre-terminal southern US (PT SUS) exploitation rate averaged 9% and the terminal exploitation rate averaged 8% from 2010-2014. Exploitation rates generally declined through the 1990s (Figure 4A). Beginning in the early 2000s northern exploitation rates began to increase to levels near where they were in the early 1990s. Terminal exploitation rates are highly variable and dependent upon whether there is a directed terminal fishery.

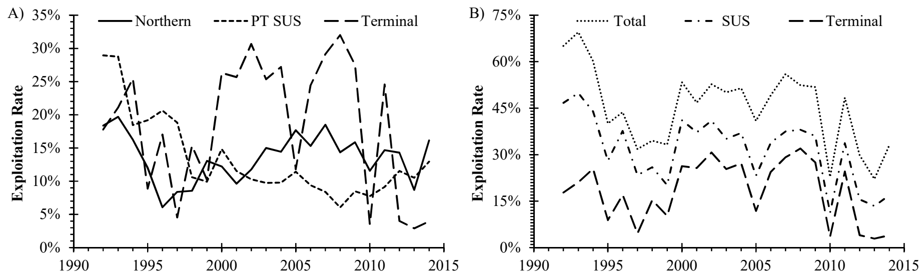

Figure 4. Trend in the A) northern (solid line), pre-terminal southern US (short dashed line), and terminal (long dashed line) exploitation rates and B) Total (dotted line), Southern US (dashed and dotted line), and terminal (long dashed line) exploitation rates on Green River natural origin Chinook from 1992-2014, based on the new FRAM base period (version 8/16/17).

Management Objectives

The Green River Chinook stock will continue to be managed for total natural escapement that includes both natural and hatchery origin adults on the Green River spawning grounds; as well as hatchery rack escapement at Soos Creek hatchery needed to achieve program goals[1]. Green River escapement goals will be consistent with escapement according to MSY under current habitat conditions. The Upper Management Threshold (UMT) will be set at MSY escapement with a set of triggers that allow progressively higher pre-terminal exploitation rates during the pre-season planning process contingent on meeting management objectives in the Lake Washington and Puyallup River management units (MUs). These triggers are designed to account for uncertainties in the pre-season forecast and pre-terminal fisheries, and to increase the likelihood of attaining sufficient terminal abundance to allow terminal area Chinook-directed fisheries to proceed. Southern U.S. fisheries will be planned in the pre-season according to a tiered management regime that accounts for uncertainties in the pre-season forecast. Terminal directed fisheries will be planned in the pre-season when terminal run size meets a threshold abundance that can be reasonably assumed to meet the natural spawning and hatchery escapement objectives, but will only go forward when in-season run size estimates project that natural and hatchery escapement goals will be met. The Low Abundance Threshold (LAT) will be set at 40% of the escapement goal.

Commented [S10]: Still unclear the basis of the 40%

Commented [JD11R10]: See comment in MUP questions doc, response to S4.

MSY associated with current habitat conditions is 2,003 (1,525-2,232 95%CI) naturally spawning adult Chinook, less than half of the 5,800 that were managed for under previous plans. The first UMT trigger will allow a pre-terminal exploitation rate of up to 12% and will be triggered when 3,800 adult Chinook in the terminal area are destined for the spawning grounds. This represents the MSY escapement goal of 2,003, plus a buffer that accounts for forecast uncertainty and a limited Chinook-directed terminal fishery. The second UMT trigger will allow a pre-terminal exploitation rate of up to 13% and will be triggered when 6,000 adult Chinook in

[1]However, among pre-terminal entities, the State has agreed to take responsibility for meeting hatchery escapement objectives.

the terminal area are destined for the spawning grounds. Similar to the first trigger, the second trigger represents the MSY escapement goal of 2,003, plus a buffer that accounts for forecast uncertainty and a limited Chinook-directed terminal fishery. The second trigger can only be met if both the Lake Washington and Puyallup River MUs meet or exceed their respective UMT (Table 2).

The hatchery escapement goal has consistently been met under the previous natural spawner escapement goal even when natural abundances have fallen below management objectives (Figure 1C). Hatchery escapement will be managed for approximately 4,452 adult Chinook needed to meet hatchery program objectives. Annual variations in abundance levels of hatchery and natural Chinook may require in-season terminal fishery management to insure the hatchery and natural escapement objectives are met. The LAT will be 802 adult Chinook on the spawning grounds. The lowest observed natural spawning escapement on the Green River was 688 in 2009, which produced 984 recruits from this cohort.

Consistent with the goals of achieving the natural spawning and hatchery escapement goals and ensuring that terminal directed fisheries will occur, at abundances above the UMT triggers of 3,800 and 6,000 adults in the terminal area destined for the spawning grounds, PT SUS fisheries will be planned not to exceed a 12% or 13% exploitation rate, depending on which trigger has been met. In the terminal area (Area 10A /Inner Elliott Bay and 80B), directed Chinook fisheries will be designed to achieve spawning and hatchery escapement at or above management objectives. This approach reflects the primary goal of meeting the conservation objective of achieving MSY escapement, as well as the importance of achieving a sufficient abundance in the terminal area to allow fisheries directed at Chinook.

If FRAM/TAMM pre-season model output of terminal run size falls between the UMT and LAT, the SUS fisheries will implement the moderate management threshold (MMT) where total Southern United States (SUS) fisheries will not exceed 18% (pre-terminal + terminal) ER. If FRAM/TAMM pre-season model output of spawning escapement falls below the LAT, a critical exploitation rate ceiling of 12% will be implemented for SUS fisheries (pre-terminal + terminal). Under this approach, terminal fisheries planned in the pre-season at the MMT or LAT will only have incidental impacts to Chinook as fisheries will be directed at other salmonids. Due to the use of in-season monitoring and management in the terminal area, abundance may be observed that is sufficiently greater than MSY such that a limited directed terminal fishery could be prosecuted which would result in higher exploitation rates in the terminal area than modeled in the pre-season but would result in meeting both natural spawning and hatchery escapement goals. The lowest SUS ER observed was 11.3% in 2010 and is the only time since 1992 the SUS ER has been below 12% according to post-season validation runs.

Commented [S12]:

Commented [JD13R12]: Confirm that this is the escapement goal that co-managers will manage for.

Commented [S14]: How will this approach provide the variability in abundance above the UMT in order to test habitat and the assumptions in the underlying S/R function? Is the intent to harvest all fish above the UMT?

Need to explain how this approach will affect the NOR component of the population as well consistent with criteria B of the 4d Rule such that the management approach will not impede its ability to rebuild toward recovery goals. Recovery goals are based on the NOR component.

Commented [JD15R14]: See additional comments in the MUP Questions doc, in the response to S5 section.

Commented [S16]: How does this objective relate to the underlying S/R relationship?

Commented [S17]: What is the total ER anticipated under this approach. NMFS FRAM?

NOAAF information indicates potential low to substantial increases in risks to rebuilding relative to NOAA Fisheries RERs if we understand the approach correctly and if the conversion from the CWT-based RER to FRAM RER is correct.

Commented [JD18R17]: See additional comments in the MUP Questions doc, in the response to S7 section.

Commented [S19]: What is the anticipated total ER associated with this SUS rate? How is the magnitude of the CERC consistent with criteria C of the 4d Rule, i.e., will not impede rebuilding of the NOR component back above the LAT.

Commented [JD20R19]: See additional comments in the MUP Questions doc, in the response to S6 section.

Commented [JD21]: But the total escapement was much higher than the aggregate LAT described here. The NORs were similar to the level of the aggregate LAT.

Table 2. Management thresholds and corresponding exploitation rate ceilings for stock components of the Mid-South Puget Sound FRAM stock aggregate. The MMT is triggered when natural spawning escapement is forecasted between the LAT and the UMT. In pre-terminal fisheries the stock aggregate is managed for its weakest component MU.

Management Unit	MSY	LAT (SUS)	MMT (SUS)	UMT – trigger 1 (PT SUS)	UMT – trigger 2 (PT SUS)
Lake Washington[1]	280	200 (12%)	18%	500 (12%)	500 (13%)
Green River	2,003	805 (12%)	18%	3,800 (12%)	6,000 (13%)
Puyallup River	797	319 (15%)	30%	1,300 (12%)	1,300 (13%)

[1] The Cedar River is the natural managed component of the Lake Washington MU

During the pre-season process, Puget Sound (sport and terminal) fisheries will be planned to meet the broodstock needs at Soos Creek Hatchery. Even when expected abundance of Chinook returning to the Green River to spawn naturally is above the management objectives, it is possible that additional fishery actions may be necessary to ensure broodstock needs at the hatchery are met. Broodstock needs at Soos Creek Hatchery will be calculated based on pre-spawn mortality in the adult holding ponds, fecundity, male to female ratio and egg to smolt survival that the co-managers will discuss and agree upon during the pre-season planning process. Further in-season actions consistent with the agreed to HGMP will guide actions that may be required to meet natural spawning and hatchery goals as additional information becomes available.

There is some uncertainty in rates of impact of northern fisheries (British Columbia and Alaska) on Green River Chinook, but impact of those fisheries is unlikely to decrease significantly relative to recent years (Figure 4A). SUS fisheries will be constrained to the levels described above when natural spawning abundance is expected to be below the management objectives. Those constraints, coupled with the agreed to hatchery objectives with the State, will ensure that fisheries do not reduce the likelihood of recovery of Green River Chinook, while allowing limited fisheries to continue in years when natural spawning abundance falls below the UMT.

While directed terminal fisheries are planned when the FRAM/TAMM model output of terminal run size exceeds the spawning and hatchery objectives, terminal fisheries will only proceed when in-season update (ISU) model corroborates pre-season expectations. For the Green River stock, this is accomplished with a test fishery in Elliott Bay. This test fishery occurs at 5 sites on three nights, once per week during management weeks 29-31.

Test fishery catch from each week is aggregated and used to project terminal run size (previous document), spawning escapement, and hatchery escapement. If the results of this modeling exercise match the pre-season expectations and/or the co-managers believe fishing will result in meeting or exceeding spawning and hatchery escapement objectives, directed fisheries will proceed. Conversely, if pre-season expectations and/or projections of spawning and hatchery escapements are not met, directed fisheries will not proceed.

If based on the first ISU, the co-managers decide to conduct a first opening, directed terminal fisheries in 10A and 80B are scheduled in week 32 and non-treaty fisheries are scheduled for

Commented [S22]: How has it performed? How is uncertainty accounted for? Chapter 5 of the RMP states "In practice, a substantial harvestable surplus must be available, so that the directed fishery is of practical magnitude (i.e. there is substantial harvest opportunity and the fishery can be managed with certainty not to exceed the harvest target). A directed fishery would not be planned to remove a very small surplus above the UMT. The decision to implement a directed fishery will also consider the uncertainty in forecasts and fisheries mortality projections."

Commented [JD23R22]: See additional comments in MUP Questions doc, response to S9 section.

weekend(s) in 10A and the in-river sport fishery begins in the lower Duwamish River around September 1. After the first night of a directed terminal net fishery in Elliott Bay (10A) and the Duwamish River (80B), the results of a Second ISU are examined and the co-managers evaluate the projected run size with respect to the escapement objectives.

The first ISU for the Green River occurs after completion of the 10A test fishery. From this model, the terminal run size has a mean absolute error of 21.9%. This approach can be used to update the in river spawning escapement and hatchery escapement. Before looking at spawning escapements or hatchery escapements, it is important to note that high water during the peak weeks of both 2009 and 2011 prevented a full complement of spawning surveys and resulted in much lower escapement estimates than would have occurred otherwise. These high water events did not impact hatchery escapements. The mean absolute error (when excluding 2009 and 2011) from the 10A ISU for updating expected spawning escapement on the Green River is 32.4% (Figure 5A). Similarly, the mean absolute error (including 2009 and 2011) for updating hatchery escapement is 33.5% (Figure 5B).

The second ISU for the Green River occurs after completion of the first night of directed Chinook net fisheries in Elliott Bay and the Duwamish River. There were no terminal net fisheries in the Duwamish River during 1989 or 2010 and therefore no second update. From this ISU model, the terminal run size has a mean absolute error of 16.9%. The mean absolute error from the Terminal Net ISU for updating expected spawning escapement on the Green River is 27.2% (Figure 5C). Similarly, the mean absolute error (including 2009 and 2011) for updating hatchery escapement is 30.9% (Figure 5D).

The 2017 pre-season projection for spawning escapement was approximately 7,500 prior to anticipated fisheries and after fisheries was observed at over 8,000 Chinook on the spawning grounds. The Terminal Net ISU estimated 6,300 spawners after directed terminal fisheries. Excluding years where spawning surveys missed the peak spawning due to high water (2009 and 2011), both ISU models under estimate observed spawning escapements. Hatchery escapements in the Green River were projected to be 10,000-11,000 (depending on ISU) while almost 17,000 Chinook were observed after spawning was complete. Concordance between modeled and observed hatchery escapements is much lower than for natural spawning escapements.

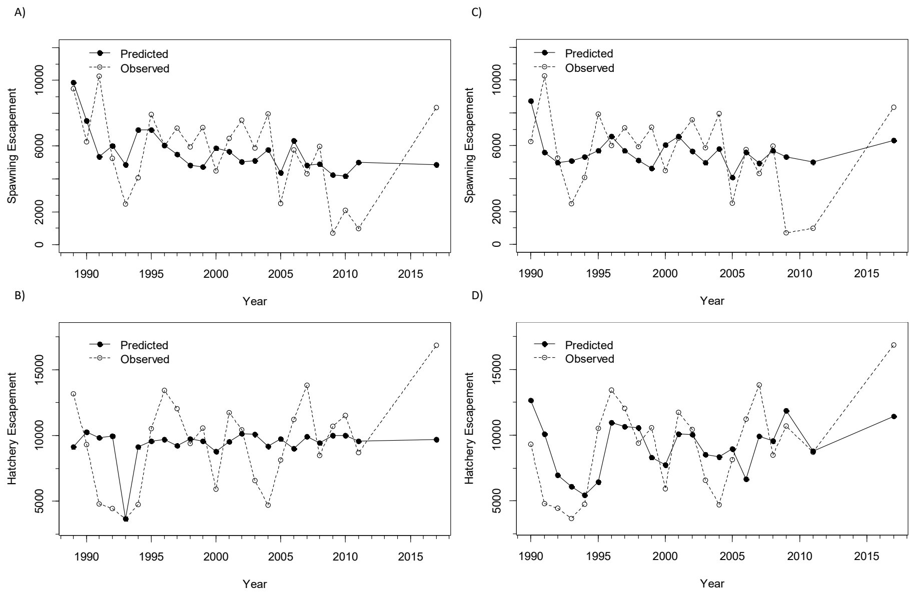

Figure 5. Observed and predicted spawning escapement (A) and hatchery escapement (B) in the Green River based on the 10A test fishery ISU and observed and predicted spawning escapement (C) and hatchery escapement (D) in the Green river based on the combined test fishery and first night of directed net fishery.

If the ISU model projects a harvestable surplus above management objectives, the planned terminal fisheries proceed. Regardless of pre-season forecasts, in-season updates will be used to manage terminal area fisheries. The in-season updates may serve to open or close terminal fisheries. In the case where no directed terminal fisheries were modeled in the pre-season (i.e. management at the MMT or LAT), Chinook directed fisheries may be implemented in terminal areas by agreement of the terminal area co-managers (Muckleshoot Indian Tribe, Suquamish Indian Tribe, and Washington Department of Fish and Wildlife) when data indicate a harvestable surplus of both Green River natural spawners and Soos Creek Hatchery broodstock. In those instances, the total SUS ER may increase over pre-season expectations; but MSY and hatchery escapement goals will be met. The in-season update method and terminal area fisheries that are based on this update will be agreed to by the terminal area co-managers prior to implementation. Any directed Chinook fisheries in the terminal area will be designed to result in spawning escapements that meet or exceed the Green River Chinook and Soos Creek Hatchery escapement objectives, 2,003 and approximately 4,452 respectively. Hatchery escapement needs will be reviewed, updated, and agreed to annually by the co-managers and available during the pre-season planning process.

Data Gaps and Information Needs

Table 2. Data gaps in Green River Chinook stock assessment and harvest management, and research required to address those data needs.

Data gap	Related research needed
Evaluation of escapement estimation methodology	Use Soos Creek outplants for a mark/recapture estimate of the spawning escapement.
Temperature impacts on adult Chinook and eggs	Quantify pre-spawning mortality and sub-lethal effects. These include the viability and maturation rate of eggs exposed to high temperatures in vivo. Estimate thermal history of Chinook migrating from Puget Sound to the spawning grounds with a combination of radio tags and temperature thermistors.
Investigate potential causes of poor egg to migrant productivity	Perform scour studies on the Green River and Newaukum Creek and investigate the impact of Nanophyetus on productivity of spawners in Soos Creek.
Estimate mortality of Chinook during years with high and low numbers of pink salmon	Encounter rate study, freshwater hooking mortality study, compliance study, tagging study
Pre-terminal in-season update models	In partnership with terminal and pre-terminal Tribes and State, examine relevant fishery dependent or independent data to develop an in-season update model for pre-terminal SUS fisheries.
Stock specific exploitation rates	The Green River stock is a component of the Mid-South Puget Sound fall fingerling release group in FRAM. Each of the component stocks should be managed separately to better assess population level impacts.

The data gaps described above assume that the current annual monitoring in place will continue. This includes spawner surveys in the mainstem Green and Newaukum Creek, including carcass sampling, outmigration estimation in the mainstem Green and Soos Creek, and hatchery sampling.

Green River MUP Questions

S1: What is emigration timing?

There is a fry pulse during February/March and a parr/smolt peak during May.

S2: Include a table of the escapement information in Figure 1. What does that tell you about the status of the NOR component consistent with criteria B of the 4d Rule. You introduce the topic here, but should comment on its status relative to the magnitude of the component and the trends compared with overall spawners.

Table 1. Natural origin recruits and hatchery origin recruits (from the fingerling and yearling programs) that escaped pre-terminal and terminal fisheries. Recruits/Spawner (R/S) includes all adult NORs caught in pre-terminal and terminal fisheries or counted on the spawning grounds in the Puyallup or White rivers. Pre-terminal mortalities from the 1988-2009 brood years are based on post season FRAM validations while data for 2010-2013 brood years includes estimates from pre-season FRAM.

Return Year	NOR	Fingerling	Yearling	Spawners	R/S[a]
1988	1,809	12,807	846	5,026	1.85
1989	3,383	17,792	1,498	9,495	0.65
1990	2,198	12,376	996	6,247	0.83
1991	3,580	10,022	1,474	10,263	0.61
1992	1,869	7,039	787	5,267	1.02
1993	887	4,851	394	2,476	1.76
1994	1,442	6,771	630	4,078	1.00
1995	2,782	14,430	1,245	7,939	0.57
1996	2,111	16,301	1,028	6,026	0.84
1997	2,494	15,506	1,154	7,101	0.81
1998	2,103	12,299	958	5,963	0.99
1999	2,522	14,054	1,136	7,135	0.58
2000	1,577	8,124	701	4,473	0.87
2001	2,263	14,875	1,063	6,473	0.24
2002	2,153	14,665	1,193	7,564	0.27
2003	1,056	10,474	901	5,864	0.34
2004	1,230	10,253	1,156	7,947	0.31
2005	389	9,785	469	2,523	0.41
2006	917	15,128	962	5,790	0.08
2007	687	16,639	799	4,301	0.09
2008	944	12,547	945	5,971	0.10
2009	107	11,002	258	688	0.87
2010	327	12,809	462	2,092	0.26
2011	157	9,245	269	993	0.84
2012	478	14,509	614	3,090	0.65
2013	319	10,437	419	2,041	1.06
2014	428	5,937	435	2,730	--
2015	634	10,683	679	4,087	--

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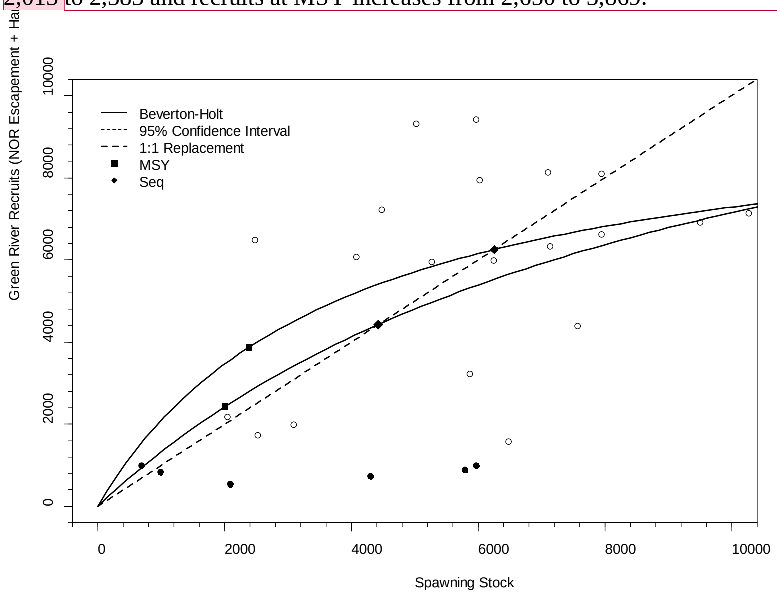
2016	1,882	19,187	1,566	10,063	--
2017	1,900	21,905	1,399	8,357	--

a The 1988 R/S estimate does not include Age-3 pre-terminal or terminal freshwater sport mortalities and the 2013 R/S estimate does not include recruits from the Age-5 portion of the cohort.

The NOR component of the Green River population is moderately unproductive compared to other Puget Sound populations. This population is in "critical" because the planning range for abundances is stated as 17,000-37,700 (NOAA 2006). Since 2001, the average NOR return to the Green River has been 934. Only one of these broods has a recruit/spawner >1. The average productivity was 0.4 recruits/spawner and likely continuing to decrease. This would indicate that the Green River NOR populations are facing extreme habitat decline whereas the NOAA 4d criteria assume stable or increasing habitat capacity.

S3: It looks like productivity has declined over this period for the Green, except for the most recent BY.

The 2001-2008 broods (2004-2013 return years) exhibited much lower production across many Puget Sound stocks. The Green River stock was no exception to this trend. More recent broods seem to be increasing towards productivities seen through the 1990s. Productivity from 2001-preent is poor but particularly the 2006-2011 brood years (filled circles) where recruits did not exceed 1,000. If these 6 brood years were not included in the S-R analysis, MSY increases from 2,013 to 2,383 and recruits at MSY increases from 2,650 to 3,869.



S4: Still unclear the basis of the 40%.

Commented [JD1]: No, the 4(d) criteria do not assume this. "Critical" should be relative to the low abundance threshold and assessed in terms of NORs. So, the average NOR spawner number, relative to the 805 LAT would be?

Commented [JD2]: Recent BYs seem like a significant improvement so what is picture under much higher harvest rates? 2015 and 2106 were mid 30% ER.

Commented [JD3]: Updated figure 2. Caption and text in body of the MUP state 2,003, so assume this is a typo and the MUP updated value is correct?

This is a built in rebuilding plan. If R/S is 2.5 (generally accepted as fully functioning habitat), and spawners were to fall to 40% of SMSY, the population could be rebuilt in one complete brood cycle. This is designed to increase the probability of recovery in the MU by preventing dramatic declines in NOR. When combined with proposed ERs at this conservative LAT, we expect to maintain growth of the MU that tracks habitat recovery.

S5: How will this approach provide the variability in abundance above the UMT in order to test habitat and the assumptions in the underlying S/R function? Is the intent to harvest all fish above the UMT? Need to explain how this approach will affect the NOR component of the population as well consistent with criteria B of the 4d Rule such that the management approach will not impede its ability to rebuild toward recovery goals. Recovery goals are based on the NOR component.

The management approach the co-managers have implemented in the Green River has been to meet an escapement goal that is reflective of current habitat capacity. Terminal fisheries are designed to take advantage of abundance above that associated with MSY. This abundance is measured with a test fishery in Elliott Bay and further refined with information from net fisheries. These projections contain error and when a fishery can't be designed that will result in escapements greater than MSY, no further fisheries will be prosecuted. This will result in variable spawning escapements that will continue to "test" the available habitat and allow the NOR component to build toward recovery goals if habitat is restored (NOAA 2006).

Habitat is continuing to decline in the Green River basin, which is reflective of the productivity observed from this population. The average productivity is 1.0 R/S and more than half of all broods produced fewer recruits than the spawners that created them. The Green River population is classified as critical according to VSP parameters (NMFS 2000) meaning that it is in a recolonization phase. The Green River will continue to rely heavily on hatchery origin recruits to maintain a natural origin component. The Green River will likely remain in this state until significant habitat recovery occurs.

S6: How does this objective relate to the underlying S/R relationship?

The 18% SUS ER at the MMT and 12%SUS ER at the LAT represents significant constraints over previous harvest plans on pre-terminal fisheries when spawning escapements do not meet those associated with MSY (2,013). These rates should allow the spawning population to quickly recover to the available habitat capacity in the Green River

S7: What is the total ER anticipated under this approach. NMFS FRAM? NOAAF information indicates potential low to substantial increases in risks to rebuilding relative to NOAA Fisheries RERs if we understand the approach correctly and if the conversion from the CWT-based RER to FRAM RER is correct.

Management under this plan (if adopted) will strongly depend on forecast abundance destined for the spawning grounds. If we are above the UMT, terminal area managers will manage this fishery at least 2,013 natural spawners. My first assumption will be for a northern ER that is

Commented [JD4]: The NOR abundance could be rebuilt? To the current levels or other? Do we have the modelling to demonstrate that the population would be rebuilt in 1 generation under current conditions if the abundance were to fall below the LAT?

To be clear, the LAT represents a spawner abundance level of 40% of Smsy, when intrinsic productivity is assumed to be 2.5 R/S, correct? What is the current intrinsic productivity of the Green River population relative to this assumption? The MUP states that the avg productivity across all brood years is 1.0 and 1.3 at MSY.

Commented [JD5]: Not aware that these two things are connected.

Recolonization phase of HSRG framework means putting more spawners on the spawning ground to test habitat capacity and adaptively manage from there.

Critical is based on the population status in NORs relative to the current habitat. In other words, relative to something like the LAT, when the LAT is based on the current productivity. Need to demonstrate that the proposed level of harvest will not impede recovery of NORs. This doesn't seem to speak to that.

Commented [JD6]: Need to understand whether and how the 18% is related to the S/R relationship. Would like to see the analysis supporting the last statement given the high overall anticipated ERs.

Since the ER under the LAT is 12% which is consistent with the prior management and the LAT abundance has been lowered, don't understand how the LAT rate represents more constraint. The MMT threshold seems to be a more conservative approach at the moderately low levels of abundance.

constant across abundances which is 13%, the recent 5 year average based on post season round 5 validations. In practice this will almost certainly vary with forecast abundance such that greater abundances result in higher exploitation rates. The abundances for the Green River during the 5 year period vary between the upper end of the MMT and the lower end of UMT1.

Assuming we are above the 3,800 trigger, this will result in up to 12% pre-terminal SUS ER and the resulting terminal ER will be about 21%. Assuming the 6,000 trigger has been met, pre-terminal SUS ER will be 13% and the resulting terminal ER will be about 28%. The 28% ER is the average ER from the 5 most recent post-season round 5 validation runs where there was a terminal fishery and the 21% (at the 3,800 trigger) assumes a reduction in catch from historic years corresponding to the assumed reduction in managed escapement at this threshold. If natural spawners are forecast in the MMT, SUS ER will be constrained to 18%. If natural spawners are forecast below the LAT, SUS ER will be constrained to 12%.

Table 1. Expected total exploitation rates at the 4 thresholds in the Green River MU.

Management	Escapement	Total ER (%)
LAT	<805	25%
MMT	806-3,799	31%
UMT 1	3,800-5,999	46%
UMT 2	>6000	54%

A conversion of the NOAA RER from CWT-based (CTC Model) to FRAM based is not necessary for the Green River MU. This MU provides a stock-recruit function that is based on FRAM pre-terminal impacts as well as terminal impacts that are consistent with those in the RER analysis. The result of this work is an MSY that differs by only 2%. The NOAA RER analysis produced an MSY of 26% while the stock-recruit modeling here produced an MSY of 24%. Had the stock-recruit modeling included jacks in the terminal areas, these rates would have likely been closer.

S8: What is the anticipated total ER associated with this SUS rate? How is the magnitude of the CERC consistent with criteria C of the 4d Rule, i.e., will not impede rebuilding of the NOR component back above the LAT.

The CERC is set at a conservative ER when escapement falls below 805 spawners (i.e. LAT at 40% MSY). We would expect the total number of recruits from this brood to increase toward MSY and the spawning component to be at MSY within 1 brood cycle.

S9: How has it performed? How is uncertainty accounted for? Chapter 5 of the RMP states "In practice, a substantial harvestable surplus must be available, so that the directed fishery is of practical magnitude (i.e. there is substantial harvest opportunity and the fishery can be managed with certainty not to exceed the harvest target). A directed fishery would not be planned to remove a very small surplus above the UMT. The decision to implement a directed fishery will also consider the uncertainty in forecasts and fisheries mortality projections."

Commented [JD7]: So the range of anticipated ERs are all greater than the estimated MSY harvest level of the population, correct? What effect does this have on the rebuilding of the NOR component? See criteria C and D in 4d Rule.

Commented [JD8]: See comment above in response to S4.

Commented [JD9]: Would like to discuss this further. In particular, how the managers propose to utilize the estimated error in the models to implement conservative approaches to terminal fisheries when the run size estimates are near, but over the UMT escapement thresholds, in other words, within the margin of error.

A test fishery has been conducted for the Green River Chinook population since 1989. The test fishery is composed of five gill net sets in Elliott Bay during week 29, week 30, and week 31. In Season Updates (ISU) have been developed and improved as more data has become available. What follows is a description of the ISUs associated with the test fishery and consecutive directed fisheries (if warranted).

First ISU

Test fishery catch from each week is aggregated and used to project terminal run size (previous document), spawning escapement, and hatchery escapement. If the results of this modeling exercise match the pre-season expectations and/or the co-managers believe fishing will result in meeting or exceeding spawning and hatchery escapement objectives, directed fisheries will proceed. Conversely, if pre-season expectations and/or projections of spawning and hatchery escapements are not met, directed fisheries will not proceed.

Second ISU

If based on the first ISU the co-managers decide to conduct a first opening, directed terminal fisheries in 10A and 80B are scheduled in week 32 and non-treaty fisheries are scheduled for weekend(s) in 10A and the in-river sport fishery begins in the lower Duwamish River around September 1. After the first night of a directed terminal net fishery in Elliott Bay (10A) and the Duwamish River (80B), the results of a Second ISU are examined and the co-managers evaluate the projected run size with respect to the management objectives.

Historical Performance

The first ISU for the Green River occurs after completion of the 10A test fishery. From this model, the terminal run size has a mean absolute error of 21.9% (previous document). This approach can be used to update the in river spawning escapement and hatchery escapement. Before looking at spawning escapements or hatchery escapements, it is important to note that high water during the peak weeks of both 2009 and 2011 prevented a full complement of spawning surveys and resulted in much lower escapement estimates than would have occurred otherwise. These high water events did not impact hatchery escapements. The mean absolute error (when excluding 2009 and 2011) from the 10A ISU (first ISU) for updating expected spawning escapement on the Green River is 32.4% (Figure 1A). Similarly, the mean absolute error (including 2009 and 2011) for updating hatchery escapement is 33.5% (Figure 1B).

The second ISU for the Green River occurs after completion of the first night of directed Chinook net fisheries in Elliott Bay and the Duwamish River. There were no terminal net fisheries in the Duwamish River during 1989 or 2010 and therefore no second update. From this ISU model, the terminal run size has a mean absolute error of 16.9% (previous document). The mean absolute error from the Terminal Net ISU (Second ISU) for updating expected spawning escapement on the Green River is 27.2% (Figure 1C). Similarly, the mean absolute error (including 2009 and 2011) for updating hatchery escapement is 30.9% (Figure 1D).

2017 Implementation

The 2017 pre-season projection for spawning escapement was approximately 7,500 prior to anticipated fisheries and after fisheries was observed at over 8,000 Chinook on the spawning grounds. The Terminal Net ISU estimated 6,300 spawners after directed terminal fisheries. Excluding years where spawning surveys missed the peak spawning due to high water (2009 and 2011), both ISU models under estimate observed spawning escapements. Hatchery escapements in the Green River were projected to be 10,000-11,000 (depending on ISU) while almost 17,000 Chinook were observed after spawning was complete. Concordance between modeled and observed hatchery escapements is much lower than for natural spawning escapements.

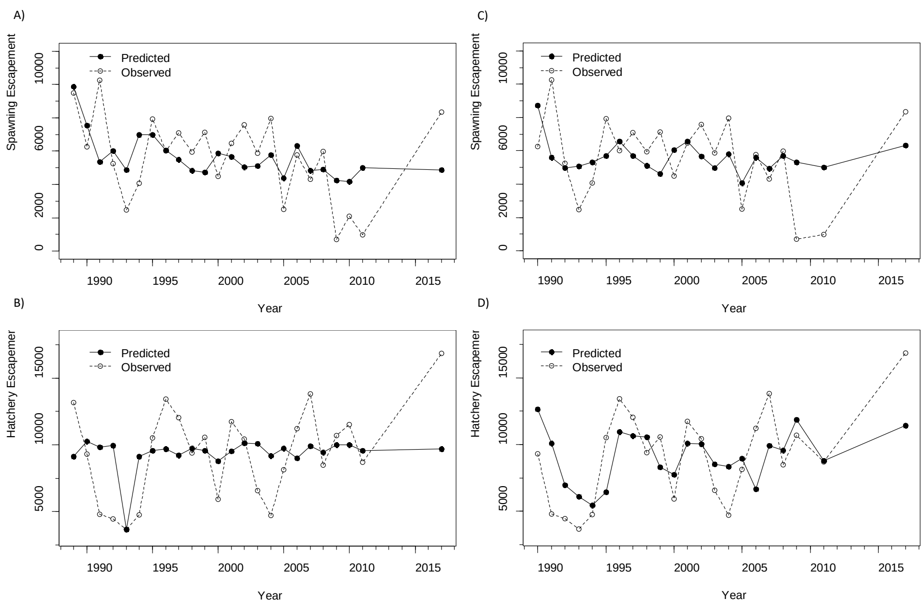


Figure X. Observed and predicted spawning escapement (A) and hatchery escapement (B) in the Green River based on the 10A test fishery ISU and observed and predicted spawning escapement (C) and hatchery escapement (D) in the Green river based on the combined test fishery and first night of directed net fishery.

White River Management Unit Status Profile

Component Populations

White River Spring Chinook

Geographic distribution

The White River is glacially influenced and was diverted into the Puyallup River in 1906 after a large flood and log jam redirected the majority of the flow into the Stuck River. This diversion was made permanent in 1915 with the construction of a concrete structure. A diversion dam was constructed on the White River at RM 23.4 for hydropower generation in 1911 along with a canal and flume system to Lake Tapps before returning flow to the White River 20 miles downstream. Hydropower production ceased in 2004 and the associated facilities and water rights were later sold to the Cascade Water Alliance for a future municipal water supply. The U.S. Army Corps of Engineers (USACE) constructed the Mud Mountain Dam at RM 29.6 in 1948 for flood control, permanently blocking anadromous access to the upper White River watershed. Chinook and other anadromous species are trapped at the diversion dam in the USACE Buckley Trap and hauled above Mud Mountain Dam. The poor condition of the diversion dam and fish trap facilities have resulted in injury, migration delay, and prespawning mortality of Chinook and other species. Within the next five years, the USACE plans to replace and upgrade both its trap and haul facilities and the diversion dam as required by a 2014 Biological Opinion.

Spring Chinook spawning above Mud Mountain Dam occurs in the mainstem White River and several tributaries including the West Fork White River, Clearwater River, Greenwater River, and Huckleberry Creek. Spring Chinook spawn below the diversion dam in the mainstem White River, Boise Creek and Salmon Creek. Spawning ground surveys are conducted in the Clearwater River, Greenwater River, Huckleberry Creek, the mainstem White River, Boise Creek, and Salmon Creek. Glacial turbidity in the mainstem White River impairs surveys in most years.

Commented [S1]: What is the migration/river entry timing and spawn timing?

Commented [S2R1]: Addressed

Life History Traits

Adult Spring Chinook enter the Puyallup River from May through mid-September, and spawn from mid-September through October. In contrast to other spring stocks in Puget Sound, White River Chinook smolts emigrate primarily as sub-yearlings. Based on scale samples taken at the Buckley Trap, 92% of Chinook sampled migrated as sub-yearlings. Further, smolt trapping data during 2016 and 2017 has indicated >99% sub-yearlings (Puyallup Tribe unpublished data). Similar to emigration timing in the Cedar, Green, and Puyallup rivers, emigration in the White River follows a bi-modal pattern with a fry peak in February/March and smolt peak in June. The average age composition of adult natural origin returns between 2005 and 2016 was 54% age 3, 44% age 4 and 2% age 5.

Commented [S3]: What is emigration timing?

Commented [S4R3]: Addressed

Hatchery Production

An emergency egg bank was begun out of basin in 1977 at the Minter Creek/ Hupp Springs Hatchery Complex. Variable numbers of yearlings and subyearlings were released into the White River basin from this program. The Muckleshoot Indian Tribe began operating the White River Hatchery in 1989 at RM 23.4. Beginning in 1992, additional Chinook were planted in the upper watershed at acclimation ponds in an effort to more fully seed available spawning habitat above Mud Mountain Dam. Releases for the acclimation pond program (APP) have been those fish surplus to the core Minter/Hupp and White River on-station programs. The APP Chinook are managed as if they are NOR Chinook and count toward the interim escapement goal.
These Chinook are reared at Clarks Creek/Puyallup Trout Hatchery and the White River Hatchery prior to transfer to the acclimation ponds. White River Hatchery has production goals of 340,000 sub-yearling smolt on-station releases, 55,000 yearling smolt on-station releases, with surplus production up to 1.3 million for the acclimation ponds. The core White River Hatchery program requires 1,100 adults to meet the juvenile release goals. Hupp-Minter has a production goal of 400,000 on-station releases with any surplus going towards the acclimation pond program. The Clarks Creek and Puyallup Trout Hatcheries take up to 1.0 million surplus eggs from White River Hatchery and rear the resulting fry until they can be taken to the acclimation ponds. Transfers from the Minter/Hupp program to the White River are being discontinued and the yearling on-station release program at White River Hatchery is being halted for up to 4 years beginning with brood year 2016 to address disease concerns.

Genetic Information

Genetic analyses have shown significant differences between White River Spring Chinook and Puyallup River Fall Chinook (Ruckelshaus et al. 2006). Within the White, the early run hatchery and wild genetic samples are indistinguishable, reflecting the effects of the broodstock program that began in the 1970s. The late-returning Chinook population in the White River is genetically indistinguishable from Green River-origin Chinook which were widely introduced into the Puyallup River.

Status

The White River Spring Chinook population is the only extant early timed population remaining in the South Puget Sound geographic region. As such, this population is categorized as a tier 1 population, meaning it is essential for preservation, restoration, and recovery of the Evolutionary Significant Unit. White River Spring Chinook declined from escapements of more than 5,000 in the early 1940s to less than 100 by the early 1970s. The initial supplementation program stabilized this trend until the construction of the White River Hatchery. From the years immediately preceding the initiation of the hatchery program up through 1996, the natural origin (NOR) Chinook stock saw slight increases in population size (Figure 1A). Two of the three subsequent brood years were among the lowest returns of NOR Chinook in the time series. However, the 2000 return year exceeded the interim escapement goal of 1,000 Chinook (NOR + APP + HOR) passed at Buckley Trap for the first time with the majority of the recruits coming from the NORs. This begins an 18 year period of widely fluctuating returns. Over these 18 years, only 3 years failed to meet the 1,000 Chinook interim passage goal with 8 of these years being met with NOR recruits.

Commented [CI5]: In years with high returns USACE stops sorting and just passes fish to reduce stress related mortality due to poor trap design. Please clarify that only NOR and APP fish were knowingly passed above the dam when sorting is possible?

Up through 2004, the APP saw only modest returns. Beginning in 2005, APP returns began making up a much larger fraction of the total passage at Buckley Trap. In addition, 2005 marked the beginning of consistently exceeding about 1,500 total Chinook passed at Buckley Trap. By 2009 the NOR stock saw its first major decline since the late 1990s and has persisted at an average of about 700 at the Buckley trap. Conversely, APP recruits have exhibited periodic explosions in abundance reaching approximately 3,000 individuals at the Buckley Trap. Adult returns from the White River Hatchery increased steadily from the initial return of 170 age-3 adults in 1992 to an average of about 1,750 beginning in 2005 (Figure 1B). Total returns have fluctuated around this level but occasional productive return years are observed such as 2017 which saw more than 4,700 adults return to the basin. The majority of adult HOR spring Chinook are held at the hatchery for spawning, but some are passed above Mud Mountain Dam when program needs are met or when Buckley Trap becomes inundated with other salmonids and sorting is terminated by the USACE.

Commented [CI6]: Is there any indication that the APP fish are outcompeting or suppressing NOR production?

What is the relationship if look at only these last years when APP fish have dominated? I understand that the White River hatchery workgroup has looked at this.

Commented [CI7]: See previous comment re passage of HOR adults.

There appears to be a weak positive relationship between APP survival and NOR survival across the 23 years of data since the APP was initiated (Figure 1C). Returns greater than 1 NOR adult per spawner occur from APP survivals of 0.001 to the largest observed value in the series. NOR returns less than 1 tend to form a cluster when APP survival is less than 0.001. While APP smolt production does not suppress NOR recruits/spawner, a moderately strong negative relationship between total adult spring Chinook spawners and NOR recruits/spawner does exist (Figure 1D). NOR recruits/spawner greater than 1 only occurred when fewer than 1,500 total spawners were passed above Mud Mountain Dam.

Commented [CI8]: Statistically positive? This looks like a cloud above 0.001. if this is true then wouldn't we seeing a stronger NOR return in recent years?

Commented [CI9]: So a prioritization of NORs could boost recovery? Since APP returns make up the majority of returns, then seems like the APP returns would take up the capacity reflected in Panel D. Panel C provides some useful information that could be used to establish a ratio of APP to NORs passed.

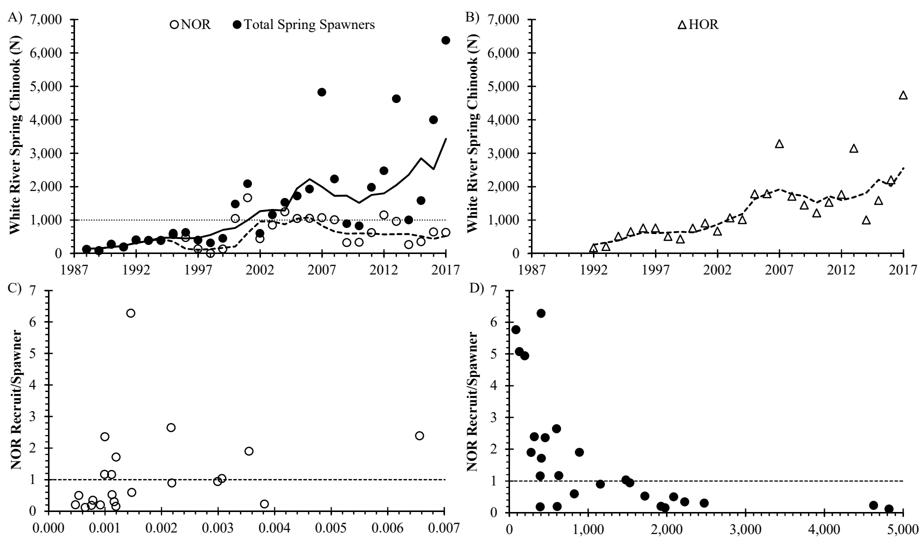


Figure 1. Observed NOR (open circle) and total spring spawning (filled circle) escapement moved above Buckley Trap (A) with 5-year running geometric mean for total escapement (solid line) and NOR escapement (dashed line). The interim escapement goal of 1,000 is

shown as a lite dashed line. Observed hatchery (fingerling + yearling) recruits (HOR) returning to the White River (B) with a 5-year running geometric mean. Relationship between NOR survival (recruits/spawner) and (C) survival (returns/release) from the APP or (D) total adult spawners passed to the spawning grounds.

An interim escapement goal of 1,000 spring Chinook (NOR + APP + HOR) spawners passed above the Mud Mountain dam, which does not include mainstem spawners downstream of the dam, has been the management goal under recent plans. White River spring Chinook escapements by age and origin (NOR, HOR, APP) were reconstructed from 1984-2017 resulting in complete brood year reconstructions from 1989-2013 (Table 1). A Ricker stock recruit function was fit to White River Spring Chinook spawning escapements and their subsequent broods from the 1988-2013 brood years (Figure 2). This resulted in a stock size of 488 spawners at maximum sustainable yield (MSY). To evaluate the variation around MSY, a jackknife procedure was used to estimate a 95% confidence interval (CI). The 95% CI ranged from 455-533 spawners at MSY. This implies that 805-1,054 (929 at MSY) recruits would be produced from this range of spawning escapement. The exploitation rate (ER) at MSY would be 47.5% (43.5-49.4% 95% CI). The expected maximum number of recruits in this population will be 1,165 (1,140-1,223 95% CI) under current habitat conditions. This number is expected to increase with planned upgrades at the trap and haul facility.

Commented [CI10]: Spawners include NOR and APP fish, yes?

See previous comments re intentionally passing HORs. Does not look like getting additional production out. We understand that due to the design they cannot sort when numbers are very high, thus all fish are passed via truck per USACE. This is reflected pretty steadily in the numbers reported as 'spawners' in Table 1 from 1994 to present in the odd years. Only an average of 50 NOR are kept for brood the rest are passed. What is the condition of fish passed above the dam?

Commented [S11]: Please include a table with estimates for NOR, APP, HOR returns and the productivity estimates for the years available.

Commented [S12R11]: Addressed

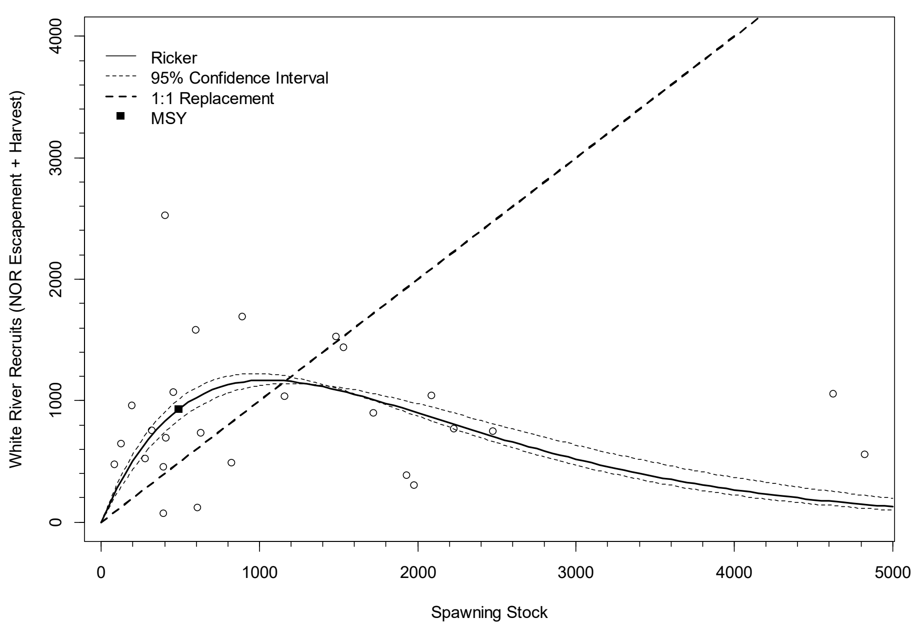


Figure 2. Ricker stock-recruit curve for White River Spring Chinook based on brood years 1988-2013. MSY is calculated from Scheuerell (2016) and results in an optimal stock size of

488 (455-533 95% CI) Chinook. The maximum number of recruits is 1,165 (1,140-1,223 95% CI).

Table 1. Natural origin recruits (NOR), hatchery origin recruits (HOR; including both fingerling and yearling program adults), and acclimation pond program (APP) recruits that escaped pre-terminal and terminal fisheries and returned to either Buckley Trap or White River Hatchery. Spawners include NOR spawners not used for brood stock integration, APP recruits, and HOR spawners that are surplus to White River Hatchery program goals or not sorted at the Buckley Trap. Recruits/Spawner (R/S) includes all adult NORs caught in pre-terminal and terminal fisheries, integrated into the White River broodstock, and NORs passed above Mud Mountain Dam. Pre-terminal mortalities from the 1988-2009 brood years are based on post season FRAM validations while data for 2010-2013 brood years includes estimates from pre-season FRAM.

Return Year	NOR	HOR	APP	Spawners	R/S[a]
1988	127	--	--	127	5.07
1989	83	--	--	83	5.76
1990	275	--	--	275	1.90
1991	194	--	--	194	4.94
1992	406	170	--	406	1.72
1993	391	207	--	391	1.16
1994	392	519	--	392	0.18
1995	568	652	40	608	0.19
1996	476	766	152	628	1.17
1997	139	766	263	402	6.28
1998	4	509	312	317	2.39
1999	134	432	318	454	2.36
2000	1,046	759	420	1,481	1.03
2001	1,666	911	374	2,086	0.50
2002	443	668	154	599	2.65
2003	847	1,065	276	1,157	0.90
2004	1,246	1,014	251	1,529	0.94
2005	1,044	1,784	568	1,720	0.52
2006	1,051	1,789	710	1,926	0.20
2007	1,068	3,289	2,732	4,823	0.12
2008	1,006	1,715	638	2,228	0.34
2009	328	1,445	277	889	1.90
2010	336	1,212	362	824	0.59
2011	625	1,529	983	1,977	0.15
2012	1,152	1,769	1,120	2,476	0.30
2013	961	3,149	2,734	4,626	0.23
2014	263	1,001	637	1,005	--
2015	472	1,588	736	1,582	--
2016	744	2,204	2,851	3,995	--
2017	741	4,738	2,749	6,373	--

a The 1988 R/S estimate does not include Age-3 pre-terminal mortalities and the 2013 R/S estimate does not include recruits from the Age-5 portion of the cohort.

Recruits per spawner have been highly variable in the White River population (Table 1; Figure 3). The 1997 brood year was the most productive brood at more than 6 recruits per spawner. The least productive brood was 2007 which produced 0.1 recruits per spawner. The 2007 brood was the largest spawning escapement observed at 4,823 total spawners. There is no correlation between productivity with Green River and White River Chinook productivity (r = 0.09). However, Puyallup River and White River Chinook productivity was moderately correlated (r = 0.62). The average productivity across all brood years is 1.7 recruits per spawner whereas 1.9 recruits per spawner is the current productivity at MSY.

Commented [S13]: Please include a table with the productivity estimates.

This is trend in NOR recruits/(NOR+APP) spawners, yes? Looks strongly negative since early 2000's BYs.

Commented [S14R13]: Addressed

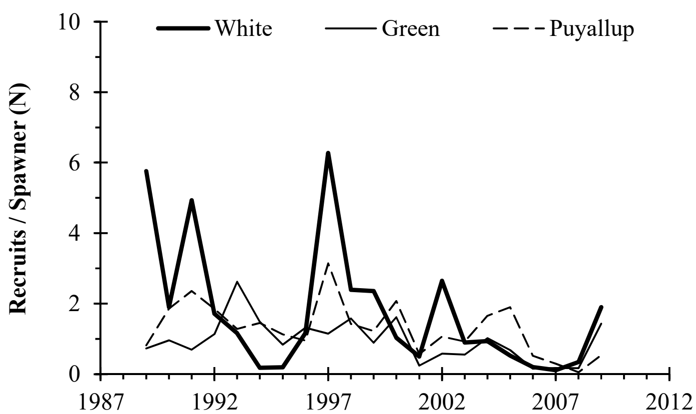


Figure 3. Trend in recruits per spawner for White River (bold line) and adjacent management unit natural origin recruits from completed brood years (1989-2009).

Harvest Distribution and Exploitation Rate Trends

White River Chinook exploitation rates are calculated based on marked fingerling release groups at the White River Hatchery from 1991-1996, which is modeled through terminal fisheries within the Terminal Area Management Module (TAMM). These set of years are out of base with most other stocks in FRAM because current production is not marked. Yearling release groups are not managed but exploitation rates can be calculated from a different set of indicator years.
As estimated by FRAM/TAMM for White River Chinook, fisheries in British Columbia and Alaska (Northern) had a combined 6% average exploitation rate, the pre-terminal southern US (PT SUS) exploitation rate averaged 6% and the terminal exploitation rate averaged 9% from 2010-2014. Pre-terminal exploitation rates declined across the series from the very high rates seen in the mid-1990s to more moderate levels seen today (Figure 4). Beginning in the late 1990s northern exploitation rates rapidly increased to near 15% but have gradually declined since. Terminal exploitation rates have increased across the series as ceremonial and subsistence fisheries were implemented by both the Muckleshoot and Puyallup tribes.

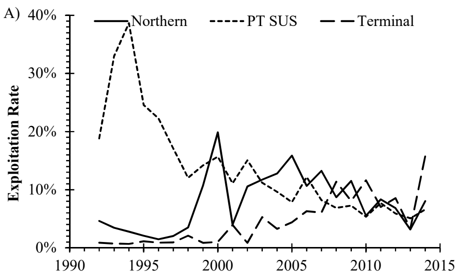


Figure 4. Trend in the A) northern (solid line), pre-terminal southern US (short dashed line), and terminal (long dashed line) exploitation rates and B) Total (dotted line), Southern US (dashed and dotted line), and terminal (long dashed line) exploitation rates on Puyallup River natural origin Chinook from 1992-2014, based on the new FRAM base period (version 8/16/17).

Management Objectives

The White River will continue to be managed for an interim Upper Management Threshold of 1,000 adult spring Chinook (NOR + APP) above Mud Mountain Dam. After upgrades to the USACE Buckley trap and haul facility which includes sorting capacity, additional fish (depending on the return) will be released upstream so increases in productivity can be measured. Increased confidence in sorting will allow managers to select the sex ratio of Chinook on the spawning grounds. Placing up to 50% females on the spawning grounds will optimize production and allow for increased certainty in productivity estimates. Based upon the Ricker stock-recruit modeling (Figure 2) and the observed relationship between spawners above Mud Mountain Dam and NOR recruits/survival (Figure 1D), approximately1,500 spring Chinook is the maximum that should be placed on the upper White River spawning grounds. NORs will have the highest priority for passage followed by APP and HOR if necessary to meet the 1,000 spawner escapement goal. These changes cannot be fully implemented until the Buckley Trap is reconstructed, and capabilities of the new facility are better understood. The Low Abundance Threshold (LAT) will be set at 40% of the escapement goal (400 adult spawners comprised of NOR and APP returns).

MSY associated with current habitat conditions is 488 (455-533 95% CI), less than half of the interim escapement goal and slightly greater than the current LAT of 400 adult Chinook. The pre-season exploitation rate management ceiling will be for a 22% Southern US ER with an assumed northern ER of 6.3% (recent 5-year average) or 9.0% (recent 10-year average) (Figure 4).

Terminal fisheries will begin to implement in-season management in the White River with in-season update models that project escapement to the White River Hatchery and Buckley Trap. This management regime will be designed to maintain at least 1,000 adult spring Chinook on the upper White River spawning grounds with as many as 1,500 to continue to test habitat capacity and ensure escapement to White River Hatchery meets program objectives. After program

Commented [CI15]: Help us to better understand what could be done now to prioritize NORs and the timeline for determining the criteria are met.

We understand that the existing adult salmon passage system presents the following hazards:

1. Injury or death at the dilapidated dam apron,
2. Injury or death in the inadequate trap,
3. Injury or death from delayed passage due to insufficient capacity of the trap and haul system, increasing exposure to the hazards at the dam apron, disease, stress, and straying, and
4. Reduced ability to sort fish due to crowding, frustrating fulfillment of current fish management goals, including maintaining the genetic integrity of the wild stock.

As a result of these hazards, fewer listed PS Chinook salmon and PS steelhead have been able to make use of high quality spawning and rearing habitats upstream of MMD. The new design is expected to be complete and operational by December of 2020.

Commented [S16]: Are NOR returns prioritized over APP returns to put upstream? We should plan for a range of escapements to continue to test the productivity and capacity of the habitat but prioritize the NOR component to maximize growth potential and take advantage of improvements.

Commented [S17R16]: Addressed

Commented [CI18R16]: Based on 2016 natural White River production estimates reported, from 658 females 2,243,122 eggs were deposited and the total outmigration estimate was 7,793. Estimated freshwater survival was 0.35%. Note that temperatures reached over 21C during the outmigration period.

Commented [CI19]: What is the relevance of this 40% to the S/R relationship for the population?

See comment under S8 in associated Questions document

Commented [CI20]: So fisheries would be managed preseason for 22% ER then when the inseason update is available, the terminal fishery would be managed to achieve a minimum of 1,000 adults above the dam, correct?

Commented [CI21]: What is the time frame for this model? What criteria will be used to determine it is sufficient? See comment S9 in associated Questions document.

Commented [CI22]: Which means what anticipated ER? Total and SUS. How is this consistent with 4d criteria B-D? The resulting total ER must allow the population to continue rebuilding based on NOR spawners. Otherwise the goal could be met with APP fish alone.

Good addition. Please see response to S10 in associated Questions document.

objectives are met, the terminal exploitation rate will not be constrained to pre-season ceilings. If escapement is forecasted to fall below the LAT, a critical exploitation rate ceiling of 15% will be implemented for the total Southern US exploitation rate and terminal fisheries directed at other species will be further shaped to reduce their impacts on Chinook.

Commented [CI23]: So the actual rate could be much higher based on fixed goal management?

Commented [CI24]: What is the basis of this rate? How will the resulting ER allow the population to rebuild above the LAT with NOR fish? Note that the average 10-14 SUS rate has been 15% under normal circumstances so would expect additional reductions would be necessary. Is the goal to reduce SUS impacts such that escapement would be at or above the LAT?

Please see response to S11 in associated Questions document.

Data Gaps/ Information Needs

Table 1. Data gaps in White River Chinook stock assessment and harvest management, and research required to address those data needs.

Data Gap	Research Needed
Uncertainty in the number of adult Chinook spawning in the White River	The current Buckley trap and haul facility is scheduled to be replaced within five years. This facility is severely constrained during large runs of pink and coho salmon. A modern facility would allow more accurate counting of all species trapped and hauled above Mud Mountain Dam.
Uncertainty in stock origin/composition of spawners above and below Mud Mountain Dam	During large pink and coho salmon runs, mark status and size are not sampled at the trap and haul facility resulting in the transportation of an unknown number of fall Chinook above Mud Mountain Dam. Increased genetic sampling on the lower White River spawning grounds is necessary to identify the numbers of spring Chinook present and their contribution.
Estimation of natural smolt production	Quantify total and tributary specific smolt production above Mud Mountain Dam.
Resolve differences between trap counts and spawner estimates above the dam	Estimate pre-spawn mortality rate of adults transported above Mud Mountain Dam, recycle rate, and mainstem spawning abundance.
Estimate the pre-spawning mortality of Chinook based on fish condition when trucked upstream	Sampling has documented large numbers of wounded Chinook in the Buckley Trap. Understanding the viability of injured Chinook on the spawning grounds is necessary to resolve differences between spawning ground estimates with the number of Chinook hauled above Mud Mountain Dam.
Uncertainty in factors governing the distribution of Chinook spawning in the White River	Comprehensive spawning ground surveys are needed to identify any interactions between Chinook salmon and other salmonids with respect to the low productivity of the natural stock.

The data gaps described above assume that the annual monitoring that is routinely done is continued. This includes sampling and enumeration at the Buckley Trap when possible, at the White River Hatchery, juvenile emigrant trapping in the lower White, and spawning ground surveys in tributaries upstream of Mud Mountain Dam including carcass sampling.

S1: What is the migration/river entry timing and spawn timing?

The following paragraph under "Life History Traits" has information on river entry and spawn timing. White River Spring Chinook enter the Puyallup River from May through mid-September, and spawn from mid-September through October.

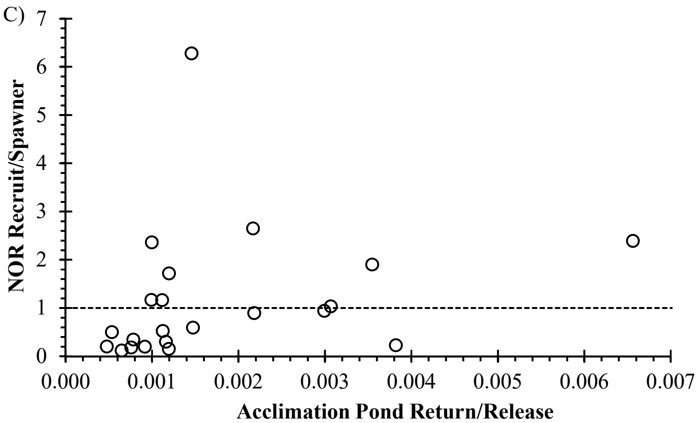
S2: What is emigration timing?

Similar to emigration timing in the Cedar, Green, and Puyallup rivers, emigration in the White River follows a bi-modal pattern with a fry peak in February/March and smolt peak in June.

S3: Is there any indication that the APP fish are outcompeting or suppressing NOR production?

There appears to be a weak positive relationship between APP survival and NOR survival across the 23 years of data since the APP was initiated (Figure 1C). Returns greater than 1 NOR adult per spawner occur from APP survivals of 0.001 to the largest observed value in the series. NOR returns less than 1, tend to form a cluster when APP survival is less than 0.001.

C)



S4: Spawners include NOR and APP fish, yes?

Spawners include NOR, APP, and HOR Chinook passed above Mud Mountain Dam. Table 1 includes NOR, HOR, and APP Chinook that are trapped at White River Hatchery or Buckley Trap and total spawners passed above Mud Mountain Dam.

Commented [CI1]: Which circles are 2009 to present? Since this is Return/release it is saying that at higher APP returns see a leveling of relationship between NORs and APP
This figure is a bit unclear.

Flow is likely related to this survival relationship. Would like to see that included. Based on the 2016 WR Juvenile Salmon Production Assessment the freshwater survival was estimated at 0.35% for 2016.

Commented [CI2]: Why passing HOR above dam? Or are these inadvertent? We understand that in years with high returns USACE stops sorting and just passes fish to reduce stress related mortality due to poor trap design. Please clarify that only NOR and APP fish were knowingly passed above the dam when sorting is possible?

S5: Please include a table with estimates for NOR, APP, HOR returns and the productivity estimates for the years available.

Table 1. Natural origin recruits (NOR), hatchery origin recruits (HOR; including both fingerling and yearling program adults), and acclimation pond program (APP) recruits that escaped pre-terminal and terminal fisheries and returned to either Buckley Trap or White River Hatchery. Passed include NORs not used for brood stock integration, APP recruits, and HORs that are surplus to White River Hatchery program goals or not sorted at the Buckley Trap and passed above Mud Mountain Dam. Number passed is a surrogate for spawners because survival and spawning of recruits passed at the Buckley Trap is not well quantified. Recruits/Spawner (R/S) includes all adult NORs caught in pre-terminal and terminal fisheries, integrated into the White River broodstock, and NORs passed above Mud Mountain Dam. Pre-terminal mortalities from the 1988-2009 brood years are based on post season FRAM validations while data for 2010-2013 brood years includes estimates from pre-season FRAM.

Commented [CI3]: Is there an estimate of the number of NORs passed above dam?

Return Year	NOR	HOR	APP	Passed	R/S[a]
1988	127	--	--	127	5.07
1989	83	--	--	83	5.76
1990	275	--	--	275	1.90
1991	194	--	--	194	4.94
1992	406	170	--	406	1.72
1993	391	207	--	391	1.16
1994	392	519	--	392	0.18
1995	568	652	40	608	0.19
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2013	961	3,149	2,734	4,626	0.23
2014	263	1,001	637	1,005	--
2015	472	1,588	736	1,582	--
2016	744	2,204	2,851	3,995	--
2017	741	4,738	2,749	6,373	--

a The 1988 R/S estimate does not include Age-3 pre-terminal mortalities and the 2013 R/S estimate does not include recruits from the Age-5 portion of the cohort.

S6: Please include a table with the productivity estimates. This is trend in NOR recruits/(NOR+APP) spawners, yes? Looks strongly negative since early 2000's BYs.

Table 1 includes recruits/spawner for the 1988-2013 brood years. 1997 is the highest R/S in the data set. There was a general trend of declining R/S beginning in 2002 but the 2009 brood year produced almost 2 R/S. Across the 12 years since 2002, NOR R/S declined an average of about 0.1 per brood, however, this general trend is evident across many stocks in Puget Sound.

S7: Are NOR returns prioritized over APP returns to put upstream? We should plan for a range of escapements to continue to test the productivity and capacity of the habitat but prioritize the NOR component to maximize growth potential and take advantage of improvements.

The 2014 biological opinion on continued operation and maintenance of the Mud Mountain Dam project states that "The existing adult collection system causes high rates of injury and mortality in the collection and handling of listed fish. Because the trap lacks sufficient capacity to handle the numbers of fish returning to the dam, and lacks up-to-date fish handling and sorting facilities, fish are delayed in finding the fishway entrance, incur injuries as they attempt to ascend the dam and trap and incur high levels of stress once they reach the trap." Once the newly constructed facility has been determined to meet the 95% attraction and 98% survival passage survival criteria, the co-managers will be able to evaluate the capacity and productivity of the upper White River watershed.

S8: What is the relevance of this 40% to the S/R relationship for the population?

This is a built in rebuilding plan. If R/S is 2.5 (generally accepted as fully functioning habitat), and spawners were to fall to 40% of MSY, the population could be rebuilt in one complete brood cycle. For the White River, we would expect a spawning escapement of 400 to produce 1,000 recruits over the course of the brood.

S9: What is the time frame for this model? What criteria will be used to determine it is sufficient?

This model is still under construction. It will use weekly terminal catch from the C&S fisheries conducted by the Muckleshoot Indian Tribe and Puyallup Indian Tribe. Weekly catches are available from both tribal net fisheries. This model will use a jackknife procedure to hind-cast escapements and compare with actual escapements.

S10: Which means what anticipated ER? Total and SUS. How is this consistent with 4d criteria B-D? The resulting total ER must allow the population to continue rebuilding based on NOR spawners. Otherwise the goal could be met with APP fish alone.

Commented [CI4]: Help us to better understand what could be done now to prioritize NORs and the timeline for determining the criteria are met. We understand that the existing adult salmon passage system presents the following hazards:

1. Injury or death at the dilapidated dam apron,
2. Injury or death in the inadequate trap,
3. Injury or death from delayed passage due to insufficient capacity of the trap and haul system, increasing exposure to the hazards at the dam apron, disease, stress, and straying, and
4. Reduced ability to sort fish due to crowding, frustrating fulfillment of current fish management goals, including maintaining the genetic integrity of the wild stock.

As a result of these hazards, fewer listed PS Chinook salmon and PS steelhead have been able to make use of high quality spawning and rearing habitats upstream of MMD. The new design is expected to be complete and operational by December of 2020.

Commented [CI5]: Please provide the analysis to demonstrate this would occur under the LAT for the White River? The productivity has been much less than 2.5.

Commented [CI6]: Please remind us of the anticipated time frame for implementation of the model. Prior discussion indicated it would be several years at best, correct? Suggest put in check point in the MUP to discuss. How will it explicitly consider the number of NORs above dam?

The current estimate of MSY is 43.5% - 49.4%. During a typical year, the total ER for White River spring Chinook is planned to be 28% - 31% depending on the magnitude of northern fisheries. This planning range is well below MSY, an ER that should provide for stable populations. MSY and spawning escapements consistent with MSY have been identified which address criteria B and the LAT proposed for this MU is designed to prevent population declines into a more critical status. Moving toward a more adaptive management strategy for the terminal area increases the likelihood that we continue rebuilding natural spawners toward the maximum productivity of the habitat. Terminal escapement goal management can and does react in-season to run sizes lower than forecast to prevent overfishing.

Commented [CI7]: Based on NOR recruitment? What will maintain the ER at 28-31% rather than a higher rate if fishing to the goal? Please provide the analysis that shows if managed for a fixed goal and the APP fish dominate it is consistent with not impeding recovery? What will maintain the ER at 28-31% rather than a higher rate if fishing to the goal?

Commented [CI8]: Our concern is that it would mask the NOR component if managing for the aggregate and with the much higher returns of APP adults, it would overharvest the NORs (see criteria D of 4d Rule).

S11: What is the basis of this rate? How will the resulting ER allow the population to rebuild above the LAT with NOR fish? Note that the average 10-14 SUS rate has been 15% under normal circumstances so would expect additional reductions would be necessary. Is the goal to reduce SUS impacts such that escapement would be at or above the LAT?

This rate, 15% SUS ER is 7% lower than under a typical year where management will fish up to 22% in SUS waters. We would assume that at lower stock abundances (<400 NOR + APP) that the northern fisheries ER would decrease below the recently observed 6%-9% range and provide further savings. The 2010-2013 APP returns were all returned above forecast while the 2014 return was well below forecast. The 2014 SUS ER was the highest (22%) among those years highlighted while the 2010-2013 ERs were typically much closer to 15%. During these years the terminal area fished to a quota which demonstrates that moving toward an adaptive framework in the terminal area will provide increased protection for the stock. It is likely that terminal fisheries would have been reduced in 2014 due to lower than expected returns. During 2014, 900 NOR + APP Chinook were passed above Mud Mountain Dam along with an additional 105 HOR Chinook.

Commented [CI9]: Please provide the analysis for impacts to NOR fish and that the LAT under a 15% SUS ER would rebuild within one generation (basis of 40%)? Escapement was much higher at SUS ERs similar to 15%. This would apply the same rate to much lower abundance.

From:	Christina Iverson - NOAA Federal
To:	Jason Schaffler; Mike Mahovlich; Chris Phinney; Losee, James P (DFW); Isabel Tinoco; Adicks, Kyle K (DFW); Warren, Ron R (DFW); Dufault, Aaron M (DFW); Robert Jones
Cc:	Susan Bishop - NOAA Federal; James Dixon
Subject:	Re: White River MUP Comments & NMFS Response
Date:	Monday, July 23, 2018 4:37:01 PM
Attachments:	Puyallup River Fall Chin MUP Changes NMFS responses 7 23 18.docx Puyallup MUP Questions comanager 070318 NMFS Response 7 23 18.docx

Hello All,

Please find the attached NMFS responses to the Puyallup River MUP Comments & Responses submitted to us for review on July 3rd. Yellow highlighting was used to indicate newly added comments/responses.

Please let us know when you would like to discuss.

Lastly, feel free to forward to anyone I may have missed in this distribution.

Best Regards,
Christina Iverson

--
Puget Sound Fishery Biologist
Sustainable Fisheries Division
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West Coast Region
510 Desmond Drive SE
Lacey, WA 98503
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White River Management Unit Status Profile

Component Populations

White River Spring Chinook

Geographic distribution

The White River is glacially influenced and was diverted into the Puyallup River in 1906 after a large flood and log jam redirected the majority of the flow into the Stuck River. This diversion was made permanent in 1915 with the construction of a concrete structure. A diversion dam was constructed on the White River at RM 23.4 for hydropower generation in 1911 along with a canal and flume system to Lake Tapps before returning flow to the White River 20 miles downstream. Hydropower production ceased in 2004 and the associated facilities and water rights were later sold to the Cascade Water Alliance for a future municipal water supply. The U.S. Army Corps of Engineers (USACE) constructed the Mud Mountain Dam at RM 29.6 in 1948 for flood control, permanently blocking anadromous access to the upper White River watershed. Chinook and other anadromous species are trapped at the diversion dam in the USACE Buckley Trap and hauled above Mud Mountain Dam. The poor condition of the diversion dam and fish trap facilities have resulted in injury, migration delay, and prespawning mortality of Chinook and other species. Within the next five years, the USACE plans to replace and upgrade both its trap and haul facilities and the diversion dam as required by a 2014 Biological Opinion.

Spring Chinook spawning above Mud Mountain Dam occurs in the mainstem White River and several tributaries including the West Fork White River, Clearwater River, Greenwater River, and Huckleberry Creek. Spring Chinook spawn below the diversion dam in the mainstem White River, Boise Creek and Salmon Creek. Spawning ground surveys are conducted in the Clearwater River, Greenwater River, Huckleberry Creek, the mainstem White River, Boise Creek, and Salmon Creek. Glacial turbidity in the mainstem White River impairs surveys in most years.

Commented [S1]: What is the migration/river entry timing and spawn timing?

