# Recovery Plan for Skokomish River Chinook Salmon

## 2017 Update

**Skokomish Indian Tribe**
**Washington Department of Fish and Wildlife**
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# Acknowledgements

This updated plan was developed by a team of individuals dedicated to the idea that a productive, naturally reproducing population of Chinook salmon can once again thrive in the Skokomish River system. The primary authorship for the plan is the Skokomish Indian Tribe and the Washington Department of Fish and Wildlife. Contributions to the plan came from a variety of individuals who were involved at different times during the plan's development. These individuals are acknowledged below. Much appreciation is extended to them for their help in this work.

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# Executive Summary

## 1. The Recovery Plan

**<u>Introduction.</u>** On March 24, 1999, the National Marine Fisheries Service (NMFS) listed all naturally spawned populations of Chinook salmon (*Onchorhynchus tshawytscha*) and five artificial propagation programs within the Puget Sound evolutionarily significant unit (ESU) as a threatened species under the Endangered Species Act (ESA). The threatened species status was reaffirmed on June 28, 2005, and an additional 21 artificial propagation programs within the ESU were added to the listing. The listing included the Chinook stock currently produced in the Skokomish watershed, comprised of hatchery-produced fish from George Adams Hatchery and naturally-produced fish from the Skokomish River. In 2016, NMFS recommended that the new North Fork Skokomish River spring-run Chinook program be also included in the listing.

The listing under the ESA requires NMFS to develop and implement recovery plans for the conservation and survival of Chinook salmon within the Puget Sound ESU. As part of the efforts to prepare recovery plans for the listed populations, the Skokomish Indian Tribe (SIT) and Washington Department of Fish and Wildlife (WDFW) co-authored the recovery plan for Skokomish Chinook. An initial version of the plan was prepared in 2007, which was followed by an extensive update done in 2010.

This document is an updated version of the plan submitted to NMFS in 2010. Parts of this current version remain similar to or unchanged from the 2010 version, but significant parts have been added or updated. Two major additions to the plan were needed to (1) incorporate new actions aimed at further improving the potential for recovering a late-timed population component and (2) incorporate the results of the U.S. Army Corps of Engineers (USACE) General Investigation on the Skokomish River, which was completed in 2015. This updated version also addresses questions and comments received from NMFS and the Puget Sound Recovery Implementation Technical Team (RITT) on the 2010 Plan.

Significant progress has been made in planning and implementing recovery actions since the 2010 Plan was issued. This updated version summarizes progress related to the major strategies of the plan. The most recent information on the status of Skokomish Chinook and critical natural habitats is also included.

Historically, Skokomish Chinook 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. Both indigenous racial groups have been extirpated from the river basin. This fact presents particular challenges for recovery since well-adapted genetic stock sources do not currently exist in the river system.

Divergent views have existed on the approach to be taken for recovering a Skokomish population, mainly related to what we call the “stock issue”—that is, whether the focus should primarily be on recovering a spring Chinook population or a fall Chinook population—or to varying extents on both a spring and fall population. The stock issue is a policy matter. The crux of the issue is that both indigenous racially distinct population groups have been extirpated—what currently is produced is significantly different from both indigenous populations in life history expression and genotype.

The extant population in the 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. 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 spawners that produced them.

The 2010 Plan focused on recovery of a spring Chinook population. In brief, it was 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 rationale is described in detail in the 2010 Plan. This updated plan incorporates meaningful steps to make significant progress in improving the potential for recovery of a late-timed Chinook population other than just progressing in habitat restoration. These steps include both hatchery and harvest-related actions. The plan, however, continues to maintain a strong emphasis on recovering a spring Chinook population.

The premise on which this plan 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. This life history perspective guides every part of the plan. Knowledge of the aboriginal life histories that existed prior to their extirpation provides an essential part of this guidance. Moreover, in developing the plan, we placed much importance on diagnosing the factors that caused the extirpation of the aboriginal life histories. A major portion of the 2010 Plan focused on the diagnosis, both with respect to the genetic and phenotypic characteristics of the extant population and the watershed conditions. The diagnosis provides direction to the plan and helps set restoration priorities and sequencing for strategies.

**Overarching Hypotheses.** Two overarching hypotheses guide this plan. The first addresses what we refer to as the stock issue, which considers what genetic stock source is suitable for achieving recovery within a reasonable time period. This matter is of particular importance to this plan because the extant stock produced in the Skokomish River is not indigenous and it has life history traits unlike those of either of the aboriginal racial groups. The second hypothesis considers the feasibility for restoring normative habitat characteristics within the Skokomish watershed.

The stock issue raises this critical question: If the proposed strategies for restoring normative habitat characteristics are successful, would life histories naturally re-emerge from the existing extant summer/early fall stock to resemble either those of true spring-run Chinook or a mature migrating fall-run Chinook? The answer may hinge on how long we are willing to wait. In theory, adapted life histories might eventually re-emerge, but probably only after many human generations, and then, only if local, regional, or trans-regional environmental issues did not develop to stymie their re-emergence.

The overarching hypothesis that addresses this question considers both the ultimate potential for success and the length of time that might be needed to realize success. The hypothesis is that a reasonably close match is required between life history traits of the genetic stock source to be used in the recovery effort and those of the aboriginal racial groups that were adapted to the Skokomish watershed.

The plan relies on an outside donor stock for re-introducing spring Chinook into the Skokomish watershed. The donor stock, Skagit River spring Chinook from Marblemount Hatchery, exhibits a river entry pattern and other life history traits essentially identical to the aboriginal Skokomish spring-run population.

For fall chinook, the prospect that a late-timed true fall Chinook life history could re-emerge from the extant stock seems plausible given the fall Chinook stock origin. However, domestication effects appear to have been so significant that the potential of this occurring is highly uncertain. We note, however, that 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 hypothesize that if 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 second overarching hypothesis within this plan is that normative habitat characteristics can be sufficiently restored to the Skokomish River to support a self-sustaining, productive Skokomish Chinook population. In its current state, the river system is radically different than its prior state. A major thrust of this plan is to restore normative watershed processes, which in turn, will form and maintain habitat function that can support naturally produced Chinook life histories. The plan also incorporates habitat strategies that will use engineered solutions, such as those that will provide for upstream and downstream passage at the Cushman Project.

**Planning Horizons.** Achievement of the desired future condition is a long-term endeavor. The foreseeable planning horizon ranges between 20 to 30 years depending on the salmon population in focus. For the extant summer/early fall population, we consider a 20-year time horizon because of the experimental nature of the actions to be employed. These actions aim to shift the run timing curve of the extant population to later timing—most notably to alter the latest segment of the run greatest to more closely resemble the historic pattern. We hypothesize that this shift for the late timing segment should improve the reproductive success to produce adult progeny of naturally spawning fish. We are unaware of another effort like this for Chinook salmon, and we consider this part of the plan as highly experimental. A 20-year time horizon is presumed needed to evaluate progress. At the end of this 20-year period, we expect that a major re-evaluation of all aspects of this part of the plan will be needed, even though monitoring and evaluation activities will proceed uninterrupted over the period.

The planning horizon for the spring Chinook part of the plan encompasses the time period associated with the FERC license for the Cushman Project, which extends to 2048 or 30 years from present. During this period, a suite of strategies—many of which are required under the Cushman license—aimed at restoration and recovery of habitat and salmon in the North Fork, lower Skokomish River, and the estuary will be implemented. Other strategies, unrelated to the Cushman Project, will also be implemented, some of which will likely extend well beyond the 30-year horizon. It is expected, for example, that some strategies aimed at restoring the upper South Fork will need to mature over at least a 100-year time frame before their full benefit is realized. Active restoration of some normative conditions benefiting Chinook salmon will occur over much shorter time periods also.

## 2. Chinook Salmon Life Histories

The life histories of the historic Skokomish Chinook populations are reviewed and compared to those expressed by the contemporary extant population. The contemporary population, derived from a historic fall-run population, has been significantly advanced in river-entry timing, spawning timing, and fry emergence timing. The fry produced from spawners that spawn naturally in the river now demonstrate peak fry emergence in early to mid-winter. Historically, fry produced from natural spawners—both spring and fall-run racial groups—emerged in late winter and spring, when the likelihood of freshets was diminishing, water was warming, and prey availability was increasing. The performance of the contemporary population when spawning naturally in the river is poor, demonstrating poor egg-to-fry survival and poor adult recruitment rates.

The plan consists of actions aimed at improving the reproductive success of naturally spawning Chinook in the Skokomish watershed. To do this, the plan calls for different approaches for spring and fall-run Chinook.

## 3. Approaches and Phases

The approaches for the two populations differ significantly, though both require effective recovery actions within each 4-H strategy (habitat, hatchery, harvest, and hydropower).

The approach for spring Chinook is to reintroduce true spring Chinook into the watershed using a non-native donor stock. A four-phased framework to guide the effort is presented with a progression through the phases determined by the performance response of the reintroduced stock. The planning horizon for this part of the plan is 30 years, which aligns with the time period remaining under the existing Cushman Project license. Full recovery of a spring Chinook population in the watershed by the end of this period is unlikely, however. Phase 1 (establishing the founder stock) of the part of the plan directed at spring Chinook is currently being implemented.

The approach to be employed for improving the potential of recovering a late-timed fall population is experimental. It requires a substantial re-shifting of the timing of certain life stages of the existing George Adams summer/early fall population in an attempt to recreate life history patterns that have been lost in the population. We hypothesize that these life history patterns, which would more closely resemble aboriginal patterns, are needed to improve the success of natural spawners to produce adult progeny. We project that a 20-year time period will be needed to evaluate whether this approach can be successful at progressing toward the potential recovery of a true fall-run population.

The approach to restructure river entry and spawning timing of the summer/early fall Chinook population is intended to accomplish the following:

1. Create a distinct timing separation between returning spring Chinook and George Adams Chinook, thereby minimizing potential complications due to overlapping runs both in harvest management and in spawning;
2. Stabilize the central river-entry timing mode of George Adams hatchery fish to primarily occur in August, enabling both treaty and non-treaty fisheries to more effectively harvest returning fish with minimal harvest conflicts to natural production potential and other salmon runs and species; and

3. Experimentally determine the success of re-creating later-timed George Adams fish and subsequently to assess their reproductive performance when spawning naturally in the river.

The new approach to managing the extant summer/early fall Chinook population is developed around three river-entry timing segments of the population, an early, middle, and late timing segment. Based on recent performance patterns of the population, we define the early segment to currently be that part of the run that enters the river before about August 1. Substantial numbers of George Adams Chinook now return to the river prior to this date, with some returning as early as late June.

The middle segment of the population now primarily returns to the river during August with peak entry appearing to occur early in the month. This segment includes fish that return over the entire month—it forms the central core of the population's river-entry pattern. The late timing segment of the population as it currently exists consists of those fish that enter the river after the end of August. Some fish continue to enter through September with the run rapidly diminishing during this time.

## 4. Habitat Strategies

Since the 2010 Plan was issued, substantial progress has been made toward improving conditions for Chinook recovery, as well as to prepare for implementing new actions.

**Upper South Fork.** In the upper South Fork, restoration work over the past decade has focused primarily on reducing sediment delivery to stream channels and on the installation of large wood to the river to restore normative watershed processes. Most work to date on National Forest lands has been aimed at reducing sediment inputs. As a result, in accordance with the Watershed Condition Framework guidelines, the upper South Fork was reclassified as a "properly functioning watershed" with respect to sediment inputs from past logging related activities (ONF news release June 9, 2016). Watershed conditions are still recovering, but certain key watershed processes have been significantly improved.

Effort to restore log jams in the upper South Fork has focused over the past decade on a three-mile river section called Holman Flats, which was intensively logged and cleared of logjams for a proposed new reservoir in the 1950s. Another phase of work for restoring logjams in the upper South Fork is in the assessment stage. In 2016, the USFS TEAMS Enterprise specialists assessed the 12 miles of upper South Fork upstream of Holman Flats (RM 14 to 26)—the assessment concluded that substantial work is needed to restore wood loads.

The 2010 Plan identified a series of cascades within the South Fork gorge as a potential partial barrier to upstream migrating spring Chinook. In 2015, Mason Conservation District (MCD), in cooperation with the Skokomish Tribe, secured funding and initiated an assessment of the gorge cascades for adult salmon passage. The services of Waterfall Engineering, LLC were retained to complete the assessment. Staff of MCD participated in the investigation. The assessment was finished in 2017. A final technical report will be available in early 2018; a summary of the methods and key findings is provided in this plan update.

**North Fork.** Significant progress has been made in restoration work in the North Fork since 2010 as a result of implementing the 2009 Cushman Agreement. Four aspects of the work are particularly relevant to this plan: a new flow regime, construction of fish passage facilities at the dams, improvements in passage at Little Falls, and monitoring of habitat conditions within lower North Fork. The monitoring work that has been done has enabled planners to draw conclusions about the current state of habitat in lower North Fork.

The Cushman Agreement requires Tacoma Power to develop a Fish Habitat Enhancement and Restoration Plan (FHER Plan) to guide implementation of projects to restore habitat in the North Fork and McTaggert Creek. Based on the first three years of monitoring, several habitat restoration projects have been identified and one is in the process of being implemented.

**Lower Watershed.** Progress in habitat restoration work in the lower watershed since 2010 was primarily achieved by completing the USACE General Investigation (GI) and in related planning to implement locally funded actions. In late 2016, as part of the process to update this recovery plan, a restoration forum was held to obtain additional information to help inform this update. Also to inform this update, an assessment was made in 2017 of current conditions in the lower South Fork and Skokomish River valley.

As a result of the GI, five major projects were proposed for implementation. Over 60 different projects were considered and evaluated. Many of the projects not selected as part of the federal action were deemed to have substantial benefit to restoration but did not satisfy all of the criteria considered for adoption as part of the federal package. Many of the projects not selected are still being considered or advanced for funding from other funding sources.

The package of five actions proposed as the Skokomish River Basin Ecosystem Restoration Project was authorized for funding by Congress in 2017. The package of actions awaits final funding approval. The estimated total cost for the combined project is approximately $20 million, of which about $13 million would be the federal responsibility. These costs include the monitoring portions of the project.

Natural Systems Design, Inc. (NSD 2017) assessed channel conditions in the lower valley based on LiDAR data and aerial imagery. The findings are informative to this recovery plan. The assessment also provided metrics that can be used for assessing changes in future conditions due to various factors including restoration actions. The complete assessment is provided in Appendix A of this recovery plan.

**Estuary.** During the past 12 years, the Skokomish Tribe has worked effectively with many partners, particularly Mason Conservation District and Tacoma Power, as well as different funding agencies, in a major large-scale, multi-phased effort to restore much of the Skokomish estuary to its historic and natural form and function. While the estuary has not been completely restored to its pristine state as it existed 150 years ago, the level of restoration has been very large and comprehensive. Roads and dikes have been removed or breached, fill has been removed, large amounts of sediment have been removed or flushed out to Hood Canal, tidal channels have been opened or reformed, and estuarine marsh and wetlands have been restored. Some estuarine restoration work remains in planning stages.

## 5. Hatchery Strategies

Hatchery technology is an essential tool for recovering Chinook life histories adapted to the environmental conditions being restored to the Skokomish watershed. Habitat restoration and hatcheries, operating in unison, are mutually necessary to achieve both the short- and long-term recovery goals for the watershed. Hatchery actions are needed to re-establish spring Chinook in the watershed, redevelop a later returning population segment of the extant summer/early fall Chinook population to aid in potentially recovering a fall-timed population, and to help ensure the maintenance of treaty-protected and non-treaty fisheries.

Several hatchery strategies are being implemented as part of the plan. The strategies are aimed at achieving the following:

1. Reintroduce spring Chinook sequentially to the upper North Fork and then into the upper South Fork of the Skokomish River;
2. Maintain genetic diversity and abundance of spring Chinook in the river system while promoting local adaptation of the introduced fish in the basin using conservation hatchery principles and tools;
3. Manage genetic diversity and composition of the extant, George Adams Hatchery summer/early fall Chinook population to achieve the following:
    a. Reduce or eliminate the continued advance of run entry and spawning timing of the population, particularly reducing or eliminating the June and July run entry segment of the population;
    b. Stabilize the core run entry timing mode to maintain an August run entry timing; and
    c. Extend and enhance the latest run entry timing segment of the population, i.e., the September and October segment, and facilitate increased natural spawning of this segment into the lower North and South forks and Vance Creek.
4. Continue providing for harvest even after such time as natural production produces a stable, self-sustaining population.

## 6. Harvest Strategies

Harvest-related strategies are being implemented to (1) ensure that fishery-related mortality will not impede recovery of spring Chinook in the watershed and (2) help evaluate the potential for recovering a late-timed (fall run) Chinook population. As the plan goes forward, the potential for expanding recovery efforts to include the late-timed racial group will be evaluated based on progress of experimental work to adjust important life history characteristics and at recovering the spring Chinook population.

Fisheries are being implemented to achieve the following objectives related to spring Chinook and summer/early fall Chinook:

1. Protect and conserve the abundance and life history diversity of a locally adapted, self-sustaining spring Chinook population during and after its recovery;
2. Recognizing the advance in run timing that has occurred on the summer/early fall Chinook over time, shape terminal area fisheries to better utilize the early and mid-portions of returning hatchery fish and give greater protection from harvest mortality to the late-returning segment of the run to facilitate an increase in natural reproductive rates of natural spawners.
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, re-introduced sockeye, hatchery-origin and wild coho, and fall chum).

4. Recognizing the importance of ceremonial and subsistence (C&S) tribal fisheries, prioritize C&S fisheries over any other fisheries targeting the Skokomish River spring Chinook during all phases 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 among treaty and non-treaty fishers.
6. Monitor abundance, productivity, and spawning distribution of spring and summer/early fall Chinook populations, which will include estimating catch distribution, age composition, and mortality in all fisheries.

Harvest objectives and guidelines for Skokomish spring Chinook are to be incorporated in subsequent revisions of the Puget Sound Chinook Harvest Management Plan.

## 7. Hydropower Strategy

The Cushman Project will continue to have a major role in the Skokomish watershed over at least the next 40 years. On July 15, 2010, the Federal Energy Regulatory Commission (FERC) issued a new license to the City of Tacoma to operate the Cushman Project. License articles call for the implementation of a variety of measures aimed at restoring normative watershed functions and salmon life histories adapted to the watershed, as spelled out in the Cushman Settlement. Tacoma is required to fund and implement these measures over the life of the license.

As Tacoma had a role in the demise of the aboriginal salmon life histories, it now has an important role in their recovery. The actions specified in the new license call for the re-establishment of early-timed Chinook in the upper North Fork, which is a foundational part of this recovery plan.

The hydropower strategy is comprised of the following components:

1. New flow regime with normative characteristics;
2. Provisions for upstream and downstream passage at the Cushman Dams;
3. Use of appropriate donor stocks to reintroduce salmon species upstream of the Cushman Dams, including the construction of modern hatchery facilities to maintain these reintroductions;
4. Habitat restoration in the lower North Fork; and
5. Monitoring and evaluation activities to monitor the progress of all aspects of the program.

## 8. Strategy Integration

The co-managers, working with their recovery partners in the basin, such as the U.S. Forest Service and Tacoma Power, are collaborating on all aspects of the plan to ensure coordination and updating the plan’s provisions going forward. A critical part of this integration effort will be close working with the USACE once funds are appropriated from Congress to implement the actions identified through the General Investigation.

## 9. Adaptive Management and Monitoring

The co-managers and their restoration partners are committed to maintaining a coordinated monitoring effort to support adaptive management for the recovery plan. Major components of the monitoring effort will be funded and implemented through different sources, namely the Cushman Settlement and USACE's Skokomish River Basin Ecosystem Restoration Project. Other monitoring efforts are expected to be maintained as part of on-going fisheries management activities of the co-managers and various other sources of restoration funds being expended in the watershed.

The elements of monitoring contained in the plan do not in themselves constitute a monitoring plan for recovery. Instead, they are being woven into monitoring efforts either already underway, soon to be implemented, or to be undertaken in the future as funding becomes available.

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# Chapter 1. Introduction

> *"The recovery of the Pacific salmon will be thwarted until at least some of the natural pathways through the riverscape are restored, until we give life to the ghosts of those salmon life histories that were once present in healthy rivers."*
>
> \- Jim Lichatowich, *Salmon Without Rivers*
>
> *"There is no saying where the Northwest salmon story will eventually conclude, but it is certain that man and salmon will be linked, for as the Indians said from the start: the fate of one mirrors the fate of the other."*
>
> \- Bruce Brown, *Mountain in the Clouds*

On March 24, 1999, the National Marine Fisheries Service (NMFS) listed all naturally spawned populations of Chinook salmon (*Onchorhynchus tshawytscha*) and five artificial propagation programs within the Puget Sound evolutionarily significant unit (ESU) as a threatened species under the Endangered Species Act (ESA). The threatened species status was reaffirmed on June 28, 2005, and an additional 21 artificial propagation programs within the ESU were added to the listing. The listing included the Chinook stock currently produced in the Skokomish watershed, comprised of hatchery-produced fish from George Adams Hatchery and naturally-produced fish from the Skokomish River. In 2016, NMFS recommended that the new North Fork Skokomish River spring-run Chinook program be also included in the listing.

The listing under the ESA requires NMFS to develop and implement recovery plans for the conservation and survival of Chinook salmon within the Puget Sound ESU. As part of the efforts to prepare recovery plans for the listed populations, the Skokomish Indian Tribe (SIT) and Washington Department of Fish and Wildlife (WDFW) co-authored the recovery plan for Skokomish Chinook. An initial version of the plan was prepared in 2007 (SIT and WDFW 2007), which was followed by an extensive update done in 2010 (SIT and WDFW 2010).

This document is an updated version of the plan submitted to NMFS in 2010 (hereafter referred to as the 2010 Plan). Parts of this current version remain similar to or unchanged from the 2010 version, but significant parts have been added or updated. Two major additions to the plan were needed to (1) incorporate new actions aimed at further improving the potential for recovering a late-timed population component and (2) incorporate the results of the U.S. Army Corps of Engineers (USACE) General Investigation on the Skokomish River, which was completed in 2015. This updated version also addresses questions and comments received from NMFS and the Puget Sound Recovery Implementation Technical Team (RITT) on the 2010 Plan.

Significant progress has been made in planning and implementing recovery actions since the 2010 Plan was issued. This updated version summarizes progress related to the major strategies of the plan. The most recent information on the status of Skokomish Chinook and critical natural habitats is also included.

This update also incorporates refinements in metrics for measuring progress towards recovery, as well as in the desired future condition targets (i.e., recovery goals) to better define both targeted habitat restoration levels and related performance of the Chinook population(s). These refinements were initiated as part of the Phase I Monitoring and Adaptive Management process (PSP 2014) and have been further improved here through funding provided by the Puget Sound Partnership (PSP).

The ultimate goal of this plan is to re-establish a productive, self-sustaining, naturally produced Chinook population in the Skokomish watershed—one that will be sustainable in the face of climate change projections while meeting broad-sense goals for ecosystem services, such as fishery harvest. A salmon recovery goal typically includes two aspects: ESA recovery, which deals with the statutory requirements under the federal ESA for meeting viability criteria for populations and the ESU as a whole, and a broader view of recovery (or broad-sense recovery) that reflects societal goals for ecosystem services, such as harvest (McElhany et al. 2000; NMFS 2000). Recovery is to be determined by population performance, as measured by four characteristics of performance: abundance, productivity, biological diversity, and spatial structure (or spatial distribution) (McElhany et al. 2000).

To achieve this goal will require the re-emergence of a naturalized population adapted to the Skokomish River, its estuary, and connecting marine waters. Presumably, when this happens, life histories that are now absent in the extant Skokomish population will once again be expressed and resemble those seen in aboriginal Skokomish Chinook.

Historically, Skokomish Chinook 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 (Table 1.1). Quinn et al. (2016) referred to spring Chinook as premature migrating because they return to their home rivers in a sexually premature condition; fall chinook were called mature migrating because they are largely sexually mature when they enter freshwater as adults. Besides differences in river entry timing, these groups differed markedly in their spatial use of the watershed.

Both indigenous racial groups have been extirpated from the river basin (Ruckelshaus et al. 2006; SIT and WDFW 2010). This fact presents particular challenges for recovery since well-adapted genetic stock sources do not currently exist in the river system.

**Table 1-1. River entry timing of the historic and extant Chinook populations in the Skokomish River.**

| Era | Population | River entry timing | Status and comments |
|---|---|---|---|
| Historic | Spring Chinook | Apr - Aug | Also called early-timed Chinook or premature migrating; extirpated; focus of re-introduction efforts currently. |
| | Fall Chinook | Sep - Nov | Also called late-timed Chinook or mature migrating; extirpated; experimental efforts initiated to re-develop the primary life history characteristics from the extant summer/early fall population. |
| Current | Summer/early fall Chinook | Jul - Sep | Derived from Green R. hatchery stock, originally a fall-run population; contemporary life history characteristics are unlike the historic Green R. stock or the historic Skokomish fall-run stock. |

Divergent views have existed on the approach to be taken for recovering a Skokomish population, mainly related to what we call the "stock issue"—that is, whether the focus should primarily be on recovering a spring Chinook population or a fall Chinook population—or to varying extents on both a spring and fall population. The stock issue is a policy matter. The crux of the issue is that both indigenous racially distinct population groups have been extirpated—what currently is produced is significantly different from both indigenous populations in life history expression and genotype (see Chapter 2).

The extant population in the river is a highly domesticated hatchery stock (George Adams) derived from Green River hatchery fish (Table 1.1).[1] 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 (Quinn et al. 2002; SIT and WDFW 2010). Available evidence (presented herein) 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 spawners that produced them.

The 2010 Plan focused on recovery of a spring Chinook population. In brief, it was 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 rationale is described in detail in the 2010 Plan. This updated plan incorporates meaningful steps to make significant progress in improving the potential for recovery of a late-timed Chinook population other than just progressing in habitat restoration. These steps include both hatchery and harvest-related actions. The plan, however, continues to maintain a strong emphasis on recovering a spring Chinook population.

The premise on which this plan 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. This life history perspective guides every part of the plan. Knowledge of the aboriginal life histories that existed prior to their extirpation provides an essential part of this guidance. Moreover, in developing the plan, we placed much importance on diagnosing the factors that caused the extirpation of the aboriginal life histories. A major portion of the 2010 Plan focused on the diagnosis, both with respect to the genetic and phenotypic characteristics of the extant population and the watershed conditions. The diagnosis provides direction to the plan and helps set restoration priorities and sequencing for strategies.

This introductory chapter includes the following sections:

- 1.1 Demise of Indigenous Skokomish Chinook;
- 1.2 The Environment;
- 1.3 Vision for Restoration and Recovery;
- 1.4 Overarching Hypotheses; and
- 1.5 Plan Organization.

[1] / Green River is in the Duwamish River watershed, which drains to Puget Sound in Seattle.

## 1.1 Demise of Indigenous Skokomish Chinook

The demise of the indigenous racial groups was due to multiple factors, operating in concert and set in motion by various events—both locally and in distant waters—since the late 1800s. In brief, a combination of effects, escalating in intensity over time, far exceeded the productive resiliency of the indigenous populations for sustaining themselves. Hydro development, water diversion, floodplain development, estuarine alterations, liquidation of old growth forests, greatly expanded fishing patterns—all of these contributed to the extirpation of the aboriginal Chinook populations in the Skokomish River.

As the runs declined, the need to bolster their abundances became evident—leading to the construction of George Adams Hatchery in 1961. Hatchery Chinook stock of Green River lineage was imported to facilitate startup. Over time, this event, combined with all of the other factors listed above, led to a complete replacement of population structure (Myers et al. 1998; Ruckelshaus et al. 2006). The life history diversity of Chinook produced in the watershed today is a distant shadow of that of the historic aggregate populations.