Commented [S2R1]: Addressed

Life History Traits

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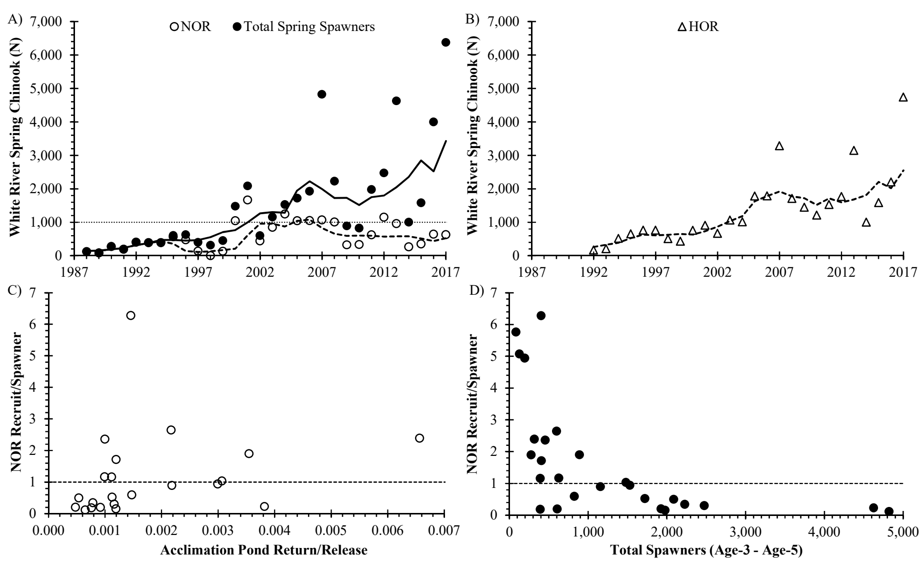

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An interim escapement goal of 1,000 spring Chinook (NOR + APP + HOR) spawners passed above the Mud Mountain dam, which does not include mainstem spawners downstream of the dam, has been the management goal under recent plans. White River spring Chinook escapements by age and origin (NOR, HOR, APP) were reconstructed from 1984-2017 resulting in complete brood year reconstructions from 1989-2013 (Table 1). A Ricker stock recruit function was fit to White River Spring Chinook spawning escapements and their subsequent broods from the 1988-2013 brood years (Figure 2). This resulted in a stock size of 488 spawners at maximum sustainable yield (MSY). To evaluate the variation around MSY, a jackknife procedure was used to estimate a 95% confidence interval (CI). The 95% CI ranged from 455-533 spawners at MSY. This implies that 805-1,054 (929 at MSY) recruits would be produced from this range of spawning escapement. The exploitation rate (ER) at MSY would be 47.5% (43.5-49.4% 95% CI). The expected maximum number of recruits in this population will be 1,165 (1,140-1,223 95% CI) under current habitat conditions. This number is expected to increase with planned upgrades at the trap and haul facility.

Commented [CI10]: Spawners include NOR and APP fish, yes?

See previous comments re intentionally passing HORs. Does not look like getting additional production out. We understand that due to the design they cannot sort when numbers are very high, thus all fish are passed via truck per USACE. This is reflected pretty steadily in the numbers reported as 'spawners' in Table 1 from 1994 to present in the odd years. Only an average of 50 NOR are kept for brood the rest are passed. What is the condition of fish passed above the dam?

Commented [S11]: Please include a table with estimates for NOR, APP, HOR returns and the productivity estimates for the years available.

Commented [S12R11]: Addressed

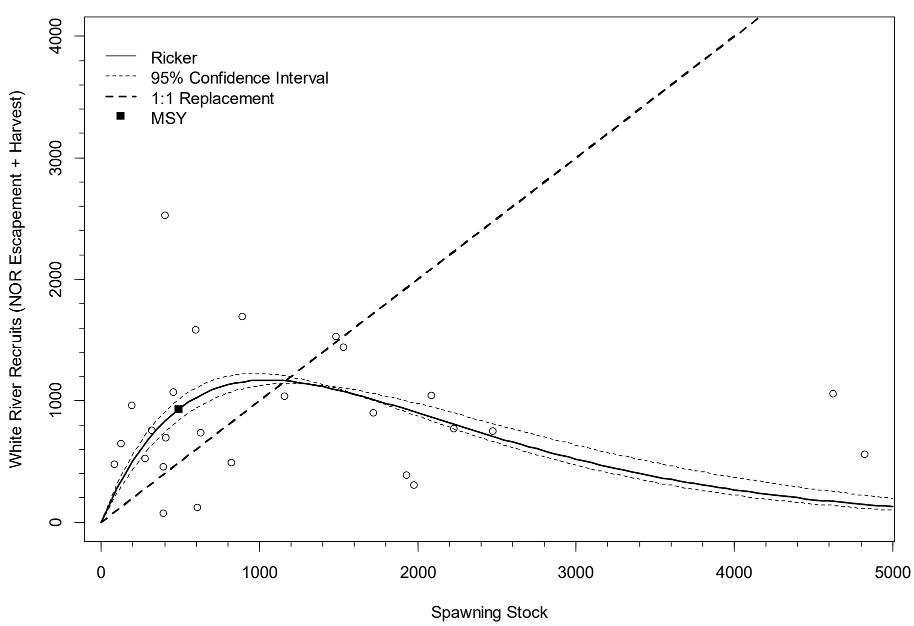

Figure 2. Ricker stock-recruit curve for White River Spring Chinook based on brood years 1988-2013. MSY is calculated from Scheuerell (2016) and results in an optimal stock size of

488 (455-533 95% CI) Chinook. The maximum number of recruits is 1,165 (1,140-1,223 95% CI).

Table 1. Natural origin recruits (NOR), hatchery origin recruits (HOR; including both fingerling and yearling program adults), and acclimation pond program (APP) recruits that escaped pre-terminal and terminal fisheries and returned to either Buckley Trap or White River Hatchery. Spawners include NOR spawners not used for brood stock integration, APP recruits, and HOR spawners that are surplus to White River Hatchery program goals or not sorted at the Buckley Trap. Recruits/Spawner (R/S) includes all adult NORs caught in pre-terminal and terminal fisheries, integrated into the White River broodstock, and NORs passed above Mud Mountain Dam. Pre-terminal mortalities from the 1988-2009 brood years are based on post season FRAM validations while data for 2010-2013 brood years includes estimates from pre-season FRAM.

Return Year	NOR	HOR	APP	Spawners	R/S[a]
1988	127	--	--	127	5.07
1989	83	--	--	83	5.76
1990	275	--	--	275	1.90
1991	194	--	--	194	4.94
1992	406	170	--	406	1.72
1993	391	207	--	391	1.16
1994	392	519	--	392	0.18
1995	568	652	40	608	0.19
1996	476	766	152	628	1.17
1997	139	766	263	402	6.28
1998	4	509	312	317	2.39
1999	134	432	318	454	2.36
2000	1,046	759	420	1,481	1.03
2001	1,666	911	374	2,086	0.50
2002	443	668	154	599	2.65
2003	847	1,065	276	1,157	0.90
2004	1,246	1,014	251	1,529	0.94
2005	1,044	1,784	568	1,720	0.52
2006	1,051	1,789	710	1,926	0.20
2007	1,068	3,289	2,732	4,823	0.12
2008	1,006	1,715	638	2,228	0.34
2009	328	1,445	277	889	1.90
2010	336	1,212	362	824	0.59
2011	625	1,529	983	1,977	0.15
2012	1,152	1,769	1,120	2,476	0.30
2013	961	3,149	2,734	4,626	0.23
2014	263	1,001	637	1,005	--
2015	472	1,588	736	1,582	--
2016	744	2,204	2,851	3,995	--
2017	741	4,738	2,749	6,373	--

a The 1988 R/S estimate does not include Age-3 pre-terminal mortalities and the 2013 R/S estimate does not include recruits from the Age-5 portion of the cohort.

Recruits per spawner have been highly variable in the White River population (Table 1; Figure 3). The 1997 brood year was the most productive brood at more than 6 recruits per spawner. The least productive brood was 2007 which produced 0.1 recruits per spawner. The 2007 brood was the largest spawning escapement observed at 4,823 total spawners. There is no correlation between productivity with Green River and White River Chinook productivity (r = 0.09). However, Puyallup River and White River Chinook productivity was moderately correlated (r = 0.62). The average productivity across all brood years is 1.7 recruits per spawner whereas 1.9 recruits per spawner is the current productivity at MSY.

Commented [S13]: Please include a table with the productivity estimates.

This is trend in NOR recruits/(NOR+APP) spawners, yes? Looks strongly negative since early 2000's BYs.

Commented [S14R13]: Addressed

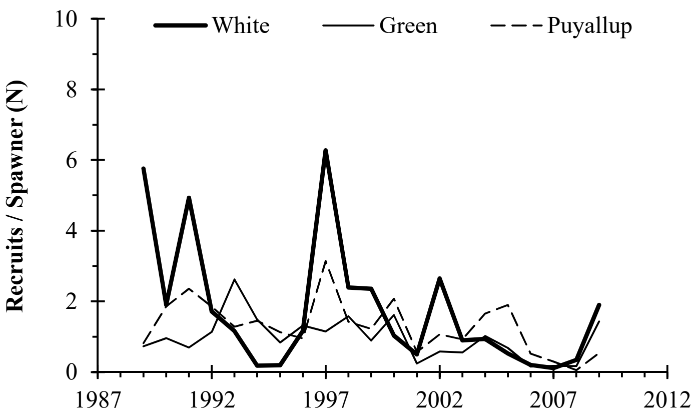

Figure 3. Trend in recruits per spawner for White River (bold line) and adjacent management unit natural origin recruits from completed brood years (1989-2009).

Harvest Distribution and Exploitation Rate Trends

White River Chinook exploitation rates are calculated based on marked fingerling release groups at the White River Hatchery from 1991-1996, which is modeled through terminal fisheries within the Terminal Area Management Module (TAMM). These set of years are out of base with most other stocks in FRAM because current production is not marked. Yearling release groups are not managed but exploitation rates can be calculated from a different set of indicator years.
As estimated by FRAM/TAMM for White River Chinook, fisheries in British Columbia and Alaska (Northern) had a combined 6% average exploitation rate, the pre-terminal southern US (PT SUS) exploitation rate averaged 6% and the terminal exploitation rate averaged 9% from 2010-2014. Pre-terminal exploitation rates declined across the series from the very high rates seen in the mid-1990s to more moderate levels seen today (Figure 4). Beginning in the late 1990s northern exploitation rates rapidly increased to near 15% but have gradually declined since. Terminal exploitation rates have increased across the series as ceremonial and subsistence fisheries were implemented by both the Muckleshoot and Puyallup tribes.

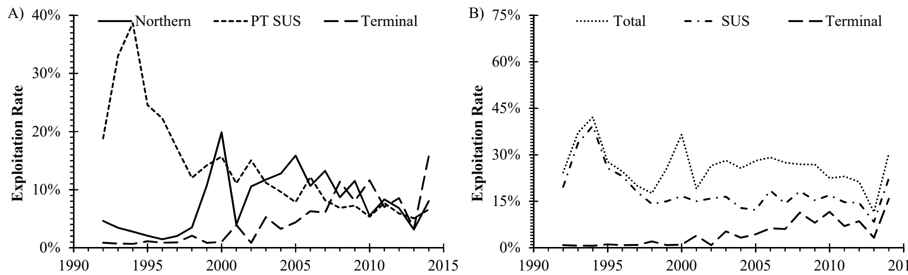

Figure 4. Trend in the A) northern (solid line), pre-terminal southern US (short dashed line), and terminal (long dashed line) exploitation rates and B) Total (dotted line), Southern US (dashed and dotted line), and terminal (long dashed line) exploitation rates on Puyallup River natural origin Chinook from 1992-2014, based on the new FRAM base period (version 8/16/17).

Management Objectives

The White River will continue to be managed for an interim Upper Management Threshold of 1,000 adult spring Chinook (NOR + APP) above Mud Mountain Dam. After upgrades to the USACE Buckley trap and haul facility which includes sorting capacity, additional fish (depending on the return) will be released upstream so increases in productivity can be measured. Increased confidence in sorting will allow managers to select the sex ratio of Chinook on the spawning grounds. Placing up to 50% females on the spawning grounds will optimize production and allow for increased certainty in productivity estimates. Based upon the Ricker stock-recruit modeling (Figure 2) and the observed relationship between spawners above Mud Mountain Dam and NOR recruits/survival (Figure 1D), approximately1,500 spring Chinook is the maximum that should be placed on the upper White River spawning grounds. NORs will have the highest priority for passage followed by APP and HOR if necessary to meet the 1,000 spawner escapement goal. These changes cannot be fully implemented until the Buckley Trap is reconstructed, and capabilities of the new facility are better understood. The Low Abundance Threshold (LAT) will be set at 40% of the escapement goal (400 adult spawners comprised of NOR and APP returns).

MSY associated with current habitat conditions is 488 (455-533 95% CI), less than half of the interim escapement goal and slightly greater than the current LAT of 400 adult Chinook. The pre-season exploitation rate management ceiling will be for a 22% Southern US ER with an assumed northern ER of 6.3% (recent 5-year average) or 9.0% (recent 10-year average) (Figure 4).

Terminal fisheries will begin to implement in-season management in the White River with in-season update models that project escapement to the White River Hatchery and Buckley Trap. This management regime will be designed to maintain at least 1,000 adult spring Chinook on the upper White River spawning grounds with as many as 1,500 to continue to test habitat capacity and ensure escapement to White River Hatchery meets program objectives. After program

Commented [CI15]: Help us to better understand what could be done now to prioritize NORs and the timeline for determining the criteria are met.

We understand that the existing adult salmon passage system presents the following hazards:

1. Injury or death at the dilapidated dam apron,
2. Injury or death in the inadequate trap,
3. Injury or death from delayed passage due to insufficient capacity of the trap and haul system, increasing exposure to the hazards at the dam apron, disease, stress, and straying, and
4. Reduced ability to sort fish due to crowding, frustrating fulfillment of current fish management goals, including maintaining the genetic integrity of the wild stock.

As a result of these hazards, fewer listed PS Chinook salmon and PS steelhead have been able to make use of high quality spawning and rearing habitats upstream of MMD. The new design is expected to be complete and operational by December of 2020.

Commented [S16]: Are NOR returns prioritized over APP returns to put upstream? We should plan for a range of escapements to continue to test the productivity and capacity of the habitat but prioritize the NOR component to maximize growth potential and take advantage of improvements.

Commented [S17R16]: Addressed

Commented [CI18R16]: Based on 2016 natural White River production estimates reported, from 658 females 2,243,122 eggs were deposited and the total outmigration estimate was 7,793. Estimated freshwater survival was 0.35%. Note that temperatures reached over 21C during the outmigration period.

Commented [CI19]: What is the relevance of this 40% to the S/R relationship for the population?

See comment under S8 in associated Questions document

Commented [CI20]: So fisheries would be managed preseason for 22% ER then when the inseason update is available, the terminal fishery would be managed to achieve a minimum of 1,000 adults above the dam, correct?

Commented [CI21]: What is the time frame for this model? What criteria will be used to determine it is sufficient? See comment S9 in associated Questions document.

Commented [CI22]: Which means what anticipated ER? Total and SUS. How is this consistent with 4d criteria B-D? The resulting total ER must allow the population to continue rebuilding based on NOR spawners. Otherwise the goal could be met with APP fish alone.

Good addition. Please see response to S10 in associated Questions document.

objectives are met, the terminal exploitation rate will not be constrained to pre-season ceilings. If escapement is forecasted to fall below the LAT, a critical exploitation rate ceiling of 15% will be implemented for the total Southern US exploitation rate and terminal fisheries directed at other species will be further shaped to reduce their impacts on Chinook.

Commented [CI23]: So the actual rate could be much higher based on fixed goal management?

Commented [CI24]: What is the basis of this rate? How will the resulting ER allow the population to rebuild above the LAT with NOR fish? Note that the average 10-14 SUS rate has been 15% under normal circumstances so would expect additional reductions would be necessary. Is the goal to reduce SUS impacts such that escapement would be at or above the LAT?

Please see response to S11 in associated Questions document.

Data Gaps/ Information Needs

Table 1. Data gaps in White River Chinook stock assessment and harvest management, and research required to address those data needs.

Data Gap	Research Needed
Uncertainty in the number of adult Chinook spawning in the White River	The current Buckley trap and haul facility is scheduled to be replaced within five years. This facility is severely constrained during large runs of pink and coho salmon. A modern facility would allow more accurate counting of all species trapped and hauled above Mud Mountain Dam.
Uncertainty in stock origin/composition of spawners above and below Mud Mountain Dam	During large pink and coho salmon runs, mark status and size are not sampled at the trap and haul facility resulting in the transportation of an unknown number of fall Chinook above Mud Mountain Dam. Increased genetic sampling on the lower White River spawning grounds is necessary to identify the numbers of spring Chinook present and their contribution.
Estimation of natural smolt production	Quantify total and tributary specific smolt production above Mud Mountain Dam.
Resolve differences between trap counts and spawner estimates above the dam	Estimate pre-spawn mortality rate of adults transported above Mud Mountain Dam, recycle rate, and mainstem spawning abundance.
Estimate the pre-spawning mortality of Chinook based on fish condition when trucked upstream	Sampling has documented large numbers of wounded Chinook in the Buckley Trap. Understanding the viability of injured Chinook on the spawning grounds is necessary to resolve differences between spawning ground estimates with the number of Chinook hauled above Mud Mountain Dam.
Uncertainty in factors governing the distribution of Chinook spawning in the White River	Comprehensive spawning ground surveys are needed to identify any interactions between Chinook salmon and other salmonids with respect to the low productivity of the natural stock.

The data gaps described above assume that the annual monitoring that is routinely done is continued. This includes sampling and enumeration at the Buckley Trap when possible, at the White River Hatchery, juvenile emigrant trapping in the lower White, and spawning ground surveys in tributaries upstream of Mud Mountain Dam including carcass sampling.

White River Management Unit Status Profile

Component Populations

White River Spring Chinook

Geographic distribution

The White River is glacially influenced and was diverted into the Puyallup River in 1906 after a large flood and log jam redirected the majority of the flow into the Stuck River. This diversion was made permanent in 1915 with the construction of a concrete structure. A diversion dam was constructed on the White River at RM 23.4 for hydropower generation in 1911 along with a canal and flume system to Lake Tapps before returning flow to the White River 20 miles downstream. Hydropower production ceased in 2004 and the associated facilities and water rights were later sold to the Cascade Water Alliance for a future municipal water supply. The U.S. Army Corps of Engineers (USACE) constructed the Mud Mountain Dam at RM 29.6 in 1948 for flood control, permanently blocking anadromous access to the upper White River watershed. Chinook and other anadromous species are trapped at the diversion dam in the USACE Buckley Trap and hauled above Mud Mountain Dam. The poor condition of the diversion dam and fish trap facilities have resulted in injury, migration delay, and prespawning mortality of Chinook and other species. Within the next five years, the USACE plans to replace and upgrade both its trap and haul facilities and the diversion dam as required by a 2014 Biological Opinion.

Spring Chinook spawning above Mud Mountain Dam occurs in the mainstem White River and several tributaries including the West Fork White River, Clearwater River, Greenwater River, and Huckleberry Creek. Spring Chinook spawn below the diversion dam in the mainstem White River, Boise Creek and Salmon Creek. Spawning ground surveys are conducted in the Clearwater River, Greenwater River, Huckleberry Creek, the mainstem White River, Boise Creek, and Salmon Creek. Glacial turbidity in the mainstem White River impairs surveys in most years.

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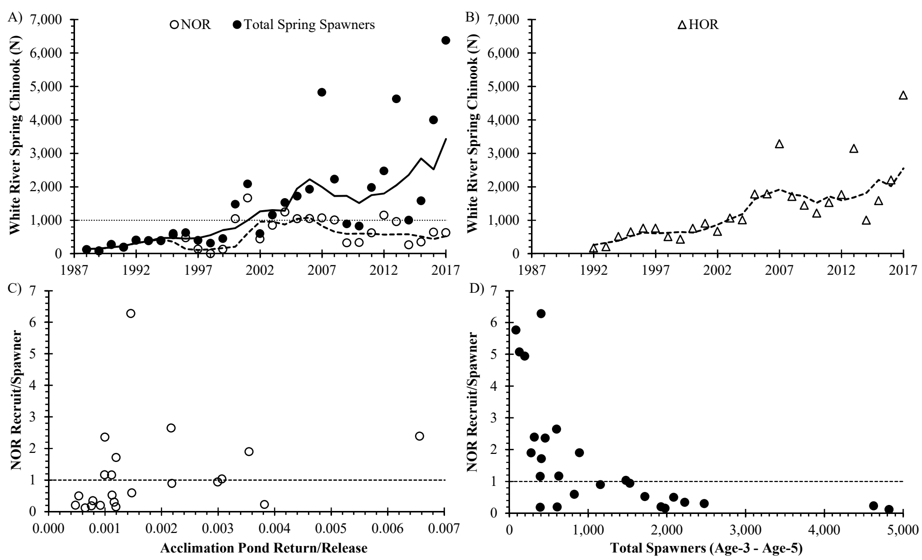


Figure 1. Observed NOR (open circle) and total spring spawning (filled circle) escapement moved above Buckley Trap (A) with 5-year running geometric mean for total escapement (solid line) and NOR escapement (dashed line). The interim escapement goal of 1,000 is

shown as a lite dashed line. Observed hatchery (fingerling + yearling) recruits (HOR) returning to the White River (B) with a 5-year running geometric mean. Relationship between NOR survival (recruits/spawner) and (C) survival (returns/release) from the APP or (D) total adult spawners passed to the spawning grounds.

An interim escapement goal of 1,000 spring Chinook (NOR + APP + HOR) spawners passed above the Mud Mountain dam, which does not include mainstem spawners downstream of the dam, has been the management goal under recent plans. White River spring Chinook escapements by age and origin (NOR, HOR, APP) were reconstructed from 1984-2017 resulting in complete brood year reconstructions from 1989-2013 (Table 1). A Ricker stock recruit function was fit to White River Spring Chinook spawning escapements and their subsequent broods from the 1988-2013 brood years (Figure 2). This resulted in a stock size of 488 spawners at maximum sustainable yield (MSY). To evaluate the variation around MSY, a jackknife procedure was used to estimate a 95% confidence interval (CI). The 95% CI ranged from 455-533 spawners at MSY. This implies that 805-1,054 (929 at MSY) recruits would be produced from this range of spawning escapement. The exploitation rate (ER) at MSY would be 47.5% (43.5-49.4% 95% CI). The expected maximum number of recruits in this population will be 1,165 (1,140-1,223 95% CI) under current habitat conditions. This number is expected to increase with planned upgrades at the trap and haul facility.

Commented [CI10]: Spawners include NOR and APP fish, yes?

See previous comments re intentionally passing HORs. Does not look like getting additional production out. We understand that due to the design they cannot sort when numbers are very high, thus all fish are passed via truck per USACE. This is reflected pretty steadily in the numbers reported as 'spawners' in Table 1 from 1994 to present in the odd years. Only an average of 50 NOR are kept for brood the rest are passed. What is the condition of fish passed above the dam?

Commented [S11]: Please include a table with estimates for NOR, APP, HOR returns and the productivity estimates for the years available.

Commented [S12R11]: Addressed

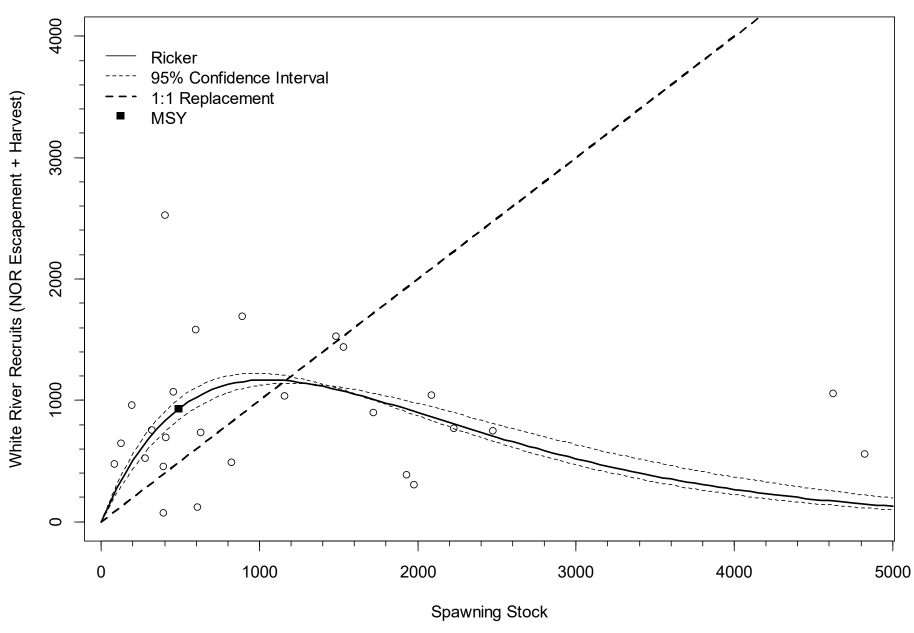


Figure 2. Ricker stock-recruit curve for White River Spring Chinook based on brood years 1988-2013. MSY is calculated from Scheuerell (2016) and results in an optimal stock size of

488 (455-533 95% CI) Chinook. The maximum number of recruits is 1,165 (1,140-1,223 95% CI).

Table 1. Natural origin recruits (NOR), hatchery origin recruits (HOR; including both fingerling and yearling program adults), and acclimation pond program (APP) recruits that escaped pre-terminal and terminal fisheries and returned to either Buckley Trap or White River Hatchery. Spawners include NOR spawners not used for brood stock integration, APP recruits, and HOR spawners that are surplus to White River Hatchery program goals or not sorted at the Buckley Trap. Recruits/Spawner (R/S) includes all adult NORs caught in pre-terminal and terminal fisheries, integrated into the White River broodstock, and NORs passed above Mud Mountain Dam. Pre-terminal mortalities from the 1988-2009 brood years are based on post season FRAM validations while data for 2010-2013 brood years includes estimates from pre-season FRAM.

Return Year	NOR	HOR	APP	Spawners	R/S[a]
1988	127	--	--	127	5.07
1989	83	--	--	83	5.76
1990	275	--	--	275	1.90
1991	194	--	--	194	4.94
1992	406	170	--	406	1.72
1993	391	207	--	391	1.16
1994	392	519	--	392	0.18
1995	568	652	40	608	0.19
1996	476	766	152	628	1.17
1997	139	766	263	402	6.28
1998	4	509	312	317	2.39
1999	134	432	318	454	2.36
2000	1,046	759	420	1,481	1.03
2001	1,666	911	374	2,086	0.50
2002	443	668	154	599	2.65
2003	847	1,065	276	1,157	0.90
2004	1,246	1,014	251	1,529	0.94
2005	1,044	1,784	568	1,720	0.52
2006	1,051	1,789	710	1,926	0.20
2007	1,068	3,289	2,732	4,823	0.12
2008	1,006	1,715	638	2,228	0.34
2009	328	1,445	277	889	1.90
2010	336	1,212	362	824	0.59
2011	625	1,529	983	1,977	0.15
2012	1,152	1,769	1,120	2,476	0.30
2013	961	3,149	2,734	4,626	0.23
2014	263	1,001	637	1,005	--
2015	472	1,588	736	1,582	--
2016	744	2,204	2,851	3,995	--
2017	741	4,738	2,749	6,373	--

a The 1988 R/S estimate does not include Age-3 pre-terminal mortalities and the 2013 R/S estimate does not include recruits from the Age-5 portion of the cohort.

Recruits per spawner have been highly variable in the White River population (Table 1; Figure 3). The 1997 brood year was the most productive brood at more than 6 recruits per spawner. The least productive brood was 2007 which produced 0.1 recruits per spawner. The 2007 brood was the largest spawning escapement observed at 4,823 total spawners. There is no correlation between productivity with Green River and White River Chinook productivity (r = 0.09). However, Puyallup River and White River Chinook productivity was moderately correlated (r = 0.62). The average productivity across all brood years is 1.7 recruits per spawner whereas 1.9 recruits per spawner is the current productivity at MSY.

Commented [S13]: Please include a table with the productivity estimates.

This is trend in NOR recruits/(NOR+APP) spawners, yes? Looks strongly negative since early 2000's BYs.

Commented [S14R13]: Addressed

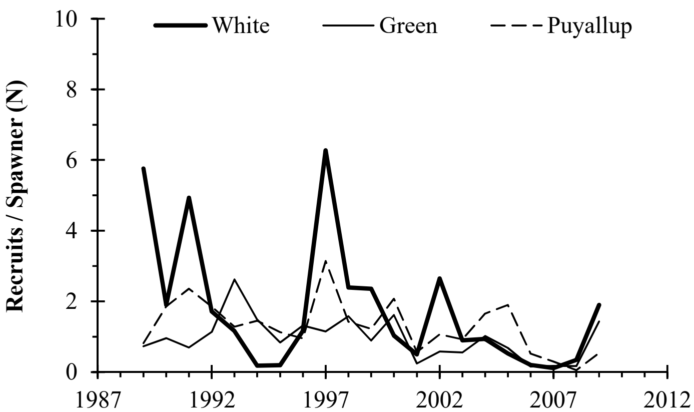


Figure 3. Trend in recruits per spawner for White River (bold line) and adjacent management unit natural origin recruits from completed brood years (1989-2009).

Harvest Distribution and Exploitation Rate Trends

White River Chinook exploitation rates are calculated based on marked fingerling release groups at the White River Hatchery from 1991-1996, which is modeled through terminal fisheries within the Terminal Area Management Module (TAMM). These set of years are out of base with most other stocks in FRAM because current production is not marked. Yearling release groups are not managed but exploitation rates can be calculated from a different set of indicator years.
As estimated by FRAM/TAMM for White River Chinook, fisheries in British Columbia and Alaska (Northern) had a combined 6% average exploitation rate, the pre-terminal southern US (PT SUS) exploitation rate averaged 6% and the terminal exploitation rate averaged 9% from 2010-2014. Pre-terminal exploitation rates declined across the series from the very high rates seen in the mid-1990s to more moderate levels seen today (Figure 4). Beginning in the late 1990s northern exploitation rates rapidly increased to near 15% but have gradually declined since. Terminal exploitation rates have increased across the series as ceremonial and subsistence fisheries were implemented by both the Muckleshoot and Puyallup tribes.

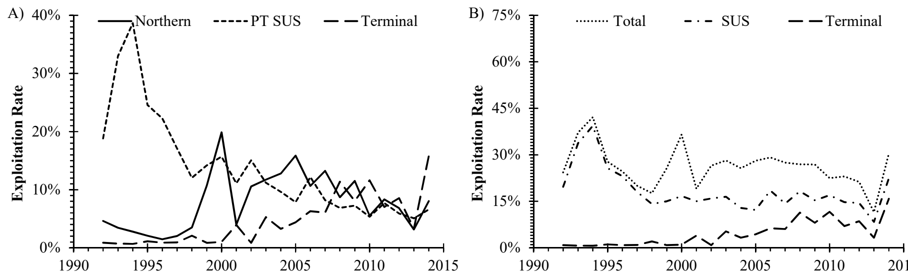


Figure 4. Trend in the A) northern (solid line), pre-terminal southern US (short dashed line), and terminal (long dashed line) exploitation rates and B) Total (dotted line), Southern US (dashed and dotted line), and terminal (long dashed line) exploitation rates on Puyallup River natural origin Chinook from 1992-2014, based on the new FRAM base period (version 8/16/17).

Management Objectives

The White River will continue to be managed for an interim Upper Management Threshold of 1,000 adult spring Chinook (NOR + APP) above Mud Mountain Dam. After upgrades to the USACE Buckley trap and haul facility which includes sorting capacity, additional fish (depending on the return) will be released upstream so increases in productivity can be measured. Increased confidence in sorting will allow managers to select the sex ratio of Chinook on the spawning grounds. Placing up to 50% females on the spawning grounds will optimize production and allow for increased certainty in productivity estimates. Based upon the Ricker stock-recruit modeling (Figure 2) and the observed relationship between spawners above Mud Mountain Dam and NOR recruits/survival (Figure 1D), approximately1,500 spring Chinook is the maximum that should be placed on the upper White River spawning grounds. NORs will have the highest priority for passage followed by APP and HOR if necessary to meet the 1,000 spawner escapement goal. These changes cannot be fully implemented until the Buckley Trap is reconstructed, and capabilities of the new facility are better understood. The Low Abundance Threshold (LAT) will be set at 40% of the escapement goal (400 adult spawners comprised of NOR and APP returns).

MSY associated with current habitat conditions is 488 (455-533 95% CI), less than half of the interim escapement goal and slightly greater than the current LAT of 400 adult Chinook. The pre-season exploitation rate management ceiling will be for a 22% Southern US ER with an assumed northern ER of 6.3% (recent 5-year average) or 9.0% (recent 10-year average) (Figure 4).

Terminal fisheries will begin to implement in-season management in the White River with in-season update models that project escapement to the White River Hatchery and Buckley Trap. This management regime will be designed to maintain at least 1,000 adult spring Chinook on the upper White River spawning grounds with as many as 1,500 to continue to test habitat capacity and ensure escapement to White River Hatchery meets program objectives. After program

Commented [CI15]: Help us to better understand what could be done now to prioritize NORs and the timeline for determining the criteria are met.

We understand that the existing adult salmon passage system presents the following hazards:

1. Injury or death at the dilapidated dam apron,
2. Injury or death in the inadequate trap,
3. Injury or death from delayed passage due to insufficient capacity of the trap and haul system, increasing exposure to the hazards at the dam apron, disease, stress, and straying, and
4. Reduced ability to sort fish due to crowding, frustrating fulfillment of current fish management goals, including maintaining the genetic integrity of the wild stock.

As a result of these hazards, fewer listed PS Chinook salmon and PS steelhead have been able to make use of high quality spawning and rearing habitats upstream of MMD. The new design is expected to be complete and operational by December of 2020.

Commented [S16]: Are NOR returns prioritized over APP returns to put upstream? We should plan for a range of escapements to continue to test the productivity and capacity of the habitat but prioritize the NOR component to maximize growth potential and take advantage of improvements.

Commented [S17R16]: Addressed

Commented [CI18R16]: Based on 2016 natural White River production estimates reported, from 658 females 2,243,122 eggs were deposited and the total outmigration estimate was 7,793. Estimated freshwater survival was 0.35%. Note that temperatures reached over 21C during the outmigration period.

Commented [CI19]: What is the relevance of this 40% to the S/R relationship for the population?

See comment under S8 in associated Questions document

Commented [CI20]: So fisheries would be managed preseason for 22% ER then when the inseason update is available, the terminal fishery would be managed to achieve a minimum of 1,000 adults above the dam, correct?

Commented [CI21]: What is the time frame for this model? What criteria will be used to determine it is sufficient? See comment S9 in associated Questions document.

Commented [CI22]: Which means what anticipated ER? Total and SUS. How is this consistent with 4d criteria B-D? The resulting total ER must allow the population to continue rebuilding based on NOR spawners. Otherwise the goal could be met with APP fish alone.

Good addition. Please see response to S10 in associated Questions document.

objectives are met, the terminal exploitation rate will not be constrained to pre-season ceilings. If escapement is forecasted to fall below the LAT, a critical exploitation rate ceiling of 15% will be implemented for the total Southern US exploitation rate and terminal fisheries directed at other species will be further shaped to reduce their impacts on Chinook.

Commented [CI23]: So the actual rate could be much higher based on fixed goal management?

Commented [CI24]: What is the basis of this rate? How will the resulting ER allow the population to rebuild above the LAT with NOR fish? Note that the average 10-14 SUS rate has been 15% under normal circumstances so would expect additional reductions would be necessary. Is the goal to reduce SUS impacts such that escapement would be at or above the LAT?

Please see response to S11 in associated Questions document.

Data Gaps/ Information Needs

Table 1. Data gaps in White River Chinook stock assessment and harvest management, and research required to address those data needs.

Data Gap	Research Needed
Uncertainty in the number of adult Chinook spawning in the White River	The current Buckley trap and haul facility is scheduled to be replaced within five years. This facility is severely constrained during large runs of pink and coho salmon. A modern facility would allow more accurate counting of all species trapped and hauled above Mud Mountain Dam.
Uncertainty in stock origin/composition of spawners above and below Mud Mountain Dam	During large pink and coho salmon runs, mark status and size are not sampled at the trap and haul facility resulting in the transportation of an unknown number of fall Chinook above Mud Mountain Dam. Increased genetic sampling on the lower White River spawning grounds is necessary to identify the numbers of spring Chinook present and their contribution.
Estimation of natural smolt production	Quantify total and tributary specific smolt production above Mud Mountain Dam.
Resolve differences between trap counts and spawner estimates above the dam	Estimate pre-spawn mortality rate of adults transported above Mud Mountain Dam, recycle rate, and mainstem spawning abundance.
Estimate the pre-spawning mortality of Chinook based on fish condition when trucked upstream	Sampling has documented large numbers of wounded Chinook in the Buckley Trap. Understanding the viability of injured Chinook on the spawning grounds is necessary to resolve differences between spawning ground estimates with the number of Chinook hauled above Mud Mountain Dam.
Uncertainty in factors governing the distribution of Chinook spawning in the White River	Comprehensive spawning ground surveys are needed to identify any interactions between Chinook salmon and other salmonids with respect to the low productivity of the natural stock.

The data gaps described above assume that the annual monitoring that is routinely done is continued. This includes sampling and enumeration at the Buckley Trap when possible, at the White River Hatchery, juvenile emigrant trapping in the lower White, and spawning ground surveys in tributaries upstream of Mud Mountain Dam including carcass sampling.

S1: What is the migration/river entry timing and spawn timing?

The following paragraph under "Life History Traits" has information on river entry and spawn timing. White River Spring Chinook enter the Puyallup River from May through mid-September, and spawn from mid-September through October.

S2: What is emigration timing?

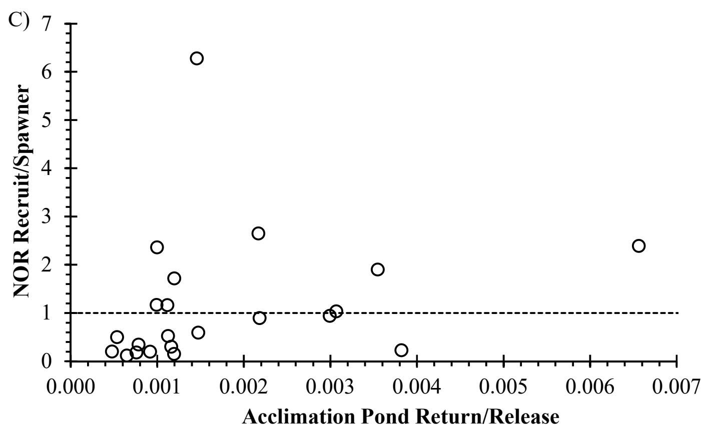
Similar to emigration timing in the Cedar, Green, and Puyallup rivers, emigration in the White River follows a bi-modal pattern with a fry peak in February/March and smolt peak in June.

S3: Is there any indication that the APP fish are outcompeting or suppressing NOR production?

Commented [CI1]: Which circles are 2009 to present? Since this is Return/release it is saying that at higher APP returns see a leveling of relationship between NORs and APP
This figure is a bit unclear.

Flow is likely related to this survival relationship. Would like to see that included. Based on the 2016 WR Juvenile Salmon Production Assessment the freshwater survival was estimated at 0.35% for 2016.

There appears to be a weak positive relationship between APP survival and NOR survival across the 23 years of data since the APP was initiated (Figure 1C). Returns greater than 1 NOR adult per spawner occur from APP survivals of 0.001 to the largest observed value in the series. NOR returns less than 1, tend to form a cluster when APP survival is less than 0.001.



S4: Spawners include NOR and APP fish, yes?

Commented [CI2]: Why passing HOR above dam? Or are these inadvertent? We understand that in years with high returns USACE stops sorting and just passes fish to reduce stress related mortality due to poor trap design. Please clarify that only NOR and APP fish were knowingly passed above the dam when sorting is possible?

Spawners include NOR, APP, and HOR Chinook passed above Mud Mountain Dam. Table 1 includes NOR, HOR, and APP Chinook that are trapped at White River Hatchery or Buckley Trap and total spawners passed above Mud Mountain Dam.

S5: Please include a table with estimates for NOR, APP, HOR returns and the productivity estimates for the years available.

Table 1. Natural origin recruits (NOR), hatchery origin recruits (HOR; including both fingerling and yearling program adults), and acclimation pond program (APP) recruits that escaped pre-terminal and terminal fisheries and returned to either Buckley Trap or White River Hatchery. Passed include NORs not used for brood stock integration, APP recruits, and HORs that are surplus to White River Hatchery program goals or not sorted at the Buckley Trap and passed above Mud Mountain Dam. Number passed is a surrogate for spawners because survival and spawning of recruits passed at the Buckley Trap is not well quantified. Recruits/Spawner (R/S) includes all adult NORs caught in pre-terminal and terminal fisheries, integrated into the White River broodstock, and NORs passed above Mud Mountain Dam. Pre-terminal mortalities from the 1988-2009 brood years are based on post season FRAM validations while data for 2010-2013 brood years includes estimates from pre-season FRAM.

Return Year	NOR	HOR	APP	Passed	R/S[a]
1988	127	--	--	127	5.07
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2015	472	1,588	736	1,582	--
2016	744	2,204	2,851	3,995	--
2017	741	4,738	2,749	6,373	--

Commented [CI3]: Is there an estimate of the number of NORs passed above dam?

a The 1988 R/S estimate does not include Age-3 pre-terminal mortalities and the 2013 R/S estimate does not include recruits from the Age-5 portion of the cohort.

S6: Please include a table with the productivity estimates. This is trend in NOR recruits/(NOR+APP) spawners, yes? Looks strongly negative since early 2000's BYs.

Table 1 includes recruits/spawner for the 1988-2013 brood years. 1997 is the highest R/S in the data set. There was a general trend of declining R/S beginning in 2002 but the 2009 brood year produced almost 2 R/S. Across the 12 years since 2002, NOR R/S declined an average of about 0.1 per brood, however, this general trend is evident across many stocks in Puget Sound.

S7: Are NOR returns prioritized over APP returns to put upstream? We should plan for a range of escapements to continue to test the productivity and capacity of the habitat but prioritize the NOR component to maximize growth potential and take advantage of improvements.

Commented [CI4]: Help us to better understand what could be done now to prioritize NORs and the timeline for determining the criteria are met. We understand that the existing adult salmon passage system presents the following hazards:

1. Injury or death at the dilapidated dam apron,
2. Injury or death in the inadequate trap,
3. Injury or death from delayed passage due to insufficient capacity of the trap and haul system, increasing exposure to the hazards at the dam apron, disease, stress, and straying, and
4. Reduced ability to sort fish due to crowding, frustrating fulfillment of current fish management goals, including maintaining the genetic integrity of the wild stock.

As a result of these hazards, fewer listed PS Chinook salmon and PS steelhead have been able to make use of high quality spawning and rearing habitats upstream of MMD. The new design is expected to be complete and operational by December of 2020.

The 2014 biological opinion on continued operation and maintenance of the Mud Mountain Dam project states that "The existing adult collection system causes high rates of injury and mortality in the collection and handling of listed fish. Because the trap lacks sufficient capacity to handle the numbers of fish returning to the dam, and lacks up-to-date fish handling and sorting facilities, fish are delayed in finding the fishway entrance, incur injuries as they attempt to ascend the dam and trap and incur high levels of stress once they reach the trap." Once the newly constructed facility has been determined to meet the 95% attraction and 98% survival passage survival criteria, the co-managers will be able to evaluate the capacity and productivity of the upper White River watershed.

S8: What is the relevance of this 40% to the S/R relationship for the population?

Commented [CI5]: Please provide the analysis to demonstrate this would occur under the LAT for the White River? The productivity has been much less than 2.5.

This is a built in rebuilding plan. If R/S is 2.5 (generally accepted as fully functioning habitat), and spawners were to fall to 40% of MSY, the population could be rebuilt in one complete brood cycle. For the White River, we would expect a spawning escapement of 400 to produce 1,000 recruits over the course of the brood.

S9: What is the time frame for this model? What criteria will be used to determine it is sufficient?

Commented [CI6]: Please remind us of the anticipated time frame for implementation of the model. Prior discussion indicated it would be several years at best, correct? Suggest put in check point in the MUP to discuss. How will it explicitly consider the number of NORs above dam?

This model is still under construction. It will use weekly terminal catch from the C&S fisheries conducted by the Muckleshoot Indian Tribe and Puyallup Indian Tribe. Weekly catches are available from both tribal net fisheries. This model will use a jackknife procedure to hind-cast escapements and compare with actual escapements.

S10: Which means what anticipated ER? Total and SUS. How is this consistent with 4d criteria B-D? The resulting total ER must allow the population to continue rebuilding based on NOR spawners. Otherwise the goal could be met with APP fish alone.

The current estimate of MSY is 43.5% - 49.4%. During a typical year, the total ER for White River spring Chinook is planned to be 28% - 31% depending on the magnitude of northern fisheries. This planning range is well below MSY, an ER that should provide for stable populations. MSY and spawning escapements consistent with MSY have been identified which address criteria B and the LAT proposed for this MU is designed to prevent population declines into a more critical status. Moving toward a more adaptive management strategy for the terminal area increases the likelihood that we continue rebuilding natural spawners toward the maximum productivity of the habitat. Terminal escapement goal management can and does react in-season to run sizes lower than forecast to prevent overfishing.

Commented [CI7]: Based on NOR recruitment? What will maintain the ER at 28-31% rather than a higher rate if fishing to the goal? Please provide the analysis that shows if managed for a fixed goal and the APP fish dominate it is consistent with not impeding recovery? What will maintain the ER at 28-31% rather than a higher rate if fishing to the goal?

Commented [CI8]: Our concern is that it would mask the NOR component if managing for the aggregate and with the much higher returns of APP adults, it would overharvest the NORs (see criteria D of 4d Rule).

S11: What is the basis of this rate? How will the resulting ER allow the population to rebuild above the LAT with NOR fish? Note that the average 10-14 SUS rate has been 15% under normal circumstances so would expect additional reductions would be necessary. Is the goal to reduce SUS impacts such that escapement would be at or above the LAT?

This rate, 15% SUS ER is 7% lower than under a typical year where management will fish up to 22% in SUS waters. We would assume that at lower stock abundances (<400 NOR + APP) that the northern fisheries ER would decrease below the recently observed 6%-9% range and provide further savings. The 2010-2013 APP returns were all returned above forecast while the 2014 return was well below forecast. The 2014 SUS ER was the highest (22%) among those years highlighted while the 2010-2013 ERs were typically much closer to 15%. During these years the terminal area fished to a quota which demonstrates that moving toward an adaptive framework in the terminal area will provide increased protection for the stock. It is likely that terminal fisheries would have been reduced in 2014 due to lower than expected returns. During 2014, 900 NOR + APP Chinook were passed above Mud Mountain Dam along with an additional 105 HOR Chinook.

Commented [CI9]: Please provide the analysis for impacts to NOR fish and that the LAT under a 15% SUS ER would rebuild within one generation (basis of 40%)? Escapement was much higher at SUS ERs similar to 15%. This would apply the same rate to much lower abundance.

From:	Susan Bishop - NOAA Federal
To:	Christopher Ellings; Adicks, Kyle K (DFW); dave troutt; Craig Smith; Jones, Robert
Cc:	Warren, Ron R (DFW); Craig.Busack; Barry Berejikian; Chris James; Craig Bowhay; Peter Dygert; Sheila Lynch
Subject:	NOAA Fisheries Comments: Nisqually River MUP and Stock Management Plan for Nisqually Chinook
Date:	Saturday, January 27, 2018 11:18:12 AM
Attachments:	Nisqually River Management Unit Status Profile_012618.docx NisquallyFCR_Final_12042017-NOAAF comments.docx

Good morning,

Please find attached NOAA Fisheries comments on the Nisqually MUP from the December 1 version of the Puget Sound Chinook Harvest Management Plan (RMP) and the December 4 version of the Stock Management Plan for Nisqually Fall Chinook Recovery (SMP).

My comments relate to several primary themes:

(1) The MUP should better reflect the framework in the SMP. The SMP provides the long term context for the proposed management framework in the MUP. In particular how it addresses 4d criteria B-D and the risk to the NOR component of the population. The pieces are all there in the SMP.

(2) LAT and CERC. The definition and specifics of the LAT and CERC do not seem consistent with how they are defined in the main text of the RMP. Based on recent average ERS in northern fisheries, total exploitation rates could be between the low 30%s and mid 40%s depending on the level of reduction which do not seem consistent the description of extraordinary measures taken when abundance is below the LAT. It is unclear how the natural spawners or NOR spawners are considered in the LAT, e.g., would the LAT of 7000 be satisfied if it were all hatchery returns? The 2014 agreement for the CERC indicated it would a minimum reduction of 50% in the SUS which seems more consistent with the description of the LAT.

(3) What is the UMT (see criteria B of the 4d Rule)?

(4) More information on the proposed treaty commercial fishery. The basis of the proposed 2%, how it will be assessed and development of the implementation plan prior to its 2018 implementation.

(5) More discussion, detail and clarification regarding some of the monitoring programs in the MUP and SMP. In particular, the parentage study and monitoring of the selective fishery components of the harvest strategy. For example, the parentage study is a positive addition and a critical component of a rigorous evaluation of the program. However, key aspects of the program appear 'dependent on the ability to obtain funding'. So it is difficult to understand in a couple of cases what will and will not be done with respect to the some key monitoring programs. Same with fishery monitoring. We suggest further technical discussion for some of these programs as well to clarify goals and implementation.

(6) The SMP is clearly written and does a good job of explaining the rationale, context and strategy for a long-term transitional strategy. Most of our comments relate to clarification, consistency among the different sections of the document, clearer acknowledgement in some places that, given the years it may take to get there, the hatchery strategy and methodology in phases after colonization will depend on the best available science, and echos the many of the themes above.

I will be on leave next week. Please forward to others I may have missed. See you all on February 7th.
Susan

--
Susan Bishop
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NOAA Fisheries Service WCR - Sustainable Fisheries Division
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Nisqually River Management Unit Status Profile

Component Populations

Nisqually River fall-run Chinook

Commented [S1]: The MUP needs to better crosswalk with the SMP for Nisqually Chinook and should be included as an appendix to the RMP. For example, the check-ins in the SMP indicate a transition to the local adaptation phase within the 10 years of this plan is possible and that could change the harvest management provisions. It also includes more detail on the specifics and context of the harvest management provisions than are included in the MUP.

It is the full package of all H provisions in the SMP that define the long-term transition strategy which provides the justification and underlying rationale for the acceptability of the higher risk in the short term from harvest.

Geographic Description

Adult Chinook ascend the mainstem of the Nisqually River to river mile 42.5, where migration is blocked by the La Grande and Alder hydroelectric complex, which was constructed by the City of Tacoma's public utility in 1945. Below La Grande the river flows to the northwest across a broad and flat valley floor, characterized by mixed coniferous and deciduous forest and cleared agricultural land. Between river miles 5.5 and 11 the river runs through the Nisqually Indian Reservation, and between river miles 11 and 19 through the largely undeveloped Fort Lewis military reservation. At river mile 26 flow is diverted into the Yelm Power Canal, which carries the water downstream to the Centralia powerhouse, where the flow returns to the mainstem at river mile 12. A fish ladder provides passage over the diversion. The Federal Energy Regulatory Commission licenses issued to Tacoma and Centralia require maintenance of minimum flows in the mainstem Nisqually.

Chinook spawn in the mainstem above river mile 3, in numerous side channels, in the lower reaches of the Mashel River and in several tributaries, if flow allows.

Life History Traits

Run Timing

Table 1. Run timing distribution for various life stages of Nisqually River fall-run Chinook salmon.

Nisqually Chinook	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
River entry (fishery)												
Spawn timing												
Emergence timing												
FW Outmigration												

Table 2. Nisqually Chinook Age Composition.

Marked	Age 2	Age 3	Age 4	Age 5	Unmarked	Age 2	Age 3	Age 4	Age 5
2004	25.2%	23.9%	47.4%	3.5%	2004	22.4%	15.2%	60.2%	2.2%
2005	16.4%	56.4%	23.5%	3.7%	2005	12.5%	52.9%	24.9%	9.7%
2006	27.3%	47.6%	24.9%	0.2%	2006	31.7%	37.7%	30.6%	0.0%
2007	17.6%	63.0%	18.6%	0.8%	2007	12.5%	66.3%	20.4%	0.8%
2008	22.8%	31.1%	45.6%	0.5%	2008	12.1%	28.6%	59.0%	0.3%
2009	35.8%	31.0%	33.1%	0.0%	2009	30.0%	25.1%	44.5%	0.4%
2010	5.9%	76.2%	17.8%	0.1%	2010	5.4%	75.0%	19.6%	0.0%
2011	26.2%	16.3%	56.8%	0.7%	2011	18.6%	19.3%	61.6%	0.5%
2012	11.2%	65.4%	22.4%	1.1%	2012	6.3%	54.8%	37.2%	1.7%
2013	11.1%	40.6%	47.7%	0.6%	2013	10.7%	33.8%	55.5%	0.0%
2014	11.6%	41.1%	44.4%	2.8%	2014	8.4%	49.1%	38.6%	3.9%
average	19.2%	44.8%	34.7%	1.3%	average	15.5%	41.6%	41.1%	1.8%

Nisqually River Chinook juveniles primarily migrate downstream as sub-yearlings in two distinct modes, an early fry component and a later parr component (Klungle et al. in prep). The fry component rears in the Nisqually Delta for over a month before migrating offshore in late June (Ellings and Hodgson 2007) Nisqually Chinook parr outmigrate in June through July and move quickly through the river and estuary.

Population Status

In determining the status of the Nisqually fall Chinook population, several parameters are considered: productivity, abundance, spatial diversity, and life-history diversity. Collectively these parameters describe attributes of viable salmonid populations (VSP).

The average number of natural-origin adult returns (adults returning to the Nisqually River) has been less than 1,000 Chinook in recent years, following two strong returns in 2007 and 2008 (Figure 1). Natural-origin natural spawning escapement has been relatively stable despite declining natural-origin adult runs to the river (Figure 1). The number of hatchery-origin Chinook escaping to natural spawning areas declined beginning in 2013, likely in response to changes in operation of the fish ladders to the hatcheries and poor survival of hatchery Chinook in some of the years. Beginning in 2013, the fish ladders were kept open at the Kalama and Clear Creek hatcheries for the entire adult migration period. Prior to 2013, the ladders were closed during the first part of the adult migration and then only opened for short periods during the season to meet hatchery broodstock collection needs.

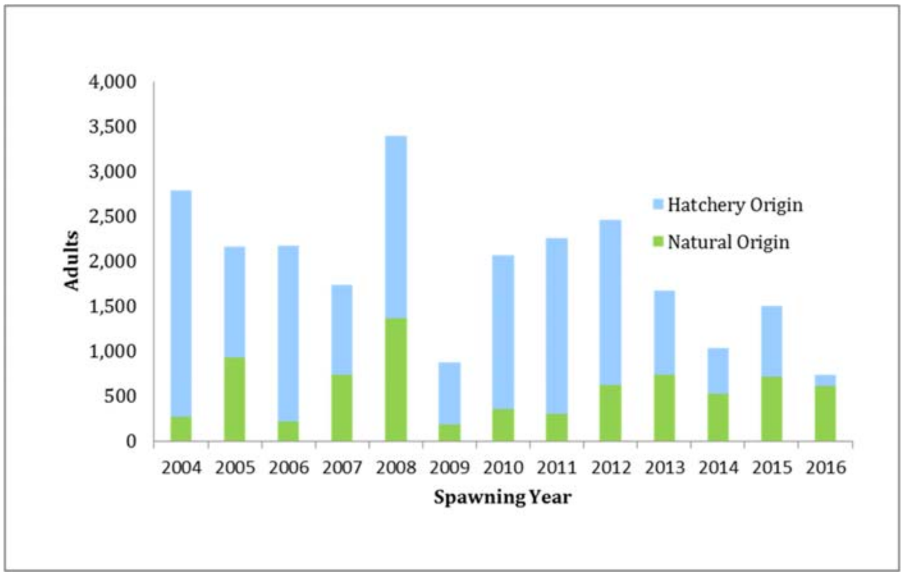


Figure 1. Natural Spawning Escapement of Natural-Origin and Hatchery-Origin Chinook. Source: Nisqually Chinook run reconstruction ISIT file (January 2017).

Commented [S2]: Same numbers as in Table 2 of Appendix 1, yes?

Estimated annual natural production of juvenile Chinook (subyearling and yearling), estimated by WDFW since 2009 in terms of outmigrant juveniles at RM 12.8, has varied from less than 3,000 fish in 2016 to over 400,000 fish in 2009 (Figure 2). The high estimated abundance in 2009 of subyearlings followed the highest estimated natural spawning escapement of nearly 3,500 Chinook in the fall of 2008 (Figure 3).

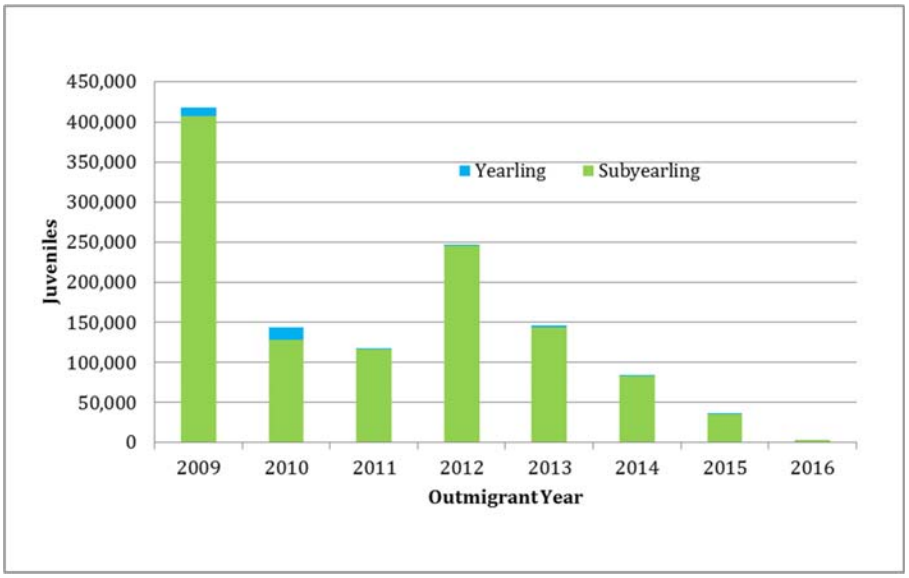


Figure 2. Estimated Annual Juvenile (Subyearling and Yearling) Chinook Abundance at RM 12.8. Source: Klungle et al. in prep

Commented [S3]: Is this information provided in Appendix 1 of the SMP?

Juvenile recruits per spawner, as estimated by the number of sub-yearling and yearling juveniles divided by the number of naturally spawning Chinook (hatchery- and natural-origin), has varied from a low of 2.0 recruits per spawner from the 2015 brood year to 150 recruits per spawner from the 2009 brood year (Figure 3). Compared to the Skagit River, a watershed with an abundant Chinook population and long-time series, where the range of out-migrants per female spawners varied from 270 to 1,230 out-migrants per female (Zimmerman et al. 2015) the Nisqually River Chinook productivity is much lower. Assuming a 1:1 sex ratio for Nisqually River Chinook, the number of juvenile recruits per female spawner ranged 4.0 to 300, with a geometric mean freshwater productivity of 93. The extremely low juvenile abundance in 2016 was the likely result of poor in-river environmental conditions during adult migration and spawning in the parent year (fall of 2015). In the fall of 2015, Nisqually River water temperatures exceeded 20˚C during the first half of the adult migration. A thermal barrier in the Centralia Diversion Dam reach just upstream of the WDFW outmigrant trap location affected upstream movement of migrating Chinook.

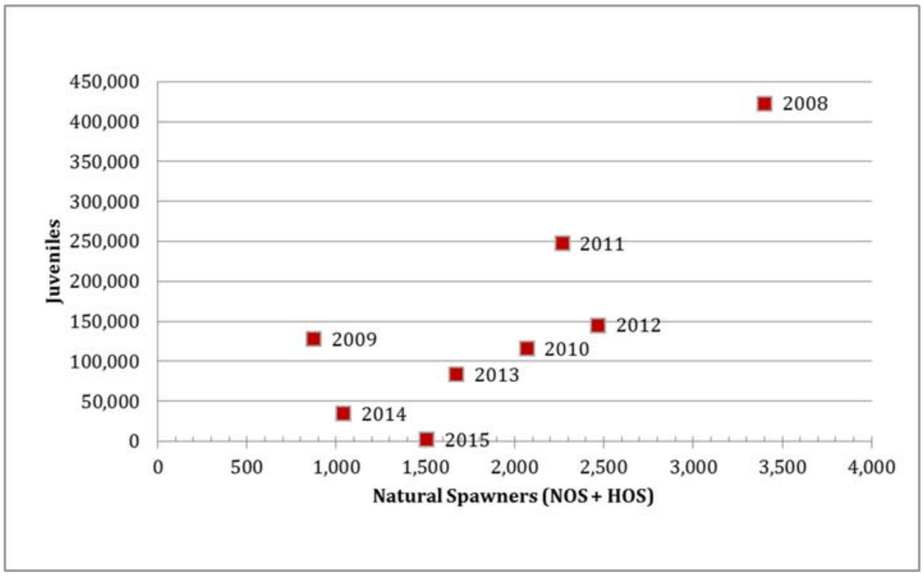


Figure 3. Juvenile Recruits per Spawner (brood years shown). Source: NIT and WDFW year pending.

Commented [S4]: Consistent with Appendix 1 of SMP?

Adult recruits per natural spawner has varied from 0.2 to 1.5 from 2004 to 2011. Adult recruitment exceeded replacement (recruits per spawner greater than 1.0) in just two brood years (2004 and 2009) over the eight-year period (Figure 4). An assessment of habitat potential using the Ecosystem Diagnosis and Treatment (EDT) model suggests observed population performance is much less than habitat potential for the watershed.

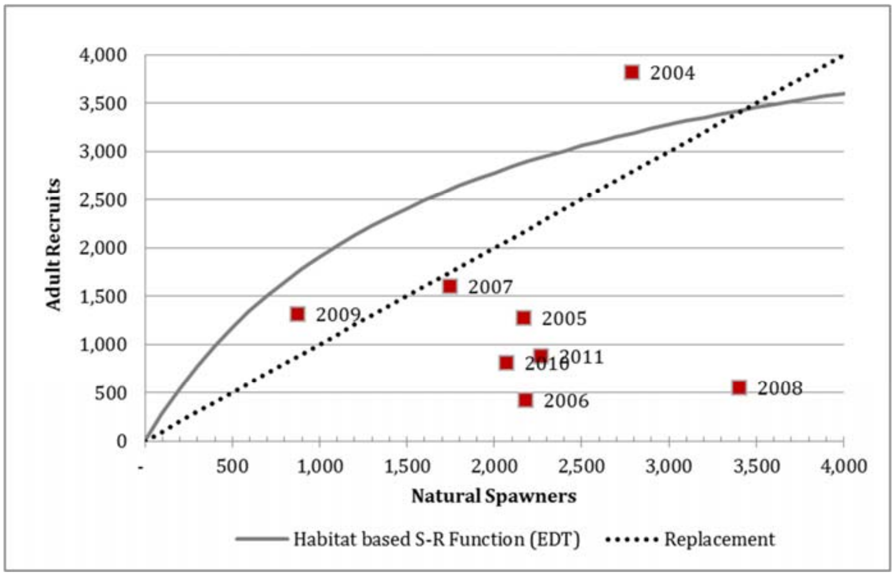


Figure 4. Natural-Origin Adult Recruits per Spawner (brood years shown). Source: Pending.

Taking these various aspects of VSP parameters into consideration, the Nisqually technical work group agreed that, based on the HSRG recovery phase framework, the population status is in the Colonization phase and management priorities should focus on substantially increasing natural-origin fish (NIT and WDFW, in draft).

Hatchery Programs

The Nisqually River watershed, like most of southern Puget Sound, has a long history of hatchery enhancement. Hatchery production is currently necessary for sustaining harvest that natural production cannot support due to habitat degradation and reduced population productivity. The Tribe initiated hatchery production in 1979 at Kalama Creek Hatchery and 1990 at Clear Creek Hatchery with the sole purpose of supporting harvest. The 2017 Nisqually Stock Recovery Plan identifies hatchery program objectives for the current population status (NSIT 2017). Under that plan, release strategies will include 3.0 million sub-yearling releases from Kalama Creek Hatchery and Clear Creek Hatchery combined, as well as 1.0 million off-station releases at McAllister Creek (NSIT 2017). Changes to the hatchery program are envisioned, dependent on evaluation of population status (NSIT 2017).

Habitat Limiting Factors

Since the implementation of the original Nisqually Chinook Recovery Plan (Nisqually Chinook Recovery Team 2001), major habitat restoration initiatives have been accomplished in core areas while efforts have continued to protect existing habitat and evaluate restoration activities. Habitat monitoring and evaluation efforts have generated new insights into the status of core habitat-forming processes in the watershed and led to the development of large-scale restoration and protection initiatives. However, Nisqually Chinook have the longest migration through Puget Sound of all the core populations in the ESU, making their successful recovery dependent on habitat recovery throughout the region.

The *Nisqually Chinook Recovery Plan* (Nisqually Chinook Recovery Team 2001) contained an action plan that outlined specific restoration and protection priorities. The action plan, which was guided by Ecosystem Diagnostic and Treatment (EDT) model results, identified the following general priority areas: the Nisqually delta, portions of the Nisqually mainstem, Ohop Creek, and the Mashel River. We continue to work on actions listed in the 2001 plan and to refine the habitat priorities through research, assessments, monitoring, and evaluation. Juvenile Chinook sampling since 2001 has indicated that the nearshore areas adjacent to the Nisqually Delta are important for Chinook rearing and migration. Additionally, several nearshore assessments have been completed, including the Nisqually to Point Defiance Nearshore Habitat Assessment and now consider South Sound Nearshore habitat protection and restoration to be a high priority. The continued evaluation of key physical processes in the watershed have resulted in the identification of critical large-scale initiatives that need to occur for recovery of essential salmon habitat.

Extensive post-restoration research by the Tribe, USGS, and others of the restoration of 900 acres of the Nisqually Delta identified altered physical processes (river flow control, reduced sediment inputs) and the 100-year history of subsidence since initial diking threaten to undermine the recovery trajectory of the Nisqually Delta (Curran et al. 2016). When viewed in light climate change and sea level this threat is even greater. In order to alleviate the sediment deficit, the routing of sediment needs to be improved through I-5 and more sediment needs to make it through Alder and LaGrande Reservoirs. These projects will cost more than $1 billion but are critical for the long-term recovery of Chinook.

The Mashel River, identified by both the *Nisqually Chinook Recovery Plan* (Nisqually Chinook Recovery Team 2001) and the *Draft Nisqually Winter Steelhead Recovery Plan* (Nisqually Steelhead Recovery Team 2014), is the most important tributary for Chinook and steelhead recovery in the “tributary poor” Nisqually watershed. The Mashel watershed has been decimated by commercial forestry operations for over a century. To date, recovery actions in the Mashel have consisted of constructing engineered log jams and land acquisition in the lower Mashel. This large-scale, multimillion-dollar effort has been extremely successful at increasing instream habitat diversity, restoring riparian zones, and reducing channel confinement. However, continued and future degradation of watershed processes in the upper watershed threatens to negate the progress already made and makes recovery of Nisqually salmon improbable. In response, the Nisqually Land Trust, Nisqually Indian Tribe, Nisqually River Council, and others have launched the Nisqually Community Forest Initiative. The goal of the initiative is to purchase much of the privately held timberlands in the upper Mashel and manage them for long-term ecosystem services recovery and sustainable local economies. This initiative will cost nearly $200 million and take decades to come to fruition.

The location of the Nisqually River in South Puget Sound makes the Nisqually fall Chinook stock arguably the most dependent on the Puget Sound ecosystem out of all the 27 stocks listed in the Puget Sound Chinook ESU. Juvenile Nisqually Chinook need functional nearshore habitat as well as offshore-based prey resources to feed, grow, and survive during their lengthy migration to the Pacific. Additionally, returning adults must have forage fish throughout Puget Sound to put on growth essential for the arduous river migration and spawning stages of their life history. The cumulative effect of marine mammal predation on juveniles and adult Nisqually Chinook is yet another impact magnified by their lengthy traverse through the Sound.
The effort to protect and restore salmon habitat in the Nisqually River has been incredibly successful in the face of persistent human population pressure, insufficient funding, and wavering political will. While the current condition of the Nisqually watershed is more conducive to salmon recovery than it was just 20 years ago, the need for massive investments in watershed process– based recovery still remains. EDT modeling indicates that the improvements made since implementation of the 2001 plan have resulted in increases of 31%, 58%, and 82% in productivity, capacity, and abundance, respectively (Figure 5). However, even larger jumps in Nisqually Chinook population performance can be expected from successful implementation of large-scale habitat initiatives, including recovery of sediment delivery and channel migration in the Delta and changing management of the forestland in the Mashel watershed to focus on ecosystem services and watershed processes. The long road to a viable, self-sustaining, and productive Nisqually Chinook population starts at the watershed but will ultimately depend on sustained and aggressive actions to recover the Puget Sound ecosystem.

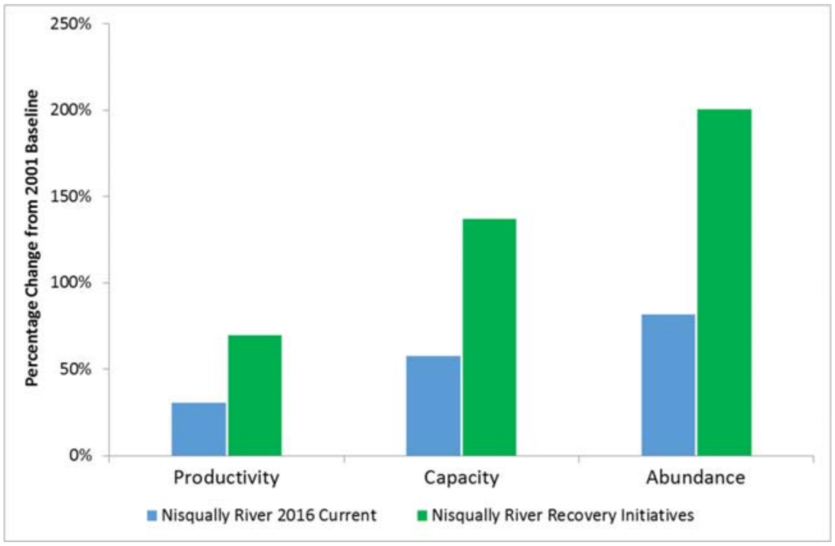


Figure 5. Modeled Improvements in Nisqually Chinook Population Performance. Source: Pending

Harvest distribution and Exploitation rate trends

Terminal harvest of unmarked Chinook has decreased since 2009 consistent with terminal harvest objectives described in the *Puget Sound Chinook Comprehensive Management Plan* (PSIT and WDFW 2010). FRAM-based reporting of total exploitation rates shows a decrease from approximately 70% in 2008 and 2009 to 50% or less in recent years (Figure 6). This decrease has been primarily from reductions in the terminal treaty fishery; recent year (2012–2014) terminal rates averaged 27% compared to an average rate of 49% from 2008 to 2010 (Figure 7). SUS pre-terminal impact has seen a positive trend since 2011 (Figure 8). From 2011 to 2015, the average terminal harvest rate among treaty and non-treaty sportfishers was 35.2% (±.12.2 S.D.).

Pre-terminal (fisheries operating outside of the Nisqually River) exploitation rates have tended be stable over the period, averaging 21% (Figure 6).

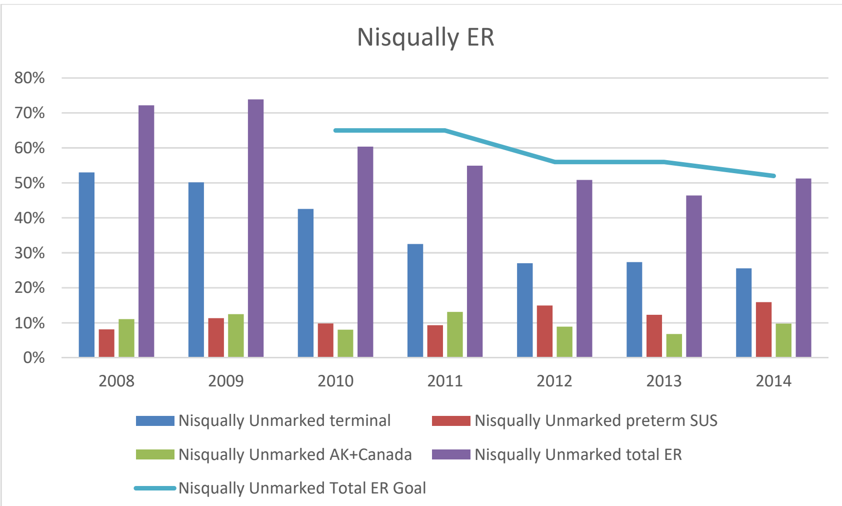


Figure 6. Exploitation Rates on Unmarked Nisqually Chinook. Source: FRAM Validation August 2017

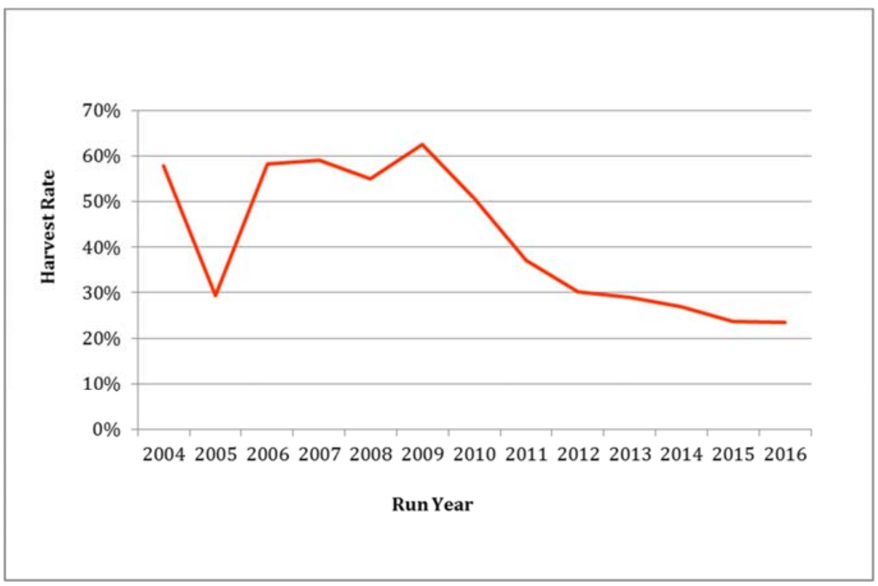


Figure 7. Nisqually Treaty Net Harvest Rates on Unmarked Chinook. Source: Nisqually Chinook run reconstruction ISIT file (January 2017).

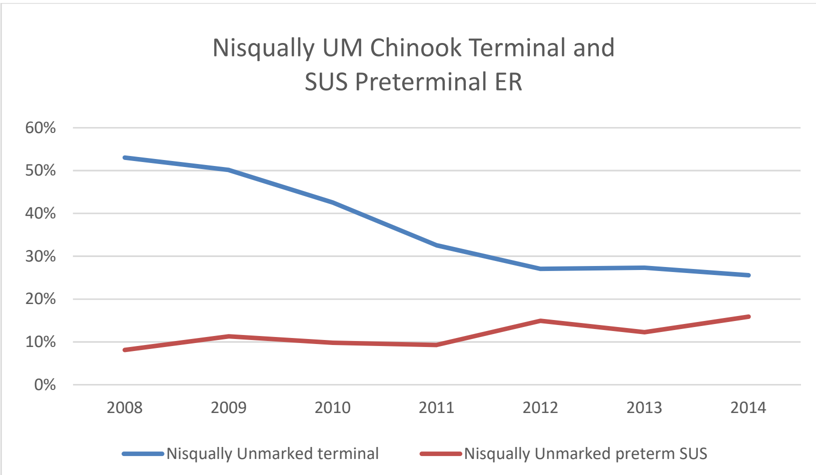


Figure 8. Increasing trend in SUS Pre-terminal fisheries.

Management Objectives

During colonization, the goal is to achieve escapement of at least 3,500 natural spawning adults, which is likely to include a substantial component of trucked fish from the hatchery. As a result, the LAT will consist of a total basin escapement goal (to the hatcheries and spawning grounds) of at least 7,000 adult chinook including a minimum of 2,800 for broodstock needs. The 7,000 LAT also includes a buffer for anticipated pond mortalities and to assure trucked adults will be representative of the complete run-timing. When pre-season escapement estimates are projected to exceed the LAT, an ER ceiling of 47% will be implemented for Nisqually unmarked Chinook, with the Nisqually Tribe maintaining a minimum 20% harvest rate in river. The LAT of 7,000 has been obtained in the past 13 years, during much higher ER ceilings, (Figure 9.)

Commented [S5]: See comment at beginning. Need to briefly describe the structure of the long-term transition strategy and provide the SMP as an appendix in order to put all these objectives in context. Discussion of colonization has no context on its own.

The text needs to explain how the management framework addresses the 4d criteria including why it will not impede survival and recovery. The SMP provides this context.

Commented [S6]: This seems high compared with the definition of the LAT in the main document, i.e., "a spawning level, set aboe the point of biological instability, which triggers extraordinary fisheries conservation measures to minimize fishery related impacts and increase spawning escapement." I need a better understanding of this.

What is the UMT and how does the 3,500 spawning adults relate to either the UMT or LAT thresholds. You need to put this in the context of the SMP strategy in order to address the 4d criterial.

Commented [S7]: Does this include triggers to achieve the 3500 spawning adults and hatchery requirements or only the 7000? If the latter, how is this consistent with the 4d criteria for setting critical and viable thresholds reflecting the status of the NOR component. As written, it infers the LAT could be meet with only returns to the hatchery.

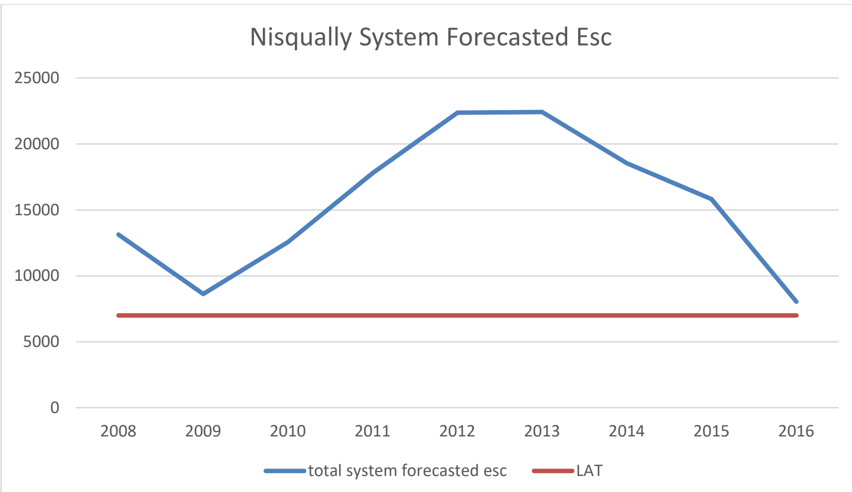


Figure 9. Nisqually LAT if applied to historical data set.

In order to fulfill a core objective in the 2017 Nisqually Stock Management plan, the Nisqually Indian Tribe will be investigating selective fishing techniques to consider using in its traditional in-river commercial and C&S fisheries. In order to provide the incentive to meet this objective, we will utilize up to 2% additional ER to support this effort. The Nisqually Indian Tribe, with the full agreement of the WDFW, will be conducting an investigation into gear types and opportunities to selectively harvest hatchery origin chinook in the Tribe's traditional commercial fisheries during the colonization phase. The Tribe will undertake this investigation utilizing up to an additional 2% ER through a combination of staff and fisher implemented actions consistent with the recovery objectives for the colonization phase. We will monitor the instantaneous mortality associated with each gear type, the relative success of the gear types, and the response of the fishers to the gear. The Tribe will report the results of the annual investigation of selective gear types during our annual adaptive management review.

The investigation will occur utilizing up to an additional 2% ER during a non-pink year in 2018 and a pink year in 2019. We will not experiment in 2020. We will then select our preferred gear types for additional testing utilizing up to an additional 2% ER in 2021 and 2022. Unless agreed to by the co-managers and NOAAF, the experimental phase of this effort will sunset after the 2022 season. Based on the results of our previous work and with input from WDFW and NOAFF, the Tribe will determine which gear type(s) to integrate into our commercial fishery within the 47% ER in 2023 consistent with the recovery objectives for that season. Our desire is to identify and implement selective opportunities acceptable to the tribal community with an agreed to understanding of the release mortality by the time we reach the local adaptation phase and an increased need to manage for escapement composition.

Commented [S8]: Where are these described?

Commented [S9]: See comments on SMP. Need more detail as to basis of 2%, development of selective fishing experiment, an how will account for this impact separately from other components of the fishery.

The specifics need to be developed prior to implementation in 2018.

Need to be clear that it will be developed and implemented consistent with provisions of SMP.

Commented [S10]: What are the criteria for selection?

It is unlikely that the LAT cannot be met during the colonization phase. However if pre-season escapement does not exceed the LAT escapement, the Critical Exploitation Rate (CERC) will be triggered. For the Nisqually River MU, the CERC will be up to a maximum 50% reduction in SUS ER impacts (including elimination of the freshwater gear evaluation fishery) after accounting for Alaskan and Canadian fisheries to a FRAM estimated total escapement of 7,000 fish, thereby providing greater certainty of achieving escapement needs of the Stock Recovery Plan Objectives for the colonization phase. The SUS ER reduction will be made equal and commensurate to both marked and unmarked Nisqually Chinook. No further SUS fishery reductions will occur, if after a maximum reduction of 50% US fishery impacts on marked and unmarked Nisqually Chinook does not result in a total FRAM escapement estimate of 7,000 fish.

The co-managers have also agreed to move 1.0 million fall chinook fingerling production from the Clear Creek Hatchery to an acclimation site on McAllister Creek. Adult fish returning to McAllister Creek are excess to escapement needs and will be fully harvested by treaty and non-treaty fishers. These releases are fully marked and representatively tagged and will be monitored in all sampling activities from juvenile to returning adult.

Data gaps

The following monitoring activities and directed studies would provide additional information to evaluate program assumptions and population performance. These activities are dependent on funding that has not yet been identified and are not part of the core monitoring program that will be implemented under the 2017 Nisqually Stock Management Plan (NSIT 2017).

Adult Catch and Escapement Monitoring

Nisqually River Catch in Treaty and Sport Fisheries

- Creel surveys could be conducted to improve estimates of landed and incidental mortality of natural-origin Chinook from the sport fishery catch.
- Mark-selective treaty fishery study: test an array of potential commercial selective fishing gear for catch efficiency, incidental mortality, and fishery compatibility.
- Mark-selective sport fishery study: test for differential sport release mortality between estuary and river caught Chinook.
- Study of net dropout rate in treaty commercial fishery to improve fishery mortality estimates.

Commented [S11]: Reduction from the 47%. Should reflect 2014 agreement language which was a minimum of 50% reduction. Preliminary analysis indicates this could result in total ERs below the LAT in the low 30s% to high 40%s which seems high to rebuild or maintain abundance.

Needs to focus on spawning escapement rather than overall return.

Please provide an example so we are all clear on how this will be calculated and what anticipated total exploitation rates would result. The outcome should support that the rate would meet the 4d criteria to not impede rebuilding above the LAT.

Commented [S12]: If the point of the colonization phase is fish on the spawning ground seems reasonable to take actions to get the fish on the grounds.

Under recent SUS rates, this would still provide a CERC of 15-20%.

Commented [S13]: Should include monitoring that will be part of the core program and what gaps it is designed to address.

Commented [S14]: Why aren’t these part of the core program? I thought the second bullet was the point of the selective gear program….

Nisqually Watershed-Wide Adult Escapement and Composition

- A genetic-based mark-recapture study to estimate spawning escapement based on tissue samples[1] from adult spawners and the following spring's outmigrants (Pearse et al. 2001; Rawding et al. 2014). These escapement estimates would be compared to those from the change-in-ratio method, described under the core monitoring programs to improve estimates of juveniles to adult.
- Genetic-based estimates of effective breeders to juvenile production by origin based on tissue samples from adult spawners by origin and the juveniles outmigrating the following spring to assess differential reproductive success between spawners of natural origin, hatchery-origin strays, and hatchery-origin trucked Chinook.
- Historical escapement could be estimated from live and dead counts and expansion formula (Tweit 1986) and calculated to better understand bias in the historical abundance estimates.
- Carcass recovery surveys of the Mashel River above Highway 7 and along the Nisqually mainstem from the mouth of the Mashel to Powell Creek would further expand understanding of composition.
- Radio tagging and tracking of adults (hatchery- and natural-origin) captured would improve evaluation of migration and spawning behavior above and below the Centralia Diversion Dam.

Commented [S15]: I understood these would be part of the core monitoring.

Juvenile Nisqually River Delta Monitoring

- Lampara net sampling (May to September) in the shallow open delta mudflats areas (including eelgrass bed adjacent areas), and lampara or tow-net sampling in the offshore areas adjacent to the delta would improve life-history and delta productivity estimates.
- Biweekly fyke net sampling (April to September) of sloughs in the emergent marsh zone, areas not reachable by beach seine, would improve delta capacity estimates. As with the beach seine sampling, index fyke trap sites would be chosen from the five sites with data for multiple years, along with a limited number of randomly selected new sites. Index and new sites would be chosen to represent different levels of connectivity to the mainstem Nisqually and to represent the geography of the area, including the Red Salmon Slough and McAllister Creek sides of the delta. Catch and density records would be adjusted for trap efficiency as measured with mark-recapture sampling at each trap on one sampling day.
- Benthic core samples, invertebrate fallout trap samples, and neuston tow samples could be collected monthly from April to July to quantify prey from the substrate, the terrestrial environment, and the water column, respectively.

[1] Genetic-based estimate of spawner abundance for 2012 through 2014 will be completed by the Northwest Indian Fisheries Commission in 2018.

- PIT tags to mark and recapture individual fish also be used to study fish movements within the delta and timing patterns between tagging (at the outmigrant trap, hatchery, or hatchery off-station release site), entry into the delta, and capture or presence at an antenna in the delta. PIT tag recapture rates in the delta and differences between recaptures at well-connected mainstem sites and less well-connected sites could be compared to outmigrant trap annual estimates to look for evidence of differences in habitat use and dispersal with differences in abundance of juvenile Chinook entering the delta.
- Otoliths collected from returning adults to determine the delta residence patterns of adults that survived to return could be paired with juvenile otolith sampling to characterize residence time and growth of juveniles and to compare life-history types between juveniles and successfully returning adults.

Stock Recruitment Analysis

Natural-Origin Adult Abundance to River

- Creel surveys to improve estimates related to the sport fishery catch would also improve estimates of natural-origin adult abundance to river.
- Genetic mark-recapture study described under *Nisqually Watershed-Wide Adult Escapement and Composition* would also improve estimates of natural-origin adult abundance to river.

Survival Rates (Juvenile Outmigrants to Adult Recruits to River)

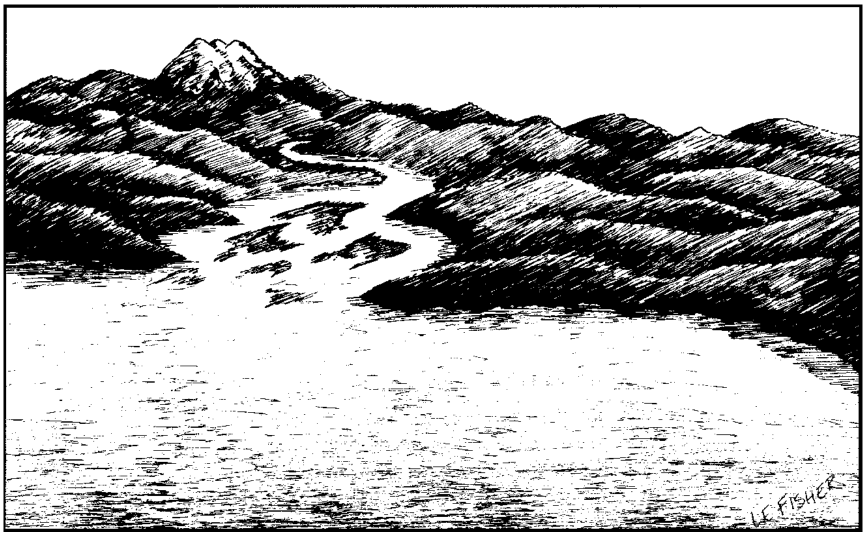
- Otolith microchemistry for growth, residence time, and life-history types surviving to adult return would improve estimates of survival rates.

Recruitment Rates (Spawners to Adults by Brood Year)

- Genetic-based study of contribution by origin to adult recruitment would improve estimates of recruitment rates.

Habitat Monitoring

A habitat status and trends program, as recommended in *Methods and Quality of Salmonid Habitat Monitoring of ESA Listed Puget Sound Salmon and Steelhead with Identified Critical Gaps* (Crawford 2013) would link Chinook population response to habitat recovery actions.



Stock Management Plan for Nisqually Fall Chinook Recovery

December 2017
Final

Prepared by the Nisqually Chinook Work Group

Nisqually Chinook Work Group

The Nisqually Chinook Stock Management Plan is a collaborative product between Nisqually Indian Tribe and Washington Department of Fish and Wildlife with assistance from consultants at ICF. The individuals listed below attended one or more of the Nisqually workshops or contributed to developing the management plan.

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Smith, Craig	Nisqually Indian Tribe
St. Jean, Bill	Nisqually Indian Tribe
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Bartley, Deb	ICF (Consultant)

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Acronyms and Abbreviations

°C	degrees Celsius
APR	Annual Project Review
CDDFL	Centralia Diversion Dam Fish Ladder
CV	coefficient of variation
EDT	Ecosystem Diagnosis and Treatment
ESA	Endangered Species Act
ESU	evolutionarily significant unit
GMR	genetic mark-recapture
HSRG	Hatchery Scientific Review Group
MP-PNI	Multi-Population PNI
Nb	number of breeders
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
pHOS	percent hatchery-origin in natural spawning
PNI	proportionate natural influence
RM	river mile
tGMR	trans-generational genetic mark recapture
Tribe	Nisqually Indian Tribe
VSP	viable salmonid populations
WDFW	Washington Department of Fish and Wildlife

Chapter 1
Introduction

Salmon are important to the economic, social, cultural, and aesthetic values of the people in the Pacific Northwest, including the Nisqually Indian Tribe (Tribe). To ensure sustainable salmon runs and fishing in perpetuity, the Tribe and the Washington Department of Fish and Wildlife (WDFW) co-managers, and several watershed partners have led a multidecade-long effort to protect and restore the watershed, resulting in some of the best Chinook habitat quality and quantity in Puget Sound.

Recovery of Chinook is important to the Tribe and is guided by the following overarching goal (Nisqually Chinook Recovery Team 2001).

> …to provide meaningful harvest for treaty and non-treaty fisheries in the Nisqually River and to restore a viable, self-sustaining, and locally-adapted population of fall Chinook salmon that adds to the spatial diversity, abundance, and recovery of the Puget Sound Chinook ESU.

The central importance of Chinook salmon to the Tribe's community and treaty fishery is reflected in its treaty harvest goal of 10,000 to 15,000 Nisqually fall Chinook annually in the in-river fishery.

Native Nisqually River fall and spring Chinook were extirpated[1] over half a century ago as a result of habitat degradation, hydropower development, and other anthropogenic activities including high harvest rates[2] associated with hatchery operations and hatchery straying. The Nisqually River watershed, like most of southern Puget Sound, has a long history of hatchery enhancement.[3] From 1956 to 1988, fall Chinook of Green River origin were regularly introduced to the Nisqually River. Hatchery production is currently necessary for sustaining harvest that natural production cannot support due to habitat degradation and reduced population productivity. Figure 1-1 shows the location of the Nisqually watershed in the context of the broader Puget Sound region.

The Tribe initiated hatchery production in 1979 at Kalama Creek Hatchery and 1990 at Clear Creek Hatchery with the sole purpose of supporting harvest. Initial releases occurred the first year following the start of production at the respective facilities. The Tribe began managing the Kalama Creek and Clear Creek hatchery program in 1994 with a 600,000 Chinook release goal at Kalama Creek and with a 3.4 million Chinook release goal at Clear Creek. The Kalama Creek hatchery operations are funded by the Bureau of Indian Affairs; Clear Creek Hatchery operations are funded by Tacoma City Light as mitigation for the effects of Nisqually River hydropower project per a 1989 settlement agreement. Figure 1-2 shows the locations of these hatcheries in the Nisqually watershed. The last introductions of Chinook salmon (of Green River origin) to the Nisqually River were in 1988. Since then, the tribal hatchery programs in the system have been self-sufficient (Nisqually Chinook Recovery Team 2001).

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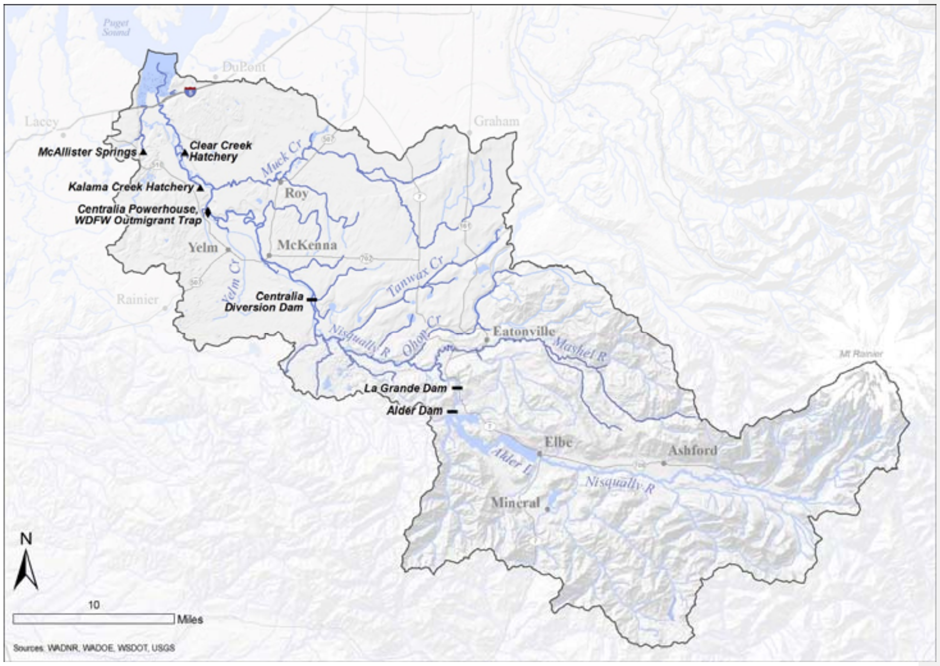
[1] Locally extinct in the Nisqually Basin.

[2] As in most of southern Puget Sound, harvest rates for fall Chinook have been based on full harvest of hatchery-produced fish.

[3] Records indicate that hatchery fall Chinook have been planted in the Nisqually River since 1943, and likely earlier. Data from early years on stock origin are not available, but plants in the 1960s and 1970s were from at least nine different Puget Sound and Hood Canal hatcheries.

Figure 1-1. Nisqually Watershed

Figure 1-2. Hatchery, Hydropower, and Fishery Facilities in the Nisqually Watershed



The Nisqually River fall Chinook population has been managed as a composite stock (hatchery-bred and naturally spawned).[4] Harvest has been managed to achieve hatchery broodstock escapement[5] and natural spawning escapement with minor consideration of composition of hatchery- and natural-origin adults in the escapement.[6] Since 2004, an annual average of approximately 2,000 fall Chinook (hatchery- and natural-origin) spawned naturally in the Nisqually River[7] and 1,400 natural-origin adults returned to the system.

This Stock Management Plan for Nisqually Fall Chinook Recovery replaces the 2011 stock management plan (Nisqually Chinook Work Group 2011) as the guidelines for adaptively managing the Nisqually fall Chinook stock (hatchery, harvest, escapement) to promote adaptation of the stock to the river's unique conditions (i.e., temperature, flow, food and seasonality), increase spawning

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[4] The Nisqually Tribe stopped importing fish from the Green River in 1996 to promote adaptation of the hatchery stock to the river's unique conditions. WDFW continued to import broodstock for its McAllister Creek hatchery until the hatchery closed in 2002.

[5] A sufficient number of fish avoid harvest and continue upstream to the hatchery to be used in the hatchery breeding program.

[6] Hatchery- and natural-origin Chinook avoid harvest and continue upstream to the natural spawning grounds,

[7] Natural spawning occurs in 42 miles of the mainstem Nisqually River accessible to anadromous salmonids as well as tributaries, the Mashel River, and other smaller tributaries.

abundance of natural-origin Chinook, and ultimately achieve a self-sustaining, productive population.

Stock management is one element of a broader integrated management program that is required for recovery of Nisqually fall Chinook salmon. An integrated management program considers all factors affecting Nisqually fall Chinook salmon throughout their life cycle, including freshwater, estuarine, and marine habitats; ecological interactions; harvest; and the hatchery program (Rawson and Crewson 2017; Hatchery Scientific Review Group 2014).

In 1999, Puget Sound Chinook salmon was listed as threatened under the Endangered Species Act (ESA). The *Nisqually Chinook Recovery Plan* (Nisqually Chinook Recovery Team 2001), the product of a 3-year effort to develop a habitat protection and restoration plan for the Nisqually watershed and the initial step in an integrated multispecies plan for the watershed, was released in 2001. The plan was used to chart the path to Nisqually Chinook recovery and contribute more broadly to Puget Sound Chinook recovery. The plan has provided the overarching recovery framework for Nisqually Chinook over the last 15 years and guided a strategic ecosystem-scale habitat protection and restoration effort. In 2007, the National Oceanic and Atmospheric Administration (NOAA) approved the Puget Sound Recovery Plan, which incorporated the 2001 *Nisqually Chinook Recovery* Plan and other watershed plans for the Puget Sound Chinook evolutionarily significant unit (ESU).

Puget Sound steelhead was listed as threatened under ESA in 2007. The *Draft Nisqually Steelhead Recovery Plan* was released in 2010 to identify and prioritize factors affecting Nisqually River steelhead and fold steelhead recovery into the multispecies plan for the watershed.

In 2010, the Puget Sound Indian Tribes and WDFW released the *Draft Puget Sound Chinook Resource Management Plan*, which represents the legal plan for permitting take of listed species under ESA resulting from fisheries in the state (Puget Sound Indian Tribes and Washington Department of Fish and Wildlife 2010).

The National Marine Fisheries Service (NMFS) Supplement to the Puget Sound Salmon Recovery Plan (National Marine Fisheries Service 2006; Ruckleshaus et al. 2002) identified the Nisqually Chinook salmon population or another late-timed population in Central/South Puget Sound as needing to be at low risk for the Puget Sound Chinook salmon ESU to be considered viable. At the time, NMFS concluded the Nisqually population to be among those that would have the best chance of recovery because of habitat conditions. In 2010, the NMFS Northwest Region Puget Sound Domain Team (2010) proposed an approach to recover Puget Sound Chinook. The approach identified the Nisqually Chinook population as a Tier 1 population, which is most important for preservation, restoration, and recovery of the ESU, and has greater importance to overall ESU viability relative to other ESU populations.[8] Nisqually Chinook are proposed as Tier 1 based on the existence of functional habitat relative to other fall-run Chinook watersheds in the Central/South Puget Sound biogeographical region, and the watershed's future potential to support a self-sustaining and productive Nisqually Chinook population.

[8] Nisqually Chinook is identified as a Tier 1 population (must achieve recovery) within the Central/South Puget Sound Major Population Group. This Major Population Group also includes the Cedar, Sammamish, White, Green, White, and Puyallup River Chinook.

In 2009, the Tribe started developing a Hatchery and Genetic Management Plan[9] (HGMP) to support a permit from NOAA Fisheries for take under ESA related to Nisqually Chinook hatchery operations. The Nisqually Chinook Work Group (2011) released the *Nisqually Chinook Stock Management Plan* to support the HGMP, as well as the *Harvest Management Component of the Comprehensive Management Plan* for Puget Sound Chinook (Puget Sound Indian Tribes and Washington Department of Fish and Wildlife 2010). As described in detail in Chapter 2, *Recovery Successes, Challenges, and Adaptive Response*, the 2011 plan objectives were not met. This 2017 stock management plan replaces the 2011 plan and supports the 2017 Nisqually Chinook HGMP.

[9] A Hatchery Genetic Management Plan (HGMP) describes, in a format prescribed by NOAA Fisheries, the operation of the artificial production program for salmon and steelhead in the Puget Sound region and the potential effects of each program on listed species.

Chapter 2
Recovery Successes, Challenges, and Adaptive Response

This chapter describes the elements of recovery planning, implementation, and evaluation that have occurred since the 2001 plan. It documents completed and planned restoration and protection projects, the development of the 2011 stock management plan to take advantage of the resulting improved habitat conditions, and the adaptive response to the evaluation of the first 5 years of the plan's implementation.

Developments in the Nisqually River since the 2001 Plan

Since the implementation of the *Nisqually Chinook Recovery Plan* (Nisqually Chinook Recovery Team 2001), major habitat restoration initiatives have been accomplished and efforts to protect existing habitat, monitor and evaluate restoration activities, and develop and implement a stock management plan to take advantage of habitat improvements have occurred.

Habitat Restoration and Protection

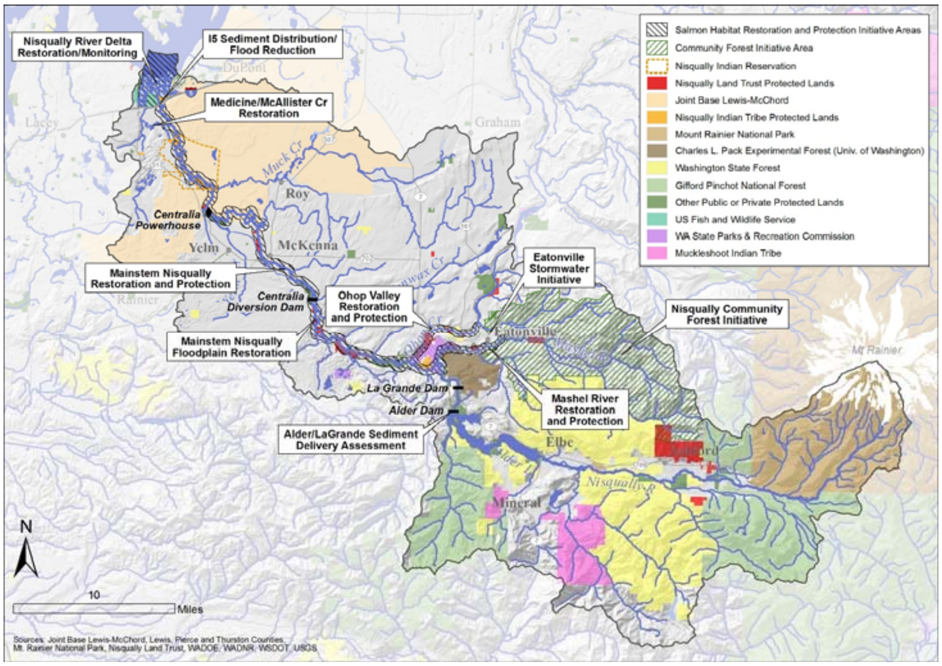
Many, but not all, of the major habitat elements of the 2001 plan have been implemented (Table 2-1) and further protection and restoration actions are planned for implementation. Modeled assessments of habitat potential and data collected during restoration monitoring suggest that fall Chinook potential has increased substantially since the habitat components of the recovery plan were started in 2001 (e.g., monitoring studies in the Nisqually delta confirms broad use of restored habitat and increased capacity) and will continue to increase as projects mature (e.g., riparian revegetation, natural recruitment of woody material to streams, and establishment of estuarine channel network) and additional projects are implemented (Figure 2-9). Table 2-1 lists the recovery projects implemented since 2001, and identifies the major recovery initiatives they fit within. Figure 2-1 depicts the major completed, ongoing, and conceptual habitat restoration and protection initiatives.

Table 2-1. Habitat Restoration and Protection Projects Implemented since 2001

Year	Recovery Initiative	Project
1991	Mainstem Nisqually Restoration and Protection	Large sections of the Nisqually mainstem are protected by Fort Lewis and Nisqually Indian Reservation. However, sections of the mainstem and tributaries are not protected. The Nisqually estuary is severely reduced in area from dikes on both sides of river.
1996	Nisqually Delta Restoration	Red salmon slough estuary restoration: dike breached to restore 12 acres of salt marsh.
1997		Minimum flows established for hydropower impacted mainstem reaches (LaGrande bypass reach, the mainstem to the Centralia City Light Yelm Hydroproject diversion dam (Centralia Diversion Dam), and the Yelm project diversion reach downstream of the dam) during relicensing of the Nisqually River project.

Year	Recovery Initiative	Project
2001	Mainstem Nisqually Restoration and Protection	63% of mainstem Nisqually River shoreline in protected status.
2004	Mashel River Restoration and Protection	Lower Mashel Restoration Project (install 7 logjams).
2005	Mainstem Nisqually Restoration and Protection	70% of mainstem Nisqually River shoreline in protected status.
2006	Nisqually Delta Restoration	Red Salmon Slough dike removal for estuary restoration (150 acres + wetland and surge plain).
2007	Mashel River Restoration and Protection	Eatonville Mashel Phase 1 project (12 logjams).
2009	Nisqually Delta Restoration	NNWR estuary restoration with dike removal restoring 760 acres.
2010	Mashel River Restoration and Protection	Eatonville Mashel Phase 2 project (installed 23 logjams) .
	Ohop Restoration	Ohop Phase 1 completed, restored 1 mile of creek and protected 100 acres of floodplain.
2011	Mainstem Nisqually Restoration and Protection	75% of Nisqually River mainstem shoreline in protected status.
2013		Produce new habitat action plan; incorporate updated steelhead EDT modeling.
2015	Ohop Restoration	Ohop Phase 3 complete; 121 acres permanently protected and 1.4 miles of creek restored.
	Nisqually Community Forest Initiative	Nisqually Community Forest becomes 501(c)(3) organization with a goal to purchase over 100,000 acres of private timberlands in the upper watershed to manage for ecosystem services and local economies.
2016	Mashel River Restoration and Protection	First 640 acres of upper Mashel watershed purchased for inclusion in Nisqually Community Forest.
2017	Mainstem Nisqually Restoration and Protection	77% of Nisqually River mainstem shoreline in protected status.
	Mashel River Restoration and Protection	Mashel Phase 3 restoration planned.
	Nisqually Community Forest Initiative	1280 acres of upper Mashel watershed purchased for inclusion in Nisqually Community Forest.
	Nisqually Delta Restoration	Estuary research confirms broad use of restored habitat and increased capacity.

Figure 2-1. Major Completed, Ongoing, and Conceptual Habitat Recovery Initiatives



Stock Management

Based on the significant implementation of habitat protection and restoration actions identified in the 2001 recovery plan and estimated large natural-origin adult runs in 2007 and 2008 from naturally spawning Chinook, the co-managers decided to take the next step identified in the 2001 Chinook recovery plan. The next step in the 2001 plan was to foster adaptation of the population to the Nisqually River system by reducing contribution of hatchery fish to natural production a by managing harvest, the hatcheries, and natural spawning escapement.

While habitat potential had improved considerably and was expected to improve further, a substantial portion of this current and future habitat potential was going unrealized. The co-managers concluded that habitat potential was unrealized because of hypothesized low fitness level of the population due to hatchery effects as described by the Hatchery Scientific Review Group (HSRG) (2014).[10]

In 2010, several milestones occurred and additional tools were available to manage the population and monitor productivity and abundance of the population leading to the decision to transition

[10] With the native Nisqually fall Chinook population extirpated, the current Green River–based population has undergone multiple generations of hatchery propagation and influence, which has disrupted the natural selection of population characteristics that are tailored to local conditions.

stock management in the river. In 2006, sport fishery regulations in the river were revised to require the release of all adult Chinook with an intact adipose fin (unmarked adults). The hatchery releases achieved a mark rate of 95% with the 2010 release improving the co-managers ability to manage to reduce harvest of natural-origin Chinook. In 2009, WDFW began operating a juvenile outmigrant trap at river mile (RM) 12.8, and juvenile production in that year and the next indicated an abundant natural population. Finally, in 2010, the Harvest Management Component of the Comprehensive Management Plan for Puget Sound Chinook (Puget Sound Indian Tribes and Washington Department of Fish and Wildlife 2010) was developed to guide annual harvest. The schedule for Nisqually Chinook was to reduce the total exploitation rate from 72% in 2010 to 47% by 2014. The schedule was subsequently revised and the 47% exploitation rate was achieved in 2016.

HSRG (2014) has concluded that hatchery programs should either be managed to achieve proper integration with or be isolated from natural populations—depending on the unique circumstances of the program and the natural population—to ensure that hatchery programs are not an impediment to recovery.[11] The biological principle behind proper integration or segregation of hatchery programs is local adaption. When populations are allowed to adapt to the local conditions of the natural environment, their productivity is expected to increase.

HSRG proposed a third type of program—the “stepping-stone” program—in its review of Columbia River hatchery programs (Hatchery Scientific Review Group 2009); it includes a small integrated program as a broodstock generator to support a larger isolated harvest program.[12] The intent of a stepping-stone program is to support harvest while allowing populations to adapt to the local conditions of the natural environment.

HSRG has developed criteria for hatchery influence on natural populations for integrated and isolated programs based on the population’s biological significance (Hatchery Scientific Review Group 2014). For integrated programs the intent is for the combined hatchery/natural population to attain the genetic characteristics of the locally adapted natural population. This requires that the natural habitat has a stronger selective influence than the hatchery environment. To this end, HSRG concluded that the proportion of hatchery broodstock comprising natural-origin fish (pNOB) must be greater than the proportion of the natural spawning population comprising hatchery-origin fish (pHOS). The proportionate natural influence (PNI) is an approximate measure of gene flow and is calculated as pNOB/(pNOB+pHOS). For populations with the highest biological significance within their ESU (Primary or Tier 1), the PNI index should exceed 0.67. For populations with different roles within the ESU, a PNI of 0.5 may be acceptable.

For isolated programs the intent is to maintain a genetically distinct hatchery population, isolated from the natural population. For populations with the highest biological significance within their

[11] In the isolated approach, the intent is to limit the fraction of natural spawners that are of hatchery-origin and manage the hatchery as a genetically distinct population, promoting adaptation to the hatchery environment. In the integrated approach, the intent is to manage the hatchery and natural components as one population, local adaptation to the natural environment is achieved by managing gene flow such that gene flow from the natural component to the hatchery component is higher.

[12] A stepping-stone (or two-staged) hatchery program combines a small integrated program and larger isolated program when the natural population is too low to support a fully integrated program. It then transitions into a fully integrated program once natural production is sufficient to provide the required number of natural-origin fish in the broodstock.

ESU, HSRG has recommended that pHOS be less than 5%. For other populations, pHOS values up to 10% may be acceptable.

HSRG has modeled the long-term genetic risks to natural populations of hatchery strays using the phenotypic fitness model described by Ford (2002). The analysis of hatchery effects on natural Nisqually Chinook completed in 2011 adopted the fitness model parameters used by HSRG in the Pacific Northwest, including a fitness floor of 50% to limit the maximum fitness effects on a population. The high percent of hatchery fish spawning in nature over multiple generations and that hatchery fish in the system were derived from a hatchery stock outside the watershed suggests the maximum effect is appropriate for Nisqually Chinook.

The previously described PNI criteria for integrated programs also applies to stepping-stone programs because the goal of local adaptation is the same. However, the PNI calculation for integrated programs presented by HSRG does not apply to stepping-stone programs. The 2011 plan did not make a distinction between naturally spawning adults from the stepping-stone program and adults from the integrated program in the calculation of PNI. In other words, pHOS in the PNI formula was the combined integrated and stepping-stone hatchery-origin spawners. In 2017, Craig Busack with NOAA Fisheries provided a calculation of PNI applicable to stepping-stone programs to be used for developing decision rules for Chinook local adaptation in the Nisqually. The plan and decision rules will be updated with new data and consistent with the check points described in the Colonization Phase. The hatchery strategy during local adaptation, including the addition of a stepping-stone program, is based on current scientific thinking and data. It is also based on the assumption that the magnitude of natural-origin spawners relative to the hatchery component of natural spawners will be sufficient at the transition from colonization to local adaptation to achieve a PNI greater than 0.50, given the hatchery production and harvest objectives. This strategy will be reviewed at the point of transition to local adaptation to ensure the strategy that is adopted reflects best science and information at that time.

The 2011 stock management plan (Nisqually Chinook Work Group 2011) was developed, based on the findings and principles described above, to improve natural population fitness by minimizing the genetic and ecological influence of hatchery fish on the naturally spawning population. The plan included the following measures.

- **Reduce hatchery-origin spawning.** Install and operate a weir at river kilometer 20.6 on the mainstem Nisqually River to remove hatchery-origin adults to limit the proportion of hatchery-origin Chinook naturally spawning. Proportion of hatchery spawners (pHOS) to be limited to less than 10%.
- **Improve genetic continuity of hatchery program.** Implement an integrated and stepping-stone hatchery program,[13] by operating the Kalama hatchery as an integrated broodstock generator (using hatchery- and natural-origin Chinook in the broodstock) and using

[13] The plan will be updated based on new data and information consistent with the check points described in the Colonization Phase. The hatchery strategy during local adaptation, including inclusion of a stepping-stone program, is based on current scientific thinking and data, and the assumption that the magnitude of natural-origin spawners relative to the hatchery component of natural spawners will be sufficient at the transition from colonization to local adaptation to achieve a PNI greater than 0.50 given the hatchery production and harvest objectives. This strategy will be reviewed at the point of transition to local adaptation to ensure the strategy that is adopted reflects best science and information at that time.

broodstock from the Kalama hatchery return (integrated fish returns) in the Clear Creek hatchery.

- **Reduce exploitation rates on natural-origin adults.** Reduce harvest rates for natural-origin adults in the preterminal and terminal fisheries to limit the total exploitation rate to 47% and increase hatchery component of terminal harvest to maintain harvest goal.

These measures were intended to improve population adaptation to local conditions and overall fitness as measured by high PNI on the composite hatchery- and natural-origin population.[14] This hypothesis is revisited in detail in Chapter 3, *Phased Recovery Approach*.

The feasibility of this approach, which was dependent on accurate identification of hatchery-origin adults in harvest and escapement, was based on dramatically improved mark rates of hatchery fish through use of auto-marking trailers; by 2010, mark rates were at over 95% efficiency.

The weir had to achieve an efficiency of 95% and meet the following performance criteria established by a multiagency weir evaluation team.

- Unbiased trapping
- Trapping throughout the run
- Negligible influence on spawner distribution
- Measurable trapping efficiency

The co-managers began implementing the plan, including operation of the weir, in 2011. During its 5 years of operation, the weir faced numerous challenges: during the first year of operation, multiple design issues were discovered; a late-September 2013 flood ended weir operation early for the season; and drought and unusually warm water temperatures in 2015 led to problems with weir operation.

Monitoring for the years 2011 through 2015 concluded that the weir was not a success: it did not achieve a 95% efficiency rate or meet the performance criteria. It was also expensive to operate and required a high level of staff. The co-managers concluded in 2015, based on these factors, that the weir was not a sustainable method for moving the population toward adaptation to local conditions and improved fitness.

Other monitoring activities such as the juvenile outmigrant trap operated by WDFW beginning in 2009 and an adult video counter at the Centralia City Light Yelm Hydroproject diversion dam (Centralia Diversion Dam) installed in 2014 provided additional information about the status of natural production.

In 2015, the combination of poor environmental conditions in the freshwater and marine environments leading to low population abundance, and failed weir operations resulted in the decision that the 2011 plan was unworkable.

To address poor natural spawning in 2015, 785 adults were trucked from the Clear Creek and Kalama Creek hatcheries and released to natural spawning. The co-managers began considering other options for managing the hatcheries and reducing hatchery strays to natural spawning. In

[14] PNI is calculated as pNOB/(pNOB + pHOS). It can be thought of as the percentage of time the genes of a composite population spend in the natural environment.

2016, 500,000 juvenile Chinook were transferred from the Clear Creek Hatchery to McAllister Springs for acclimation and release. The objective of this release was to provide a treaty net fishery at the mouth of McAllister Creek with lower impacts on natural-origin adults returning to the Nisqually River and to reduce straying of hatchery-origin returns to natural spawning grounds. In 2017, this release was increased to 1 million and the hatchery on-station release at Clear Creek was reduced from 3.4 million to 2.4 million.

Current status of the natural population is described in the following section with respect to juvenile and adult abundance and productivity.

Current Status of Natural Population

In determining the status of the Nisqually fall Chinook population, several parameters are considered: productivity, abundance, spatial diversity, and life-history diversity. Collectively, these parameters describe attributes of viable salmonid populations (VSP). The following indicators of population performance were considered for each of the VSP attributes.

- **Productivity**: freshwater productivity (measured number of outmigrants[15] per spawner), delta and marine survival (measured in number of adult natural-origin recruits per outmigrant[16]) and life cycle productivity (measured in number of adult natural-origin recruits per natural spawner).
- **Abundance**: number of juvenile outmigrants, number of natural-origin adult recruits, number of natural-origin annual run to the river, and number of natural-origin escaping fisheries to spawn in the wild.
- **Spatial diversity**: distribution of natural-origin spawners and juveniles relative to spawning and rearing habitat in freshwater and the Nisqually delta.
- **Life-history diversity**: adult migration and spawn timing, age at spawning, adult body size at age, age and life stage at outmigration, body size and timing of outmigration, and juvenile habitat rearing choice.

Figures 2-2 and 2-3 depict Nisqually fall Chinook abundance as indicated by annual unmarked, natural-origin adult run to the river[17] (Figure 2-2) and natural spawning escapement by natural- and hatchery-origin (Figure 2-3). Figures 2-4 and 2-5 depict harvest impacts affecting annual run to the river and escapements as indicated by terminal (in-river) harvest rates (Figure 2-4) and total exploitation rates (Figure 2-5) on unmarked, natural-origin Chinook.[18]

Commented [S1]: Does this also factor in an estimate of mis-clips?

[15] Outmigrants are juveniles that leave the river system for the ocean as measured at the WDFW trap at river mile 12.8 (river kilometer 20.6).

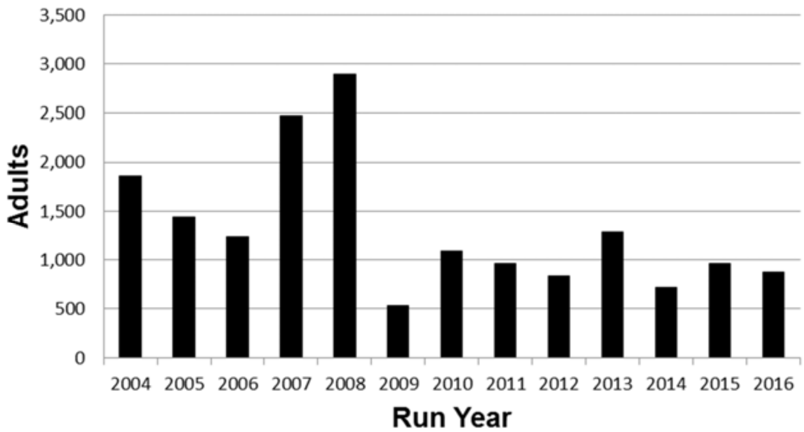
[16] Adult recruits are Chinook produced from a brood year (from one year's spawners). Adult recruits are measured as the number of adults returning to the Nisqually River (includes marine survival and preterminal harvest) or number that would have returned absent preterminal harvest (just marine survival).

[17] Unmarked natural-origin Chinook in the fishery and escapement are estimated by subtracting unmarked hatchery-origin from the catch and escapement estimate. The fraction of hatchery-origin without an adipose fin clip or CWT (unmarked) is based on annual adult monitoring at the hatchery ponds (see Nisqually Chinook run reconstruction ISIT file, January 2017 for details).

[18] Data tables and recruit per spawner results are presented in Appendix 1, *Nisqually Chinook Run Reconstruction and Spawner-Recruit Analysis.*

As shown in Figure 2-2, the average number of natural-origin adult returns (adults returning to the Nisqually River) has been less than 1,000 Chinook in recent years, following two strong returns in 2007 and 2008.

Figure 2-2. Natural-Origin Adult Returns to Nisqually River

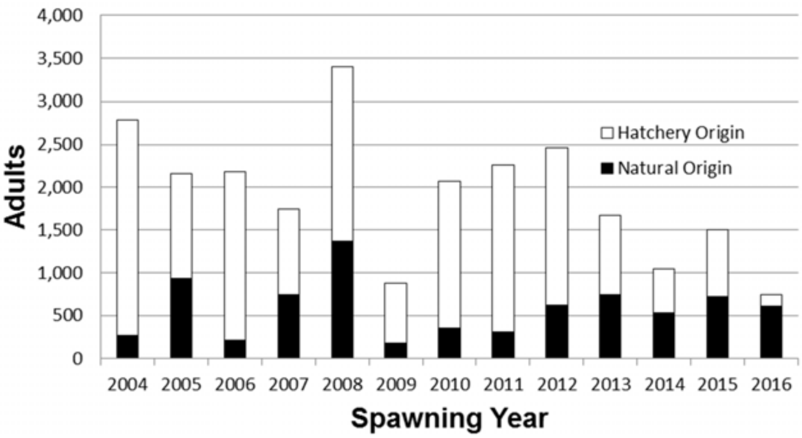


Source: Nisqually Chinook run reconstruction ISIT file (September 2017).

Commented [S2]: When were hatchery returns 100% mass-marked?

Natural-origin natural spawning escapement has been relatively stable (Figure 2-3) despite declining natural-origin adult runs to the river (Figure 2-2). The percent hatchery-origin in natural spawning (pHOS) in averaged 66% from 2004 to 2016. Since 2013 the pHOS has been less, averaging 44%. The number of hatchery-origin Chinook escaping to natural spawning areas declined beginning in 2013, possibly in response to changes in operation of the fish ladders to the hatcheries and poor survival of hatchery Chinook in some of the years. Beginning in 2013, the fish ladders were kept open at the Kalama and Clear Creek hatcheries for the entire adult migration period to minimize straying to natural spawning. Prior to 2013, the ladders were closed during the first part of the adult migration and then opened only for short periods during the season to meet hatchery broodstock collection needs.

Figure 2-3. Natural Spawning Escapement of Natural-Origin and Hatchery-Origin Chinook



Source: Nisqually Chinook run reconstruction ISIT file (September 2017).

The depressed adult run to the river shown in Figure 2-2 is likely because of a combination of factors affecting freshwater and ocean survival. It does not appear to be caused by low parent spawning escapements (Figure 2-3). Stability in escapement has been mediated by reductions in terminal (in-river) harvest;[19] terminal harvest of unmarked Chinook[20] has decreased since 2009 consistent with terminal harvest objectives described in the *Puget Sound Chinook Comprehensive Management Plan* (Puget Sound Indian Tribes and Washington Department of Fish and Wildlife 2010). FRAM-based reporting of total exploitation rates[21] shows a decrease from approximately 70% in 2008 and 2009 to 50% in recent years, consistent with exploitation rate objectives for the Nisqually River (Figure 2-5). This decrease has been from reductions in the terminal treaty net fishery; recent year (2012 through 2016) terminal rates averaged 27% compared to an average rate of 51% from 2004 to 2011.

From 2011 to 2015, the average terminal harvest rate among treaty and nontreaty sport fishers was 35.2% (±.12.2 S.D.). Preterminal (fisheries operating outside of the Nisqually River) exploitation rates have tended be stable over the period, averaging 21% and ranging from 17 to 24% (Figure 25).

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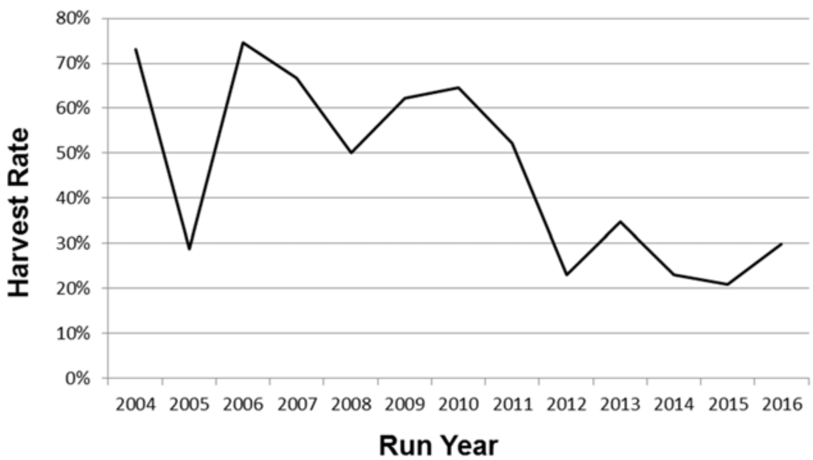
[19] The harvest rate is the number of Nisqually fall Chinook harvested in the Nisqually treaty net fishery divided by the number of adults entering the Nisqually fishery (i.e., annual catch divided by annual run to the Nisqually River after preterminal fishery impacts).

[20] Most hatchery fish are visually marked by clipping the adipose fin. However, for purposes of monitoring mark-selective fisheries, some are tagged with a code-wire tag but with no visual mark. In addition, marking has an approximate 95% success rate. Therefore, unmarked Chinook comprise mostly natural-origin Chinook but with a small percentage of unmarked hatchery fish. The incidence of unmarked, hatchery–origin adult Chinook in the terminal run is estimated from adult sampling for marks at the Clear Creek and Kalama Creek hatcheries.

[21] Exploitation rate is the number of Chinook removed by a fishery divided by the total annual number of fish vulnerable to all fisheries. Preterminal and terminal rates are comparable as they are both based on the annual run of Chinook returning to the Nisqually River.

Figure 2-4. Nisqually Treaty Net Harvest Rates on Unmarked Chinook

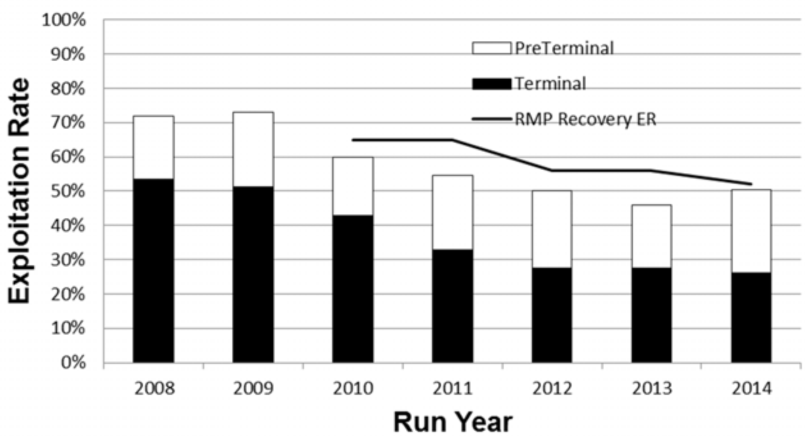


Source: Nisqually Chinook run reconstruction ISIT file (September 2017)

Figures 2-6 and 2-7 depict Nisqually fall Chinook freshwater natural production as indicated by annual juvenile abundance and juvenile recruits per parent spawner.

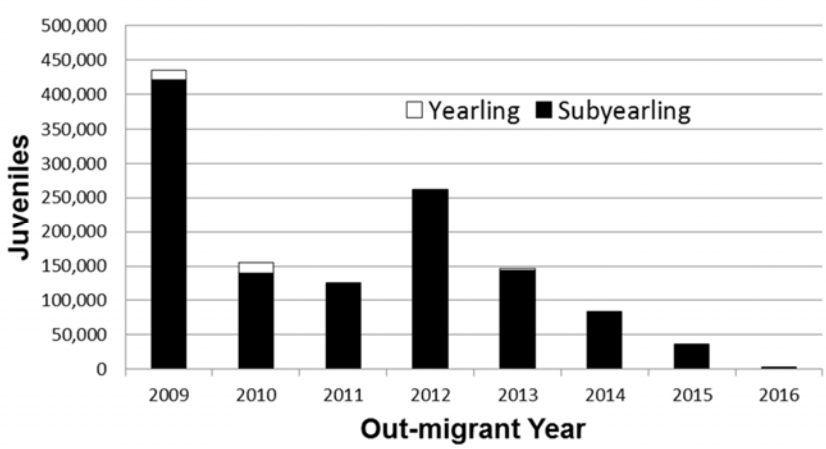
Estimated annual natural production of juvenile Chinook (subyearling and yearling), estimated by WDFW since 2009, in terms of outmigrant juveniles at RM 12.8, has varied from less than 3,000 fish in 2016 to over 400,000 fish in 2009 (Figure 2-5). Subyearling Chinook are progeny from the previous fall natural spawning escapement and yearling Chinook are from natural spawning 2 years prior. The high estimated abundance in 2009 of subyearlings followed the highest estimated natural spawning escapement of nearly 3,500 Chinook in the fall of 2008 (Figure 2-2). The extremely low juvenile abundance in 2016 was the likely result of poor in-river environmental conditions during adult migration and spawning in the parent year (fall of 2015). In the fall of 2015, Nisqually River water temperatures exceeded 20 degrees Celsius (°C) during the first half of the adult migration. A thermal barrier in the Centralia Diversion Dam reach just upstream of the WDFW outmigrant trap location affected upstream movement of migrating Chinook.

Figure 2-5. FRAM-Based Annual Exploitation Rates on Unmarked Nisqually Chinook



Source: Post Season ER NEW BP run date January 24, 2017 Craig Smith, NIT

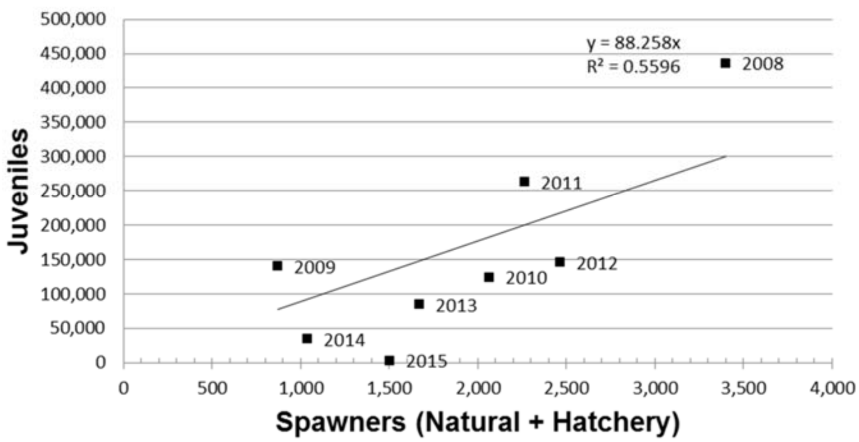
Figure 2-6. Estimated Annual Juvenile (Subyearling and Yearling) Chinook Abundance at RM 12.8



Source: WDFW Klungle et al. in prep

Juvenile recruits per spawner as estimated by the number of subyearling and yearling juveniles divided by the number of naturally spawning Chinook (hatchery- and natural-origin), has varied from a low of 2.0 recruits per spawner from the 2015 brood year to 150 recruits per spawner from the 2009 brood year (Figure 2-7). The number of juvenile recruits per spawner from the Nisqually River watershed was low in all years when compared to the Skagit River, a watershed with an abundant Chinook population and long-time series. Zimmerman et al. (2015) reported 270 to 1,230 outmigrants per female spawner. Assuming a 1:1 sex ratio for Nisqually River Chinook, the number of juvenile recruits per female spawner ranged from 4 to 300, with an average across all years of 153 juveniles per female spawner.

Figure 2-7. Number of Juvenile Recruits (Subyearling and Yearling) per Spawner (brood years shown)

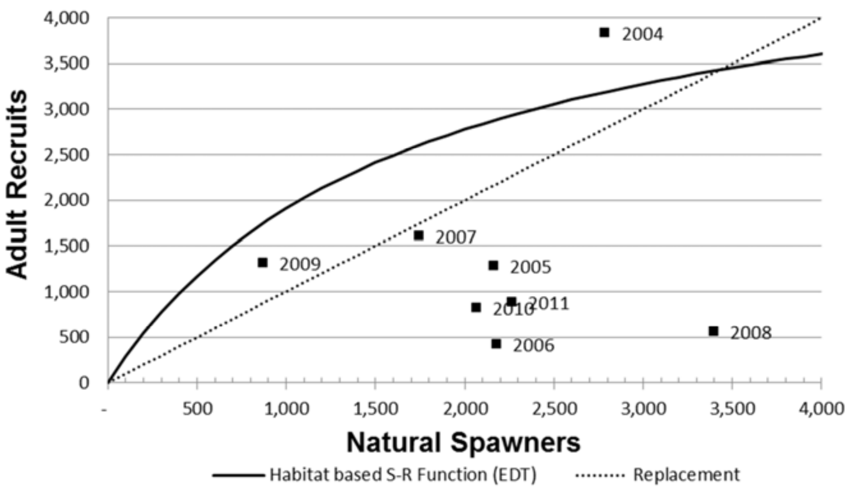


Source: NIT and WDFW data in Nisqually Chinook run reconstruction ISIT file (September 2017)

Figure 2-8 depicts Nisqually Chinook natural spawner to adult recruits back to the Nisqually River. In this case adult recruits are the number of Chinook returning to the Nisqually River by brood year.[22] Annual run to the river was allocated to brood year based on marine age data for unmarked Chinook provided by the Tribe. Adult recruits per natural spawner has varied from 0.2 to 1.5 from 2004 to 2011. Adult recruitment exceeded the replacement line (recruits per spawner greater than 1.0) in just 2 brood years (2004 and 2009). An assessment of habitat potential using the Ecosystem Diagnosis and Treatment (EDT) model suggests observed population performance is much less than habitat potential for the watershed.

[22] Future analyses will evaluate the number of adult recruits per spawner including Nisqually Chinook harvested in preterminal fisheries.

Figure 2-8. Natural-Origin Adult Recruits per Spawner (Brood Years Shown), Solid line is Current Condition Habitat Potential from the Ecosystem Diagnosis and Treatment (EDT) Model



Source: NIT and WDFW data in Nisqually Chinook run reconstruction ISIT file (September 2017)

In summary, productivity and abundance trends for natural production suggest the following.

- Abundance of natural-origin adult runs to the river were relatively strong in 2007 and 2008, but tended to be less than 1,000 Chinook from 2009 to 2015. Hatchery practices and preterminal harvest have not meaningfully changed across this time and therefore the reduction in natural-origin terminal run is not likely to be due to genetic effects from the hatchery program.
- Juvenile outmigrant production was relatively stable at over 100,000 fish from 2009 to 2013, but declined sharply in recent years. The extremely low juvenile outmigrant abundance in 2016 suggests poor adult spawning success caused by the exceptional drought conditions in 2015.[23]
- Juvenile outmigrant production data do not suggest a density-dependent effect on survival; in other words, the data suggest the system can accommodate greater freshwater production. Accordingly, higher escapement should result in higher juvenile production upstream of RM 12.8, assuming favorable environmental conditions in the river.
- Juvenile productivity data suggest the number of juveniles per spawner is low relative to other more productive populations in Puget Sound such as the Skagit River.
- Survival of adults back to the river (combined effects of marine survival and preterminal harvest) is highly variable with indications that the 2009 brood year (2010 subyearling

[23] Temperatures in excess of 20 degrees Celsius (°C) were measured throughout the mainstem Nisqually River.

outmigrants and adults returning in 2012 and 2013 at ages 3 and 4, respectively) survived at a higher rate compared to other years.

- Fry migrating in late January to mid-February represent a majority of the migrants in some years. More study is needed to better understand habitat use by juvenile Chinook in the Nisqually delta. Otolith microstructure analysis has found that Chinook that migrate downstream as fry and then rear in the delta as parr from May to June before migrating to sea survive better than other life histories (Lind-Null et al. 2009).
- Adult recruits per spawner have been less than replacement in most years. Low adult to adult productivity is a combination of relatively low freshwater productivity of the population (average of 153 juveniles per female spawner) and low survival of juveniles in the Nisqually delta and marine environments.
- Composition of hatchery-origin Chinook in natural spawning was high prior to 2013. What effect this may have on observed productivity of the population has not been evaluated, but should be considered a factor.

Reevaluation of the 2011 Stock Management Plan

Trends in abundance of natural-origin adult returns to the Nisqually River, spawning escapement, and juvenile production all indicate that natural-origin production is less than the potential of the system. Current natural productivity (juvenile recruits per spawner and adult recruits per spawner) and expected adult abundance over the short term reflect a population that is severely depressed relative to the habitat potential. The long history of out-of-basin transfers of hatchery fish into the Nisqually and multiple generations of hatchery propagation, combined with high pHOS, lead to the conclusion that the genetic make-up of the current Nisqually Chinook is significantly different than the native stock suggesting low fitness may be a significant factor affecting performance of the population.

Since the weir was no longer a viable tool to move the stock into local adaptation and future adult abundances are well below levels necessary to manage for local adaptation, the objectives contained in the 2011 plan around pHOS management and PNI had to be re-evaluated based on these current populations conditions.

In 2016, the co-managers began a new planning process focused on moving the Nisqually population toward local adaptation using the HSRG (2014) recovery phase framework. The co-managers concluded the current depressed status of the population and projected low future adult run sizes based on low juvenile abundance from 2014 to 2016 (less than 100,000 annual outmigrants) would require stepping back from moving into the local adaptation phase of the framework identified in the 2011 plan and refocus efforts on rebuilding natural production (colonization phase of the framework). The co-managers concluded the abundance of natural-origin Chinook salmon returning to the river was too low to manage for PNI (reduce pHOS and integrate broodstock with natural-origin) given escapement and harvest objectives. The technical recommendation was to prioritize rebuilding the natural origin component through a strategic colonization approach. This recommendation delays the transition to local adaptation, but does not appreciably erode its success because of the long history of out-of-basin hatchery stocking in the Nisqually River and high hatchery contribution to natural spawning.

The recommendation was based on past information that indicates natural production of Chinook could exceed 400,000 juveniles. Therefore, there may be potential to increase natural population abundance by increasing spawner abundance (without regard to composition of hatchery or natural origin) to a point where either natural production is sufficient to transition to local adaptation or there is evidence of density dependence limiting natural production. If the natural population could be increased, the likelihood of obtaining PNI objectives would improve.

The hypothesis that the Nisqually River may have greater potential to produce natural-origin juvenile and adult recruits than had been previously documented is based on the following.

- A generally positive relationship between total spawners and juvenile recruits (Figure 2-6) indicating the watershed is not at capacity.
- An assumption that there is underutilized capacity in the Nisqually estuary and there is now otolith-based evidence that migrants that spend appreciable time in the Nisqually estuary contribute disproportionately to adult returns (Lind-Null et al. 2009; NIT and U.S. Geological Survey unpublished data).
- Estimates of habitat potential for freshwater production and estimates of productivity and capacity of the much improved Nisqually River estuary to support juvenile Chinook.

In February 2017, a Nisqually technical work group was convened to develop a technical approach to colonization that would help understand population potential for natural production and rebuild abundance to allow the transition to local adaptation. A substantial unknown is whether the population is sufficiently productive to sustain natural production after transiting to local adaptation and active supplementation of natural spawning with hatchery adults is terminated.

The Nisqually technical work group agreed that, based on the HSRG recovery phase framework, population status is in the colonization phase and management priorities should focus on substantially increasing the number of naturally spawning adults throughout the watershed to improve natural production and identifying monitoring and evaluation efforts to better understand the natural production potential and use of the watershed and biological triggers for transitioning through the recovery phases. This new stock management approach is described in detail in Chapter 3, *Phased Recovery Approach*.

Continuing Habitat Efforts and Watershed-Wide Issues

Since the implementation of the original Nisqually Chinook Recovery Plan (Nisqually Chinook Recovery Team 2001), major habitat restoration initiatives have been accomplished in core areas and efforts have continued to protect existing habitat and evaluate restoration activities. Major habitat restoration initiatives have been completed in the Nisqually delta and the two primary tributaries important for Chinook, the Mashel River and Ohop Creek. Habitat protection efforts continue to advance, ensuring that existing high-quality habitat will remain and the quality and quantity of Nisqually salmon habitat will increase over time. Habitat monitoring and evaluation efforts have generated new insights into the status of core habitat-forming processes in the watershed, which led to the development of large-scale restoration and protection initiatives. However, Nisqually Chinook have the longest migration through Puget Sound of all the core populations in the ESU, making their successful recovery dependent on habitat recovery throughout the region.

Commented [S3]: Cite sources

The *Nisqually Chinook Recovery Plan* (Nisqually Chinook Recovery Team 2001) contained an action plan that outlined specific restoration and protection priorities. The action plan, which was guided by EDT model results, identified the following general priority areas: the Nisqually delta, portions of the Nisqually mainstem, Ohop Creek, and the Mashel River. Work on actions listed in the 2001 plan is ongoing to refine the habitat priorities through research, assessments, monitoring, and evaluation. For example, when the 2001 plan was developed, information was lacking on how Nisqually Chinook utilize the nearshore environment and about the condition of the nearshore habitat. Juvenile Chinook sampling since then has indicated that the nearshore areas adjacent to the Nisqually delta are important for Chinook rearing and migration. Additionally, several nearshore assessments have been completed, including the Nisqually to Point Defiance Nearshore Habitat Assessment. South Sound Nearshore habitat protection and restoration is now considered to be a high priority. The continued evaluation of key physical processes in the watershed have resulted in the identification of critical large-scale initiatives that need to occur for recovery of essential salmon habitat.

Commented [S4]: Cite sources and studies

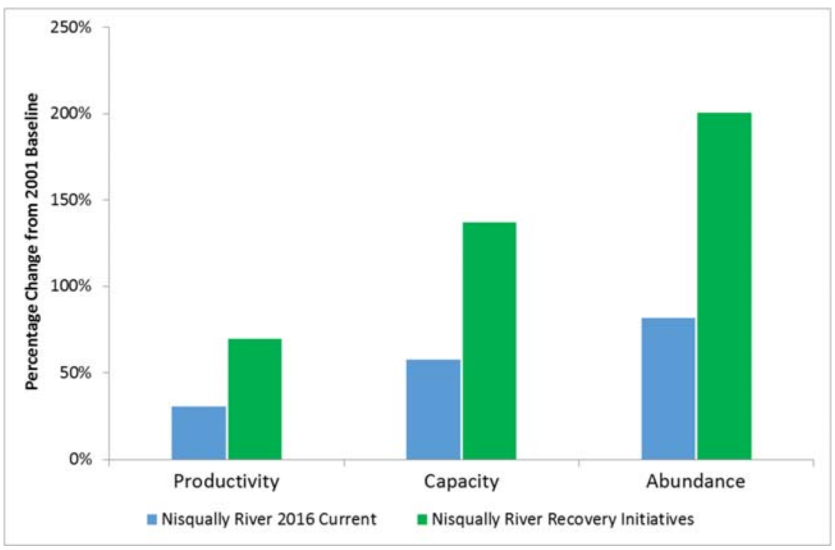
The return of tidal inundation to over 750 acres of the U.S. Fish and Wildlife Service Billy Frank Jr. National Wildlife Refuge at Nisqually in fall of 2009 was the crowning moment in the effort to protect and restore the Nisqually delta. The refuge project complemented three earlier restoration projects completed by the Tribe to restore over 900 acres of the delta, representing the largest tidal marsh restoration project in the Pacific Northwest and one of the most significant advances to date toward the recovery of Puget Sound. However, extensive post-restoration research by the Tribe, U.S. Geological Survey, and others identified that altered physical processes (river flow control, reduced sediment inputs) and the 100-year history of subsidence since initial diking threaten to undermine the recovery trajectory of the Nisqually delta (Curran et al. 2016). Especially as sea level rises due to climate change. To alleviate the sediment deficit, the routing of sediment needs to be improved through Interstate 5 and more sediment needs to make it through Alder and LaGrande Reservoirs. These projects will cost more than $1 billion but are absolutely critical for the long-term recovery of Chinook. New analyses have pointed to impaired watershed processes in the upper watershed, which also need to be addressed (citation pending).

The Mashel River is the most important tributary in the Nisqually watershed, a relatively “tributary poor” system, for Chinook and steelhead recovery identified in both the *Nisqually Chinook Recovery Plan* (Nisqually Chinook Recovery Team 2001) and the *Draft Nisqually Winter Steelhead Recovery Plan* (Nisqually Steelhead Recovery Team 2014). The Mashel watershed has been decimated by commercial forestry operations for over a century. To date, recovery actions in the Mashel have consisted of constructing engineered log jams and land acquisition in the lower Mashel River. This large-scale, multimillion-dollar effort has been extremely successful at increasing instream habitat diversity, restoring riparian zones, and reducing channel confinement. However, continued and future degradation of watershed processes in the upper watershed threatens to negate the progress already made and makes recovery of Nisqually salmon improbable. In response, the Nisqually Land Trust, Nisqually Indian Tribe, Nisqually River Council, and others have launched the Nisqually Community Forest Initiative. The goal of the initiative is to purchase much of the privately held timberlands in the upper Mashel and manage them for long-term ecosystem services recovery and sustainable local economies. This initiative will cost nearly $200 million and take decades to come to fruition.

The location of the Nisqually River in South Puget Sound makes the Nisqually fall Chinook stock arguably the most dependent on the Puget Sound ecosystem out of all the 27 stocks listed in the Puget Sound Chinook ESU. Juvenile Nisqually Chinook need functional nearshore habitat, as well as offshore-based prey resources to feed, grow, and survive during their lengthy migration to the Pacific. Additionally, returning adults must have forage fish throughout Puget Sound to put on growth essential for the arduous river migration and spawning stages of their life history. The cumulative effect of marine mammal predation on juveniles and adult Nisqually Chinook is yet another impact magnified by their lengthy traverse through the Puget Sound.

The effort to protect and restore salmon habitat in the Nisqually River has been incredibly successful in the face of persistent human population pressure, insufficient funding, and wavering political will. While the current condition of the Nisqually watershed is more conducive to salmon recovery than it was 20 years ago, the need for massive investments in watershed process–based recovery still remains. EDT modeling indicates that the improvements made since implementation of the 2001 plan have resulted in increases of 31%, 58%, and 82% in productivity, capacity, and abundance, respectively (Figure 2-9). However, even larger jumps in Nisqually Chinook population performance can be expected from successful implementation of large-scale habitat initiatives, including recovery of sediment delivery and channel migration in the Delta and changing management of the forestland in the Mashel watershed to focus on ecosystem services and watershed processes (Figure 2-1). The long road to a viable, self-sustaining, and productive Nisqually Chinook population starts at the watershed but will ultimately depend on sustained and aggressive actions to recover the Puget Sound ecosystem.