## 1.2 The Environment

The Skokomish River, located in the southeast corner of the Olympic Peninsula, drains 240 square miles of mostly forested land. Originating in the Olympic Mountains and foothills, it empties to the southern end of Hood Canal, a branch of the Puget Sound complex (Figure 1.1). Hood Canal is a natural, glacier-carved fjord more than 60 miles long, which forms the westernmost waterway and margin of the Puget Sound basin.

The Skokomish watershed's topography is widely varied, consisting of steep mountain slopes, more moderately sloping foothills, and flat valley bottoms. The two arterial rivers, the North and South forks, that join to form the main Skokomish River flow south and east out of the mountains, descending through incised valleys, interspersed with steep gorges and sections of widened valley bottoms, before joining in the wide, flat lower valley. From here, the river generally meanders to its extensive delta in the southwestern corner of Hood Canal (Figure 1.2).

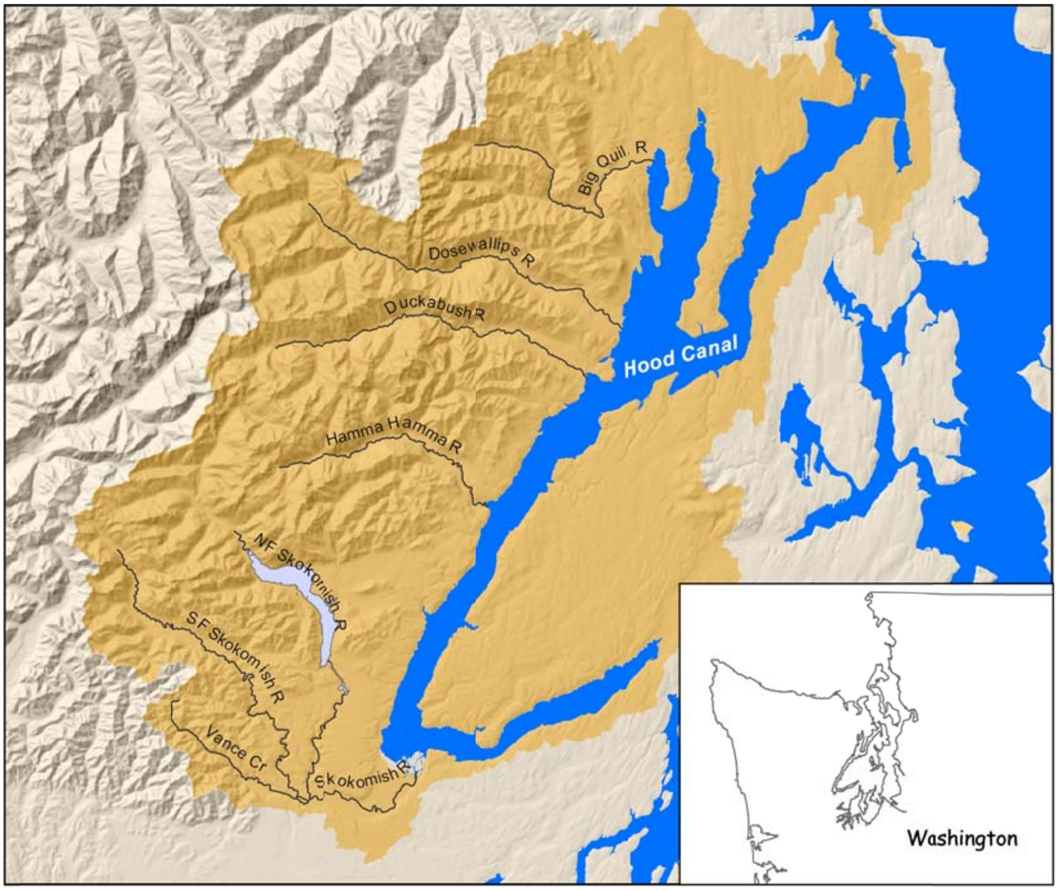
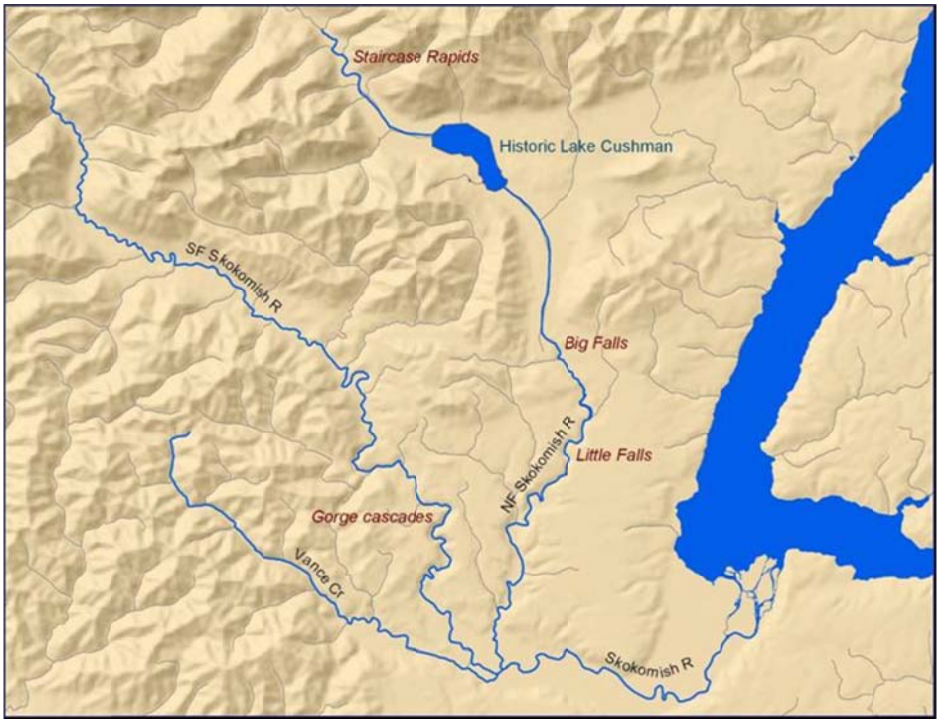



**Figure 1-1. Map of the Hood Canal basin with major river systems draining to it. The geographic area draining to Hood Canal is shaded. The Skokomish River is located in the southern end of the basin.**



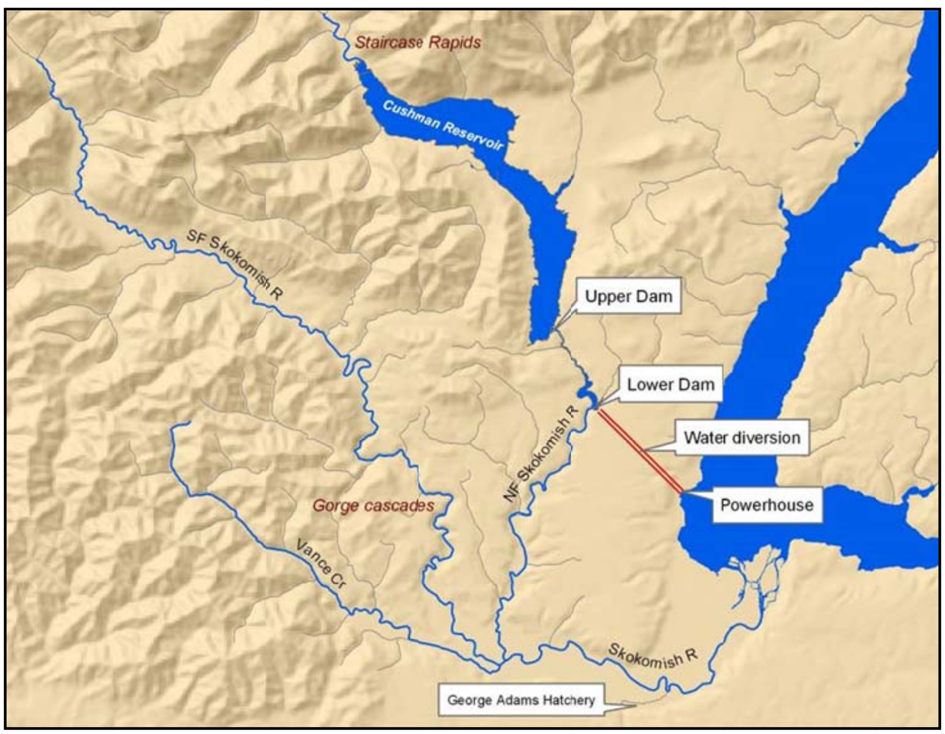




**Figure 1-2. Features of the Skokomish River system prior to and after construction of the Cushman Project. The top map shows the approximate size of the original Lake Cushman and the locations of Big and Little Falls. The major components of Cushman Project are shown in the bottom map, as well as the location of George Adams Hatchery. Location of the South Fork gorge cascades is shown.**

Over the past 150 years, many features of the watershed have been radically altered through landuse and hydro development, including river flow, lake size, land cover, and riverine and riparian characteristics. Forest harvest and agricultural practices since the late 1800s are two principal reasons for these changes. The most dramatic alterations, however, occurred in the North Fork, with the construction of the two Cushman dams, inundation of much of the upper North Fork to form Cushman Reservoir, and the diversion of the river's flow out of the watershed and directly to Hood Canal (Figure 1.2). No provisions for fish passage were provided at the dams, which were built in the late 1920s. The Cushman Settlement, agreed on in January 2009, provides for fish passage, re-introductions of salmon into the upper North Fork, and restoration of normative flow characteristics, among other provisions (see Chapter 7).

The George Adams Hatchery is located in the lower part of the Skokomish River valley (Figure 1.2). Built in 1961, it is operated by WDFW primarily for the purpose of augmenting harvest opportunity for treaty Indian and non-treaty fisheries. The facility was built to mitigate for lost salmon production due to the extensive watershed alterations, of which the Cushman Project was considered to be the most significant (WDF 1957b).

## 1.3 Vision for Restoration and Recovery

Defining recovery goals, strategic objectives, and implementation actions within this recovery plan begins with establishment of a vision statement for the Skokomish watershed:

> *The co-managers envision the watershed restored to normative ecosystem functions, supporting productive, diverse salmon populations that meet recovery goals, as well as providing for sustainable social, cultural, and economic values within and outside the recovery region.*

Realizing this vision would mean:

- Meeting the recovery goals for abundance, productivity, spatial distribution, and diversity for Chinook salmon and other ESA-listed species;
- Achieving healthy and harvestable populations of species that are either currently ESA-listed or unlisted; and
- Recognizing and preserving the social, cultural, and economic values derived from the Skokomish ecosystem by tribal and non-tribal communities.

The terms "normative ecosystem" and "normative river flow" are used throughout this plan to mean an altered system that has a balanced mix of natural and cultural features such that indigenous life histories of salmon populations can be supported. These terms, developed for application to salmon recovery planning in the much altered Columbia River system (Williams 2006; Liss et al. 2006), recognize that modern society often causes substantial changes in watershed processes and functions. Still, in many watersheds, ecological processes can be maintained—or restored—sufficiently to support salmon life histories that were historically adapted to them. Normative refers to the norms of ecological functions and processes characteristic of salmon-bearing streams. These features, when balanced with society's needs and demands, result in an ecosystem in which both natural and cultural elements exist in a balance, allowing salmon to thrive and many of society's present uses of the river to continue, although not without modification (Liss et al. 2006).

The importance of each of the H's is implicit in our vision. Habitat must be accessible and exist in sufficient quality and quantity for all salmonid life stages. Hatcheries cannot produce more risks than benefits to the ecosystem and the salmonid populations. Harvest must be at levels that do not diminish populations beyond their ability to sustain themselves at productive levels within the available habitat. Hydropower must facilitate—not hinder—restoration of naturally-produced Chinook and other species. The approaches to recovery described herein for each Chinook population—both the spring and fall-run populations—include actions that address each of the H's.

Achievement of the desired future condition is a long-term endeavor. The foreseeable planning horizon ranges between 20 to 30 years depending on the salmon population in focus. For the extant summer/early fall population, we consider a 20-year time horizon because of the experimental nature of the actions to be employed. These actions aim to shift the run timing curve of the extant population to later timing—most notably to alter the latest segment of the run greatest to more closely resemble the historic pattern. We hypothesize that this shift for the late timing segment should improve the reproductive success to produce adult progeny of naturally spawning fish. We are unaware of another effort like this for Chinook salmon, and we consider this part of the plan as highly experimental. A 20-year time horizon is presumed needed to evaluate progress. At the end of this 20-year period, we expect that a major re-evaluation of all aspects of this part of the plan will be needed, even though monitoring and evaluation activities will proceed uninterrupted over the period.

The planning horizon for the spring Chinook part of the plan encompasses the time period associated with the FERC license for the Cushman Project, which extends to 2048 or 30 years from present. During this period, a suite of strategies—many of which are required under the Cushman license—aimed at restoration and recovery of habitat and salmon in the North Fork, lower Skokomish River, and the estuary will be implemented. Other strategies, unrelated to the Cushman Project, will also be implemented, some of which will likely extend well beyond the 30-year horizon. It is expected, for example, that some strategies aimed at restoring the upper South Fork will need to mature over at least a 100-year time frame before their full benefit is realized.[2] Active restoration of some normative conditions benefiting Chinook salmon will occur over much shorter time periods also.

It is important to also recognize that hatchery operations will play an essential role in (1) re-establishing spring Chinook in both the North and South forks, (2) experimentally advancing the potential for recovering late-timed fall Chinook, and (3) in continuing to provide important harvest benefits (Figure 1.3). The recovery effort will be benefitted by hatchery production to initiate the re-introductions of spring Chinook and to evaluate the potential for re-establishing fall-run Chinook while habitat restoration progresses. At the same time, hatchery production of the existing George Adams summer/early fall Chinook stock will be maintained to help meet harvest needs as part of on-going mitigation for lost fish production. Hence, hatcheries and habitat restoration strategies operating in unison can provide an effective approach to achieve both the short- and long-term goals for the watershed.

---

[2] / It is expected that the complete re-establishment of large, stable conifers near and adjacent to the South Fork mainstem will exceed 100 years. See Chapter 4 for details.

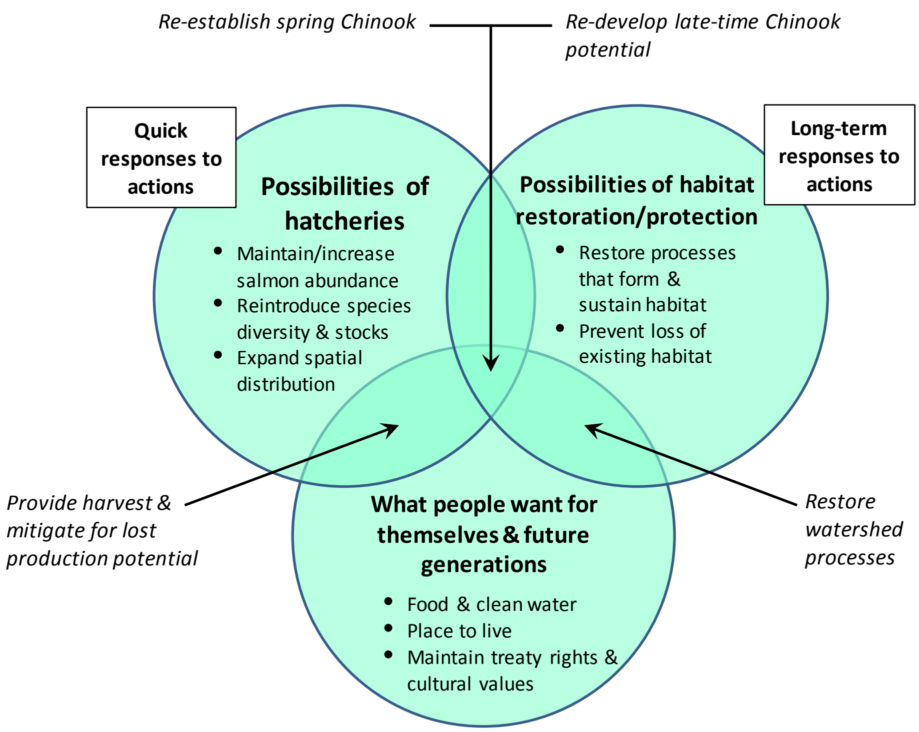



**Figure 1-3. Relationship of the roles of hatcheries and habitat restoration with public policy for recovery of Skokomish River Chinook salmon.**

## 1.4 Overarching Hypotheses

Two overarching hypotheses guide this plan. The first addresses what we refer to as the stock issue, which considers what genetic stock source is suitable for achieving recovery within a reasonable time period. This matter is of particular importance to this plan because the extant stock produced in the Skokomish River is not indigenous and it has life history traits unlike those of either of the aboriginal racial groups (see Chapter 2). The second hypothesis considers the feasibility for restoring normative habitat characteristics within the Skokomish watershed.

The stock issue raises this critical question: If the proposed strategies for restoring normative habitat characteristics are successful, would life histories naturally re-emerge from the existing extant summer/early fall stock to resemble either those of true spring-run Chinook or a mature migrating fall-run Chinook? The answer may hinge on how long we are willing to wait. In theory, adapted life histories might eventually re-emerge, but probably only after many human generations, and then, only if local, regional, or trans-regional environmental issues did not develop to stymie their re-emergence.

The overarching hypothesis that addresses this question considers both the ultimate potential for success and the length of time that might be needed to realize success. The hypothesis is that a reasonably close match is required between life history traits of the genetic stock source to be used in the recovery effort and those of the aboriginal racial groups that were adapted to the Skokomish watershed.

One of the key life history traits is river entry timing. This trait provides a measure, albeit a partial one, of how matched the extant stock is as a genetic source for recovering either a spring-run or a fall-run Chinook population. A single life history trait, such as run timing, is not disconnected to other life history traits in the life of an animal. Physiological interdependence among life history traits constrains and adjusts phenotypic plasticity, determining the effect of an environmental pressure on one trait on other traits (Ricklefs and Wikelski 2002).

The river entry timing of the two aboriginal Chinook races in the Skokomish River differed widely—hence the names for the two races: spring-run and fall-run. The Skokomish spring Chinook entered the river principally during April through July corresponding to the timing of the spring runoff (Smoker 1952). In contrast, the aboriginal fall chinook entered the river primarily during September, October, and November, corresponding largely with the onset and occurrence of fall rains. These timing patterns are described in greater detail in Chapter 2.

The extant Skokomish population enters the river today primarily between mid-July and early September, essentially intermediate between the timing patterns of the two aboriginal racial groups. This timing pattern has developed over many generations of hatchery propagation (Quinn et al. 2002; SIT and WDFW 2010).[3]

For spring Chinook, the prospect that a true spring-run life history could develop from the extant hatchery stock is highly unlikely despite the advancement in run timing that has occurred over past decades. Recently published research has reported that the spring-run Chinook life history arose from a rare evolutionary event in the distant past and that genetic mechanisms capable of producing this phenotype are extremely limited (Prince et al. 2017). The authors concluded that if current premature migration alleles are lost, new premature migration alleles and the phenotype they promote cannot be expected to re-evolve in time frames relevant to conservation planning (for example, over tens to hundreds of years). It bears noting that the lead researcher of that project considers the river entry timing advancement of the extant Skokomish population to be the result of hatchery propagation and domestication—not a re-evolution of a premature migrating life history suited to the natural environment (Michael Miller, UC Davis, *personal communications*).

For these reasons, this plan relies on an outside donor stock for re-introducing spring Chinook into the Skokomish watershed. The donor stock, Skagit River spring Chinook from Marblemount Hatchery, exhibits a river entry pattern essentially identical to the aboriginal Skokomish spring-run population.

For fall chinook, the prospect that a late-timed true fall Chinook life history could re-emerge from the extant stock seems more plausible than the emergence of a spring Chinook life history, given the fall Chinook stock origin. However, domestication effects appear to have been so significant that the potential of this occurring is highly uncertain. We note, however, that 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 hypothesize that if 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

[3] / The Green River hatchery program has been in existence since 1901 (Quinn et al. 2002).

the effectiveness of the stock as it currently exists. As the river conditions are improved through restoration, reproductive success should be further improved.

Active steps, therefore, are seen as necessary for both the spring-run and fall-run racial groups to introduce or develop life histories that will be predisposed for river entry timing more comparable to the aboriginal races than currently exhibited by the extant population. These life histories should be reasonably adapted to the restored flow regime pattern and its associated habitats as part of this plan.

The plan gives strong emphasis to the recovery of spring Chinook because of less uncertainty in the recovery of life history traits that more closely match those of aboriginal Chinook life histories. The recreation of late-timed Chinook with sufficient reproductive success in the natural environment is seen as experimental and therefore more uncertain. The degree of domestication in the extant population is seen as a major hurdle because of its long history of hatchery propagation (>100 years). Chapter 2 of the plan presents this hypothesis in greater detail.

The second overarching hypothesis within this plan is that normative habitat characteristics can be sufficiently restored to the Skokomish River to support a self-sustaining, productive Skokomish Chinook population. In its current state, the river system is radically different than its prior state. A major thrust of this plan is to restore normative watershed processes, which in turn, will form and maintain habitat function that can support naturally produced Chinook life histories. The plan also incorporates habitat strategies that will use engineered solutions, such as those that will provide for upstream and downstream passage at the Cushman Project. Chapter 4 of this plan presents this hypothesis in greater detail.

## 1.5 Plan Organization

This plan is organized into nine chapters as follows:

1. Introduction;
2. Chinook Salmon Life History Patterns;
3. Population Recovery Phases and Planning Targets;
4. Habitat Recovery Strategies;
5. Hatchery Recovery Strategies;
6. Harvest Management Recovery Strategies;
7. Hydropower Recovery Strategy;
8. Integration of Habitat, Hatchery & Harvest Strategies; and
9. Adaptive Management and Monitoring.

The flow of information through the plan and its integration are illustrated in Figure 1.4.

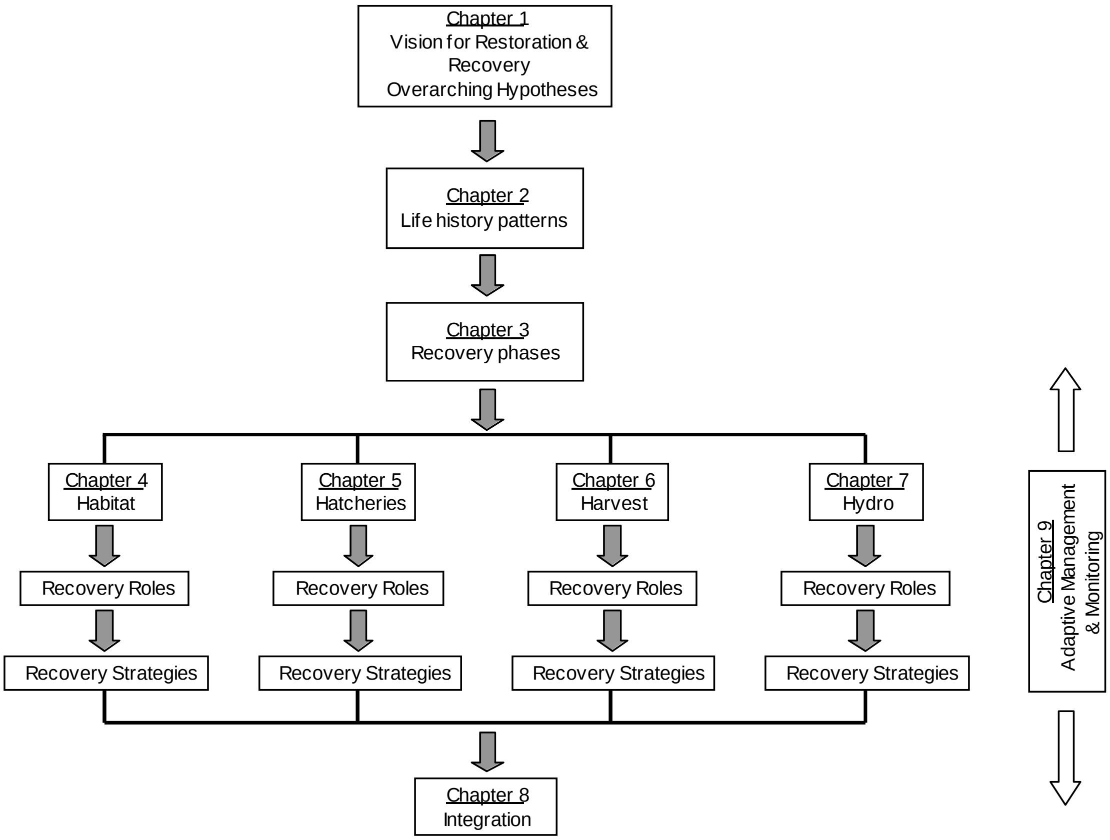



**Figure 1-4. Components of the recovery plan as described in its nine chapters and how they relate to one another.**

# Chapter 2. Chinook Salmon Life History Patterns

The premise on which this plan is built is that population recovery will require restoring life histories that are adapted to the environmental conditions that either still exist in the watershed or that are being restored. Knowledge of the aboriginal life histories that existed prior to their extirpation, therefore, provides an essential part of the guidance needed to develop the plan (e.g., Lichatowich et al. 1995).

This chapter reviews what is known, or can be inferred from available evidence, about the historic Skokomish Chinook populations and their life histories. We then compare the characteristics of those historic populations to those of the contemporary Skokomish Chinook population, which is supported by George Adams Hatchery production. At the close of the chapter we provide our conclusions about how the recovery plan needs to address the life history aspects of recovery.

The reader should be aware that a more complete description of some of the changes in Skokomish Chinook life history than given here was provided in the 2010 Plan (SIT and WDFW 2010). That document should be used to gain a more complete accounting of the history of the contemporary population.

We focus in this chapter on aspects of Chinook life history most relevant to this recovery plan. The aspects that inform our diagnosis of the issues affecting Skokomish Chinook performance are particularly relevant. More complete descriptions of Chinook life history in general are found in Healey (1991) and Quinn (2005) and are not summarized here.

Quinn (2005) advised that any salmon restoration effort needs to be firmly grounded in the basic biology of the species in question. Life histories lie at the heart of the biology of a species (Stearns 1992). Life history traits are directly related to survival and reproduction—they are phenotypic expressions of the interaction of genotype and environment. Individuals of a population that express different life history traits vary in fitness within a set of environmental conditions, which drives natural selection. Habitats are the templates that organize life history traits (Southwood 1977), giving rise to life history variations and to the dominant life history patterns seen within a species.

This chapter examines those life history patterns relevant to this recovery plan.

The chapter is organized into the following sections:

2.1 Historic Skokomish Chinook Populations;

2.2 Contemporary Skokomish Chinook Population; and

2.3 Application.

## 2.1 Historic Skokomish Chinook Populations

Within the past 100 years, the Skokomish River system supported two racially distinct population components: an early-timed, or spring-run, component and a true late-timed, or fall-run, component. The historic population structure of the combined Chinook runs is unclear, and as a result the Puget

Sound TRT chose to identify the components as one population (Ruckelshaus et al. 2006). The TRT identified, however, three separate run-timing groups: (1) an early-timed group in the upper North Fork, (2) an early-timed group in the upper South Fork, with spawning occurring as far downstream as Vance Creek, and (3) a late timed group in the lower North and South forks and the mainstem below the forks. All of these indigenous spawning aggregations are now extinct in the watershed.

This plan recognizes the uncertainty in attempting to delineate distinct populations in situations as this. The population structure in some Western Washington rivers where both spring and fall Chinook exist is similarly unclear, such as on the Washington coast (Ken Currens, NWIFC, *personal communications*). Efforts aimed at trying to recover either the spring or fall component would require different approaches, which, in effect, would treat them as different populations. Therefore, we refer to them in this plan as separate populations. It bears noting that recent findings about the genetic legacies of spring and fall-run Chinook in the Pacific Northwest supports a conclusion that they are distinct populations with unique evolutionary histories (Prince et al. 2017).