Figure 2-9. Modeled Improvements in Nisqually Chinook Habitat Potential Since Implementation of the 2001 Recovery Plan and Projected Improvements with Future Projects



Source: Ecosystem Diagnosis and Treatment model run September 20, 2017

Chapter 3
Phased Recovery Approach

This stock management plan uses a phased recovery approach, based on HSRG (2014), to achieve the conservation and harvest goals for Nisqually fall Chinook.[24] The phased recovery approach provides a science-informed, policy-directed framework that balances harvest and conservation. The framework is intended to help organize the following.

- The three elements of recovery: habitat restoration and protection, harvest management, and population productivity.
- Interim policies to guide harvest, hatchery management, and conservation as habitat recovers and population productivity and abundance improves.
- A process that is responsive to uncertainty in the plan and expected variability in recovery progress.

The framework provides a means to balance the goals of recovery and rate of progress and compliance with treaty rights, with a strong commitment to utilizing the best available information in an informed adaptive management process. The framework includes all elements of recovery essential to complying with treaty rights, interim policies to guide annual decisions to make progress toward recovery and comply with treaty rights, and a recognition of uncertainty and variability in population status that will affect progress to recovery and implementation of treaty rights.

Hatchery Scientific Review Group Framework

HSRG (2014) defines four biologically based phases for "restoration and rebuilding" of salmon populations: 1) preservation, 2) re-colonization, 3) local adaptation, and 4) full restoration. This stock management plan starts with the re-colonization phase (renamed Colonization phase for this plan) and continues through full restoration (renamed Viable Population phase for this plan). These three phases, the ecological conditions characterizing each phase, and the primary objective during each phase, as defined by HSRG and revised slightly to better reflect the Nisqually population, are described in Table 3-1. These phases represent milestones toward recovery and mark a shift in population status as well as priorities and policy direction (i.e., harvest, conservation, and maintenance of progress).

[24] Chapter 1, *Introduction*, presents the overarching goal for Chinook recovery. The harvest and conservation goals and objectives are presented in full in the *Nisqually Chinook Recovery Plan* (Nisqually Chinook Recovery Team 2001).

Table 3-1. Ecological Conditions and Plan Objectives Associated with the HSRG Recovery Phases

Recovery Phase	Ecosystem Conditions[a]	Plan Objectives
Colonization	Underutilized habitat available through habitat restoration and improved fish access to habitats.	Repopulate vacant, underutilized, and restored habitats to increase natural production, abundance, and diversity of the population through the supplementation of natural spawning with hatchery-origin adults.
Local Adaptation	Habitat capable of supporting abundances that minimize risk of extinction, as well as tribal harvest needs; population performance sufficient to promote genetic and life-history diversity.	Meet and exceed abundance/escapement thresholds for natural-origin spawners; reduce hatchery influence on the population to promote adaptation to natural habitat conditions in the Nisqually River basin and deep South Sound; increase fitness, reproductive success, and life history diversity.
Viable Population	Habitat restored and protected to allow full expression of abundance, productivity, life-history diversity, and spatial distribution; population performance (abundance, productivity, and diversity) sufficient to meet long-term sustainability of the population based on natural-origin fish.	Maintain a productive, resilient, spatially and temporally diverse population that is taking full advantage of the available habitat with minimal hatchery supplementation.

Source: Hatchery Scientific Review Group 2014

VSP attributes such as productivity and abundance and measurable metrics, or indicators, of those attributes—such as spawner abundance and composition, and natural-origin adult recruits and recruitment rates—are monitored and evaluated to understand the characteristics of the population and the success of management actions. Biological targets describe the population characteristics—in terms of desired conditions for a set of VSP attribute indicators—that must occur for the population to function within each recovery phase and to transition from one phase to the next.

Annual management decisions are related to harvest, broodstock collection, hatchery release, and removal of hatchery-origin adults from natural spawning. Annual management targets, representing the desired outcomes of these decisions, are developed annually based on predefined decision rules[25] and on annual run forecasts. Decision rules and annual management targets change as the population transitions through the recovery phases. Implementation of the annual preseason and in-season hatchery and harvest management actions are important to respond to uncertainty and variation in run size.

Commented [S5]: Clarify the role of the biologically based triggers here? As written this infers there are no considerations of the biologically based triggers and information in Tables 4-1 and 4-2

Chapter 4, *Implementation Plan,* describes the VSP attributes, indicators of VSP attributes, biological targets, and management targets specific to this stock management plan. Chapter 5, *Monitoring Tools and Objectives*, presents the monitoring programs that will be implemented under this plan to track progress toward these targets. Monitoring results are reviewed and evaluated annually to identify successes and failures of management actions during the previous year and to inform

[25] Predefined decisions rules, which reflect policy priorities as well as biological considerations, are established to guide the development of management targets for harvest, broodstock collection, hatchery release, and removal of hatchery-origin adults from natural spawning

targets and management decisions for the upcoming year, as described below under *Adaptive Management Framework*.

Local Adaptation Approach

Commented [S6]: The local adaptation approach involves a combination of elements as described in Chapters 4 and 5. Why is hatchery influence the only variable discussed here?

This section describes guidance from HSRG (2014) to promote local adaptation of salmonids to the natural environment. This guidance was used to develop the implementation plan for the Local Adaptation phase, presented in Chapter 4, *Implementation Plan*, including biological targets, management targets, and recommendations on how information will be used to inform program planning and adaptive management for Nisqually Chinook.

The overarching strategy identified by HSRG (2014) during the Local Adaptation phase is to manage hatchery programs to not impede adaptation to existing and changing (e.g., habitat restoration and climate change) natural conditions. This means that fitness-related traits (e.g., adult spawn timing) must be determined by the natural environment experienced by the population and not the hatchery environment.

However, a key assumption for local adaptation is natural-origin spawners are sufficiently abundant to assure the population will persist and grow with reduced or absent hatchery supplementation. Thus, the Colonization phase is an important step to rebuilding natural production. However, it does not address the potential underlying risk of low productivity of the population due to fitness effects hypothesized by HSRG. If fitness is a significant factor affecting productivity of the population, then moving as quickly as feasible to the Local Adaptation phase is advisable.

Commented [S7]: This could also be due to limitations by habitat or environmental conditions.

Hatchery Influence

Many of the traits related to reproductive success (e.g., spawn timing, age-at-maturity, and fecundity) can be influenced by hatchery propagation (Carlson and Seamons 2008). Hatchery-origin salmonids spawning in nature are often observed to produce fewer adult offspring than natural-origin fish due to both environmentally induced characteristics (e.g., choice of spawning location as a consequence of release location and homing) and domestication selection affecting heritable traits (e.g., spawn timing) (Christie et al. 2014). Moreover, these traits are heritable. Even hatchery programs that are operated using benign spawning techniques, such as those described by Campton (2004), result in domestication selection through relaxation of natural and sexual selection during spawning (Quinn 2005) and can affect reproductive success (i.e., fitness) of future generations in the wild. The consequence is that the fitness of future generations may be impaired depending on the degree of artificial selection during hatchery propagation and the heritability of maladaptive traits.

There is evidence that hatchery propagation, even for one or two generations and when broodstock is collected from wild fish populations, can result in lower fitness of hatchery-reared fish in nature than wild fish (Araki e al. 2008). These studies are for salmonids with long freshwater residence and may be subject to additional domestication selection while in the hatchery. Berejikian and Ford (2004) suggest it is reasonable to assume domestication selection may be less for salmon with a short freshwater period (i.e., subyearling Chinook). Nevertheless, it is reasonable to assume that fitness of Nisqually Chinook in the wild is much less than the ancestral population for two reasons:

Chinook in the Nisqually River are derived from an out-of-watershed hatchery stock[26] and the stock has been largely a hatchery stock with no attempt to include gene flow from natural-origin adults.[27]

Annual management targets for spawning composition and natural-origin in hatchery broodstock during the Local Adaptation phase are based on a single-trait phenotypic fitness model developed by Ford (2002). The fitness model predicts a shift in a hypothetical trait value toward an environmental optimum representing the hatchery and natural environments. The fitness model includes assumptions of selection strength, trait heritability, and trait variance. Application of the Ford model to Nisqually Chinook for the current condition predicts a mean population trait value strongly shifted toward the hatchery optimum, suggesting a low current fitness condition. This does not take into account that Nisqually Chinook may be further removed from the natural optimum because the historical population was extirpated and replaced with an out-of- watershed hatchery-derived stock.

The Multi-Population PNI (MP-PNI) model developed by Craig Busack with NOAA Fisheries[28] was used to evaluate program assumptions, develop gene flow guidelines, and set annual management targets during the Local Adaptation phase of this effort. Assumptions used in the model included a two part natural population (natural spawning downstream and natural spawning upstream of the Centralia Diversion Dam), an integrated hatchery component (Kalama Creek Hatchery), and a "stepping-stone" hatchery program (Clear Creek Hatchery and McAllister Springs release).[29]

Modeling Foundation for Local Adaptation Management Targets

Direct measures of genetic effects of hatchery propagation on wild population fitness are difficult to obtain and beyond the objectives of this stock management plan. Monitoring annual management targets for the following indicators of gene flow is a reasonable substitute.

- pHOS: Annual proportion[30] of adults spawning in nature that are of hatchery origin.
- pNOB: Annual proportion of hatchery broodstock that are natural-origin adults from the donor population component.

Commented [S8]: Should include or reference where else in the document the reader can find the monitoring actions that will be taken to address it.

[26] The most recent stocking of an out-of-watershed hatchery stock was in 1996.

[27] Monitoring to evaluate production potential of the existing hatchery-dominated population and possibly the relative reproductive success of hatchery-origin adults spawning in the wild compared to natural-origin adults will be conducted during the Colonization phase. However, the relative fitness of hatchery-origin Chinook cannot be compared to locally adapted wild Nisqually fall Chinook because the wild population no longer exists.

[28] The MP-PNI model is a multi-population extension of the Ford model that links several population components through assumptions of gene flow. In the Nisqually case, natural-origin Chinook are used in the integrated program broodstock (pNOB) and the stepping-stone program broodstock is linked to the natural population through the use of returns from the integrated program.

[29] The plan will be updated based on new data and information consistent with the check points described in the Colonization Phase. The hatchery strategy during local adaptation, including inclusion of a stepping-stone program, is based on current scientific thinking and data, and the assumption that the magnitude of natural-origin spawners relative to the hatchery component of natural spawners will be sufficient at the transition from colonization to local adaptation to achieve a PNI greater than 0.50 given the hatchery production and harvest objectives. This strategy will be reviewed at the point of transition to local adaptation to ensure the strategy that is adopted reflects best science and information at that time.

[30] Monitored separately for the natural populations upstream and downstream of the Centralia diversion dam.

Management targets for these indicators and for the resulting estimate of the PNI[31] of the composite population will be one of the indicators used to monitor progress toward achieving a population adapted to the environmental conditions in the Nisqually River watershed and Puget Sound and will be updated as new science and information becomes available.

The MP-PNI model is used to calculate the equilibrium PNI, which is the PNI value that over multiple generations of modeling no longer changes with subsequent generations.[32] Annual estimates of equilibrium PNI based on the estimated pHOS and reported pNOB in the integrated program broodstock will be the basis for monitoring progress toward local adaptation.

PNI and the resulting prediction of fitness effects are based on PNI values varying from 0.0 to 1.0, where *PNI = 0.0* or *PNI = 1.0* imply that the genetic structure and mean phenotypic values for the composite population are influenced only by the hatchery or natural environment, respectively. Theoretically, a PNI value greater than 0.5 indicates that selective forces in the natural environment will have a greater influence on the population than selective forces in the hatchery environment.

In the equation for PNI, pHOS is based on census data of the proportion of hatchery-origin spawners (correction factor of 1.0). Monitoring programs described in Chapter 5, *Monitoring Tools and Objectives*, provides sufficient and unbiased sampling of spawners and accurate identification of hatchery- and natural-origin spawners to calculate annual PNI estimates.

A census-based estimate of pHOS implies a relative contribution of hatchery-origin adults spawning in the wild of 1.0, meaning hatchery-origin adults have the same contribution to the next generation as natural-origin adults when spawning in the wild. The Nisqually technical work group decided to not include a correction factor for hatchery-origin spawners. A study plan to evaluate a reproductive success of hatchery-origin spawners relative to natural-origin for Nisqually Chinook is discussed in Chapter 5, *Monitoring Tools and Objectives, Additional Monitoring and Studies*. HSRG (2014) has in some cases applied a correction factor on hatchery-origin adults spawning in the wild to estimate an effective hatchery contribution.

Commented [S9]: Core monitoring element

Annual PNI will be estimated by computing the equilibrium point based on the previously described metrics and reported as a running 4-year average to monitor progress toward local adaptation. The 95% confidence intervals for pHOS will be estimated and reported to track the range of possible pHOS and resulting PNI values. The annual PNI estimate will be based on the hatchery broodstock pNOB in the integrated program for the same year.

Equilibrium PNI is a long-term trend (tens of generations) and is used only to indicate a range of possible effects of managing for higher natural influence for multiple generations. The Nisqually technical work group has set a PNI objective of 0.50 at the beginning of the Local Adaptation phase (consistent with a Tier 2 population). Following the transition annual management decisions will attempt to annually increase PNI to achieve a PNI objective of 0.67 (consistent with a Tier 1 population) to move into the Viable Population phase. The higher PNI objective is expected to occur through increased abundance of natural-origin with hypothesized improvements in population performance (productivity and capacity) with predicted increase in fitness and through additional

Commented [S10]: Need to explain. First time this is mentioned.

[31] PNI is an indicator of the degree to which the hatchery and natural environments influence selective pressures in the composite natural population upstream and downstream of the Centralia diversion dam.

[32] The PNI approximation described by the HSRG (2014) does not account for the stepping-stone program or the differences in gene flow among the natural population components.

habitat restoration in freshwater, the delta, and nearshore marine areas. Additional management actions to increase PNI to the 0.67 objective are discussed in Chapter 4, *Implementation Plan*.

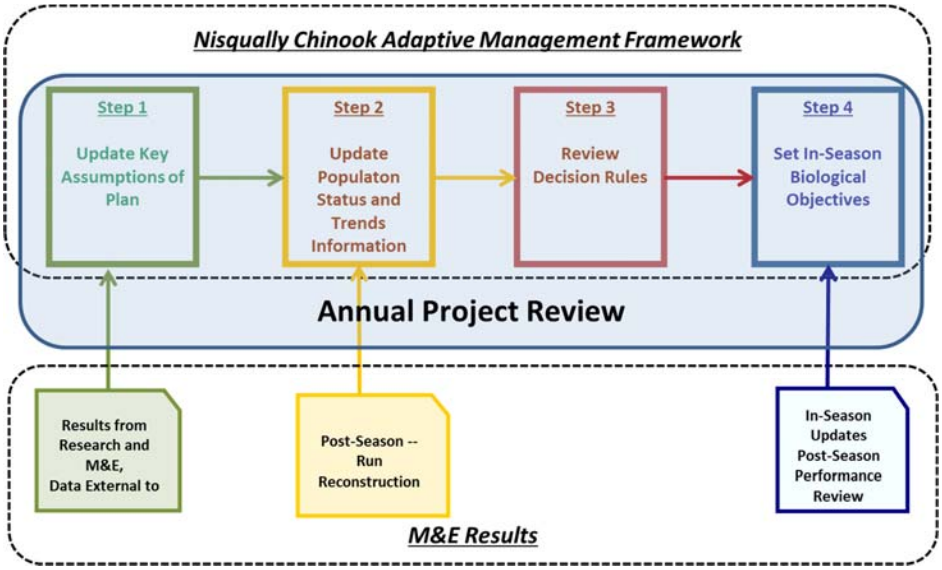
Adaptive Management Framework

This adaptive management framework establishes the systematic review and evaluation of information to audit performance, challenge key assumptions, guide decisions, and plan activities for the upcoming year (Figure 3-1). The process is formalized in a database and a set of management tools that ensure consistency and accountability from year to year (Chapter 6, *Data Management, Record Keeping, and Accounting*).

The 3-day Annual Project Review (APR) convened each year by the co-managers is the cornerstone of the adaptive management framework. The APR is convened to allow the Nisqually Indian Tribe, WDFW, NOAA Fisheries, and other participants to provide updates, review monitoring results, and plan for the upcoming season. The APR includes the following elements.

- Review previous year's performance against management targets and biological targets.
- Update status and trends information, based on post-season run reconstruction and evaluation of monitoring results for VSP attribute indicators and biological targets.
- Update key assumptions, based on monitoring and evaluation results and ongoing research, to ensure a scientifically defensible working hypothesis for recovery.
- Review and apply decision rules for harvest, hatcheries, and escapement using preseason run size projections.
- Review and update biological targets for the coming year to reflect any change in status of the population and for consistency with recovery objectives.
- Update monitoring programs to reflect information needs to evaluate population status, key assumptions, and research questions.
- Develop action plan for next year.

Figure 3-1. Adaptive Management Framework



In addition to review during the APR, a more thorough data-driven assessment to evaluate assumptions about the productive potential of the stock and the capacity of the watershed and delta and to determine if the management strategies are adequate is described in Chapter 4, *Implementation Plan*.

Adaptive management decisions vary in the degree of policy involvement and the frequency with which they need to be revisited. While overall recovery goals will be reviewed less frequently, management policies guiding fisheries and conservation decisions may need to be reviewed more often, depending on status of the population, environmental conditions, and progress toward recovery. Near-term objectives such as annual management targets, strategies, and implementation will be reviewed annually prior to the fall management season. Finally, the Nisqually technical work group will meet at regular intervals throughout the year to ensure that activities are coordinated among the agencies working toward recovery.

Chapter 4
Implementation Plan

This chapter presents the plan for implementing the phased recovery approach, beginning with the implementation of an 8-year colonization experiment to boost natural production and ending with the establishment of a self-sustaining viable population based on the best available scientific information. It describes the anticipated outcomes of hatchery, harvest, and continued habitat actions on the population through multiple generations. For each recovery phase an approach to the management of harvest, hatchery, and escapement is described.

Table 4-1 presents the VSP indicator characteristics of the population by plan phase. VSP indicators for abundance, productivity, spatial diversity, and life-history diversity are shown for each recovery phase. The indicators describe population characteristics consistent with each phase of the plan and are used to develop decisions rules and evaluate hatchery, harvest, and escapement objectives for each phase. Nisqually Chinook management will shift from the Colonization phase to the Local adaptation phase within 8 years independent of population status. The transition from the Local Adaptation phase to Viable Population phase is expected to occur after multiple generations of management under Local Adaptation and is strongly dependent on achieving habitat recovery objectives for freshwater, estuarine and marine areas as well as expected improvements in population fitness predicted under local adaptation.

The biological characteristics for each recovery phase presented in Table 4-1 will be updated as new information becomes available through VSP indicator monitoring identified in Table 4-2. Monitoring VSP indicators at each phase will inform the update of biological characteristics and management needs of each successive phase.

Table 4-2 describes the indicators identified by the Nisqually technical work group to evaluate population status. Specific monitoring programs are described in Chapter 5, *Monitoring Tools and Objectives, Additional Monitoring and Studies*.

Overview of Phase Goals and Objectives

A brief overview of each phase and rationale for biological characteristics in Table 4-1 is provided below.

Colonization

In addition to rebuilding natural-origin abundance, the Colonization phase is an important first step in the monitoring plan. The Colonization phase is when monitoring methods will be tested and refined, and data collected to be used to evaluate freshwater potential (spawner to juvenile outmigrant capacity and productivity), behavior and survival of juveniles in the delta, and juvenile to adult survival back to the river.

During the Colonization phase, management actions are to increase adult natural spawning with no regard to composition. The objectives are to increase juvenile outmigrant abundances and corresponding adult returns. Current adult mean annual natural-origin escapement abundances are low, with low forecasts for the next several years based on number of juvenile outmigrants in recent years. During colonization, natural spawning will be supplemented with hatchery-origin adults. The

Nisqually technical work group hypothesized this action will result in higher annual juvenile abundances and higher annual natural-origin returns to the Nisqually River. Productivity, as measured both by juvenile outmigrants per spawner and adult recruits per outmigrant and per spawner, will be evaluated for the presence of an asymptote in outmigrants per spawner (an indication of freshwater capacity constraints) and adult recruits per outmigrant (an indication of delta and early marine capacity constraints). Evidence of an asymptote at higher natural spawning for either stage would reflect an upper bound to natural spawning abundance, which will be used to refine escapement objectives during local adaptation. Adult monitoring for natural spawning abundance and distribution, as measured by number of adults spawning downstream and upstream of the Centralia Diversion Dam, in tributaries, and composition (hatchery-origin/natural-origin), will be evaluated to determine effectiveness of adult supplementation actions and habitat potential.

The Colonization phase will be when several key components of the plan are developed and tested. An adult trap in the Centralia Diversion Dam Fish Ladder at RM 26.2 will be installed and tested. The trap will be used to enumerate adult Chinook returning to the upper basin during the Colonization phase, and to remove hatchery-origin and collect natural-origin broodstock during the Local Adaptation phase. Although objectives during colonization do not include reducing hatchery-origin contribution to natural spawning, actions to manage hatchery-origin contribution to natural spawning will be evaluated during the Colonization phase, including moving 1.0 million Chinook from the Clear Creek hatchery release to McAllister Springs and testing fishing methods to differentially harvest hatchery-origin Chinook in the Nisqually treaty fishery. These measures will be important during the Local Adaptation phase.

Local Adaptation

Management actions during local adaptation are intended to meet and exceed abundance thresholds for natural-origin spawners; reduce hatchery influence on the population to promote adaptation to natural habitat conditions in the Nisqually River basin and deep South Sound, improve reproductive success of the population and increase spatial and life history diversity of the population.

A brief description of each population metric in Table 4-1 under local adaptation and a rationale for the range of values are provided below. Results from the colonization experiment will be used to update these population characteristics for the Local Adaptation phase.

The anticipated population characteristics for the Local Adaptation phase in Table 4-1 are set broadly to support a transition to local adaptation within eight years. They characterize the expected response from the colonization experiment and the low end of the ranges are generally based off of the high end of past population performance, reflecting current habitat potential and ability of the population to take advantage of the habitat. Ranges for productivity characteristics consider effects of density dependent factors. Freshwater and delta productivity indicators may be lower with higher abundances because of density effects on survival.

During the Local Adaptation phase the natural-origin adult spawning escapement would range from 1,500 to 3,400. Escapement targets will be refined utilizing monitoring results during the Colonization phase in order to optimize natural production. The transition to the Viable Population phase will occur when the 5-year running average of natural-origin spawning escapement exceeds 3,400 adults. The 3,400 Viable Population spawner abundance target is the high productivity planning target in the Puget Sound Salmon Recovery Plan (National Marine Fisheries Service 2006). The 1,500 adult natural spawning escapement is consistent with the high end of observed run sizes (a Nisqually River run greater than 2,200 adults in 2007 and 2008; see Figure 2-2).

Commented [S11]: Good discussion

The outmigrant abundance during the Local Adaptation phase is anticipated to range from 250,000 to 400,000 outmigrants, which corresponds with the upper range of observed outmigrant abundances. During the first 5 years of trap operations (2009 to 2013) estimates of abundance ranged from a low of 146,292 Chinook (2013) to a high of 434,969 Chinook (2009) and averaged 224,241 Chinook. Since 2013, juvenile abundance has not exceeded 100,000 outmigrants. The monitoring location for juvenile abundance is upstream of approximately 8 river miles of spawning habitat that would also contribute to natural production. The location for was factored into this range. A watershed-wide juvenile abundance estimate is not possible for the Nisqually River. The Nisqually River delta monitoring program described in Chapter 5, *Monitoring Tools and Objectives, Additional Monitoring and Studies*, will evaluate juvenile timing and densities in the delta, but is not able to provide an estimate of juvenile abundance.

During the Local Adaptation phase, the anticipated range in productivity is 1.5 to 3.0 adult recruits per spawner. Productivity above 3.0 recruits per spawner would trigger the transition to the Viable Population phase. The 3 recruits per spawner represents the high productivity planning target identified in the 2006 Puget Sound Recovery Plan. The low end of this range is the high end of recruits per spawner that have been observed. From brood year 2004 to brood year 2011 productivity ranged from a low of 0.2 recruits per spawner (brood year 2006) to a high of 1.5 recruits per spawner (brood year 2009) and averaged 0.7 recruits per spawner. The level of 1.5 recruits per spawner was met in only one year. However, two major factors were considered when evaluating the historical data. First, the number of parent spawners includes hatchery-origin adults with an unknown contribution to natural production. Second, a majority of the historical recruitment estimates are for brood years prior to major habitat restoration in the Nisqually delta (completed for the 2010 juvenile outmigration).

The range for juvenile freshwater productivity (number of outmigrants [fry, parr, and yearlings] per spawner) during the Local Adaptation phase is anticipated to be from 150 to 300 outmigrants per spawner. The low end value is partially based on historical observations of productivity for the population. Observed productivity has ranged from a low of 2.0 juveniles per spawner (the highly unusual 2015 brood year) to a high of 161 juveniles per spawners (brood year 2009) and has averaged 87 recruits per spawner, excluding 2015. The low estimate for brood year 2015 is likely the result of unusually low flow and warm water temperature in the Nisqually River in the fall of 2015. These factors may have limited upstream movement of adult Chinook salmon through the Centralia Dam diversion reach immediately upstream of the trap location and resulted in pre-spawn mortality. The anticipated range also considered productivity data reported for the Skagit River Chinook. Zimmerman et al. (2015) reported 270 to 1,230 outmigrants per female spawner for Skagit River Chinook. For comparison, assuming a 1:1 sex ratio for Nisqually River Chinook, the number of juvenile recruits per female spawner ranged from 4 to 322, with an average freshwater productivity of 174 recruits per female spawner (again excluding brood year 2015). The Skagit River data suggest a much higher productivity potential for Chinook salmon then currently observed in the Nisqually River that the work group hypothesizes should be achievable for Nisqually River Chinook with improved fitness. The work group also considered that spawner to outmigrant productivity estimates from the Nisqually are based on outmigrant estimates from the trap located at RM12.8 and adult spawner estimates include the entire watershed. Juvenile abundance estimates do not include production from natural spawners below the outmigrant trap. The estimation method for natural spawners does not allow a means to separate escapement abundance above and below the outmigrant trap. The outmigrant trap data will be used to provide a relative estimate of productivity.

The anticipated range of outmigrant to adult survival rates during the Local Adaptation phase was set at 0.75 to 1.0%. Survival rates for brood years 2008 to 2011 (years with complete adult returns) have ranged from 0.1% (brood year 2008) to 0.9% (brood year 2009) and averaged 0.5%. The high survival of outmigrants from brood year 2009 was predominately subyearlings migrating in 2010, immediately after restoration of 750 acres of the Nisqually delta, providing some confidence that future rates with favorable marine conditions will tend to be higher than the data series suggests. In addition, survival through the delta and marine nearshore may be where significant improvements in fitness occur. Over multiple generations of managing for local adaptation juvenile Chinook outmigration timing may shift to later in the season with shifts in spawn timing and selection for later time migration to take advantage of better survival conditions in late winter and spring in the recovering delta and offshore habitats. A survival rate of 1.0% would indicate a transition to the Viable Population phase.

At this time specific numeric targets are not identified for spatial diversity and life history diversity during Local Adaptation. Indicators to characterize spatial diversity include the distribution of adult spawners upstream and downstream of the Centralia Diversion Dam and in the Mashel River consistent with estimated habitat potential. Other indicators are monitoring of juvenile Chinook use of current and restored habitats in freshwater and the delta. The expectation is that management actions will maintain and grow spatial diversity of the population. Adult and juvenile life history traits will be monitored and compared to current patterns. Life history diversity is expected to increase with habitat restoration and expansion. Habitat restoration will increase the complexity of habitat available to Chinook salmon and the potential ways in which adults and juveniles can use that habitat. Indictors for life history diversity may include an increase in variance in life history traits such as age, sex, juvenile life history, and migration and spawning timing.

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Viable Population

The anticipated characteristics during the Viable Population phase represent the characteristics of a self-sustaining, locally adapted population. These characteristics will be refined over time as monitoring yields further information about the changing population.

Table 4-1. Anticipated Population Characteristics for Nisqually Chinook within Recovery Phases

VSP Metric[a]	Colonization[b]	Local Adaptation	Viable Population
Adult escapement abundance (natural-origin)	Mean annual escapement (2021-2025) exceeds pre-experiment (2012–2020)	>1,500 to 3,400 adults	>3,400 adults
Juvenile abundance (number outmigrants at WDFW outmigrant trap at RM 12.8)	Mean annual juvenile abundance (2018-2022) exceeds pre-experiment abundance (2009–2017)	250,000 to 400,000 outmigrants	>400,000 outmigrants
Productivity –juvenile outmigrants per spawner	Observed asymptote in outmigrants per spawner trend, measured over 8 years	>150 to 300 outmigrants per spawner	>300 outmigrants per spawner
Productivity – survival rate from juvenile outmigrant to adult	NA	>0.75% to 1.0%	>1.0%
Productivity –adult recruit to Nisqually River per spawner	Observed asymptote in number of recruits per spawner rate trend measured over 8 years	>1.5 recruits per spawner to 3.0 recruits per spawner	>3.0 recruits per spawner
Spatial diversity – Adult use of natural spawning habitats and juvenile use rearing of habitats	Available habitat is utilized for spawning and rearing consistent with assessed habitat potential, in particular identified core areas	Available habitat is utilized for spawning and rearing consistent with assessed habitat potential.	Available habitat is fully utilized for spawning and rearing consistent with assessed habitat potential.
Life-history diversity – age, sex, juvenile life history, and migration and spawning timing adults and juveniles	Increasing variance in juvenile and adult traits over time	Increasing variance in juvenile and adult traits over time	Life history traits stabilized over time

[a] VSP metrics for all recovery phases will be updated through multiple generations of monitoring.
[b] Transition to Local Adaptation phase will occur at the end of the eight-year colonization experiment.

Table 4-2. VSP Attributes and Indicators

VSP Attribute	VSP Indicator	Relationship to Plan	Variables Monitored
Abundance	Natural-origin annual run to river	A key indicator of increased productivity of Nisqually Chinook. Indicator of response to increased spawner abundance, improved freshwater, delta, and marine habitat, and hatchery management actions.	Annual terminal run reconstruction estimates of natural-origin adults entering Nisqually River from fisheries and escapement variables
	Natural-origin adult recruits	Indicator of long-term trends in adult abundance and effectiveness of preterminal harvest rate constraints.	Estimates of adult equivalent recruitment (number of adults that would return to river absent preterminal harvest)
	Juvenile outmigrants	Indicator of response to increased spawner abundance, improved freshwater habitat, and age or life stage at migration attributable to hatchery management actions.	Abundance, age, and life-stage composition of outmigrant population over time across the entire juvenile migration period
	Natural-origin spawning escapement	Key indicator of increased productivity of Nisqually Chinook and effectiveness in meeting annual management targets (including harvest) for natural-origin spawning	Annual estimates of natural-origin and hatchery-origin spawners for all natural population components identified in plan
Productivity	Freshwater productivity (outmigrants per spawner)	Indicator of effectiveness of a) habitat efforts in freshwater to increase natural productivity and b) fitness effects attributable to hatchery management actions. Will be used to assess evidence for density dependence and fitness effects attributable to management actions.	Spawner escapement estimates, composition, and outmigrant abundance
	Marine survival (outmigrant to adult recruit back to river)	Indicator of a) habitat efforts in Nisqually delta and Puget Sound to increase natural productivity, b) fitness effects attributable to hatchery management actions and c) effectiveness of pre terminal harvest rate constraints.	Outmigrant abundance estimates (at outmigrant trap) and estimates of adult recruits back to river
	Life cycle productivity (adult run to river per spawner)	Indicator of potential of population to achieve recovery goals and effectiveness of management actions across entire life cycle.	Annual basin-wide estimates of natural natural-origin and hatchery-origin spawners and adult natural-origin return to river by brood year.
Spatial Distribution	Distribution of natural-origin spawners and juveniles relative to spawning and rearing habitat	Effectiveness of colonization and improved habitat—use of vacant or sparsely populated spawning and rearing habitat and newly restored habitat	Adult counts at Centralia Diversion Dam, spawning ground surveys in mainstem and tributaries upstream and downstream of Centralia Diversion Dam. Juvenile distribution and residence time in Nisqually delta

VSP Attribute	VSP Indicator	Relationship to Plan	Variables Monitored
Life-History Diversity	Migration and spawn timing, age at spawning, age and life stage at outmigration, body size and timing of outmigration, juvenile habitat rearing choice	Indicates to what extent increased influence of the natural habitat will affect diversity in observable attributes.	Multiple methods

Proposed Nisqually Chinook Implementation Plan

The primary goal of the Nisqually Chinook plan is the recovery of the population. The purpose of the hatchery program is to contribute to harvest (treaty and nontreaty) in a manner consistent with the long-term goal to recover the population.

The following sections summarize key aspects of the plan by recovery phase. Each section begins with a general overview of the working hypothesis underlying the phase, followed by the phase goals and objectives. The action plan for the phase is described and harvest, hatchery and escapement management actions described. Finally each phase concludes with an overview of monitoring activities specific to the phase. Additional monitoring details are described in Chapter 5, *Monitoring Tools and Objectives*.

Colonization Phase

The approach during the Colonization Phase is based on the hypothesis that habitat capacity in the Nisqually River, the delta, and the Puget Sound nearshore environment is under-utilized and thus can support greater abundances of juvenile and adult Chinook salmon than at recent levels of escapement and natural production. That is, there is under-utilized capacity in these areas to produce more Nisqually Chinook. The historical population data summarized in Chapter 2, *Current Status of Natural Population*, support this assumption.

The co-managers will use the Colonization Phase to refine biologically based decision rules for hatchery, harvest and escapement management for the Local Adaptation recovery phase. Those rules will be designed to improve population performance in terms of VSP attributes over time as the Chinook salmon population adapt to the watershed and to move the population toward the Viable Population phase.

The Colonization phase will follow a fixed timetable and will terminate by 2024 after approximately two brood years of Chinook supplementation and intensive monitoring. The management of Nisqually Chinook will then move into the Local Adaptation Phase.

Goal

Repopulate vacant, under-utilized, and restored habitats to increase natural production, abundance, and diversity of the population.

Objectives

Rebuild natural production to a level that meets abundance and productivity targets necessary to move management to the Local Adaptation Phase through the supplementation of natural spawning with hatchery-origin adults (i.e., trucking of hatchery adults and hatchery-origin adults naturally straying to spawning areas) by focusing on the following objectives:

1. Achieve an aggregate natural spawning escapement of hatchery- and natural-origin fish that exceeds 3,500 spawners. This escapement level is set to improve natural production to meet or exceed the lower end of the Local Adaptation biological targets for juvenile and adult abundance. The 3,500 adult objective corresponds to the highest level of outmigrants observed (2008 brood year and 2009 outmigrants [Figure 2-7]). This will be achieved through truck-and-haul techniques with hatchery-origin adults collected from the Clear Creek and Kalama Creek

hatcheries. The aggregate natural spawning escapement will be reviewed annually and may be updated if distribution of supplemented adults or juvenile production suggests a different escapement objective.

2. Monitor the population and evaluate management actions to:
   a. improve our understanding of freshwater habitat potential from adult spawning to juvenile outmigration,
   b. improve our understanding of fish use, resource constraints, and ecological interactions of juvenile Chinook throughout the river and delta to better understand relationship between freshwater production and survival to adult, and
   c. use these monitoring results to refine biological targets and management actions for the Local Adaptation phase
3. Continue the development of management tools for:
   a. preseason forecasting and in-season updates, and
   b. protocols for in-season updates to better forecast and manage preterminal and terminal area fisheries.
4. Explore new fishing techniques, gears and harvest management strategies to more effectively harvest hatchery-origin adults (more detail below).
   a. Implement co-manager proposal for testing commercial selective gear in treaty fishery in 2018
      - Develop criteria to evaluate success of program to ensure those are monitored and assessed
      - Identify feasible gears (tangle net, selective sport, beach seines, circular seines, mesh sizes, etc?)
      - Different strategies for different locations (river, McAllister, estuary)
      - Implementation details
      - How to assess ER in fishery?
   - Review information at first check-in, finalize program to implement if phase shifts and based on information from check-in and new science, decide next steps if not.

Commented [S13]: Add details here or define schedule to develop details for fishery prior to implementation in 2018

Action Plan

The approach in the Colonization Phase is to increase the total number of naturally spawning Chinook salmon (hatchery- and natural-origin) through adult supplementation to produce a greater abundance of juvenile outmigrants and natural-origin adult recruits back to the river.

The transition from Colonization to Local Adaptation will follow a fixed timetable (Table 4-3). Monitoring the response of the Chinook population to aggressive supplementation through the duration of the Colonization Phase will be used to inform management actions including harvest rates, hatchery production and natural spawning escapement to achieve the goals of the Local Adaptation phase. In the Local Adaptation phase, the number of natural-origin adults entering the river needs to exceed 2,200 Chinook to support management actions for natural spawning and hatchery broodstock integration described in the next section for Local Adaptation. Escapement (?) is projected to achieve a lower end escapement objective of 1,500 natural spawners. Monitoring

Commented [S14]: How does this fit with the triggers in Table 4-1?

Commented [S15]: Is this the same as the low end of the NOR spawning range in Table 4-1? If so, should state there are NOR spawners.

results during the Colonization phase will be used to review and potentially replace the population characteristics identified for the Local Adaptation phase.

Check-In Timeline and Adaptive Management

The Colonization phase will follow an 8-year timeline (Table 4-3) before a transition to Local Adaptation is made for the 2025 management season. During this period annual project reviews will occur to provide preliminary assessments of VSP attribute indicators described in Table 4-2, refine monitoring activities described in Chapter 5, *Monitoring Tools and Objectives*, and set actions and associated management targets for the upcoming year. Two formal check-ins to review progress are scheduled, the first in spring of 2022 and the second in spring of 2025 following the 2024 management season and at the end of the 8-year timeline.

The check-ins will be used to report on progress, update anticipated population characteristics for local adaptation (Table 4-1), and adjust program strategies. The check-ins will evaluate the relationship between total spawner abundance and juvenile outmigrants to assess freshwater productivity and abundance for indications of density-dependence. Indicators of density-dependence would suggest an upper capacity limit to freshwater production. Data collected to date indicate a linear relationship between spawner abundance and juvenile migrants (Figure 2-7). Evidence for a density-dependent relationship would show a declining productivity and upper limit to juvenile migrant abundance. In other words, a change in the linear relationship to an asymptotic relationship with an upper abundance. Other indicators of density-dependence could include greater variation in emigration timing (winter fry, spring parr, and summer fingerlings) and reduced mean size or condition of juvenile migrants.

- **Check-in #1 (2022):** After five years of adult supplementation (2017–2021) and outmigrant monitoring at the WDFW-operated screw trap (2018–2022), the relationship between total spawner abundance and juvenile outmigrants will be assessed for indications of a density-dependent relationship. Data collected to date indicates a linear relationship between spawner abundance and juvenile migrants (Figure 2). Evidence for a density dependent relationship would include an upper limit to juvenile migrant abundance, and a change in the nature of that relationship from linear to asymptotic. Other indicators of density-dependence would include greater variation in emigration timing and reduced mean size or condition of juvenile migrants. After five years of juvenile monitoring, the capacity parameter in a Beverton-Holt, Ricker, or hockey-stick stock-recruitment model will be estimated. There are two potential outcomes:
    - **Outcome 1:** Data indicate a better fit to a density independent (linear regression) model than a density-dependent stock-recruit. Should the spawner-juvenile recruit relationship indicate a density-independent relationship (linear), adult supplementation will continue until 2024. Managers will try to explore the upper bounds of the system capacity during this time.
    - **Outcome 2:** Data indicate a better fit to a density dependent stock-recruit model than a density-independent, linear model. If this is the case, adult supplementation would be discontinued and estimates of past juvenile to adult survival rates for the population will be applied to the juvenile abundance estimates to provide an estimate of adult recruits expected in years 2021 to 2025. Until adult returns are complete, these natural-origin adult recruit estimates, productivity assessment and other indicators can be used in a life cycle modeling approach to develop a hatchery actions (broodstock management; number, size, location of release) that achieve PNI targets, harvest actions and escapement thresholds

consistent with local adaptation. The life cycle model approach would use the best available information on smolt to adult return rates in the Nisqually River and elsewhere in Puget Sound. Under this outcome, the program will enter the local adaptation phase.

- **Check-in #2 (Spring of 2025):** This is the final check-in the Colonization phase.
  - **Outcome 1**: The adult-to-juvenile stock-recruit relationship would be repeated as described in Check-in #1 above. However, the maximum number of years that the adult supplementation would be implemented is 8 years. If there is still no evidence for density dependent capacity limits after 8 years of supplementation, escapement targets for the Local Adaptation phase would be set based on the best available science.
  - **Outcome 2**: In 2024, age-4 natural-origin adult returns produced from the initial 2017–2021 adult supplementation phase will be complete. At this point, natural-origin recruits from 5 years of adult supplementation reflect the capacity of the Nisqually River basin, estuary, and Puget Sound nearshore environment to support naturally reproducing Chinook salmon. Although monitoring will continue, the HSRG framework indicated in this plan and the accompanying emphasis on broodstock management, including PNI objectives, will be used as the basis for hatchery production, broodstock management, and harvest management during the Local Adaptation phase. Decisions will incorporate the data ganed during the implementation period and the best available science related to hatchery and harvest management.

Commented [S16]: 2025? 2021 + 4 is 2025

Table 4-1. Timeline for the Colonization Phase

Brood Year[a]	Plan Year 2017	2018	2019	2020	2021	2022[b]	2023	2024[b]
2017	Start	Outmigrant	Age-2	Age-3	Age-4	Age 5		
2018			Outmigrant	Age-2	Age-3	Age-4	Age 5	
2019				Outmigrant	Age-2	Age-3	Age-4	Age 5
2020					Outmigrant	Age-2	Age-3	Age-4
2021						Outmigrant	Age-2	Age-3
2022							Outmigrant	Age 2

[a] Brood Years are planned years of adult supplementation described in text.
[b] Check-ins will occur in these years as described in the text, the last check-in will be in spring 2025 after the 2024 management season and before the 2025 season.

Adult Supplementation Operations Plan

Hatchery Chinook from Clear Creek and Kalama Creek hatcheries will be collected from the hatchery adult return ponds, biologically sampled (length, scales, tissue sample for DNA analysis, and mark status), jaw tagged, and released into the Nisqually mainstem upstream of the hatcheries at the Centralia City Light Yelm Hydro project Powerhouse (Centralia Powerhouse) boat ramp, and upstream of the Centralia Diversion Dam (Figure 4-1). Release sites were chosen because of transport time and the number of Chinook to be released. The upper site at Centralia Diversion Dam was chosen to allow adults to freely migrate to spawning locations in the upper Nisqually River and Mashel River. Release locations may be modified through the adaptive management process if transported Chinook are not distributing to spawning areas.

Adults with a coded-wire tag will not be transported and instead processed to remove the tag to collect as many coded-wire tag samples in the hatchery as possible to ensure tag recoveries sufficient for management purposes.

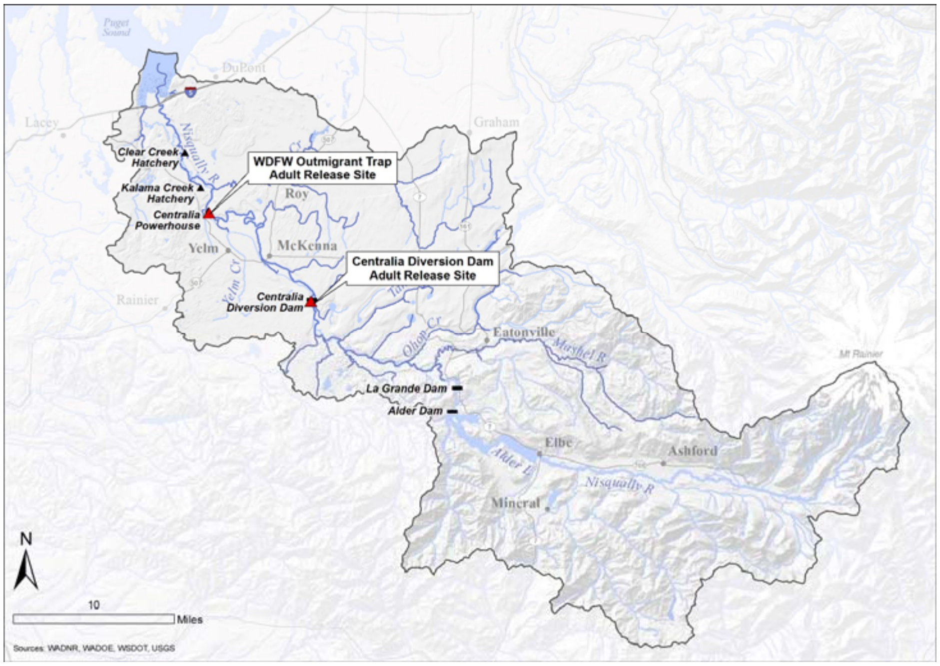
Transported adults will be equal numbers of males and females; the male portion will include 10% jacks (age 2). Adults that exhibit poor condition and deemed not viable for transport will not be transported.

The truck-and-haul operation will span the temporal extent of the annual adult return period, commencing during the first week adults enter the hatchery ponds and continuing until adults in the ponds appear to be no longer viable. A weekly schedule has been developed to avoid spawning days at the hatcheries and maximize the number of trucked fish. The objective is to truck and release up to 470 Chinook per week. Early in the season and near the end of the season when fewer adults are entering the pond a smaller truck will be used to transport adults to allow for smaller batches to be collected, sampled, and trucked. The daily objective of the plan are described below.

Commented [S17]: This adds up to about 4300 total spawners assuming 1500 volitional natural spawners. Are you assuming fewer natural spawners than previously discussed?

- **Monday:** Process, transport, and release approximately 70 Chinook at the Centralia Diversion Dam (RM 26.2). It is anticipated that the fish entering the adult return ponds over the weekend will provide adequate abundance to fill the Tribe's smaller transport trucks: 60 to 70 Chinook.
- **Tuesday:** Process approximately 200 Chinook for loading and transport in the larger WDFW trucks on Wednesday. No Chinook will be transported on Tuesday.
- **Wednesday:** Transport and release approximately 200 Chinook at the Centralia Diversion Dam at RM 26.2.
- **Thursday:** Process approximately 200 Chinook for loading and transport in the larger WDFW trucks on Friday. No Chinook will be transported on Thursday.
- **Friday:** Transport and release approximately 200 Chinook at the Centralia Powerhouse at RM 12.8.

Figure 4-1. Locations of Adult Hatchery Chinook Releases



Other Elements

The following activities will be implemented during the Colonization phase to prepare for the transition to the Local Adaptation phase and to support monitoring programs.

- Continue development of an operations plan for the integrated and stepping-stone hatchery programs based on the most current science, broodstock collection plan and spawning operations, and renovations to hatchery facilities.
- Install an adult trap in the Centralia Diversion Dam Fish Ladder (CDDFL). Designs are currently being developed and the current plan is to have the trap operational for the 2018 season. The trap will play a pivotal role for monitoring and evaluation during the Colonization phase and for broodstock collection and pHOS reduction in the Local Adaption phase.

Harvest Management

The harvest management objective during Colonization is to not exceed a 47% total exploitation rate cumulative through all fisheries for natural-origin Nisqually Chinook. The 47% exploitation rate management objective reflects the most recent incremental reductions identified for Nisqually River natural-origin Chinook in the Harvest Management Component of the *Comprehensive Management Plan for Puget Sound Chinook* (Puget Sound Indian Tribes and Washington Department of Fish and Wildlife 2010). Fisheries were successfully managed to not exceed a total exploitation rate of 65% in 2010 and 2011; 56% in 2012 and 2013; 52% in 2014 and 2015; 50% in 2016; and 47% in 2017. The reductions in the total exploitation rate bared solely by the treaty and sport terminal fisheries have helped stabilize escapements following a decline in natural-origin abundance and ensured adequate number of Chinook spawning naturally.

During preseason planning, the FRAM projection of the exploitation rate for unmarked Nisqually Chinook stock will inform compliance with the harvest management objective. Preterminal and terminal fishery rates will be set during the North of Falcon process for preseason to comply with the 47% total exploitation rate. The Tribe's preseason harvest goals for Chinook in the terminal area (Nisqually River) include a treaty harvest rate target that will not exceed the total exploitation rate of 47% and a floor harvest rate of 20%. Nontreaty sport harvest has been limited to adipose fin-clipped Chinook since 2005; the harvest rate on unmarked Chinook, from incidental mortality caused during catch and release, has averaged 4% since the implementing mark-selective fisheries. Preterminal fisheries will make necessary adjustments to not exceed the exploitation rate.

The co-managers will continue to manage the terminal fishery to meet preseason expectations and reduce the chances of exceeding the harvest management objectives while providing for meaningful treaty right fishery and nontreaty sport fishery.

Selective Fishery

The Nisqually Indian Tribe, with the full agreement of the WDFW, will be conducting an investigation into gear types and opportunities to selectively harvest hatchery-origin Chinook in the Tribe's traditional commercial fisheries during the Colonization phase. The Tribe will undertake this investigation utilizing up to an additional 2% ER through a combination of staff and fisher implemented actions consistent with the recovery objectives for the Colonization phase. We will monitor the instantaneous mortality associated with each gear type, the relative success of the gear types, and the response of the fishers to the gear. The Tribe will report the results of the annual investigation of selective gear types during our annual adaptive management review.

The investigation will use up to an additional 2% ER during a nonpink year in 2018 and a pink year in 2019. We will not experiment in 2020. We will then select our preferred gear types for additional testing utilizing up to an additional 2% ER in 2021 and 2022. Unless agreed to by the co-managers and NOAA Fisheries, the experimental phase of this effort will sunset after the 2022 season. Based on the results of our previous work and with input from WDFW and NOAA Fisheries, the Tribe will determine which gear type(s) to integrate into our commercial fishery within the 47% ER in 2023 consistent with the recovery objectives for that season. Our desire is to identify and implement selective opportunities acceptable to the tribal community with an agreed to understanding of the release mortality by the time we reach the Local Adaptation phase and an increased need to manage for escapement composition.

Commented [S18]: Basis for this? How will you estimate preseason and account for postseason?

The co-managers will work together to continue to provide meaningful sport fishing opportunities in the Nisqually River.

McAllister Off-Site Fishery

The McAllister extreme terminal fishery will target the returning adults from releases of sub-yearling marked Chinook from McAllister springs. The treaty fishery will be open in the extreme terminal area from the mouth of McAllister Creek up to the trap at the outlet of the springs. This fishery will not be open the same days as the Nisqually River treaty fishery to eliminate confusion when sampling. The McAllister treaty fishery will utilize a combination of gear types and will harvest as many returns as possible because all broodstock production needs will come from Clear

Creek Hatchery in the Nisqually River. The fishery will be sampled at a minimum of 20% of the total catch. The distribution of McAllister off-site release adults will be monitored in preterminal and extreme terminal area fisheries, at both Clear Creek and Kalama Creek hatchery racks, and on the spawning grounds.

Commented [S19]: What are these? Thought all McCallister releases were on-site.

Hatchery Management

Planned hatchery releases during the Colonization phase are presented in Table 4-4 by release location. During this phase, hatchery broodstock will continue to use hatchery-origin returns; natural-origin adults will not be incorporated for use as broodstock. Relocating 1.0 million fish of the total annual hatchery subyearling production of 4.0 million fish to an out-of-river release location at McAllister Springs is expected to allow high harvest rates on returning hatchery-origin fish by the treaty net fishery in McAllister Creek with a low impact on natural-origin escapement in the Nisqually River. Furthermore, moving a portion of the production to McAllister Creek may be an important strategy to reduce contribution of pHOS in the Local Adaptation phase.

All hatchery releases will be adipose-fin-clipped except for a portion of the Clear Creek release that will instead not be adipose fin clipped but will be code-wire-tagged to monitor mark-selective fisheries. A portion of the fish released at each release location will be coded-wire tagged with a tag code unique to each release site to monitor survival, contributions to fisheries, and adult spawning distribution.

Commented [S20]: But fisheries will be monitored for all marks, clipped and unclipped yes?

Table 4-2. Planned Annual Chinook Release by Location

Release Location	Annual Release	Life Stage
Clear Creek	2.4 million	Sub-yearling (fingerling)
Kalama Creek	600,000	Sub-yearling (fingerling)
McAllister Springs	1.0 million	Sub-yearling (fingerling)

Commented [S21]: How much and where are off-site releases referred to in previous text.

Escapement Management

As described previously, during the Colonization Phase the objective for natural spawning is to exceed 3,500 natural spawners throughout the watershed. Natural spawning will include adults from three sources:

- Natural-origin returns escaping fisheries
- Hatchery-origin volunteers to natural spawning (strays)
- Hatchery-origin fish trucked and hauled from Kalama Creek and Clear Cleek hatcheries

Commented [S22]: Including unclipped returns from earlier stepping stone program, yes?

During the Colonization Phase, the escapement objective will be met through transport and release of hatchery-origin fish from the two hatchery facilities. Releases will occur at two mainstem locations to allow free migration of adults to spawning areas in the mainstem and tributaries (Figure 4-1). An aggregate natural spawning escapement of natural-origin adults and hatchery-origin volunteers (i.e., strays) may comprise up to 1,500 spawners in a year. Therefore, truck-and-haul of adults from the hatcheries will need to augment natural spawning areas with at least 2,000 fish each year. Assuming trucking capacity described previously to haul approximately 500 adults per week, 4 to 5 weeks of transport will be required.

Monitoring

The focus of the monitoring program during the Colonization phase is to evaluate Nisqually River freshwater and delta potential and use for natural production, to provide the information necessary to evaluate VSP attribute indicators and biological targets, and to evaluate plan assumptions for the Local Adaptation phase (e.g., distribution of returning adults from the McAllister Springs release).

Monitoring actions during the Colonization phase will focus on collecting information to evaluate the plan premise that natural production of Chinook is limited by low natural spawning. In other words, escapements of 3,500 adults will test the limits to freshwater and delta abundance from habitat capacity.

Monitoring methods will be refined during the Colonization phase in anticipation of transitioning to the Local Adaptation phase. Operational guidance of the adult trap in the Centralia Diversion Dam Fish Ladder will be developed during this phase. The trap will be used in the Colonization phase to enumerate escapement to the upper basin and collect tissues samples for the genetic parentage study. The trap will be used in the Local Adaptation phase to collect natural-origin broodstock and remove hatchery-origin from natural spawning and continue sampling and monitoring programs to assess relative reproductive success.

The Colonization phase will depend on the successful transportation of hatchery-origin Chinook throughout the watershed to maximize the number of adults on the spawning grounds. Intensive monitoring will allow for the evaluation of the success of these fish by gaining a better understanding of: the movement and distribution of trucked hatchery adults; the spawning success of trucked hatchery adults; and the abundance, age structure, and genetic composition relative to natural-origin Chinook and naturally straying hatchery fish.

An important monitoring element during the Colonization phase will be a genetic parentage study to evaluate relative contribution of hatchery-origin and natural-origin spawners to natural production (juvenile and adult). The details of the genetic parentage study are described in Chapter 5, *Monitoring Tools and Objectives*. The parentage study is a core monitoring element during the Colonization phase.

The monitoring activities are designed to meet the goals of understanding the movement and distribution of trucked hatchery Chinook, monitoring the spawning success of trucked hatchery Chinook, collecting abundance and biological data from natural-origin Chinook and hatchery-origin strays, assessing contribution from the McAllister release program, and gathering stock composition data to estimate spawning and return abundance using the change-in-ratio method. Spawning ground survey locations and methods are described in more detail in Chapter 5, *Monitoring Tools and Objectives*. All trucked Chinook will be released with a jaw tag on the right side of the jaw. This will allow surveyors and those monitoring Chinook passage at the Centralia Diversion Dam (camera in 2017 and adult trap in future years) to distinguish trucked adults from hatchery-origin strays and natural-origin spawners. To evaluate spawning success of trucked fish, egg retention and distribution of carcasses will be compared for trucked hatchery-origin, natural-origin, and straying hatchery-origin Chinook salmon. Egg retention will be estimated by comparing the residuals of egg mass in the body cavity to fish length of individual carcasses. Release locations may be modified through the adaptive management process described in Chapter 3, *Phased Recovery Approach,* if data indicate transported Chinook are not distributing to spawning areas.

Hatchery adult ponds will be monitored for jaw-tagged Chinook to evaluate the number that return back to the hatchery after trucking. These will be subtracted from the number released to get the total number of Chinook supplemented to the river.

The total number of fish transported and released will be added to the change-in-ratio based escapement estimate described in Chapter 5, *Monitoring Tools and Objectives,* to estimate total watershed-wide spawning abundance.

McAllister Creek will be surveyed weekly for adults to determine distribution of returning hatchery-origin from the McAllister Springs release and to improve the accuracy of estimates of survival rates for this release. Coded-wire tag recoveries from spawners in the mainstem Nisqually will be assessed for origin to determine the stray rate of McAllister releases to the Nisqually.

Local Adaptation Phase

The transition to local adaptation will occur after no more than 8 years of colonization. Population characteristics described in Table 4-1[33] represent the desired conditions for initiating management actions for local adaptation such as removing hatchery origin Chinook from the river and integrating a portion of the hatchery program. However, even if population productivity and abundance conditions described in Table 4-1 are not achieved the transition to local adaptation will still occur and hatchery program size, integrated broodstock should it occur, natural-origin and natural spawning escapement described in this plan will need to be revised to ensure successful management in local adaptation. Hatchery program size may need to be reduced to meet objectives for pHOS and PNI necessary to achieve the goals of local adaptation.

In local adaptation harvest management will shift from a exploitation rate objective to a combined escapement based and exploitation rate management regime, to be protective of conservation objectives at lower run sizes and to take advantage of larger run sizes while growing the population toward recovery. The new harvest objectives will be informed from the data collected in the Colonization phase.

Goal

Establish a thriving, locally adapted natural population of Chinook salmon in the Nisqually River by reducing hatchery influence to promote rebuilding and improvements in fitness in natural origin Chinook while maintaining hatchery production to support treaty and nontreaty fisheries.

Objectives

The Local Adaptation phase will shift priorities and decision rules based on the information learned from the Colonization phase, which will affect harvest, hatchery, and escapement management.

The management priority during Local Adaptation is to emphasize conservation and growth of natural production gains achieved during the Colonization phase. The management of harvest rates, hatchery size, and broodstock composition will be adjusted as needed to meet the Local Adaptation

[33] Population characteristics described in Table 4-1 will be evaluated and possibly revised at the two check-ins described during the Colonization phase. The evaluation will use monitoring information collected during colonization.

goal. This includes managing for an escapement range of natural-origin adults that optimizes natural production, reducing the contribution of hatchery-origin adults to natural spawning, using natural-origin adults in the hatchery broodstock[34], and realizing improvements in freshwater, delta, and nearshore marine habitat. Objectives for habitat improvement are described in Chapter 2, *Continuing Habitat Efforts and Watershed-Wide Issues.* Substantial progress has been made in the watershed and continuing efforts are expected to build on this progress.

The goal of reducing hatchery influence on the population will be achieved by focusing on the following objectives. These targets and the associated strategy and technical methods will be adjusted based on the results of the colonization phase experiment and as new science becomes available.

1. Manage hatchery broodstock and escapement composition to achieve a 4-year running average management objective for PNI of 0.50 or greater and to ensure progress toward a PNI of 0.67. PNI calculations will use pNOB values for the integrated component at Kalama Creek and pHOS will be based on hatchery-origin spawners from all three release groups (Kalama Creek, Clear Creek and McAllister Springs). PNI will be calculated using the MP-PNI calculator developed by NOAA F.

Commented [S23]: Where would production size be reviewed and evaluated?

2. Manage watershed-wide escapement composition to not exceed an annual pHOS of 30% and escapement composition upstream of the Centralia Diversion Dam to not exceed an annual pHOS of 10%.
3. Manage hatchery broodstock for the integrated program at Kalama Creek Hatchery to initially comprise 25% natural-origin Chinook and increase to 100% with higher natural-origin abundance. This would represent between 110 and 425 natural-origin broodstock although this number could change as the program is adjusted to meet the Local Adaptation goal.
4. Manage hatchery broodstock for the stepping-stone program at the Clear Creek Hatchery and the McAllister Springs release to comprise only returns of integrated adults to the Kalama Creek Hatchery.

Annual management objectives for pHOS, pNOB, and resulting PNI will be developed and reported during preseason planning for the upcoming year. Annual management objectives will be developed consistent with recovery status and be based on preseason run size forecasts of natural-origin Chinook to the Nisqually River.

During the Annual Program Review each spring preseason objectives developed during the previous program review will be evaluated against actual results for the year. A 4-year running average of pHOS and PNI will be used to evaluate long-term recovery progress.

[34] The current hatchery strategy, including inclusion of a stepping-stone program, is based on current scientific thinking and data, and the assumption that the magnitude of NOR spawners relative to the hatchery component of natural spawners will be sufficient at the transition from colonization to local adaptation to increase PNI adequately given the hatchery production and harvest objectives. This strategy will be reviewed at the point of transition to local adaptation to ensure the strategy that is adopted reflects best science and information at that time.

Action Plan

The Local Adaptation phase will not follow a set timeline. Population characteristics described in Table 4-1 will define progress and the transition to the Viable Population phase. Monitoring will be an important element to update status and trends of the natural population using indicators of VSP described in Table 4-2. The adaptive management process described in Chapter 3, *Phased Recovery Approach,* will be used to adjust strategies and set annual management actions.

Specific measures to reduce the number of hatchery-origin adults spawning in nature include the removal of marked (adipose-fin-clipped and/or coded-wire-tagged) adults at the Centralia Diversion Dam adult trap, the release of 1.0 million Chinook from McAllister Springs and an associated directed fishery, and implementing mark-selective fishing techniques in the treaty terminal and non-tribal recreational fisheries. If these measures are not sufficient to meet the pHOS objectives for Local Adaptation then the Tribe will reduce the Clear Creek Hatchery release.

In addition to these measures to reduce the number of hatchery-origin adults spawning in nature, pHOS will be reduced by managing preterminal and terminal harvest on natural-origin adults to meet or exceed the escapement range for natural-origin spawning described in Table 4-1[35]. The escapement range will be met using an annually adjusted exploitation rate not to exceed 47%. Meeting the escapement target may require reducing the integrated Kalama Creek Hatchery release to maintain the pNOB target in years of low abundance of natural-origin adults. Reductions in the integrated program may have a consequence on future program size of the stepping-stone program if the number of integrated hatchery returns is insufficient to meet the stepping-stone broodstock needs.

Plan assumptions during local adaptation are described in Table 4-5. The assumed proportion of hatchery-origin Chinook that stray to the spawning grounds is based on recent year observations. Currently, it is estimated that 6% of adult Chinook returning to the Clear Creek and Kalama Creek hatcheries stray to natural spawning areas. The number of hatchery-origin Chinook escaping fisheries to spawn is based on a Nisqually River Chinook release of 3.0 million Chinook and a 1.0 million Chinook release from McAllister Springs with an associated directed fishery. The plan assumes 90% of the hatchery-origin adults attempting to migrate to the upper watershed will be removed at the adult trap in the Centralia Diversion Dam fish ladder. The plan assumes that hatchery-origin Chinook stray at equal proportions above and below the Centralia Diversion Dam. This assumption will be evaluated during the Colonization phase.

Under the assumptions shown in Table 4-5 with a run size to the Nisqually River of 2,300 adults at the initial transition (Early) to Local Adaptation phase, results from the MP-PNI model indicate an average PNI exceeding 0.50.

Under the assumptions shown in Table 4-5 with a run size to the Nisqually River of 5,400 adults at the end of the Local Adaptation phase (Late) and the transition to Viable Population Phase, results from the MP-PNI model indicate an average PNI exceeding 0.67. A run size of 5,400 adults represents a spawning escapement of approximately 3,400, after terminal harvest and broodstock removal, which is the high productivity target abundance in the 2006 Puget Sound Salmon Recovery Plan.

[35] Population characteristics described in Table 4-1 will be evaluated and possibly revised at the two check-ins described during the Colonization phase. The evaluation will use monitoring information collected during colonization.

Table 4-3. Local Adaptation MP-PNI Modeling Assumptions and Results

		Local Adaptation Phase	
		Early	**Late**
Population Characteristics	Productivity - Spawner to Adult	1.5	3.0
	Abundance - Natural-Origin Run to the River	2,300	5,400
	Abundance - Natural-Origin Spawning Escapement (after terminal harvest and broodstock removal)	1,527	3,411
Terminal Area Fisheries Management	Treaty Net Fishery Harvest Rate	25%	25%
	Non Treaty Sport Impact (non-landed mortality)	4%	4%
	Combined	29%	29%
Hatchery Broodstock Management Integrated Program	pNOB	25%	100%
	# Natural-origin Removed for Broodstock	106	423
Escapement Management and Resulting Management Targets for pHOS	Percent Hatchery-origin Straying to Natural Spawning	6%	6%
	Number Hatchery-origin Spawning Below Centralia Diversion Dam	508	508
	Percent Hatchery Removed at Centralia Diversion Dam	90%	90%
	Number Hatchery-origin Spawning Upstream of Diversion Dam	51	51
	pHOS below Centralia Diversion Dam	33%	17%
	pHOS Above Centralia Diversion Dam	10%	5%
	Combined pHOS Basin-wide	27%	14%
MP-PNI Results	Calculated Equilibrium PNI using MP-PNI formula with Integrated and Stepping-stone Hatchery	0.59	0.86

It is possible that the population may get "stuck" in local adaptation if PNI remains at or near 0.50, in which case the natural environment is counter-balanced by the hatchery environment and adaptation to the natural environment stalls. In this scenario, multiple generations with PNI higher than 0.50 are needed to move adaptation to the natural environment and improve fitness and productivity (recruits per spawner). Increasing PNI beyond 0.50 depends, at least in part, on greater natural productivity to increase abundance of natural origin to reduce pHOS and allow management actions to increase pNOB of the integrated component. Therefore, it may be necessary to manage for PNI greater than 0.67 before realizing gains in natural productivity. In practice, this would mean that the size of the aggregate hatchery programs during local adaptation would be limited by the total abundance of natural-origin adult returns.

During the Local Adaptation phase annual management decisions will consider the 4 year running average of PNI with the objective to continually improve the PNI running average. That means small deviations in PNI from year to year are acceptable as long as the running average is continuing to improve. In practice, the 4 year running average PNI will be calculated each spring during the annual project review based on previous year data. The next year forecast PNI will be calculated and added to the 4 year running average. If the forecast running average is declining then additional management actions will be developed to increase the next year PNI to produce an upward trend in the running average. Additional actions may include reducing the hatchery program size and implementing additional selective fisheries to remove more hatchery origin returns.

Harvest Management

The harvest management approach, including management objectives, will be reviewed consistent with the data-driven assessment of the Nisqually Chinook salmon population productivity and capacity during the Colonization phase, described above. Adjustments will be made to harvest impacts to protect the natural-origin Chinook run to the river and spawning escapement consistent with the productivity and capacity of the natural population. The intent is to ensure that harvest management is consistent with annual management objectives set for the Local Adaptation phase such as escapement abundance, productivity, and composition, hatchery broodstock pNOB, and resulting PNI.

Harvest management objectives during the Local Adaptation phase will shift to an escapement-exploitation based approach for natural-origin Chinook with a total exploitation rate in years of high abundance to not exceed 47%. For planning purposes a lower end escapement goal is set at 1,500 natural-origin Chinook. However, more refined numeric escapement objectives and associated exploitation rate for local adaptation will be developed based on the data assessment during the colonization experiment.

The purpose of the escapement objectives coupled with a sliding exploitation rate is to optimize natural production and to maintain the Nisqually Indian Tribe treaty fishery. A sliding scale exploitation rate not to exceed 47% will provide higher escapements in years of high abundance and opportunities to evaluate natural production at higher escapement levels.

Harvest management decisions will be reviewed and adjusted to ensure natural abundance does not revert back to the previous recovery phase. Preterminal fisheries will adjust accordingly during the preseason planning process to meet management objectives for the natural-origin run to the Nisqually River. Management objectives for the terminal fishery will be to provide a meaningful treaty fishery in the Nisqually River while protecting natural production. A meaningful Nisqually Indian Tribe fishery is defined as a 25% harvest rate on natural-origin returns. Alternative fishing gear and area management (McAllister off-site fishery, see description under Colonization) to target hatchery-origin adults will be important to achieving the Tribe's Chinook harvest goals.

In the event that the abundance of natural-origin Nisqually Chinook in preterminal fisheries and forecast abundance back to the river are below the escapement objective for the population, preterminal and terminal fisheries will be adjusted to the maximum extent possible. However, reducing harvest on natural-origin adults will have a consequence on the number of hatchery-origin adults returning to the river and escaping to spawn in nature, thereby impacting management objectives for pHOS and PNI.

Hatchery Management

Commented [S24]: What is the marking strategy?

Recognizing that harvest is an important goal for treaty and nontreaty fisheries, the plan initially will maintain the hatchery production of 4.0 million fish (Table 4-4) while implementing measures to meet conservation goals. However, the hatchery program size will be carefully reviewed with new information collected during Colonization, and reductions in program size may be necessary to achieve annual management targets for pHOS and pNOB.

The isolated hatchery program at Kalama Creek will be converted to an integrated program to continue to provide Chinook for treaty and nontreaty harvest while reducing hatchery influence. Integration of the Kalama Creek program will occur in phases. Initially, pNOB will be set at 25% (approximately 110 Chinook) independent of projected natural-origin spawning escapements that may exceed 1,500 Chinook. However, PNOB will be incrementally increased to 100% (approximately425 Chinook) in subsequent years when run sizes are higher and projected natural-origin spawning escapements would exceed 1,500 natural-origin Chinook. The decision rule for incremental increases in pNOB with higher projected escapements will be developed based on the spawner-recruit analysis conducted following the colonization experiment.

Commented [S25]: Based on triggers, NOR escapement would need to be >1,500

Specific rules will be developed at the time based on data collected during the colonization phase, yes?

Commented [S26]: Consistent with Table 4-1, yes?

Consistent with the best available science and the MP-PNI model, and assumptions refined during the Colonization phase, the isolated hatchery program at Clear Creek will be converted to a stepping-stone program to continue to provide Chinook for treaty and nontreaty harvest while reducing hatchery influence. During the Local Adaptation phase, the broodstock for the stepping-stone hatchery program will be entirely from returns from the integrated Kalama Creek hatchery program. Therefore, the pNOB rule for the stepping-stone program is 0%.

The release at McAllister Springs, which consists of Chinook from the isolated hatchery program during Colonization, will consist entirely of returns from the Kalama Creek Hatchery integrated program during the Local Adaptation phase.

Commented [S27]: What there consideration of taking broodstock at McCallister to minimize straying into the mainstem Nisqually?

If the number of adults returning to the Kalama Creek Hatchery is unable to support broodstock needs for the two stepping-stone programs, then the Clear Creek and the McAllister Springs releases will be reduced. The formula for adjusting these releases will be developed in the future. Factors affecting this decision are survival of and harvest opportunities on the McAllister release and stray rates from this program. These factors may favor maintaining the Clear Creek over the McAllister release.

At full implementation of the integrated program at Kalama Creek (pNOB = 100%), Chinook will be exposed to the hatchery environment for no more than two successive generations (once at Kalama Creek and again at Clear Creek in the harvest component of the program), thereby further reducing the risk that the harvest program will diverge substantially from the natural-origin component of the Nisqually population that is becoming locally adapted.

Escapement Management

During the Local Adaptation phase, reducing hatchery influence on natural spawning becomes a priority. This will be achieved through removing hatchery-origin strays from natural spawning at the Centralia Diversion Dam, managing fisheries to protect gains made in natural-origin abundance during the Colonization phase, and developing methods to selectively harvest marked hatchery adults.

During local adaptation, escapement will be managed for a target range of natural-origin spawners. The escapement range will be developed using information collected during the Colonization phase.

Commented [S28]: Is this the same as the 1,500-3400 in Table 4-1 or something else? If the latter, how will the range be determined?

Escapement management is closely tied to harvest management decision rules. Harvest and natural-origin removals for broodstock will be adjusted to achieve the targeted escapement range. Fisheries and broodstock collection will be adjusted to the extent possible to stay within the range.

Commented [S29]: These two sentences seem inconsistent.

Monitoring

Commented [S30]: Reference where this information is described in Chapter 5.

Monitoring programs during Local Adaptation include activities to evaluate plan assumptions for productivity and abundance of the natural population, the number of hatchery-origin returns and their distribution, spatial structure and diversity of the naturally spawning population and juvenile production, and the operational criteria for the integrated and stepping-stone hatchery programs.

Monitoring programs during Local Adaptation will collect information to evaluate the plan premise that reducing hatchery influence on the natural population will improve fitness of the population. Monitoring programs will estimate natural-origin adult run size, spawning escapement, and natural production and habitat use of juveniles. (See indicators in Table 4-2)

Several monitoring activities are specific to evaluating annual management targets. Monitoring will need to estimate the number of adults spawning upstream and downstream of the Centralia Diversion Dam, reproductive success, and the associated pHOS for these components.

Viable Population Phase

Goal

Maintain a productive, resilient, spatially and temporally diverse Nisqually River Chinook population that is taking full advantage of the available habitat.