### 2.1.1 Spawning distributions

The historic spawning distribution of Chinook 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 (Figure 2.1) (Elmendorf and Kroeber 1992; Smoker et al. 1952; Deschamps 1955; WDF 1957a). The spatial separation between the spring and fall populations was generally regarded to be in the vicinity of Little or Big Falls[4] 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.[5]

James (1980), after interviewing many people who had visited or fished at the two sets of falls, including both Indians and non-Indians, described the two falls in the North Fork as follows:

> "The Upper and Lower Falls on the North Fork were not a total barrier to Chinook, steelhead, coho or sockeye. The falls were excellent sites for fishing during salmon and steelhead runs. Fish congregated below the falls during spawning runs and navigated the falls during high flows."

Big Falls, located between the two dam sites, was described as being between 12 to 15 ft high. Little Falls was described as being about 10 ft high. As seen today, Little Falls is stair-stepped, allowing fish prior to dam construction to pass under certain flow conditions.

### 2.1.2 River entry timing

Smoker et al. (1952) summarized information available in the 1940s to characterize run timing of the spring and fall runs in the river at that time. Their characterization provides the most detailed view of

[4] / The two falls are also often referred to as Upper Falls (Big Falls) or Lower Falls (Little Falls), as discussed in James (1980).
[5]/ The spatial separation of early from late-timed fish in the South Fork is based on limited observations on spawning timing made by Deschamps (1955). Deschamps' conclusions were based on inference and not on being able to tie time of spawning to river entry timing.

run timing prior to construction of the George Adams Hatchery. Their conclusions were drawn from an examination of tribal gillnet catch data. They concluded:

> "The spring Chinook enter from April through July with no apparent peak. The fall Chinook rise to a sharp peak in late October."

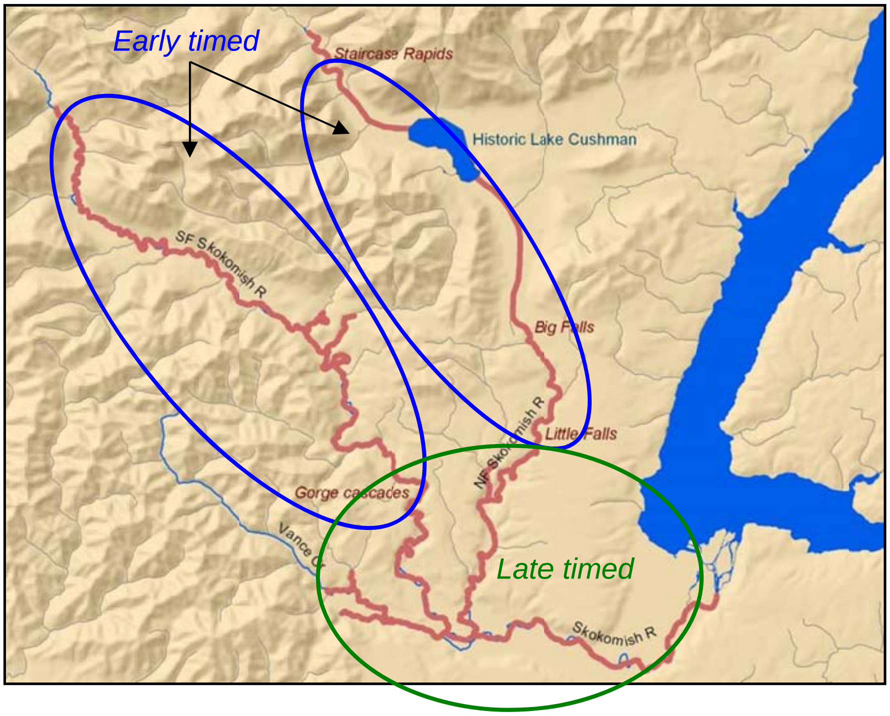



**Figure 2-1. Historic distribution of Chinook in the Skokomish River system. Sources: WDFW SalmonScape for overall distribution; Deschamps (1955) and WDF (1957a) for distribution of the early (spring) and late-timed (fall) populations.**

The gillnet catch data for that period suggested that the strongest run component was the fall population, although it should be noted that by that time the spring population would have been extirpated in the North Fork due to the Cushman Dams. The abundance and distribution of the fall run would also have been affected by the Cushman project by this time. It is uncertain, therefore, what the relative strengths were prior to dam construction of the two racially distinct populations. The catch data evaluated by Smoker et al. (1952) showed that, in general, the majority of the fall-run fish were caught in October with smaller numbers taken in September and November.

Smoker's conclusions regarding the fall run are consistent with how Skokomish tribal elders have characterized Chinook run timing into the river, seen below in information assembled by Elmendorf and Kroeber (1960)[6]:

> "The king run starts in later September and continues for two to three months, annually. The runs come mixed with silvers and, in alternate years, with humpbacks. The kings were said to appear slightly earlier than the other two kinds, and to "lead them in."

[6] / Source is attributed to Henry Allen, a Skokomish Indian, born in 1865 and died in 1956.

Other information summarized in the 2010 Plan demonstrates the fall run's river entry timing would have corresponded closely with the timing of fall freshets, beginning in September and continuing through October or early November. Other true fall-run Chinook populations that still exist on the Olympic Peninsula, in the Chehalis River basin, and on the Oregon Coast demonstrate a close correspondence between river entry timing and fall freshets (Nicholas and Hankin 1988; WDF, WDW and WWTIT 1993).

### 2.1.3 Spawning timing

The Washington Department of Fisheries (WDF), as part of an assessment of salmon populations in the South Fork in the mid-1950s, characterized spawning timing as follows (WDF 1957a):

> "The spring and summer Chinook which are confined to the upper South Fork, spawn from August through October. The fall run spawns from September through November in the South Fork within and below the canyon and in the main Skokomish River and various river tributaries."

Elsewhere in the same assessment the authors stated with regard to fall Chinook spawning timing:

> "Spawning occurs from September through November, with the peak in October."

It bears noting that the statement about the "peak in October" was based on very limited data.[7] The river entry timing presented by Smoker et al. (1952) for the fall run suggests that peak spawning time in 1945 would likely have not occurred prior to about November 1 and may not have occurred until several days or more later. Peak spawning for fall Chinook on the Washington coast typically occurs in early November (WDFW and WWTIT 1993; Larry Lestelle, Biostream Environmental, *personal communications*). The Smoker report suggests run timing and spawning timing similar to that on the Washington coast. The timing of fall freshets in the Skokomish River is essentially identical to the timing on the Washington coast.

### 2.1.4 Fry emergence timing

The only known data available to characterize juvenile life history patterns of Skokomish Chinook prior to operation of the George Adams Hatchery are from surveys made in 1955 by WDF (WDF 1957a). The surveys were part of an assessment to collect baseline data in anticipation that another dam was likely to be built in the South Fork by Tacoma. Fyke nets were operated at several sites in the river system to assess outmigration timing and relative juvenile abundance. Sites trapped included lower and upper South Fork, lower Vance Creek, lower North Fork, and the mainstem river below the forks. Trapping occurred between mid-January and September, though the starting and ending dates varied by site.

[7] / The WDF (1957a) study drew its conclusions about spawning timing from field work reported by Deschamps (1955). Deschamps made two surveys upstream of the South Fork gorge, on September 24 and October 15, 1954. Downstream of the gorge, two surveys were also made—on October 1 and October 15, 1954. No surveys were made after October 15; hence no data were collected during the time period that would have reflected late-timed fall Chinook adults having a river entry timing described by Smoker et al. (1952). Indeed, the counts of live adults on the spawning grounds categorized by Deschamps as being fall Chinook were highest on October 15, suggesting that spawning activity was still increasing at the time of the October 15 survey.

Trap catches combined with data on fry sizes suggest that fry emergence occurred between late February and early May, peaking between mid-March and early-May depending on site. The migration of newly emerged fry at the South Fork sites occurred primarily in April. Emergence timing in Vance Creek appears to have been primarily in March and April. In the North Fork, peak emergence appears to have been in late March and early April. The movement of newly emerged Chinook past the lower river site appears to have been highest from mid-March to early April.

### 2.1.5 Parr-smolt outmigration timing

The outmigration timing of parr and smolt Chinook in 1955 can be inferred to an extent from the fyke net data presented in WDF (1957a). The patterns suggest that the outmigration occurred over a period of weeks, perhaps several months, generally in mid to late summer.

These juvenile life history patterns for the historic Skokomish Chinook demonstrate that considerable diversity likely existed, consisting of a variety of rearing and outmigration patterns. While some fry began emerging in late February, the large majority apparently emerged between mid-March and mid-May with different rates of seaward emigration occurring afterwards. Such a suite of rearing and outmigration patterns is consistent with what has been observed for wild Chinook in the Queets River (QDNR 1978; QDNR 1979), the Skagit River (Beamer et al. 2005), and in small rivers on the Oregon coast (Reimers 1973).

It bears noting that the upper South Fork data suggest that spring Chinook juveniles reared in the upper river for several months prior to moving downstream in mid to late summer. The pattern, together with size of the emigrants, strongly suggests that spring Chinook produced in the upper South Fork were ocean-type migrants, i.e., they emigrated seaward largely as young-of-the-year juveniles. This pattern is common for spring Chinook populations west of the Cascade crest (Lichatowich and Mobrand 1995; Lestelle et al. 2005). In contrast, spring Chinook produced in rivers east of the Cascade crest generally emigrate as yearlings (stream-type). It bears noting, however, that spring Chinook juveniles produced in rivers with strong snow-melt hydrographs west of the Cascades can have a significant portion of the outmigrants leaving as yearlings (SRSC and WDFW 2005; Beechie et al. 2006). Water temperatures and growth rates during freshwater residency seem to be the controlling factor. Streams with high growth rates produce ocean-type Chinook while those with low growth rates produce stream-type (Quinn 2005).

### 2.1.6 Patterns among populations

The observations and conclusions about life history for the historic Skokomish populations are compared to patterns seen for other wild Chinook populations in Western Washington in Figure 2.2. 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. A comparison of the patterns among these populations is instructive for this plan.

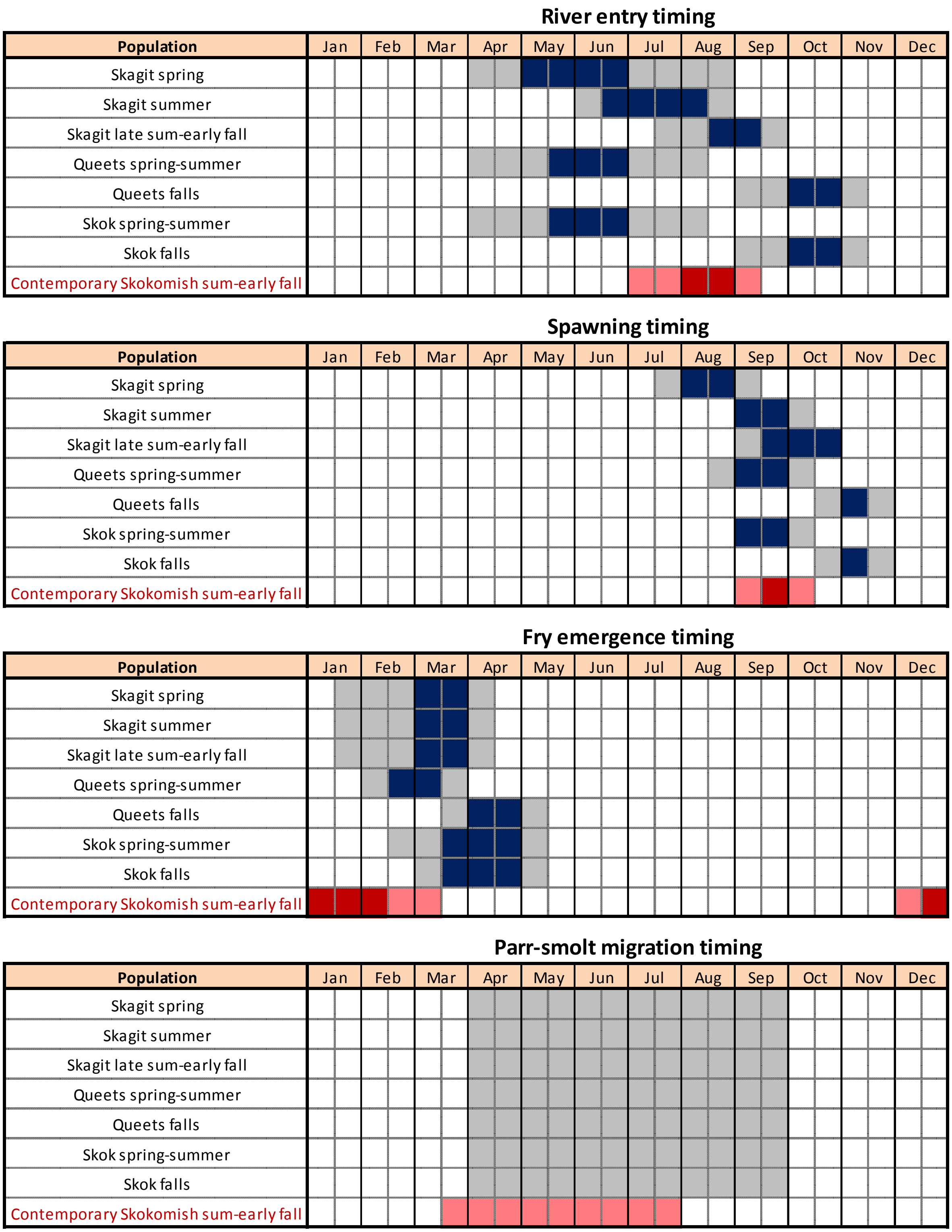



**Figure 2-2. Periodicity table showing timing of freshwater life stages for seven wild populations of Chinook, compared to the timing patterns for the contemporary Skokomish Chinook population. Weekly time intervals are highlighted gray for the range of timing seen; dark blue highlighting shows peak migration periods. Cells are highlighted red for the contemporary Skokomish population. See text for data sources.**

The Skagit River is a large river system with several distinct Chinook populations, some of which are considered spring-run, summer-run, or fall-run. This river has very significant snowpack runoff in the spring and summer, and the mainstem river and its major tributaries are large streams compared to the Skokomish River. These characteristics can be expected to affect how life histories are expressed in this river; notably river entry generally precedes the onset of major fall freshets, though spawning timing still corresponds closely with these events (WDFW and WWTIT 1993; Mark Downen, WDFW, *personal communications*). Extensive studies have been conducted over many years to understand Chinook life history patterns in the Skagit system; these studies are well documented (e.g., Seiler et al. 2001; Kinsel et al. 2008). Information on run entry and spawning timing for the different Skagit populations is contained in WDFW and WWTIT (1993) and SRSC and WDFW (2005).

The Queets River originates in the Olympic Mountains like the Skokomish River. It is modestly larger than the Skokomish River. The hydrograph for the Queets River closely resembles that seen on the Skokomish River (SIT and WDFW 2010). Water temperatures in the two rivers are similar (QDNR unpublished; SDNR unpublished). The Queets River supports both spring and fall Chinook. Extensive studies on fry emergence timing and parr-smolt outmigration patterns were conducted in the 1970s and early 1980s by the Quinault Department of Natural Resources (QDNR 1976; QDNR 1977; QDNR 1981).[8] Information on run entry and spawning timing for the two populations is contained in WDFW and WWTIT (1993) and in QDNR unpublished data.

The periodicity table was assembled by reviewing the available data for the populations, and then highlighting the weekly periods in the table for each life stage and each population to show both the range of timing and generally when the peak of migration occurred. The range was depicted as the time period when a large part of the migration occurred, ignoring very early or late tails to movement. For example, the river entry timing for both the historic and present-day Queets spring Chinook population occurs between April and August, the peak of the run occurring from mid-May to late June. However, the earliest entry can be as early as February and as late as August. (It is noted that in the figure, Queets spring Chinook are referred to as a spring-summer run because of how river entry is extended into August, which also occurred in the Skokomish River—see Table II in Smoker et al. 1952.)

A comparison of patterns among the populations shows the following:

- River entry timing of the historic Skokomish spring Chinook run closely resembled the pattern in the Queets River. The Skagit spring and summer runs bracketed the timing in the Skokomish River, likely because the Skagit is such a large river with many major tributaries having variations of runoff patterns, thereby creating a wide range and diversity of timing among the population groups.
- The late-timed fall runs in the Queets and Skokomish rivers appear to have had very similar river entry timing. The late summer/early fall run (usually referred to as just a fall run) in the Skagit was earlier than the fall runs in the Queets and Skokomish rivers, very likely due to the different flow and temperature regimes among these rivers.
- The range in timing for spawning is much reduced than the overall range seen in river entry timing. Spawning timing of salmon populations is driven by temperature regimes, both when the water cools to optimal conditions and its pattern through the incubation period, coupled with the preferred time of fry emergence in late winter and spring. Fry emergence for salmon

[8] / Larry Lestelle, one of the authors of this document, was the lead biologist on those studies.

typically begins to occur in late winter and extends well into spring—this is the period when water is warming, food is becoming abundant, and freshets are less frequent (Nickelson et al. 1986; Quinn 2005).

    - Peak spring Chinook spawning typically is in September, though this varies somewhat throughout the Northwest depending on water temperatures.
    - Spawning timing of Skokomish fall Chinook was likely very similar to what it is in the Queets River.

- Timing of peak fry emergence among all of the populations was/is similar, occurring in March or April, though it can start much earlier in some cases or be extended later. Miller and Brannon (1981) and Quinn (2005) describe fry emergence timing as a critical period for survival, having been determined by many generations of natural selection. Fry emergence timing is keyed to when food resources will generally be readily available.

## 2.2 Contemporary Skokomish Chinook Population

The contemporary Skokomish Chinook population is sometimes described as being a summer/fall run (WDFW and WWTIT 1993), in recognition that its river entry and spawning timing encompass both summer and early fall periods. The Puget Sound TRT labeled it a late-timed Chinook population (Ruckelshaus et al. 2006), although many of its life history characteristics bear no resemblance to a true late-timed population (SIT and WDFW 2010). The Green River hatchery stock, which is the original source stock for George Adams Hatchery, originated from a wild fall-timed population in Green River over 100 years ago.

The contemporary Skokomish population is the result of a large hatchery program at George Adams Hatchery, started in 1961 using imported Green River stock, and the simultaneous loss of wild Skokomish Chinook due to habitat degradation and overfishing. Over time, the George Adams Hatchery stock replaced the indigenous Skokomish fall population (Ruckelshaus et al. 2006; SIT and WDFW 2010). The genetic legacy of the contemporary population is recognized as being of Green River hatchery lineage (Marshall 2000, cited in HGMP 2002).

### 2.2.1 Natural spawning distribution

Approximately 1,200 adult Chinook have spawned naturally in the lower parts of the Skokomish River system annually from 2008 to 2016 (Figure 2.3; Table 2.1). Most of these fish are stray hatchery fish produced from George Adams Hatchery. On average, hatchery-origin spawners (pHOS) have comprised approximately 81% of the total naturally spawning escapement since 2012 when returns were from 100% marked brood years. The remainder are natural-origin recruits (NORs) that return to spawn naturally in the river, though their ancestry is recognized as being from George Adams hatchery fish.

The current distribution of naturally spawning Chinook is less than 1/3 of what it was historically in the river basin. There are presently only about 16 miles of stream habitat 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. In some years, adult Chinook have had difficulty accessing the lower South Fork due to aggradation and dewatering of the channel (see Chapter 4).

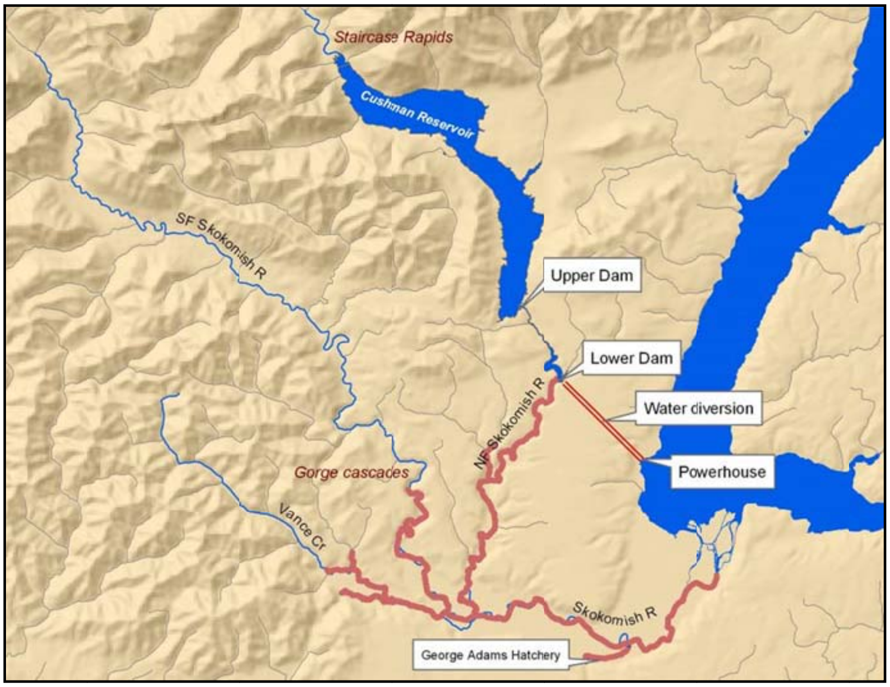



**Figure 2-3. Current distribution of Chinook in the Skokomish River. Source: WDFW SalmonScape.**

**Table 2-1. Chinook escapement to George Adams (GA) Hatchery and the Skokomish River from 1999-2016. Natural spawners in the Skokomish River are designated as hatchery origin (HOR) or natural origin (NOR); the proportion of HOR fish in the natural spawning escapement is pHOS. Estimates of pHOS prior to 2008 are based on CWT recoveries and low sample sizes and are considered less reliable than estimates beginning in 2008. Average values are shown for years 2008-2016. Stray rates represent the proportion of total HOR spawners returning to the watershed (hatchery plus Skokomish River) that spawned naturally. Source: WDFW, 2017.**

| Spawning escapement | | | | | | Hatchery origin spawners | | |
|---|---|---|---|---|---|---|---|---|
| Return Year | GA Hatchery total | Skokomish River | | | | Total | Return rate to hatch. | Stray rate |
| | | HOR | NOR | Total | pHOS | | | |
| 1999 | 8,235 | 1,310 | 382 | 1,692 | 0.774 | 9,545 | 0.863 | 0.137 |
| 2000 | 4,031 | 742 | 220 | 962 | 0.771 | 4,773 | 0.845 | 0.155 |
| 2001 | 8,816 | 1,808 | 105 | 1,913 | 0.945 | 10,624 | 0.830 | 0.170 |
| 2002 | 9,394 | 109 | 1,370 | 1,479 | 0.074 | 9,503 | 0.989 | 0.011 |
| 2003 | 1,022 | 266 | 860 | 1,126 | 0.236 | 1,288 | 0.793 | 0.207 |
| 2004 | 12,275 | 1,650 | 748 | 2,398 | 0.688 | 13,925 | 0.882 | 0.118 |
| 2005 | 16,026 | 1,599 | 433 | 2,032 | 0.787 | 17,625 | 0.909 | 0.091 |
| 2006 | 12,358 | 717 | 492 | 1,209 | 0.593 | 13,075 | 0.945 | 0.055 |
| 2007 | 13,270 | 112 | 419 | 531 | 0.211 | 13,382 | 0.992 | 0.008 |
| 2008 | 13,695 | 842 | 292 | 1,134 | 0.743 | 14,537 | 0.942 | 0.058 |
| 2009 | 13,220 | 873 | 193 | 1,066 | 0.819 | 14,093 | 0.938 | 0.062 |
| 2010 | 12,891 | 902 | 312 | 1,214 | 0.743 | 13,793 | 0.935 | 0.065 |
| 2011 | 14,385 | 1,147 | 174 | 1,321 | 0.868 | 15,532 | 0.926 | 0.074 |
| 2012 | 22,874 | 1,323 | 210 | 1,533 | 0.863 | 24,197 | 0.945 | 0.055 |
| 2013 | 21,444 | 1,469 | 253 | 1,722 | 0.853 | 22,913 | 0.936 | 0.064 |
| 2014 | 6,227 | 643 | 206 | 849 | 0.757 | 6,870 | 0.906 | 0.094 |
| 2015 | 6,032 | 310 | 122 | 432 | 0.718 | 6,342 | 0.951 | 0.049 |
| 2016 | 22,076 | 1,110 | 232 | 1,342 | 0.827 | 23,186 | 0.952 | 0.048 |
| Average | 14,760 | | | 1,179 | 0.799 | 15,718 | 0.937 | 0.063 |
| Weighted average (2008+) | | | | | 0.812 | | | |

## 2.2.2 River entry timing

The river entry timing of the contemporary Skokomish population has been significantly advanced compared to the indigenous fall run that existed in the river (Figure 2.2), as well as compared to the original wild source population in Green River (SIT and WDFW 2010). Available information shows that this advanced run timing occurred over many generations of propagation at the Green River Hatchery (Soos Creek) and at George Adams Hatchery. Despite some efforts to prevent further timing advances (Mark Downen, WDFW, *personal communications*), the time of river entry has continued to move earlier, as seen in tribal gillnet catch data over the past 30 years (Figure 2.4). Some form of inadvertent selection within the hatchery is apparently the cause. The median river entry now appears to be in early August, whereas it appears to have been about one month later in the mid-1980s. But by then, run timing had already been significantly advanced. Although not seen in Figure 2.4 because no fishery had been open, it is known that substantial numbers of fish now return in early July (Cindy Gray, SDNR, p*ersonal communications*). Some fish are seen in Purdy Creek near the hatchery in late June.

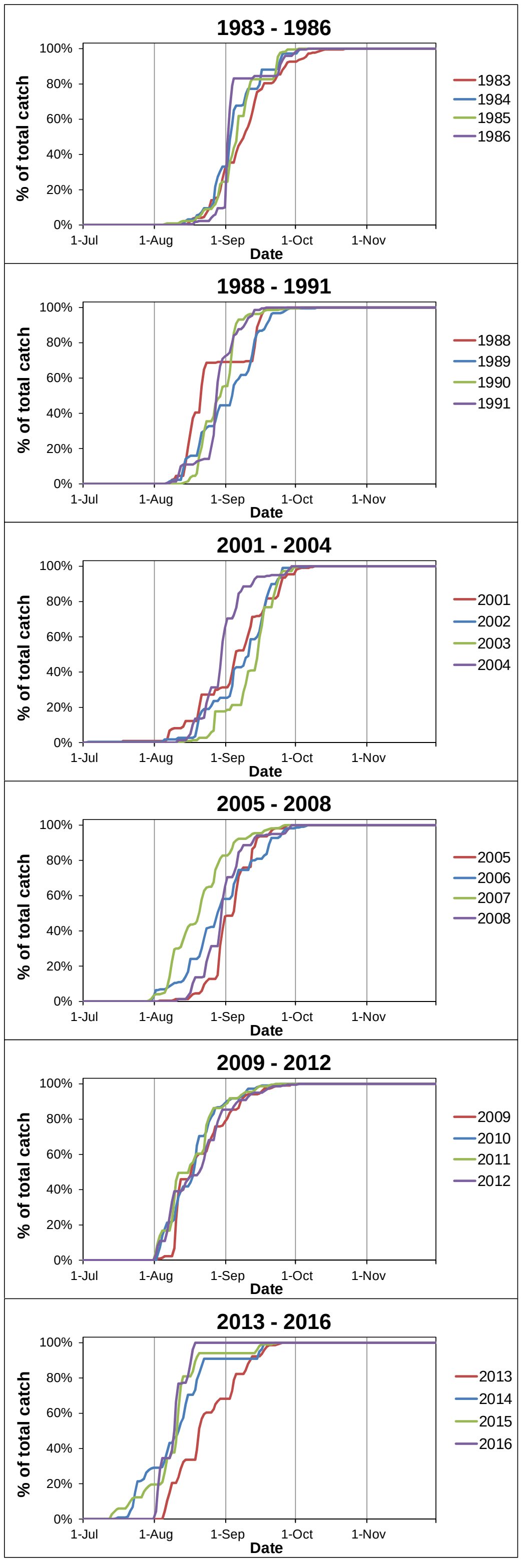



**Figure 2-4. Timing patterns of tribal gillnet catches of Chinook in the Skokomish River (82G), 1983-2016. Some years are missing because of fishery closures. The fishery was closed for three weeks from late August to mid-September in 2014 and 2015. In 2016, the fishery began on August 1 and closed on August 18 (3 days/week).**

## 2.2.3 Spawning timing

The spawning timing of the contemporary Skokomish population has been significantly advanced compared to the indigenous fall run that existed in the river (Figure 2.2). The timing of natural spawning by contemporary Chinook in the lower Skokomish River, lower South Fork, and lower North Fork is reflected by redd counts made by WDFW and the Skokomish Tribe. Recent year results show that peak spawning occurs in mid-September (Figure 2.5). Spawning timing appears to have advanced by at least one week compared to the patterns seen in years 2002 to 2005 (SIT and WDFW 2010). Peak spawning in the hatchery in recent years also occurs in mid-September (Figure 2.6).

Spawning timing of the contemporary population is similar to the timing patterns seen for wild spring/summer Chinook in the Skagit and Queets rivers (Figure 2.2).

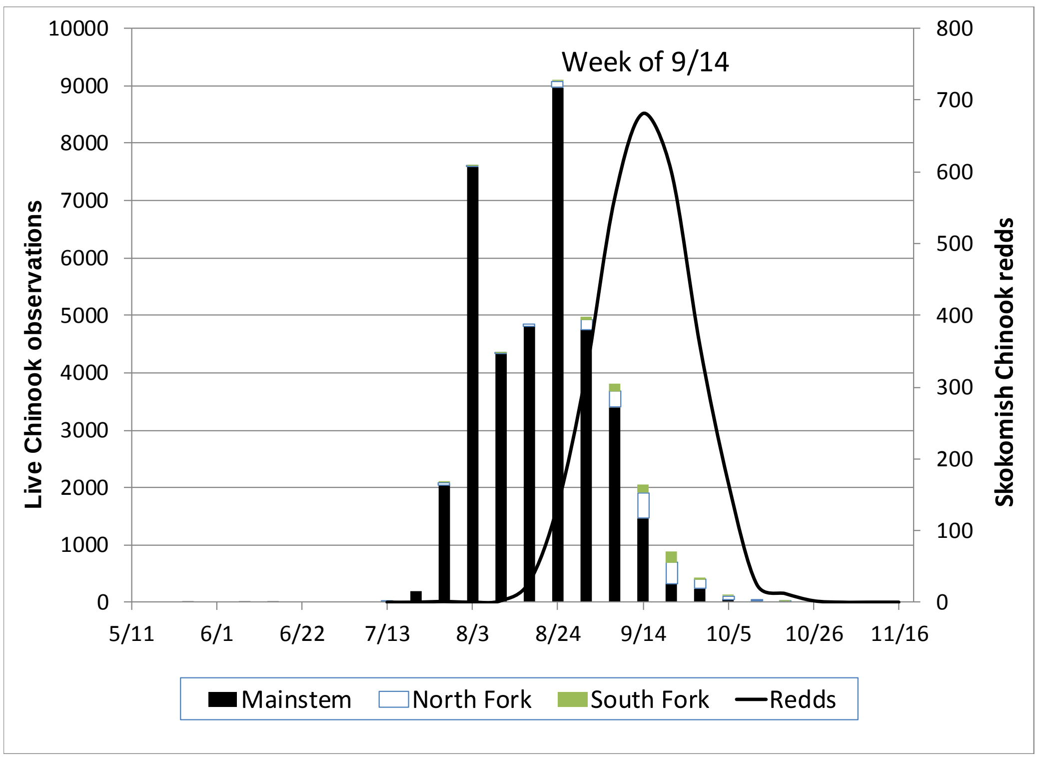



**Figure 2-5. Average Skokomish Chinook live fish observations and redd deposition from 2009 through 2016. Source: WDFW, 2016.**

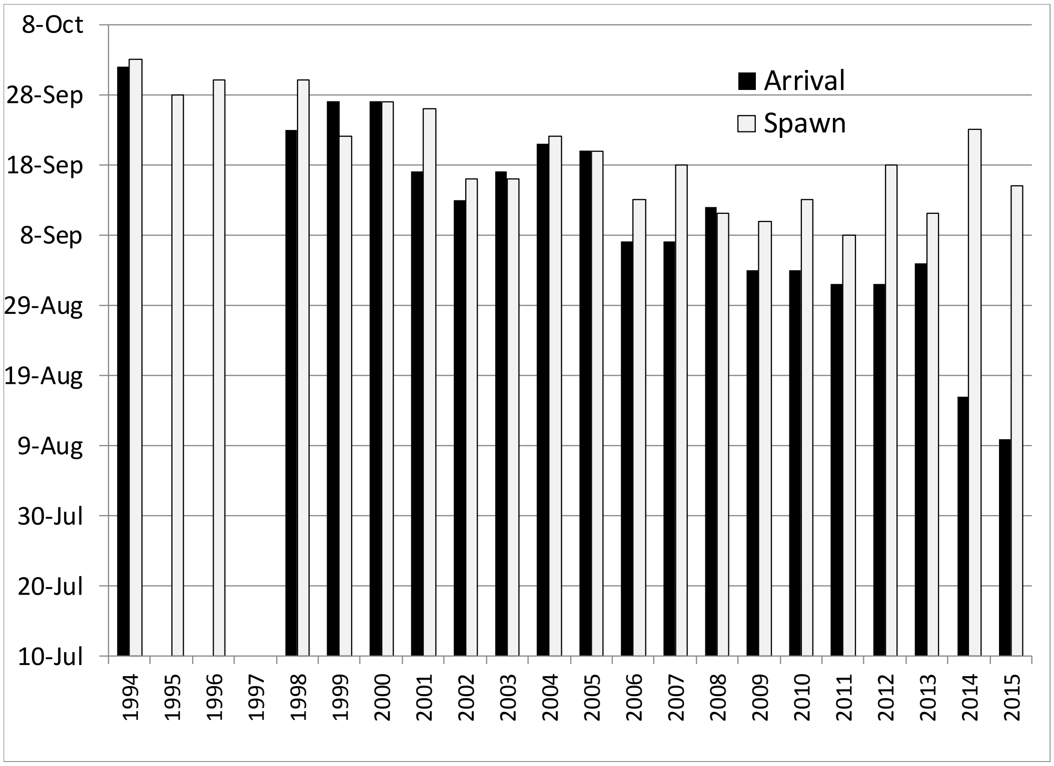



**Figure 2.6. George Adams Hatchery Chinook peak arrival and peak spawn timing from 1994 through 2015. Source: WDFW, 2016.**

## 2.2.4 Fry emergence timing

Fry emergence timing for the contemporary Skokomish population spawning naturally in the river has been significantly advanced from the timing patterns seen for the historic populations (Figure 2.2.). Tacoma Power, as part of its annual monitoring requirements, traps emigrant salmonid juveniles in the lower North Fork. In 2016, trapping began in late December, demonstrating that Chinook fry emergence was already occurring (Figure 2.7). Although trapping was interrupted for several periods due to high flows, the results for 2016 showed peak emergence of fry (<40 mm in size) occurring between about January 1 and mid- February, which was then followed by a considerable period of no Chinook emigration. Small numbers of parr and smolts (>65 mm) were then caught moving downstream after early April. Figure 2.8 compares the timing patterns from trapping in the North Fork for 2014 to 2016. Trapping began several weeks later in 2014 and 2015. The patterns among years are consistent, showing peak emergence occurring prior to mid-February.

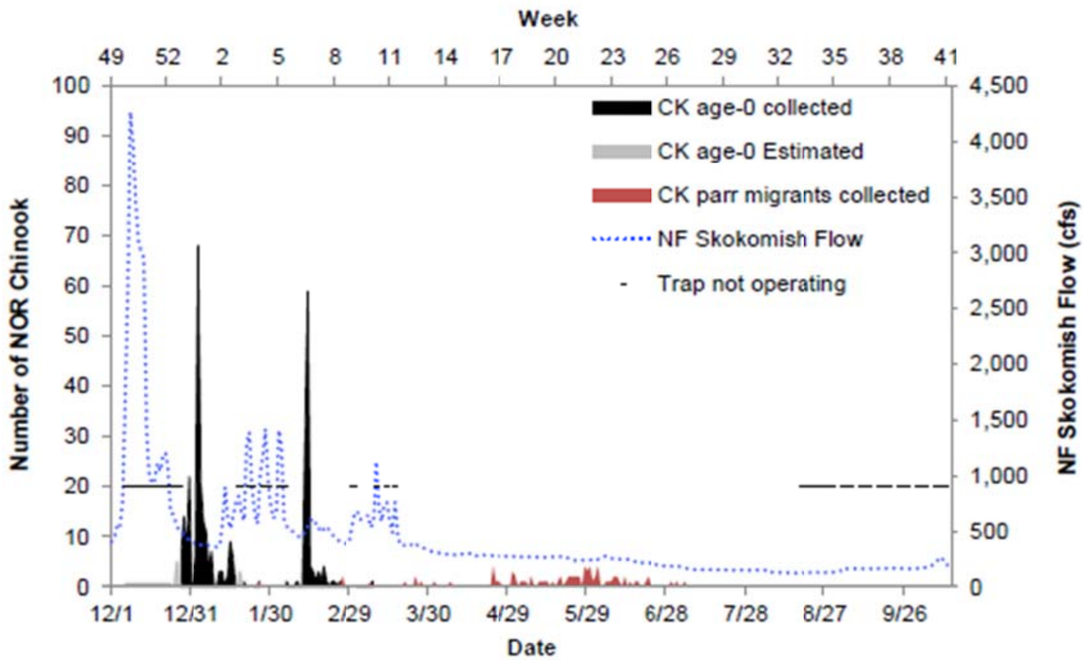



**Figure 2-7. Daily catch of natural origin (NOR) Chinook fry and parr migrants at the North Fork Skokomish River rotary screw trap during the 2016 trapping season. Source: Tacoma Power (2017b).**

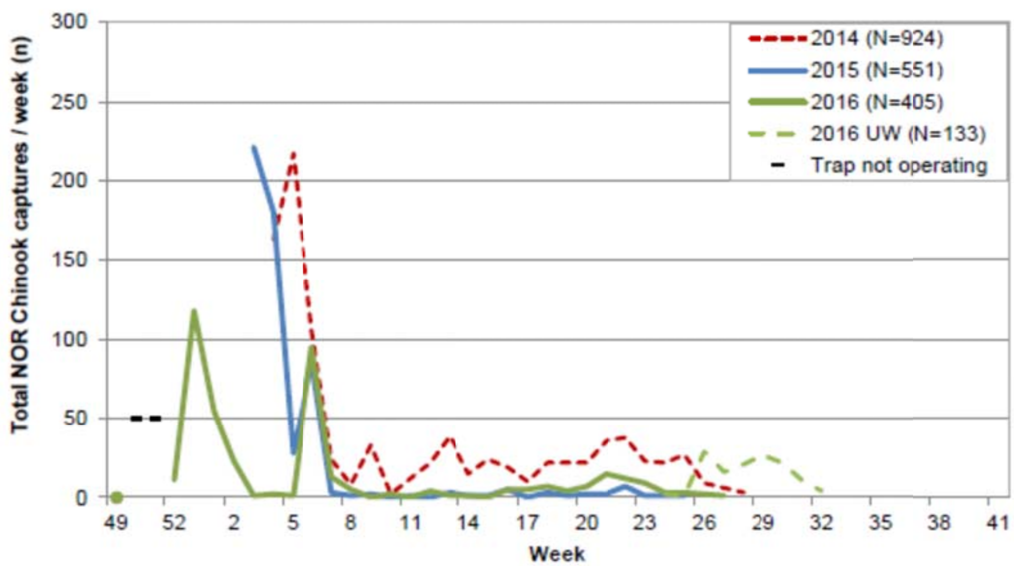



**Figure 2-8. Weekly catches (actual) of natural origin (NOR) Chinook at the North Fork Skokomish River rotary screw trap during the 2014 through 2016 trapping seasons. UW = fish from the upper North Fork (see Tacoma Power 2017b for description). Source: Tacoma Power (2017b).**

It bears noting that sampling using beach seines by the Skokomish Tribe in recent years shows wild Chinook fry are present in the estuary in January of each year. In 2015, newly emerged fry began appearing in mid-November in the estuary (SDNR unpublished).

Most Chinook fry in George Adams Hatchery are placed on feed between mid-December and the end of December. The last group to be ponded in 2009 at the hatchery was on January 9 (Assistant Manager George Adams Hatchery, *personal communications*). While the time of hatchery ponding is not the same as when fry emerge under natural riverine conditions, primarily due to warmer temperatures during incubation in the hatchery, it provides some indication of timing.

The timing of fry emergence of the contemporary Skokomish population that spawns naturally in the river system occurs much earlier than other wild Chinook populations. The Skokomish fry emerge at a time when freshets are large and frequent (see Figure 4.16), water temperatures cold (see Figure 4.8), and food is likely scarce. While this timing may be advantageous for fry within the hatchery environment, given that technicians start feeding as soon as fish are ready to eat, it is mismatched to the norms for wild salmon fry emergence, which typically occurs in spring (Quinn 2005).

The effect of early emergence for naturally spawned Skokomish Chinook on survival to adult is not known—but such a mismatch compared to normative timing patterns suggests a strong adverse impact, given the critical role of emergence timing (Miller and Brannon 1981; Quinn 2005). Table 2.2 compares egg to fry survival rates estimated in the lower North Fork by Tacoma Power in 2014 to 2016 (Tacoma Power 2015, 2016, and 2017b) to rates published in the scientific literature. The overall average for the North Fork of 5.1% (range of 2.5 – 9.6%) is much lower than rates reported elsewhere (Quinn 2005; Kinsel et al. 2008; Schroder et al. 2008).

A few remarks about the studies cited in Table 2.2 are needed. Quinn's (2005) rate of 38% is an average of many studies, reflecting a wide range of conditions. The Skagit River data, encompassing over ten years of monitoring, shows a strong correlation to winter flood events; major freshets produced egg-to-fry survival rates < 5%. More benign winter flows produced rates averaging about 15%. It is important to recognize, however, that survival for the Skagit River measured to the trapping site (in the lower river) is a function of the distance that fry need to travel from their incubation sites, which can be large in this big river system (Seiler et al. 2001). In contrast, distance from incubation sites in the lower North Fork Skokomish River to the trapping site is at most only a few miles. The values published by Schroder et al. (2008) for spring Chinook are based on natural spawning in an experimental spawning channel and reflect nearly ideal incubation conditions.

**Table 2-2. Summary of egg-to-fry survival rates estimated for naturally produced Chinook in the lower North Fork in 2014 to 2016 (Tacoma Power 2015, 2016, and 2017b) compared to rates estimated in other rivers.**

| Study | % egg to fry survival |
|---|---|
| Tacoma Power in North Fork | |
| - In 2014, average of estimates | 3.2% |
| - In 2015, average of estimates | 9.6% |
| - In 2016, one estimate | 2.5% |
| - Average of three years | 5.1% |
| Quinn (2005) | |
| - compilation of studies, average given | 38.0% |
| Skagit R studies, Kinsel et al. (2008) | |
| - when flow effects not seen | 15.0% |
| - when strong flow effects significant | < 5% |
| Yakima R spawning channel, Schroder et al. (2008) | |
| - wild spring chinook, average | 60.2% |
| - 1st generation hatchery fish, average | 54.6% |

For the same three years when Tacoma Power estimated egg-to-fry survivals for Chinook in the North Fork, estimates were also made for chum. The egg-to-fry survival for chum averaged 48%, ranging from 36% to 50%. Tacoma Power (2015) noted that these survival rates are on the high side of published rates and suggested that the reason may be due to the controlled flow releases from the dam. (This is discussed further in Chapter 4, Section 4.2.2.3).

These survival rates estimated for chum in the North Fork suggest that fully fit Chinook (i.e., without any loss of fitness due to hatchery domestication, such as seen in the shift in emergence timing) should exhibit egg-to-fry survivals of at least 48%. Both Bradford (1995) and Quinn (2005) suggested that egg-to-fry survival for Chinook should be at least as high as seen for other salmon species in suitable spawning environments.

### 2.2.5 Parr-smolt outmigration timing

The available data to describe parr-smolt outmigration timing for the contemporary Skokomish population suggests that the migration is over by about the end of June in the North Fork (Figures 2.7 and 2.8) and in the estuary by the same time (SDNR unpublished). It is important to note that generally few wild juvenile Chinook are caught in these locations after the migrations of fry have ended. Sampling in both areas has continued through the summer and into the fall in recent years but almost no juvenile Chinook are caught after about June 15. Other salmonid species are caught during these months, most notably juvenile coho in the estuary. The observed pattern of wild juvenile Chinook outmigration through the North Fork and estuary demonstrate that very little diversity exists in how these fish currently use the lower Skokomish River and estuary.

## 2.2.6 Productivity of the extant stock

In spite of ample numbers of Chinook on the spawning grounds, natural-origin returns (NORs) are consistently low and likely below numbers required for a minimum viable population (Figure 2.9). The quasi-extinction threshold (QET) likely would be in the range of 50 to 350 fish, based on information summarized in ICTRT (2007) and Sands et al. (2009); viability defined as less than a 5% risk of extinction in 100 years would be higher (Sands et al. 2009). The George Adams stock appears to be poorly adapted for successful natural reproduction and survival through subsequent life stages in the Skokomish system, likely due to hatchery influences and impaired habitat. Natural spawners have demonstrated a long-term failure to achieve spawner to spawner productivity values approaching replacement (Table 2.3). Productivity, here the population growth rate (lambda or λ), by brood year is consistently less than 1.0. Values less than 1.0 indicate that the population does not replace itself. The implication of such low productivity is that without hatchery origin fish spawning naturally in the basin, there would likely be no naturally spawning Chinook in the Skokomish basin.

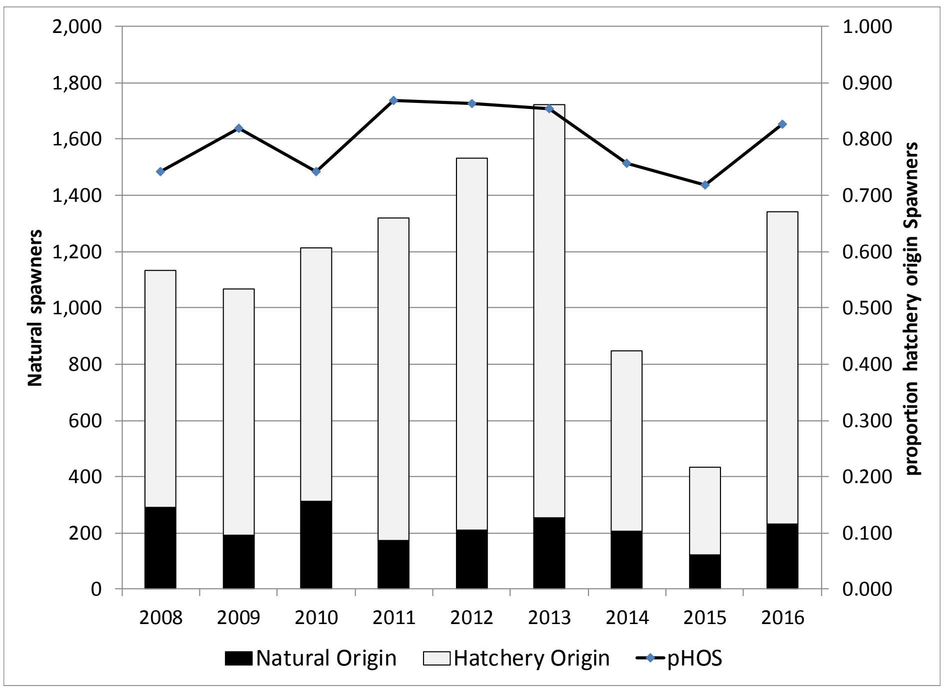



**Figure 2-9. Skokomish Chinook natural spawning escapement by origin for 2008-2016 (bars). Solid line shows the proportion of total natural spawners comprised of hatchery-origin fish (pHOS) by year.**

**Table 2-3. Spawner to spawner productivity (population growth rate or λ) of Skokomish River fall Chinook salmon. Analysis does not account for harvest. Age structure of natural-origin (NOR) fish is assumed to be the same as hatchery-origin (HOR) fish due to lack of natural-origin scale samples. For spawning years 1999–2007, NOR estimates are based on expanded CWT recoveries (small sample size with high variability). For spawning years 2008–2011, NOR estimates are based on the proportion of adipose marked broods (increased sample size, lower variability than 1999–2007). For spawning years 2008–2016, NOR estimates are based on approximately 100% marked broods (greatest sample size, lowest variability). Arithmetic (AM) and geometric (GM) means are given at the bottom of the table.**

| Brood year | Spawning escapement | | | Returning spawners | | | | | Productivity (λ) |
|---|---|---|---|---|---|---|---|---|---|
| | NOR | HOR | Total | Age-2 | Age-3 | Age-4 | Age-5 | Total | |
| 1999 | 382 | 1,310 | 1,692 | 1 | 450 | 622 | 13 | 1,087 | 0.643 |
| 2000 | 220 | 742 | 962 | 19 | 226 | 499 | 23 | 767 | 0.798 |
| 2001 | 105 | 1,808 | 1,913 | 0 | 223 | 195 | 12 | 429 | 0.225 |
| 2002 | 1,370 | 109 | 1,479 | 13 | 211 | 328 | 0 | 552 | 0.373 |
| 2003 | 860 | 266 | 1,126 | 4 | 85 | 236 | 0 | 325 | 0.288 |
| 2004 | 748 | 1,650 | 2,398 | 67 | 111 | 70 | 0 | 249 | 0.104 |
| 2005 | 433 | 1,599 | 2,032 | 72 | 211 | 164 | 4 | 451 | 0.222 |
| 2006 | 492 | 717 | 1,209 | 10 | 29 | 104 | 0 | 143 | 0.119 |
| 2007 | 419 | 112 | 531 | 0 | 191 | 104 | 1 | 297 | 0.560 |
| 2008 | 292 | 842 | 1,134 | 12 | 25 | 27 | 1 | 66 | 0.058 |
| 2009 | 193 | 873 | 1,066 | 44 | 160 | 114 | 4 | 323 | 0.303 |
| 2010 | 312 | 902 | 1,214 | 21 | 121 | 112 | 4 | 258 | 0.213 |
| 2011 | 174 | 1,147 | 1,321 | 17 | 77 | 88 | 3 | 184 | 0.139 |
| 2012 | 210 | 1,323 | 1,533 | 13 | 50 | 43 | 5 | 111 | 0.072 |
| 2013 | 253 | 1,469 | 1,722 | 8 | 119 | | | | |
| 2014 | 206 | 643 | 849 | 73 | | | | | |
| 2015 | 150 | 282 | 432 | | | | | | |
| 2016 | 237 | 1,105 | 1,342 | | | | | | |
| AM | 392 | 939 | 1,331 | | | | | 374 | 0.294 |
| GM | 313 | 727 | 1,229 | | | | | 293 | 0.222 |

## 2.3 Application

An overarching hypothesis for this plan is that recovery success will require a reasonably close match in the life history traits expressed in the genetic stock sources to be used and those of the aboriginal populations that were adapted to the Skokomish watershed. The existing George Adams hatchery population does not exhibit traits seen as a reasonable match for recovering either spring or fall Chinook in the watershed. As described in this chapter and seen in Figure 2.2, freshwater life history patterns of the contemporary population have strongly diverged from normative patterns for both spring and fall Chinook. Moreover, the performance of these fish, when spawning naturally in the river, is poor, demonstrating poor egg-to-fry survival and poor adult recruitment rates.

The approach to be taken to address stock source differs for the two populations as explained below.

A donor stock for the spring Chinook recovery program was selected on the basis of timing characteristics, performance, and potential availability. Following consideration of different options, the Skokomish Tribe and WDFW, in consultation with other affected treaty Indian tribes, selected spring Chinook propagated at the WDFW Marblemount Hatchery on the Skagit River. Marblemount Hatchery broodstock consist of indigenous Skagit River spring Chinook adults that return to that facility. The original stock source for the hatchery was the Cascade River and Suiattle River, both major tributaries to the Skagit River. Marblemount Hatchery is located on the lower Cascade River. Hatchery stock has been maintained there with adults returning to the hatchery since 1995. Life history timing characteristics of the stock are consistent with those shown in Figure 2.2 for Skagit spring-run fish.

A different approach than simply using the existing George Adams stock as it currently exists is required if progress is to be made toward improving the potential for recovery of a late-timed population. The current performance of fish from the contemporary population produced by natural spawning in the river is poor. We assume that the reasons for this are due to a combination of poor fitness for natural production and the degraded state of the natural habitats. The major shifts in the timing of freshwater life stages of the population that are evident over the decades must be reflective of strong selection for certain traits that have occurred. This is seen most dramatically in the shift that has occurred in fry emergence timing.

The results of monitoring egg-to-fry survivals in the North Fork by Tacoma Power are particularly enlightening. Poor survival has been estimated in three consecutive years for Chinook. In contrast, high survival has been estimated in the same three years for chum. Tacoma Power surmised that the high chum survivals were likely due to the largely controlled flow regime. The obvious question is why were Chinook survivals so poor if conditions were so favorable for a similar salmon species? Under such favorable conditions, Chinook egg-to-fry survival should reasonably be comparable to chum, if not better (inferred from Bradford 1995 and Quinn 2005).

We conclude that the poor performance of the contemporary population in reproducing in nature is due to the population's existing characteristics resulting from a long history of domestication. Some of these characteristics are seen in the timing shifts of life history. Other population characteristics, though not measured, may have also been changed through domestication.

Actions presented in this plan to address the issue of poor performance by the contemporary population produced in nature focus on the timing of freshwater life stages, namely river entry timing, spawning timing, and fry emergence timing. We hypothesize that the key to improving performance, based on information currently available, is to shift natural spawning later, thereby producing a later pattern for fry emergence. Steps are described in the plan to accomplish this. However, due to significant uncertainties about the extent that shifting these patterns to more normative characteristics can be achieved in a reasonable period, we regard this part of the plan as experimental.

We assume, based on information reviewed in the plan, that natural-origin recruits (NORs) are now being largely produced by the latest-timed spawners in the river. The earliest spawners would generally produce an earlier emergence than the later timed spawners, based on patterns of accumulated temperature units; the earliest emerging fry are most mismatched to norms of fry emergence and therefore should have the poorest performance.

# Chapter 3. Approaches, Phases, and Recovery Targets

This chapter describes the major approaches, associated phases or stages in recovery, and the planning targets for the spring and summer/early fall Chinook populations. The approaches for the two populations differ significantly, though both require effective recovery actions within each 4-H strategy (habitat, hatchery, harvest, and hydropower). We present an overview for each approach and the key planning targets to be used in measuring progress in this chapter. Details of the actions associated with the individual 4-H strategies are provided in the four chapters that follow this one.

This chapter is divided into two parts. Part 1 addresses spring Chinook. The approach is to reintroduce true spring Chinook into the watershed using a non-native donor stock. A four-phased framework to guide the effort is presented with a progression through the phases determined by the performance response of the reintroduced stock. The planning horizon for this part of the plan is 30 years, which aligns with the time period remaining under the existing Cushman Project license. Full recovery of a spring Chinook population in the watershed by the end of this period is unlikely, however.