Objectives

The primary objective during this phase will be to monitor the natural-origin population for trends in natural production and adjust harvest and hatchery management actions to continue to support a thriving natural-origin population.

Action Plan

The Viable Population Phase is achieved once conservation and harvest goals can be achieved and sustained over time. The biological targets for this phase (Table 4-1) represent a population is productive, fit and taking full advantage of a healthy watershed.

Annual management targets include a high PNI (greater than 0.67) consistent with a Tier 1 population. Abundance and productivity of the natural-origin population is expected to be high, which will allow greater flexibility in setting annual management targets. Escapement composition is expected to be dominated by natural-origin adults with higher abundance.

Harvest Management

Harvest management objectives during the Viable Population Phase will continue to be based on protecting natural-origin Chinook escapement. Successful transition to Viable Population status implies high productivity and abundance for the natural population, which will support a higher overall harvest rate than during Local Adaptation. Preterminal and terminal fisheries will adjust accordingly to meet management objectives for the natural-origin run to the Nisqually River. As described in the next section, the number of hatchery Chinook released would likely be lower and the stepping-stone program would have switched to an integrated program. Harvest management objectives will be revised to support an integration of hatchery broodstock to a level that on average exceeds a PNI of 0.67.

Hatchery Management

The stepping stone hatchery program will be discontinued and replaced with a high-pNOB integrated program to supplement harvest. The specific size of the program will be determined through population and habitat monitoring, and will strike a balance between broodstock requirements, natural-origin escapement needs, and harvest goals.

Escapement Management

During the Viable Population phase, maintaining a low proportion of hatchery-origin Chinook proportion on the spawning grounds is a priority. This will be achieved through hatchery program reductions, removing hatchery-origin strays from natural spawning at the Centralia Diversion Dam, managing fisheries to protect gains in natural-origin abundance, and applying methods to selectively harvest marked hatchery adults.

Monitoring

Monitoring programs during Viable Population are needed to monitor status and trends of the natural population and provide information to make corrections to strategies with a changing climate and future pressures on population viability.

Chapter 5
Monitoring Tools and Objectives

This chapter describes the core monitoring programs that are fundamental to support implementation of the stock management plan and to evaluate progress. It also describes additional monitoring that could supplement the core programs pending additional funding.

An important objective of the monitoring programs is to apply the best possible methods with the resources available and consistently monitor the VSP attribute indicators identified in Table 4-1. The success of this plan will be tied to the effectiveness and speed of learning about the relative efficiency of different strategies and actions, and the ability to adapt to changing circumstances, including climate change. Making timely decisions and adjusting management actions based on new information and circumstances obtained through the monitoring program are essential to the success of the plan.

Plan implementation will be grounded in a scientific approach of hypothesis testing and informed decision making. The adaptive management process described in Chapter 3, *Phased Recovery Approach,* will evaluate VSP attribute indicators and the need for exercising contingencies or other adaptive responses to revise strategies and schedules for managing Nisqually Chinook, and define the end points at which goals are attained.

The monitoring programs described in the following sections are the best possible methods given the resources available and constraints of the Nisqually watershed. They are intended to inform the following factors, all of which are fundamental to the adaptive management process:

- Key assumptions (e.g., freshwater capacity) for which uncertainty and data gaps exist
- Status and trends analysis used to evaluate plan progress
- Achievement of annual management targets for harvest, hatchery, and escapement
- Assessment of biological targets that guide transition between phases

Table 5-1 describes the core and additional monitoring activities by monitoring variable for each of the five programs: adult catch and escapement monitoring, juvenile freshwater monitoring, juvenile Nisqually River delta monitoring, hatchery monitoring, habitat monitoring, and stock-recruitment analysis.

Table 5-1. Monitoring Programs

Monitoring Program	Monitoring Variables	Core Monitoring	Additional Monitoring
Adult Catch and Escapement Monitoring	Nisqually River Catch in Treaty and Sport fisheries	• Sampling of the treaty net fishery (sampling min 20%, typical 45%) for marks, CWT, age, and size and sex. Sampling estimates contribution of natural-origin fish to catch • In the absence of creel samples Catch Record Cards reporting of the sport catch of harvest marked and harvested unmarked Chinook and estimates impact of landed and incidental mortality of natural-origin • Total encounters estimated from years of CRC and creel study years	• Creel sampling of sport fishery and methods to estimate impact of landed and incidental mortality of natural-origin • Mark-selective fishery study commercial selective fishery and sport nonlanded mortality • Study net dropout rate in freshwater commercial fishery
	Nisqually Watershed-Wide Adult Escapement and Composition	• Escapement estimated from change-in-ratio method (Seber 1982) • Watershed-wide composition and distribution (hatchery- and natural-origin) based on: o Carcass sampling priority index reaches in the Mashel (RM 3.2 to RM 0) and Nisqually River (RM 26.2 to RM 21.9); these will be surveyed weekly o Supplemental nonindex reaches (Nisqually River RM 32.9 to RM 26.2 and RM 15.7 to RM 10.1); these will be surveyed biweekly.	• Historical escapement estimated from live and dead counts and expansion formula (Tweit 1986) and will be calculated to better understand bias in the historical abundance estimates. • Additional surveys may be conducted in the Mashel and Nisqually River as resources allow
	Adult Escapement and Composition Upstream of the Centralia Diversion Dam	• Abundance and composition from adult passed or excluded at the Centralia Diversion Dam adult trap (Colonization will include hatchery origin) • Composition estimated from carcass recoveries from priority index reach (surveyed weekly) in the Mashel (RM 3.2 to RM 0); supplemented with nonindex reach (Nisqually River RM 32.9 to RM 26.2) surveyed biweekly	• Radio tagging and tracking of adults (hatchery- and natural-origin) captured in lower river/delta to evaluate migration and spawning behavior through lower river and above Centralia Diversion Dam

Commented [S31]: This needs to be part of core monitoring since the commercial MSF fishery is a key piece of the strategy.

Monitoring Program	Monitoring Variables	Core Monitoring	Additional Monitoring
	Adult Escapement and Composition Downstream of the Centralia Diversion Dam	• Abundance based on subtraction of CDDFL counts • Composition estimated from carcass recoveries from priority index reach (surveyed weekly) in the Nisqually River (RM 26.2 to 21.9); supplemented with nonindex reach (Nisqually River RM 15.7 to RM 10.1) surveyed biweekly	• Radio tagging and tracking of adults (hatchery- and natural-origin) captured in lower river/delta to evaluate migration and spawning behavior through lower river and above Centralia Diversion Dam • Additional surveys could be conducted to supplement carcass data below CDDFL
Juvenile Freshwater Monitoring	Freshwater Productivity, Capacity, and Juvenile Life History	• Operation outmigrant trap at RM 12.8 to estimate abundance, timing, life stage, and size of juvenile migrants • Productivity: # outmigrants per natural spawner • Capacity: # outmigrants by life stage • Life history: relative abundance of outmigrants by life stage	
Juvenile Nisqually River Delta Monitoring	Juvenile Life History Diversity (temporal and spatial), Delta Productivity and Capacity,	• Beach seining sites in all habitat zones (matching sites that have been monitored regularly in previous years), allows for understanding of spatial and temporal diversity, relative abundance, and long-term comparisons • Randomly selected beach seine sites in each habitat zone for density and capacity analyses	• Lampara net sampling of mudflats • Fyke net sampling of channels • Benthic, fallout and neuston sampling for prey availability monitoring • Bioenergetics, habitat connectivity, accessibility, and fish density across a wide range of natural and hatchery juvenile abundances • Monitoring habitat use, movement, and residence time of juveniles using passive integrated transponder (PIT) tags; • Otolith analyses for growth, residence time, and life history types surviving to adult return.

Commented [S32]: How will monitor and assess juvenile habitat use?

Monitoring Program	Monitoring Variables	Core Monitoring	Additional Monitoring
Hatchery Monitoring	Hatchery broodstock, in-hatchery survival, release, and post-release survival	• Number of adults and jack counts to hatcheries and McAllister Springs/Creek plus outlet creeks and McAllister Creek • Number of hatchery-origin adults used for broodstock • Number of natural-origin adults and jacks collected for broodstock • Survival rates (surviving to spawn) of natural-origin adults used for broodstock • Fecundity of hatchery- and natural-origin adults used for broodstock • Age composition (hatchery- and natural-origin) • Survival rates green egg to eyed egg • Survival rates eyed egg to ponding • Survival rates ponding to release • Number released, dates, size of fish, and number marked	
Habitat Monitoring	Habitat Project Implementation and Habitat Condition	• Track implementation of Chinook habitat action plan o Percentage of mainstem and primary tributaries protected o Acres of floodplain and estuary restored o Miles of tributary restored (e.g., engineered logjams, channel reconnection)	• Habitat status and trends monitoring to track impervious surface, riparian condition, temperature, flows, in-stream habitat diversity, sediment, etc.
Stock Recruitment Analysis	Natural-Origin Adult Abundance to River	• Terminal adult natural origin run calculated as the sum of the following: ○ In-river catch and nonlanded mortality (released fish) (sport based on catch record card, treaty based on fishery samples) ○ Natural-origin adults removed for broodstock (Local Adaptation) ○ Watershed-wide natural spawning escapement of natural-origin adults	• Sport catch may be estimated from creel survey data
	Survival rates from juvenile outmigrant to adult	• Survival rates based on outmigrant estimates and estimate of natural-origin adult recruits to river • Requires age data from unmarked (natural-origin) for recruit analysis; check this data	• Otolith microchemistry and microstructure for growth, residence time, and life history types surviving to adult return

Monitoring Program	Monitoring Variables	Core Monitoring	Additional Monitoring
	Spawner to adult brood year recruitment rates	• Recruitment rates calculated from the following: o Parent natural spawning abundance by origin o Terminal natural-origin run allocated to brood year; data from treaty fishery sampling used to estimate total age of adults in annual run (catch plus escapement) o Estimation of age 2 recruits/spawner	
Nisqually Chinook Genetics Assessment	Genetic Mark Recapture	• Estimate adult abundance using trans-generational genetic mark recapture (tGMR) • Estimate effective breeders by origin • Estimate relative contribution to juvenile production for the three adult types in the escapement (natural origin, hatchery origin volunteers, and hatchery origin truck and hauled) • Conduct a genetic based brood year reconstruction to evaluate relative contribution of natural and hatchery origin to adult recruits	

Commented [S33]: Includes tissue sample collection and processing

Core Monitoring Programs

Commented [S34]: NOAAF would like to meet and discuss additional details, goals and desired outcomes for some programs.

This section describes each of the core monitoring programs, including program objectives, methods, and expected results. These core monitoring programs will be implemented annually by the co-managers as part of this stock management plan and funded through the co-managers annual fish management programs. Additional monitoring elements that could be implemented under each program but are not currently funded are described in the following section, *Additional Monitoring and Studies*.

Adult Catch and Escapement Monitoring

Purpose

The adult catch and escapement monitoring program is a critical core component of the Nisqually Chinook stock management plan. Effective enumeration of the total natural and hatchery Chinook run to the river, catch by treaty and sport fisheries, and the escapement of both components to the spawning grounds are direct effectiveness measures of the management strategies contained within the plan.

Methods

The methods and tools described below will be implemented to support the adult catch and escapement monitoring program. The methods are presented by monitoring variable: river catch and adult escapement and composition (basin-wide, upstream of the Centralia Diversion Dam, and downstream of the dam). Additional monitoring elements for catch and escapement, dependent on available funding, are described in the *Additional Monitoring* section below.

Nisqually River Catch in Treaty and Sport Fisheries

The treaty net fishery will be sampled for mark, coded-wire tag, age, size, and sex and to estimate the contribution of natural-origin fish to catch consistent with previous monitoring years. At least 20% of the catch will be sampled for marks, though actual sampling is expected to be much higher.[36] Estimated catch of natural-origin Chinook is based on counts of unmarked Chinook (intact adipose fin and no coded-wire tag) in the catch after subtracting unmarked hatchery-origin Chinook counts based on a mark rate for a given run. Hatchery-origin Chinook are nearly all (greater than 95%) marked (adipose-fin-clipped or coded-wire-tagged). The hatchery mark rate for a run is computed annually based on the number of unmarked, untagged Chinook that are sampled in the hatcheries. The sampling assumes that all Chinook entering the hatcheries are of hatchery-origin.

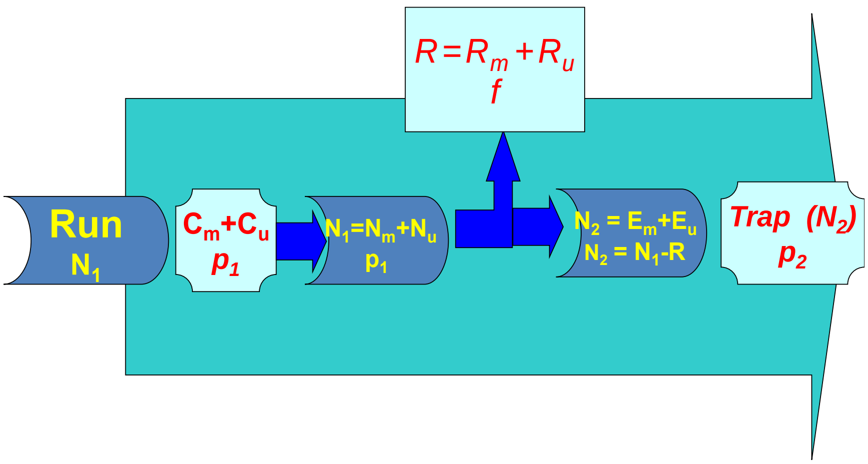
The sport fishery will be monitored through the use of Catch Record Cards that report harvest of marked and unmarked Chinook consistent with previous monitoring years. Total encounters, which comprised landed and unlanded catch, will be estimated from years of Catch Record Cards and creel study years.

[36] Sampling over the past [pending] years has averaged 45%.

Nisqually Watershed-Wide Adult Escapement and Composition

Commented [S35]: How will spawning above CDFL be included in spawning estimates?

Chinook escapement to the Nisqually River will be estimated using a change-in-ratio (CIR) method (Seber 1982). The following description of the CIR methodology for calculating escapement was updated from a January 30, 2013 memo from Marianna Alexandersdottir, Northwest Indian Fisheries Commission biometrician. The approach will continue to evolve as improved escapement estimation methods become available.



The CIR estimator relies on the fact there are two subpopulations that separate spatially through time. The Chinook run entering the river is comprised of the two subpopulations, the hatchery run and the natural run. The hatchery run separates from the natural run at the two hatcheries. Further, nearly all hatchery fish are marked with an adipose fin clip that allows visual detection as to whether the fish are hatchery-origin recruits or natural-origin recruits. The proportion of marked Chinook upstream of the hatcheries will be estimated based on counts at an adult fish trap in the Centralia Diversion Dam fish ladder (adult trap). In the event that the trap is not functioning or usable, other data collection devices will be used to calculate the final proportion for the change-in-ratio estimate. The total number of Chinook salmon entering the river (N_1) is estimated using the CIR method by,

$$\hat{N}_1 = \frac{\hat{R}(\hat{f} - \hat{p}_2)}{\hat{p}_1 - \hat{p}_2}$$

where,

N_1	=	total estimate of abundance
R	=	removal of Chinook by fisheries and hatchery, R is the sum of marked and unmarked removals.
f	=	proportion of total removals that are marked

p_1 = proportion below hatchery that is marked (estimated from sample of tribal fishery below hatchery)

p_2 = proportion above hatchery that is marked (estimated from sample at the adult trap or from sampling fish using a different live capture method)

The variance of the number entering the river is estimated by,

$$\mathrm{var}(\hat{N}_1) = \frac{\hat{N}_1^2 V(\hat{p}_1) + \hat{N}_2^2 V(\hat{p}_2) + \hat{R}^2 V(\hat{f}) + (\hat{f} - \hat{p}_2) V(\hat{R})}{(\hat{p}_1 - \hat{p}_2)^2}$$

Escapement Estimate

The total escapement of Chinook is estimated by subtracting the in-river fishery and hatchery removals from the estimate of abundance entering the river

$$\hat{N}_2 = \hat{N}_1 - \hat{R}$$

Where N_2 represents the escapement and has a variance approximated by

$$\mathrm{var}(\hat{N}_2) = V(\hat{N}_1) + V(\hat{R})$$

The escapement of Chinook above the CDDFL is estimated using the trap census count (TC) of all Chinook encountered. The escapement of Chinook below the CDDFL (BT) is calculated by subtracting the total escapement ($\hat{N}_2$) from the trap count (TC).

$$\mathrm{BT} = \hat{N}_2 - \mathrm{TC}$$

TC can be converted to escapement above trap by subtracting any removals. The proportion marked at the CDDFL is used to separate the escapement between marked and unmarked.

Proportion Marked

The proportion of marked (adipose fin clipped) fish in the population is estimated in the fishery (p_1) below the hatchery and at the trap (p_2) by,

$$\hat{p}_i = \frac{n_{i,m}}{n_{i\bullet}}$$

and,

$$\mathrm{var}(\hat{p}_i) = \frac{\hat{p}_i(1 - \hat{p}_i)}{n_{i\bullet} - 1}$$

where,

$n_{i,m}$ = number of marked fish observed in sample i, i = 1,2

$n_{i,\cdot}$ = number of fish in sample i, i = 1,2

Removals

The total removed, R, is estimated by summing harvest and hatchery removals,

$$\hat{R} = \sum_{i=1,s} \hat{C}_i + \hat{H}$$

where,

C_s = catch in fishery in stratum s (above or below hatchery or sport fishery)
H = hatchery removals

And the variance of the removals is the sum of the variances of each component. The variance of a single component may be zero, e.g. for the hatchery removal where all rack returns are expected to be counted and sampled for mark status.

In the fishery strata, the total marked removals cannot be counted and the proportion marked in each of these components will be an estimate as shown in Eqs 5 and 6 from a sample from that stratum. The number marked is then estimated by:

$$\hat{C}_{s,m} = \hat{p}_{s,m}\hat{C}_s$$

and the variance by,

$$\mathrm{var}(\hat{C}_{s,m}) = V(\hat{p}_{s,m})C_s^2 + \hat{p}_{s,m}^2 V(\hat{C}_s) - V(\hat{p}_{s,m})V(\hat{C}_s)$$

The total marked removal is then the sum of the estimates of the marked removals and the variance the sum of the variances.

The estimate of the proportion marked in the total removal is estimated by:

$$\hat{f} = \frac{\sum_{i=1,s} \hat{C}_{i,m} + \hat{H}_m}{\hat{R}} = \frac{\hat{R}_m}{\hat{R}}$$

and variance is:

$$\mathrm{var}(\hat{f}) = \hat{f}^2 \left[\frac{V(\hat{R}_m)}{\hat{R}_m^2} + \frac{V(\hat{R})}{\hat{R}^2} \right]$$

CIR Assumption of Equal Distribution of Marked to Unmarked above Hatcheries

The CIR method assumes an equal distribution of marked to unmarked Chinook in the spawning grounds above the hatcheries. The composition of marked to unmarked will be measured at the CDDFL and applied to the total escapement. Carcass surveys conducted just below CDDFL and at the lower Mashel River from years 2004 to 2013 do not indicate significant differences in composition between the two reaches (Table 5-2) for any year (two-tailed test P>0.05). Additional carcass surveys will be conducted below the CDDFL in order to validate this assumption. If the composition of marked to unmarked is significantly different between the trap counts and the carcass recoveries below the trap, then the proportion below the trap will be used to correct for the below trap escapement estimate.

Table 5-2. Carcass Recovery Survey Results (2004–2013)

	Nisqually River RM (26.2 to 21.9)				Mashel River (RM 3.2 to 0.0)			
Year	Marked	Unmarked	Total	% Marked	Marked	Unmarked	Total	% Marked
2004	22	20	42	52%	No Data			
2005	2	0	2	100%	62	66	128	48%
2006	56	13	69	81%	4	1	5	80%
2007	34	24	58	59%	54	59	113	48%
2008	77	57	134	57%	52	49	101	51%
2009	7	2	9	78%	35	15	50	70%
2010	18	7	25	72%	36	10	46	78%
2011	23	5	28	82%	63	17	80	79%
2012	17	8	25	68%	19	5	24	79%
2013	0	6	6	0%	4	10	14	29%

Carcass Recovery Surveys

Carcass recovery surveys will be conducted to validate the CIR assumption of even composition of marked and unmarked Chinook on the spawning grounds and to monitor trends in adult distribution. The surveys will consist of two index reaches (Figure 5-1), which have been surveyed since 2004, and secondary surveys to increase spatial coverage.

The two index surveys will be conducted weekly and can be used to calculate a secondary escapement estimate consistent with historical methods for comparison to the CIR method.

- Mashel River from Highway 7 Bridge to Mashel Mouth (RM 3.2 to 0.0)
- Nisqually River from the Centralia Diversion Dam to McKenna Bridge (RM 26.2 to 21.9).

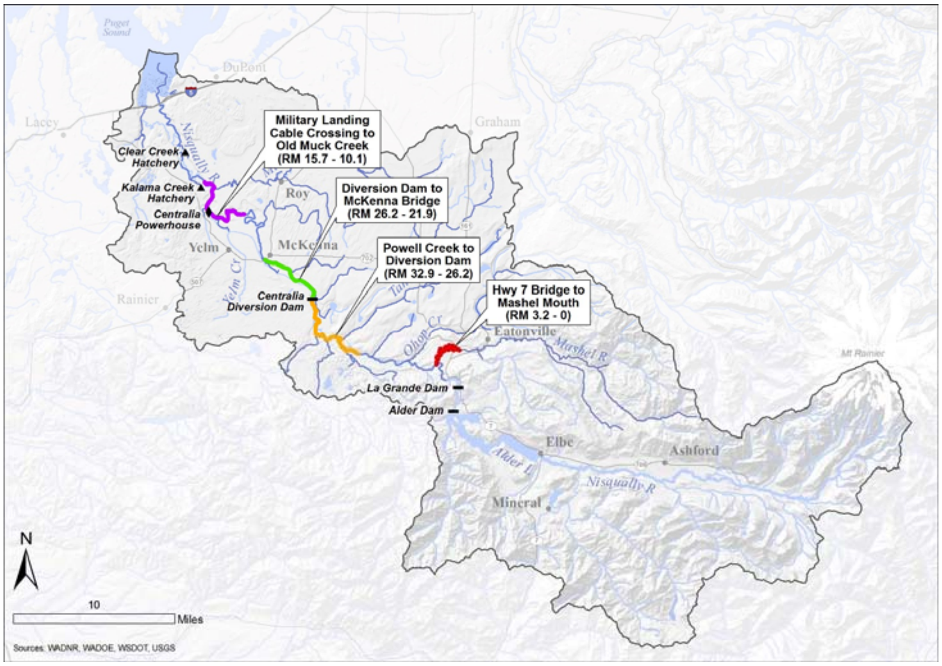
The index reach based escapement method was developed in the 1980s and uses the following equation:

$$Escapement = 6.81 * ((2.5 * PeakCoundMainstem) + PeakCountMashel)$$

Surveys will also be conducted in two additional reaches (Figure 5-1), secondary to the index reaches, to further inform understanding of the movement and spawning patterns of natural-origin Chinook, hatchery-origin Chinook, and Chinook trucked and released during the Colonization phase.

- Nisqually River from Powell Creek to the Centralia Diversion Dam (RM 32.9 to 26.2)
- Nisqually River from the Military Landing to River Bend Campground (RM 15.7 to 10.1)

Figure 5-1. Carcass Recovery Survey Locations



Expected Results

The effective enumeration of the Treaty catch, sport catch, and escapement is a key monitoring program for gauging the effectiveness of the stock management actions through all recovery phases. During colonization, escapement is the primary explanatory variable for determining the Nisqually watershed's capacity to support juvenile Chinook production and during the local adaptation and viable population phases, escapement becomes the key management target driving harvest decisions. Additionally, after the colonization experiment sunsets, the magnitude and distribution of hatchery strays is an essential input for tracking PNI and the recovery trajectory of Nisqually Chinook.

Commented [S36]: What biological and mark-sampling will occur?

Juvenile Freshwater Monitoring

Commented [S37]: Any studies discussed to assess habitat use as well as number, or have these studies already been done? Important to get a full picture of adult and juvenile use of habitat.

Purpose

The juvenile monitoring program is intended to provide unbiased estimates of abundance, migration timing, and body size to inform freshwater productivity, capacity, and juvenile life-history estimates. When combined with adult spawner estimates, the juvenile abundance data facilitate a stock-recruit analysis of freshwater productivity and capacity.

Freshwater productivity, capacity, and juvenile life history are determined as follows:

- Productivity: Number of outmigrants per natural spawner

- Capacity: Number of outmigrants by life stage
- Juvenile life history: Relative abundance of outmigrants by life stage

Methods

The methods and tools described below will be implemented to support the juvenile freshwater monitoring program.

The outmigrant trap operated by WDFW on the mainstem Nisqually River will continue to be operated to estimate abundance, timing, life stage, and size of juvenile migrants. The trap, an 8-foot-diameter rotary screw trap, located at RM 12.8, approximately 100 meters upstream from the Centralia Powerhouse (Figure 1-2). This site, selected for its yield of relatively high catch efficiencies and location upstream of the primary hatchery release locations (Figure 5-2), has been monitored since 2009. The trap will continue to be installed annually in mid-January and operated continuously through approximately mid-August. During some time periods, high river conditions and recreational use of the river preclude trapping operations.

The trap will continue to be checked at least daily, and more frequently during peak migration periods and high-flow events. All salmonids are identified to species, counted, and checked for previous fin clips and dye marks. Chinook salmon are classified as either subyearlings or yearlings. Yearlings are identified by body size (larger than subyearlings), faint parr marks, and silvery appearance. In some cases, scale samples for age determination are collected to confirm subyearling and yearling classifications. Fork length is collected from every tenth fish marked for release in efficiency trials and all recaptured fish.

A single-trap, stratified mark-recapture study design will be used to estimate trap efficiency throughout the season (Volkhardt et al. 2007). Each week, newly emerged subyearling Chinook salmon are batch marked Monday through Thursday with Bismarck Brown-Y dye (~ 10 mg/L) to evaluate recapture Tuesday through Monday. Larger subyearlings and yearling Chinook are marked with week-specific fin clips. All fish are broadcast released approximately 1.6 km upstream of the trap to ensure complete mixing of the mark groups.

Abundance will be estimated using the following general approach.

1. Estimate missed catch and associated variance during trap outages using catch rates before and after the outage.
2. Consolidate consecutive weekly efficiency trial data into strata with similar recapture rates using a G-test test of homogeneity (Sokal and Rohlf 1981).
3. Estimate abundance and associated variance using a modified Petersen method (Carlson et al. 1998).

Klungle et al. (in prep) provide a detailed explanation of methods and equations used to estimate abundance.

A series of spawner-juvenile recruit models will be fitted, using the total number of spawners to predict the number of juveniles within each cohort. These models will be used to evaluate the productivity and capacity parameter values of the population. The initial aim is to determine whether the relationship between spawners and juveniles follows a linear, density-independent relationship by which more spawners yield more juveniles with no evidence of an upper limit, or an asymptotic, density-dependent relationship with an upper limit to juvenile production at higher spawner abundances. If juvenile production follows a density-dependent relationship, capacity and the number of spawners needed to reach that capacity are estimated. Three different abundance variables will be explored: fry component only, parr component only, and total number of subyearlings (fry and parr). For each response variable, a density-independent, intercept-only model of constant production will be compared to a density-dependent model (e.g., Ricker, Beverton-Holt, or Hockey Stick).

Expected Results

The outmigrant trap has been operated as described above since 2009; operations will likely remain unchanged across the recovery phases.

From 2009 to 2016, the juvenile monitoring yielded abundance estimates ranging from 2,868 to 408,158 subyearling[37] Chinook, with coefficients of variation[38] ranging from 3.5 to 20.4% (Klungle et al. in prep), and 240 to 15,240 yearling Chinook, with coefficients of variation ranging from 14.0 to 139.1 % (Klungle et al. in prep). Thus, despite the inevitable trap outages, there is a high confidence level of producing reasonably precise abundance estimates (coefficients of variation < 15% in most years) of subyearlings, the life-history type that tends to predominate in the Nisqually, during the recolonization experiment and beyond.

Based on results from smolt trap monitoring in the Skagit and Green rivers (Zimmerman et al. 2015; Anderson and Topping in review), density-dependent productivity of subyearling parr and yearlings density-independent productivity of subyearling fry are expected to be observed. Throughout Puget Sound, subyearling fry abundance typically continues to increase with increasing numbers of spawners, whereas subyearling parr reach a maximum, asymptotic abundance with increasing numbers of spawners. Where yearlings are observed, their productivity appears to be density-dependent. Thus, although the Skagit and Green rivers in Puget Sound must have some carry capacity for production of subyearling fry based on the quantity and quality of spawning habitat, it does not appear that adult abundances commonly reach the level that would invoke such limits.

In the Nisqually watershed, downstream migrating fry would have the opportunity to rear in the tidally influenced delta for weeks to months prior to movement into Puget Sound proper. Thus, estimating the carrying capacity of the delta, particularly its ability to provide rearing habitat for small-bodied Chinook salmon migrants, is a complement to proposed estimates of freshwater capacity. Carrying-capacity estimates of the Nisqually delta will be conducted if additional resources become available, as described below under *Additional Monitoring and Studies*. Nearshore Puget Sound likely also has some capacity for rearing small Chinook salmon, though without systematic monitoring surveys in these habitats, this life stage would be combined with all others in an adult-to-adult estimate of capacity.

[37] Two broad categories of subyearling Chinook salmon are typically observed: small newly emerged fry more than 45 mm migrating January through March, and larger reared parr ≥45 mm migrating June through August (Klungle et al. in prep).

[38] Higher coefficients of variation were associated with low abundance years.

Juvenile Nisqually River Delta Monitoring

Purpose

The purpose of the juvenile Nisqually delta core monitoring program is to track juvenile life-history diversity (temporal and spatial) and relative density across distinct delta habitat zones. Additional monitoring would also provide estimates of delta productivity and delta capacity. Data on the capacity of the delta to support juveniles is important to place the Chinook habitat use data in context each year, especially since delta capacity is changing following restoration. However, this sampling is very intensive and is dependent on additional resources (see *Additional Monitoring and Studies*).

Methods

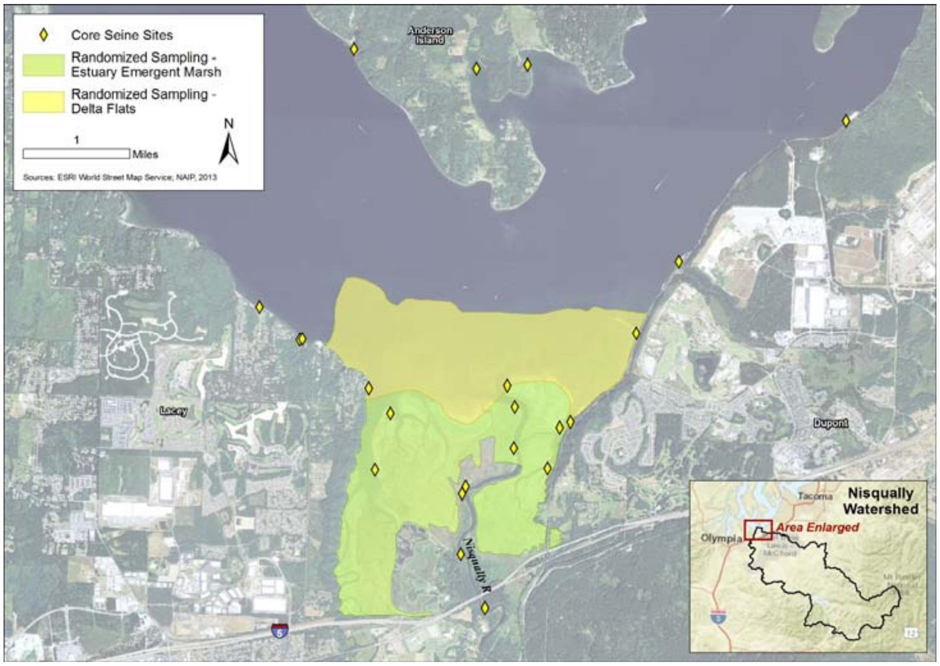
The methods and tools described below will be implemented to support the juvenile delta monitoring program.

Biweekly beach seining will be conducted from January/February through October in all habitat zones (freshwater tidal, forested riverine tidal, emergent forested transition, estuarine emergent marsh, delta flats, and nearshore) to measure relative abundance in time and space.[39] Seining sites in all habitat zones, matching sites that have been monitored regularly in previous years informs understanding of spatial and temporal diversity and long-term comparisons. Catches at seine sites will be converted into density estimates[40] to compare densities of fish through time and space and look for effects of different-sized outmigrations on abundance. Sites that have been monitored in previous years will be selected from each habitat zone as index sites (one to two per zone), while additional sites (about two per zone) will be randomly selected for additional sampling to provide a representative sampling of fish density across the entire Nisqually delta (Figure 5-3). The methods are modeled after the Skagit River Estuary Intensively Monitored Watershed Project (Greene and Beamer 2011).

[39] This continues long-term monitoring that the Nisqually Indian Tribe has been conducting since 2003 (Ellings and Hodgson 2007).

[40] Using area fished estimates computed with a Trimble GPS on board the sampling boat.

Figure 5-2. Beach Seine Sites



Data collected at seine sites include counts of each fish species caught, lengths and weights for 10 Chinook per site visit (if present), and water quality measures including temperature, salinity, and dissolved oxygen. Captured Chinook and coho salmon will be checked for an adipose fin clip and scanned for a coded-wire tag. Some of the Chinook and coho with a coded-wire tag will be sacrificed to recovery the tag to determine origin.

Expected Results

Post-restoration monitoring data in the Nisqually delta (2009–2012) have detected rapid, landscape-scale improvements in habitat suitability for juvenile Chinook and other salmon, with some sites exhibiting greater functionality than others. Immediate benefits appear to be driven by the connectedness of restoring habitat and its invertebrate prey productivity (David et al. 2014; Ellings et al. 2016).

Simenstad and Cordell (2000) laid the foundation for a three-tiered monitoring framework by which restoration success criteria are evaluated for the Nisqually delta. This framework is based on long-term measures of opportunity, capacity, and realized function.

- Opportunity is related to the amount of habitat available and physical features including how accessible the habitat is.

- Capacity is related to the types and abundance of prey items available for forage in newly-available habitats.
- Realized function describes the direct physiological responses of fishes that result from improvements in habitat and prey availability.

This framework is used to determine success of the restoration program by asking if juvenile salmonids are successfully accessing and benefiting from restored estuarine habitat.

Detailed monitoring results from intensive post-restoration monitoring in the Nisqually delta are described in Table 5-2. The success of the Nisqually delta restoration appears to be more functionally driven, as opposed to structurally driven. For example, two restored sites (known as 2006 Restoration and 2009 Restoration) have had different results. Juvenile Chinook were captured at the 2006 Restoration site in less than half of the times sampled and had emptier guts and smaller size than those captured at the 2009 Restoration site where they were present most of the times sampled (Ellings et al. 2016; Davis et al. in press). The 2006 Restoration site shares characteristics with the sampled reference sites in terms of channel morphology and vegetative composition; however, this site is less functional than the 2009 Restoration site (Table 5-2) most likely due to its distance from the mainstem Nisqually (Ellings et al. 2016). On the other hand, the 2009 Restoration site is still physically degraded, but it is used throughout the rearing season by Chinook and produces just as much (if not more) prey as the reference sites (David et al. 2014; Ellings et al. 2016; Davis et al. in press).

Chinook densities will be compared among sample sites with different connectivity to the Nisqually River mainstem. We hypothesize that at lower annual outmigration abundances as reported by the outmigrant trap, densities will be highest at sites with good connectivity and easy access from the mainstem (e.g., Animal Slough) compared to less well-connected sites. With higher abundances of outmigrants, densities across sites are expected to be more similar, as juvenile Chinook spread out across the delta to occupy less well-connected sites. Chinook densities will also be compared to annual outmigration abundance to look for evidence of an asymptote in densities, suggesting an upper limit to the number of Chinook that occupy a site. In addition to densities, Chinook lengths will be compared to annual outmigration abundance to look for effects of higher densities on growth.

Table 5-2. Nisqually River Delta Monitoring Metrics

Variables	Historic Marsh (Reference Sites)	2006 Restoration Site (Red Salmon Slough)	2009 Restoration Site (Billy Frank Jr. Nisqually National Wildlife Refuge)	Nisqually Delta-Wide
Opportunity	• Channel depths remained stable • Sites are generally closest to the Nisqually mainstem • Sites are available 47–67% of the time • Easiest access at mean tidal level (~0.6 tortuosity ratio) • Temperatures remained stable • Highest salinity (10–20 ppt) • Full coverage of high salt marsh vegetation • 62–93% proportional presence for juvenile Chinook • 68–87% proportional presence for juvenile chum	• 78,000 m^2 of tidal channels added to the Nisqually Delta (including Pilot and Phase I) • Channels became marginally deeper through time (-1.6 cm/year) • Temperatures remained stable • Lowest salinity (5–8 ppt) • Full coverage of high salt/brackish marsh vegetation • 32–47% proportional presence for juvenile Chinook • 50% proportional presence for juvenile chum	• 450,000 m^2 of tidal channels added to the Nisqually Delta • Channels became substantially deeper through time (-7.4 cm/year) • Up to three separate accessible paths at high tide, with a tortuosity ratio of 0.84 • Gradual temperature decline (~2˚C) at seaward sites • Broad range of salinity values (5–20 ppt) • Primarily mudflat with some low marsh vegetation • 80–89% proportional presence for juvenile Chinook • 42% proportional presence for juvenile chum	• 42% increase in channel area (1.6 million to 2.3 million m^2) • 131% increase in channel length (37,000–85,000 m) • 126% increase in channel edge (76,000–173,000 m) • Tidal channel accessibility increased from 30 to 75% of the tidal cycle
Capacity	• Post-restoration increases in amphipods, potentially due to organic matter exchange • Very high proportion of arachnids and hemipterans in terrestrial drift	• Post-restoration increases in amphipods, potentially due to organic matter exchange • Terrestrial prey community highly diverse	• Immediate post-restoration increases in copepods and amphipods, decreases in insect larvae • Terrestrial prey community dominated by dipteran flies • Prey biomass equivalent to or greater than other sites, primarily comprising terrestrial taxa	• Delta-wide increases in benthic, terrestrial, and aquatic biodiversity may support multiple salmon species and life history strategies

Variables	Historic Marsh (Reference Sites)	2006 Restoration Site (Red Salmon Slough)	2009 Restoration Site (Billy Frank Jr. Nisqually National Wildlife Refuge)	Nisqually Delta-Wide
Realized Function	• Prey energy availability frequently topped 1 million kJ at the reference sites	• Lowest prey energy availability (< 250,000 kJ) of sites monitored	• Estimated 6 million kJ available prey energy at any given time (enough to feed ~ 900,000 juvenile Chinook salmon for 1 week)	• Juvenile Chinook diets were almost entirely comprised of amphipods, dipterans, and mysids (when calculated as dry-weight biomass) • Otolith-derived growth rates did not differ among sites • Evidence for recant delta entrants using reference sites more frequently (due to their greater connectivity)

Hatchery Monitoring

Purpose

The purpose of hatchery monitoring is to provide an annual accounting of the adult returns to the hatcheries, the number of Chinook used for broodstock, in-hatchery and post-release survival, and number Chinook released by program component including size at release, time of volitional release and end of release period, and number adipose fin-clipped and coded-wire tagged. This accounting of hatchery program attributes for broodstock, fecundity, mating, and in-hatchery and post release survival will be used to update management objectives for hatchery broodstock and release. The count of hatchery-origin and mark status of adults entering hatcheries will be used to test and update plan assumptions regarding the collection of hatchery-origin adults at the hatchery ponds, the percentage of the hatchery escapement not entering hatcheries, and annual mark rates of the hatchery run.

All of the variables are measured through direct enumeration or classification by hand or by machine as part of hatchery operations. They will be reported by hatchery staff in the annual hatchery report. A summary of all hatchery operations and data collection conducted as part of hatchery operations are presented in the Nisqually River Chinook Hatchery and Genetic Management Plan (currently being developed).

Methods

The following metrics will be monitored at the hatcheries:

- Number of adults and jack counts to hatcheries and McAllister Springs/Creek plus outlet creeks and McAllister Creek
- Number of hatchery-origin adults used for broodstock
- Number of natural-origin adults and jacks collected for broodstock
- Survival rates (surviving to spawn) natural-origin used for broodstock
- Number of surviving natural-origin adults and jacks used for broodstock
- Fecundity hatchery- and natural-origin used for broodstock
- Age composition hatchery- and natural-origin
- Survival rates green egg to eyed egg
- Survival rates eyed egg to ponding
- Survival rates ponding to release
- Number of juveniles released, date of release, size of juveniles at release, and number adipose fin clipped and number coded-wire tagged.

Expected Results

Historical results from the Clear Creek and Kalama Creek hatcheries were used to shape program broodstock and number of Chinook released (see HGMP in development). The two hatcheries have been operated as isolated programs to support harvest. As such, hatchery monitoring focused on information to report size of the release and number marked in the release and monitor post-release survival. In-hatchery survival was monitored to adjust broodstock requirements.

The hatchery monitoring program will have a greater emphasis as conservation issues will have a higher priority, particularly when natural-origin adults are collected for broodstock.

Habitat Monitoring

Purpose

The purpose of the habitat monitoring program is to track progress implementing the habitat actions detailed in the Nisqually Chinook Recovery Plan (2001) and subsequent 3-and 4-year work plans (http://www.psp.wa.gov/salmon-four-year-work-plans.php). Habitat gains that result from protection and restoration projects can be characterized using a variety of variables depending on the type of project and location within the watershed.

Table 5-3 lists variables that will be monitored for the different types of habitat recovery projects through time.

Table 5-3. Variables Monitored for Habitat Restoration Projects by Type

Project Type	Monitoring Variable
Estuary Restoration	Acres re-connected to tidal exchange
Floodplain Restoration	Acres of floodplain re-connected to fluvial processes
Mainstem and Tributary Protection	Miles of shoreline protected from development Acres of floodplain protected from development
Watershed Process Protection	Acres of forestland protected or converted from commercial forestry to Ecosystem Services based management
Instream Habitat Diversity Restoration	Number of engineered logjams constructed miles of stream treated
Riparian Restoration	Acres of riparian planted and/or treated for invasive species
Barriers	Number of fish barriers removed Miles of stream made accessible

Methods

All variables will be measured using a combination of post project as-built reports, field visits, and remote sensing based mapping. Project outcomes will be reported using Habitat Work Schedule, an online habitat tracking database (http://hws.ekosystem.us/site/220).

Expected Results

The core habitat monitoring program will enable the Nisqually Chinook Recovery Team to track progress made toward implementing the habitat recovery goals listed in the Nisqually Chinook Recovery Plan.

Stock Recruitment Analysis

Purpose

The purpose of the Stock Recruitment analysis is to assess the productivity and abundance of Nisqually River Chinook by brood year. Results of the analysis will be used by the Nisqually technical work group to evaluate brood-year abundance and recruitment rates. The Nisqually work group will use this information to determine if the population can transition to Local Adaptation and what revisions in strategies are needed to make the transition.

Methods

The stock recruitment analysis estimates natural-origin adult abundance to the river, spawner abundance and composition, and survival rates of juvenile outmigrants compared to adult recruits to the river.

Natural-Origin Adult Abundance to River

Natural-origin adult abundance in the terminal run will be calculated as the sum of the following:

- In-river catch and nonlanded mortality (released fish) estimates, described in *Adult Catch and Escapement Monitoring*
- Natural-origin adults removed for broodstock[41]
- Watershed-wide natural spawning escapement estimates of natural-origin adults are described in *Adult Catch and Escapement Monitoring*

Survivals Rates (Juvenile Outmigrants to Adult Recruits to River)

Survival rates will be based on the following:

- Outmigrant estimates, described in *Juvenile Freshwater Monitoring*
- Estimates of natural-origin adult recruits to river, described in *Adult Catch and Escapement Monitoring.*

Recruitment Rates (Spawners to Adults by Brood Year)

Recruitment rates will be based on the following.

- Parent natural spawning abundance by origin estimates, described in XX or based on XX estimates described in *Adult Catch and Escapement Monitoring*.
- Terminal natural-origin run allocated to brood year, based on estimates of total age of adults in annual run (catch plus escapement) described in *Adult Catch and Escapement Monitoring*

[41] This will occur as part of the integrated hatchery program implemented during the Local Adaption phase Whether the stepping-stone program occurs will be based on current scientific thinking and data at the time, and the assumption that the magnitude of NOR spawners relative to the hatchery component of natural spawners will be sufficient at the transition from colonization to local adaptation to increase PNI adequately given the hatchery production and harvest objectives. This strategy will be reviewed at the point of transition to local adaptation to ensure the strategy that is adopted reflects best science and information at that time.

Nisqually Chinook Genetics Assessment

Purpose

The purpose of the Nisqually Chinook Genetics Assessment is to evaluate the response of the stock to plan implementation through the following analyses:

1. Estimate adult abundance using trans-generational genetic mark recapture (tGMR)
2. Estimate effective breeders by origin
3. Estimate relative contribution to juvenile production for the three adult types in the escapement (natural origin spawners, hatchery origin spawners, and hatchery recruits trucked to the upper Nisqually)
4. Conduct a genetic based brood year reconstruction to evaluate relative contribution of natural and hatchery origin to adult recruits

Methods

The proposed genetics assessment plan during the Colonization phase is summarized in Table 5-4.

Adult Abundance

Tissue samples from adult spawners and subyearling migrants will be collected each year. Genetic mark-recapture (GMR) will be used to estimate spawning escapement from those samples (Pearse et al. 2001, Rawding et al. 2014) as funding permits.

GMR escapement estimates will be compared to those from the change-in-ratio method (proportion of hatchery fish in harvest samples downstream of Clear Creek Hatchery compared to proportion of hatchery fish in samples upstream of Clear Creek Hatchery, either collected at the weir or from spawning ground surveys farther upstream) used to estimate spawner abundance in the Nisqually River. The coefficient of variation (CV) for the GMR estimate should be less than 15% to meet United States-Canada reporting requirements, as has been found for GMR estimates in other systems (Coweeman, Stillaguamish, Nooksack). The CV of change-in-ratio method will be compared as will the absolute estimates of spawning escapement.

Estimates of Effective Breeders

Cohorts of juveniles sampled for the GMR study will be used to estimate effective population size of natural production in the Nisqually River by examining temporal variation in allele frequency between the cohorts (Waples 1989). The effective population size estimate will give insight to the relative importance of genetic drift and natural selection in the population’s response as it continues to adapt to the river. If Ne is low, genetic drift will take on outsized significance in the shaping the population’s future. In addition, for each individual cohort, effective number of breeders (Nb) will be estimated using the method of Wang (2009). The effective number of breeders will be used with the escapement estimate (census population, Nc) to estimate the proportion of escapement contributing to natural production (Nb/Nc ratio). Estimates of the number of breeders contributing will give insight to the potential for inbreeding as the population persists and also will give insight to the amount of production to be expected from a particular level of escapement.

Contribution by Type to Juvenile Production

In addition to the GMR study outlined above that is funded for samples representing brood-years 2012–2014, in the future, tissue samples will continue to be taken from each category of adults spawning in the Nisqually (natural-origin fish intercepted at the Centralia Diversion dam, hatchery-origin fish trucked to the upper Nisqually to increase spawner density, and also samples taken from hatchery- and natural-origin carcasses collected above and below the Centralia Diversion Dam). 50% of total spawners in the Nisqually are expected to be sampled. Samples will also be taken from up to 3000 natural-origin smolts handled at the Nisqually smolt trap downstream. Processing these samples for DNA analysis will be dependent on ability to obtain funding in the future. Should funding be available, production of smolts at the trap will be able to be assigned to natural- and hatchery-origin spawners above the smolt trap and potentially above and below the Centralia Diversion Dam.

The proportion of hatchery-identified parents (verified through identification of progeny) will be compared to the proportion of hatchery-identified carcasses. A consistent difference across years between proportion of hatchery-origin parents and proportion of hatchery-origin carcasses, by sex, would be consistent with a difference in reproductive success of hatchery vs. natural fish. Methods to this point will follow those outlined in Rawson and Crewson et al. (2017). Through time, if parentage studies continue, it may become possible to determine if there are differences in reproductive success of natural-origin progeny of hatchery-origin spawners and natural-origin progeny of natural-origin spawners. Such a difference that is maintained through generations would be consistent with a heritable difference in reproductive success of hatchery- and natural-origin spawners.

Contribution by Origin to Adult Recruitment (Adults Back to Nisqually River)

Over time, sampling adults for genetic mark recapture above and below the Centralia Diversion Dam will yield samples of adults that are progeny of adults sampled in previous years. Adults sampled in 2017, for instance, will be parents of 2-year old adults sampled in 2019, 3-year-old adults sampled in 2020, 4-year-old adults sampled in 2021, and 5 year-old adults sampled in 2022. Tissue from such adults will be archived from at least 7 successive years so that a cohort produced with and without pink salmon spawning in the river will have been sampled. If sampling is extended to a total of 13 successive years than pairs nonoverlapping cohorts, each spawned with and without pink salmon in the river, will have been sampled. Genetic analysis of such samples will depend upon future funding availability. Once the samples are analyzed, production of spawning adults will be apportioned to each category of spawner that has been identified: hatchery- and natural-origin adults that spawn above and below the Centralia Diversion Dam, and hatchery recruits that are trucked above the Diversion Dam.

Table 5-4. Preliminary Genetic Sample Plan

Study Year	Brood Year Spawners	Juvenile Migrants	Study Results
Year 1	1,500 adults (~250 NOS, ~250 HOS volunteers, 1,000 HOS trucked)	----	Initial genotype NOS, HOS and HOS trucked
Year 2	1,500 adults (~250 NOS, ~250 HOS volunteers, 1,000 HOS trucked)	2,000 subyearlings	Year 1 adult abundance using tGMR, # effective breeders by origin (natural-origin, hatchery-origin volunteers, and hatchery-origin truck and hauled), and relative

Study Year	Brood Year Spawners	Juvenile Migrants	Study Results
			contribution to juvenile production of three groups of spawners
Year 3	1,750 adults (~500 NOS, ~250 HOS volunteers, 1,000 HOS trucked)	2,000 subyearlings	Year 2 adult abundance using tGMR, # effective breeders by origin (natural-origin, hatchery-origin volunteers, and hatchery-origin truck and hauled), and relative contribution to juvenile production of three groups of spawners **Brood Year Reconstruction:** Age 2 recruits from Year 1
Year 4	500 adults (NOS)	2,000 subyearlings	Year 3 adult abundance using tGMR, # effective breeders by origin (natural-origin, hatchery-origin volunteers, and hatchery-origin truck and hauled), and relative contribution to juvenile production of three groups of spawners **Brood Year Reconstruction:** Age 2 recruits from Year 2 Age 3 recruits from Year 1
Year 5	500 adults (NOS)	---	**Brood Year Reconstruction:** Age 2 recruits from Year 3 Age 3 recruits from Year 2 Age 4 Recruits from Year 1
Year 6	500 adults (NOS)	---	**Brood Year Reconstruction:** Age 3 recruits from Year 3 Age 4 Recruits from Year 2 Age 5 Recruits from Year 1
Year 7	500 adults (NOS)	---	**Brood Year Reconstruction:** Age 4 Recruits from Year 3 Age 5 Recruits from Year 2
Year 8	500 adults (NOS)	---	**Brood Year Reconstruction:** Age 5 Recruits from Year 3

Additional Monitoring and Studies

The following monitoring activities and directed studies would provide additional information to evaluate program assumptions and population performance. These activities are dependent on funding that has not yet been identified and are not part of the core monitoring program that will be implemented under this plan.

Adult Catch and Escapement Monitoring

Nisqually River Catch in Treaty and Sport Fisheries

- Creel surveys could be conducted to improve estimates of landed and incidental mortality of natural-origin Chinook from the sport fishery catch.
- Mark-selective treaty fishery study: test an array of potential commercial selective fishing gear for catch efficiency, incidental mortality, and fishery compatibility.

Commented [S38]: This should be part of the core monitoring program given that it is a key element of the harvest strategy.

- Mark-selective sport fishery study: test for differential sport release mortality between estuary and river caught Chinook.
- Study of net dropout rate in treaty commercial fishery to improve fishery mortality estimates.

Nisqually Watershed-Wide Adult Escapement and Composition

- Historical escapement could be estimated from live and dead counts and expansion formula (Tweit 1986) and calculated to better understand bias in the historical abundance estimates.
- Carcass recovery surveys of the Mashel River above Highway 7 and along the Nisqually mainstem from the mouth of the Mashel to Powell Creek would further expand understanding of composition.
- Radio tagging and tracking of adults (hatchery- and natural-origin) captured would improve evaluation of migration and spawning behavior above and below the Centralia Diversion Dam.

Juvenile Freshwater Monitoring

No additional methods beyond those identified in the core program have been identified.

Juvenile Nisqually River Delta Monitoring

- Lampara net sampling (May to September) in the shallow open delta mudflats areas (including eelgrass bed adjacent areas), and lampara or tow-net sampling in the offshore areas adjacent to the delta would improve life-history and delta productivity estimates.
- Biweekly fyke net sampling (April to September) of sloughs in the emergent marsh zone, areas not reachable by beach seine, would improve delta capacity estimates. As with the beach seine sampling, index fyke trap sites would be chosen from the five sites with data for multiple years, along with a limited number of randomly selected new sites. Index and new sites would be chosen to represent different levels of connectivity to the mainstem Nisqually and to represent the geography of the area, including the Red Salmon Slough and McAllister Creek sides of the delta. Catch and density records would be adjusted for trap efficiency as measured with mark-recapture sampling at each trap on one sampling day.
- Benthic core samples, invertebrate fallout trap samples, and neuston tow samples could be collected monthly from April to July to quantify prey from the substrate, the terrestrial environment, and the water column, respectively.
- PIT tags to mark and recapture individual fish also be used to study fish movements within the delta and timing patterns between tagging (at the outmigrant trap, hatchery, or hatchery off-station release site), entry into the delta, and capture or presence at an antenna in the delta. PIT tag recapture rates in the delta and differences between recaptures at well-connected mainstem sites and less well-connected sites could be compared to outmigrant trap annual estimates to look for evidence of differences in habitat use and dispersal with differences in abundance of juvenile Chinook entering the delta.
- Otoliths collected from returning adults to determine the delta residence patterns of adults that survived to return could be paired with juvenile otolith sampling to characterize residence time and growth of juveniles and to compare life-history types between juveniles and successfully returning adults.

Hatchery Monitoring

No additional methods beyond those identified in the core program have been identified.

Stock Recruitment Analysis

Natural-Origin Adult Abundance to River

- Creel surveys to improve estimates related to the sport fishery catch would also improve estimates of natural-origin adult abundance to river.

Survival Rates (Juvenile Outmigrants to Adult Recruits to River)

- Otolith microchemistry for growth, residence time, and life-history types surviving to adult return would improve estimates of survival rates.

Habitat Monitoring

A habitat status and trends program, as recommended in *Methods and Quality of Salmonid Habitat Monitoring of ESA Listed Puget Sound Salmon and Steelhead with Identified Critical Gaps* (Crawford 2013) would link Chinook population response to habitat recovery actions.

Chapter 6
Data Management, Record Keeping, and Reporting

Plan Monitoring Data Tracker

The monitoring program to support the Chinook management plan will be designed to collect data that supports implementation of the plan. Specifically the monitoring program will collect:

- Data to update key assumptions
- Data to update population status and trends information
- Data necessary to review and apply the decision rules for harvest, hatchery, and escapement management
- Data necessary to compute in-season biological objectives for the coming year and to review these for consistency with conservation and harvest objectives

The information that informs the plan will be gathered and analyzed from a wide variety of sources as described in Chapter 5, *Monitoring Tools and Objectives*. Some of this information is updated annually with results from specific monitoring activities and results from the previous year operations; some information may not be available for several years (e.g., genetics assessment).

The In-Season Implementation Tool (ISIT?) is a Microsoft Excel-based application that is organized to follow the outline of the APR. It includes worksheets for each of the components of the APR (key assumptions, status and trends, decisions rules, and plan objectives). Its purpose is to store and document data and assumptions, and derive annual management objectives for the operation of the Nisqually terminal fisheries, escapement, and hatchery programs. The ISIT? documents the basis for these objectives and establishes expectations for all management indicators; it also simplifies the implementation process and documents the rationale for the management actions taken each year.

Inputs to ISIT? are mostly summaries of information collected for status and trend monitoring and evaluation of key assumptions, and results from preseason and in-season forecasting models. The ISIT? tool is not a replacement for a comprehensive data system to store and manage information collected to support the plan. That data system still needs to be developed. A single database is generally inadequate to cover all monitoring activities across multiple agencies. The technical work group will need to discuss an interconnected data management system that can operate across multiple databases. The technical work group might decide to develop a data mapping system that describes the relationships among the different datasets and the pedigree of data used in the decision process.

In addition, the technical work group will need to develop and manage other tools and models (some existing such as EDT to track habitat) and some that need to be developed such as for in-season updates.

Annual Project Review

The APR workshop will be conducted each year by the technical work group, after preseason projections are available for the coming Chinook management season. The agenda will follow the four-step procedure outlined in Figure 3-1 with special emphasis on Chinook terminal area management. The APR is a science-driven process that informs the workshop participants and will result in an action plan for the coming season. This action plan will be presented as a subsequently adopted action plan and will constitute the All-H coordinated implementation component of the Nisqually Chinook Plan.

Prior to the workshop, the technical work group will meet with the various action leads to compile draft annual summaries on each of the following subjects to be available at the workshop.

- Habitat and natural production
- Terminal and preterminal harvest
- Hatchery operations
- Escapement management

The tools used to support the plan will be populated with the most recent data and analytical results prior to the workshop. The objective of the APR workshop is to address four questions.

1. Were objectives met last year and if not, why not?
2. What are trends in population status and management objectives (e.g., pHOS and PNI)?
3. How can operations be improved in terms of effectiveness and efficiency in the coming year?
4. Should management objectives be modified; are they consistent with most recent and best available science?

The technical group will use this information to review the implications of information presented in during the APR. The NCSMP technical team will review conclusions from the workshop and supporting material, and discuss alternative options for the decision rules as necessary to advance recovery. Note, the purpose of the decision rules is to ensure that the long-term goals for conservation and harvest established in the plan are met over time. A product of workshop will be a recommended action plan for operating fisheries, managing escapement, and hatchery operations in the coming year. A final task of the APR workshop will be staff assignments for year-end activities (i.e., finalizing annual reports) and for implementing harvest, hatchery, escapement, and M&E plans for the coming year.

Chapter 7
Budget

Successful implementation of this plan is dependent on adequate funding to support monitoring and evaluation components, staffing for operations, and infrastructure to implement the plan. The co-managers are coordinating technical staff and identifying additional resources to implement the plan.

Table 7-1 presents the estimated annual cost of implementing the core monitoring programs described in Chapter 5, *Monitoring Tools and Objectives*.

Table 7-1. Annual Cost Estimates for Core Monitoring Programs

Monitoring Program	Core Monitoring	Annual Cost
Adult Catch and Escapement Monitoring	Treaty net fishery sampling	$125,000
	Catch Record Cards reporting of the sport catch	N/A
	Total encounters estimated from years of CRC and creel study years	N/A
	Adult counts at adult fish trap in the Centralia Diversion Dam fish ladder	$250,000
	Carcass recoveries from priority index reaches (weekly) and nonindex reaches (biweekly)	$100,000
	Estimates of escapement, proportion marked, and removals	N/A
Juvenile Freshwater Monitoring	Outmigrant trap operation	$225,000
	Abundance estimates and stock-recruit curves	N/A
Juvenile Nisqually River Delta Monitoring	Beach seining	$150,000
Hatchery Monitoring	Hatchery staffing (Kalama Creek and Clear Creek Hatcheries)	N/A
	Seasonal staffing at McAllister Springs Release Pond	$30,000
	Adipose fin clipping and coded- wire tagging	N/A
Habitat Monitoring	Track implementation of *Nisqually Chinook Recovery Plan* Habitat Action Plan	$65,000
Stock Recruitment Analysis	Estimates	N/A
	Estimates	N/A
	Estimates	N/A
Genetics Assessment	Genetic mark recapture study	$100,000
Total average cost per year		**$1,045,000**

N/A = Denotes costs that are covered under other budgets not directly tied to this stock management plan.

Chapter 8
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Appendix 1

Nisqually Chinook Run Reconstruction and Spawner-Recruit Analysis

From:	Christina Iverson - NOAA Federal
To:	Robert Jones; Gray, Cindy; Dave Herrera; Downen, Mark R (DFW); Joseph Pavel; Adicks, Kyle K (DFW)
Cc:	Sheila Lynch; Susan Bishop - NOAA Federal; James Dixon - NOAA Federal
Subject:	Re: [US v WA Mediation Communication] Skokomish MUP
Date:	Wednesday, September 26, 2018 11:39:57 AM
Attachments:	2018_Skok River MUP Final for Dist._CG_8-31-18 KA_NOAAF Response_9_26_18.docx

Hello Everyone,

Please see the attached NOAA Fisheries review of the draft Skokomish MUP submitted August 31, 2018.

There has been great progress, and only two overarching themes needing clarification, or further discussion remain. These would be related to the role of the spring Chinook salmon population, and the timing of the October coho fishery with respect to the anticipated return timing for the establishing late-fall Chinook salmon population.

When you are ready we would be glad to schedule a follow-up call if that would be a good way to address these remaining questions, and wrap up the MUP.
Thank you again to everyone for all the hard work and continued progress.

Best Regards,
Christina Iverson

On Fri, Aug 31, 2018 at 2:29 PM Christina Iverson - NOAA Federal <christina.iverson@noaa.gov> wrote:

> Thank you Robert for the August 31st submission of the Skokomish MUP for our review. We will be in touch as soon as possible regarding a timeline and next steps.
>
> Best Regards,
> Christina
>
> **From:** "Jones, Rob" <rjones@nwifc.org>
> **Date:** August 31, 2018 at 1:42:37 PM PDT
> **To:** US v WA Mediation -- Combined Groups <usvwamediationcombinedgroups@nwifc.org>
> **Subject: [US v WA Mediation Communication] Skokomish MUP**
>
> All,
> Attached is the Skokomish MUP. After review by all comanagers, it is now being transmitted to NOAA for review via this email.
>
> Rob
>
>

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Puget Sound Fishery Biologist
Sustainable Fisheries Division
NOAA Fisheries Service
West Coast Region
510 Desmond Drive SE
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360-753-6038

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Skokomish River Management Unit Status Profile

Component Populations

North Fork Spring Chinook Salmon
George Adams Summer/Fall Chinook Salmon
George Adams late-timed Fall Chinook Salmon

Geographic description and Life History Traits

Two hydroelectric dams block passage to the upper North Fork Skokomish River watershed. The reservoirs inundate 18 miles of river habitat that was formerly suitable to Chinook salmon production. Under the terms of the Cushman settlement, Tacoma Power was responsible to design, construct, and implement methods of providing effective fish passage—both upstream and downstream—at the Cushman Dams. Both upstream and downstream passage facilities are now in place and operational.

The historic spawning distribution of Chinook salmon in the basin extended to the upper reaches of both the North and South forks, major tributaries to both forks, and the entirety of the mainstem downstream of the forks (Elmendorf and Kroeber 1992; Smoker et al. 1952; Deschamps 1954; WDF 1957). The spatial separation between the spring and fall populations was generally regarded to be in the vicinity of Little or Big Falls[1] in the North Fork and the vicinity of the gorge in the South Fork. As noted by the TRT, however, some spring run fish may have spawned as far downstream as Vance Creek in the South Fork. The historic Skokomish River spring Chinook salmon were produced in the upper North and South Fork reaches of the Skokomish River.

Historically, Skokomish River Chinook salmon exhibited a diverse set of life histories, having, among other traits, a wide range of river entry timing patterns. Both spring-run and fall-run racial groups were supported by the river. Besides differences in river entry timing, these groups differed markedly in their spatial use of the watershed with spring Chinook salmon utilizing the upper reaches of the North and South forks and fall Chinook salmon utilizing the lower reaches of the forks and mainstem. Both indigenous racial groups are now extinct in the river basin and what remains is a highly domesticated hatchery population derived from Green River falls, which has been propagated at the George Adams Hatchery since the early 1960's (Ruckelshaus et al. 2006; SIT and WDFW 2017). This fact presents particular challenges for recovery since well-adapted genetic stock sources have not recently existed in the river system.

Chinook (Spring, Summer/Fall and Late-Timed) salmon currently spawn throughout the Mainstem Skokomish River up to the confluence of the South and North Forks. In the South Fork spawning primarily occurs below River Mile (RM) 5.0 including Vance Creek. In the North Fork spawning occurs upstream to Cushman Dam at RM 17.0. However, the current

[1] / The two falls are also often referred to as Upper Falls (Big Falls) or Lower Falls (Little Falls), as discussed in James (1980).

distribution of naturally spawning Chinook salmon is less than 1/3 of what it was historically in the river basin. There are presently only about 16 miles of stream habitat are being used by natural spawners, which occur mostly in the lower North Fork and in the mainstem downstream of the confluence of the North and South Forks. Only approximately 2.5 miles of the 16 miles are located in the lower South Fork—a number that has shrunk because of the difficulties that adult Chinook salmon have had in accessing the lower South Fork in recent years due to aggradation and dewatering of the channel.

The aggraded channel of the lower South Fork Skokomish River has resulted in seasonal subsurface flows preventing adult Chinook salmon migration to access about five miles of spawning habitat in the river. Starting in 2008 the Skokomish Tribe (SIT) has been monitoring the presence, location, and timing of these low flow events in which the channel of the South Fork goes completely dry. During five out of the ten years (2009, 2010, 2012, 2015, 2016) of monitoring a completely dry streambed was observed on the South Fork downstream of the old confluence (confluence up to 2007) to the new confluence of the North Fork (one river mile below old confluence) although this section of the river did not go completely dry in 2014, it was extremely low possibly preventing/limiting access. This section of river is described in the WRIA 16 catalog as the mainstem RM 8.0-9.0. Significant changes in the river in the 2012-2013 river split the South Fork channel just below the old mainstem confluence (RM 9.0 or 0.0) into two channels. One channel carries more than half of the water into the North Fork channel at this location. This channel completely bypasses the section of South Fork that has been going dry in the recent past. In 2013 and 2017 this channel remained wetted and allowed Chinook salmon unimpeded migration into the South Fork spawning habitat throughout the entire season.

Under the terms of the recent Cushman settlement agreement, flow in the North Fork below the lower dam will be regulated to track the natural hydrologic regime. Increased volume flow will be provided in the winter and early spring to restore channel function in the North Fork and Mainstem. These measures are expected to improve conditions for migration passage and rearing in the North Fork[2]. Under the new restoration strategy, spring Chinook salmon will be introduced into the lake and upper watershed with upstream and downstream passage provided through the two dams.

The observations and conclusions about life history for the historic Skokomish populations are compared to patterns seen for other wild Chinook salmon populations in Western Washington in Figure 1. The figure reflects common patterns among freshwater life stages among populations with little or no hatchery influence. The figure is displayed as a periodicity table. Five non-Skokomish populations are shown, three in the Skagit River system and two in the Queets River (SIT and WDFW 2017).

[2] / Component 3 flows of the Cushman Settlement, intended as flushing flows for the mainstem Skokomish River, have been suspended until channel capacity has been increased in the mainstem river (see RPSRCS 2017).

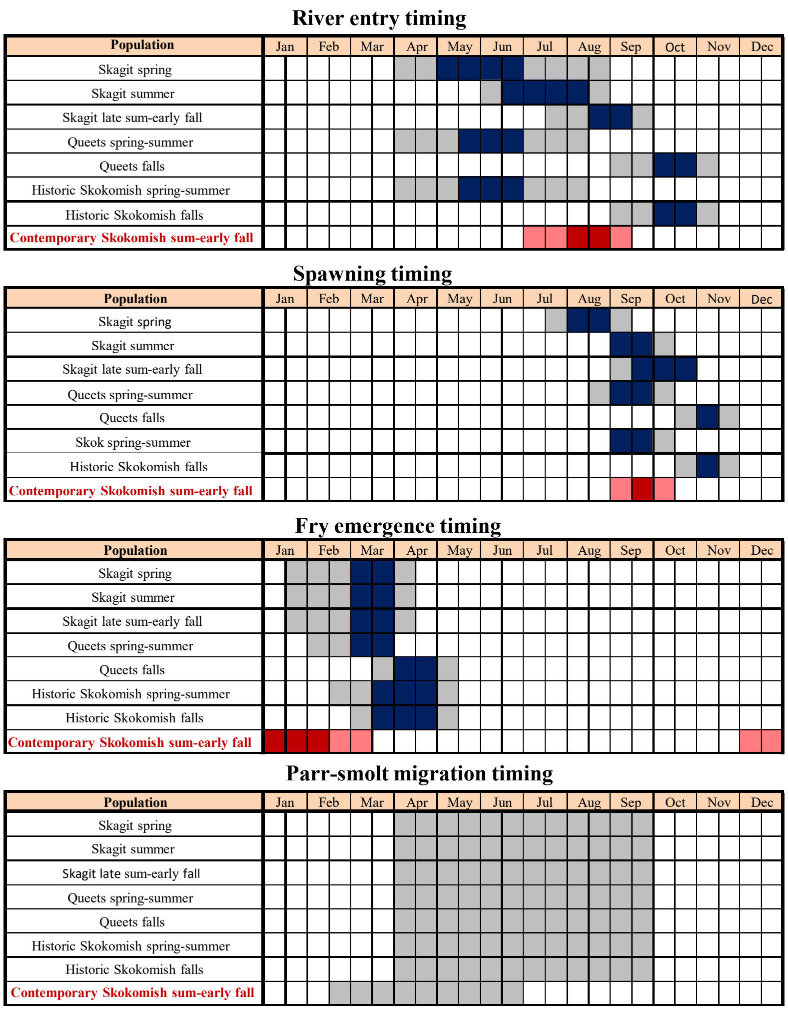

Figure 1. Periodicity table showing timing of freshwater life stages for seven wild populations of Chinook, compared to the timing patterns for the contemporary Skokomish Chinook salmon population. Weekly time intervals are highlighted gray for the range of timing seen; dark blue highlighting shows peak migration periods. Cells are highlighted red for the contemporary Skokomish population (SIT and WDFW 2017).

The extant population in the Skokomish River is a highly domesticated hatchery stock (George Adams) derived from Green River Hatchery fish. The life history characteristics of the stock as it now exists differ dramatically from both the original source fall-run wild population in Green

River and from the indigenous fall-run Skokomish population, with river entry for these fish beginning as early as June and peaks in August. Unlike wild fall populations such as the lower Skagit in Puget Sound, fish enter the river in early summer (June through August) and hold for extended periods of time prior to spawning in mid-September. Available evidence shows that reproductive success of George Adams Hatchery fish spawning naturally in the Skokomish River is extremely poor. The evidence shows that egg to emergent fry survival is poor and that the number of natural-origin recruits (NORs) is less than the number of original spawners (see Abundance Status section). Because it originated from a fall stock, has been historically referred to as a fall stock, but exhibits run timing and spawning characteristics of a summer-run population, presumably due to years of domestication at the George Adams Hatchery, we refer to it as the George Adams Summer/Fall.

The 2010 Skokomish Chinook Salmon Recovery Plan focused on recovery of a spring Chinook salmon population. In brief, the co-manager Recovery Plan concluded that recovery of a true fall-run population presented more uncertainties and that it would require a longer period of time to make significant progress than for the re-establishment of a spring-run population. The primary basis for this conclusion is the level of habitat degradation in the lower watershed where fall Chinook would be recovered and the time horizon for restoring properly functioning conditions in the lower watershed. The development of the 2010 Recovery Plan coincided with the Settlement Agreement with Tacoma Power, which included a Spring Chinook salmon Program to be implemented at the North Fork Hatchery (Table 1).

Commented [CI1]: It is not necessary to include consideration of the effects of the proposed RMP on the spring Chinook salmon population, it will not be evaluated as part of our 4d determination due to its current role in PS Chinook salmon recovery. It is important to note however, that NOAA F may have to consider the effects of the RMP to the spring population if its role in Puget Sound recovery changes. If the co-managers want to include the anticipated effects to the spring population in the RMP in the chance that the role could change to a recovery population role in the next ten years then the co-managers would need to address our questions here, or identify a process to reassess. This process could be based on provisions of the 2017 co-managers recovery plan (if they exist, this could help build the framework). We could set up a call to discuss this further if there is interest. Otherwise we can leave the spring anticipated impacts in the RMP silent for now and consider the late-fall component only, as the recovery population, and anticipated effects as provided.