Part 2 of the chapter addresses the use of the contemporary population in recovery. The approach to be employed is experimental. It requires a substantial re-shifting of the timing of certain life stages of the existing George Adams summer/early fall population in an attempt to recreate life history patterns that have been lost in the population. We hypothesize that these life history patterns, which would more closely resemble aboriginal patterns, are needed to improve the success of natural spawners to produce adult progeny. We project that a 20-year time period will be needed to evaluate whether this approach can be successful at progressing toward the potential recovery of a true fall-run population.

## 3.1 Spring Chinook

### 3.1.1 Approach

Recovery of a spring Chinook population in the Skokomish River requires a reintroduction of a true spring-run stock from a non-native source within the Puget Sound ESU. The donor stock selected by the co-managers is a Skagit River spring Chinook stock that has been propagated at the Marblemount Hatchery in the Skagit system since 1995. These fish exhibit life history characteristics believed to be a reasonably close match to the historic Skokomish spring Chinook population.

The reintroduction effort is to be supported by a new hatchery facility constructed in the North Fork just upstream from the lower Cushman Dam. The new hatchery, built in 2016 and funded entirely by Tacoma Power under the Cushman Agreement, is to handle all of the on-going hatchery needs for the reintroduction program.

The recovery plan for spring Chinook consists of four phases following guidance given by the Hatchery Scientific Review Group (HSRG) on using hatchery methods to assist in salmon recovery (HSRG 2014), as follows:

1. **Establish founder stock –** Select and establish the founder stock for use in the reintroduction effort (Note: Phase 1 is called "Preservation" when an established natural stock already exists in the watershed);
2. **Recolonization –** Recolonize natural habitat that is being restored with progeny of the founder stock;
3. **Adaptation –** Improve the fitness of the reintroduced population by ensuring that the natural environment has a stronger influence on the adaptation of the population than the hatchery environment; and
4. **Restored/recovered –** Maintain sustainable natural production that meets recovery goals. It is expected that hatchery supplementation will continue in the North Fork due to the constraints imposed on natural production by the dams and reservoirs.

Phase 1 aims to develop a locally adapted hatchery brood stock produced and maintained by the new North Fork Hatchery from the donor stock imported during the first part of the phase. Once this is achieved, no further importation of donor stock would be needed from the Marblemount Hatchery. Phase 2 would then be initiated for the purpose of recolonizing natural habitats in both the upper North and South forks using hatchery-origin adults that return to the North Fork Hatchery. After it is demonstrated that a target level of natural production is being produced from the hatchery-origin spawners transported to the spawning grounds, the program would move to Phase 3—adaptation of the reintroduced fish to the natural habitats. This phase is expected to continue for a number of years as hatchery-origin spawners transported to the spawning grounds are phased out. Over time, and as the conditions of natural habitats are improved through restoration actions, the performance of natural-origin fish being produced should increase as the population adapts to the watershed. When the target performance is achieved, Phase 4—the recovered population—would be achieved.

Various actions associated with each 4-H strategy would continue through all phases of the recovery plan. The magnitude and/or objectives for the actions would evolve through the phases.

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. Planning targets for population performance have been identified, however, to determine the endpoint for each phase based on habitat and population modeling.

We expect that recovery will not be achieved by the end of the current license for the Cushman Project, which extends 30 years into the future from the present. PSIT and WDFW (2017) concluded that the local adaptation phase for at least some Chinook 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 (citing Ford 2002 and NMFS unpublished analyses). We 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), as defined below (see also Chapter 4).

The recovery target for the population represents a broad-sense goal, i.e., it would support a re-established, viable spring Chinook population as well as provide a range of ecological services, including meaningful fisheries. Using models described below, 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[9] 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. De-listing criteria are policy constructs that consider biological goals, mitigation of threats, legal obligations, risk tolerance and other considerations (ICTRT 2007).

We used the Ecosystem Diagnosis and Treatment (EDT) model (Blair et al. 2009) and the All-H Analyzer (AHA) model (HSRG 2009) to quantify planning targets. EDT is a salmon habitat model that evaluates the effects of habitat conditions on the survival of salmon during each life stage and produces estimates of population performance expressed through abundance and intrinsic productivity parameters. The model has been used extensively throughout the Pacific Northwest to predict the benefits and impacts of changes in habitat conditions resulting from land uses or restoration actions. It is used widely to guide ESA recovery planning (e.g., Thompson et al. 2009; Lestelle et al. 2014).

The AHA model was developed by the HSRG as a life cycle model that estimates salmon population performance under different assumptions about the four H's (habitat, hatcheries, harvest, and hydropower). The tool illustrates the implications of alternative ways of balancing the four H's so that informed decisions can be made. It integrates the effects of each of the H's to produce an expected outcome for the population as it would tend toward an equilibrium state under a given set of conditions. The model calculates gene flow between hatchery-origin and natural-origin spawners over time, estimating changes in fitness and predicts the relative numbers of fish returning to nature, the hatchery, and to harvest (HSRG 2009; HSRG 2017).

For EDT modeling, we characterized all river reaches in the watershed, using the standard EDT attributes and procedures (Blair et al. 2009). The characterization was done for the historic (pre-settlement by Euro-Americans), current, and restored (Properly Functioning, i.e., PFC) habitat conditions. The restored condition reflects how we expect the lower river reaches to respond over the long-term to restoration actions described in this plan (see Chapter 4). The model produced results that we found to be reasonable and consistent with levels for spring Chinook in other comparably sized rivers in Western Washington, based both on empirical observations and modeling (WDFW and WWTIT 1993; Puget Sound Shared Strategy 2005; QDNR unpublished).

Restored conditions were modeled using NMFS' indices of Properly Functioning Conditions (PFC) of habitat. The PFC concept was created originally by the Bureau of Land Management (BLM) to assess the natural habitat-forming processes of riparian and wetland areas (Pritchard et al. 1993). Proper function (analogous to normative) is assumed to be needed to support productive populations of native fish species. The concept as applied to salmon was advanced by NMFS (1996) to address recovery under ESA. PFC does not imply pristine or unaltered conditions. It is consistent with the normative river concept described in Chapter 1 of this plan.

[9] / Modeled range of approximately 400 to 2,500 annually.

As originally conceived, the PFC concept did not incorporate a similar level of ecosystem function in estuarine systems, nor have estuarine attributes been incorporated into the EDT model. Given that functional estuarine habitat is essential to the early life history of Chinook, Puget Sound planners developed a PFC Plus (shown as PFC+ here) concept, defined as PFC in freshwater and the historic (unaltered) conditions in the estuary (Thompson et al. 2009). Targets based on PFC+ are higher than those based on just PFC. We recognize, however, that full restoration of estuarine systems within Puget Sound is unreasonable within the foreseeable future given the extent of alterations that occurred over the past 150 years. Therefore, we applied results in-between PFC and PFC+ to represent more reasonable expectations.

We modeled these restoration scenarios to be consistent with provisions of the Cushman license, i.e., keeping the reservoirs in place, providing a flow pattern as dictated by the license, and achieving NOAA standards for fish passage at the dams. The PFC and PFC+ scenarios produced intermediate production characteristics between those of the current and historic scenarios. The average spawner abundance for the PFC+ scenario was estimated to be approximately 50% of the estimated historic abundance. It is important to note that the model assumes that the fish population is genetically fully fit; hence the model provides estimates of habitat potential under each scenario and not population performance under altered genetic fitness (as would be the case for phases 1-3).

Results from the EDT model (i.e., resulting parameter values for capacity and intrinsic productivity) for the current and restored scenarios were used as inputs (representing habitat conditions) to the AHA model following recommended procedures for using this life cycle model (HSRG 2009 and Appendix D-User Guide of that report). The other inputs were the size of the spring Chinook hatchery program, hatchery fish survival rates, initial fitness of the donor stock for reproducing in nature, fishery exploitation rates (pre-terminal and terminal), numbers of returning hatchery-origin fish to be transported to the spawning grounds, and the proportional mix of hatchery-origin and returning-natural origin spawners to use in the hatchery brood stock. Many of these inputs changed under the different phases of the program.

Output from the AHA model included estimates of mean harvest levels, abundance of hatchery-origin (HOR) and natural-origin (NOR) recruits and associated returns to the river, spawning escapements, and the estimated values of Proportionate Natural Influence (PNI) for the composite hatchery- and natural-origin spawning population. The PNI value can be thought of as the percentage of time the genes of a composite population spend in the natural environment, which is critically important in determining the rate that the population adapts to natural habitat conditions.

### 3.1.2 Spring Chinook Recovery Framework and Phases

A four-phased framework guides the planning and evaluation of progress toward achieving recovery for the spring Chinook plan. The framework is adapted from guidance given by the HSRG (2014).

#### 3.1.2.1 Spring Chinook Phase 1: Establish founder stock

The purpose of Phase 1 is to establish a spring Chinook Salmon founder stock in the North Fork Skokomish River and to maintain and increase its genetic diversity.[10] This phase establishes a locally adapted hatchery stock, or at least partially adapted, to support the program. The endpoint of Phase 1 will be a self-sustaining hatchery program at the newly-constructed North Fork Hatchery, primed to initiate outplanting of pre-spawners to the upper North Fork and upper South Fork. A self-sustaining hatchery program means that adult returns to the North Fork facility will be sufficient to provide for all broodstock requirements—transfers from the source hatchery population will no longer be needed.

During this phase, the number of hatchery fish returning to the facility is expected to increase over time as the brood stock adapts to the conditions encountered in the Skokomish River and to local marine conditions beyond the river. Also during this phase, habitat actions are expected to continue to progress in the watershed to restore normative watershed processes and functions. Progress is also expected during the phase to continue to test and refine the upstream and downstream fish passage facilities at the dams.

This phase is currently underway. It was initiated by the co-managers and Tacoma Power soon after the Cushman Settlement Agreement of 2009 and the completion of amendments to the licensing of the Cushman Dams in 2010. Based on a selection process employed by the co-managers, the donor stock for the program was chosen to be Skagit River spring Chinook stock, which originated from Cascade River and Suiattle River (both are Skagit tributaries) wild fish; the stock is now propagated at Marblemount Hatchery in the Skagit River system. As per the terms of Cushman Settlement, a new hatchery facility was constructed in the North Fork just upstream from the lower Cushman Dam to handle the spring Chinook hatchery needs. The new facility was completed in 2016 (Figure 3.1) and is now fully functional.

[10] / This phase is called the Preservation Phase for a program that already has a locally adapted population. In that case, the purpose is aimed at ensuring the preservation of the existing stock source.

**Figure 3-1. The North Fork Skokomish Hatchery built and operated by Tacoma Power under terms of the Cushman Settlement Agreement. The facility was built in 2016.**

The first eggs to initialize establishing the founder stock were taken from brood year 2014 brood stock at Marblemount Hatchery. Eggs from brood years 2014 and 2015 were transferred to the Long Live the Kings (LLTK) Hatchery on Lilliwaup Creek located in southern Hood Canal to meet hatchery propagation needs while construction of the North Fork Skokomish Hatchery was being completed. The juveniles produced from brood year 2014 eggs were reared to the yearling smolt stage and released into North Fork downstream of the lower dam in 2016.

Key elements that comprise Phase 1 are outlined below.

**Biological Targets for Phase 1 (endpoints of phase**):

a. Abundance of returning adults: A consistent (i.e., running eight year average) return of 600 hatchery origin adults will occur to the North Fork Hatchery.

b. In-hatchery productivity: One thousand yearling smolts or more will be produced per spawner and 1,200 subyearling smolts or more will be produced per spawner.

c. Hatchery fish post-release survival: The average post-release survival (i.e., survival of smolts to adult recruitment or SAR) will be approximately 0.5% for yearling releases and approximately 0.25% for subyearling releases. These are recruitment rates to fisheries. It is expected that SARs may be less than these values initially because of the use of a non-adapted stock for hatchery startup. The rates shown here are targets to achieve by the end of the phase. These rates are expected to subsequently improve in the next phase as the stock continues to adapt to the conditions encountered during juvenile downstream migration, ocean migration, and return.

d. Juvenile and adult passage effectiveness at dams: Upstream and downstream fish passage effectiveness at the Cushman Dams will approach NOAA passage standards set forth in the dam licensing articles.

e. Genetic diversity of the hatchery population: Targets need to be established for the stock by co-manager geneticists.

f. Spatial structure and diversity: No specific biological targets need to be met in this phase but habitat conditions within the mainstem Skokomish River, North Fork, and South Fork should be improved over existing conditions, particularly with respect to any passage issues.

**Key assumptions for Phase 1:**

a. Minimum hatchery fish productivity:

   i. Eggs per female: 3,500

   ii. Percent females: 50%

   iii. Female prespawning survival: 90%

   iv. Egg to smolt survival: 70% for subyearlings, 60% for yearlings

b. Fishery exploitation rates: The combined total exploitation rate in terminal and pre-terminal fisheries (including incidental mortality or by-catch) will not exceed 16%.

c. Improvements in habitat conditions: Habitat conditions in the mainstem Skokomish River, North Fork, and South Fork will continue to be improved from current conditions in preparation for the Recolonization Phase (Phase 2). This also includes passage effectiveness of juveniles and adults at the Cushman Dams.

**Management strategies and actions to meet Biological Targets for Phase 1:**

In-river harvest management:

Limited in-river fisheries will occur for ceremonial and subsistence purposes.

Habitat and natural production:

a. Adult fish passage facilities at the lower dam (Cushman No. 2) will be tested and refined as needed to achieve required passage criteria.

b. Juvenile downstream passage facilities at the upper dam (Cushman No. 1) will be tested and refined as needed to achieve required passage criteria.

c. Habitat actions will progress in the South Fork, lower North Fork, and in the mainstem Skokomish River to continue to restore normative processes and habitat functions in the watershed. During Phase 1, efforts will strive to close the gap between current habitat condition and PFC by at least 25%.

d. No sustained natural spawning is expected during this phase.

North Fork Hatchery:

a. Release of 300,000 subyearlings and 75,000 yearling smolts will occur annually from the hatchery, indicating achievement of an operational hatchery.

b. To maximize diversity, egg transfers from Marblemount Hatchery will represent the appropriate run timing spectrum, and best management spawning protocols (mate selection) will be implemented.

c. Rearing and release protocols will be evaluated and modified as necessary to achieve adult return objectives.

d. Coded wire tags (CWT) will be used to aid in evaluating SARs and fishery exploitation rates.

e. Spawning protocols for returning adults will be developed to minimize hybridization with the extant summer/early fall Chinook stock.

f. Importation of Skagit stock eggs will be discontinued as soon as possible to move toward development of a locally adapted brood stock.

g. When adult returns to the North Fork hatchery are 400 or less, they will all be utilized for broodstock. Returns in excess of the broodstock requirement will be outplanted to the upper North Fork. The purpose of outplanting in Phase 1 is to develop and test methods for selecting, transporting, and releasing adults to the spawning grounds and to help evaluate downstream juvenile passage effectiveness out of Cushman Reservoir.

<u>Monitoring and evaluation (M&E)</u>:

M&E activities will test the key assumptions outlined above and measure progress toward the biological targets and management triggers to determine the appropriate time to shift to Phase 2. Key indicators to monitor include:

a. In-hatchery and post-release survival;

b. Sex-age composition and fecundity by age;

c. River-entry timing and the timing of return to the North Fork trap;

d. Spawning timing;

e. Hatching and first feeding timing;

f. Timing and habitat utilization of outmigrants;

g. Genetics;

h. Catch contribution to pre-terminal and terminal fisheries (including incidental catch);

i. In-river survival of outmigrants and of returning adults;

j. Adult fish passage at the lower Cushman Dam;

k. Destination of returning adults and rate of homing to hatchery rack; and

l. Fish health, including testing of broodstock, eggs, and juveniles for bacterial, fungal, and viral pathogens;

m. Habitat characteristics (including water temperatures) in the North Fork, South Fork, mainstem Skokomish River, and the river estuary. (North Fork characteristics are monitored by Tacoma Power and some monitoring will be required in the lower South Fork and mainstem river as part of the implementation phase of the USACE's project "Skokomish River Basin Ecosystem Restoration.")

**Management Triggers for shift from Phase 1 to Phase 2**:

The plan will move to Phase 2 (Recolonization) when the 8-year running average return of spring Chinook 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.

#### 3.1.2.2 Spring Chinook Phase 2: Recolonization

The primary purpose of Phase 2 is to recolonize natural habitat with spring Chinook Salmon, beginning in the upper North Fork and then in the upper South Fork. Recolonization will occur by initially transporting by tanker truck adult fish that return to the North Fork Hatchery, and it will then be advanced as the adult progeny of those spawners (spawning naturally) are also transported (North Fork) or they subsequently return naturally to their natal areas (South Fork). As this phase matures, the abundance of natural-origin returns is expected to increase in response to improving habitat conditions, increased numbers of transported spawners, and the initial progress of adaptation to the natural habitats. It is expected that this will result in increased spatial and temporal diversity of habitat use and the initial re-emergence of life histories suited to those conditions. This can be expected to increase genetic diversity over time.

Habitat measures will continue to be implemented during this phase to restore normative watershed processes and habitat functions in the mainstem river valley, South Fork, and lower North Fork. During Phase 2, efforts will strive to close the gap between current habitat conditions and PFC by at least 50%. Also, continued improvements in fish passage actions will be made as needed.

Key elements that comprise Phase 2 are outlined below.

**Biological Targets for Phase 2 (endpoints of phase):**

a. Abundance of returning adults: A consistent (i.e., running eight year average) return of 1,000 adults (natural and hatchery-origin combined) will occur to the North Fork trap at the lower Cushman Dam, of which a substantial number (no specific target) will be natural-origin fish. This will indicate continued operational effectiveness of the North Fork Hatchery to support the overall program and a re-emergence of sustained natural production from the upper North Fork. Similarly, a return of natural-origin adults is to be evident in the upper South Fork every year during the latter part of this phase, indicating a re-emergence of some sustained natural production from the upper South Fork and successful passage at the gorge cascades.

b. Transported adult hatchery pre-spawners: Consistent annual releases of adult hatchery pre-spawners into both the upper North and South forks will occur so that the total number of naturally spawning spring Chinook in each fork exceeds 200 spawners (combined hatchery and natural-origin fish).

c. Productivity of natural spawners: Returns per natural spawner in the North and South forks (combined) will exceed 2.0 when the number of spawners in each fork exceeds 200 fish. This assumes that habitat functions have been restored to 50% of PFC conditions and indicates that habitat conditions have the potential to sustain natural production. This further assumes that outplanted hatchery fish can adapt to local conditions (i.e., the fitness of their progeny will improve over time).

d. Hatchery fish post-release survival: The average post-release survival (i.e., survival of smolts to adult recruitment or SAR) will exceed 0.5% for hatchery yearling releases and 0.25% for subyearling hatchery releases. These are recruitment rates to fisheries.

e. Juvenile and adult passage effectiveness at dams: Upstream and downstream fish passage effectiveness at the Cushman Dams will meet or exceed NOAA passage standards as set forth in the dam licensing articles.

f. Adult upstream passage through the gorge cascades: Clear evidence will be established that returning adults to the South Fork are able to negotiate the gorge cascades to reach the upper river. If conditions in the South Fork gorge are determined to impede migration, measures will need to be developed to improve passage, although local adaptation under Phase 3 can be expected to also improve passage effectiveness.

g. Genetic diversity of the hatchery population: Targets need to be established for the stock by co-manager geneticists.

h. Spatial structure and biological diversity: Evidence will be clearly established of dispersal of natural spawners in both the upper North and South forks to the upper limits of available spawning habitat. Evidence will also be established of a re-emergence of life history patterns similar to those expected to have existed historically and which are evident in other extant spring Chinook populations in Western Washington.

**Key assumptions for Phase 2:**

a. Minimum hatchery fish productivity: Hatchery fish productivity within the hatchery will remain equal to or higher than attained in Phase 1.

b. Fishery exploitation rates: Exploitation rates in terminal and pre-terminal fisheries (including incidental mortality or by-catch) will not exceed 19%.

c. Improvements in habitat conditions: Habitat conditions in the mainstem Skokomish River, North Fork, and South Fork will continue to be improved relative to the end of Phase 1; conditions would provide for intrinsic productivity of at least 50% of PFC conditions based on population modeling (such as with the EDT model) or based on empirical evidence.

**Management strategies and actions to meet Biological Targets for Phase 2**

In-river harvest management:

Ceremonial and subsistence harvest will occur annually, and it is expected that the level of harvest will vary with run size. Throughout Phase 2, harvest will primarily be of hatchery-origin returns.

Habitat and natural production:

a. Adult and juvenile fish passage facilities at the Cushman Dams will continue to be tested and refined as needed to achieve required passage criteria.

b. Habitat actions will continue to progress in the South Fork, lower North Fork, and in the mainstem Skokomish River to progress in restoring normative processes and habitat functions in the watershed. It is expected that natural production of juvenile outmigrants will be sustained every year from both the upper North and South forks in the latter years of this phase.

North Fork Hatchery:

a. Release of 300,000 subyearlings and 75,000 yearling smolts will occur annually from the hatchery to continue to support the program. It is understood, however, that the co-managers, in cooperation with Tacoma Power, will periodically evaluate program release sizes and make adjustments if deemed appropriate.

b. The hatchery program will be sustained entirely with the locally adapted brood stock established in Phase 1. The program will move toward a fully integrated brood stock using HSRG guidelines.

c. Coded wire tags (CWT) will continue to be used to evaluate SARs and fishery exploitation rates.

d. Spawning protocols will continue to be refined to minimize hybridization with the extant summer/early fall Chinook stock.

e. Preliminary guidelines for the disposition of natural-origin returns returning to the North Fork trap are as follows: When natural-origin returns (NORs) are less than 200, all of them will be transported to the upper North Fork to colonize habitat. When the return is between 200 and 400, up to 30% may be utilized for broodstock to increase genetic diversity, implying that 70% will transported to the upper North Fork. When the NOR return exceeds 400, up to 50% may be utilized for broodstock and the remainder outplanted. The first priority for use of hatchery origin returns to the North Fork will be to meet broodstock requirements. Hatchery-origin returns in excess of broodstock will be outplanted into the upper North and South forks. Ceremonial and subsistence harvest may increase under these circumstances.

Monitoring and evaluation (M&E):

M&E activities will test the key assumptions outlined above and measure progress toward the biological targets and management triggers to determine the appropriate time to shift to Phase 2. Key indicators to monitor include:

a. In-hatchery and post-release survival;

b. Sex-age composition and fecundity by age;

c. River-entry timing for NORs and HORs to the mouth of Skokomish River and to the North Fork trap;

d. Spawning timing for NORs and HORs;

e. Hatching and first feeding in the hatchery and fry emergence timing in nature;

f. Timing and habitat utilization of outmigrants;

g. Rates of juvenile fish passage through Cushman Reservoir and past the upper dam;

h. Adult fish passage at the lower Cushman Dam and at the gorge cascades in the South Fork;

i. Genetics;

j. Catch contribution to pre-terminal and terminal fisheries (including incidental catch);

k. In-river survival of outmigrants and of returning adults;

l. Destination of returning adults and rate of homing to hatchery rack;

m. Fish health, including testing of broodstock, eggs, and juveniles for bacterial, fungal, and viral pathogens;
n. Habitat characteristics (including water temperatures) in the North Fork, South Fork, mainstem Skokomish River, and the river estuary. (North Fork characteristics are monitored by Tacoma Power and some monitoring will be required in the lower South Fork and mainstem river as part of the implementation phase of the USACE's project "Skokomish River Basin Ecosystem Restoration.")

**Management Triggers for shift from Phase 2 to Phase 3**:

The plan will move to Phase 3 (Local adaptation) when the 8-year running average return of spring Chinook adults to the North Fork trap and to the upper South Fork combined exceeds 1,200 fish, including at least 400 natural-origin fish. The abundance of natural-origin returns is an indicator of natural abundance potential and a partial indicator of productivity.

The triggers are based on the likelihood of meeting biological targets given key assumptions and policy judgement about balancing the rate of recovery versus harvest. The abundance trigger is set conservatively high (i.e., 1,200) relative to the biological target of 1,000 to be more certain before committing to manage broodstock to reduce hatchery influence. Alternatively, the trigger could be set lower (e.g., 800) to be more aggressive relative to conservation and thus making constraints on harvest and hatchery production more likely. This will require a policy decision as the plan moves forward and is refined through adaptive management.

The recovery sequence would move back to Phase 1 if the 8-year running average of total return (NORs plus HORs) falls below 500 adults. (This number is set lower than the "moving up" trigger to ensure that local adaptation is given a chance to improve fitness before prematurely returning to the recolonization phase.) There is a policy component to this trigger decision.

#### 3.1.2.3 Spring Chinook Phase 3: Local adaptation

The primary purpose of Phase 3 is to facilitate the adaptation of the reintroduced population to local habitat conditions within the watershed as those conditions are being improved through restoration. As this phase progresses, the performance of naturally produced spring Chinook is expected to steadily improve as the population adapts to the diversity of habitats in the watershed. Abundance and intrinsic productivity of the population will increase both in response to improving habitat conditions and to adaptation to local conditions. This phase will continue, unless population performance regresses, until recovery is achieved.

Hatchery supplementation will continue during the phase but the program will evolve. It will be phased out entirely within the South Fork as the naturalized population increases in performance. The schedule for phasing out in the South Fork would be determined by the rate of progress in watershed restoration together with the performance of natural-origin returns to the South Fork.

In the North Fork, broodstock selection protocols for the hatchery supplementation program will change to include a larger proportion of natural-origin fish in the brood stock. The proportion of hatchery-origin returns that spawn naturally in the upper North will decline. By the end of the phase, the hatchery would continue to operate but as an integrated, safety net program, applying HSRG operational guidelines. The PNI would be expected to increase, and then be maintained at 0.67 or higher as per those guidelines. Hatchery release sizes would be re-evaluated and adjusted if necessary.

Habitat measures will continue to be implemented during this phase to restore normative watershed processes and habitat functions in the mainstem river valley, South Fork, and lower North Fork. Continued improvements in fish passage actions will be made as determined to be needed.

The total combined exploitation rate on the naturally produced population during this phase would be managed to not exceed 25%. The exploitation rate on hatchery-origin fish may reach a higher level if these fish are externally marked and mark-selective fisheries are implemented. Such selective fisheries within the watershed should be encouraged for both treaty and non-treaty fisheries.

Key elements that comprise Phase 3 are outlined below.

**Biological Targets for Phase 3 (endpoints of phase):**

a. Abundance of returning adults: A consistent (i.e., running eight year average) return of at least 1,000 natural-origin returns to the mouth of the Skokomish River with natural-origin spawners returning to both the North and South forks in comparable proportions. The number of natural-origin spawners should average at least 800 fish. It is noted that some of the natural-origin fish returning to the North Fork will be annually incorporated into the brood stock for hatchery production.

b. Transported adult pre-spawners: Annual releases of at least 400 adult pre-spawners will be transported to the upper North Fork from the fish collection facilities. Some of these fish may be hatchery-origin fish in years when total returns to the river are low due to natural fluctuations. The number of fish to be released is to be based on evaluation of the spawner-production relationship that is developed through the years for the upper North Fork.

c. Proportion of Natural Influence (PNI): The average PNI is to be greater than 0.67 (South and North forks combined) with the proportion of hatchery-origin natural spawners (pHOS) being less than 30%. This implies that the proportion of natural-origin returns used for broodstock (pNOB) will be twice the proportion of hatchery origin recruits that spawn naturally, e.g., pNOB = 60% if pHOS is maintained at or less than 30%.

d. Hatchery fish post-release survival: The average post-release survival (i.e., survival of smolts to adult recruitment or SAR) will exceed 0.5% for hatchery yearling releases and 0.25% for subyearling hatchery releases. These are recruitment rates to fisheries. It is expected that the SAR values may be substantially higher than the rates shown here due to adaptation of the stock over time.

e. Juvenile and adult passage effectiveness at dams: Upstream and downstream fish passage effectiveness at the Cushman Dams will meet or exceed NOAA passage standards as set forth in the re-licensing articles.

f. Genetic diversity of the hatchery population: Targets need to be established for the stock by co-manager geneticists.

g. Spatial structure and biological diversity: A diverse range of juvenile life history patterns will be evident in the natural population, comparable to the patterns seen in other rivers in Western Washington that produce spring Chinook.

**Key assumptions for Phase 3:**

a. Minimum hatchery fish productivity: Hatchery fish productivity within the hatchery will remain equal to or higher than attained in Phase 2.

b. Fishery exploitation rates: Exploitation rates in terminal and pre-terminal fisheries combined (including incidental mortality or by-catch) would average approximately 21% on natural-origin fish. This assumes that the combined exploitation rate on these fish does not exceed 12% outside of the Hood Canal region. The combined exploitation rates on hatchery-origin fish would be expected to exceed 25% assuming that some forms of mark-selective fisheries would be in effect.

c. Improvements in habitat conditions: Habitat conditions in the mainstem Skokomish River, North Fork, and South Fork will continue to be improved relative to the end of Phase 2. By the end of Phase 3, it is expected that habitat conditions would provide for intrinsic productivity of a level (7.3) expected associated with conditions intermediate between PFC and PFC+, based on modeling (such as with the EDT model) or on empirical evidence.

d. Continuity of the South Fork and North Fork spawning aggregates: Some level of genetic exchange will naturally occur between the spawning aggregations in the North and South forks so that in effect the two aggregations can be considered one population. The minimum PNI value for the combined population would be 0.67, consistent with HSRG guidelines.

**Management strategies and actions to meet Biological Targets for Phase 3**

In-river harvest management:

Ceremonial and subsistence harvest will occur annually on returning natural-origin fish in addition to harvest within the Hood Canal region (includes in-river) that targets hatchery-origin fish. The level of harvest will vary with run sizes. Fishery impacts would be consistent with exploitation rates listed under Key Assumptions.

Habitat and natural production:

a. Adult and juvenile fish passage facilities at the Cushman Dams will be maintained as needed to ensure that fish passage effectiveness meets or exceeds required passage criteria.

b. Habitat actions will continue to progress in the South Fork, lower North Fork, and in the mainstem Skokomish River to restore normative processes and habitat functions in the watershed. It is expected that conditions will approach PFC by the end of the phase.

North Fork Hatchery:

a. Release of 300,000 subyearlings and 75,000 yearling smolts will occur annually from the hatchery as stipulated by the dam licensing articles. It is understood, however, that the co-managers, in cooperation with Tacoma Power, will evaluate program release sizes and make adjustments if deemed appropriate.

b. The hatchery program will operate as a fully integrated program consistent with HSRG guidelines. Minimum PNI by the end of the phase should be 0.67 or higher.
c. Coded wire tags (CWT) will continue to be used to evaluate SARs and fishery exploitation rates.
d. Spawning protocols will continue to be refined to minimize hybridization with the extant summer/early fall Chinook stock.

Monitoring and evaluation (M&E):

M&E activities will test the key assumptions outlined above and measure progress toward the biological targets and management triggers to determine the appropriate time to shift to Phase 2. Key indicators to monitor include:

a. In-hatchery and post-release survival;
b. Sex-age composition and fecundity by age;
c. River-entry timing for NORs and HORs to the mouth of Skokomish River and to the North Fork trap;
d. Spawning timing for NORs and HORs within the watershed (all areas);
e. Hatching and first feeding in the hatchery and fry emergence timing in nature;
f. Timing and habitat utilization of outmigrants;
g. Rates of juvenile fish passage through Cushman Reservoir and past the upper dam;
h. Adult fish passage at the lower Cushman Dam and at the gorge cascades in the South Fork;
i. Genetics in the North and South forks;
j. Catch contribution to pre-terminal and terminal fisheries (including incidental catch);
k. In-river survival of outmigrants and of returning adults;
l. Destination of returning adults and rate of homing to hatchery rack; and
m. Fish health, including testing of broodstock, eggs, and juveniles for bacterial, fungal, and viral pathogens;
n. Habitat characteristics (including water temperatures) in the North Fork, South Fork, mainstem Skokomish River, and the river estuary. (North Fork characteristics are monitored by Tacoma Power and some monitoring will be required in the lower South Fork and mainstem river as part of the implementation phase of the USACE's project "Skokomish River Basin Ecosystem Restoration.")

**Management Triggers for shift from Phase 3 to Phase 4**:

As proposed here, the plan would move to Phase 4 and achieve recovery when the 8-year running average return of natural-origin spring Chinook to the mouth of the Skokomish River exceeds 1,000 fish. The total number of natural-origin spawners in the system would average approximately 800 fish and PNI would be greater than 0.67.

If the performance of natural-origin fish regresses, the plan would move back to Phase 2 if the average number of natural-origin returns to the river mouth drops below 400 fish.

#### 3.1.2.4 Spring Chinook Phase 4: Recovered Population

At the time when the performance of the spring Chinook population exceeds the management trigger to advance to Phase 4, the population should be considered recovered. Under Phase 4, the purpose will be to maintain sustainable natural production at abundance levels that will support harvest objectives and prevent a regression in performance. The population will be monitored closely to detect any changes in status. The North Fork Hatchery will continue to operate as an integrated safety net program. Habitat conditions will continue to require assessment. Additional restoration work may continue to be needed to offset the effects of climate change. The fish passage facilities and flow regime specified under the Cushman Settlement will continue to be required for the life of the dam license.

The biological targets and key assumptions for Phase 4 remain the same as specified for Phase 3, as will the triggers for moving down to previous phases.

**Management strategies and actions to meet Biological Targets for Phase 4:**

The North Fork Hatchery will continue to operate as an integrated demographic safety net and harvest augmentation program for as long as the dams exist. Hatchery recruits may be used to supplement natural spawning in the upper North Fork if natural spawning levels fall below threshold for a pre-determined number of years. Use of natural-origin fish as hatchery broodstock will continue at prescribed levels, including use of adults returning to the South Fork if the returns to the North Fork trap fall below an acceptable level. The proportion of natural-origin recruits used for broodstock will exceed 20%, or two times the proportion of hatchery-origin recruits that spawn naturally, whichever is greater.

## 3.2 Summer/Early Fall Chinook

### 3.2.1 Approach

This plan presents an approach not included in the 2010 Plan aimed at improving the potential for recovering a late-timed Chinook population derived from the extant George Adams Hatchery stock. The approach also includes aspects to reduce the potential for adverse fishery and genetic interactions between this stock and the spring Chinook stock being reintroduced into the watershed. We project that a 20-year time period will be needed evaluate whether this approach can be successful at progressing toward the potential recovery of a true fall-run population.

In short, the new approach is to first stop, and then reverse to a significant extent the advancing run timing of the George Adams stock and also promote a much later timed segment of the run. The primary purpose for doing this is twofold: first, to create a distinct timing separation between returning spring Chinook and George Adams Chinook; and second, to experimentally determine the success of recreating later timed George Adams fish and subsequently to assess their reproductive performance when spawning naturally in the river. Actions to accomplish these steps will occur while progress continues toward restoring normative habitat functions in the lower river valleys.

The approach to be employed is experimental because it aims to substantially alter river-entry timing of both the early and late segments of the population—most notably to shift the late part of the run to an even later timing in an attempt to restore life history patterns that have been lost in the population. This shifting of the late segment of the returning run to attempt to recreate extirpated life histories is the most experimental aspect of the plan and has high uncertainty.

Evidence shows that the original fall-run Chinook population had in-river adult life history characteristics keyed to the onset of fall rains, and further, that fry emergence and juvenile life history outmigration were timed to benefit from food and habitat conditions during spring and early summer (see Chapter 2). Continuous hatchery propagation of the George Adams hatchery Chinook stock, including its Green River hatchery source stock, for over a century has resulted in a dramatic timing advance in river entry, spawning, and fry emergence compared to the aboriginal timing patterns (Quinn et al. 2002; SIT and WDFW 2010; Chapter 2 of this document). Fry emergence from natural spawners, for example, now occurs largely in mid-January to early February, when food resources are lacking and freshet flows are the norm—conditions not conducive to good survival.

The timing of river entry, spawning, and fry emergence are heritable life history traits and under selection, both in nature and in a hatchery. The dramatic shifts to earlier dates of these traits in the George Adams stock is evidence for the results of selection within the hatchery. We suspect that other life history traits, though not directly measured, have also been altered over the long course of hatchery domestication of the stock.

Selective pressure imposed by hatchery domestication is a form of human-influenced evolution (Quinn et al. 2002; Waples and Naish 2009; Christie et al. 2012). This selection can favor the survival of hatchery-produced fish having certain phenotypic traits, such as early hatching and quickness to be fed, but these same traits may be selected against in nature. Salmonids have evolved spawning dates that are appropriate for the regimes of temperature and other environmental factors that prevail during incubation (Quinn et al. 2002), resulting in fry emergence timed to maximize survival in nature (Miller and Brannon 1981; Quinn 2005). Emergence timing in nature is keyed to food availability and other factors that favor survival of newly emerged fry. We suggest that the altered life history traits of George Adams Chinook are maladapted for the stock to thrive when it reproduces in the natural environment. Rates of reproductive success ($\lambda$) in the river by the Skokomish contemporary population are extremely poor (Table 2.3), which we infer are due both to this maladaption and to degraded habitat.

Using a combination of hatchery and harvest strategies/actions, the approach presented here aims to steadily push spawning timing later for the late segment of the run. This, in turn, is intended to shift the time of hatching and fry emergence later in the direction of the timing patterns of the aboriginal fall-run Chinook (Figure 2.2). Shifting spawning timing later by several weeks should result in both later fry emergence and outmigration timing. We hypothesize that such a shift should improve the success of natural spawners from the extant summer/early fall population to produce adult progeny. In effect, the approach, if it is found successful, could help in a re-evolution of life history patterns that have been lost.

It is important to recognize the uncertainties that exist with the approach. To our knowledge such an approach to reverse long-term domestication effects on life history patterns in Chinook salmon has not been attempted by intentionally selecting for later timed fish in the hatchery. Quinn (2005) describes the rapid selection that can occur by Chinook both in a hatchery and in nature with respect to spawning and fry emergence timing. His description, while relevant here, was given in the context of how Chinook introduced to a New Zealand river between 1901 and 1907 became established there, flourished, and then expanded their distribution to other rivers. Quinn stated:

> "We believe that the genetic control over timing of adult migration and reproduction is especially important for two reasons. First, selection will act strongly on successful return to the spawning grounds by adults and on emergence of fry at a locally appropriate time in the spring to feed and grow. Thus, adults spawning at an inappropriate date will be quickly culled from the population, moving the mean spawning date. Deliberate selection in hatcheries can rapidly change the spawning date, so such evolution in nature is not unexpected. Second, the spatial isolation that new populations start to experience from homing to natal sites will be compounded by temporal isolation as their spawning dates come to differ. Thus spawning date is both an important, fitness-related trait, and its evolution accelerates the divergence of populations in other traits."

Quinn's statement suggests that using intentional hatchery selection initially to produce later-timed spawners, then combined with natural selection in nature, may be able to facilitate a re-evolution of life histories more representative of true late-timed Chinook. Waples et al. (2007; 2008) suggested that a re-evolution of lost life histories may not be straight-forward and may require a longer period of time than it took for the stock to develop the life history traits that currently exist. The issue involves what has been called a "Darwinian debt" (Loder 2008)—an evolutionary change associated with human-altered environments that must be repaid before the population can re-adapt to more natural conditions, if the human changes to the ecosystem are reversed. The concept has mostly been applied to the effects of harvest-related selection (resulting in a change in body size and age structure), but Waples et al. (2007) suggested the principle could apply in trying to reverse the effects of hatchery selection as well. The effect, if real, would be to slow the rate at which a re-evolution might occur (Hard and Waples 2015).

We recognize that other phenotypic traits besides spawning timing—and the related time of fry emergence—may be involved, and these may contribute to the complexity of re-evolution starting from a strongly domesticated stock. Other traits that may influence success of the approach are spawner size and egg size; evidence exists that these have been altered through a combination of harvest effects and hatchery domestication (Heath et al. 2003; Quinn et al. 2004). We speculate that the extent of timing advance in hatching and emergence of the contemporary population may in part be due to selection for more rapid yolk-sac conversion, which should favor survival in the hatchery but be maladaptive in nature. In any case, the effectiveness and speed of being able to shift the timing of key traits to more resemble those of true late-timed Chinook are uncertain.

It bears noting that Green River hatchery Chinook stock was successfully introduced into the Great Lakes in the 1960s. Hatchery production in that region has been maintained since then as well as the outplanting of smolts into areas removed from the hatcheries. Over time, natural production has been established from these hatchery releases and from strays in a number of streams in the region (Johnson et al. 2010). There is also evidence of weak genetic structuring among the populations that have been established (Suk et al. 2012), suggesting that there is potential for phenotypic divergence of early life history traits (Thorn and Morbey 2017).

As stated at the start of this section, the updated approach to managing the extant summer/early fall Chinook population involves more than just the late part of the population. The overall approach includes a significant restructuring of the timing of the whole population to meet objectives related to the reintroduction of the spring Chinook population, the hatchery-supported treaty and non-treaty fisheries, and to improve the potential for recovering a late-timed natural population.

The key elements of the approach to restructure the timing of the George Adams population are primarily addressed through updated hatchery and harvest actions. These elements are explained briefly in the next section of this chapter; further details are then given in the chapters that follow this one.

### 3.2.2 Key Elements of the Summer/Early Fall Chinook Approach

The approach to restructure river entry and spawning timing of the summer/early fall Chinook population is intended to accomplish the following:

1. Create a distinct timing separation between returning spring Chinook and George Adams Chinook, thereby minimizing potential complications due to overlapping runs both in harvest management and in spawning;
2. Stabilize the central river-entry timing mode of George Adams hatchery fish to primarily occur in August, enabling both treaty and non-treaty fisheries to more effectively harvest returning fish with minimal harvest conflicts to natural production potential and other salmon runs and species; and
3. Experimentally determine the success of re-creating later-timed George Adams fish and subsequently to assess their reproductive performance when spawning naturally in the river.

The importance of creating timing separation between returning spring Chinook and George Adams fish is due to the need to minimize harvest management overlaps between the two runs (to avoid harvest conflicts) and to prevent to the maximum possible extent any timing overlaps in breeding between the stocks. The latter is needed to minimize genetic mixing of the two stocks whether in a hatchery or on the spawning grounds. It is important to recognize that significant numbers of George Adams hatchery Chinook now begin entering the river in late June. The actions that would be implemented to create this timing separation, therefore, would strive to reduce to the maximum extent possible the number of George Adams hatchery fish that return to the river prior to about August 1.

Under this approach, managers would aim to stabilize the central mode of river entry of George Adams hatchery Chinook to the month of August. The purpose in doing this is to the maximize harvest on the portion of the returning population that provides the greatest harvest opportunity with minimal potential conflicts to viable natural production and recovery goals. The peak river entry timing of the George Adams population is estimated to currently occur in early August; under this approach, we project that the peak entry would be pushed somewhat later to mid-month.

While stabilizing the central core of the returning run to August, management efforts would strive to significantly extend the timing of the late segment of the run and simultaneously increase the abundance of this segment. The aim is to increase the number of naturally spawning Chinook from the latest segment of the population, and over time to push this segment to be closer in timing to a true fall-type Chinook. The operating hypothesis is that later-timed George Adams fish that spawn naturally in the river would be more successful at producing offspring that survive to adult and return to spawn in the river.

Changing the run timing of the George Adams hatchery population involves changes in management of the hatchery program and in the terminal area harvest patterns. These changes are expected to complement progress that can be achieved in restoring habitat function essential to natural Chinook production.

The key elements of the approach to accomplish the objectives are described briefly below. These elements include delineating three timing segments of the George Adams Chinook population and different hatchery and harvest management actions directed to each of the three segments.

#### 3.2.2.1 Three run timing segments

The new approach to managing the extant summer/early fall Chinook population is developed around three river-entry timing segments of the population, an early, middle, and late timing segment. The timing shifts that have occurred over the past 30 years for these segments are evident in Figure 2.4.

Based on recent performance patterns of the population, we define the early segment to currently be that part of the run that enters the river before about August 1. Substantial numbers of George Adams Chinook now return to the river prior to this date, with some returning as early as late June. The objective over about the next 10 years is to greatly reduce, or essentially eliminate, this segment of the population.

The middle segment of the population now primarily returns to the river during August with peak entry appearing to occur early in the month. This segment includes fish that return over the entire month—it forms the central core of the population's river-entry pattern. The objective over about the next 10-15 years is to stabilize the run timing of the central core of the river-entry pattern so that it continues to occur in August. It is the intention of the co-managers that this timing segment provide the major fishery benefits to be derived from the George Adams Chinook population on an on-going basis.

The late timing segment of the population as it currently exists consists of those fish that enter the river after the end of August. Some fish continue to enter through September with the run rapidly diminishing during this time. The objective over the next 20 years is to extend the timing of this segment throughout September and into October, and to enhance the abundance of this segment, particularly for the latest part of the segment. Harvest and hatchery measures are to be taken to increase the number of natural spawners in the river produced within this population segment.

#### 3.2.2.2 Harvest elements

Harvest management objectives are stated for three components of the current George Adams run, based on early, middle, and late river entry timing. The composition as a percentage of the aggregate population within each timing component would differ over time during this 20 year planning horizon as the timing shifts proposed above occur. Moreover, we expect that the abundance of NORs will differ among the timing components, and we hypothesize that nearly all NORs now being produced come from the latest timed component of the George Adams run that spawns naturally.

Each component would have a different harvest rate objective, which would help facilitate the desired run timing shifts described above, as well as provide greater protection from harvest for NORs. The objective would be to harvest at the highest rate possible on the earliest component, then to incrementally reduce the rate for the two later components. The latest component, which should contain the highest proportion of NORs, would be harvested at the lowest rate (most of the harvest impact would be expected to occur in pre-terminal fisheries).

The policy that has been adopted by the co-managers for harvest impacts on George Adams-related Chinook NORs has been to not exceed an exploitation rate ceiling of 50% (combined for all fishery impacts). Consistent with this policy, we propose implementing actions that would shift run timing later, while also reducing wastage of returning George Adams Hatchery Chinook (hatchery-origin recruits) of earlier returning fish and giving greater protection to late returning NORs.
In the initial stage of the 20-year planning horizon harvest actions would be implemented in the Skokomish River and in Area 12C of Hood Canal to harvest at the highest practical rates on fish returning to these areas prior to August 1. The purpose is to remove as many of these fish as possible from the breeding stock, i.e. prevent them from spawning naturally or use as broodstock. Details of how these fisheries would be implemented are described in Chapter 6.

Chinook harvest in Area 12C and the Skokomish River, prior to August 1, would be exempted from counting toward the 50% exploitation rate ceiling being applied to George Adams-related Chinook. The rationale is that all reasonable measures should be implemented at removing these early returning George Adams Chinook from the gene pool, and therefore, harvest restrictions should be lifted to the extent practical. It is reasonable to assume that members of this early timed component have a very low probability of producing natural-origin juveniles or adult recruits.

On the component of the George Adams Chinook population that returns to the river beginning approximately August 1 and prior to September 1, the overall exploitation rate would be expected to be in the range of 50-65% (not including any impacts from the fishery that occurs in Purdy Creek). This exploitation rate is safely within the range of what a hatchery run like George Adams can sustain. The majority of the George Adams hatchery run would move through the lower river during this period. The number of NORs that would enter the river during this period can reasonably be expected to be few. Fisheries would be designed to maximize harvest on the overall in-river run of George Adams hatchery Chinook during this time period. Tribal fishing would operate 3-4 days per week, as in recent years. As noted, we would expect the overall exploitation rate on this segment of the run to not exceed 65%. The intent is to stabilize run timing on this segment of the run such that the core of the George Adams hatchery Chinook production is maintained with an August river entry timing.

To reduce the surplus of adults returning to the hatchery, harvest would be intensified in Purdy Creek prior to the return of fish in the late timed component, while ensuring sufficient spawning escapement to the hatchery. Sampling of tribal catch in Purdy Creek in recent years indicates that few NORs are caught.

Options for mark selective fisheries, mutually agreed to by the co-managers might also be implemented to reduce hatchery surpluses and proportions of hatchery-origin fish on the spawning grounds during the month of August.

The component of the run that enters the river after September 1 and matures after October 1 will be enhanced through hatchery practices to both increase abundance of this segment and extend its river entry and spawn timing to promote successful natural spawning. Terminal area fisheries would be closed throughout September to protect the later-returning fish and to increase their spawning escapement. The overall exploitation rate on Chinook entering the river after September 1 is projected to be substantially less than 50% and would largely be associated with pre-terminal fisheries. The in-river rate on this component would be kept as low as practically could be achieved.

#### 3.2.2.3 Hatchery elements

The following summarizes changes in management of the George Adams Hatchery summer/early fall Chinook program. Broodstock selection would change so that no adults entering the hatchery trap prior to August 1 will be spawned; all of these fish would be sampled (all pertinent data) and treated as surplus to the program. Historically, June and July returning fish have been the fish that mature in August. Therefore, eggs will no longer be taken in August. Instead, adults that enter the trap in August and mature after Sept 1 will be targeted for broodstock. The majority of the program will be taken in the first two weeks of September in order to (1) represent August river entry timing, (2) reduce overlap in spawn timing with spring Chinook, and (3) increase potential for separating the core of the summer/early fall run with late-timed Chinook. The program egg take goal for the core of the population is expected to be achieved by September 20. Over time, as fish enter the trap that are closer in timing to a true fall-entry Chinook, fish in excess of broodstock needs will be treated as surplus so that the late-timed program will be more and more comprised of only September-river entry and October-maturing fish. Egg takes for this part of the program will occur after October 1 utilizing the latest available maturing fish.

Given the current river entry and spawn timing of the earliest George Adams Chinook, there is potential for introgression with spring Chinook in the Skokomish River.  While little can be done to eliminate this risk in the wild, it is imperative that hatchery management practices not favor the earliest returns of George Adams Chinook or inadvertently magnify such introgression in the hatchery environment.  In order to prevent entrainment of spring Chinook into the George Adams broodstock it will be necessary to avoid spawning adipose intact fish prior to September 10, thus segregating the program during the summer while allowing for inclusion of NORs into the late-timed program.

These actions would be expected to re-shape run timing in three ways: first, the very early portion of the run as it currently exists would be greatly diminished, and second, the median date of return would be shifted well into August; and third, the latest timed component (beginning approximately September 20) would be enhanced such that the overall run would tail off creating a protracted late segment with a peak spawn timing six weeks later than the core of the George Adams summer/early fall return (although the hatchery program will exhibit much lower abundance compared to the core of the run, late timed fall natural origin returns are hypothesized to increase over time). Under the plan, the core of the population would still be expected to return primarily during August when in-river Chinook harvest would be maximized.

#### 3.2.2.4 Natural escapement target

The Chinook spawning escapement to the natural spawning grounds in the lower river valleys of the watershed is expected to remain at approximately 1,200 fish or higher during the 20-year planning horizon covered in this plan—excluding any spring Chinook that might spawn in these areas. As natural spawning escapements of the late-timed segment of the summer/early fall population increases through outplanting (see Chapter 5), the total number of natural spawners should be increased over 1,200. The median spawning date of naturally spawning fish should gradually be shifted later into October.

### 3.2.3 Recovery outlook and decision to proceed

This part of the plan that addresses potential recovery of fall-run Chinook encompasses a 20-year planning horizon. At the end of that period, we expect that sufficient information should be available to evaluate progress in being able to shift timing of key life stages and whether there is a positive signal that reproductive success of later-timed spawners is likely to respond as needed. A decision at that time to continue to develop the late-timed program will depend on the level of success achieved by the end of the 20-year period.

# Chapter 4. Habitat Recovery Strategies

Over the past 150 years, the Skokomish watershed has undergone extraordinary alterations, transforming riverine and estuarine habitats from their prior productive states. These changes were a major cause of the decline and extirpation of the indigenous Chinook life history types. This chapter describes the principal habitat-related threats that need to be addressed to achieve recovery and identifies habitat strategies for doing so.

In 2014, the Skokomish Watershed Action Team (SWAT) completed an impressive 14 minute video on the story of restoration in the Skokomish watershed. The video, made in conjunction with the Skokomish Tribe, U.S. Forest Service, and Mason Conservation District, provides stunning evidence for the extent of habitat changes that have occurred in the watershed and how restoration actions are now benefitting those habitats. https://www.youtube.com/watch?v=KeOcE9ENHm0

This chapter is organized into the following sections:

- 4.1 Historic Background Summary;
- 4.2 Progress since 2010 and Current Status;
- 4.3 Strategies, Actions, and Projects; and
- 4.4 Habitat Goals.

## 4.1 Historic Background Summary

The 2010 version of the Recovery Plan provided an extensive review of the history of the Skokomish watershed and the various events that occurred that transformed it to its current state. These events, which continued over decades, were described as the principal habitat threats related to the status of Chinook salmon in the basin (Table 4.1). A brief summary of this history is given here.

The emigration of Euro-American settlers to the Skokomish River in the mid to late 1800s brought the onset of major alterations to the watershed. Over the next century, as land clearing for agriculture and residences moved up the river valleys, combined with largescale logging and deforestation, the character of the rivers underwent great changes. Extensive clearing of numerous, large logjams occurred in the rivers and flooding occurred more frequently (Richert 1965). The Skokomish River, at least in the lower valleys, was known to have had huge amounts of in-channel wood prior to its removal. The river's delta was diked and cleared for farming. Diking along the river in the lower valley became widespread, cutting off side channels and reducing access of high waters to the floodplain. All of these events had significant adverse effects on salmon habitat within the watershed (SIT and WDFW 2010; Peters et al. 2011; Celedonia 2014).

In the late 1920s, two high dams, the Cushman Dams, were built in the middle reaches of the North Fork (SIT and WDFW 2010). The dams, including their large reservoirs, would have had major, direct consequences both to the salmon populations and to their habitats regardless of how they were operated. But their adverse effects were particularly severe for two reasons: (1) no fish passage was provided at the dams, blocking all access of salmon and steelhead to the upper North Fork, and (2) all flow to the lower North Fork was diverted out of the watershed directly to Hood Canal, except for occasional spills for the sake of dam safety. This alteration of the flow regime in the North Fork as a result of dam operations had a wide range of cascading effects in the North Fork and to the river channels downstream, both in the mainstem river below the forks as well as in the lower South Fork. The altered flow regime affected sediment transport rates in these areas as well as the entire character of the river channels with regard to fish habitat quantity and quality (Jay and Simenstad 1996; Stover and Montgomery 2001).