Table 1. Summary of egg transfers and releases to date for the Spring Chinook salmon program at North Fork Hatchery (NFH) (Ollenburg, Tacoma Power, pers comm., 2018)

Brood Year	Eyed Eggs	Release	Comments
2014	149,000	131,026	Incubated, hatched, and reared at Lilliwaup
2015	400,000	339,632	Incubated and hatched at Lilliwaup, reared at the NFH
2016	400,000	375,728	Brought in to NFH
2017	425,000	323,816	Brought in to NFH, 77,000 still on station for yearling release in 4/19

The donor stock, Skagit River spring Chinook salmon from Marblemount Hatchery exhibits a river entry pattern and other life history traits similar to the aboriginal Skokomish spring-run population. Program targets for the spring Chinook salmon program call for the release of 300,000 fingerlings and 75,000 yearlings, all of which are unclipped and coded-wire-tagged (CWT). The 2017 Skokomish Recovery Plan update continues to maintain a strong emphasis on recovering a spring Chinook salmon population. Implementation of this program is underway with the first transfer of eggs occurring in 2014 and the first release occurring in 2015 such that Age-4 fish should be returning in 2018. We refer to this component population as the North Fork Spring Chinook salmon. Although this stock is likely to eventually recolonize or be introduced into the upper South Fork as well, there is little likelihood this will occur within the timeframe of this management plan. Based upon life history characteristics exhibited in their watershed of origin, we expect this component to return to the river from May through June, and spawn in early to mid-August.

The premise on which the Skokomish Chinook Salmon Recovery Plan update is built is that population recovery requires restoring life histories that are adapted to the environmental conditions that either still exist in the watershed or that are being restored. For fall Chinook salmon, the prospect that a late-timed true fall Chinook salmon life history could re-emerge from the extant stock seems plausible given the fall Chinook salmon stock origin. Domestication effects appear to have been so significant that the potential of this occurring carries uncertainties. Part of the experimental aspect of this program will be testing to what degree run timing and spawn timing are heritable traits. Should efforts to reestablish these traits prove successful, the resulting component population will also require exhibition of other traits such as outmigration timing and ocean survival to complete a successful life history. However, the extant stock has demonstrated some degree of adaptation with regards to ocean migration and survival and an affinity for returning through the Hood Canal environment to the Skokomish River. For this reason, we are currently testing whether a later timed component of the extant stock could be redeveloped, i.e., one that enters the river in September and early October and spawns in synchrony with the fall flow regime, that it would be more effective at producing natural-origin fish compared to the effectiveness of the stock as it currently exists. As the river conditions are improved through restoration, reproductive success should be further improved.

The success of this “Late-Timed” George Adams Chinook salmon program will depend on 1) whether we have sufficient later returning and maturing George Adams late-timed Fall Chinook salmon to take eggs, 2) whether these timing characteristics have a high degree of heritability, and 3) whether those characteristics lead to the production of natural origin returns above replacement on the spawning grounds. Over the last four years we have successfully taken eggs for this program, which calls for the release of 200,000 from the hatchery, and 100,000 in off-station releases, all unmarked and 100% CWT (Table 2). Our preliminary success in answering whether we have sufficient later returning and maturing George Adams late-timed Fall Chinook salmon from which to take eggs, will be followed by assessing the return rates both at the hatchery and on the spawning grounds through CWT analysis. We refer to this component population as the George Adams late-timed Fall Chinook salmon. Based on life history characteristics of other wild “true fall” populations in Puget Sound, particularly the lower Skagit falls, we expect the return timing to the river to be in September with spawning occurring in October and November.

Table 2. Summary of egg transfers and releases to date for the late-time fall Chinook salmon program at George Adams (Mark Downen, WDFW, FishBooks database, 2018)

Brood year	Date	Females	Males	Eggs	Release Date	Release Number	size	mark/tag	Release site
2014	6-Oct	36	36	162,214	5/15/2015	186,287	72	CWT Only	GA Hatchery
	13-Oct	12	9	54,732					
Total				216,946		186,287			
2015	6-Oct	29	30	109,579	5/17/2016	202,225	72	CWT Only	GA Hatchery
	13-Oct	9	11	36,268					
/b	12-Oct			75,150					
Total				220,997		202,225			
2016	6-Oct	90	87	333,850	4/26/2017	35,354	82	CWT Only	Vance Cr
					4/26/2017	37,138	80	CWT Only	NF Skok
					5/17/2017	197,385	73	CWT Only	GA Hatchery
Total				333,850		269,877			
2017	10-Oct	108	108	435,997	5/4/2018	53,506	139	CWT Only	NF Skok
	17-Oct	13	13	44,722	5/4/2018	53,855	139	CWT Only	Vance Cr
	24-Oct	36	33	127,087	5/16/2018	202,262	80	CWT Only	GA Hatchery
Total				607,806		269,877			
Grand Total				**1,379,599**		**928,266**			

/b These eggs were received from Hoodsport Hatchery in order to make program

Abundance Status

Historically, the Skokomish River supported the largest natural Chinook salmon production of any stream in Hood Canal, but the construction and operation of the Cushman hydroelectric project coupled with severe habitat degradation, has reduced the productive capacity of the basin. As previously noted, the North Fork has been blocked by two hydroelectric dams.

Hatchery Chinook salmon production has been developed at the George Adams Hatchery to augment harvest opportunities and to provide partial mitigation for the loss of production due to destruction of Chinook salmon habitat in the North Fork caused by construction and operation of the Cushman hydroelectric project.

Chinook salmon escapements to George Adams Hatchery remained stable during the 1980s reached record lows in the 1990s and have increased from the early 2000s ranging from about 6,000 to 24,000 fish from 2008-2016 (Table 2). There is significant uncertainty in estimates of natural escapement for return years prior to 2010. Reliable estimates of the proportions of hatchery-origin and natural-origin fish among natural spawners are not possible for return years prior to 2010 due to low mark and sampling rates, few recoveries of CWT or marked Chinook salmon, and uncertainty about expanding marked recoveries to fully account the hatchery proportion. Estimates of hatchery-origin fish in the natural escapement averaged approximately 91% from 2010-2013 but has averaged approximately 84% from 2014-2017 (Table 3).

Table 3. Chinook salmon spawning escapement-Skokomish River watershed (SIT and WDFW 2017).

Year	Non-selective FW catch	Mark-selective FW catch	GAH escapement	Spawning escapement (HOR +NOR)	NOR escapement	pHOS	HOR ETRS	NOR ETRS	ETRS
1988	9,237	-	4,439	2,666					16,342
1989	9,938	-	2,523	1,204					13,665
1990	5,977	-	2,186	642					8,805
1991	6,458	-	3,068	1,719					11,245
1992	549	-	294	825					1,668
1993	521	-	612	960					2,093
1994	275	-	495	657					1,427
1995	-	-	5,447	1,398					6,845
1996	-	-	3,100	995					4,095
1997	4	-	1,885	452					2,341
1998	13	-	5,584	1,177					6,774
1999	2,340	-	8,235	1,692					12,267
2000	1,081	-	4,032	926					6,039
2001	6,549	-	8,816	1,913					17,278
2002	5,674	-	9,395	1,479					16,548
2003	7,315	-	10,034	1,125					18,474
2004	6,811	-	12,278	2,398					21,487
2005	12,259	-	16,018	2,032					30,309
2006	13,493	-	12,356	1,209					27,058
2007	15,364	-	13,270	429					29,063
2008	13,267	-	13,695	1,134					28,096
2009	12,041	-	13,220	1,066					26,327
2010	9,654	6,336	12,891	1,214	162	87%	29,821	274	30,095
2011	11,761	5,784	24,581	1,321	54	96%	43,368	79	43,447
2012	15,434	12,261	22,874	1,533	142	91%	51,870	231	52,102
2013	8,894	5,458	21,444	1,722	171	90%	37,282	236	37,518
2014	3,680	2,167	6,227	849	109	87%	12,758	165	12,923
2015	6,286	3,297	6,033	432	117	73%	15,817	231	16,048
2016	10,314	-	22,076	1,342	179	87%	33,474	258	33,732
2017	16,515	-	35,129	8,058	886	89%	58,477	1,225	59,702
4 year Means:									
2010-2013	11,436	7,460	20,448	1,448	132	91%	40,585	205	40,790
2014-2017	9,199	1,366	17,366	2,670	323	84%	30,131	470	30,601
% increase	-20%	-82%	-15%	84%	144%	-8%	-26%	129%	-25%

In order to clarify ongoing updates to estimates of natural origin fish some background on past methodologies is in order. The first rigorous analysis of the contributions of hatchery fish to the spawning grounds and returns of natural origin fish was conducted as part of the Skokomish Rebuilding Exploitation Rate derivation analysis. This analysis produced estimates for years 1987 through 2006 and was continued afterward (Figure 2). The pHOS estimate was generated by CWT and adipose-clip return rate divided by the tag/mark rate, divided by the sample rate on the spawning grounds for each return year (NMFS 2009). This old method of estimating pHOS is essentially the same as the current method, where the adipose clip rate of Chinook salmon carcasses from spawning ground surveys are divided by the adipose clip rate at George Adams Hatchery (adipose clip rate for different brood years contributing to return is weighted by the return year age comp). The one difference in methodology is to use only the adipose clip rates (not including CWT rates) to avoid error due to CWT retention and detection. However, the accuracy and precision of a carcass mark rate expanded by a hatchery mark rate is dependent on a high proportion of the hatchery releases being marked.

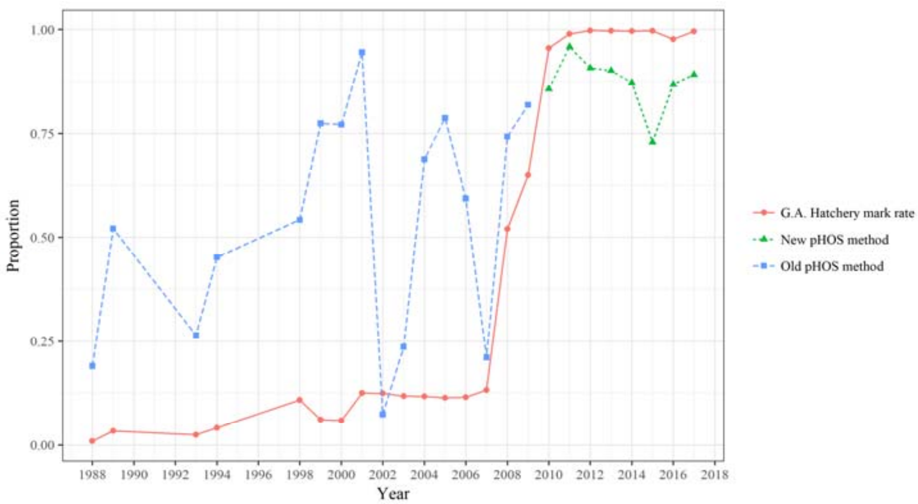

Figure 2. The old pHOS estimation method was not viable because of very low George Adams Hatchery (GAH) mark rates (including CWTs and adipose fin clips). After return year 2010, the mark rate at GAH has been above 95%, and the pHOS estimates have stabilized.

In the old pHOS methodology, including the adipose-clipped fish was necessary due to the extremely low sample sized of tag recoveries. However, only a small proportion of each hatchery release was marked and/or tagged prior to brood year 2006. Not all hatchery facilities which contributed Chinook salmon strays to the Skokomish spawning grounds had quantified mark rates at release. Not all cohorts were tagged and small random samples from the spawning grounds coupled with tag detection error, tag loss, and variable survival and straying of hatchery fish likely resulted in underestimates of hatchery fish and a poor signal to noise ratio. Highly variable estimates and dramatic swings in the proportions of hatchery fish on the spawning grounds from year to year (Figure 2) are not reasonable in the context of the Skokomish River watershed. Total hatchery releases have been very consistent since 1995 (Figure 3), with a mean of 3,848,320 Chinook salmon, and a coefficient of variation of only 5.6%. With a hatchery program of this size with very consistent total releases that supports a small population of NORs in the hundreds of fish every year, it is not reasonable to believe the pHOS would drop from 95% to 7% in one year as indicated in the old pHOS estimates (2001-2002). The large standard deviation and wide 95% confidence estimates in the old pHOS estimates (Table 3) further calls into question their accuracy and precision given more recent estimates which show a much more consistent pattern, it seems unlikely that the last 20 years of restoration work in the river, implementation of mark selective fisheries, increased flows in the north fork, and adoption of lower exploitation rates in 2010 would coincide with declining returns of natural origin spawners to the Skokomish.

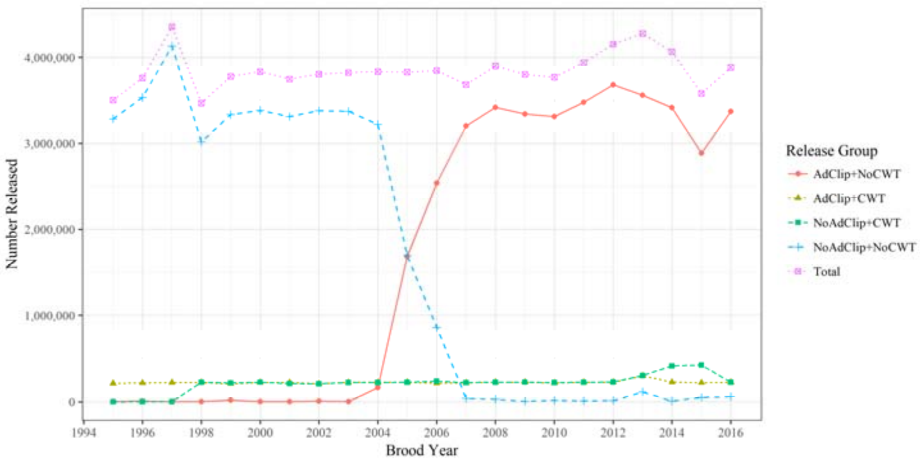

Figure 3. Total fingerling releases from George Adams Hatchery have been very consistent from Brood Year 1995 to the present, although mass marking has increased dramatically after Brood Year 2006.

Table 4. The old pHOS estimates are not consistent with the new estimates from after the onset of mass marking.

pHOS method	Mean	SD	N	95% CI
old	54%	27%	16	39-68%
new	87%	7%	8	82-93%

By 2008, higher mark rates for returning brood years were being phased in. In 2008, 50% of Age 3s and 5% of Age 4s were marked, in 2009 75% of Age 3s and 50% of Age 4s were marked, and by 2012 the first return of 100% (minus Double Index Tag (DIT) groups and clip error) of all broods were marked. From 2008 through 2013, the co-managers expanded clip rates of each brood year to estimate the marked fish on the spawning grounds, then added expanded CWT detections to estimate the total hatchery contribution to escapement. As clip rates for the non-DIT production reached 100% this method continued to be implemented up through 2016.

However, an alternative approach was taken in 2017 with the idea of validating the ad-clip rate plus CWT methodology. The new pHOS methodology used only ad clip rates, including the DIT group and expanded returns by brood year ad-clip rate using CWT age composition. The result was a higher estimate of the proportion of hatchery fish on the spawning grounds. The explanation for this is likely error associated with tag detections in the field, either due to equipment error, sampler error, or tag migration or shedding. This hypothesis is strongly supported by data collected in the assessment of the Hamma Hamma Chinook salmon supplementation program in which all supplementation fish were 100% CWT and otolith marked. Yet over a five-year period, the number of Chinook salmon carcasses recovered in the Hamma Hamma which were otolith marked but returned no CWT either in the field or in the lab averaged about 28%. Both the adipose clip + CWT expansion method and the adipose only expansion method yielded consistent, somewhat stable, estimates as compared with the old RER analysis, but the adipose only method reduced the uncertainty associated with CWT detections and was thus deemed the cleanest method to use going forward by the co-managers. In addition fish of unknown ad clip status had been erroneously included in the unmarked group. Upon detection of this error only fish with known ad clip status were included in the new pHOS calculations.

After the new pHOS methodology was finalized by the co-managers in February of 2018, multiple tests were done to compare the old pHOS methodology to the new pHOS methodology. There is convincing evidence (Welch Two Sample t-test, t=-4.7, P = 0.000184) that the mean pHOS estimates are different (Figure 4). The 95% confidence interval on difference in means is 18-49% lower in the old pHOS methodology despite major habitat restoration efforts in the floodplain, riparian zone, and active channel (SIT and WDFW 2017), including an increased flow regime below the North Fork Dams. The combination of these habitat actions have more than doubled the available spawning habitat for summer-fall Chinook salmon after 2010, and if anything should have had a positive effect on natural spawning production that would lead to a lower pHOS. Furthermore, there is convincing evidence that the pHOS estimates from the old and new methods/data are not from the same population distribution, shown in Figure 5 (Two-sample Kolmogorov-Smirnov test, D = 0.8125, two-side P = 0.000732). Considering the above evidence, the tight distribution of the new pHOS estimates, and the consistent releases of fingerling Chinook salmon at GAH (Figure 3), the co-managers have determined the best available pHOS determination for years prior to 2010 is the mean pHOS from 2010-2017.

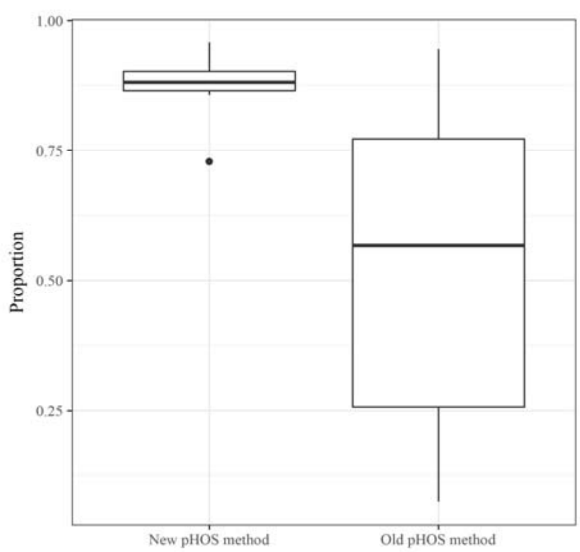

Figure 4. Estimates of pHOS using the new versus old methodology and available data.

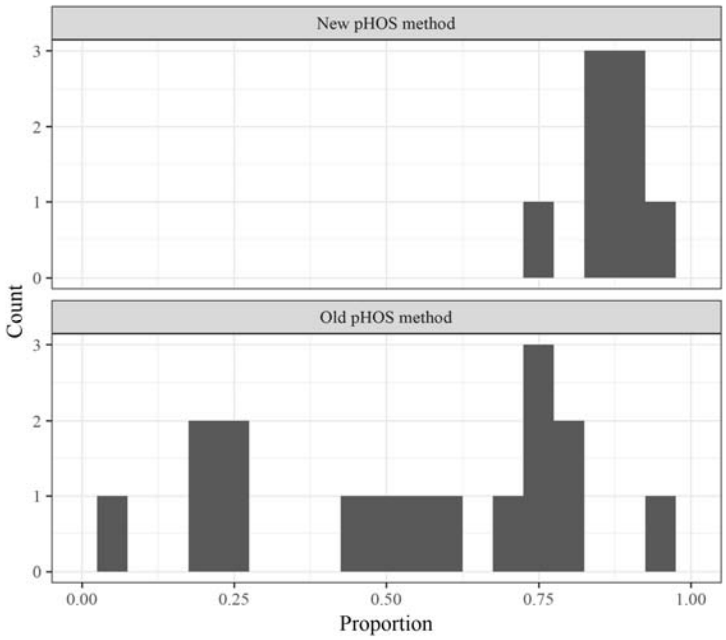

Figure 5. Frequency distributions of pHOS generated from prior to 2010 using the old method and low hatchery mark rates are not consistent with those from 2010 and after using the new method and high hatchery mark rates.

Harvest distribution and exploitation rate trends

The harvest distribution of Skokomish River Chinook salmon is described by CWT recoveries of fingerlings released from George Adams Hatchery. Since harvest estimates presented in 2010 PSCHMP and Skokomish MUP were based on this methodology, updated estimates using this approach are provided here as well. The standard analysis conducted by the PSC Chinook Technical Committee involves expansion of estimated recoveries from fisheries to account for non-landed mortality. Analysis of the 2007-2014 CWT recoveries indicate that 75% percent of harvest occurred in Washington fisheries and 24% in Canadian (BC) fisheries, with less than 1% occurring in Alaskan (AK) fisheries (Table 5).

Table 5. Harvest distribution of George Adams Hatchery fingerling Chinook salmon, from analysis of CWT recoveries (TCCHINOOK 17-1). Note, WA-Net, -Sport and -Troll include a small number of southern U.S. recoveries outside of WA.

	AK	BC	WA-Net	WA-Sport	WA-Troll
2007 to 2014	0.6%	24.4%	30.4%	38.0%	6.5%

The total annual (i.e., management year) exploitation rate as computed by post-season FRAM runs has exceeded 50% (Table 6). This exceedance can be attributed to the higher than expected terminal harvest rates on lower than forecasted abundances (i.e. possible forecasting error; climate change; the Warm Ocean Blob etc.). Pre-terminal SUS ERs ranged from 7% to 10%, and terminal ERs ranged from 19% to 35%.

Table 6. Total fishery-related adult equivalent exploitation rates of Skokomish River natural fall Chinook salmon for management years 2001- 2014, projected by post-season FRAM validation runs using the new Base-Period.

Year	North	PT SUS	Term	Total
2001	8%	15%	32%	56%
2002	13%	14%	26%	52%
2003	13%	14%	30%	58%
2004	14%	18%	24%	56%
2005	11%	15%	30%	57%
2006	12%	13%	39%	64%
2007	16%	14%	39%	69%
2008	14%	11%	40%	65%
2009	14%	9%	40%	62%
2010	11%	10%	34%	55%
2011	15%	10%	29%	55%
2012	12%	14%	35%	61%
2013	9%	11%	29%	49%
2014	11%	15%	32%	59%

Harvest Management Objectives

Salmon fisheries along the entire west coast of North America are today constrained by a variety of catch limits, harvest rates, time-area closures and restrictions, or species and size retention limits that are designed to achieve conservation objectives for wild salmon stocks (PFMC Framework Plan or Amendment, PSIT and WDFW 2010).

State and tribal co-managers developed the Puget Sound Salmon Management Plan (PSSMP) in 1985 and the Hood Canal Salmon Management Plan (HCSMP) in 1986 (both plans are currently being updated as per Federal Court Order), establishing management units and escapement goals to guide annual management of fisheries. Hood Canal Hatchery Chinook salmon stocks were designated as the “primary” management units by the HCSMP, so commercial Chinook salmon fisheries in Hood Canal during the 1980s were managed to achieve sufficient escapement to perpetuate production at the George Adams and Hoodsport Hatcheries. Natural Chinook salmon stocks were designated as “secondary” management units in the HCSMP, so fisheries were not managed to achieve a specific number of natural spawners.

After Puget Sound Chinook salmon ESU was listed as threatened, associated management objectives (i.e. ER Ceilings) were set for all natural Chinook salmon populations. The specific objectives for the Skokomish River Summer/Fall population have evolved over the several versions of the Puget Sound Chinook Salmon Harvest Management Plan. In the 2010 plan the Skokomish River objective was set at a total ER of 50%.

Harvest management objectives reflect a new strategy for recovering Chinook salmon suited to environmental conditions in the Skokomish River watershed restored to normative conditions.[3] The extant population in the river is a highly domesticated hatchery stock (George Adams) derived from Green River Hatchery fish with dramatically altered life history characteristics differing from both the original source fall-run wild population in Green River and from the indigenous fall-run Skokomish River population. Available evidence shows that reproductive success of George Adams Hatchery fish spawning naturally in the Skokomish River is extremely poor (SIT and WDFW 2017). The evidence shows that egg to emergent fry survival is poor and that the number of natural-origin recruits (NORs) is less than the number of spawners that produced them (Table 7). It is noted that the extant population in the river currently is neither a spring-timed run nor a true fall-timed run. Both river entry and spawning timing have been advanced significantly over decades of hatchery propagation such that the run now is best described as a summer-early fall run.

To meet this challenging Chinook salmon recovery issue, the SIT and Washington Department of Fish and Wildlife have embarked on an aggressive and innovative plan to restore naturally produced Chinook salmon to the river (SIT and WDFW 2010 and 2017). The plan calls for addressing both of the original spring and fall components of the population. Updated harvest management strategies constitute a key part of the plan.

The recent settlement agreement between the SIT, the City of Tacoma, State and Federal Resource agencies regarding operation of the Cushman hydroelectric project and associated mitigation supports restoration of spring Chinook salmon, initially in the North Fork, and then subsequently in the South Fork. Details of this strategy have been developed as part of the Recovery Plan for Skokomish River Chinook Salmon (RPSRCS developed by SIT and WDFW 2010 and 2017), to achieve the Co-managers' objective of recovering a self-sustaining, naturally-produced Chinook salmon population in the Skokomish River watershed.

This updated plan (specifically Chapters 1 & 5 of the SIT and WDFW 2017) also incorporates meaningful steps to make significant progress in improving the potential for recovery of a late-timed Chinook salmon population other than just habitat-related actions. These steps include both hatchery and harvest-related actions. The efforts aim to improve the potential for a

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[3] / The normative condition concept simply means that restoration will not return the river to its state prior to the way it was before the rapid human-caused alterations over the past 150 years. Restoration aims to return the river to a more productive state for wild salmon than currently exists, a state that can sustain productive salmon runs that meets the needs for recovery and delivers ecological services that achieve broad sense goals. Normative refers to the norms of ecological functions and processes characteristic of salmon-bearing streams and other natural aquatic habitats.

successful natural life history of later timed fish that complements the habitat restoration strategy. This new strategy is to first stop, and then reverse to some extent the advanced timing of the George Adams stock and also promote an even later timed segment of the run. The purpose for doing this is twofold: first, to create a distinct timing separation between the returning spring Chinook salmon (as the re-introduction effort advances) and returning George Adams Chinook salmon; and second, to experimentally determine the success of re-creating later timed George Adams fish and subsequently to assess their reproductive performance (over the entire life cycle) when spawning naturally in the river. Actions to accomplish these steps are to occur while progress continues toward restoring properly functioning habitat in the lower river valleys.

Table 7. Simulated brood table for Chinook salmon spawning in the Skokomish River. Since NOR age composition is unknown for any year, an average age comp from 168 sample fish between 2009 and 2017 was used for all years. Prior to return year 2010 (corresponding to the 2007 brood) NOR-HOR breakouts were estimated using the average PHOS from 2010-2017, denoted in red text.

	Parent Spawners		NOR Recruits by age				Total Spawner Productivity	NOR replacement
Brood Year	NOR	Total	3	4	5	total	(NOR recruits / total spawners)	(NOR recruits /NOR spawners)
1990	81	642	55	44	3	102	16%	126%
1991	217	1719	38	93	2	133	8%	61%
1992	104	825	80	66	1	147	18%	142%
1993	121	960	57	30	3	90	9%	74%
1994	83	657	26	78	4	108	16%	130%
1995	176	1398	67	113	2	182	13%	103%
1996	125	995	97	62	4	163	16%	130%
1997	57	452	53	127	3	184	41%	322%
1998	148	1177	110	98	3	211	18%	142%
1999	213	1692	85	75	6	165	10%	77%
2000	117	926	64	160	5	229	25%	196%
2001	241	1913	137	135	3	275	14%	114%
2002	186	1479	116	80	1	198	13%	106%
2003	142	1125	69	29	3	100	9%	71%
2004	302	2398	25	75	2	102	4%	34%
2005	256	2032	65	71	3	139	7%	54%
2006	152	1209	61	86	1	148	12%	97%
2007	54	429	74	29	3	105	24%	194%
2008	143	1134	25	75	3	103	9%	72%
2009	134	1066	64	90	2	156	15%	116%
2010	162	1214	78	57	2	137	11%	84%
2011	54	1321	49	62	3	114	9%	210%
2012	142	1533	53	94	16	164	11%	116%
2013	171	1722	81	468		549	32%	322%
2014	109	849	402			402	47%	371%
2015	117	432						
2016	179	1342						
2017	886	8058						
						means:		
						1990-2006	15%	116%
						2007-2014	20%	186%

The purpose of the harvest-related strategies presented in this plan is to ensure that fishery-related mortality will not impede recovery of spring Chinook salmon in the watershed and maximize the potential for recovering a late-timed (fall) population component. Further, fisheries will be adaptively managed to not impede recovery of Spring Chinook salmon or the "late-timed" George Adams fish. This will be accomplished by managing the genetic diversity and composition of the extant summer/early fall George Adams Hatchery population to achieve three sub-objectives: (1) minimize impacts on the reintroduced spring Chinook salmon by reducing or eliminating the earliest segment of the summer/fall hatchery population; (2) support treaty Indian and non-treaty fisheries by stabilizing the core mode of this run with an August river entry timing; and (3) closing treaty fisheries in 12C (September) and the Skokomish River (September – 2nd week of October) to facilitate an extension of the latest segment of river entry (September-October) and spawn timing to improve the potential for recovering a late/fall George Adams Chinook salmon population. As the plan goes forward, the success of recovery efforts will to be re-evaluated based on progress of efforts aimed at recovering a spring population and progress toward establishing a later-timed Chinook salmon stock component (see Chapter 1 of the Recovery Plan for Skokomish River Chinook-SIT and WDFW 2017). Based on that evaluation, the approach may be revised as per the adaptive management provisions of the Recovery Plan (SIT and WDFW 2017) and the Addendum to 2014 Plan for Management of Fall Chinook in the Skokomish River (SIT and WDFW 2014).

Commented [CI2]: How do the proposed Sept-Nov fisheries contribute a key goal of the late fall program to move the peak spawning timing 5-6 weeks later to better reflect historic timing (SIT and WDFW 2017)? This isn't clear from the information presented.

Fisheries will be planned and implemented to achieve the following objectives related to spring and summer/fall Skokomish River Chinook salmon:

1. Protect and conserve the abundance and life history diversity of a locally adapted, self-sustaining, spring population during and after its recovery.
2. Maintain stable abundance and genetic diversity of naturally spawning summer/fall George Adams Chinook salmon, with emphasis on the late/fall George Adams Chinook salmon component.
3. Maximize the opportunity to harvest surplus production from other species and populations, including those produced in hatcheries (e.g., George Adams and Hoodsport hatchery-origin Chinook salmon, re-introduced sockeye, hatchery-origin and wild coho, and fall chum).
4. Emphasize the importance of ceremonial and subsistence (C&S) tribal fisheries, prioritize C&S fisheries over any other fisheries targeting the Skokomish River spring Chinook salmon during all stages of recovery.
5. Adhere to the principles of the Puget Sound Salmon Management Plan and the Hood Canal Salmon Management Plan, and other legal mandates pursuant to *U.S. v. Washington* to ensure equitable sharing of harvest opportunity, and among treaty and non-treaty fishers.
6. Monitor abundance, productivity, and spawning distribution of spring and summer/fall Chinook salmon, which will include estimating catch distribution, age composition, and mortality in all fisheries.

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Harvest Management Objectives and Strategies

Harvest management strategies embody specific actions designed to achieve the objectives stated above. Consequently, this section describes in more detail the terminal area fisheries directed at the fish arriving earlier(the July and August sub-components) of the George Adams summer/fall Chinook salmon, protective actions for the ‘late-fall’ Chinook stock, and fisheries for sockeye, coho, and fall chum that involve indirect impacts on either Chinook salmon stocks.

Spring Chinook Salmon

Management of the fisheries for early timed Chinook salmon in the initial phase of the re-introduction program will apply data for the pre-terminal catch distribution for Skagit (Marblemount Hatchery) spring Chinook salmon, which is the donor stock being used for the Skokomish River re-introduction effort. A program will be implemented to collect stock-specific information on the run timing, distribution, and fishery-specific harvest mortality of the Skokomish River early population, to better inform future harvest management. Terminal harvest will be more certain, due to the unique run timing of spring Chinook salmon and the ability to identify hatchery-origin returns.

In the interim, management objectives for terminal harvest will be implemented and monitored. Early fisheries for George Adams Summer/Falls will include real time (CWT) reading should unmarked, tagged fish be encountered. Ultimately, harvest objectives will be revised to reflect the productivity and abundance of spring Chinook salmon as they colonize and adapt to habitat in the North Fork, and later, the South Fork. This Plan for a period of twenty years starting in 2018, lays out a transition in harvest management as the spring population achieves a sequence of phases of recovery, triggered primarily by achieving specific thresholds of increasing abundance and survival (Chapters 3 & 5, Section 5.4. SIT and WDFW 2017).

Planning targets for population performance have been identified: using the Ecosystem Diagnosis and Treatment (EDT) model (Blair et al. 2009) and the All-H Analyzer (AHA) model (HSRG 2009) to quantify planning targets, the recovery target for Skokomish spring Chinook Salmon has been identified to be a naturally spawning population with an average annual return of approximately 1,000 natural-origin adults to the mouth of the Skokomish River and a recruit per spawner ratio (population growth rate or productivity) of 2.0 from 400 spawners. The target presented here may differ from delisting criteria that NMFS might apply to the Puget Sound ESU (SIT and WDFW 2017). The pace of progressing through the phases will be determined by the response of the population to each phase. No explicit timeline for recovery can be projected given the levels of uncertainty that exist for how fast the watershed can be restored, about future impacts of climate change, and how quickly the reintroduced population will respond. The co-managers expect that recovery will not be achieved by the end of the current license for the Cushman Project, which spans the next 30 years.

PSIT and WDFW (2017) concluded that the local adaptation phase for at least some Chinook salmon recovery efforts within the Puget Sound ESU may require a particularly long period

(>100 years). For populations currently consisting of a mix of hatchery-origin and natural-origin fish, a considerable time period is expected to be required to gain the fitness level needed to transition to the fully restored phase (Chapters 3-5 SIT and WDFW 2017). Also note that restoration of the South Fork and lower mainstem Skokomish River are likely to be slow in their progression to Properly Functioning Conditions (PFC).

In order to maximize spawning escapement for a period of at least two brood cycles seven years starting in 2018, except for limited ceremonial and subsistence harvest, terminal fisheries targeting spring Chinook salmon will not be implemented. As abundance increases, opportunities for expanding terminal fishing will be evaluated and implemented as determined to be consistent with program management objectives (i.e. 50%ER on the George Adams Summer-/Fall Chinook salmon and the George Adams late-timed Fall Chinook salmon) and to not impede recovery of any salmonid species in the Skokomish River. Additional commercial fishing opportunities will occur once the population is recovered (Chapter 6 SIT and WDFW 2017).

During the re-introduction recovery phase, limited C&S fisheries (hook & line only) will occur in the lower mainstem. The initial fisheries will be scheduled based on expected entry and migration timing with reference to the behavior of the donor stock, from early May through mid-June (Figure 6). To generate information on local run timing a beach seine test fishery may operate, also in the lower river. C&S removals could occur from the test fishery, all other catch will be released. Harvest will not increase beyond minimal C&S harvest until survival and run timing is described, when the 8-year running average return of spring Chinook salmon adults to the North Fork trap exceeds 600 fish. This would indicate that the abundance and productivity of the hatchery population likely exceeds the biological targets.

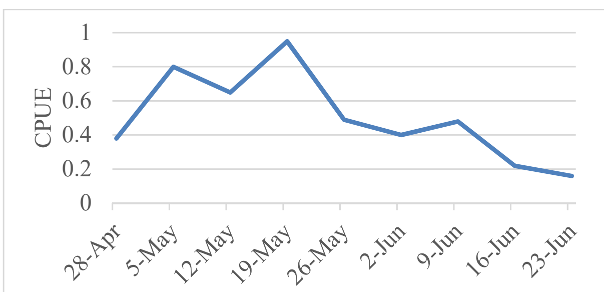

Figure 6. River entry timing for Skagit spring Chinook salmon (SIT and WDFW 2017).

Pre-terminal fisheries will involve incidental mortality of spring Chinook salmon returning to the Skokomish River. Sport Chinook salmon blackmouth fisheries in Salmon Management Areas 5, 6, 7, 9, and 12 may also involve indirect mortality via releases of these unmarked fish in mark selective fisheries. But overall, it is expected that recent constraints on pre-terminal fisheries in Washington, which have been driven by concern for weak Puget Sound Chinook salmon stocks, will be sufficient to meet the conservation and protection objectives of this Plan for Skokomish River spring Chinook salmon.

The re-introduction of spring Chinook salmon to the Skokomish River Basin began with release of BY 2014 smolts in the spring of 2015 (WDFW Hatchery Database (FishBooks, 2017), from which the first Age-3 adults were expected to return in 2017, these fish are among the survivors of 131,000 yearling Chinook salmon released into the North Fork in 2014. Due to the low number of fish released we cannot predict the level or distribution of fishing mortality these Chinook salmon experienced. However, The Recovery Plan for Skokomish River Chinook salmon specifies the elements of the monitoring and evaluation program necessary to estimate catch distribution and fishing mortality, and develop harvest objectives and conservation measures for each phase of recovery (Chapter 3 SIT and WDFW 2017).

When sufficient information has been collected to characterize fisheries mortality and distribution, the Skokomish River Chinook spring population will be added to the FRAM, for pre-season planning and post-season assessment. Specific management objectives (e.g. harvest rate or exploitation rate ceilings, and thresholds) will be developed for pre-terminal and terminal fisheries. A threshold of abundance returning to the North Fork Hatchery of 600 adults has been set to mark the transition from the Phase 1 (Establish Founder Stock) to Phase 1 (Recolonization) of recovery. The threshold is based on modeling and expected broodstock needs at the hatchery to transition to Phase 2 (Chapter 6 SIT and WDFW 2017). The threshold is based in EDT models of productivity and capacity in the context of current habitat conditions in the North Fork.

Skokomish River Summer/Fall Chinook Salmon (2010-2017)

The management objectives for the extant summer/fall population (George Adams Hatchery related fish) have been to achieve escapement sufficient to meet hatchery broodstock requirements and to maintain stable abundance of natural spawners in the Skokomish River.

Harvest measures to achieve this objective include:

- Managing southern U.S. (i.e. Washington) fisheries, and considering projected fisheries mortality in B.C. fisheries, so that the total exploitation rate does not exceed 50% on the of the summer/fall population.
- For the purposes of pre-season harvest planning, the Upper Management Threshold will be 3,650 (the aggregate of 1,650 natural spawners and 2,000 escapement to the hatchery), and the Low Abundance Threshold will be 1,300 (the aggregate of 800 natural spawners and 500 escapement to the hatchery).
- If abundance falls due to reduced survival, and pre-season projections of natural escapement are 800 or less, and/or hatchery escapement falls below 500, pre-terminal fisheries will be further constrained so as not to exceed an ER of 12%, and the terminal fisheries will be shaped to increase escapement by reducing recreational and net fishing opportunity in southern Hood Canal and the Skokomish River.

If abundance remains within the recently observed range, we expect that natural escapement will exceed 1,200 in most years.

Summer/Fall George Adams Hatchery Chinook Salmon (2018-----)

Consistent with the objectives of the 2017 Skokomish Chinook Recovery Plan (SIT and WDFW 2017) of 1) reintroduction of spring Chinook salmon, 2) stabilization of the extant George Adams summer/fall population, and 3) development of a true fall Chinook salmon population from the extant hatchery stock, the co-managers have already begun implementation of changes to fisheries. Specifically, changes related to the latter of the objectives were made under the Addendum to 2014 Plan for Management of Fall Chinook salmon in the Skokomish River (SIT and WDFW, 2015).

Terminal-area fisheries for summer/fall Chinook salmon target a mixture of Hoodsport Hatchery and George Adams Hatchery production in Marine Area 12C, and George Adams production in the Skokomish River. This terminal fishing regime was developed to maximize harvest opportunity, while achieving conservation objectives for the natural component, as specified in the Puget Sound Chinook Salmon Harvest Plan. However, extensive monitoring of this approach has called into question the long-term prospect for success in recovering the extant population in the wild. In spite of ample numbers of Chinook salmon on the spawning grounds, natural-origin returns (NOR) are consistently low and likely below numbers required for a minimum viable population (Figure 7).

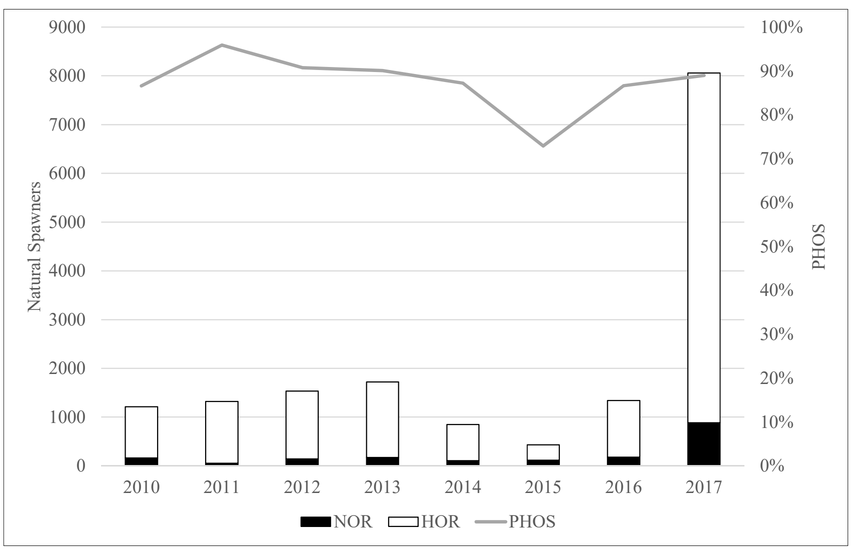

Figure 7. Skokomish River Chinook salmon natural-origin escapement (2017 Chinook Recovery Plan update).

The George Adams stock appears poorly adapted to conditions in the Skokomish River, likely due to hatchery influences and impaired habitat. Constructing an accurate brood table, and estimating productivity of Chinook salmon broods in the Skokomish River is limited by the available spawning ground data. Prior to return year 2010, accurate PHOS estimates of the natural spawners are not possible because hatchery fish were not marked. Therefore estimates of the number of NOR-HOR natural spawners is extremely uncertain prior to 2010 (see previous discussion). That uncertainty carries through to productivity estimates based on this earlier information (total spawners divided by NOR recruits). Furthermore, sample sizes of un-marked (and presumably mostly natural-origin) Chinook salmon carcasses used for scale-based age determinations were too low to produce a reliable age composition on an annual basis (Table 7). However, age compositions based on all Chinook salmon sampled from 2009-2017 suggest that the NORs have an older age structure than HORs. Trying to quantify the NOR age structure and incorporating it into management models and plans is ongoing. Due to the unknown NOR age structure for any given year, there is no way to reliably determine which brood an NOR recruit belongs to and here we have attempted to work around the above data limitations by using the average PHOS from 2010-2017 for years prior to determine the NOR-HOR breakout of parents and recruits. In addition we have applied the average age comp from unmarked fish recovered in 2009-2017 to all years (Table 8). Therefore, these results should be interpreted cautiously—the productivity or NOR replacement for any given brood year may not be accurate, but the mean productivity of broods 2007-2014 should be reliable and the mean productivity prior to brood year 2007 should provide a useable baseline. It is also noteworthy that broods 2013 and 2014 in Table 5 are incomplete, and these are the minimum productivity estimates for those years that will increase as the older age classes' return. While the total spawner productivity is on average very low (15-20%), NOR replacement is slightly above 100%. In addition there is some indication both total spawner productivity and NOR replacement are increasing.

Table 8. Scale-based age composition of Skokomish River Chinook salmon carcasses sampled from 2009 through 2017. Fish without an adipose clip or CWT were labeled unmarked and presumed to be mostly NORs. Age denotation is total-age, freshwater emigration age (0 indicates a subyearling).

	Age composition of unmarked (mostly NOR) Chinook					Age composition of known HOR Chinook				
Return Year	2,0	3,0	4,0	5,0	Total	2,0	3,0	4,0	5,0	Total
2009		3	23		26	16	12	45	1	74
2010		6	8	1	15	3	42	17		62
2011		1	5		6	14	7	28		49
2012	1	11	1		13	14	101	18	1	134
2013		6	13		19	13	103	88	1	205
2014		2	6	1	9	3	16	18		37
2015		4	6		10	26	25	34	3	88
2016	3	14	1		18	26	32	15	1	74
2017	1	27	23	1	52	31	284	86	5	406
Total	5	74	86	3	168	146	622	349	12	1129
Total %	3%	44%	51%	2%	100%	13%	55%	31%	1%	100%

The 2014 and 2017 plans both envision extending the run timing for the George Adams stock to include true fall river entry and spawn timing, which involve changes in terminal harvest strategy. To a great extent these changes have already been implemented under those plans.

In recent years George Adams Chinook salmon have exhibited earlier return timing, such that returns to the hatchery have been observed as early as June. To minimize overlap in timing with the introduced spring population, hatchery broodstock collection protocols and targeted harvest will be implemented to substantially reduce or eliminate early returns in June and July, such that river entry timing of George Adams returns begins in late July and peaks in late August.

For a period of at least two brood cycles (seven years starting in 2018) fishing pressure will be increased in the Skokomish River (as per the SCSCI) and Area 12C during the month of July to remove early George Adams returns. Fisheries directed at the earliest returning summer/fall Chinook salmon will occur in Area 12C and the Skokomish River (as per the SCSCI) through the fourth week of August. Skokomish River fisheries will include openings in the mainstem below SR 106, between SR 106 and US 101(as per the SCSCI), and in Purdy Creek. Skokomish River fisheries will commence the last week of July and end the last week of August, with regulations for use of hook & line, dip-net, gillnet, and beach seine gear as per the SCSCI. Fisheries in Purdy Creek will begin in July and the purpose of these fisheries is to remove as many of these fish as possible, i.e. prevent them from spawning naturally or use as broodstock.

Mark selective sport fisheries will be implemented in Area 12 and commercial non-treaty beach seine fisheries in the Hoodsport Hatchery Zone 12C-12H which target hatchery Chinook salmon while meeting management thresholds for wild Chinook salmon stocks. Similar fisheries may occur in-river below the Highway 101 bridge where the co-managers agree they are compatible with tribal fisheries and recovery goals.

Commercial fisheries in Area 12C will be closed during the month of September, with the Skokomish River closed for the month of September thru the first week of October in order to closing treaty fisheries in 12C (September) and the Skokomish River (September – 2nd week of October) to facilitate an extension of the latest segment of river entry (September-October) and spawning timing to improve the potential for recovering a fall-timed Chinook salmon population. Coho directed fisheries will begin October 1 in Area 12C and by the second week of October in the Skokomish River.

Commented [CI4]: Incomplete sentence

As the later run-timing of the George Adams stock emerges, we expect that opportunity targeting the peak of the run will continue to provide significant harvest benefits in late July and August. This will be followed by the complete closure of the in-river commercial fisheries during September, except ceremonial and subsistence. This closure will increase the escapement of later-timed hatchery recruits (i.e. those entering the river in September and October, which are expected to have higher natural production potential, particularly as habitat constraints can be alleviated). Although the terminal harvest rate on this later-timed component will be managed consistent with the total ER summer/fall ceiling of 50%, it is expected that the total ER on the late-timed component of the George Adams Hatchery-related fish will be substantially less since terminal harvest contributions to the total ER will be greatly reduced.

Commented [CI5]: To clarify, this indicates that the share of the 50% overall ER ceiling, on the unmarked component of the entire summer/fall Chinook run, that will be taken during the late-timed return window is not known but likely low. Is this a correct interpretation? Any idea of the likely scale, e.g., 5-10% of the TER?

If these low harvest rates are necessary for the development of the late-timed stock, How will the proposed coho fisheries in Area 12C and the lower river, October first and the 2nd week of October, respectively, be managed to keep these rates low given the river-entry timing, as detailed in Figure 1?

Lastly, these rates may be currently estimated to be low on the late-fall component now, but logically are expected to increase if the framework (SIT and WDFW 2017) is successful in moving the overall distribution of the timing five to six weeks later. How will the RMP assess this, build this in?

Should co-manager efforts to rebuild a late timed life history prove successful, this subpopulation may also be added to the FRAM, for pre-season planning and post-season assessment. The co-managers plan to estimate escapement for the late-timed Chinook salmon by combining to two strategies. The first by using live fish counts and hatchery rack returns from after September 20, and then the second by redds constructed and carcasses sampled in the river after October 1. These dates will be adaptively managed as new data becomes available over the duration of this plan. CWT recoveries will be used to estimate terminal area harvest rates. However, since these fish are unmarked, the co-managers will need to rely on preterminal harvest rates of early-timed George Adams Chinook salmon to develop an exploitation rate for late timed Chinook salmon. Specific management objectives (e.g. harvest rate or exploitation rate ceilings, and thresholds) will be developed for pre-terminal and terminal fisheries.

Based on the return timing of Marblemount spring Chinook salmon to the Skagit River (characterized by long-term test fisheries data) we expect the North Fork spring return to extend from early May until mid-June. So we expect that incidental harvest of spring Chinook salmon will be very low in summer/fall George Adams Chinook salmon fisheries in July and August. However, the timing and migration behavior of spring Chinook salmon returning to the Skokomish River will be monitored, with supplemental data from CWT recoveries in fisheries, to determine the extent of run timing overlap, and locations where spring Chinook salmon hold in the lower river, that might expose them to harvest. Should timing characteristics of the late-timed program broodstock prove heritable, a reduction in harvest rates is likely to occur for this subpopulation as well, which we expect will be confirmed or refuted with CWT recovery data collected over the next couple of brood cycles.

Sockeye

The recently initiated sockeye hatchery program in lower Hood Canal is intended to restore a naturally produced sockeye population in the upper North Fork, and to provide harvest opportunity in the terminal area. The program began with egg transfers from the Baker River Hatchery in brood year 2016, so the initial returns are expected to begin with 3+ returns in the summer of 2019 juvenile sockeye produced at the Hood Canal Hatchery are released into Cushman Reservoir.

Sockeye fisheries, beyond minimal C&S opportunity, will not be initiated until returns exceed hatchery broodstock requirements (broodstock requirement as per the pending TPU HGMP). Once that threshold is reached (i.e. returns exceed broodstock requirements), fisheries will be planned and implemented in Area 12C and the lower mainstem of the Skokomish River, however unlikely throughout the duration of this plan. No foreseeable impacts to spring or fall Chinook salmon are expected throughout the duration of this plan.

In recent years, the peak of arrival of Baker River sockeye at the Baker trap was July 9; with timing extending from early June through early August (Figure 8). Ruff et al (2015) estimated that migration timing in the Skagit River, from Skagit Bay to the Baker River trap, was 14.5. Based on these Baker River data, that river entry of sockeye will begin in late May and continue through the end of July, and that migration toward the North Fork will take about a week, considering the shorter path in the Skokomish River system, incidental harvest of sockeye salmon will be very low in summer/fall Chinook salmon fisheries in July and August.

If the Hood Canal Hatchery sockeye stock and the North Fork spring Chinook salmon stock exhibit behavior similar to the Skagit donor stocks, we would expect some overlap in the latter part of spring Chinook salmon entry with sockeye. But incidental harvest of spring Chinook salmon will be kept low during sockeye fisheries, primarily through harvest regulations that specify use of smaller mesh (5 3/4”) gillnets that target sockeye. A gill-net test fishery will be implemented in the lower Skokomish River to determine the entry and migration timing of sockeye. Incidental Chinook salmon catch in the sockeye test fishery will be carefully monitored. Ceremonial and subsistence removals of spring Chinook salmon could be taken by the test fishery.

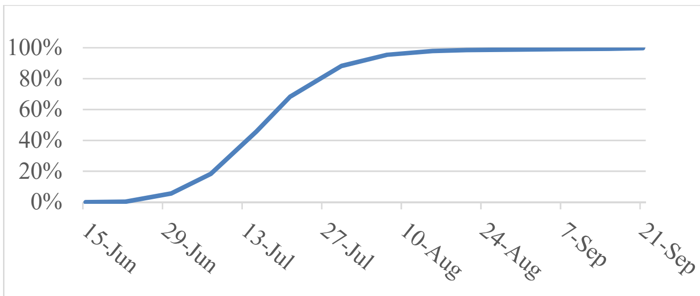

Figure 8. The timing of arrival of sockeye salmon at the Baker River trap (SIT and WDFW 2017).

Sport fisheries for sockeye in Area 12 are also planned once escapement goals are met and harvestable surpluses are identified by the co-managers. However, limited opportunity is likely to emerge in marine areas of Hood Canal given historical catch rates in Area 8 outside the Skagit River basin.

Summer Chum

Hood Canal summer chum were listed as threatened under the ESA in 1999. The ESU comprises two populations: one in the eastern Strait of Juan de Fuca, and one in Hood Canal. The Hood Canal population comprises extant sub-populations in the Big and Little Quilcene River, Hamma Hamma River, Duckabush River, Dosewallips River, Union River, and Lilliwaup Creek. Very small numbers of fish also persist in several other streams but these are not considered to be extant subpopulations. The abundance of the Hood Canal population has rebounded strongly (Figure 9) since the listing (Lestelle et al. draft 2017).

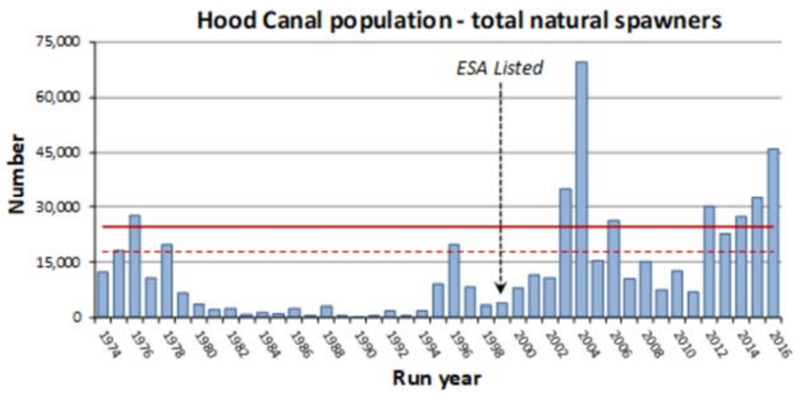

Figure 9. Estimated numbers of naturally spawning summer chum in the Hood Canal population from 1974 to 2016. The upper (solid red line) and lower (dashed red line) ends of the minimum spawning thresholds needed for recovery as shown in Table 2 are displayed; those ranges are based on analyses in Sands et al. (2009) (Lestelle et al, 2017 Figure re-printed by permission of author).

The threshold for determining low risk of extinction for the Hood Canal summer chum population is being exceeded by a substantial margin.

An abbreviated summary of results from the VRAP analysis in Sands et al. (2009) is given in Table 9 and Table 10. These results utilize population data for brood years 1974-2001. The results are given as a range in capacity (incorporating a reasonable range of productivities) and a range in expected spawning escapement associated with a specific pair of capacity and productivity values.

Table 9. Minimum abundance viability thresholds (5% risk of extinction over 100 years) for the SJDF and Hood Canal populations of summer chum as given in Sands et al. (2009) derived with VRAP modeling. The results are shown as a range, based on different values for productivity (P) that bracket a reasonable range of values for each population. The results are shown with two exploitation rates (ER): 0% and 10%. Data for brood years 1974-2001 were used in the modeling.

Population	ER	Range of average escapements		Capacity range	
		Low	High	Low	High
		P=6	P=3	P=6	P=3
SJDF	0%	4,700	5,100	3,300	4,300
	10%	4,600	5,400	3,700	5,300
		P=9	P=5	P=9	P=5
Hood Canal	0%	17,900	20,600	13,000	17,000
	10%	18,600	21,500	15,500	20,500

Table 10. Minimum abundance viability thresholds for the Hood Canal population of summer chum as given in Sands et al. (2009) derived using the VRAP model and as updated in the current analysis (2017 update). ER is exploitation rate and P is intrinsic productivity. Escapement values are arithmetic means[4] as in Sands et al. (2009) (Lestelle et al, 2017).

Population	ER	Assessment	Range of average escapements		Capacity range	
			Low	High	Low	High
			P=8	P=6	P=8	P=6
Hood Canal	0%	Sands et al. 2009	18,300	19,100	13,500	15,000
		Lestelle et al. 2014	8,700	9,100	7,000	7,800
		2017 update	4,800	4,900	3,600	3,900
	10%	Sands et al. 2009	18,300	20,400	15,500	18,500
		Lestelle et al. 2014	8,700	9,600	8,000	9,300
		2017 update	5,000	5,100	4,200	4,500

Summer chum have also rebounded substantially in the Skokomish River and this subpopulation is now considered to be robust (Figure 10). However, no special recovery efforts are warranted to be directed specifically at this subpopulation. It is recognized that the large restoration effort called the Skokomish River Basin Ecosystem Restoration Project, led by the U.S. Army Corps of Engineers and authorized for federal funding, will provide significant habitat benefits to the summer chum subpopulation (USACE 2015; SIT and WDFW 2017). (Lestelle et al. draft 2017). The summer/fall Chinook salmon fishing regime outlined above, consistent with the summer chum Base Conservation Regime (BCR), including the hiatus in fishing from late August through September, will minimize incidental impacts on summer chum.

[4]/ The arithmetic mean is skewed high (by approximately 35 to 40%) due to the lognormal distribution of observed escapements compared to the geometric mean, which is equivalent to what this report refers to as equilibrium abundance.

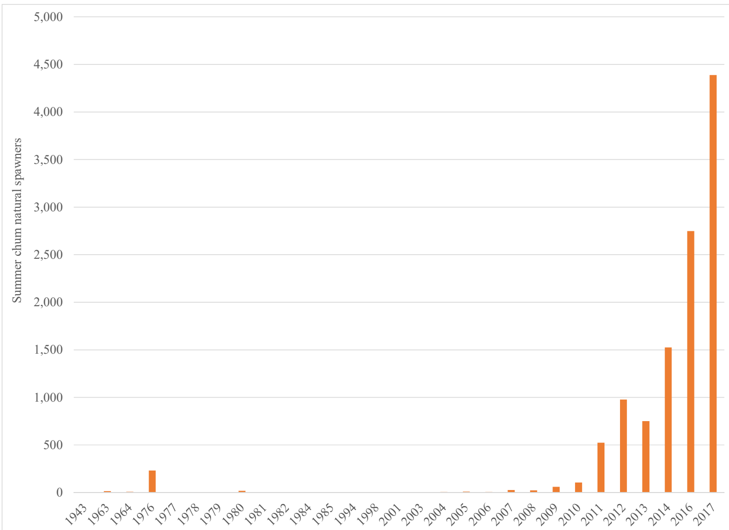

Figure 10. Live counts of summer chum in the Skokomish River, 1943 - 2017. (WDFW SaSI 2017; Larry Lestelle and Mark Downen pers comm June 6, 2017).

Coho

Fisheries directed at coho salmon in Puget Sound have been managed in accordance with the Comprehensive Coho Salmon Plan developed by the co-managers in the 1990s (though this plan was not formally agreed by all parties). Harvest of wild coho salmon originating in Hood Canal (the many stocks comprise a single, primary management unit) are restricted by a stepped exploitation rate ceiling which is set relative to forecast abundance. The ceiling rates developed for Hood Canal are in the following Status steps: Critical - 10% in all SUS fisheries; Poor - 45% in all fisheries; Moderate - 65% in all fisheries; Abundant - 65% in all fisheries, plus 90% of any recruitment over 78,000.

Though hatchery produced coho intermingle with wild coho in the terminal area, harvest is constrained to conserve wild coho and summer chum. Commercial net fisheries occur in the mainstem of Hood Canal (Areas 12, 12B, 12C, and 12D), in Quilcene and Port Gamble Bays (12A and 9A, respectively) and the Skokomish River (82G). Also, limited dip-net coho fisheries occur in the Quilcene River (82F). A sport fishery for coho also occurs in Area 12 and historically in the Skokomish River as well. Any future in-river coho sport fishery will be contingent upon co-manager agreement.

Most relevant to this Plan, commercial net fisheries for coho in Area 12C begin in late September and run through mid-October. Fisheries in the Skokomish River now occur in October to increase escapement to the spawning grounds. We hypothesize that a successfully developed true late-timed fall Chinook population will exhibit similar run timing patterns as other wild, Puget Sound fall populations, such as the lower Skagit falls. Lower Skagit falls enter the river in mid to late September, then await the first rains in October to spawn. However, CWT analysis will inform adaptive management of fisheries. In previous years the coho fishery in the river began earlier, e.g. in mid-September. Recent year catch data indicate that incidental catch of summer – fall Chinook salmon are very low by the opening of coho directed fisheries in 12C and the river, as the peak of the hatchery return to George Adams has past. Wild coho continue to return at relatively lower abundance from October to January, but fishery encounters on Chinook salmon have been consistently very low (annually ranging from 7 – 80 Chinook salmon landed) through the coho and fall chum management period.

Fall Chum

There is substantial production of fall chum salmon at Hoodsport Hatchery and GAH/McKernan Hatchery, with smaller programs at the Enetai Hatchery (SIT-South of Potlatch) and Little Boston Hatchery (Port Gamble Bay). These programs support large scale commercial fisheries, and appreciable sport fishing at Hoodsport Hatchery and in the Skokomish River. These fisheries are managed to achieve escapement of sufficient broodstock to perpetuate the hatchery programs. Natural escapements to the Skokomish River and numerous other river systems throughout the Canal have been stable.

Fall chum fisheries in the mainstem of Hood Canal (Areas 12, 12B, and 12C) start in mid-October and continue through the end of November. They incur very low incidental mortality on summer-fall Chinook salmon.

Winter Steelhead

Fisheries for winter steelhead have been highly constrained in recent decades because the wild populations have been depressed. Hatchery production was terminated, but limited experimental production operated by the NMFS / co-managers continues in the South Fork Skokomish River, Dewatto River, and Duckabush River. Very limited tribal C&S fisheries operate in the Skokomish River in December through early March; recreational fisheries have been closed. Steelhead fisheries do not incur incidental mortality of Chinook salmon.

Pink

Odd-year pink salmon, once abundant in several Hood Canal rivers, have been depressed from the 1990s through 2010, so there are no directed fisheries. Returns to the Skokomish River, however, have increased since 2013. Spawning surveys have documented pink salmon presence from late August through September. An upsurge in pink returns was observed somewhat earlier in many of the large river systems in southern Puget Sound, with terminal run abundance reaching approximately one million in some years. Their river entry and spawn timing in the Skokomish River overlaps that of summer-fall Chinook salmon in September, which can further complicate estimation of Chinook salmon escapement. No terminal fisheries targeting pink salmon returns to the Skokomish River are envisioned, but incidental harvest of pinks is expected in Chinook salmon fisheries in August.

Harvest objectives and guidelines for Skokomish River spring Chinook salmon will be incorporated in subsequent revisions of the Puget Sound Chinook Harvest Management Plan. The co-managers will continue to monitor natural escapement, age composition, and spawning distribution of fall Chinook salmon, about which recent information is summarized below, to inform subsequent recovery planning decisions.

Monitoring and Adaptive Management

- Continue spawning survey regime and re-evaluate the current methodology used to estimate natural spawning escapement (i.e. current survey reaches, survey frequency, assumptions about stream live of live fish, redd life and sex ratios).
- Continue sampling terminal catch and spawning grounds to determine age composition and hatchery/natural-origin.
- Expand the geographic and temporal coverage of surveys to encompass spring Chinook reintroduction and late-timed fall Chinook program development.
- Continue to operate the smolt trap in the North Fork to estimate production (especially after early-stock reintroduction).
- Monitor and re-evaluate success of the “Late-Timed” Chinook salmon Program using tag recoveries to identify timing, distribution, and interceptions in fisheries.
- Strategically submit CWT recoveries for real time reading where questions of spring or late-timed fall Chinook presence at hatchery facilities or interceptions in fisheries could lead to in-season management adjustments.
- Analyze differences in tag recoveries for spring Chinook, late-timed, Chinook and George Adams Chinook Double Index Tag groups to assess survival, and exploitation rates.
- Re-evaluate terminal cohort reconstruction in order to monitor recruitment and productivity.
- Develop methodologies for applying VSP parameters of abundance, geographic distribution, productivity, and diversity to spring Chinook and late-timed true fall Chinook.
- Monitor the effects of normative flows, and resulting channel changes in the North Fork on spawning distribution.
- Evaluate the feasibility and design a project in the South Fork to remove car body levies in order to reduce stream aggradation and de-watering.

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From:	Scott Bass
To:	"Christina Iverson - NOAA Federal"; "Rob Jones"; Adicks, Kyle K (DFW); Downen, Mark R (DFW); "Gray, Cindy"; abrooks@jamestowntribe.org; awelch@pgst.nsn.us; Dufault, Aaron M (DFW); Randy Harder; Scott Chitwood; "Dave Herrera"; Lyle.Almond@elwha.org; Rose, Gordon
Cc:	"Susan Bishop - NOAA Federal"; "James Dixon"
Subject:	RE: [US v WA Mediation Communication] Mid-Hood Canal MUP
Date:	Friday, September 21, 2018 2:23:14 PM
Attachments:	Mid-HC Chinook MUP Master Copy Final wTrkChg 9-21-2018.docx Mid-HC Chinook MUP Final 9-21-2018 - NOAA Version.docx

All –

Please see the Mid-Hood Canal Chinook MUP. Attached are two copies of the Mid-HC MUP: (1) the Hood Canal co-managers' master copy, and (2) the version NOAA created for its tracking needs.

Both versions show all the updates and edits made to the previously distributed draft in track changes. The difference between the two versions is that NOAA's review version shows all changes going back to the updated 2010 Mid-HC MUP that was discarded, while the co-managers' master copy (which is a newly written 2018 Mid-HC MUP) only shows the changes and edits made to it since it was first distributed.

The Hood Canal co-managers apologize to the NOAA reviewers for not fully explaining that an entirely new Mid-HC MUP had been drafted. It, unfortunately, was not made clear to the Hood Canal co-managers (from either the footnote #2 of the MUP Finalization Schedule or in the 6/21 minute order reverenced in the footnote) that the co-managers were obligated to work from the outdated 2010 MUP, even after it was deemed still insufficient by NOAA when it was updated with recent data and information.

Alternatively, to bring the Mid-HC Chinook MUP into the next decade, the Hood Canal co-managers chose to write a new much more comprehensive and greatly expanded Mid-HC MUP that synthesized all the available data, information, and analyses on the Mid-HC Chinook stock. Furthermore, it was crafted to specifically address all of NOAA's comments and concerns about the previous 2010 based version of the Mid-HC MUP.

The Hood Canal co-managers had thought of the 2018 version of the Mid-HC MUP as a greatly improved new "starting point" for the Mid-HC MUP, and not a further revision of the outdated and inadequate 2010 MUP. Therefore, it did not occur to us to try to merge the two documents. Nevertheless, all edits and updates made to the master copy have been transposed to the NOAA review version (except for some formatting), and the NOAA comments specific to the new 2018 Mid-HC MUP have been transposed to the master copy.

Below is a brief summary of the major changes (to both):

(1) Updated analyses, graphs, tables, and text with the updated FRAM validation runs through 2016;
(2) Updated analyses, graphs, tables, and text to include 2017 escapements;
(3) Edited sections for clarity and accuracy, and corrected typos;
(4) Added material and/or edited sections in response to NOAA's and co-managers' comments;
(5) Responded to many of NOAA's comments in the comments section.

At this point, the Mid-Hood Canal MUP has been thoroughly updated with the most recent data and analyses on the Mid-HC Chinook stock. Many thanks go out to all the Hood Canal co-managers and technical staff that helped with the data assembly, analyses, and editing that went into getting this Mid-HC MUP completed. Thanks!

-- Scott

From: Christina Iverson - NOAA Federal [mailto:christina.iverson@noaa.gov]
Sent: Monday, August 27, 2018 4:02 PM
To: Rob Jones <rjones@nwifc.org>; Adicks, Kyle (DFW) <Vincent.Adicks@dfw.wa.gov>; sbass@pnptc.org; Mark Downen <Mark.Downen@dfw.wa.gov>; Gray, Cindy <cgray@skokomish.org>; abrooks@jamestowntribe.org; awelch@pgst.nsn.us; Dufault, Aaron M (DFW) <Aaron.Dufault@dfw.wa.gov>
Cc: Susan Bishop - NOAA Federal <susan.bishop@noaa.gov>; James Dixon <james.dixon@noaa.gov>
Subject: Re: [US v WA Mediation Communication] Mid-Hood Canal MUP

Good Afternoon Everyone,

Please see the attached review of the draft Mid Hood Canal MUP submitted to NOAA Fisheries for review on August 8th (via email from Rob Jones, with the confidentiality header subsequently removed).

A few things to note. For tracking purposes the original MUP draft which NOAA Fisheries provided comments on back to the co-managers on in January of 2018 is the starting place for any revised drafts (see footnote #2 of the MUP Finalization Schedule - Revised MS Excel file distributed by Craig Bowhay) . With that said, our review of the Mid Hood Canal MUP took a little longer than anticipated due to the need to combine the two versions of the MUP that we received (the original in December of 2017 with January NOAA F comments to be addressed, and this new August 2018 version for our review). You will note text from the January draft that was addressed, along with the original NOAA F comments were inserted to this August 2018 draft of the MUP, and if the comment was addressed since January, or in the August revision it was 'marked as done'. Those comments now appear in the background, and as grayed out text. Those comments/questions that remain, and some new, are needed to proceed with the evaluation of the MUP. The text that changed between January and August in the body of the MUP now appears for the most part as red-line strike-out to track the progress. This can be accepted by the co-managers in this draft of the MUP to clean up the editing for ease of review moving forward with this draft. (Again, it currently appears in this version as red-line strike-out for our tracking purposes for the record. We intend to also accept the text in the final draft MUP).

Please feel free to reach out with any questions. Susan is out this week for training, but I am available if you should have any questions.

Best Regards,
Christina Iverson

On Tue, Aug 7, 2018 at 8:50 AM, Susan Bishop - NOAA Federal <susan.bishop@noaa.gov> wrote:

> Thank you for sending the revised Mid-Hood Canal MUP for our review. We will review as soon as we can and get back to you. We are reviewing two other MUPs. Leave and a busy management season has limited available staff time. We had planned workload for MUP review around the earlier schedule for distribution in early-July. Christina Iverson will be NOAA Fisheries lead staff on review.
>
> Susan
>
> On Tue, Aug 7, 2018 at 8:19 AM, Rob Jones <rjones@nwifc.org> wrote:

Greetings,
Attached is the final Mid-Hood Canal MUP that has been agree to by all comanagers. It is being transmitted to NOAA with this email.

Thanks,
Rob
--

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Susan Bishop
Anadromous Salmon Harvest Branch Chief
NOAA Fisheries Service WCR - Sustainable Fisheries Division
Office: 206-526-4587
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Mid-Hood Canal Management Unit Status Profile

Component Sub-populations

Hamma Hamma River summer/fall
Dosewallips River summer/fall
Duckabush River summer/fall

Geographic description

The flow regimes of the three Mid-Hood Canal rivers, Hamma Hamma, Duckabush, and Dosewallips, have been classified as *transitional* between rainfall dominated and snowmelt dominated (Beechie, et al. 2006). Chinook salmon spawn in the Hamma Hamma River mainstem up to river mile 2.5, where a barrier falls blocks anadromous fish migration. The Hamma Hamma River has its headwaters high in the Olympics with steep gradients in its upper reaches, similar to the other systems in this area. Spawning can also occur in its tributary, John Creek, when the river flow permits access. A series of falls block access to the upper Duckabush River at river mile seven, particularly during the period of low flows when Mid-Hood Canal Chinook migrate. A canyon section between river mile three and four contains several cascades that can partially block migration (Williams et al. 1975). The Dosewallips River is the largest drainage entering northern Hood Canal, but salmon accessibility is limited beyond river mile fourteen because of a large waterfall. Spawning may also occur in Rocky Brook Creek, a tributary to the Dosewallips at river mile 3.6. Most tributaries to these three rivers are inaccessible high gradient streams, so the mainstems provide nearly all the production potential. Forestry in the upper reaches and agricultural development in the Duckabush and Dosewallips floodplains have significantly degraded the quality of the available habitat.

Population structure

Commented [S1]: What is the entry and spawning timing? Age structure? Life history?

The overall description in the first few sections focuses on abundance and productivity and touches on spatial structure but needs more for the diversity VSP parameter. These aspects are highlighted as important in the main body of the RMP and included in the monitoring so what is known should be reflected here.

Commented [S2R1]: Addressed thoroughly, except for a couple of follow up points, see comments below.

The mid-Hood Canal Chinook management unit is one of 22 populations of Chinook salmon in the Puget Sound Chinook Salmon ESU (NMFS 2016). When the Puget Sound Technical Recovery Team (TRT) deduced the historical population structure of Mid-Hood Canal Chinook, it concluded that collectively the three mid-Hood Canal watersheds (Dosewallips, Duckabush, and Hamma Hamma) may have supported a single independent Chinook population, based on similarity of freshwater and estuarine habitats and close proximity of these rivers to each other (Ruckelshaus et al. 2006). From historical accounts, there may have been indigenous early run spawning aggregations in the Mid-Hood Canal rivers, which were extirpated long ago. However there is no historic evidence of an endemic fall or summer/fall run-timed population in Mid-Hood Canal (Ruckelshaus et al. 2006). A spring run-timed population could have accessed more habitat because of the increased flows during the spring migration period, allowing passage beyond some of the barriers present at low summer/fall flows. If there was an indigenous self-sustaining population of Chinook in the Mid-Hood Canal river systems, that population went extinct (NMFS 2016) sometime in the past, likely from a combination of factors including habitat degradation, historic use of splash dams, hatchery influence, and historic harvest practices (LLK 2010). For example the largest Mid-Hood Canal river, the Dosewallips, was blocked for many years at river mile three by an impassable dam that was removed shortly before 1932, and a subsequent 1932 WDFW survey documented a smaller than expected Chinook run in the Dosewallips River, which at that time had only been accessible to salmon for a few years (Ruckelshaus et al. 2006).

The extant Chinook population returning to the Hamma Hamma River is not genetically distinct from existing Skokomish River Chinook or from recent George Adams and Hoodsport hatchery broodstock (Marshall 2000; Jones 2006; NMFS 2016). Duckabush juvenile Chinook samples collected in 2011 were analyzed by WDFW and were found to be closely associated with the George Adams Hatchery/Green River origin stock (HGMP 2013, citing pers. comm. K. Warheit, WDFW, Sept. 2011). The hatchery lineage Chinook stock currently populating the Mid-Hood rivers does not display the broad life-history diversity that was likely present in the indigenous Mid-Hood Canal population (LLK 2011).

The TRT recognized that there could have been genetic exchange between fish originating in the Mid-Hood Canal rivers and fish originating in the Skokomish River due to the proximity of the Mid-Hood Canal rivers to the Skokomish River. Accordingly the TRT considered alternative population scenarios for Chinook salmon in Hood Canal, which included one or more self-sustaining populations of Chinook in the Skokomish River, and a Mid-Hood Canal sub-population having been largely supported by a primary spawning aggregation in the Skokomish River.

Life History

Mid-Hood Canal Chinook are a summer/fall timed run with adult river entry occurring from mid-August to late September, with spawning taking place from late September to mid-October. The average age structure of the adult return is estimated to be 6% age two, 41% age three, 50% age four, and 3% age five, based on pooling the age data collected from 2000 to 2017. However, a preliminary analysis of age composition from scale data indicates that natural origin recruits may have an older age structure than supplementation origin and hatchery origin recruits.

The Mid-Hood Canal Chinook juveniles migrate from freshwater as sub-yearlings. The majority of smolt outmigration occurs from early April through late May. Smolts appear to remain in the estuary from June through mid-July, after which most have migrated into the marine environment. The Chinook smolts may rear in Hood Canal for an extended period, many for as long as 100 days before moving out of Hood Canal (Chamberlin, et al 2011). Once in the marine environment, coded wire tag (CWT) recovery data indicate that Mid-Hood Canal Chinook typically migrate through the Strait of Juan de Fuca to the ocean waters off the west coast of Vancouver Island.

Integrated Hatchery Supplementation Program

An integrated Chinook supplementation hatchery program began in 1995 on the Hamma Hamma River with the goal of restoring a viable, self-sustaining, natural-origin Mid-Hood

Canal salmon population. The program was intended to help restore and maintain a sustainable, locally adapted, natural-origin Chinook population by increasing the number of naturally spawning adults on the spawning grounds with supplementation hatchery origin fish. Because the adults originating from the supplementation program were intended to reach the spawning grounds, there were no proportion hatchery origin spawners (pHOS) or stray rate standards applied to this program. Beginning in 2005, following a primary recommendation of the Hatchery Scientific Review Group (HSRG 2004), the supplementation program attempted to collect 100% of its broodstock from the Hamma Hamma River in order to promote local adaptation. However, the number of Chinook returning to the Hamma Hamma River were often too few to meet the supplementation broodstock collection goal, so the program continued to rely on transfers of Chinook from the George Adams Hatchery to maintain production.

The Chinook salmon returning to the Hamma Hamma supplementation program were not genetically distinct from either the natural-origin fish from the Hamma Hamma River or the George Adams Hatchery fish returning to the Skokomish River (LLK et al. 2013; NMFS 2016). This genetic relationship is presumed to have continued through long term use of George Adams Hatchery origin Chinook by the Hamma Hamma supplementation program and the straying of Skokomish River, George Adams Hatchery, and Hoodsport Hatchery Chinook into the Mid-Hood Canal watersheds.

Chinook salmon sampled from the Hamma Hamma River were categorized into three groups: natural origin recruits (NOR's), Hamma Hamma supplementation origin recruits (SOR's), and hatchery origin recruits (HOR's) that strayed into the Hamma Hamma River from other hatchery programs. The distinction was made to evaluate the performance of the supplementation program and the effect it had on the Mid-Hood Canal Chinook return. Additionally, the supplementation program attempted to primarily use Chinook salmon returning to the Hamma Hamma River as broodstock to promote local adaptation, which if that had been successful, it potentially could have created a distinct locally adapted hatchery component to the Hamma Hamma Chinook return.

A preliminary analysis of CWT and otolith marks from carcasses collected from the Hamma Hamma River from 2009 through 2017 estimated that hatchery origin Chinook (including SOR's) make up 86% of the natural spawners (Table 1). Although recoveries of hatchery Chinook have occurred in the Dosewallips and Duckabush rivers, the proportion of hatchery origin adults (both SOR's and HOR's) spawning in these rivers is uncertain, because the small run sizes have caused very few carcasses to be available for sampling. The numbers of Hamma Hamma supplementation origin fish that stray into the Dosewallip and Duckabush rivers are unknown, but are likely to represent a lower proportion of the total return to those rivers than to the Hamma Hamma River, therefore the proportions shown in Table-1 would not be applicable to the Dosewallip and Duckabush rivers.

The Hamma Hamma Chinook hatchery supplementation program ended in 2015, primarily because it was unsuccessful at achieving its goal of restoring a self-sustaining Chinook population to the Hamma Hamma River and more broadly a Chinook population to the Mid-Hood Canal Rivers (LLK 2014). It was noted that a secondary consideration for ending the program was limited staff and funding.

Table 1. Proportions of natural, hatchery, and supplementation origin Chinook returning to the Hamma Hamma River, based on broodstock collection and carcass recoveries from 2009 through 2017. These proportions should not be applied to Dosewallips and Duckabush river escapement estimates, because the proportions of supplementation origin and out of area hatchery origin fish returning to those systems is unknown.

Origin	2009	2010	2011	2012	2013	2014	2015	2016	2017	Average
NOR	0.24	0.21	0.15	0.01	0.06	0.29	0.04	0.21	0.10	0.14
HOR	0.11	0.00	0.02	0.00	0.06	0.00	0.04	0.00	0.02	0.03
SOR	0.64	0.79	0.84	0.99	0.88	0.71	0.93	0.79	0.88	0.83
Hatchery (HOR, SOR)	76%	79%	85%	99%	94%	71%	96%	79%	90%	86%
Natural Origin (NOR)	24%	21%	15%	1%	6%	29%	4%	21%	10%	14%

HORs are determined by CWT's w/o otolith marks and SORs are determined with otolith marks

Origins for years 2011 and 2016 were determined with cwt data only

A Beverton/Holt spawner-recuit analysis of Hamma Hamma River Chinook (Figure 1) shows that the population's productivity is generally well below the 1:1 replacement line, except at very low spawner abundances (below 42 spawners). It appears that increasing the number of supplementation origin spawners on the spawning grounds does not increase the number of recruits produced. This could be an indication that the productivity of supplementation origin fish is very low and may not have been meaningfully contributing to the production of recruits.

Commented [CI5]: Appreciate that this uses what data are available. However, there is some concern that the data noise described in the text limits what can be reliably predicted based on these data. Available data does support the extremely low productivity for the population, for whatever reason, and the various hypotheses are plausible as listed in the paragraph following the figure. The subsequent text regarding *what may happen* after the SOR returns stop is an important point of the MHC story. Are there other analysis such as habitat based assessments to compare?

CO-MANAGERS: What do you mean "data noise described in the text"? "Data noise" is not described in the text of this MUP. The S-R analysis is the best available scientific estimate of the current Mid-HC Chinook stock's NOR productivity and capacity that is based on the performance of the stock itself in the Mid-Hood Canal rivers, the estuaries, and the marine environment.

There are no recent habitat based assessments to which the S-R analysis can be compared.

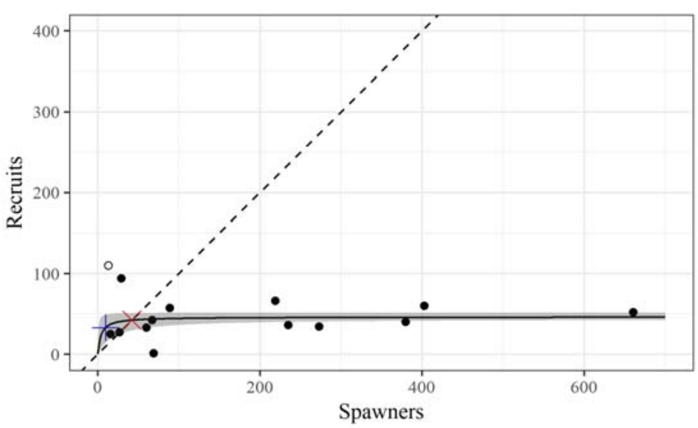

Figure 1. Beverton/Holt (BH) spawner-recruit curve (solid line) fit Hamma Hamma Chinook spawner (SOR, HOR, and NOR) and recruit (NORs from escapement and harvest estimates) data. Dashed line is the 1:1 replacement line; blue cross is point of maximum sustainable yield (MSY); red X is the point of equilibrium abundance at 42 spawners and recruits; and the grey shading shows the 95% confidence band on the BH curve.

The supplementation program's lack of success at establishing a locally adapted self-sustaining Chinook population may have been from a combination of factors, including the small size of the program, poor population fitness, lack of quality habitat, and potential mismatch of the current stock's life history with the habitat and flow regimes of Mid-Hood Canal rivers.

The ending of the supplementation program has triggered a new condition for the population dynamics of Mid-Hood Canal Chinook. The Mid-Hood Canal Chinook management unit will be entering a new phase of recovery that will likely be dominated by natural origin production, provided that NORs outnumber HOR strays in the spawning escapements. In theory, natural origin spawners should have a higher level of success spawning naturally in the wild than their hatchery origin counterparts. If so, the productivity of the natural spawners may show an increase once the influence of hatchery supplementation spawners is gone. This may help the naturalized population take hold and begin to re-colonize any underutilized habitat in the Hamma Hamma River, assuming that the current low productivity is primarily influenced by potential fitness loss induced by the hatchery-origin fish spawning naturally on the spawning grounds. Additionally, it is possible that local adaptation may occur more rapidly when recolonization is dominated by natural origin production. However, this effect has not been observed in the Duckabush or Dosewallips river systems, even though the natural Chinook productivity of those systems is presumed to be similar to the Hamma Hamma River, based on EDT habitat modeling that indicated very similar potential Chinook productivity among the three mid-Hood Canal rivers. For example, the Duckabush and Dosewallips rivers have continued to have very low escapements, despite presumably being driven primarily by natural production, in conjunction with an undetermined amount of straying SORs and NORs into those systems.

Status

Historic spawning escapement estimates for Mid-Hood Canal Chinook show persistently low escapements from 1990 to 2017 (Table 2). However, the time series shown in Table 2 may not consistently represent the total escapement in the index reaches, because both the survey effort and the survey area have increased since 2007. Surveys done in the lower reaches may include some "dip-ins" that ultimately spawned elsewhere in Hood Canal.

Table 2. Spawning escapements of Mid-Hood Canal Chinook (1990 - 2017).

Year	Hamma Hamma	Duckabush	Dosewallips	Total
1990	35	10	1	46
1991	30	14	42	86
1992	52	3	41	96
1993	28	17	67	112
1994	78	9	297	384
1995	25	2	76	103
1996	11	13	No Surveys	24
1997	5	No Estimate	No Estimate	5
1998	172	57	58	287
1999	557	151	165	873

Commented [CI9]: Can you break these out into HOR and NOR by applying Table 1 values at least to the Hamma Hamma? Could do a simple 4 year R/S to show productivity at least since 2007. Need this to show status and trend in NORs (criteria B of 4d Rule)

CO-MANAGERS: Yes, but only for the Hamma Hamma River for years 2009 – 2016.
CO-MANAGERS: Productivity is discussed elsewhere in the MUP.

Is 2017 escapement available?
Do the HH estimates include fish taken for broodstock?

CO-MANAGERS: Yes, the 2017 escapement recently became available to be included in this draft.
CO-MANAGERS: Yes.

2000	380	28	29	437
2001	248	29	45	322
2002	32	20	43	95
2003	95	12	87	194
2004	49	0	80	129
2005	33	2	10	45
2006	20	1	13	34
2007	60	4	9	73
2008	255	0	18	273
2009	98	9	23	130
2010	91	0	15	106
2011	294	5	11	310
2012	425	6	7	438
2013	707	7	4	718
2014	117	13	11	141
2015	236	20	3	259
2016	268	15	8	291
2017	365	2	7	374

Survey effort and survey area have increased since 2007.

The time series of escapement estimates shows that the spawner abundance has been above the low abundance threshold of 400 naturally spawning adults only four times since 1990 (Figure 2), even with the hatchery supplementation program augmenting natural production for two decades (1995-2015). The increase in spawner abundance observed between 1998 and 2001 coincided with the first returns from the supplementation program, but may have been also related to concurrent changes in the marine net pen yearling Chinook hatchery production in the area (WDFW memorandum to co-managers, February, 2010), therefore the increase in abundance may not have been indicative of any changes in natural productivity or status of the population at that time. A similar increase in abundance occurred from 2012 to 2013, which coincided with the Hamma Hamma River return having very high proportions of SORs (94% – 99%). Other factors could have influenced these larger returns, such as unusually high freshwater, estuarine, or ocean survival.

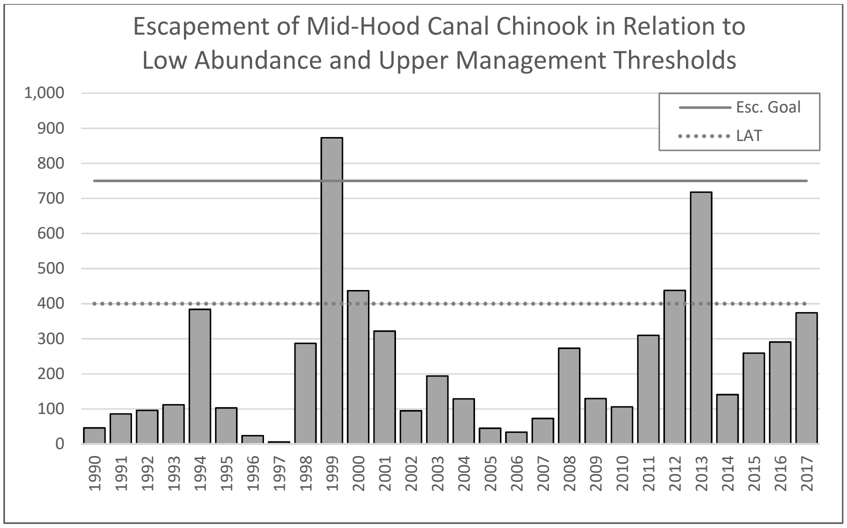

Figure 2. Spawning escapement of Mid-Hood Canal fall Chinook Salmon 1990-2017 in relation to the Low Abundance Threshold and Upper Management Threshold.

Natural productivity of the present Mid-Hood Canal Chinook stock appears to be very low in the Hamma Hamma River, with a productivity in the Hamma Hamma River of 0.27 recruits per spawner during brood years 2000 to 2013 (measured as pooled recruits/pooled spawners). It would be difficult to pinpoint the life history stage or habitat type at which failure is occurring, but freshwater survival from egg to fry/smolt appears to be low (~1.2%) based on a preliminary evaluation of smolt trap data for brood years 2001 to 2009 (LLK 2010). The low natural productivity in the Hamma Hamma River has resulted in natural origin recruits representing only a small proportion of the total escapement to the Hamma Hamma River. Now that the supplementation program has ended, there will be an opportunity to see how the Mid-Hood Canal river systems will respond to the removal of supplementation origin recruits from the spawning grounds.

Commented [CI10]: Could you show a table with the #s? The information used for Figure 1 would include the annual data even if noisy, yes? If the information is pooled, how is it averaged? Why is it limited to these years? See comment above.

CO-MANAGERS: "Averaging" was deleted, because it was technically not an average. Average productivity is not robust to errors in age composition, but the pooled productivity is. The geo-mean of brood year productivity is similar to the pooled productivity.

Those are the years that we have data to estimate natural productivity.

The George Adams (Green River origin) fall Chinook stock may not be a suitable stock for recolonizing the Mid-Hood Canal river systems (LLK 2014). Potential inconsistencies between the current stock's life history and the flow regimes of the Mid-Hood Canal rivers may be contributing to the lack of productivity of the stock (LLK 2014). Peak flows in both the Dosewallips and Duckabush rivers occur from April through early July, with the Duckabush River having a second peak from late October through December. The period of lowest flows for the Mid-Hood Canal rivers occurs from mid-August to mid-October, which coincides with the period that adult Chinook are returning to those rivers. Further research will likely need to be done to conclusively determine this mismatch between the current stock's run timing and the flow regimes of Mid-Hood Canal rivers.

Habitat has been identified as a limiting factor, although it alone does not explain the very low natural Chinook productivity in Mid-Hood Canal rivers. Currently, none of the available habitat data suggests that exceedance of the carrying capacity is limiting the Mid-Hood Canal Chinook population (NMFS 2014).

Commented [CI12]: As mentioned above, the assessment of capacity seems fairly uncertain given the limited available data to say that the carrying capacity has been exceeded for sure. And the anticipated increased proportion of NORs will provide additional information as described above.

CO-MANAGERS: This is a citation directly from NMFS 2014 that makes this assessment, with which the co-managers agree. Hood Canal regional "expert" opinions vary on the current state and suitability of the Mid-HC Chinook habitat, but available data suggest that the current stock is not matched and/or fit for the Mid-HC systems, and therefore may not be achieving the full productivity potential of the Mid-HC habitat.

An alternative view is that the lack of success of the Hamma Hamma hatchery supplementation program and low natural productivity in Mid-Hood Canal rivers could lend greater support to the alternative population structures that the TRT hypothesized in its report, including that the Mid-Hood Canal rivers may not have historically supported an independent self-sustaining Chinook population, but instead were dependent on a healthy returning Skokomish River population to contribute straying spawners to support Chinook production or that the Mid-Hood Canal rivers may have been only intermittently populated with Chinook salmon.

Considering the current stock's poor natural productivity in the Mid-Hood Canal river systems and the discontinuation of the Hamma Hamma River hatchery supplementation program, the co-managers (WDFW and the Tribes) anticipate that Mid-Hood Canal Chinook escapements will likely be below the LAT for the duration of this plan. However, within the timeframe of this plan, an alternative recovery program could be designed and implemented to help restore a self-sustaining, locally adapted Chinook population in conjunction with continued habitat restoration and improvement.

Harvest distribution and exploitation rate trends

The Fishery Regulation Assessment Model (FRAM) is used to create both preseason and postseason estimates of AEQ exploitation rates for Puget Sound Chinook, including the Mid-Hood Canal Chinook management unit. The FRAM model does not directly estimate the harvest distribution and fishery exploitation rates for Mid-Hood Canal Chinook, because there have been insufficient numbers of Mid-Hood Canal Chinook CWT recoveries from fisheries. Instead FRAM relies on coded wire tag recoveries from George Adams Hatchery, Hoodsport Hatchery, and Rick's Pond fall fingerling Chinook as a surrogate for the Mid-Hood Canal Chinook management unit. Given the indistinguishable genetic make-up and life history among these populations, it is reasonable to assume that tagged fingerling Chinook released from the George Adams Hatchery on the Skokomish River would follow a similar migratory pathway and experience mortality in a similar set of pre-terminal fisheries in Washington and British Columbia.

The FRAM model was recently updated with a new base period, which better reflects the distribution and structure of the modern salmon fisheries that impact Puget Sound Chinook. The co-managers completed a series of postseason FRAM validation runs with the new base period for the years 1992 through 2016. The postseason FRAM validation runs with the new base period have been used to re-evaluate the postseason fishery impacts on Mid-Hood Canal Chinook. It is important to note that these re-evaluations of past fisheries were done using this new management tool (the new base period), which is different from what the co-managers had available at the time when annual salmon fisheries were planned, conducted, and evaluated. For example, postseason FRAM validation runs with the new base period show SUS exploitation rates on Mid-Hood Canal Chinook to be 1.7% higher on average compared to validation runs using the old base period (Table 3). The new FRAM base period was first used to plan Pacific Fisheries Management Council (PFMC) and North of Falcon (NoF) salmon fisheries in 2017, so current and future SUS salmon fisheries that are planned using the new base period will need to be constrained more than previously done under the old base period to meet the management objectives for Mid-Hood Canal Chinook when it is a driver stock.

Table 3. Comparison of pre-terminal southern U.S. exploitation rates from postseason FRAM validation runs using old and new base periods (BPs). Multi-year averages are shown for the entire dataset and for the period of ESA listing to the end of the dataset.

Comparison of PT-SUS ERs from Old and New FRAM Base Periods			
YEAR	OLD BP	NEW BP	DIFF
1992	26.8%	39.7%	12.9%
1993	24.6%	31.3%	6.7%
1994	26.0%	25.0%	-1.0%
1995	17.9%	18.0%	0.1%
1996	18.2%	20.2%	2.0%
1997	28.7%	24.3%	-4.4%
1998	17.3%	17.2%	-0.1%
1999	8.8%	11.1%	2.3%
2000	15.0%	13.9%	-1.1%
2001	11.9%	14.3%	2.4%
2002	7.9%	11.6%	3.7%
2003	8.5%	11.6%	3.1%
2004	11.7%	14.5%	2.8%
2005	8.6%	12.5%	3.9%
2006	9.8%	10.7%	0.9%
2007	9.7%	10.1%	0.4%
2008	9.0%	9.9%	0.9%
2009	6.5%	8.0%	1.5%
2010	8.0%	8.7%	0.7%
2011	10.5%	9.1%	-1.4%
2012	12.9%	13.2%	0.3%
2013	10.0%	10.8%	0.8%
2014	11.6%	14.1%	2.5%
Average Pre-Terminal SUS ER (Old vs New Base Period)			
1992 - 2014	13.9%	15.6%	1.7%
1999 - 2014	10.0%	11.5%	1.5%

Postseason FRAM estimates of total AEQ exploitation rates on Mid-Hood Canal Chinook show a large decreasing trend in exploitation from 1992 to 1995, dropping from 47.2% to 25.1%. From 1995 to 2016 the annual total exploitation rate on Mid-Hood Canal Chinook has remained relatively steady with an average total exploitation rate of 24.3% with a standard deviation of

2.6% (Figure 3).

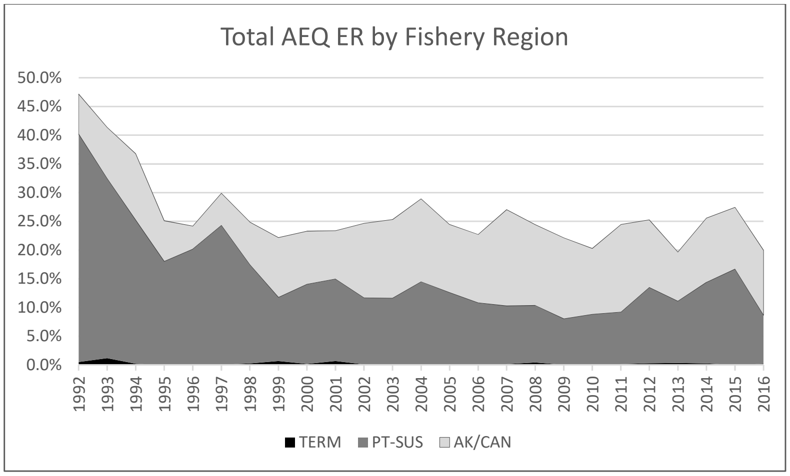

Figure 3. Total annual adult equivalent fisheries exploitation rate of Mid-Hood Canal Chinook from 1992 – 2016, as estimated by FRAM validation runs using new base period. Shaded by fishery region (terminal, pre-terminal southern U.S., northern AK/Can).

Southern U.S. fisheries and northern fisheries (Alaska and Canada) have not followed similar historical exploitation rate patterns or trends (Table 4), particularly in relation to 1999 when Puget Sound Chinook were listed as threatened under the Endangered Species Act (ESA). For example, just prior to the ESA listing of Puget Sound Chinook, southern U.S. fisheries showed a rapidly decreasing trend in exploitation rates, declining from 39.7% in 1992 down to 11.1% in 1999. Since ESA listing annual exploitation rates in southern U.S. fisheries have remained relatively stable at an average exploitation rate of 11.6% with a standard deviation 2.4% (Figure 4). In contrast, the northern fisheries showed a pattern of initially increasing exploitation rates following ESA listing of Puget Sound Chinook (Figure 5). However, beginning about 2007, there appears to be a decreasing trend in the annual exploitation rate of northern fisheries. The co-managers are cautiously optimistic that the 2019 PST Chinook agreement will help to continue this decreasing trend in the exploitation rates of northern fisheries.

Commented [CI17]: Do you mean 2007 (Figure 5)?

Table 4. Average AEQ ER's on Mid-HC Chinook by fishery region for: 1992–1998 (prior to ESA listing), 1999–2008 (10 years following ESA listing), and 2009–2016 (recent years following renegotiation of the PST Chinook agreement), as estimated by FRAM validation runs with new base period.

PERIOD	AK/CAN	PT-SUS	TERM	TOTAL
1992 - 1998	7.4%	25.1%	0.3%	32.8%

1999 - 2008	12.4%	12.0%	0.2%	24.6%
2009 - 2016	11.8%	11.1%	0.2%	23.1%

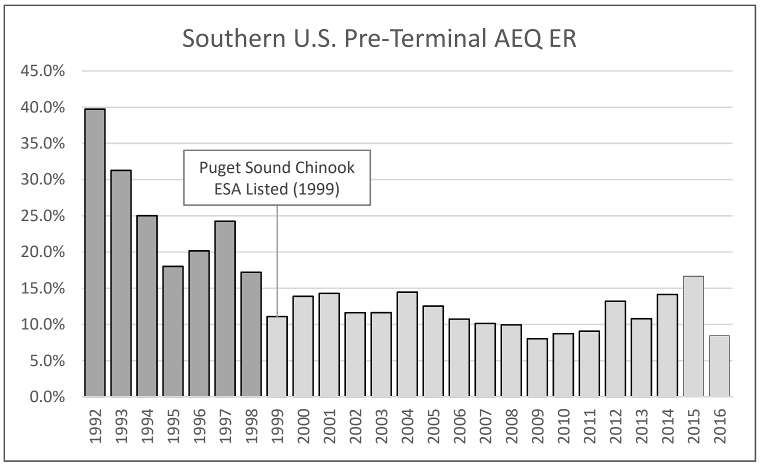

Figure 4. Southern U.S. annual adult equivalent fisheries exploitation rate of Mid-Hood Canal Chinook from 1992 – 2016, as estimated by FRAM validation runs using the new base period.

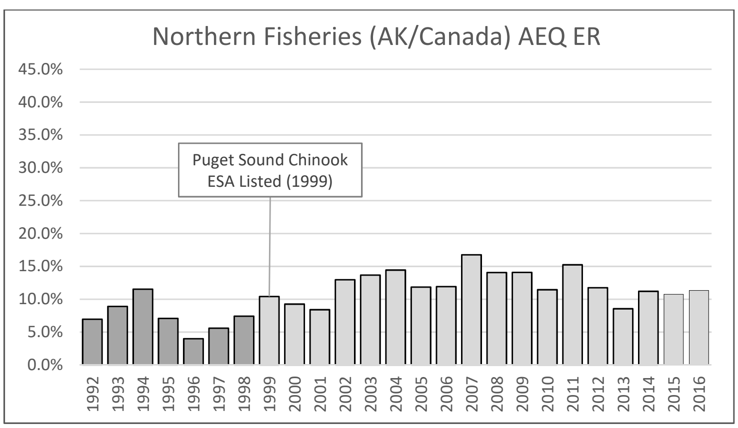

Figure 5. Northern fisheries (Alaska and Canada) adult equivalent fisheries exploitation rate of Mid-Hood Canal Chinook from 1992 – 2014, as estimated by FRAM validation runs using the new base period.

Terminal area fisheries in northern Hood Canal have been closed to directed Chinook salmon harvest since at least 1992 and have averaged only 0.2% annual exploitation rate on Mid Hood Canal Chinook since that time. The terminal area exploitation rate has not been above 0.7% since Puget Sound Chinook were ESA listed in 1999. Pre-terminal southern U.S. (PT-SUS) fisheries have averaged less than 12% exploitation rate since Puget Sound Chinook were ESA listed. Southern U.S. impacts on Mid-Hood Canal Chinook are expected to remain at this level (or below) for the term of this plan.

Past Fisheries and Harvest Management Actions

Pacific coast-wide salmon fisheries collectively do not appear to be one of the primary factors limiting the success of Mid-Hood Canal Chinook. For example, when the total annual AEQ fishery mortalities are added to the total annual escapements (approximating potential escapement in the absence of coast-wide salmon fisheries), the Mid-Hood Canal Chinook management unit would have achieved its escapement goal only once during the period 2000 to 2016, even with the hatchery supplementation augmenting Mid-Hood Canal Chinook production during this period (Figure 6). When potential escapements in the absence of coast-wide salmon fisheries are evaluated in terms of NOR escapement and AEQ fishery mortality, the Mid-Hood Canal Chinook management unit would not have reached its LAT during the period 2005 to 2016, which are years with reliable estimates of origin available (Figure 7). Moreover, the estimated NOR escapement in the absence of fisheries would have been well below the LAT in all years.

Commented [CI18]: This is a little hard to follow since the LAT is in terms of aggregate escapement, and not clear how it is related to the dynamics of the MHC pop. If I am following, the point is that even with no fishing it would not have changed the status of the population? Important to estimate the diff in NOR #s to escapement and be explicit in the MUP text. That is the most compelling point regarding the effect of the proposed ERs.

Could speak to anticipated returns during RMP most represented by Figure 6 since HH program has been discontinued.

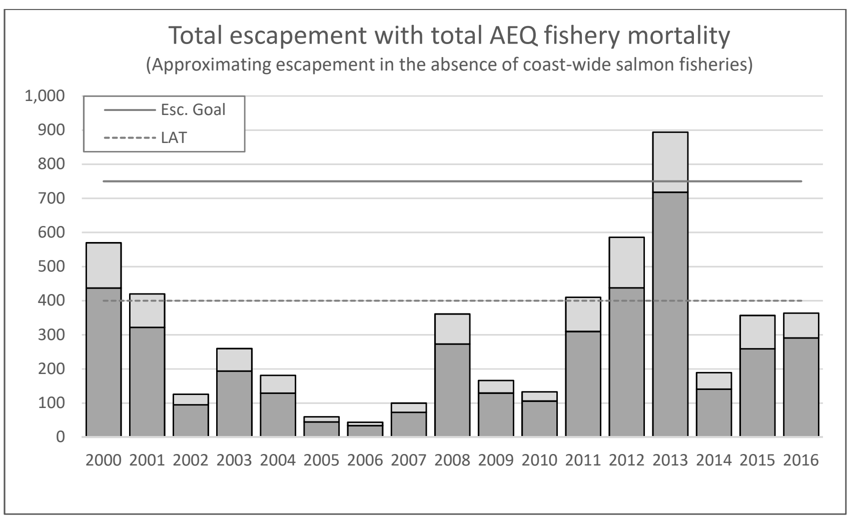

Figure 6. Mid-Hood Canal Chinook escapements with total AEQ fishery mortality of Mid-Hood Canal Chinook added to approximate total escapement in the absence of Pacific Coast-wide salmon fisheries, in relation to the escapement goal and LAT. Dark shading is

escapement and light shading is total fishery mortality. AEQ mortality from FRAM validation runs with new base period.

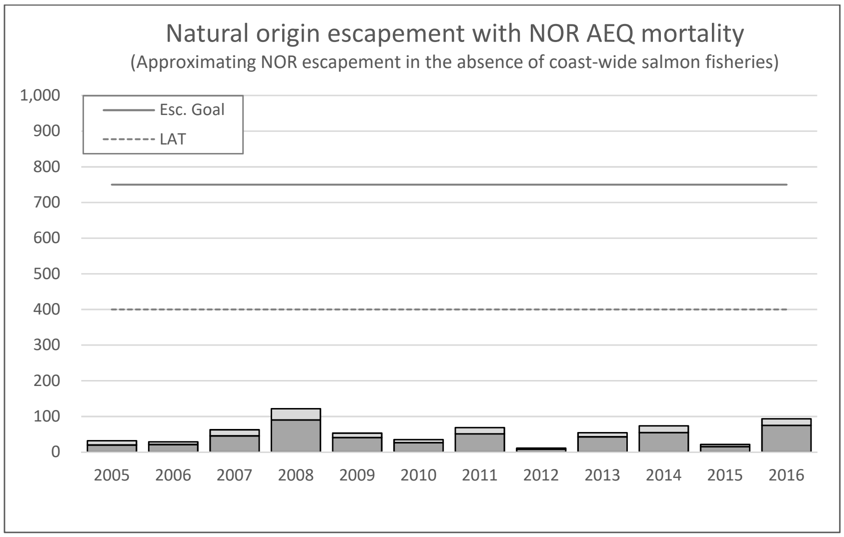

Figure 7. Mid-Hood Canal Chinook NOR escapements with total NOR AEQ fishery mortality of Mid-Hood Canal Chinook added to approximate NOR escapement in the absence of Pacific Coast-wide salmon fisheries, in relation to the escapement goal and LAT. Dark shading is NOR escapement and light shading is NOR fishery mortality. AEQ mortality from FRAM validation runs with new base period. Years prior to 2005 lack sufficient Mid-Hood Canal population data to generate reliable estimates of NOR's.

Currently natural origin Mid-Hood Canal Chinook productivity and recovery appear to be suppressed by factors other than harvest. The co-managers have been restricting fisheries to protect Mid-Hood Canal Chinook since before Puget Sound Chinook were ESA listed. Strict Chinook conservation measures have been put on northern Hood Canal fisheries since at least 1992, and those regulatory measures have kept the terminal area exploitation rates on Mid-Hood Canal Chinook extremely low, with a long term average of just 0.2% (1992 to 2016). The harvest impacts of PT-SUS fisheries were greatly reduced from 1992 to 1995 and have remained relatively low since that time.

Terminal area fisheries in northern Hood Canal have long sustained the disproportionate burden of the conservation for Mid-Hood Canal Chinook. All northern Hood Canal terminal area commercial and recreational fisheries impacting Mid-Hood Canal Chinook have either been closed or are required to release Chinook. For example, tribal net fisheries in Areas 12 and 12B have been closed during the Chinook management period; coho fisheries have been delayed until late September in Area 12 and until October in Area 12B; tribal beach seine fisheries in Area 12, 12A, and 12B are required to release Chinook until September 30; and recreational fisheries in northern Hood Canal have been closed, or when open are required to release Chinook through October 15. The extreme terminal areas for this management unit (Hamma Hamma, Dosewallips, and Duckabush rivers) have been closed and will remain closed when escapement is projected less than 750 natural spawners. Similar regulatory measures are anticipated to continue. The co-managers expect the average terminal area exploitation rate on Mid-Hood Canal Chinook to remain less than 1% for the duration of this plan.

Terminal area fisheries at the far southern end of Hood Canal, near the mouth of or in the Skokomish River, are assumed to have no impact on the Mid-Hood Canal population, therefore Chinook directed commercial fisheries in Hood Canal only occur in that area. Coded-wire tag recovery data representing Mid-Hood Canal Chinook, including recoveries of Hamma Hamma hatchery Chinook, are under review to evaluate this assumption.

Commented [CI21]: Is this generally true of all salmon fisheries that might take MHC Chinook since the objective is inclusive of all mortality? If so, would be good to clarify.

CO-MANAGERS: This paragraph continues the discussion of terminal area fisheries. Pre-terminal fisheries are discussed below.

Pre-terminal southern U.S. fisheries are planned through the annual PFMC and NoF processes and are managed to meet a suite of harvest management objectives for many Chinook stocks, including the ESA listed stocks from California, Columbia River basin, and Puget Sound. The Puget Sound fisheries covered under this plan are primarily planned in the annual WA State/Tribal NoF preseason planning process. They are typically limited in a variety of ways each year to meet the specific management objectives of a few Puget Sound driver stocks. The Mid-Hood Canal Chinook management unit is often one of the driver stocks for which salmon fisheries in Puget Sound must be reduced or constrained to get the pre-terminal southern U.S. exploitation rate below its PT-SUS exploitation rate ceiling.

Northern fisheries (AK and Canada) in relation to Puget Sound Chinook are managed primarily under the Pacific Salmon Treaty (PST) between the U.S. and Canada. The Chinook chapter of the PST was renegotiated for 2009 through 2018, with the intent of allowing slightly more Puget Sound origin Chinook to pass through the northern fisheries to return to Puget Sound. Observing postseason FRAM validation runs, the exploitation rate pattern seems to indicate that the renegotiated Chinook chapter could have had that effect on Mid-Hood Canal Chinook (except 2011 stands out as one of the highest northern ERs). The PST Chinook chapter has recently been renegotiated and will take effect in 2019 and go through 2028. The co-managers are hopeful that the new PST Chinook chapter will continue the trend of reducing the northern exploitation rate on Mid-Hood Canal Chinook, which would then pass more Mid-Hood Canal Chinook to the spawning grounds.

For decades the co-managers have managed Puget Sound fisheries to have minimal impacts on Mid-Hood Canal Chinook. The southern U.S. exploitation rate has been kept to an average of 12% since ESA listing, and Mid-Hood Canal terminal area fisheries that impact Mid-Hood Canal Chinook have been closed or required Chinook release (keeping the terminal area ER to less than 1%), and the co-managers have worked within the Pacific Salmon Commission forum to reduce the impacts of northern fisheries on Puget Sound Chinook. These harvest management efforts have not only been consistent with the goal of not impeding Mid-Hood Canal Chinook recovery, but have been carried out with an extra measure of precaution to help promote the recovery of Mid-Hood Canal Chinook in combination with other recovery efforts, such as habitat restoration and hatchery supplementation. The harvest management objectives in this plan are designed to limit Puget Sound harvest impacts to a level that will enable rebuilding of a natural Mid-Hood Canal Chinook populations, provided that Chinook habitat continues to be restored and protected within the Mid-Hood Canal rivers and their estuaries.

Management Objectives

The recovery objectives for Mid-Hood Canal Chinook are to restore and maintain a sustainable, locally adapted, natural-origin Chinook sub-population. Ultimately this goal can only be achieved with the restoration and preservation of sufficient properly functioning habitat that is populated by a locally adapted Chinook stock having adequate natural productivity. The harvest management objective is to avoid impeding the recovery process by keeping exploitation rates low on Mid-Hood Canal Chinook, while allowing harvest to occur on surplus fish from more abundant Chinook stocks and other salmon species. There are no directed fisheries on Mid-Hood Canal Chinook, and tribal and non-tribal salmon fisheries targeting other species and stocks are managed to minimize incidental impacts to Mid-Hood Canal Chinook.

The harvest management objectives for Mid-Hood Canal Chinook include a natural spawning escapement goal, a pre-terminal southern U.S. (PT-SUS) exploitation rate ceiling, a low abundance threshold (LAT), and a reduced PT-SUS exploitation rate ceiling when forecasted below the LAT. The current PT-SUS exploitation rate ceilings are the result of a negotiated compromise between state and tribal co-managers, which was recorded in a memorandum of understanding (MOU 2003).

The Mid-Hood Canal Chinook escapement goal is 750 naturally spawning adults. This value was initially established as an interim escapement goal in the Hood Canal Salmon Management Plan (1986). It was considered the best available estimate of MSY escapement for Mid-Hood Canal Chinook at that time, and more recent habitat assessments based on EDT analysis have supported this escapement goal. However, a preliminary spawner-recruit analysis of the Hamma Hamma River population (based on limited data collected on the existing Chinook stock, including naturally spawning SORs and NORs) suggests a maximum spawner capacity of around 50 fish for the Hamma Hamma River (refer to Figure 1 above). Assuming the other Mid-Hood Canal rivers have a similar maximum spawner capacity, a more suitable Mid-Hood Canal escapement goal for the existing stock under current conditions may be 150 natural spawners. However, the co-managers doubt that the productivity of the present Mid-Hood Canal stock accurately represents the productivity potential of a fit and locally adapted natural Chinook population, therefore to be consistent with the Mid-Hood Canal recovery objectives the spawning escapement goal remains 750 natural spawners.

The low abundance threshold (LAT) for the Mid-Hood Canal Chinook management unit is 400 naturally spawning adults. The LAT was set at approximately 50% of the escapement goal and is well above the preliminary estimate of maximum spawning capacity for the current population in the Mid-Hood Canal rivers, as indicated by the Beverton/Holt spawner-recruit analysis of the Hamma Hamma stock. Given the low productivity of the mid-Hood Canal Chinook population and the discontinuation of the supplementation program, Mid-

Commented [CI22]: You might consider moving this section closer to the front or defining some of these terms earlier. For example, previous graphs and text refer to the LAT which is an important benchmark, but does not explain what it is until this part of the document.

Commented [CI24]: These are NOR+HOR? If total, need to address elements B and C of the 4d Rule for the thresholds which refer the status of the NOR component. The information presented earlier could be useful, i.e., for the foreseeable future of the RMP, without significant contribution of HORs, this goal would essentially represent NOR fish and is conservative given information provided about the system.

Commented [CI25]: Concerned this relies too heavily on a very uncertain S/R function and not sure of the relevance of the 50% biologically. What about developing something similar to the justification in the Dungeness MUP for the LAT (or combine the two)? Particularly for a stock that is likely to remain at critical levels under the RMP, addressing the genetics is important. Lastly, see previous comment.

CO-MANAGERS: The S-R function does not have any bearing on the LAT, except to show that the LAT is conservative. If the current stock never seems to have more than around 50 NOR returns in the most productive system (Hamma Hamma at this point), then the LAT is well above the observed carry capacity for the GAH lineage stock currently populating the Mid-HC systems.

Hood Canal Chinook will likely remain below this LAT for the duration of this this resource management plan (RMP).

The southern U.S. pre-terminal exploitation rate ceiling is 15% when the abundance of Mid-Hood Canal Chinook is forecasted above the LAT of 400 natural spawning adults. The PT-SUS exploitation rate ceiling is comparable to the higher annual exploitation rates observed in northern fisheries in recent years, and represents an equitable balance between SUS fisheries (when Mid-Hood Canal Chinook are abundant) and northern fisheries (when at higher ER levels). Most importantly, it provides a degree of protection to Mid-Hood Canal Chinook when the management unit is at higher abundances to help ensure that southern U.S. fisheries contribute to the recovery of the management unit.

When escapement is projected to fall below the LAT, the management unit will be considered in critical status, which will trigger a pre-terminal southern U.S. critical exploitation rate ceiling (CERC) of 12%. The 12% CERC is a minimal value to allow pre-terminal salmon fisheries targeting other stocks and species to occur. The new FRAM base period may cause the 12% CERC to be slightly more restrictive to pre-terminal fisheries than it was in the past, because FRAM validation runs using the new base period estimate the average PT-SUS exploitation rate on Mid-Hood Canal Chinook to be almost 2% higher than validation runs using the old base period. This will likely cause Mid-Hood Canal Chinook to be one of the primary driver stocks that will restrict Puget Sound salmon fisheries under this RMP.

The 12% pre-terminal southern U.S. CERC will ensure that southern U.S. fisheries do not impede the recovery of the Mid-Hood Canal Chinook management unit when it is in critical status, while allowing pre-terminal fisheries targeting other salmon stocks to occur within the limits imposed by these management objectives. Setting the CERC any lower would almost certainly close or extremely limit many pre-terminal fisheries that target other more abundant Chinook stocks and other salmon species, without providing any meaningful benefits toward Mid-Hood Canal Chinook recovery. The AEQ fishery mortality of natural origin Mid-Hood Canal Chinook in coast-wide salmon fisheries has averaged 14 NORs from 2005 to 2016 (Table 5). If, for example, the CERC had been established at half its present value (6%), it might have potentially put an average of three additional NOR spawners on the spawning grounds (stdev 1.9). Had pre-terminal SUS fisheries been eliminated entirely, it might have potentially contributed an average of seven additional NOR fish to the spawning grounds (stdev 3.7). Those very low numbers of potential additional natural origin fish on the spawning grounds with a reduction or absence of PT-SUS fisheries would not appreciably contribute to the recovery of Mid-Hood Canal Chinook. However, a PT-SUS CERC lower than 12% would have severe effects on pre-terminal fisheries without the benefit of contributing toward Mid-Hood Canal Chinook recovery. The 12% CERC is expected to have minimal effect on Mid-Hood Canal Chinook recovery, while allowing fishing opportunities to occur for other Chinook stocks and salmon species in mixed stock areas.

The PT-SUS ER ceiling (15%) and CERC (12%) have been the exploitation rate limits for Mid-Hood Canal Chinook since 2001, when the Puget Sound Chinook RMP was first implemented.

Commented [CI26]: Please add a column to Table 5 that estimates the NORs using this example. That is most relevant to the effect of this action RE: 4d criteria.

Commented [CI27]: Clearly describes what is the difference between the proposed action and no action at the proposed rates when predicted below LAT. The MUP text needs to make the same point with regard to the 15% rate in order to explain why the proposed framework, as a whole, meets the 4d criteria. I think that some years in Table 5 were managed for the 15% SUS rate, correct?

Table 5. Mid-Hood Canal Chinook AEQ fishery mortality in numbers of fish calculated using AEQ ERs from post-season FRAM validation runs with new base period.

Mid-Hood Canal Chinook AEQ Fishery Mortality						
Year	AK/CAN (SOR,HOR,NOR)	PT-SUS (SOR,HOR,NOR)	TERM (SOR,HOR,NOR)	TOTAL FMORT (SOR,HOR,NOR)	PT-SUS NOR FMORT	TOTAL NOR FMORT
2005	7	7	0	15	5	12
2006	5	5	0	10	3	7
2007	17	10	0	27	9	17
2008	51	36	1	88	16	31
2009	23	13	0	37	7	12
2010	15	12	0	27	4	9
2011	63	37	1	100	10	18
2012	69	77	2	148	1	3
2013	76	96	3	176	4	11
2014	21	27	0	48	7	19
2015	38	59	0	98	2	6
2016	41	31	1	73	10	19
Average	36	34	1	71	7	14

The upper management threshold (UMT) for Mid-Hood Canal Chinook corresponds with the escapement goal of 750 natural spawners. However, as a precautionary measure to enhance the recovery of Mid-Hood Canal Chinook, the PT-SUS exploitation rate ceiling of 15% will remain the exploitation rate limit, even when natural escapement is projected above the UMT. Thus, abundances projected above the UMT will not trigger an increase in the PT-SUS exploitation rate.

Data Gaps

- Reconcile evaluations by the TRT, EDT, and TNC Ecoregional Assessment indicating relatively favorable habitat conditions and capacity with opinions that in-river habit continues to be a significant limiting factor for Chinook recovery

- Assess the ability of Mid-Hood Canal rivers to support the natural production of various Chinook life histories (e.g. re-run EDT model for spring and late-fall runs)

- Evaluate historic and current flow regimes to determine whether the environment has changed and how that may affect Chinook survival

- Evaluate habitat and flow regimes to help determine if there is a more suitable stock with life history traits that would more closely match the current environmental conditions of Mid-Hood Canal rivers

- Continue to identify and improve the understanding of factors limiting the productivity of Chinook Salmon in Mid-Hood Canal rivers
- Collect and use additional adult escapement, spawner composition, and juvenile outmigrant data as they become available to improve understanding of the productivity and capacity of the management unit
- Compare EDT modeling results with empirical data from Mid-Hood Canal rivers, when those data become available and sufficient for analyses
- Continue to improve escapement estimates
- Continue to evaluate performance of preseason forecasts and make appropriate refinements
- Continue to monitor and evaluate historic and recent coded-wire tag recoveries, including recoveries of tags from the Hamma Hamma supplementation program, in fisheries and escapement to review current assumptions about effects of fisheries within Hood Canal and other Puget Sound marine areas upon Mid-Hood Canal Chinook
- Consider potential effects of climate change

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Dungeness Management Unit Status Profile

Component Populations

Dungeness River Chinook

Distribution and Life History Characteristics

Originating in the Olympic Mountains of Washington State, the Dungeness River and its main tributary, the Gray Wolf, drain a 270-square-mile watershed of steep mountains, deep forested canyons, and a broad open valley. With headwaters at 6,400 feet in Olympic National Park, the steep, 32-mile course of the Dungeness flows almost due north before emptying into the Strait of Juan de Fuca at sea level. The lower ten miles flow through a broad alluvial valley, which is characterized by a mixed use of small forested parcels, agriculture, and increasingly, a mix of rural/urban residential development in proximity to the City of Sequim (Jamestown S'Klallam Tribe, 2007).

Glacially colored water and chronically low returns of adults tend to obscure the entry timing of Dungeness Chinook, but they generally enter the river from May through September, peaking in July. Adult weir operations indicate that most of the adult Chinook return has entered the river by early August. Spawning occurs from early August through early October (WDFW, unpublished data). At the current low level of abundance, no distinct spring or summer populations are distinguishable in the return. Chinook typically spawn first in the upstream reaches and as the spawning season progresses, further downstream in the lower mainstem reaches (WDFW et al.1993).

Freshwater entry timing has been inferred from several sources of information, among them, broodstock trapping/netting observations in the lower river (RM 2.3), spawning surveys beginning in early August and intermittent steelhead surveys in the spring as water conditions allow. A lack of visibility and high water precludes direct observations of entry timing in late spring and early summer, however we know from the sources mentioned above that entry usually takes place sometime in May. The Dungeness and Elwha River Chinook are similar in spawn timing and appear to share similar river entry timing. Entry timing and runsizes have been estimated since 2009 (except 2011) on the Elwha River using SONAR (Denton et al. 2016). Elwha Chinook river entry timing has been documented as early as May 20 and ended near September 10 based on in-river netting to determine species composition during SONAR operation. Mid-June is the typical timing for first Chinook. The 50% passage rate for Elwha Chinook has occurred between July 20th and August 1st. WDFW recently purchased a SONAR unit which will be used in the Dungeness River to detect river entry timing and run size.

Chinook spawn in the Dungeness River up to RM 18.9, where falls just above the mouth of Gold Creek block further access. Spawning distribution in recent years has been weighted toward the lower half of the accessible reach, with approximately seventy-three percent of redds located downstream of RM 10.8, which is near the Dungeness Hatchery (Table 1 and Figure 1).

Chinook also spawn in the Gray Wolf River (confluence with Dungeness at RM 15.8) up to RM 6.

Table 1. Historic comparison of Redd distribution, 1998 – 2016.

Historic Comparison of Redd Distribution, 1998 through 2016									
Stream and section	Reach	SURVEY REACHES (miles)			Minimum	Maximum	Average		Average
Lower Dungeness River (RM 0.5-RM 10.8)	Number	Lower RM	Upper RM	Total length	Redd count	Redd count	Redd count	Proportion	redds/mile
Mouth to Woodcock Bridge	1	0.50	3.30	2.80	2	127	30.2	0.174	10.79
Woodcock Bridge to Hwy 101	2	3.30	6.40	3.10	1	128	37.5	0.216	12.09
Hwy 101 to Taylor Cut-Off - May	3	6.40	9.20	2.80	5	88	33.0	0.190	11.79
Taylor Cut-Off - May to Canyon Ck.	4	9.20	10.80	1.60	4	75	25.3	0.145	15.79
Total				**10.30**				**0.725**	
Upper Dungeness River (RM 10.8-RM 18.7)									
Canyon Creek to Clink Bridge	5	10.80	13.80	3.00	0	79	18.8	0.108	6.26
Clink Bridge to Forks Campground	6	13.80	15.80	2.00	0	59	11.0	0.063	5.50
Forks Campground to East Crossing	7	15.80	17.50	1.70	0	42	7.2	0.042	4.24
East Crossing to Gold Creek	8	17.50	18.70	1.20	0	13	1.5	0.009	1.27
Total				**7.90**				**0.222**	
Gray Wolf River (RM 0.0-RM 6.1)									
Mouth to RM 1.0 Bridge	9	0.00	1.00	1.00	0	26	4.6	0.026	4.58
RM 1.0 Bridge to Above 2 Mile Camp	10	1.00	2.50	1.50	0	38	4.1	0.023	2.70
Above 2 Mile Camp to Cliff Camp	11	2.50	4.00	1.50	0	5	0.5	0.003	0.32
Cliff Camp to Slab Camp -Suppl. Surveys	12	4.00	5.10	1.10	0	3	0.3	0.002	0.24
Slab Camp and upstream 1 mile -Suppl. Surveys	13	5.10	6.10	1.00	0	0	0.0	0.000	0.00
Total				**6.10**				**0.0540**	

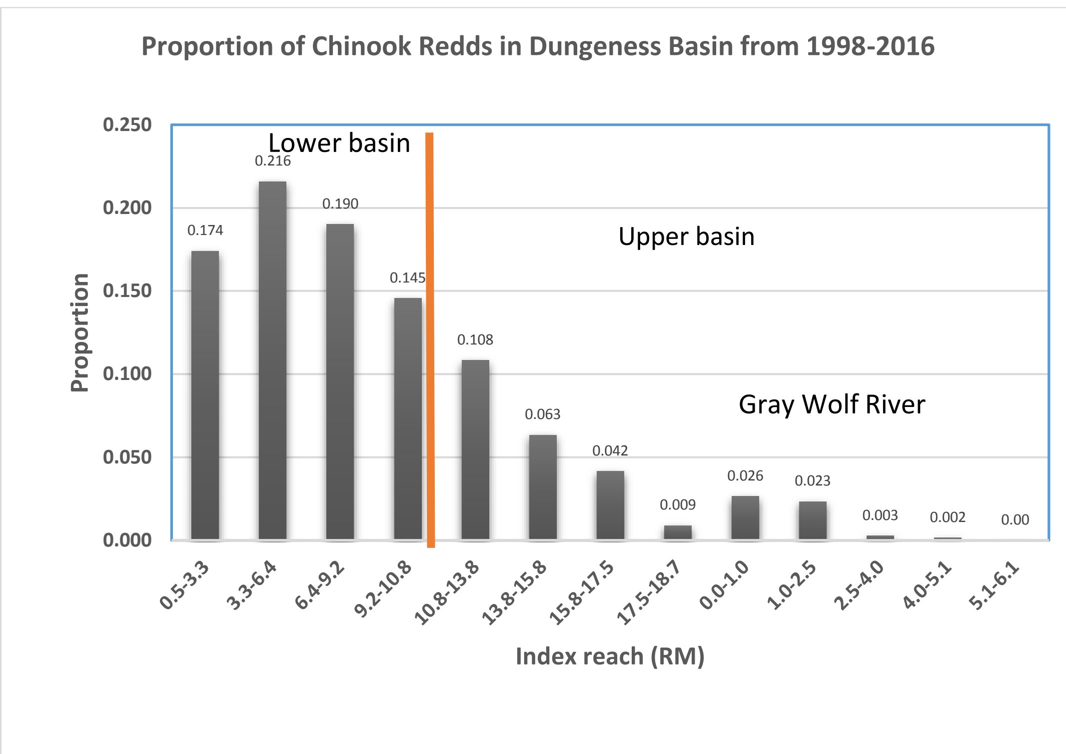

Figure 1. Proportion of Chinook redd in Dungeness Basin from 1998-2016

Juvenile Chinook from the Dungeness River exhibit primarily an ocean-type life history, with age-0 emigrants (sub-yearling) comprising 95 to 98 percent of the total (WDF et al.1993, Smith and Sele 1994, and WDFW 1995 cited in Myers et al.1998). Adults mature primarily at age four (60%), with age 3 and age 5 adults comprising 18% and 22%, of the annual returns, respectively (WDFW, unpublished data) (Table 2).

Stock Status

The SASSI report (WDF et al.1993) classified the Dungeness spring/summer as critical due to chronically low spawning escapements to levels such that the viability of the stock was in doubt and the risk of extinction was considered to be high. Dungeness Chinook continue to be classified as critical in the SASSI report (WDFW 2003) because of continuing chronically low spawning escapements.

<u>Dungeness Escapement 1986-2016</u>

The calculated escapement goal for the Dungeness River is 925 spawners, natural and supplementation origin, based on historical escapements observed in the 1970's and estimated production capacity re-assessed in the 1990's (Smith and Sele 1994). Although there have been small improvements in habitat since the 1994 survey, the escapement goal of 925 is still considered applicable due to relative similar habitat conditions. There are some major habitat restoration projects (e.g. dike setback) in the planning phases which may increase capacity. Upon completion of these projects production capacity may be assessed again. From 1986 through 2000, the average total escapement was only 153. Escapements increased from 2000 through 2006, averaging 893. However, this increase is largely attributable to the captive brood supplementation program. Estimates of natural-origin fish have remained low, averaging only 179 from 2001-2006. The captive brood program, by design, came to a conclusion after the 2003 brood (see below for description of hatchery actions), and returns from the program peaked in 2006. Subsequent escapements have again declined to lower levels. From 2007 through 2016, the average escapement was 400, natural and supplementation origin, and ranged from 204 to 665.

Dungeness Chinook escapement is considered the Terminal Run Size (TRS) due to no directed terminal harvest and minimal incidental terminal harvest. Incidental terminal catch in Dungeness Bay (Catch Area 6D) has averaged less than 1 fish per year over the last 10 years and these are not included in the TRS data included in this analysis. There are no records of incidental catch in the river itself over the last 10 years as fisheries are planned to begin after spawning is complete. See Table 2 below for TRS by year and Table 3 for Natural Origin (NOR) and Hatchery Origin (HOR) breakdown.

Table 2. Dungeness River Chinook adult ages for Return Years 1988-2016.

Return year	Age 3	Age 4	Age 5+	TRS
1988	0	306	66	372
1989	51	15	29	95
1990	0	361	0	361
1991	28	143	28	199
1992	1	115	38	154
1993	8	5	41	54
1994	12	49	4	65
1995	18	104	41	163
1996	5	112	66	183
1997	8	13	31	52
1998	3	92	15	110
1999	16	13	46	75
2000	65	140	13	218
2001	22	412	19	453
2002	114	104	415	633
2003	32	427	181	640
2004	181	627	206	1,014
2005	199	600	278	1,077
2006	19	1,025	499	1,543
2007	108	95	200	403
2008	77	146	6	229
2009	49	152	19	220
2010	231	207	19	457
2011	315	304	46	665
2012	157	413	44	614
2013	26	220	32	278
2014	88	93	23	204
2015	101	279	27	407
2016	121	303	90	514
Mean	71	237	87	395
Stand. dev	80	226	124	347
95% CI	38	108	59	165
Sample size	29	29	29	29
SQRT (n)	5.39	5.39	5.39	5.39
Lower CI	33	129	28	230
Upper CI	109	345	146	560
Proportion	0.1795	0.6003	0.2202	1.0000

For return years 2007-2016, the NOR portion of the Chinook returns ranged from 43 to 250 and the number of HOR returns ranged from 90 to 561. The ten-year average proportions of NORs and HORs are 0.3428 and 0.6572, respectively (Table 3).

Table 3. Total number of NOR and HOR natural spawners and broodstock in the Dungeness River for return years 2007-2016.*

Return year	Natural spawners 1/ NOR	Natural spawners 1/ HOR	Natural spawners 1/ NOR+HOR	Broodstock collection 2/ NOR	Broodstock collection 2/ HOR	Broodstock collection 2/ NOR+HOR	Natural Spawners + Broodstock NOR	Proportion NOR Spawners + Broodstock	Natural Spawners + Broodstock HOR	Proportion HOR Spawners + Broodstock	Total returns NOR+HOR
2007	146	159	305	47	51	98	193	0.4789	210	0.5211	403
2008	86	54	140	53	36	89	139	0.6070	90	0.3930	229
2009	71	57	128	42	50	92	113	0.5136	107	0.4864	220
2010	76	269	345	18	94	112	94	0.2057	363	0.7943	457
2011	83	452	535	21	109	130	104	0.1564	561	0.8436	665
2012	212	296	508	38	68	106	250	0.4072	364	0.5928	614
2013	46	122	168	31	79	110	77	0.2770	201	0.7230	278
2014	21	87	108	22	74	96	43	0.2108	161	0.7892	204
2015	65	200	265	37	105	142	102	0.2506	305	0.7494	407
2016	135	273	408	30	77	115	165	0.3204	350	0.6796	515 4/
Mean	94.1	196.9	291.0	33.9	74.3	109.0	128.0	0.3428	271.2	0.6572	400.0

1/ Natural spawners: Chinook that spawned naturally in the river. Natural spawner estimate based on redd surveys.
2/ Broodstock collection: Chinook that were collected in the river or returned to the hatchery and used for broodstock. Total includes pre-spawn mortalities.
3/ NORs and HORs determined by CWT detection, otolith marks, scales, or visible marks (adipose clips) from broodstock and river carcasses sampled.
4/ Excludes 8 jacks
*The NOR/HOR data is not as reliable prior to 2007 and was not included in the table

<u>Dungeness Juvenile Salmonid Outmigrant Monitoring 2005-2016</u>

WDFW has operated a floating five-foot diameter screw trap in the lower Dungeness each year since 2005, to estimate the number of juvenile salmon produced in the basin. This trap is operated continuously between February to late July or mid-August. High water events, debris, and mechanical failures may shut down trapping operations temporarily. Although the hatchery released Chinook are unmarked, they are 100% Coded Wire Tagged (CWT). Hatchery produced juvenile Chinook migrants can be distinguished from natural juveniles caught in the screw trap by scanning with a CWT detector.

Due to the low abundance of NOR yearling Chinook in the Dungeness, production estimates for them have not been calculated. Since 2005, the number of naturally produced sub-yearling Chinook in the Dungeness River ranged from a low of 3,870 in 2015 to a high of 164,815 in 2013. In that time period an average of 54,507 sub-yearlings has been naturally produced in the Dungeness River. The two lowest years for Chinook sub-yearling production have been recent with 3,870 in 2015 and 5,556 in 2016 (Table 4) (Data are available in WDFW juvenile monitoring annual report series, including Topping et al. (2008)). Juvenile Chinook outmigration in the Dungeness typically peaks around late May and is 99% complete by the beginning of August.

Table 4. Dungeness Juvenile Salmonid Production 2005-2016.

Catch and estimated production of juvenile salmonids migrating from the Dungeness River (2005-2016)

Begin	End	Subyearling Chinook Natural Prod.	Subyearling Chinook Hatchery Prod.	Natural 0+ Coho Prod.	Natural 0+ Pink Prod.	Natural 0+ Chum Prod.	Natural 1+ Steelhead Prod.
3/8/2005	8/5/2005	81,865		57,095			9,192
2/2/2006	8/17/2006	136,724		43,888	696,642	194,721	6,125
2/21/2007	8/19/2007	110,021	65,016	22,134		381,781	11,445
2/13/2008	8/12/2008	11,612	74,038	21,293	472,334	98,483	10,344
2/19/2009	8/12/2009	20,443	11,374	30,780	43,161	630,358	10,101
2/8/2010	7/28/2010	10,604	36,547	38,210	197,963	41,326	17,486
2/9/2011	8/31/2011	10,250	63,608	26,280	33,209	202,658	19,600
2/14/2012	8/28/2012	71,810	72,868	31,794	3,687,547	38,968	5,521
2/6/2013	8/8/2013	164,815	74,038	52,336	11,043	338,568	7,812
1/16/2014	8/13/2014	26,513	86,954	35,839	29,547,068	92,275	13,167
2/4/2015	7/28/2015	3,870	101,696	6,040		155,645	5,972
2/3/2016	7/25/2016	5,556	73,279	20,493	89,802	23,927	4,354
Average production all years		54,507	65,902	32,182		275,337	10,093

Data source DRAFT: Pete Topping, WDFW

1/ Natural origin Chinook production estimates are extrapolated to and starting date of 1/15 and an ending date of 8/31
2/ Production estimates for Chinook, chum and pink are generated using maiden captured fish that are marked after capture and released above the trap. Individual efficiency tests are pooled using a G-test to inform efficiency strata that are applied to the estimated maiden catch for each efficiency strata.
3/ Production estimates for coho and steelhead are generated by utilizing a two trap design, coho and steelhead captured in a weir trap on Matriotti Creek located upstream of the screw trap are marked, released, and recaptured downstream in the screw trap (Pete Topping, WDFW).

Estimated egg to smolt survival has averaged 5.03% since trapping began (Table 5). There is concern among the co-managers about flow related mortality associated with egg-to-smolt survival. When looking at peak annual flows, there is a relationship between flow and egg-to-smolt survival in the Dungeness River. In the years with higher peak flows, egg to smolt survival is down compared to years with lower peak flows. The last two years (2015 and 2016) have seen some of the highest flows, as well as the highest number of days at high flow. Consequently, the last two years have had the lowest egg-to-smolt survival since 2005 (Table 5 and Figure 2). For comparison, similar data collected in the Skagit River, a healthier Chinook system, produce egg to smolt survival estimates of around 8% for the same period, and over 10% since 1990. The low egg to smolt survival rate estimates for Dungeness Chinook are indicative of the habitat degradation mentioned in this report, along with flow related issues and of the general low productivity of the population.

Table 5. NOR sub-yearling production and egg-to-smolt survival related to peak flow (CFS) 2005-2016.

Natural origin subyearling Chinook production and estimated egg to migrant survival related to peak flow (CFS) during inter-gravel period, Dungeness River trapping years 2005-2016.								
	Max Flow (CFS) Oct 1 thru Feb 1				Estimated			
Trap			# Day's flows	Number	Deposition	Subyearling	Egg to migrant	Migrants
Year	CFS	Date	> 2000CFS	Redds	at 5,300 eggs	production	Survival	Per Redd
2005	2130	10-Dec	2	381	2,019,300	81,865	4.05%	215
2006	2440	25-Dec	1	382	2,024,600	136,724	6.75%	358
2007	1820	15-Dec	0	562	2,978,600	110,021	3.69%	196
2008	3180	4-Dec	2	122	646,600	11,612	1.80%	95
2009	1640	8-Jan	0	56	296,800	20,443	6.89%	365
2010	3100	12-Jan	5	51	270,300	10,604	3.92%	208
2011	3890	12-Dec	2	138	731,400	10,250	1.40%	74
2012	1500	23-Nov	0	214	1,134,200	71,810	6.33%	336
2013	1450	1-Dec	0	203	1,075,900	164,815	15.32%	812
2014	817	11-Jan	0	67	355,100	26,513	7.47%	396
2015	3680	10-Dec	6	43	227,900	3,870	1.70%	90
2016	3420	9-Jan	6	106	561,800	5,556	0.99%	52

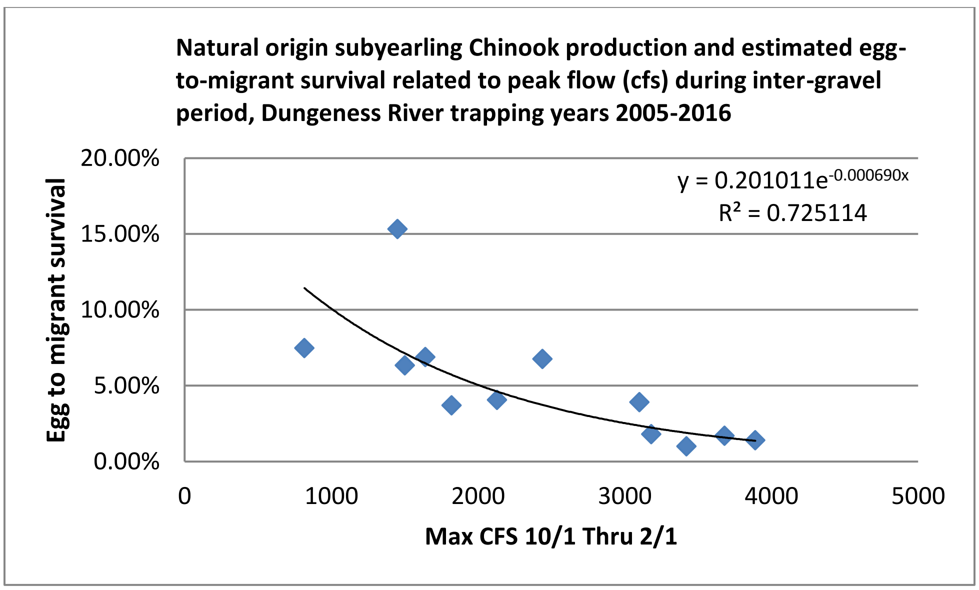

Figure 2. NOR sub-yearling Chinook production vs Peak Flow (CFS).

Another concern for co-managers is the low in-river survival rate associated with hatchery Chinook. Since 2007, the average survival rate for hatchery Chinook from release site to the trap site was 50.3% and has gone as low as 12% in 2009 (Figure 3). While we cannot directly measure predation on NOR Chinook, the mortality rate associated with HOR Chinook is high enough to raise significant concerns about NOR mortality in the river. Aside from flow related mortality, predation from native species such as Bull Trout and various shore birds is the main concern for in-river survival. In recent years, some measures have been taken to try and reduce predation on hatchery Chinook. This involved trucking one CWT release group from its rearing location to river mile 0.5 to be released. Upon return, we will be able to assess survival between release groups and if the measures were successful in helping to prevent in-river mortality by comparing them to the other release groups.

The Dungeness River drains into Dungeness Bay, which includes the 1.2 sq. mi Dungeness Wildlife Refuge (DWR). The 5.5-mile-long natural sand spit (Dungeness Spit), Graveyard Spit, and portions of Dungeness Bay and Harbor are within the refuge. This area provides habitat for nesting colonies of seabirds and haul-out areas for marine mammals. Known predators of juvenile salmon and steelhead, such as Caspian terns, Glaucous winged/Western gulls, and harbor seals are present in Dungeness Bay (Pearson et.al. 2015). The extent of predation on outmigrant salmon and steelhead by these predators in this estuary is currently unknown.

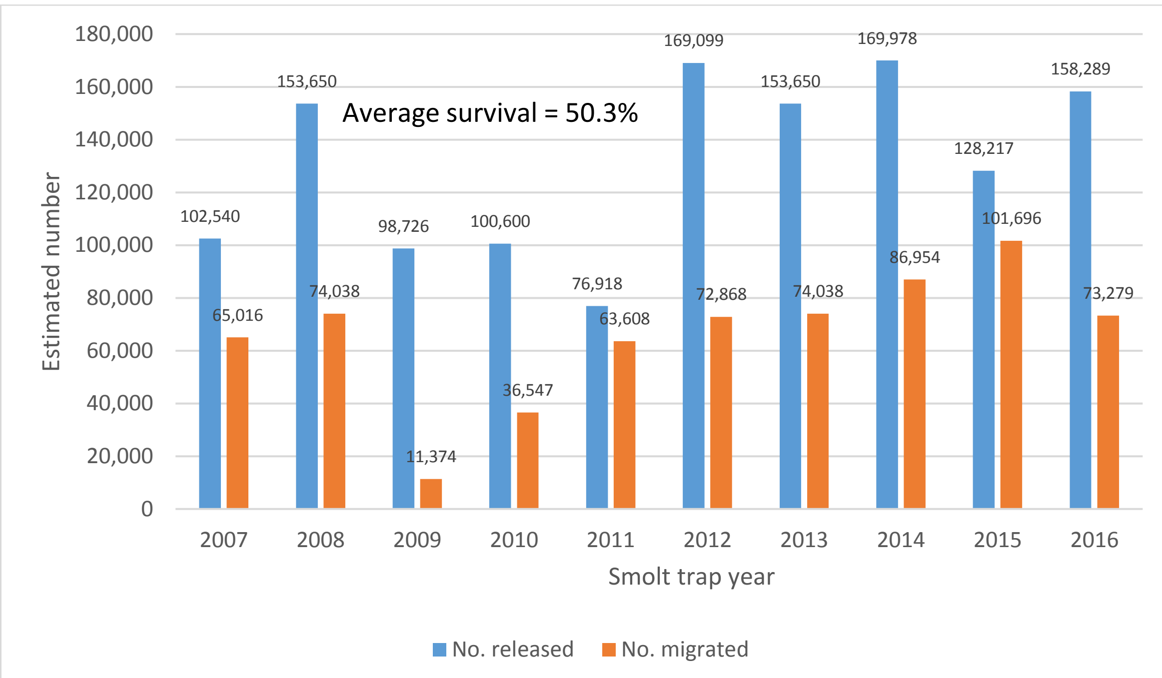

Figure 3. Number of hatchery Dungeness Chinook sub-yearlings released in the Dungeness basin and the estimated number Chinook sub-yearlings migrating past trap located at RM 0.5 by trap year.

<u>Dungeness Marine Survival and Productivity</u>

The Smolt-to-Adult Rate (SAR) survival for Dungeness Chinook is relatively low, with an average of 0.0049 from 2004 through 2011. NOR smolt-to-adult return rates were estimated by dividing the number of NOR adults produced from natural spawners by the number of natural origin smolts. NOR return rates, based on age 2 to age 5 returns, ranged from 0.0008 to 0.0116 (Table 6). Recruits per Spawner (R/S) or Adult (HOR+NOR natural spawners) to Adult (NOR) production were measured for brood years 2004 to 2011 and ranged from 0.0598 to 1.6286 and averaging 0.4499 for the 8- year period.

Table 6. NOR smolt- to- adult return rates and recruits per spawner (R/S) or adult (NOR+HOR) -to-NOR adult return rates for Dungeness River Chinook for brood years (spawn years) 2004-2011.