**Table 4-1. The principal habitat threats to the recovery of Skokomish Chinook.**

| Principal Threats | Description |
|---|---|
| Altered flow regimes (hydro and climate related) | The magnitude, timing, and variability of flow in the North Fork were dramatically altered by hydro operations beginning in the 1920s, continuing to the present. Long-term climate change patterns also has likely reduced snow melt runoff in the South Fork, potentially posing passage problems for adult spring Chinook within the gorge reach. |
| Loss of fish access to upper North Fork and inundation | Construction of two Cushman dams in the 1920s blocked fish passage to 26 miles of anadromous fish habitat. The most productive habitat for spring Chinook was inundated by the Cushman Reservoir, which will remain for at least the next 40 years. |
| Degraded upper watershed conditions in South Fork and Vance Creek | The upper South Fork watershed has not recovered from intensive harvesting of the old growth forest, associated road building, wood removal from the channel, and other alterations made in preparing for construction of a proposed third Cushman dam. |
| Degraded lower floodplain and channel conditions | A series of alterations occurred in the lower valleys (includes lower South Fork, lower North Fork, and lower Vance Creek) over the past 150 years, leading to massive changes in channel structure and stability. This, in combination with the other principal threats, has resulted in severe channel aggradation and frequent flooding. This issue is perhaps the most complex threat to be addressed for watershed restoration. |
| Degraded estuarine conditions | The Skokomish estuary was extensively diked, filled, and disconnected from its wetlands over the past 70 years for the purpose of agriculture, recreation, and development. |

Logging of the lower valleys in the watershed began soon after settlement by Euro-Americans, but accelerated rapidly in the mid-20th century into the uplands and upper parts of the subbasins outside Olympic National Park. It progressed particularly rapidly in Vance Creek and the South Fork as a result of the establishment in 1946 of the Shelton Cooperative Sustained Yield Unit created through partnership of the USFS and the Simpson Timber Company. The resulting rate of forest cut was sustainable only in name. By the early 1990's, 80 percent of the South Fork drainage area had been clear-cut (USFS 1995; SIT and WDFW 2010). The density of the extensive road network was approximately 4 miles of road for every square mile of the subbasin (SWAT 2016). Landslides were numerous, delivering enormous quantities of sediment to the channel of the upper South Fork and its tributaries (STC and WDNR 1997). The 2010 Recovery Plan describes how these forest harvest-related events re-initiated secondary paraglacial processes[11] in the river, exposing massive amounts of stored glacial sediments along the river and leading to an unraveling of the active river channel both in the upper and lower South Fork. This promoted both widening of the active channel and shallowing. Moreover, wood jams were destabilized, which likely led to a reduction in wood loading and the loss of vegetated islands and side channels. These conditions, combined with naturally high intensity rainfall in the drainage (SIT and WDFW 2010), contributed in significant ways to increased runoff patterns and greater flooding in the lower valley.

[11] / See Ballantyne (2002a) and (2000b).

A major visible effect of these enormous changes to the natural watershed and riverine processes was the significant aggradation of the river channels in the lower valleys and related increased flooding. The river gained notoriety as being the most flood-prone river in Washington (Dave Montgomery cited in Stricherz 2002). Peters et al. (2011) listed six primary factors that produced the high rate of channel aggradation: mass wasting events, flow reduction, channel destabilization due to large wood removal and riparian clearing, channel confinement through levee construction, channelization through straightening, bank armoring and dredging, and constriction by bridge embankments. They stated that the combination of these six factors greatly increased sediment supply to the channel, reduced sediment transport capabilities, and reduced stable floodplain storage for sediment.

Some of the major consequences of these events to the Skokomish salmon populations have been identified to be (SIT and WDFW 2010; Peters et al. 2011):

- The elimination of anadromous fish runs to the upper North Fork as soon as the dams were completed;
- Greatly reduced flow in the North Fork downstream of the dams, resulting in diminished salmon production;
- Completely dry river channel in large sections of the lower South Fork and mainstem Skokomish River just downstream of the forks frequently in late summer, affecting fish passage through the area and causing stranding and increased mortality rates;
- Forcing adult chinook spawners within the reaches of greatly diminished surface flows in September and early October to spawn in sub-optimal locations (i.e., in or close to the channel thalweg), resulting in the incubating eggs being more vulnerable to channel scour during fall and winter freshets;
- Widening and shallowing of the mainstem river channel and South Fork, resulting in poor quality habitat for both juveniles and adult salmon (fewer and shallower pools, lack of refuge habitat from predators and elevated water temperatures);
- Flashier flows during winter and spring, which are less suited to emergent fry;
- More frequent and greater flooding, resulting in stranding of fish in locations that become disconnected from the main river once flows recede.

Four pivotal events have taken place in the Skokomish watershed since 1994 to begin a new history of alterations to aquatic habitats in the basin—these events have aimed to reset the watershed on a course toward improved conditions for salmon. These events were:

1. The Northwest Forest Plan implemented on USFS lands in 1994;
2. The Simpson Timber Company (now Green Diamond) Habitat Conservation Plan (HCP) implemented in 2000;
3. The 2009 Cushman Settlement Agreement between the Skokomish Indian Tribe and the City of Tacoma; and
4. The Skokomish River Restoration Project (SRRP), the result of the U.S. Army Corps of Engineers' Skokomish Watershed General Investigation (GI) completed in 2015 and authorized for congressional funding in 2017.

Each of these pivotal events is described briefly below.

The Northwest Forest Plan (NWFP) of 1994 is a Pacific Northwest regional strategy being applied to aquatic ecosystems across the region on federal lands. It is intended to prevent further degradation of aquatic ecosystems and to restore and maintain habitat and ecological processes important to those ecosystems. The NWFP is being applied to public lands administered by the U.S. Department of Agriculture Forest Service (USFS) and the Bureau of Land Management (USFS and BLM 1994). As such, it is being applied to USFS lands in the upper South Fork that were previously being very intensively logged. The South Fork Skokomish River was designated as a "key watershed" under the NWFP. This designation raised the profile of the watershed and it became a focus of restoration efforts to improve aquatic habitats. Between the early 1990s and 2005, the Olympic National Forest and various partners accomplished $10.6 million of restoration work in the subbasin, including $7.9 million for road decommissioning, road stabilization and drainage upgrades (ONF news release June 9, 2016). The rate of forest harvest on USFS lands in the South Fork dropped sharply (nearly eliminated) following implementation of the NWFP.

Within the same decade as the NWFP, the Simpson Timber Company (now Green Diamond) Habitat Conservation Plan (HCP) was developed and adopted on Green Diamond forest lands within the Skokomish watershed. It was implemented in 2000. Extensive land holdings exist by this company in the South Fork drainage outside of USFS lands, in Vance Creek, and in lower North Fork. While the HCP provides for continued resource harvest and management integral to the company's business, a goal of the plan is to conserve and develop intact, ecologically connected and naturally functioning aquatic ecosystems (STC 2000). Measures within the plan are outlined to progress toward this goal. From the mid-1990s to mid-2000s, Green Diamond spent $950,000 on road upgrades and decommissioning within the Skokomish watershed as part of its strategy to disconnect roads from watercourses and restore fish passage (SWAT 2016).

In 2009, after decades of litigation, the Skokomish Tribe, the City of Tacoma, state and federal agencies signed the Cushman Settlement Agreement for the Cushman Project as a part of the Federal Energy Regulatory Commission (FERC) Cushman Project Relicensing (FERC Project No. 460). The agreement resolved litigation against Tacoma by the Skokomish Tribe and outlined a minimum volume and distribution of flow releases to the North Fork. This began a new chapter in the history of the North Fork and for the Skokomish River ecosystem as a whole. Key components of the settlement include restoring a more normative flow regime in the North Fork, providing for upstream and downstream fish passage facilities at the dams, the construction and operation of two conversation fish hatcheries aimed at restoring spring Chinook and other salmon species to the river upstream of the dams, implementing habitat restoration actions in the North Fork downstream of the dams, and funding a yearly monitoring plan to measure effectiveness of the actions. The provisions of the settlement have been implemented.

In 1999, the U.S. Army Corps of Engineers (USACE) was authorized to begin a reconnaissance of the Skokomish River valley to investigate possible flood hazard reduction and ecosystem restoration in the lower valley. This led to the start of a General Investigation (GI) by the USACE in the late 2000s under the sponsorship of the Skokomish Tribe and Mason County. From the formal start of the project in the late 2000s, it was aimed at addressing ecosystem restoration and not specifically flood hazard reduction, though the study sought to find ways of restoring ecosystem processes without increasing flood hazards to private property, infrastructure, and the Skokomish Indian Reservation.

Other restoration actions were also initiated in the mid-2000s. Notably, the Skokomish Tribe and Mason Conservation District partnered with Tacoma Power to restore the west side of the old Nalley Farm, located on the river delta within the estuarine zone. This project, Phase 1 of a longer-term estuarine restoration plan, removed 5000 feet of dike to reopen 116 acres of intertidal wetlands. More work like this would be done in the coming years.

When the 2010 Recovery Plan was written, the restoration actions called for in the Cushman Settlement were just beginning to be implemented and the USACE GI study was in its early stages. Flooding in the Skokomish valley was frequent and habitat conditions within the river were seen as worsening overall. The next section describes progress in restoration to each of the geographic areas within the watershed since the 2010 Recovery Plan was written.

## 4.2 Progress since 2010 and Current Status

Since the 2010 Recovery Plan was issued, substantial progress has been made toward improving conditions for Chinook recovery, as well as to prepare for implementing new actions. This section describes the current status of recovery measures and the current state of habitat conditions within the watershed as they are understood at the time of this report's preparation.

### 4.2.1 Upper South Fork

Restoration work in the past decade has focused primarily on reducing sediment delivery to stream channels and on the installation of large wood to the South Fork to restore normative watershed processes. Most work to date on National Forest lands has been aimed at reducing sediment inputs.

#### 4.2.1.1 Logging-related sediment sources

The Legacy Roads and Trails Program was established in 2008 by the USFS to address large-scale restoration needs associated with chronically under-funded road and trail maintenance work within the USFS transportation system, including in the South Fork. Since 2008, the Legacy Roads and Trails Program funds have totaled $6.6.million for the Olympic National Forest (SWAT 2016). These funds have been a primary instrument to address critically needed road and trail work within the South Fork. Since 2005, all of the high priority road decommissioning, road closure, and trail conversion work identified has been implemented, including all such road work in major tributaries to upper South Fork, including Brown, Lebar, Church, Pine, and Cedar creek drainages. The success of the work is due in large part to strong support by the SWAT and the Skokomish Tribe and receipt of $6.6 million in Legacy Road and Trail funds targeted for the South Fork Skokomish subwatershed.

Despite progress in reducing sediment inputs, in 2010 the USFS as part of a nationwide Watershed Condition Framework process classified the South Fork Skokomish as an "at-risk" watershed. Many studies had highlighted the damaging impacts of roads and the need to remove and stabilize roads in this subbasin.

Starting in 2011, the USFS implemented the first of three steps of what it called the Watershed Condition Framework; the three steps being watershed condition classification, priority watershed designation, and watershed restoration action plans. As part of this effort, the Olympic National Forest (ONF) identified both the Upper and Lower South Fork Skokomish as priority subwatersheds. The ONF then collaborated with SWAT and the Skokomish Tribe in development of restoration action plans for these subwatersheds, creating the Upper South Fork Skokomish River Watershed Restoration Action Plan (WRAP) and the Lower South Fork Skokomish River Watershed Restoration Action Plan. Collectively, these plans identified an estimated $12.5 million in restoration projects, $8.6 million within the Lower WRAP and $3.9 million in the Upper WRAP, much of which has now been completed. These plans also listed additional restoration opportunities.

Then, in FY 2016, the ONF completed the last of the large-scale road removal and stabilization projects in the upper South Fork watershed. In all, the agency removed 91 miles of road, closed or converted that land to trails, and stabilized or improved 85 miles of road with new culverts and drainage features (USFS 2017) (Figure 4.1). Much of the recent road restoration work was funded through the Legacy Roads and Trails Program, with partner funding from the Washington Salmon Recovery Funding Board, the U.S. EPA, and stewardship receipts from commercial thinning timber sales.

As a result, in accordance with the Watershed Condition Framework guidelines, the upper South Fork was reclassified as a “properly functioning watershed” with respect to sediment inputs from past logging related activities (ONF news release June 9, 2016). Watershed conditions are still recovering, but certain key watershed processes have been significantly improved.

**Figure 4-1. An example of culvert and road fill removal on a tributary drainage to the upper South Fork (USFS 2017).**

### 4.2.1.2 In-channel wood restoration

Work in the upper South Fork has also been aimed at restoring more normative amounts of large wood to the river channel to improve habitat conditions in addition to storing and stabilizing in-channel and along-channel sediments. Three phases of logjam installation have been carried out since 2010, the first two in 2010 and a third one in 2016 (Bair et al. 2009; USFS 2010; Habitat Work Schedule). All three phases have focused on a three-mile river section called Holman Flats, which was intensively logged and cleared of logjams for a proposed new reservoir in the 1950s. The dam was never built. As a result of the channel clearing and near-stream forest cutting, the stream underwent significant changes. The channel within the entire section widened and shallowed and sediments accumulated there over time. These sediments have likely contributed to the greater sediment loading to the lower valley due to the increased sediment delivery rates in the upper South Fork.

Prior to Phase 1 of the project, the ONF and USDA TEAMS Enterprise Unit assessed stream channel conditions in the project area. They found the following (Bair et al. 2009):

- Riparian vegetation coverage within the flood-prone area has been reduced from the alterations made in the 1950s from greater than 50 percent (78 acres) to less than 36 percent (54 acres), reducing bank and stream channel stability, stream shade, future LWD recruitment, and fish habitat.
- The erosion of near-channel terraces and streambanks has caused the expansion of the bankfull stream channel, resulting in severe impacts to water quality, fish habitat, and recovery of riparian vegetation.
- Since 1929 (first aerial photos available):
    - pool to pool spacing has increased 30 percent (from 901 to 1,164 feet)
    - average bankfull width has increased 68 percent (from 186 to 313 feet)
- Compared to a reference reach's conditions:
    - average stream width-to-depth ratios have increased 174 percent (from 35:1 to 96:1)
    - LWD within the floodplain and bankfull channel has decreased 67 percent (from 758 to 247 pieces per mile, or 47 to 15 pieces per 100 meter).

In 2010, the USFS completed Phases 1 and 2 on a one mile reach of the river (RM 12-13); nearly 30 logjam structures were built (Figure 4.2-4.4). All jams were installed on USFS land. In 2011, following the first winter after installation of the large wood structures at Holman Flats, USFS TEAMS Enterprise specialists conducted initial monitoring within the one-mile reach. Results showed stored sediment within the reach increased significantly after treatment (river bars increased in elevation 2.4 ft on average), the channel thalweg downcut (decreased in elevation by 2 ft), bankfull and low flow channel width to depth ratios decreased 49% and 36%, respectively, and the total number of pools greater than 5 ft residual pool depth doubled from three to six (SWAT 2016). It is particularly notable that the width to depth ratio decreased, moving it toward the desired future condition target for the reach (<50).

Subsequently the treatment reach was extended downstream by one mile and another 22 jams were built in 2016 as part of a Phase 3, bringing the total to about 50 logjams over two miles of river. Phase 3 focused on non-federal property adjacent to USFS land.

Combined, these three phases on the Holman Flats represent a significant amount of work near the lower end of the upper South Fork geographic area.

Another phase of work for restoring logjams in the upper South Fork is in the assessment stage. In 2016, the USFS TEAMS Enterprise specialists assessed the 12 miles of upper South Fork upstream of Holman Flats (RM 14 to 26). The analysis is in progress at the time of this report's preparation. The assessment aims to develop a prioritized list of large wood treatments for the entirety of the 12 miles of river.

Projects to be identified would direct appropriate large wood placement in response to the loss in structural and habitat diversity that has occurred, facilitating sediment storage, sediment processing, normative channel patterns, and reformation of stable vegetated islands. Preliminary findings of the assessment show degraded conditions throughout the 12 miles as described in the 2010 Recovery Plan for this area (Evan Bauder, MCD, *personal communications*).

**Figure 4-2. Top - Phase 1 logjam placed in the Holman Flats reach in 2010. Bottom - In November 2010, the project site experienced a major flow event. All structures that had been installed remained intact and gained wood from upstream sources.**


**Figure 4-3. Construction of logjams in Phase 1 in the Holman Flats reach.**

**Figure 4-4. Example of changes to a gravel bar where a logjam had been built in Phase 1. On average gravel bar heights increased 2.4 feet through the project reach. Maximum accumulation height on structure #5 (shown) was 6.6 feet. From Geiger (2015).**

#### 4.2.1.3 Fish passage in the South Fork canyon

The 2010 Recovery Plan identified a series of cascades within the South Fork gorge as a potential partial barrier to upstream migrating spring Chinook. Besides steelhead and bull trout, only spring Chinook were known to have ascended the rapids during the 1950s (WDF 1957a). The early-entry timed spring Chinook migrated upstream primarily when flows were elevated during spring runoff. Some migrants, however, also held in the gorge during summer and apparently ascended the upper part of the gorge just prior to spawning, according to observations made by biologists (WDF 1957a). The movement just prior to spawning probably occurred in August. Conclusions reached by WDF biologists and engineers were that certain cascades were particularly difficult to traverse at lower flows, resulting in injuries, and even mortality, to some fish. The WDF engineers concluded that some type of corrective action may have been needed to facilitate safe passage of upstream migrants over the cascades.[12]

It should be noted that the 2010 Recovery Plan provided evidence that the spring runoff in the South Fork appears to have diminished over time and suggested that this was likely due to long-term climate change patterns. More recent analysis by the U.S. Bureau of Reclamation (USBOR) found that there has occurred an increasing trend for greater flow in March, indicating snowpack loss and a greater transition to a more rain dominated hydrologic regime (McGuire 2017). This suggests that passage by reintroduced spring Chinook, when it occurs, through the canyon would be at best comparable to what WDF observed in the 1950s, or worse. The 2010 Plan concluded that some form of corrective action to certain cascades may be needed at some future time. The Plan recommended that an assessment be made to help determine whether passage through the canyon is likely to be difficult for reintroduced fish.

In 2015, Mason Conservation District (MCD), in cooperation with the Skokomish Tribe, secured funding from the Salmon Recovery Funding Board (SRFB) and initiated an assessment of the gorge cascades for

[12] / The WDF assessment was made as part of that agency's evaluation of a new dam proposed to be built in the South Fork upstream of the gorge. If that dam had been built, it was expected that flows during spring and summer would have been reduced from what was occurring naturally at that time. The engineers' conclusions were that the issue of difficult passage as they believed it was then occurring would have been made worse with dam operations.

adult salmon passage. The services of Waterfall Engineering, LLC (Pat Powers, principal) were retained to complete the assessment. Staff of MCD participated in the investigation. The assessment was finished in 2017. A final technical report will be available in early 2018; a summary of the methods and key findings is provided below.

The field assessment was made from August 2015 to April 2017. The investigation covered the entirety of the canyon reach, extending from RM 5 to 9 on the South Fork. The project team initiated the assessment by traveling through the entire four mile reach during summer low flow to identify potential fish passage concerns using the geographic coordinates identified by WDF in 1957 as a guideline. The team identified five sites of potential concern (Figure 4.5).

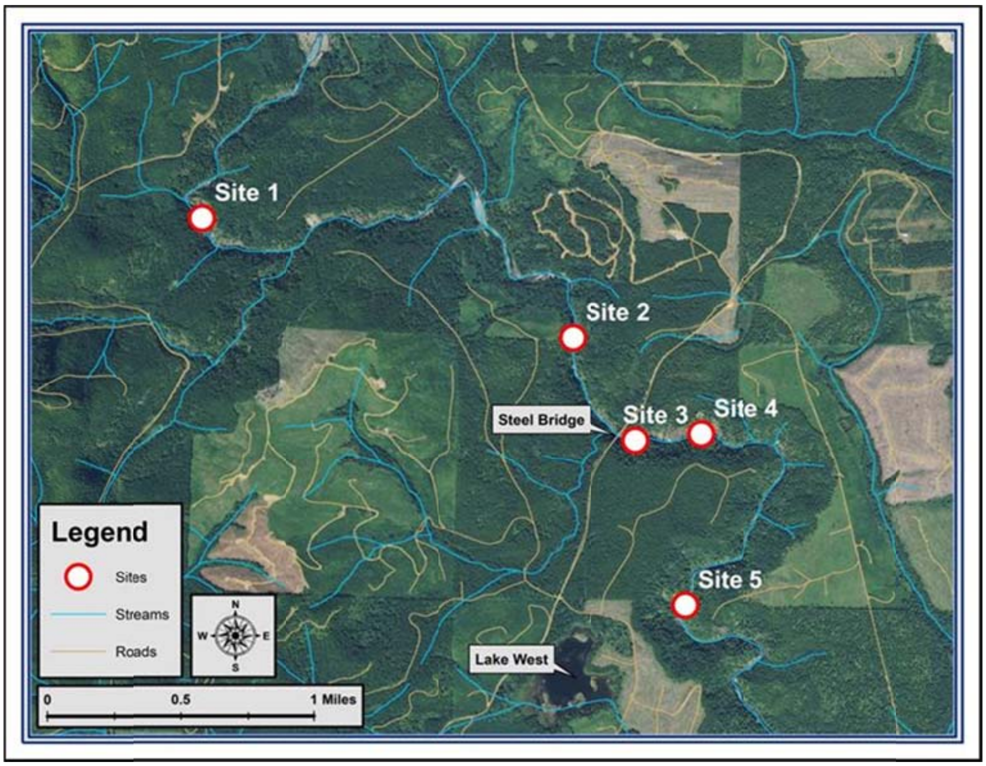



**Figure 4-5. Locations of five sites identified for evaluation of potential adult salmon passage within the South Fork gorge. The lower end of the gorge is located approximately one mile downstream of Site 5. The upper end of the gorge is approximately ½ mile upstream of Site 1.**

Based on the initial review, the team concluded that sites 1 and 5 were unlikely to present passage problems across a range of flow levels, though both sites aligned well with geographic coordinates given by WDF for two of the sites assessed by its engineers. The other three sites (2, 3 and 4) were found to pose potentially difficult passage conditions for upstream migrating adult salmon; these sites were identified as needing further investigation and additional data collection (Figure 4.6). The dominant geologic feature that formed each site is large boulders/rock slabs that have fallen from the canyon slopes and blocked the channel (Figure 4.7).

The canyon is only assessable to surveyors by walking, climbing, and swimming during summer low flows. Conditions during higher flows are hazardous for conducting on-site work. Therefore, the assessment over a range of flows was done using aerial drone videos taken at various flows to assess turbulence and alternative fish migration pathways together with HEC-RAS 2D modeling. Additional observations were also planned by employing time-lapse photography using cameras anchored to the canyon walls, though success with this method was only achieved at one site due to equipment loss at the other sites during extreme high flows.

**Figure 4-6. Characteristics of Site 3 located just downstream of the Steel Bridge (approximately RM 6.5). This site together with sites 2 and 4 were determined to require extensive data collection over a range of flows. Pat Powers of Waterfall Engineering, LLC is standing in the center of the photo.**

**Figure 4-7. Site 5 showing the size of boulders typical of all sites that can partially impede fish passage and redirect flows along different migration pathways.**

The evaluation of passage conditions at each of the three sites of concern (2, 3, and 4) was done using HEC-RAS 2D modeling supplemented with aerial videos by assessing hydraulic drop, hydraulic slopes, water velocity, and turbulence. Turbulence was calculated using the Energy Dissipation Factor (EDF), which is commonly employed in the design of fishways for fish passage (USFWS 2017) and culverts at road crossings (Bates et al. 2003). EDF provides an indirect metric of turbulence. All of these factors can affect adult salmon passage through steep stream channel reaches.

The measured hydraulic drop at sites 2, 3, and 4 was determined to range from 7 to 12 feet. Three flows (80, 400 and 1360 cfs) were evaluated for fish passage difficulty based on historical flow patterns for months when spring Chinook adults would be passing through the canyon. Hydraulic slopes for the three sites ranged from 15% to 30% at low flow and from 10% to 15% at high flow. Velocities ranged from 4 to 9 feet per second (fps) within the 2 foot square modeled cells. The calculated velocities are “bulk” values which include a component of entrained air. Point velocity values are likely higher. The model was calibrated based on measured stage to discharge information.

Turbulence (or EDF) was calculated based on slope and velocity. EDF quantifies the capacity of a water body to dissipate the energy (potential or kinetic) of flowing water as it moves through a channel. A high EDF implies high turbulence, which can potentially be a barrier to fish passage (Pavlov et al. 2000). For effective fish passage through fishways and culverts for adult salmonids, it has been recommended that EDF not exceed 5 ft-lb/ft3/s (Bates et al. 2003; USFWS 2017). Love (2013) noted, however, that EDF can exceed 20 ft-lb/s/ft3 during normal-operations of Alaskan Steeppass or Denil-type fishways while still achieving fish passage. That author noted with respect to application to passage through culverts that the effect of baffles in culverts, which can create excessive turbulence, is unclear.

For sites 2, 3, and 4, average EDF values were calculated to be 15, 21 and 28 ft-lb/s/ft3 respectively. High values for EDF exceeded 100. These values suggest that turbulence at the three sites may impede passage under some conditions.

The site evaluation also considered passage effectiveness based on knowledge of fish energetics and leaping ability for salmon. The evaluation was made assuming a 26 inch long spring Chinook was attempting to pass each of the sites under the three different flow levels listed above. The assessment considered swimming ability and calculated fish energetics, as well as a leaping analysis where the slope exceeded 25%. Passage was then rated as barrier, poor, fair, or good. A good passage rating would be equivalent to a 90% passability with a low potential for fish injury at that given flow. A fair passage rating would be equivalent to a 50% passability and a moderate potential for fish injury from attempting to pass. A poor passage rating would be equivalent to a 10% passability with a high potential for fish injury. A barrier passage rating would mean that the fish cannot pass and is injured during multiple attempts. This rating system was applied to each site at each of the three flows assessed; results are summarized in Table 4.2.

**Table 4-2. Results of rating passability effectiveness at five cataracts in the South Fork canyon for spring Chinook. See text for definitions of ratings.**

| Flow through canyon (cfs) | Percent of time exceeded | South Fork canyon RM 5 to 9 | | | | |
|---|---|---|---|---|---|---|
| | | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
| | | RM 8.9 | RM 7.3 | RM 6.6 | RM 6.4 | RM 5.3 |
| 80 | 95% | Good | Poor | Poor | Poor | Good |
| 400 | 50% | Good | Poor | Good | Barrier | Good |
| 1,360 | 5% | Good | Fair | Good | Fair | Good |

Site 4 was determined to pose the most difficulty for spring Chinook passage. A flow rate of 400 cfs was estimated to be a barrier to effective passage. Sites 2 and 4 were judged to likely present some level of passage difficulty at each of the three flow levels evaluated. Table 4.3 summarizes average daily flows for April through August for the past 10 years having complete data, which provides the reader a basis for judging the frequency of potential passage problems at each of the sites based on Table 4.2.

**Table 4-3. Average daily flow (cfs) for months relevant to upstream migration of spring Chinook for 2007 to 2016 within the South Fork canyon. Gauge site is USGS 12060500 South Fork Skokomish River.**

| Year | Apr | May | Jun | Jul | Aug |
|---|---|---|---|---|---|
| 2007 | 592 | 431 | 251 | 348 | 148 |
| 2008 | 393 | 623 | 433 | 225 | 176 |
| 2009 | 542 | 618 | 212 | 110 | 73 |
| 2010 | 905 | 624 | 527 | 197 | 110 |
| 2011 | 984 | 699 | 607 | 377 | 169 |
| 2012 | 991 | 617 | 426 | 235 | 117 |
| 2013 | 843 | 521 | 373 | 197 | 123 |
| 2014 | 692 | 611 | 192 | 114 | 82 |
| 2015 | 260 | 150 | 106 | 82 | 81 |
| 2016 | 491 | 218 | 149 | 107 | 78 |
| Mean | 669 | 511 | 328 | 199 | 116 |

These results provide up-to-date evidence that difficulties likely exist within the canyon for spring Chinook passage under some flow conditions. It bears noting that assessing passage effectiveness through an area like the South Fork is not a simple matter given the dynamic nature of flows there and the complexity of fish behavior and movement patterns in response to the various factors of concern (Kerr 2015). We conclude that uncertainty remains about how well spring Chinook will be able to pass through the canyon reach. The real test of passage effectiveness will occur when spring Chinook adults return to the South Fork following reintroduction into the area. We note that the project team found based on their observations that corrective measures appear to be feasible at the sites where passage difficulties are evident (Evan Bauder, MCD, personal communications).

#### 4.2.1.4 Current status of habitat in the upper South Fork

Salmon habitat conditions within the upper South Fork are generally believed to be improving due to the significant curtailment of active logging and the many corrective measures aimed at restoring normative sediment delivery rates to streams. Actions to restore wood loads to the Holman Flats section have also been significant in restoring more normative channel characteristics to the lower part of the upper South Fork. Despite these efforts, much of the active river channel in the upper South Fork remains braided with large amounts of exposed coarse sediment due to channel widening and unraveling over the past 60+ years. Projected effects of climate change over the next 60-80 years are expected to worsen these conditions without additional restorative measures taken (see Section 4.2.2.2).