Spawn year	Total natural spawners	Smolt trap year	Juvenile Chinook abundance	Age 2 NOR	Age 3 NOR	Age 4 NOR	Age 5 NOR	Age 6 NOR	Total NOR	NOR Smolt- to-Adult Rates (SAR)	R/S Adult-to-Adult Rate
2004	953	2005	81,865	0	75	98	17	0	190	0.0023	0.1994
2005	955	2006	136,724	0	38	96	12	0	146	0.0011	0.1529
2006	1,405	2007	110,021	0	4	57	23	0	84	0.0008	0.0598
2007	305	2008	11,621	0	25	44	19	0	88	0.0076	0.2885
2008	140	2009	20,443	0	37	175	16	0	228	0.0112	1.6286
2009	128	2010	10,604	0	56	57	10	0	123	0.0116	0.9609
2010	345	2011	10,250	0	2	21	11	0	34	0.0033	0.0986
2011	535	2012	71,810	0	13	74	26	TBD	113	0.0016	0.2112
2012	508	2013	164,815	0	14	120	TBD	TBD	134	TBD	
2013	168	2014	26,513	0	16	TBD	TBD	TBD	TBD	TBD	
2014	108	2015	3,870	4	TBD	TBD	TBD	TBD	TBD	TBD	
2015	265	2016	5,556	TBD	TBD	TBD	TBD	TBD	TBD	TBD	

It should be noted that smolt-to-adult survival in the natural spawning population is higher than that of the hatchery component on average. Hatchery SAR's typically fall below 0.4% and average around 0.1% (Figure 4.)

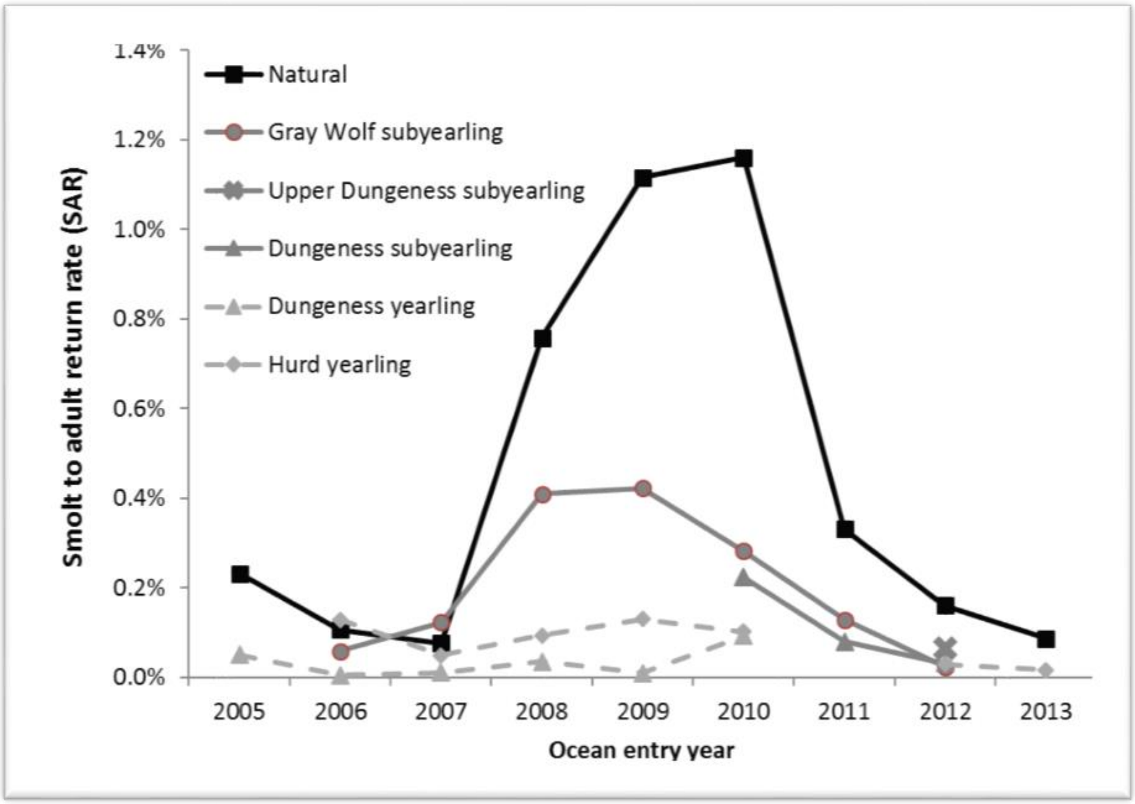

Figure 4. Smolt to adult return rate of natural origin (black) and hatchery produced (gray) Chinook salmon in the Dungeness River. Natural survivals are from the river mouth (smolt trap location) to adult return, whereas hatchery survivals are from release to adult return. In comparison to the natural survival, hatchery estimates therefore include the additional mortality suffered in the river prior to ocean entry. We do not know in-river mortality for natural smolts due to the fact that the trap is near the mouth. Natural SAR rates are likely less when taking into account in-river mortality. Estimates are total return to the river, and do not account for fishing mortality. DRAFT January 10 2017: Randy Cooper, Pete Topping, and Joe Anderson WDFW.

<u>Hatchery and Habitat Practices/Projects</u>

Chinook production in the Dungeness River is constrained primarily by degraded spawning and rearing habitat in the lower half of the basin. Significant channel modification has contributed to substrate instability in spawning areas, and has reduced and isolated side channel rearing areas. Water withdrawals for irrigation during the migration and spawning season have also limited access to suitable spawning areas and decreased habitat availability.

The co-managers, in cooperation with federal agencies and private-sector conservation groups, implemented a captive brood stock program in December 1991 to rehabilitate Chinook runs in the Dungeness River. The primary goal of this program was to increase the number of fish spawning naturally in the river, while maintaining the genetic characteristics of the existing stock. The last significant egg-take from the captive brood program occurred in 2003. Beginning in 2004, returning adults were collected and spawned, with the goal of releasing 100,000 accelerated zeros (sub-yearlings) and 100,000 yearlings each year. Subsequent escapement data demonstrated that the accelerated zero releases out-performed the yearling releases. Consequently, the release strategy has been adjusted to include 200,000 accelerated zero aged Chinook as well as an additional 50,000 yearling Chinook annually. There are 4 separate rearing and release sites for Dungeness Chinook. Chinook are reared at Hurd Creek Hatchery and Dungeness Hatchery. CWT groups are released from these hatcheries along with two upper river acclimation sites in the Grey Wolf River and Upper Dungeness. Each release group has a distinctive CWT ID and all releases are unmarked.

In 2013, the Washington Department of Ecology adopted the Dungeness Water Management Rule. "The intention of the Water Rule is to guide planning and decision making for new water users, as well as set policies to help protect the availability of water for current and future needs of people and the environment" (Dungeness Water Exchange, website). The Rule sets instream flow levels for the mainstem Dungeness as well as several of its tributaries. These established instream flow levels are used to determine how much water is withdrawn from the river during the low flow season. As the flow and water levels drop, the amount of water that is withdrawn from the river is reduced in correlation.

In addition to the broodstock program and Water Rule implementation, the local watershed council (Dungeness River Management Team) and the local lead entity for salmon (North Olympic Lead Entity for Salmon) along with a group of state, tribal, county and non-profit organizations are working on several habitat restoration efforts. Following the recommendations of the various recovery, restoration, and conservation plans, restoration practitioners have installed 20 engineered log jams, lengthened and made salmon-friendly the pedestrian bridge at Railroad Bridge Park, installed many miles of water conserving irrigation piping, and permanently over conserved 200 acres of floodplain properties. Two projects have restored Dungeness Estuary habitats. Other projects including larger scale riparian land acquisition, dike setback and bridge lengthening are in the planning, analysis and proposal phases. The Middle-Corps dike setback is expected to begin construction in 2018.

Management Objectives

The management objectives for Dungeness Chinook are to stabilize escapement and recruitment, with the ultimate objective of restoring the natural-origin recruit population through adaptive hatchery supplementation, habitat improvements, and fishery restrictions.

The Upper Management Threshold (UMT) for the Dungeness MU is a TRS of 925 naturally spawning adults, corresponding to the calculated escapement goal described above. The Low Abundance Threshold (LAT) is a TRS of 500 adult returns (HOR + NOR). This threshold represents a reasonable balance between demographic and genetic risks facing this small population. Based on the recent-year average of NORs in the population (32.04%; Table 3), the 500 LAT would correspond to an average of 160 NORs and 340 HORs. These abundances would provide enough brood stock to sustain the small hatchery program, which is an important demographic safety net for the population, while allowing NORs to spawn naturally.

Historically, however, abundance of NORs has ranged between 43 and 250 with the population above the critical level in three of the last 10 years, and experience has shown that when TRS is less than 500 additional management actions should be considered to protect the population. Genetically, the LAT of 500 would also minimize potential inbreeding depression and maintain the evolutionary potential of the population. This can be seen in the context of the 50/500 rule, where a genetic effective size (N_e) of greater than 50 minimizes the loss of fitness from inbreeding and N_e of 500 or more maintains the balance between genetic diversity lost to genetic drift and the new genetic diversity from mutation and gene flow (Franklin 1980, Frankel and Soule 1981), which preserves the adaptive potential of the population. For the Dungeness population with an LAT of 500, inbreeding N_e would be 384 after accounting for Ryman-Laikre effects from the hatchery (Ryman and Laikre 1991), assuming future variability for the proportions of hatchery fish spawning in the wild, brood stock sizes, and abundance of the natural spawning aggregation are similar to what occurred between 2007-2016. Therefore, the appropriate criterion to compare 384 to is 50 in the 50/500 rule**.** Conversely, to evaluate the capacity of an LAT to maintain the evolutionary potential of the population, it is necessary to consider the loss of genetic diversity from genetic drift and new diversity from gene flow. This involves calculating a global genetic effective size based on metapopulation structure (Jamieson and Allendorf 2012). Based on analysis of gene flow among 35 Puget Sound Chinook Salmon populations at 13 microsatellite loci, Dungeness Chinook are part of a larger metapopulation consisting of Skykomish and Snoqualmie Chinook Salmon. (Note: The Elwha Chinook population, which based on empirical observations that straying is more common as geographical proximity increases, may also be part of this metapopulation but no data were available to analyze its contribution). The available data show that Skykomish and Snoqualmie populations contributed an average of 8-9 genetically effective migrants per generation to the Dungeness. This leads to a global genetic effective size of approximately 5520. The appropriate criterion to compare 5520 to is 500 in the 50/500 rule. All of this indicates that an LAT of 500 maintains the evolutionary potential of the population.

The above analysis is based on data from Dungeness Chinook using genetic markers to estimate straying. While data is lacking for actual NOR stray rates we do observe some straying in the HOR component. Since 2002, nineteen sampled HOR Chinook in the Dungeness River have come from various other hatcheries. Of those 19 Chinook, fifteen of them were from the Elwha River hatchery, while the other 4 came from George Adams, Glenwood Springs and Nooksack hatcheries. This is based on CWT's recovered on the spawning grounds or for the supplementation program. The observed straying in the HOR component is likely to be replicated in the NOR component, although we cannot estimate how much straying or from what populations it will occur.

The Fisheries Regulation Assessment Model (FRAM) is the tool used for the following management metrics. When projected escapement to the Dungeness River exceeds the LAT of 500, Southern U.S. (SUS) fisheries will be managed to not exceed a 10.0% Exploitation Rate (ER) ceiling. If escapement is projected to be below the LAT, SUS fisheries will be managed to further reduce fishery mortality to AEQ (adult equivalent mortality) impacts of less than 6.0%. Projected escapement refers to the FRAM accounting for the combined hatchery and natural origin recruits or adults. Fishery mortality in terminal and extreme terminal fisheries (Dungeness Bay and River) is expected to be very low for the duration of this plan. This is because Chinook-directed commercial and recreational fisheries are not expected to occur, and coho and pink fisheries will be regulated to limit incidental Chinook mortality. In general, SUS harvest is minimal, especially when compared to harvest in Canadian and Alaska fisheries (Table 7). Using projections of the FRAM new base period post-season runs (as of round five of the QAQC process, August 2017), the pre-terminal SUS ER has averaged 3% over the last 10 years and the terminal ER has averaged 0.7% over the same time period. In contrast, harvest in Canadian and Alaska fisheries have averaged 12% ER over the last 10 years with 2 years reaching as high as 20%. In years 2011 and 2012, when the forecast exceed the LAT and preseason fisheries were managed to 10%, projected SUS harvest (based on new base period post-season FRAM) stayed at 6% or below (Table 7). NOAAF currently recommends a 4% Recovery Exploitation Rate (RER) for Dungeness Chinook based on surrogate data used from the Nooksack River. However the co-managers feel that may unnecessarily constrain SUS fisheries while providing little in return to the Dungeness River. A 6% difference in ER amounts to 30 total Chinook using a forecast of 500 adult returns. Applying the 34% NOR rate results in only 10 more NOR Chinook returning to the river, which is insignificant regarding recovery of the stock. The pre and post-season mortality estimates for each SUS fishery are very minimal (Table 8). To return an additional 30 Chinook to the Dungeness River, entire fisheries in mixed stock areas would need to be closed. Therefore a 10% ER ceiling when the forecast is above the LAT and a 6% ER ceiling when the forecast is below the LAT are expected to have a minimal impact on Dungeness Chinook and may provide fishing opportunities for other Chinook stocks in mixed stock areas.

Table 7. New Base Period post season FRAM exploitation rates for Dungeness Chinook 2005-2014.

Year	Northeren ER	PT SUS ER	Terminal SUS ER	Total ER
2005	7%	1%	0%	8%
2006	5%	1%	0%	6%
2007	14%	3%	0%	18%
2008	20%	4%	2%	26%
2009	8%	3%	5%	16%
2010	14%	6%	0%	20%
2011	20%	5%	0%	25%
2012	13%	4%	0%	17%
2013	7%	4%	0%	10%
2014	11%	4%	0%	15%
10 yr Avg	**12%**	**3%**	**1%**	**16%**

The co-managers have not identified a point of instability, or lower bound, below the Low Abundance Threshold for Dungeness Chinook. The LAT of 500 returning adults is likely close to the point of instability, and will be treated as such. Should preseason forecasts slip much below the LAT, the co-managers will consider what additional fishery actions may be appropriate to provide further protection for Dungeness Chinook. Past fishery actions have included closure of terminal fisheries during times of spring Chinook presence, and closure of summer marine area recreational Chinook fisheries in the vicinity of the Dungeness River (eastern portion of Catch Area 6). The east part of Area 6 is a rather large area in the Eastern Strait of Juan de Fuca and as such a mixed stock area. It has been closed to protect Dungeness

Chinook for several years now. This is currently the only complete closure of a mixed stock area to protect a listed species. In 2017, the winter Chinook fisheries in the Strait of Juan de Fuca (catch areas 5 and 6) were also shortened in duration to help protect Dungeness Chinook. These actions are likely to continue in the future, and other actions such as additional closures or restrictions may be considered if there is not an improvement in the status of this stock.

Dungeness Chinook CWT release groups were not adipose fin clipped during the updated base period years used to calibrate the FRAM. The FRAM is used by the co-managers during preseason fisheries planning and postseason exploitation rate evaluation, and an adipose fin clip is essential for CWT detection in many FRAM fisheries. Therefore, for the new Base Period FRAM calibration, a surrogate procedure was used to simulate the Elwha and Dungeness River Chinook (ELDU) CWT recoveries. After an analysis of Salish Sea Chinook populations, it was determined that the Stillaguamish Chinook population was the best proxy for ELDU exploitation in fisheries outside of the Salish Sea (McHugh, unpublished). For pre-terminal fisheries outside the Salish Sea, ELDU CWT recoveries were simulated using a one-to-one ratio with Stillaguamish CWT recoveries from the new Base Period. For fisheries inside the Salish Sea, ELDU CWT recoveries were based on Stillaguamish CWT recoveries from the new Base Period, and the historic relationship of CWT recoveries between ELDU and Stillaguamish in years when both management groups were released with CWTs and adipose fin clips (Gordon Rose, NWIFC, personal communication). The accuracy of FRAM's projections of Dungeness Chinook exploitation may be limited by the small stock size and surrogate procedure. However, the co-managers will continue to develop and adopt conservation measures that protect critical management units, while realizing the constraints on quantifying their effects in the simulation model. Specifically, when sufficient years of CWT and adipose clipped Elwha Chinook releases have accrued, an out-of-base FRAM calibration procedure using those tag groups will be explored.

Contribution to Fisheries

No harvest is presently directed on wild or hatchery Chinook produced in the Dungeness River. Treaty and non-Treaty fisheries directed at species other than Chinook are managed to minimize incidental effects to Dungeness Chinook salmon. While there is currently no directed harvest on Dungeness spring Chinook salmon in the terminal area, there is a commercial fishery directed at hatchery coho, that takes place in Dungeness Bay (Catch area 6D). The start date for this fishery is intentionally delayed until late September to avoid incidental harvest on Dungeness Chinook. Furthermore, any Chinook that may be caught during the early part of the fishery is required to be released unharmed. The fishery is heavily monitored to ensure incidental Chinook are not harvested as well as to record mark rates for coho. Incidental Chinook impacts in the Dungeness Bay coho commercial fishery have averaged less than one fish per year over the last 10 years. There is also a sport fishery for coho in Dungeness Bay and River as well as a hand held treaty subsistence fishery in the river, all of which are restricted to the time period after Chinook spawning is considered 100% complete. There are also commercial opportunities and mark selective sport fisheries in mixed-stock areas that have minimal incidental impacts to Dungeness Chinook (table 8). Since 2004, hatchery produced Dungeness Chinook have been CWT'd but not clipped in order to avoid direct harvest in mixed stock selective fisheries. There are no plans to adipose clip hatchery Chinook released from the Dungeness. Harvest opportunity is the long-range objective, both direct and indirect, when recovery goals are attained.

Table 8 below was provided by the WDFW Fish Management Ocean Management group and contains information on the contributions to fisheries for Dungeness Chinook salmon. These data reflect mortalities, rather than “landed catch” or escapements for unmarked hatchery- and natural-origin Dungeness Chinook salmon. Looking at the table, SUS AEQ mortality is very minimal, averaging 23 total mortalities annually from 2008 through 2014, while fisheries to the North (particularly Canada) have averaged 77 total mortalities annually during the same time period. Most SUS impacts to Dungeness Chinook occur in the winter/spring time period due to the fact that the Chinook and start to return to the river in May. Currently, the main SUS fisheries impacting Dungeness Chinook are the Area 5 and 6 sport fisheries during the winter time period (spring blackmouth fishery) and the Strait of Juan de Fuca treaty troll during the winter time period with some smaller impacts associated with the same fisheries in the summer time period. Tables 9 and 10 below represent recent CWT Recovery estimates from all North Pacific fisheries, although Dungeness Chinook CWT’s are only detected in fisheries that electronically sample catch because Dungeness hatchery releases are not adipose clipped.

Table 8. Impacts on Dungeness Chinook by fishery expressed as adult equivalent (AEQ) mortalities.

Impacts on Dungeness Chinook By Fishery Expressed as adult equivalent (AEQ) Mortalities										
Fishery	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**
Canada	58	77	N/A	24	21	102	177	76	18	61
Alaska	10	11	N/A	3	3	13	20	13	2	6
South of Falcon	0	0	N/A	0	0	0	0	0	0	0
NoF Ocean (Non-Treaty)	2	1	N/A	0	0	2	2	1	0	0
NoF Ocean (Treaty)	4	5	N/A	2	2	9	4	3	0	2
PS Treaty Troll	5	7	N/A	1	2	1	4	7	1	0
Area 5 Sport	4	3	N/A	1	1	3	13	7	1	1
Area 6 Sport	5	9	N/A	4	3	4	16	6	3	1
Area 7 Sport	2	2	N/A	1	1	3	3	1	0	1
Area 8-13 Sport	4	4	N/A	1	1	4	4	3	1	1
Puget Sound Net (Non-Treaty)	1	1	N/A	0	0	0	0	0	0	0
Puget Sound Net (Treaty)	1	2	N/A	2	1	3	2	2	9	10
FW Sport	0	0	N/A	0	0	0	0	0	2	0
FW Net	0	0	N/A	0	0	0	0	0	0	0
Escapement	364	347	N/A	198	271	614	649	435	189	222

1/2016 and 2017 data come from pre-season estimates.
2/2014 and earlier data come from post-season data.
3/2015 data are not yet available (managers have a new base period for Chinook, so no preseason run is available for 2015; the most recent post-season run was for 2014).

Table 9. Dungeness River Hatchery Spring Chinook Fishery Contributions.

Brood Years: 2000-2011			
Fishery Years: 2004-2015			
Average SAR% [a]		**0.09**	**0.19**
Agency	***Non-WA Fishery***	***% of total Survival***	
		Sub-yearlings	***Yearlings***
CDFO	All	*5.81*	*11.15*
NMFS	All	*3.93*	*0.06*
Agency	***WA Fishery***	***Sub-yearlings***	***Yearlings***
WDFW	10- Ocean Troll	---	*0.32*
WDFW	15- Treaty Troll	---	*1.35*
MAKA	15- Treaty Troll	*3.35*	---
QDNR	22- Coastal Gillnet (Strays)[b]	---	*0.15*
SUQ	23- PS Net	---	*0.23*
WDFW	23- PS Net	---	*0.42*
WDFW	23- PS Net (Strays)[c]	---	*0.31*
WDFW	41- Ocean Sport- Charter	---	*0.09*
WDFW	42- Ocean Sport- Private	---	*0.74*
WDFW	45- PS Sport - May to September	---	*2.89*
WDFW	45- PS Sport - Winter Blackmouth (Oct - April)		*2.43*
WDFW	50- Hatchery Escapement (Strays)[d]	*0.66*	*0.42*
SUQ	54- Spawning Grounds[f]	---	*0.09*
WDFW	54- Spawning Grounds[h]	*85.22*	*78.84*
WDFW	54- Spawning Grounds[i]	*1.03*	*0.48*
Total :		*100*	*100*

RMIS 2017
a Average SAR% = (tags recovered/tags released).
b Strays to WRIA 21
c Strays to WRIA 11 and 16.
d Strays to Elwha, Marblemount and Minter Creek hatcheries
f Strays to WRIA 15
h Spawning Ground recoveries in the Dungeness and Gray Wolf Rivers
i Strays to the Elwha River

Table 10. Gray Wolf River Hatchery Spring Chinook Fishery Contributions.

Brood Years: 2000-2011		
Fishery Years: 2004-2015		
Average SAR% [a]		**0.26**
Agency	***Non-WA Fishery***	***% of total Survival Sub-yearlings***
CDFO	All	*3.67*
NMFS	All	*12.84*
Agency	***WA Fishery***	***Sub-yearlings***
WDFW	10- Ocean Troll	*0.43*
MAKA	15- Treaty Troll	*0.2*
WDFW	15- Treaty Troll	*0.38*
QDNR	22- Coastal Gillnet (Strays)[b]	*0.17*
WDFW	23- PS Net	*0.08*
WDFW	41- Ocean Sport- Charter	*0.06*
WDFW	42- Ocean Sport- Private	*0.09*
WDFW	50- Hatchery Escapement (Strays)[c]	*0.19*
WDFW	54- Spawning Grounds[d]	*81.19*
WDFW	54- Spawning Grounds (Strays)[e]	*0.7*
	Total :	*100*

RMIS 2017
a Average SAR% = (tags recovered/tags released).
b Strays to WRIA 21
c Strays to Elwha Hatchery
d Spawning Ground recoveries in the Dungeness and Gray Wolf Rivers
e Strays to the Elwha River

Data Gaps

- Describe river entry timing
- Assess predation impacts on juvenile chinook in the river and bay
- Continue annual estimates of smolt production, and corresponding estimates of freshwater survival
- Continue to collect scale or otolith samples to describe the age composition of the terminal run

Literature Cited

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From:	Christina Iverson - NOAA Federal
To:	Lyle Almond; Robert Jones; Adicks, Kyle K (DFW)
Cc:	Sheila Lynch; Susan Bishop - NOAA Federal; James Dixon - NOAA Federal
Subject:	Re: [US v WA Mediation Communication] Elwha MUP
Date:	Wednesday, September 26, 2018 10:45:23 AM
Attachments:	Elwha MUP Rvsd Draft Co-mngr Revision 8-24-18_NOAA F Response_9_26_2018.docx

Hello All,

Please see the attached NOAA Fisheries review of the draft Elwha MUP submitted to us August 31, 2018.

There are a few items to resolve, these have been highlighted in yellow in comment boxes, but we feel they could easily be addressed, and would suggest a follow-up call when you are ready to do so.

Thanks everyone for all the hard work, and we look forward to scheduling a call to wrap up the last few pieces.

Best Regards,
Christina Iverson

On Thu, Sep 6, 2018 at 8:21 AM Susan Bishop - NOAA Federal <susan.bishop@noaa.gov> wrote:

> Thank you, Rob, for sending the Elwha MUP. We appreciate the collaboration to resolve our questions and concerns. We will take a look and get back to you as soon as we can.
>
> Susan
>
> On Fri, Aug 31, 2018 at 2:32 PM, Jones, Rob <rjones@nwifc.org> wrote:
>
>> Greetings,
>> With this email, I am transmitting the Elwha MUP to NOAA. It has been reviewed by all comanagers.
>>
>> Rob
>>
>>
>
>

0Zk7Tdag0S9aBMmAc5ai_nCFnPVjUmktRw%40mail.gmail.com.

--
Susan Bishop
Anadromous Salmon Harvest Branch Chief
NOAA Fisheries Service WCR - Sustainable Fisheries Division
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Elwha River Management Unit Status Profile (2019 PS RMP)

Component Populations

Elwha River Chinook

Geographic Distribution and Life History Characteristics

In terms of sheer magnitude, the Elwha River is the site of the most significant fish passage barrier removal in United States history. For over a century prior to removal of the Elwha and Glines Canyon Dams, utilization by Chinook salmon was confined to the lower 4.9 miles of the river below the Elwha Dam. A legacy of channel manipulation that altered the habitat-forming processes of alluvial sediment and large woody debris transport and deposition restricted most of the available spawning habitat to the river channel below the City of Port Angeles water diversion structure at RM 3.4. The Elwha River Ecosystem and Fisheries Restoration Act of 1992 authorized the removal of the two dams.

Dam deconstruction began in September 2011; demolition of the Elwha Dam was completed in March 2012, and the Glines Canyon Dam removal was completed in late August 2014. As the largest dam decommissioning to date in the United States, removal of these dams restored approximately 71.5 miles of Chinook spawning and rearing habitat, allowing Chinook and the other species of Pacific salmon, as well as sea-run cutthroat and bull trout, to begin recolonizing a major watershed that had been blocked since 1913 (Hosey and Associates 1988).

Removal of the Elwha and Glines Canyon Dams has released a large proportion of the estimated 21 million m^3 (± 3 million m^3) of sediment stored behind the two dams. Approximately 7.1 million m^3 of this sediment was released during the first two years following dam removal (2011 and 2012), much of which has been transported and stored in river channels, floodplains, delta, and nearshore. Nearly 50% of the estimated sediment release is classified as fine (silt and clay) material, which could have deleterious effects on downstream salmonid spawning habitats (Peters *et al.* 2017).

Puget Sound Chinook Salmon and Puget Sound steelhead are both listed as threatened under the Endangered Species Act (ESA); an adaptive management framework has been adopted and federally approved to guide restoration of these species on the Elwha River. The “Guidelines for Monitoring and Adaptively Managing Restoration of Chinook Salmon (*Oncorhynchus tshawytscha*) and Steelhead (*O. mykiss*) on the Elwha River” (Peters et al. 2014) describes a long-term recovery monitoring process requiring Federal, State, and Lower Elwha Klallam tribal scientists to work together to monitor and document changes in the abundance, spatial structure, genetic composition, and life history diversity of these populations during and after dam removal.

Elwha River Management Unit Status Profile (2019 PS RMP)

Status

Viable Salmon Population (VSP) metrics – including abundance, productivity, spatial distribution, and diversity (McElhany et al. 2000) – are used to monitor and adaptively manage the salmon recovery process, functioning as trigger values for moving the Elwha Chinook salmon recovery process through the four distinct biologically based restoration phases of Preservation, Recolonization, Local Adaptation, and Viable Natural Population, as defined in the "Guidelines for Monitoring and Adaptively Managing Restoration of Chinook Salmon (*Oncorhynchus tshawytscha*) and Steelhead (*O. mykiss*) on the Elwha River"(Peters et al. 2014). Several of these VSP metrics rely on data describing adult abundance, productivity, the proportion of natural and hatchery fish, and the number of out-migrating smolts.

Abundance: SONAR enumeration

Prior to dam removal, adult enumeration was conducted using foot and boat surveys as well as rack returns to the hatchery to estimate the returning numbers of Chinook salmon. Dam removal was expected to make visual techniques even more limiting as sediment levels increased during and immediately following project implementation. Facing the prospect of not being able to accurately enumerate any species of salmon following dam removal, NOAA awarded a grant to the Lower Elwha Klallam Tribe to assess the feasibility of counting returning salmon with a SONAR camera (Didson Corporation) (Lower Elwha Klallam Tribe 2016).

Initial efforts to evaluate the Didson camera were made in 2010 and 2011 and focused solely on returning Chinook salmon. A camera power and mounting system was developed and the unit was deployed into the lower mainstem during the Chinook migration period (June to early October). The timeframe was expanded in 2012 to estimate wild winter steelhead returning to the Elwha River from late winter through early summer. In 2013, a second SONAR system (Didson multi-beam) was added in the Hunt Road Channel (HRC) complex at river kilometer (RKM) 0.8. The SONAR equipment cannot monitor during periods of high flow and turbidity events, so passage during these periods is estimated by averaging passage from four days before and after each data gap.

Commented [CI1]: Please include the results of the SONAR estimates. These were included in the first version, were removed here? Are the sonar counts the basis of the subsequent escapement figures and discussion?

Commented [S2R1]: Addressed

Table 1: Annual estimates using sonar of adult Chinook returning to the Elwha River. The return was broken into hatchery or natural origin using carcass sampling for coded wire tags and otolith marks.

Commented [LA3]: The HOR/NOR classification estimates are based on annual salmon carcass surveys conducted by WDFW

Commented [CI4R3]: Thank you.

Year	Chinook	HOR	NOR
2010	1,278	1,221	57
2011	1,864	1,811	53
2012	2,638	2,407	231
2013	4,230	4,029	201
2014	4,360	4,193	167
2015	4,112	3,879	233
2016	2,628	2,517	111

Elwha River Management Unit Status Profile (2019 PS RMP)

Escapement of adult (non-jack) Chinook to the river (technically above the SONAR sites at rkm 0.8) in 2017 was estimated to be 3,083 fish (Figure 1), including hatchery broodstock. This number is assumed to represent the entire Chinook return to the Elwha. The 2016 and 2017 returns were adversely impacted when out-migrating as juveniles by the extraordinary rate of sediment transport in the Elwha River while dam removal was taking place. Despite the adverse conditions, these returns are in the realm of the twenty-year average return for the Elwha River Chinook stock, which appears to be increasing (Denton et al. 2018).

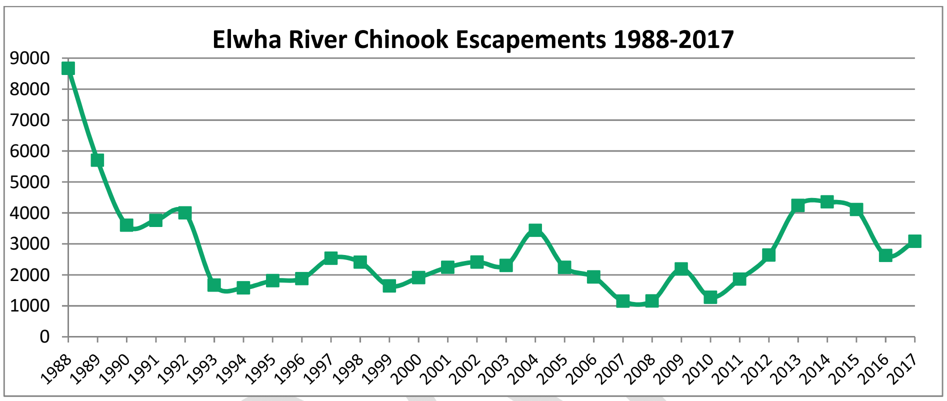

Figure 1: Trend in Elwha River Chinook escapement 1988-2017.

To estimate the abundance of natural-origin salmon, the proportion of the total return that was produced in hatcheries was subtracted from the overall abundance. WDFW carcass surveys conducted in late 2017 found that the overall proportion of hatchery-origin Chinook among all Chinook returning to spawn was 96% (Figure 2) (Weinheimer et al. 2018).

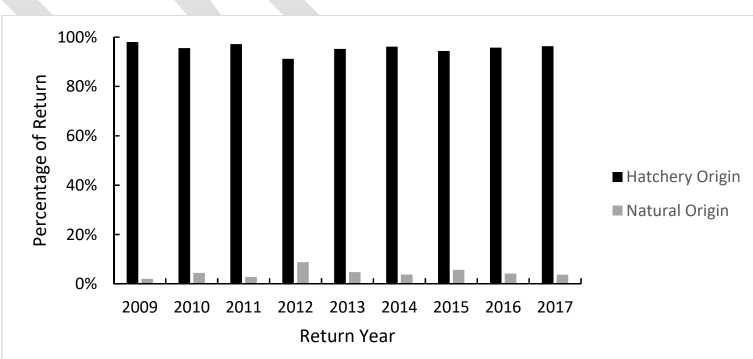

Figure 2: Percent composition of hatchery- vs. natural-origin spawning Chinook detected in the Elwha River between 2009 and 2017 (Weinheimer 2018).

Commented [CI5]: This is above the 1,500 LAT so would have triggered a 10% SUS RER if the fishing moratorium agreed to through 2019 was over, correct? The wording is a little confusing since it states 'escapement above the SONAR sites', but includes hatchery broodstock. How is the 1,700 used for broodstock related to the LAT of 1,500. In other words, is the LAT met after broodstock is subtracted from the total escapement, or are broodstock removed included in the LAT? What proportion of the LAT is expected to be comprised of NORs during the current Preservation phase? Is there an NOR target in the current (Preservation) phase?

Commented [LA6]: Yes, this is correct, we would have been in the 10% SUS RER based on the 2017 escapement, regardless of the status of the terminal fishing moratorium.
To clarify, the SONAR sites are located downstream from the State's Chinook hatchery rack, at rkm 0.8. There is little suitable spawning area below the sonar.
To clarify, 1,700 is the broodstock target, but this goal is rarely met due to a number of extenuating circumstances in collecting brood fish.
There is no NOR target in the Elwha Preservation phase (see Figure 5). Hatchery production is considered essential during this phase. The LAT agreed to with the State in our 2017 concurrence memo is 1,500 (see page 11). The broodstock taken into the hatchery are included in the LAT. As a practical matter, the Chinook do not home consistently to the Elwha Rearing Channel, so a varied strategy is employed to gather broodstock, including Elwha Rearing Channel volunteers, Lower Elwha Hatchery volunteers, river gillnet transfers, and river snagged and spawned. This effectively limits the proportion of the return that can be collected for hatchery broodstock. As an example, in 2017 these broodstocking efforts resulted in 1,079 adult Chinook, including those spawned and pre-spawn mortalities, or 35% of the terminal return of 3,083 Chinook.

Commented [CI7R6]: By included in the LAT, does that mean that you could fall below the LAT if taking broodstock? The LAT should reflect the expected level of escapement

Commented [LA8]: This escapement data is based on field observation and hatchery returns prior to 2010, and on SONAR count estimates from 2010-present.

Elwha River Management Unit Status Profile (2019 PS RMP)

Productivity:

Hatchery marks (CWT, adipose, and otolith marks) in combination with SONAR counts and age data from scale collections provided the cohort analysis needed to evaluate spawner-to-spawner productivity for Chinook spawning naturally in the river (of hatchery and natural origin) (Table 2) and all spawners combined (both in river and in the hatchery) (Table 3) (Weinheimer et al. 2017).

Table 2: Ratio of natural spawners (all Chinook, regardless of origin, spawning naturally in the Elwha River) -to-returning adults of natural origin, brood years 2004-2015 (Weinheimer et al. 2018).

Commented [CI9]: Includes HOS in column two, but only natural-origin recruits back, total natural production from the system estimate, correct?

Commented [GML(10]: Correct.

Brood Year	Natural Spawners	Returning natural-origin spawners (NOR returns)						Spawner to spawner ratio
		Age-2	Age-3	Age-4	Age-5	Age-6	Total	
2004	2,075	NA	16.4	47.4	0.5	0	64.2	0.03
2005	835	2.0	10.5	41.3	22.7	0	76.6	0.09
2006	693	0	2.3	10.1	0.1	0	12.6	0.02
2007	380	0.0	15.8	17.3	5.9	0	39.1	0.10
2008	470	8.6	29.2	66.3	5.9	0	110.0	0.23
2009	678	6.0	147.4	144.8	32.4	1.6	330.6	0.49
2010	569	11.8	47.0	95.1	32.6	0.2	186.4	0.33
2011	852	4.4	38.4	150.6	25.1		218.5	0.26
2012	1,480	1.2	46.0	68.1			115.4[A]	0.08[A]
2013	2,313	1.9	10.3					
2014	2,513	6.6						
2015	2,548							

[A] Incomplete cohort, age-5 offspring will return in 2017.

Table 3: Spawner-to-spawner ratio for all Chinook, (in river and in hatchery spawners of natural and hatchery origin combined) brood years 2004-2015 (Weinheimer et al. 2018).

Brood Year	Hatchery + Natural Spawners	Returning natural- and hatchery-origin spawners						Spawners to spawner ratio
		Age-2	Age-3	Age-4	Age-5	Age-6	Total	
2004	3,439	NA	143	279	23	0	445	0.13
2005	2,231	29	784	2,053	507	0	3,372	1.51
2006	1,920	0	116	226	5	0	347	0.18
2007	1,140	0	354	613	67	0	1,034	0.91
2008	1,137	191	1,034	756	123	0	2,105	1.85
2009	2,192	210	1,680	3,041	846	28	5,806	2.65
2010	1,278	134	986	2,481	576	6	4,183	3.27
2011	1,862	92	1,003	2,660	596	0	4,351	2.34
2012	2,638	31	813	1,618	158		2,620	0.99
2013	4,243	34	245	910			1,189[A]	0.28[A]
2014	4,360	158	1,850					
2015	4,112	165						

[A] Incomplete cohort, age-5 offspring will return in 2018.

Hatchery and natural spawners had a combined average of 1.6 returning adults per spawner for complete brood years 2004-2011, and the last four complete brood cycles (2008 - 2011) have each exceeded the replacement value of 1.0 (Table 3). However, natural spawner productivity averaged only 0.19, or one returning adult for every five natural spawners (Table 2), well below the replacement value of 1.0 required for Elwha Chinook salmon recovery (Peters 2014).

By combining the carcass samples with the SONAR data, it was estimated that 114 (3.7%) of the non-jack adults returning in 2017 were of natural-origin (Table 4). The 2017 return was dominated by age-3 hatchery-origin Chinook salmon that were spawned in 2014 and released during spring of 2015 as sub-yearlings (Table 4). This cohort was the first out-migration to occur after the dam removal process, and the return of spawners from this cohort likely dominated the 2017 return age structure due at least in part to mortality suffered by earlier cohorts released prior to 2015 because of the extraordinary rate of sediment transport in the Elwha River during and after dam removal (Schwartz 2013).

Table 4: Estimated age composition of returning adults to the Elwha River in 2017, based on age data from scales and SONAR abundance estimates (Denton et al. 2018).

Origin	Age at Outmigration	Age					SUBTOTALS
		2	3	4	5	6	
Natural	**Subyearling**	1	10	20	2	0	**33**
	Yearling	NA	NA	NA	NA	NA	**0**
Hatchery	**Subyearling**	47	518	73	27	0	**665**
	Yearling	0	9	171	16	0	**196**

Diversity: juvenile and adult life histories of Chinook returning to the Elwha River

Currently, the vast majority of natural-origin Elwha Chinook exhibit the ocean-type juvenile life history strategy (migrate seaward as sub-yearlings) (McHenry et al. 2015). It is hypothesized that access to the upper watershed might allow for a stream-type life history trait (seaward migration as yearlings) to emerge (Pess *et al.* 2008, McHenry et al. 2016). Adult Chinook return timing is currently from June into September, peaking in July. The July peak timing is similar to summer Chinook populations in North Coast rivers and in the Dungeness River to the east along the Strait. Return timing may broaden as the population transitions to natural origin and increases in numbers. Spawning occurs from late August to mid-October, again similar to the North Coast and Dungeness summer Chinook populations. It is worth noting that the North Coast populations (Queets, Hoh, and Quillayute systems) also host fall Chinook that return in larger numbers and peak in mid-October. It remains to be seen if this life history pattern will develop in the Elwha.

Spatial distribution

In 2015, a total of 937 Chinook salmon redds and 753 adults (366 live/387 dead) were observed and 77% of those redds were located above the former Elwha Dam site (Figure 3). Over 95% of those Chinook salmon redds were observed in mainstem Middle Elwha (between the former dam sites) habitats rather than the tributaries. A high number (100) Chinook salmon redds were

Commented [GML(11]: Correction. The 33 number is un-expanded to the whole return i.e. it is the number of natural origin in the 894 sampled carcasses.

Commented [CI12]: Total return for 2017 is above the LAT of 1,500 (estimated at 3,083), of which were confirmed NORs. The escapement of 3,083 would have triggered a SUS RER of 10%. This seems high on such a low number of natural-origin fish, and could have additional terminal impacts added after both the 4,300 UMT is met, and the moratorium is lifted? What is the estimated total harvest rate in such a situation?

Commented [GML(13R12]: I assume you are suggesting that the moratorium holds the exploitation rate below 10% because the ocean doesn't take it all,, but that when the moratorium is removed, the terminal fisheries will target the rest of the available rate after ocean harvest, and that seems a big bite for a return with only 114 natural origin Chinook. When the moratorium is removed, and assuming the co-managers choose to impact Chinook in river, they will be limited to the remainder of the RER, or roughly 5%, which would equate to roughly 5 natural origin Chinook at current return rates, to be taken, let's assume, collaterally to, say a coho fishery. Viewed that way it doesn't seem too big an impact. Co-managers have not yet determined when the fishing moratorium might be lifted, nor yet developed fishery plans.

Commented [CI14R12]: Just to be clear, it is not anticipated that during the life of this ten year RMP total SUS ER will exceed 10%, including any terminal fisheries, yet to be developed? See comment below.

observed immediately downstream of the former Glines Canyon Dam. Neither adult Chinook salmon nor Chinook salmon redds were observed immediately upstream of Glines Canyon Dam in 2015. This was probably because large boulders originating from Glines Canyon fell into the channel shortly after dam removal was completed in 2014. These boulders created a vertical drop of 12-15 feet through the canyon reach and were blasted in October, 2015, in an effort to improve fish passage. The blasting was too late to affect passage conditions during the 2015 Chinook migration period. However, the first Chinook spawning above the Glines Canyon Dam site was observed during the 2016 return (Figure 4). The distribution of Chinook salmon redds in the Middle Elwha suggested that mainstem spawning habitat in particular, and to a lesser extent tributary habitat was being colonized by Chinook salmon (McHenry *et al.* 2016).

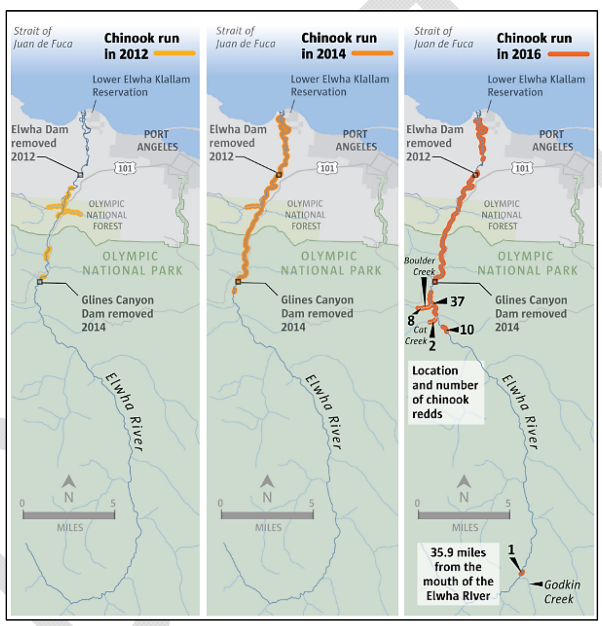

Figure 3: Distribution of Chinook salmon redds in the Elwha River between 2012 and 2016 based on data in McHenry *et al.* 2016 (Nowlin and Martinez 2017).

Elwha River Management Unit Status Profile (2019 PS RMP)

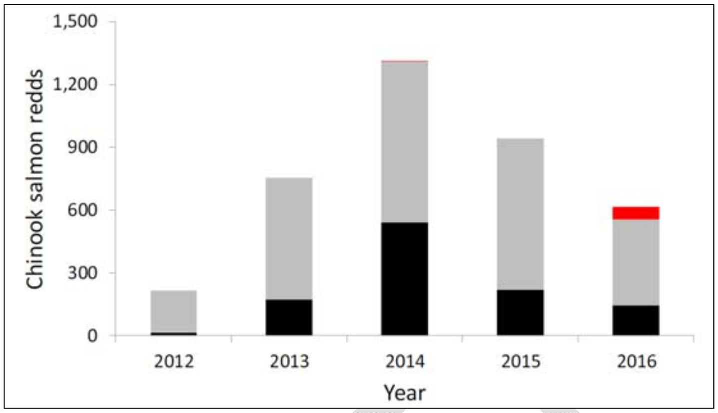

Figure 4: Utilization of the Elwha River by Chinook salmon since dam removal. Black bars indicate the number of Chinook redds below former Elwha dam. Grey bars indicate the number of Chinook redds between former Elwha dam and former Glines Canyon dam, and red bars indicate the number of redds above former Glines Canyon dam (McHenry *et al.* 2017).

Harvest Distribution and Exploitation Rate Trends

FRAM (the Fisheries Regulation Assessment Model) is used by the co-managers during pre-season fisheries planning and post-season evaluations to estimate pre-terminal rates of exploitation (Figure 3 and Table 5). FRAM uses fishery data that includes catches, size limits, encounters, growth functions, mark rates, and abundances to calculate CWT-derived exploitation rates by stock, age, fishery, and time period.

Table 5: Total Adult-Equivalency Exploitation Rates (AEQ ERs) of Elwha River Chinook.

Elwha River Chinook (NOR + HOR) Exploitation Rates						
Return Year	Alaska	Canada	SUS			SUS Subtotal
			Washington Sport	Puget Sound Net	Washington Troll	
1992	1.90%	22.40%	6.10%	0.40%	3.40%	9.80%
1993	1.40%	11.20%	6.10%	5.10%	1.10%	12.20%
1994	0.90%	5.80%	0.40%	0.00%	0.90%	1.30%
1995	1.00%	7.30%	7.50%	0.40%	2.00%	9.90%
1996	1.40%	4.90%	5.10%	0.10%	0.80%	6.00%
1997	0.80%	3.70%	2.10%	0.10%	0.20%	2.30%
1998	0.70%	2.80%	1.60%	0.00%	0.20%	1.80%
1999	2.90%	10.70%	1.80%	0.10%	0.80%	2.70%
2000	1.30%	8.50%	2.80%	0.10%	0.60%	3.50%
2001	0.90%	6.20%	1.60%	0.20%	0.40%	2.30%
2002	0.90%	7.00%	1.50%	0.10%	0.30%	1.90%

2003	1.00%	8.90%	1.50%	0.20%	0.50%	2.20%
2004	0.70%	7.20%	0.50%	0.10%	1.60%	2.20%
2005	0.70%	4.20%	0.40%	0.00%	0.50%	0.90%
2006	0.60%	3.90%	0.70%	0.10%	0.40%	1.20%
2007	1.80%	13.30%	2.20%	0.00%	1.00%	3.30%
2008	2.00%	18.30%	1.60%	2.00%	0.70%	4.30%
2009	1.00%	6.60%	2.00%	0.00%	0.40%	2.40%
2010	2.30%	11.70%	3.00%	0.50%	2.00%	5.50%
2011	2.30%	18.10%	3.90%	0.30%	1.10%	5.30%
2012	1.80%	12.30%	2.10%	0.40%	1.30%	3.90%
2013	1.10%	6.10%	2.10%	0.20%	1.40%	3.80%
2014	1.60%	10.00%	2.40%	0.40%	1.50%	4.30%
2015	2.30%	11.90%	3.50%	0.30%	2.30%	6.20%
Mean ERs	**1.39%**	**9.29%**	**2.60%**	**0.46%**	**1.06%**	**4.13%**

An adipose fin clip is essential for CWT detection in many Canadian and Alaskan FRAM fisheries. However, in order to minimize exposure to mark-selective fisheries and reduce ocean interception rates during the early restoration phases for Elwha Chinook, CWT release groups were not adipose fin clipped during the updated base period years used to calibrate FRAM. Therefore, a surrogate procedure was developed to simulate the Elwha and Dungeness River Chinook (ELDU) pre-terminal exploitation rates. An analysis of Salish Sea Chinook populations suggested that the Stillaguamish Chinook population was the best proxy for Elwha River exploitation rates.Consequently, the accuracy of FRAM's projections of pre-terminal Elwha Chinook exploitation are limited by this surrogate procedure. To address this data gap, beginning with the 2012 brood, a group of 250,000 subyearling releases (10% of the subyearling release goal) is annually marked with an adipose fin clip as well as a coded wire tag and an otolith mark. The first adipose clipped adults from these releases returned to the Elwha in 2015 as 3 year olds. FRAM modelers have determined that when results from three complete brood returns of adipose clipped Chinook are available, they can reliably estimate ocean exploitation rates on Elwha Chinook. A 5 year life cycle and the advent of adipose clipping in 2012 points to 2019 for the completion of the minimal 3 brood returns. Two more years would be required for most CWT recovery information to be available. Therefore 2021 would be the earliest possible date Elwha CWT information could be incorporated into FRAM. However, for the ad-clipped and CWT release groups there are data issues with the 2012 brood year, the 2013 brood year has produced no CWT recoveries in RMIS (Regional Mark Information System) as of 8/23/2018, and it is too early to determine if there are sufficient recoveries from the 2014 brood year (although the 2014 brood has started to show up in fisheries). Furthermore, it is not clear if using release groups from the dam removal era is appropriate for future modeling. It may be more realistic to expect incorporating Elwha CWT information into FRAM from 2022-2026.

Commented [CI15]: This marking was set at 10 percent of the sub-yearling production to gain this information so that fish produced through the program are not subject to unnecessary risk. Results were expected after 2017, when the first results of this trial tagging experiment were to become available, including effects of the tagging on Chinook salmon escapement and hatchery broodstock needs, adipose tagging. What did the results reveal about the effects of the tagging? If not yet available, do we have a timeframe for this work to occur and data to become available during the ten year RMP?

Commented [CI16R15]: Addressed, thank you.

Management Considerations

Elwha River Management Unit Status Profile (2019 PS RMP)

Recovery of Elwha Chinook salmon populations will require significant management actions in the areas of habitat, harvest, and hatchery management, and the integration of these actions with one another. Because the outcome of salmon recovery efforts depends on this combined and cumulative effort, the effectiveness of actions in one of these areas is best evaluated by knowing the status of actions in the other areas. Harvest management plans typically acknowledge that productivity is dependent on the state of fresh and salt water habitats, and assume a constant habitat condition. Habitat restoration plans typically state that their effectiveness is predicated on continued control of harvest levels. Hatchery plans assume stable harvest rates and habitat conditions.

For example, the effectiveness of harvest management planning depends critically on habitat conditions. If habitat is functioning properly in all areas affecting all life stages of a salmon stock, then the failure of the stock to respond to a harvest rate reduction might mean that the harvest rate reduction was not sufficient to allow recovery. On the other hand, if the habitat supporting a stock is significantly degraded or lost, then the failure of that stock to respond to a harvest rate reduction most likely cannot be addressed through further harvest rate reductions alone. Lost habitat must be restored and degraded habitat must be upgraded for harvest management to be effective. The same is true for hatchery management actions. The dam removals on the Elwha River have provided an opportunity for the Lower Elwha Klallam Tribe and the State of Washington to implement and integrate all three areas of harvest, hatchery, and habitat management.

Brief Description of Current Management Approaches

Harvest Management

The harvest strategy for Elwha Chinook salmon is to limit overall fishery-related mortality to a level that will allow the Elwha Chinook population to increase (Ward *et al.* 2008).

Recovery of Elwha Chinook as the population expands into the upper watershed depends on the transition from primarily hatchery origin to natural origin recruits. To encourage this process and maximize the number of spawners in the Elwha, the Lower Elwha Klallam Tribe, WDFW, and Olympic National Park have since spring of 2012 jointly implemented a fishing moratorium in the Elwha River that by agreement precludes all fishing of all species. The moratorium will remain in effect through spring of 2019, at which time it will be re-assessed to determine if it continues to be needed.

WDFW and the Lower Elwha Klallam Tribe remain concerned about the impact to Elwha Chinook from the current levels of Canadian and Alaskan harvest of this stock (Table 5). These high harvest rates exerted by Alaska and Canada on Elwha and other Washington Chinook stocks result in reduced terminal area returns, an unbalanced sharing of the burden of conservation, and heavy constraints on Washington fisheries, which are required to protect Chinook salmon (ERFRP, 166).

Elwha River Management Unit Status Profile (2019 PS RMP)

Fishing regulations affecting Chinook salmon in the area from Southeast Alaska to south of the Columbia River are negotiated annually through the regional North of Falcon process and the international Pacific Salmon Commission in a manner that makes cumulative harvest impacts on salmon originating from the Elwha River basin predictable. Fisheries in US waters other than Alaska that affect ESA-listed Elwha Chinook salmon are developed according to the co-managers' harvest management plan (Puget Sound Indian Tribes and Washington Department of Fish and Wildlife 2010), then evaluated and approved annually by NMFS.

The 2011 Biological Opinion issued by NMFS acknowledges that Chinook salmon maintained and produced by the hatchery mitigation program in the Elwha River system will be a key component of watershed rehabilitation and population preservation and restoration before, during, and after dam removal (NMFS 2012). Given the condition of the salmon habitat in the watersheds, the prospects for the survival and recovery of the Elwha population depend on maintaining the hatchery program in the short term, and using it for reintroduction into pristine areas in the Olympic National Park now that the dams have been removed (NMFS 2011). To achieve the goal of restoring Chinook salmon to the Elwha during the Preservation and Recolonization phases, adequate monitoring of hatchery supplementation is required to achieve desired adult return levels and to maintain the genetic characteristics of the extant population (Elwha River Summer/Fall Chinook HGMP 2012; HSRG 2012). There is no precedent for estimating the effects that removal of two large dams will have on the spawning and rearing habitat of five critically depressed populations of anadromous salmonids, two of which are at risk of extinction and federally protected, The Biological Opinion on the Elwha Chinook recovery plan (NMFS 2012) recognized the prudence of agreeing to a restoration strategy that preserved as many options as possible. The lowest risk option, and the one recommended by the Elwha River Fish Restoration Plan (Ward et al. 2008), was to combine supportive breeding and passing adult fish upstream of the disturbed area to spawn naturally. The desire to ensure that useful progress towards fish restoration would occur within a 20- to 30-year time frame was also a factor in supporting hatchery supplementation to ensure the recovery of natural-origin Chinook in the Elwha River watershed (Ward et al. 2008).

The Lower Elwha Klallam Tribe and Washington Department of Fish and Wildlife have concurred in adjusting the Low Abundance Threshold (LAT) escapement level in order to better align escapement goals with the VSP restoration strategies for Elwha Chinook (NMFS 2012; Peters et al. 2014). This addresses the use of VSP criteria required in 4(d) Sec. B and the need to establish viable (UMT) and critical (LAT) escapement targets. The previous LAT of 1,000 Chinook salmon (combined natural-origin and hatchery-origin) in the 2010 RMP is outdated given the recently opened access to 70 additional miles of spawning and rearing habitat in the Elwha watershed upstream of the two former dams. Additional Chinook are now considered necessary to maintain the stock at minimal levels given the gains that have begun and are anticipated in the expansion of the Chinook stock into the newly accessible river.

Commented [CI17]: This sets the thresholds but does not explicitly address the risk criteria also included in criteria B, i.e., what is the status of the population (i.e. critical based on NOR level in Table 2). Suggest incorporating language similar to that on page 12 of Dungeness MUP regarding effective population size. (This may also be included in the Elwha Recovery Plan, if so please cite location or bring details into MUP.)

Commented [CI18R17]: Addressed

Elwha River Management Unit Status Profile (2019 PS RMP)

Analysis of the demographic data for Elwha River Chinook Salmon from 2004-2015, when natural spawning abundances ranged from 380-2548, indicates that, were similar return patterns to occur in the future, the population would likely maintain an average inbreeding genetic effective size of 1962 (95% CL: 1573-2079). Similarly, analyses based on the worst-case scenario of escapement levels at the Low Abundance Threshold (LAT) of 1500 indicate that the inbreeding genetic effective size would likely be 1996 (95% CL: 1716-2080). Because approximately 95% of fish in the population originate from hatchery production, this means that the hatchery is successfully maintaining genetic diversity in this population despite the potential effects of supportive breeding (Ryman and Laikre 1991) while providing demographic security as habitat is restored in the lower river and fish can recolonize the upper river. Genetically, the LAT of 1500 would minimize potential inbreeding depression and maintain the evolutionary potential of the population. This can be seen in the context of the 50/500 rule, where a genetic effective size greater than 50 minimizes the loss of fitness from inbreeding and N_e of 500 preserves the adaptive potential of the population by maintaining a balance between genetic diversity lost to genetic drift and the new genetic diversity from mutation and gene flow (Franklin 1980, Frankel and Soule 1981). The estimated inbreeding effective size for the LAT of 1500 exceeds both of these thresholds. Technically, the 500 effective size threshold is best compared against the global genetic effective size calculated based on metapopulation structure (Jamieson and Allendorf 2012). Although we did not calculate the global effective size for Elwha River Chinook, genetic data indicate that that they are likely part of the same metapopulation as Dungeness River Chinook (Ruckelshaus et al. 2006), for which we have previously calculate a global genetic effective size of approximately 5520.

Returns to the river forecasted to be at or below a Low Abundance Threshold of 1,500 Chinook of hatchery- plus natural-origin will trigger a critical SUS exploitation rate of 6%. This addresses the 4(d) Sec. C concern that maximum exploitation rates must not appreciably reduce the likelihood of survival and recovery of the ESU. We expect that the annual escapement of Elwha Chinook will continue to exceed this LAT threshold during the 10-year scope of the RMP. We also expect exploitation rates during the duration of the plan to remain similar to rates seen over the past 10 years.

Forecasts that exceed the LAT will trigger a SUS rebuilding exploitation rate of 10%. SUS harvest restricted to levels below this ceiling will assist recovery by providing sufficient escapement to the river to increase natural spawning as the population continues expansion into the upper watershed, and to provide broodstock for the supplementation program.

The new LAT of 1,500 Chinook salmon agreed to by the co-managers is a more appropriate low abundance threshold for the expanded habitat capacity of the Elwha River. Over the last few years, Elwha Chinook salmon have maintained total escapement levels well above the 1,000 spawners (hatchery plus natural origin) needed to avoid invoking the LAT and the consequent lower SUS harvest rate ceiling. Escapement to natural spawning habitat is currently expanding as a result of improvements in the quantity and quality of spawning and rearing habitat. Total

Commented [CI19]: A few questions on this piece should be discussed, we would like to set up a call to walk through when you are ready.

Commented [CI20]: This states that it addresses the criteria but does not explain how is does not appreciably reduce the risk. **Suggest include language similar to page 13 of Dungeness MUP, i.e., how many NORs spawners would result if fisheries were further constrained or closed under the 6 or 10% rates.**

Commented [CI21]: See previous comment. The LAT of 1,500 was met in 2017, which would have triggered a 10% SUS RER, if the fishing moratorium was over. It is unclear how many NORs are expected to make up the 1,500 total LAT. Thus unclear how the 10% RER relates to the NOR component.

Into the future, if the annual escapement were to exceed the 4,340 MSY target within this RMP timeframe what is the anticipated harvest rate?

Commented [LA22]: Under the BiOp for the Recovery Plan, there is no goal regarding the proportion of NOR abundance making up the total escapement abundance in the Preservation and Recolonization phases. There is no harvest ceiling above the LAT of 4,340 (MSY), although historically harvest rates for Elwha Chinook have been 4.13% on average (Table 5).

Commented [CI23]: In answer to our above comment, can we make the assumption for modeling impacts based on this statement. Can you confirm this Lyle/Mike?

Commented [CI24]: True, but the proportion of NORs that make up the total escapement has not been measured over 10% yet, correct? How will the ten year plan track the exploitation on the NOR component of the LAT? Demonstrating that the plan accommodates the increase of NOR's expected as the habitat recovers.

escapements since 1988 shown in Figure 1 ensure that more than 1,000 spawners are likely to return to natural spawning areas after hatchery broodstock are collected.

It should be noted that during the timeframe in which this RMP is in effect, we are currently in the initial Preservation phase, in which there are no specific objectives for the percent of natural origin spawners (pNOS) to trigger movement to the subsequent Recolonization phase (NMFS 2012). The management goal of the Preservation phase is focused on protecting the species from extinction during the post-dam removal period when high sediment loads are expected, at times, to be lethal to fish. For a successful and significant pNOS increase to occur, the contribution of hatchery-origin Chinook will continue to be critically important during the tenure of this RMP. The spatial distribution trigger ("portion of population accessing above Elwha Dam") has already been met (McHenry et al. 2018), the abundance trigger (natural spawners > 950) has already been met (Denton et al. 2017, and prior SONAR reports) and there are no diversity or productivity triggers required to move to the Recolonization Phase (NMFS 2012).

The currently low productivity and abundance of NOR Chinook (Table 2) and the much larger abundance and productivity of the HOR component (calculated at 3.10 by removing NOR data from Table 3 for 2011, the most recent year representing all age classes), is consistent with the plan to use the hatchery component during the recolonization phase of the of the Elwha Monitoring and Adaptive Management Guidelines to drive the near-future expansion of abundance and distribution into the newly opened watershed. Consequently, both the natural and hatchery components of the current Elwha Chinook population are essential to recovery, and are managed under the same harvest regulations. Although the potential reduction of reproductive success of hatchery fish in the wild from genetic changes associated with hatcheries remains a concern, an increasing number of studies indicate that the lower relative reproductive success of hatchery fish may be largely explained by spawning in poorer habitats (Williamson et al. 2010, Hughes and Murdoch 2017). As Chinook recovery moves from the Recolonization to the Local Adaptation Phase, hatchery influence will be scaled back in response to an expected increase in the proportion of natural-origin Chinook (Figure 5).

Combined with the limits on pre-terminal harvest rates, the current lack of any freshwater fisheries in the Elwha River effectively maximizes the escapement and subsequent spawning of Chinook in the river and hatchery for each return year. When the Elwha fishing moratorium expires, any in-river fisheries directed at other species will be structured to avoid Chinook impacts. However, to provide a further layer of protection for Elwha Chinook, a lower bound (LB) management threshold has been established at the previous 2010 Harvest Plan LAT of 1,000 fish, below which co-managers will reach agreement on what, if any, incidental and ceremonial and subsistence fisheries will occur.

The Upper Management Threshold (UMT) is 4,340 natural spawners, below which a 10% Rebuilding Exploitation Rate (RER) will be imposed on SUS pre-terminal fisheries. Peters *et al.*

Commented [CI25]: NOR productivity is obviously low from habitat degradation, but literature indicates hatchery fish may also depress productivity so would be good to cite Elwha Fish Recovery Plan provisions that address this as the population moves through the phases.

Commented [CI26R25]: Addressed, thank you.

Commented [CI27]: See previous comment about numerating how many more spawners would return if SUS fisheries were further constrained or closed (maximum effect).

Commented [CI28]: Based on Figure 1, returns could exceed 4,340 natural spawners (NOR+HOR). Is the intent not to exceed the 10% SUS during the duration of the RMP? Need to be explicit so that our analysis is comprehensive.

Commented [LA29]: There is no RER ceiling on SUS exploitation above the MSY of 4,340 Chinook.

Commented [CI30R29]: What is the expected harvest rate above 4,300 spawners on the NOR? The 4,300 will be all NORs at this phase of "self-sustaining / exploitable"? Correct, per Figure five below? Understanding it is unlikely the population will achieve this phase of recovery during the ten year RMP, however, if it does we will need to re-evaluate any rate over 10% SUS. If 10% is sufficient, or for the life of the ten year RMP there is no expectation the SUS will go over 10% it should be explicit in the RMP.

(2014) estimated maximum sustained yield (MSY) for Elwha Chinook to be in the vicinity of 4,300 spawners.

Hatchery Management

The Elwha River Fish Restoration Plan (Ward *et al.* 2008) identifies two main strategies for Chinook stock restoration in the Elwha River: natural recolonization and hatchery supplementation. Hatchery operations are a necessary component of the preservation and restoration strategies outlined in the fish restoration plan. The use of hatcheries to restore and preserve stocks is supported by the trust responsibilities of the federal government to exercise its authorities to promote the harvestable surplus of anadromous fish in accordance with treaties between the United States and the tribes.

Achieving the various restoration thresholds outlined in the Elwha Fish Restoration Plan relies heavily on increasing natural-origin spawning abundance, (Peters 2014, p. 20).To reach a sustainable recovery of Chinook, Ward *et al.* (2008) stipulates that Elwha Chinook spawners must maintain a proportion of natural influence (PNI - proportion of the spawning stock that is of natural origin) greater than 67%. However, Peters *et al.* (2014) established goals for reducing hatchery influence that far exceed the 67% PNI by designating the transitional trigger value required to move from the Local Adaptation Phase to full recovery as zero% hatchery-origin fish (i.e., elimination of hatchery production). At this time, however, approximately 95% of Chinook spawning in the Elwha River are of hatchery-origin (Figure 4).

Importance of Hatchery-Harvest Integration

Reductions in hatchery production may begin over the course of this ten-year resource management plan as escapement of natural origin Chinook grows toward an estimated MSY escapement of 4,340 natural-origin Chinook. Other key measures are productivity greater than 1.56 recruits per natural-origin spawner, and Chinook salmon spawning above the former dam sites (Peters *et al.* 2014). Until then, hatchery supplementation will continue to play a major role in stock rebuilding.

Commented [LA31]: Figure 5 (below) from the BiOp (NMFS 2012) serves as the federally-approved guidance for Elwha Chinook restoration. Note that there is no goal set for changing the proportion of NOR vs. HOR Chinook in the Preservation and Recolonization stages, and therefore hatchery influence will continue to be a factor in productivity while NOR production improves.

Commented [CI32R31]: But this does not override the need to address the 4d criteria.

Commented [CI33]: It might be useful to include a table (i.e. Figure 3 from the 2014 EMAM?) of the triggers by phase so underscores this transition to NORs and recognition of the role of hatcheries. This could help clear up some inconsistencies in the text throughout the RMP as well regarding the trigger being specific to natural or natural-origin fish.

Commented [CI34R33]: Figure five added below.

Elwha River Management Unit Status Profile (2019 PS RMP)

Restoration Phase	Abundance			Productivity			Spatial Structure	Diversity 2/	
	Hatchery-origin adult escapement (broodstock)	Natural-origin adult spawning escapement	Proportion Natural Influence (PNI)	Juveniles/ female	R/S (spawner to spawner)	R/S (pre-fishing)		Allele Frequency in Selected Loci	Expected Population Heterozygosity
Preservation	1,700	1,028 (707, 321) 1/	No goal set	200	>1.0 (hatchery+ natural fish)	>1.56 (hatchery+ natural fish)	Some adults spawning above Elwha Dam site	No change	No change
Recolonization	1,700	4,847 (3,333, 1,314) 1/	No goal set	200	>1.0 (for natural fish only)	>1.56 (for natural fish only)	Adults spawning above Elwha Dam and 33% of intrinsic potential	No change	No change
Local Adaptation	500	9,694 (6,664, 3,029) 1/	Work towards PNI = 1.0	200	>1.0 (for natural fish only)	>1.56 (for natural fish only)	Adults spawning above Glines Canyon Dam and 66% of intrinsic potential	Initial decrease, then stable	Initial decrease, then stable
Self-Sustaining Exploitable Population	0	14,688 (10,099, 4,589) 1/	PHOS = 0; PHOB = 0	200	~1.0 (natural fish only)	>~1.85 (natural fish only)	100% of intrinsic potential	Stable, < historical	Stable, < historical

Figure 5. Population viability (VSP) triggers defining the four phases of Elwha River Chinook restoration (NMFS 2012).

1 Values in parentheses are numerical components of total escaping adult abundance composed by ocean-type and stream-type origin fish, respectively.

2 There are two additional indicators of diversity that apply only to the Local Adaptation and Self-Sustaining Exploitable Population phases — proportion of stream type Chinook salmon (yearling migrants returning to spawn) and variation in adult entry timing. For the Local Adaptation phase, a positive trend for both indicators will be the trigger values. For the Self-Sustaining Exploitable Population phase. the population will have stabilized with well-defined early and late run timing and a consistent proportion of the returning spawners each year will have resulted from yearling smolt migrants.

Habitat Management

Habitat Restoration and Assessment

In addition to directly monitoring the size, diversity, and viability of salmonid populations, it is also important to study the ecosystems upon which salmon depend, and their responses to dam removal. A number of tools and methods have been developed and implemented to restore habitat and assess changes in habitat quantity and quality after dam removal by measuring available spawning and rearing habitats (quantity and quality), and water quality. Because of the large changes expected in the areas downstream of the dams, as well as the effect that the salmon themselves will have on the ecosystem (e.g., from marine derived nutrients, bioturbation of spawning gravels, interactions with predators and scavenger communities), measuring the responses of the aquatic ecosystem is vital to understanding changes in the salmon populations. One important component is the direct and indirect effects of high sediment levels on biological food webs.

Ecosystem Response

Since dam removal, available habitat has increased as the river has become more dynamically engaged with its floodplain. These floodplain reaches have been serving as fine sediment retention sites, mitigating the potentially negative effects of fine sediment on the mainstem channel substrate. This buffering effect has improved the effectiveness of cobble-strewn mainstem reaches to function as higher quality spawning and rearing habitat for Chinook. In general, these findings demonstrate the ability of river systems like the Elwha to attenuate the impacts of dam removal (Peters *et al.* 2017).

Revegetation

The overall revegetation effort for Elwha restoration is guided by the Elwha Revegetation Plan (Chenoweth et al. 2011). The plan's goals, broadly stated, are to establish native vegetation communities and to accelerate natural succession toward older communities. As dam removal neared completion, dewatering of the Mills and Aldwell Reservoirs exposed approximately 800 acres of former hillslope and floodplain habitat along seven miles of newly transformed river channel. Revegetation of the former reservoirs has been critical to habitat restoration processes and was necessary to stabilize sediment that had accumulated on hillslopes and terraces during dam removal.

Revegetation activities are co-managed by Olympic National Park, leading revegetation efforts in the former Lake Mills Reservoir within the Park, and the Lower Elwha Klallam Tribe, leading revegetation efforts in the former Lake Aldwell Reservoir downstream from the Park. Revegetation began in 2004 and the vast majority of the planting of native vegetation has been completed. Control of exotic vegetation continues to be carried out during the summer and fall seasons. (McHenry 2017, *personal communication*). Monitoring plans have been developed to assess the need to modify and refine planting actions (Peters et al. 2014).

Habitat restoration efforts complementary to dam removal were developed and implemented by the Lower Elwha Klallam Tribe, and concentrated on floodplain habitats in the lower river downstream of the former Elwha Dam site. To date, these efforts include the construction of 50 engineered logjams between river miles 1.0-3.5, additions of large wood to four side-channels, removal of four relic push-up flood control dikes, the planting of 60,000 native trees and shrubs in areas disturbed during construction or dike removal, and the control of non-native vegetation.. Future restoration is being planned for Little River and Indian Creek, which includes wood additions and culvert barrier corrections; the first of these projects in Little River has been funded by the Salmon Recovery Funding Board and will be implemented in 2018-19.

Additional restoration efforts focusing on the Elwha River estuary and on the dewatered Aldwell reservoir are being considered. The Elwha estuary has been severely degraded over its history by diking and channelization (Duda et al. 2011). The former Aldwell reservoir, which was logged prior to filling, appears to lack large wood and may be an excellent candidate for engineered logjams (Peters et al. 2014).

Two new logjams were installed in 2017 to address habitat connectivity issues with the surface water diversion structure that provides water to the City of Port Angeles. A larger engineered logjam structure designed for installation in the lower river channel awaits funding for pending construction. In addition, a major restoration project in the lower portion of Indian Creek has been identified. An agreement between LEKT and the US Bureau of Reclamation to do a partial design of that project beginning fall 2017 is currently underway. Once completed, full engineering design and funding for construction will begin (McHenry 2017, *personal communication*).

Suspended Sediment

Suspended and bedload sediment transport are being monitored in real time by the Bureau of Reclamation (BOR), the National Park Service (NPS), and the US Geological Survey (USGS) as part of the sediment monitoring and adaptive management activities of the Elwha dam removal project (Randle et al. 2012). Additionally, changes in reservoir and riverbed elevation as well as water surface elevation are monitored through time, as is sediment erosion from the reservoirs, floodplain deposition, and volumetric changes in the river mouth and adjacent shoreline. Monitoring of particle size distribution of suspended, bedload, and deposition sediment continues. Regular aerial photogrammetry occurs on weekly to monthly intervals depending on hydrology and flight conditions.

Data from these monitoring activities have contributed to a broader effort to test and verify the U.S. Bureau of Reclamation model for predicting vertical and lateral sediment erosion in river and reservoir settings (Bradley and Bountry 2014; Warrick and Bountry 2015; Randle *et al.* 2015)

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