Water temperatures in 2010 and 2011 at several sites in the upper parts of the upper South Fork remained cool throughout the summer (Figure 4.8). Observed temperatures upstream of about RM 19 are particularly suited for spring Chinook. WDF (1957a) found that spring Chinook spawning occurred primarily from Brown Creek (approximately RM 13) to near Rule Creek (approximately RM 24).

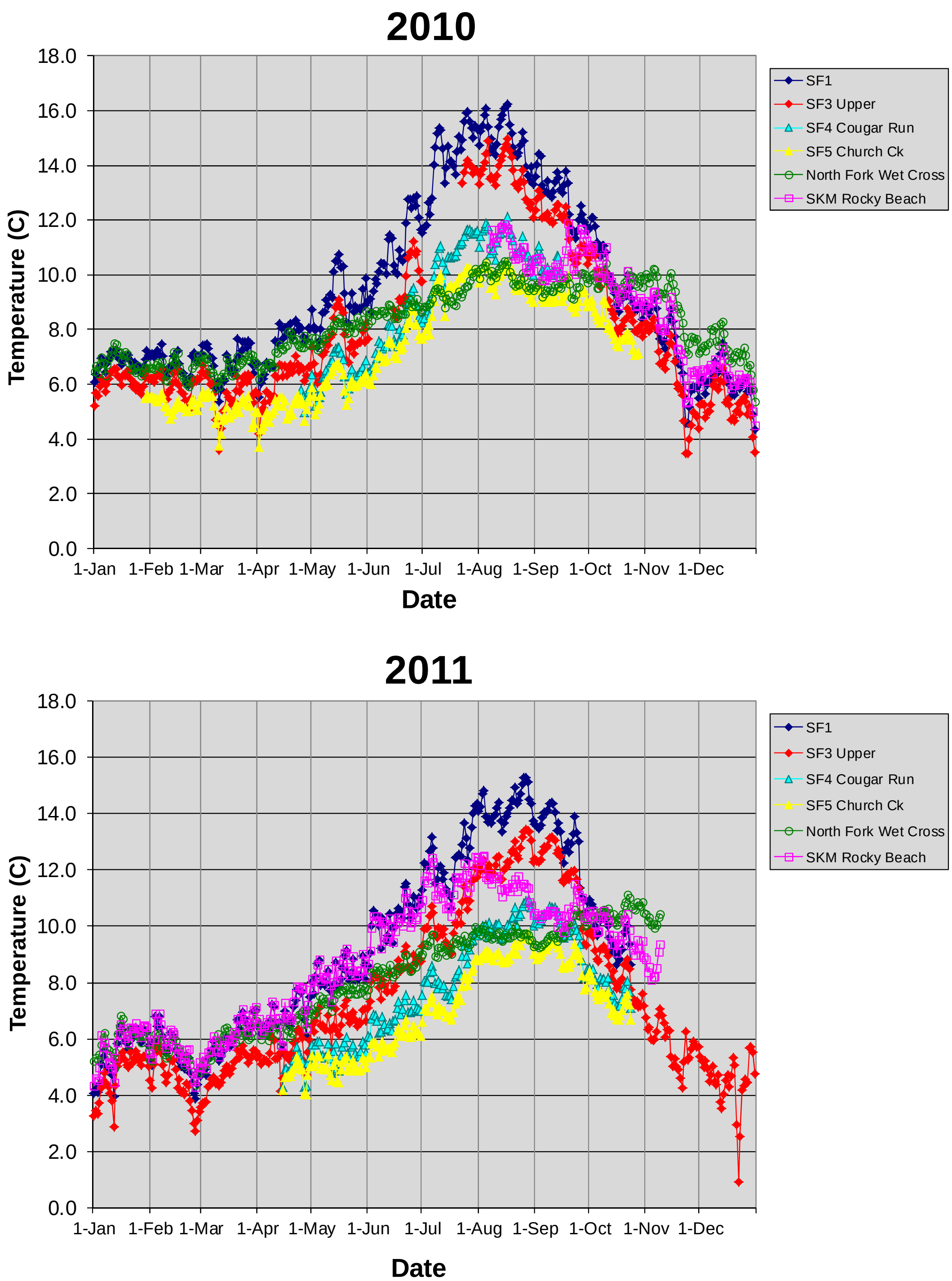



**Figure 4-8. Daily average water temperatures at six sites in the Skokomish watershed: lower South Fork near RM 0.5 (SF1), upper South Fork near LeBar Cr at RM 13.5 (SF3 Upper), upper South Fork below Pine Cr near RM 19.0 (SF 4 Cougar Run), upper South Fork above Church Cr near RM 21.0 (SF5 Church Ck), lower North Fork at the Wet Crossing near RM 12.7 (downstream of McTaggert Cr), and the mainstem Skokomish River near RM 7.0 (SKM Rocky Beach). Source: Skokomish Tribe, unpublished.**

## 4.2.2 North Fork

Significant progress has been made in restoration work in the North Fork since 2010 as a result of implementing the 2009 Cushman Agreement. Four aspects of the work are particularly relevant to this plan: a new flow regime, construction of fish passage facilities at the dams, improvements in passage at Little Falls, and monitoring of habitat conditions within lower North Fork. The monitoring work that has been done enables us to draw conclusions about the current state of the habitat in lower North Fork.

### 4.2.2.1 New flow regime

The Cushman Settlement called for implementing a new flow regime for the North Fork. Between creation of the dams and 1988, very small base flows were released from the project. Starting in 1989, the base flow released to the North Fork was increased to maintain a minimum in-stream flow of 60 cfs. Larger flow releases were made in rare instances for the purpose of dam safety flow discharges. The new regime associated with the Cushman Settlement was implemented in 2008, prior to the formal agreement. The new flow regime, as stipulated in the agreement, called for three components, each with a different purpose.

**Component 1:** This component provides for a year-round base flow, shaped by month to be generally consistent with seasonal flow patterns that had been historically present. The total amount of water to be released for base flow is based on a total amount of acre-feet of water set aside for this purpose. The Fisheries and Habitat Committee (FHC), a technical committee operating under terms of the settlement, has some leeway each year to shape the monthly releases, provided the total amount of water released as base flow does not exceed the set-aside amount for this purpose. The default release schedule by month is as follows:

| Month | Flow cfs |
|---|---|
| Jan | 230 |
| Feb | 215 |
| Mar | 215 |
| Apr | 220 |
| May | 240 |
| Jun | 230 |
| Jul | 220 |
| Aug | 200 |
| Sep | 200 |
| Oct | 210 |
| Nov | 225 |
| Dec | 235 |

**Component 2:** This component provides additional flow for the purpose of acting as channel formation (or maintenance) flows for the North Fork channel. These added flows are to occur when flows at the Staircase USGS gauge (upstream of Cushman Reservoir) exceed certain triggering levels. The triggers were derived to achieve a more normal pattern of flow variation during storm events within the North Fork downstream of the dams. The resulting increased flows, when augmented by flows from McTaggert Creek (downstream of the lower Cushman Dam), provide for wetted channel expansion (and into side channels and off-channels) and habitat forming events in the North Fork. Moreover, flows released as part of Component 3 would then further add significant peak flows to the channel—thereby providing for habitat formation as well. The Component 2 flows are to be (a) 500 cfs whenever the daily average

flow at the Staircase gauge exceeds 3,000 cfs; (b) 750 cfs whenever the daily average at Staircase exceeds 4,000 cfs; and (c) 1,000 cfs whenever the daily average at the Staircase exceeds 5,000 cfs. (It is noted that the Component 2 flows may be delayed up to 7 days if necessary to avoid flood impacts to the lower Skokomish valley.)

**Component 3:** This component was intended to provide still greater flow increases from the Cushman Dams to improve sediment transport in the mainstem Skokomish River downstream of the North Fork. The component calls for increasing flow releases to a maximum of 2,200 cfs for two consecutive days when a flood event on the mainstem Skokomish River at the Potlatch gauge exceeds 9,800 cfs. The component was designed so that the releases would be timed with flows in the South Fork to promote channel maintenance in the lower Skokomish River. A critical part of this component, however, is that the flows need to be timed to not exacerbate flooding in the Skokomish valley. Instead, releases would be timed to hold the flow in the mainstem Skokomish River at levels to prolong the duration of bankfull flows to facilitate sediment transport.

Component 3 flows have not been implemented to date. This component has been suspended indefinitely for two reasons: (1) high flows are no longer being recorded at the Potlatch gauge on the lower Skokomish River due to how river flows now split in the lower valley, with a major portion at high flow now going through the Purdy Creek channel (USACE 2011), and (2) most importantly, flows over about 4,000 cfs in the very lower part of the river start flooding landowners. The parties to the settlement determined that at this time there is no practical way of implementing Component 3 flows.

In lieu of not being able to release Component 3 flows, revenue generated from water that would have been released into the North Fork under Component 3 is to be added into the Habitat Restoration Account (HRA), which was required under the terms of the agreement. The purpose of the account is to fund habitat restoration projects in the lower North Fork. The HRA is described near the end of this section.

The new flow regime has been fully implemented without Component 3 flows.

#### 4.2.2.2 Fish passage

Under the terms of the 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 upstream passage facility, finished in 2013, is located at the base of the lower dam (Figure 4.9). Upstream returning adult salmonids are guided into a trap, from where a tram transports them to the top of the dam, where they are processed and loaded into a tank truck for delivery to the upper reservoir, the river upstream of the reservoir, or to the conservation hatchery just upstream of the lower dam. The tram also serves to lower juveniles caught in the downstream fish collector at the lower end of the upper reservoir into the lower North Fork where they are released. It bears mention that Tacoma Power was recognized nationally for innovative design and operational excellence employed at this facility through the Outstanding Stewards of America’s Waters Award given by the National Hydropower Association.

The first returns of adult spring Chinook (age-3) are expected to return to the base of the lower dam in summer 2017. These fish will be the first returns to the new conservation hatchery built along Lake Kokanee, just upstream from lower Cushman Dam.

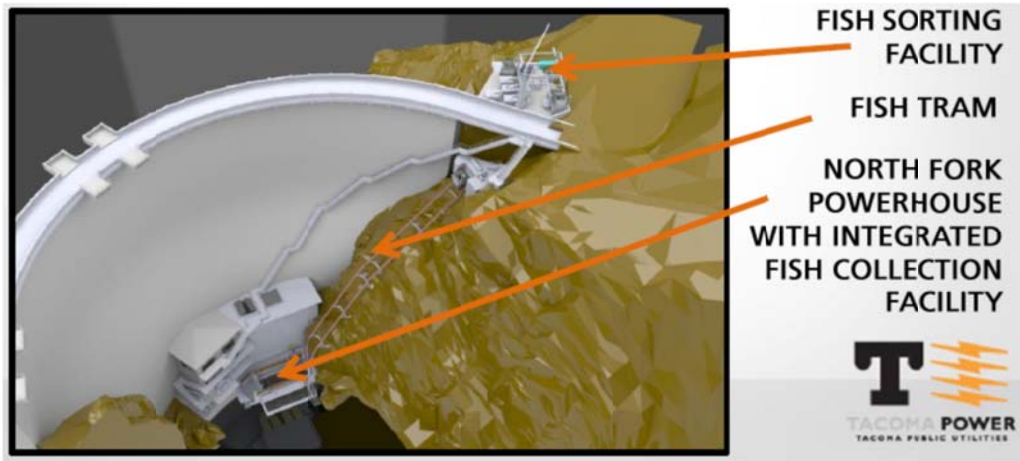




**Figure 4-9. Top – Diagram showing location of the upstream passage facility on the downstream side of lower Cushman Dam and its main components. Bottom – Photo showing the fish collection trap (at bottom) and the tram rail on the right side that lifts a container with trapped adults to the top of the dam.**

The downstream passage facility, built in 2013-2015, is located at upstream face of the upper dam (Figure 4.10). The Floating Fish Collector (FCE), designed with some features similar to those at the Baker Lake downstream passage facility in the Skagit system, but with significant innovations for Cushman, is built to collect juvenile salmon emigrating from Cushman Reservoir. The 50-foot-wide, 100-foot-long barge that supports the collector also supports large pumps that draw attraction flow through the collection device, which screens off fish and diverts them to a trap. The facility incorporates surface-to-reservoir bottom nets that guide juvenile emigrants toward the collector (seen in figure). Trapped fish are sorted and processed, then moved to a transport truck that takes them to the lower dam, from where they are lowered to the river below and released. As happened for the upstream passage facility, Tacoma Power was recognized nationally for innovative design and operational excellence employed at the Floating Fish Collector, being given the Outstanding Stewards of America's Waters Award by the National Hydropower Association.

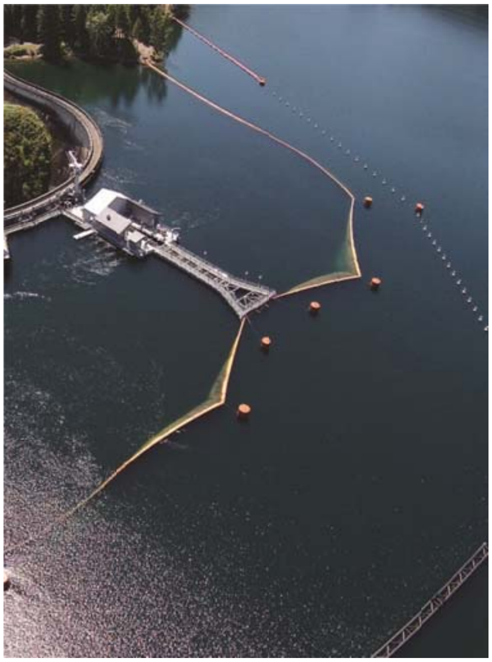
 

**Figure 4-10. Left – Aerial photo showing the Floating Surface Collector (FSC) in place at the lower end of the upper reservoir and attached to the upstream face of the dam. The guide nets, arranged roughly in a "W" shape to help guide downstream emigrants to the upstream opening of the FSC, are also seen. Right – The FSC structure as seen from the rim of the dam.**

While the Floating Fish Collector is now fully operational, it is still undergoing testing, evaluation, and refinements to meet the passage criteria called for in the articles of the dam license (Tacoma Power 2017a). Those passage criteria were set by NMFS.

Approximately 1.8 miles downstream of lower Cushman Dam, another fish passage issue was identified to exist at Little Falls (see Figure 1.2 for location). Prior to dam construction and flow diversion, passage by adult salmon at the falls was facilitated during spring runoff when flow was high. Spring Chinook ascended the falls during that period to move upstream and spawn in the upper North Fork. The diminished flows that now exist were determined to be a deterrent to upstream passage. Tacoma Power completed a modification to the falls in 2014 in a manner that preserved its natural appearance, thereby protecting its cultural significance to the Skokomish Tribe (Figure 4.11). Upstream passage by salmon has been determined to now be effective.

**Figure 4-11. Workers completing modifications to Little Falls to improve passage for upstream migrants.**

#### 4.2.2.3 Current status of habitat in lower North Fork

Tacoma Power is responsible to assess habitat conditions within lower North Fork on a schedule prescribed in the Cushman Settlement (see Chapter 7). Tacoma Power has issued five monitoring reports to date (Tacoma Power 2013, 2014, 2015, 2016, and 2017b); these reports are thorough and well presented. The reports provide a strong basis for tracking changes in the North Fork as a result of the new flow regime, as well as from future habitat restoration projects.

A short summary of the current status of habitat conditions within the lower North Fork is provided here, based on the annual monitoring reports issued by Tacoma Power. Figure 4.12 and Table 4.4 provide information on the locations of the river segments referred to in the summary.

Two major aspects of monitoring that is to occur are:

1. Assessment of changes in channel morphology, substrate composition, and substrate scour and fill resulting from changes in the flow regime, and presumably to habitat restoration projects; and
2. Assessment of changes to in-channel mesohabitat composition (e.g., pool-riffle composition) resulting from changes in the flow regime and restoration projects.

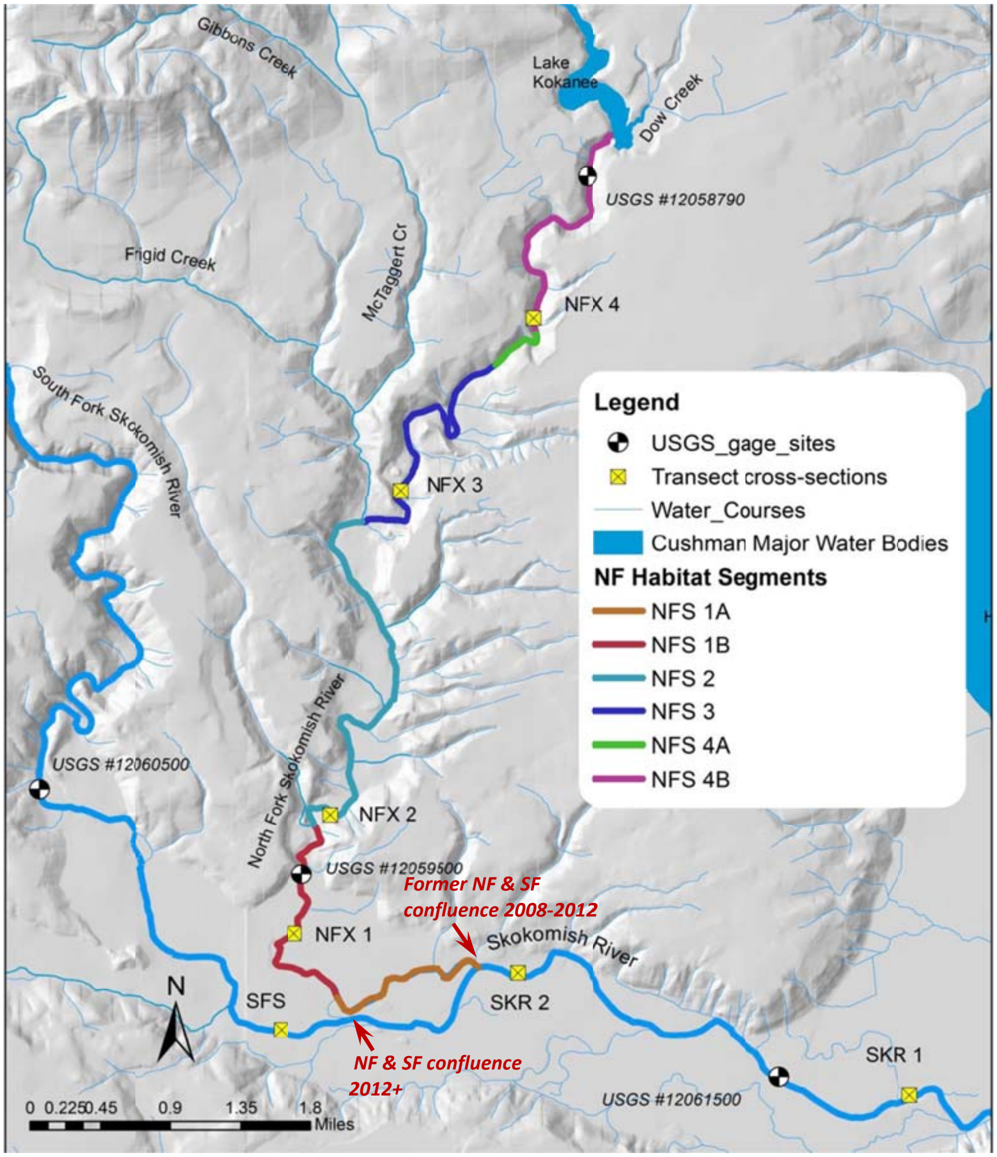



**Figure 4-12. Map of the lower North Fork and reach segments delineated for monitoring. NFS 1C (not shown) is a small sub-reach of NF S1B, located near the top end of NFS 1B. Also, note that 1A is now considered the mainstem Skokomish River since the South Fork avulsed back into it in 2012. The change in locations of the confluence is also shown.**

**Table 4-4. Descriptions of reach segments used in monitoring the lower North Fork. Table is based on Tacoma Power (2013) and Tacoma Power (2017).**

| NF segment | Description | River miles | Length (m) | Gradient % | Confinement |
|---|---|---|---|---|---|
| 1A | Avulsed new channel from NF Skokomish River confluence to historic confluence with South Fork | 8.0-9.0 | 1,984 | 0.15 | Unconfined |
| 1B | Wide alluvial lowland valley from old confluence to confluence with RB trib (16.0100) | 9.0-10.3 | 2,117 | 0.24 | Unconfined |
| 1C | From the property boundary between Skokomish Farms and Green Diamond to confluence with right bank (RB) trib (WRIA 16.0100) | 10.3-10.7 | 443 | 0.4 | Unconfined |
| 2 | Alluviated valley floor from confluence with RB trib upstream to confluence with McTaggert Creek (WRIA 16.0105) | 10.7-13.3 | 4,602 | 0.4 | Unconfined |
| 3 | Alluviated valley floor from confluence with McTaggert Creek to change in confinement and start of V-shape valley | 13.3-15.4 | 3,439 | 0.35 | Medium confined |
| 4 | V-shape valley to Cushman No. 2 Dam | 15.4-17.4 | 3,404 | 1.25 | Confined |

1/ River miles shown are reference locations commonly used in Skokomish River studies and documents.

It is noted that item one (channel morphology and scour) is being addressed both in the lower North Fork (seven locations) and in the mainstem Skokomish River (three locations). Item two (habitat composition) is being assessed just within the lower North Fork; articles of the settlement called for this to be done in the mainstem Skokomish River also. Subsequently the parties to the settlement deferred monitoring of habitat types within the main river to the work that USACE will be doing as part of the major restoration work that agency will oversee once congressional funding is secured for those actions.

Results of the annual assessment of channel bed morphology and scour in the North Fork show that scour that can affect incubating salmon eggs has been rare since 2012. In the five winters beginning with 2011-12, peak flows have exceeded 2,000 cfs in four years and nearly attained 5,000 cfs in one year as measured at the lower North Fork gauge. The highest peak flow occurred in the winter of 2015-16 (4,720 cfs). The flood recurrence interval for that event (representative of the North Fork downstream of McTaggert Creek) was about 10 years. This was the highest flow since 2009 when monitoring started (Tacoma Power 2017b). Upstream from McTaggert Creek the flood recurrence interval for that event was estimated to be 6 years. Estimates of the flood recurrence interval show that this event was a very substantial one for the North Fork channel. Preliminary conclusions for these years as given by Tacoma Power are as follows:

- Substrate scour to a depth that would impact incubating salmon eggs in the lower North Fork is uncommon.
    - During winter 2015-16, salmon redds in the North Fork appear to have experienced more scour than in any monitored year prior to this winter, although mostly at depths above where most buried salmon eggs would be located. Coarse sediment is most easily transported during freshets in the canyon reach and the confined reach upstream of McTaggert Creek, but the large majority of Chinook spawn below there.

- The lower North Fork appears to resist scour to egg pocket depth at actual spawning locations during floods with a flood recurrence interval in the single digits.
  - Relatively high egg-to-emergent fry survival of chum (see below) observed in several years of monitoring supports a conclusion that winter scour is not a limiting factor to salmon production in the lower North Fork.
- While there is evidence for some aggradation occurring downstream of McTaggert Creek, it appears that it is of a magnitude not adversely affecting egg to fry survival to much extent, if at all, based on the aforementioned survival to emergence of chum.

Estimates for egg-to-emergent fry survival of chum in the North Fork for three consecutive years are listed below:

| Brood year | Fry year | Survival | Data source |
|---|---|---|---|
| 2013 | 2014 | 50.2% | Tacoma Power (2015) |
| 2014 | 2015 | 48.0% | Tacoma Power (2016) |
| 2015 | 2016 | 36.0% | Tacoma Power (2017b) |
| Average | | 42.0% | |

The estimated egg-to-emergent fry survivals are on the high side of values reported elsewhere for wild chum spawning and much higher than values reported for some streams (Salo 1991; Quinn 2005). Quinn (2005) gave an overall average value of 12.9% based on averaging results from many studies, though the overall range is from near 0% to over 80% (Salo 1991). Tacoma Power (2015) provides useful insights into these survival rates in the North Fork:

> "High survival rates (e.g., over 50 percent) have been found in hatchery production or controlled stream environments, such as constructed spawning channels (Salo 1991). The high survival rate in the North Fork is likely a result of controlled stream flow. Releases from Cushman Dam No. 2 affect flows in the main channel and a side-channel complex that provides spawning habitat for a large portion of the chum population (Tacoma Power 2014). One quarter of all the chum redds (1,004 of 4,242) were found in this stable habitat feature in 2013, which could have a boosting effect on the entire North Fork egg-to-fry survival rate. However, even if survival in this side channel were to match the highest egg-to-fry survival rate found by Salo (1991) in controlled environments (86 percent), the rate in the rest of the North Fork would still have to be at least 37 percent to result in a basin-wide 50-percent survival rate. Both spawning locations show an exceptionally high survival rate, which is almost three times the rate that Quinn (2005) found and four times the rate Bradford found (1995)."

Tacoma Power monitors a set of habitat metrics in the North Fork downstream of the dams on a yearly schedule as set forth in the dam license articles, which are based partly on whether the flow level during fall and winter released from the dam exceeds 1,000 cfs. An initial assessment was to be done soon after implementation of the license; that assessment was made in 2012 (establishing Year 1). Thereafter, a re-assessment is to be done whenever the fall/winter flow exceeds 1,000 cfs below the dam between Years 2 and 12. After Year 12, a re-assessment is to be done every five years for the life of the dam operating license.

It bears noting that Tacoma Power did some amount of habitat assessment in the lower North Fork in 1989 and 1991 and used those data for some comparisons made in the report issued in 2017. (It is further noted that an assessment of most of the lower North Fork was also done in 2004 by Tacoma Power; those data have not yet been used for comparisons to more recent assessments.)

Metrics being used by Tacoma Power for assessing habitat characteristics in the North Fork downstream of the dams include the following:

- Bankfull width of the channel and bankfull depth
- Composition of mesohabitat units and substrate quantity available for spawning
- Residual pool depth
- Side channels and off-channel features
- Large woody debris (LWD)
- Riparian vegetation density

As noted above, the initial assessment using the standard protocols was done in 2012. Re-assessments due to the flow trigger having been reached were subsequently done in 2015 and 2016. Findings that merit highlighting here are listed below:

- Pool habitat has changed comparatively little from 2012 to 2016. Moreover, relatively small changes in percentage of pool habitat in summer are evident when recent observations are compared to data for 1989 and 1991 (Tacoma Power 2017). The percentage of wetted surface area comprised of pool habitat ranges from about 30% to over 80% depending on the stream segment within the lower North Fork.
- Pools are relatively infrequent but are large and deep in segments NFS 3 and 4 (segments upstream of McTaggert Creek); they are more frequent but smaller and shallower in segments NFS 1C and 2 (downstream of McTaggert Creek).
- Residual pool depth is the only indicator of pool quality used in monitoring because there are no standard protocols established that would address cover, complexity and temperature gradient. Overall, the conclusion is that pool habitat is in fairly good condition in the lower North Fork.
    - In the stream segments downstream of McTaggert Creek, pools have consistently been frequent in overall distribution but remain small and shallow.
    - Upstream of McTaggert Creek, pool habitat is very stable, likely due to the highly regulated flows and the stable geology. The deepest pools in the entire lower North Fork occur within the confined bedrock valley section of stream in segment NFS 4, where in 2016 all 42 pools combined had a mean residual pool depth of 1.54 meters. (It is noted that this section of stream will likely be an important holding area for adult spring Chinook returning to the upper North Fork as re-introduction efforts progress.)
- The role of wood in creating and shaping pools appears to be changing over time, particularly downstream of McTaggert Creek. A paragraph from the 2017 report is useful here (from page 120):

    > "Forces creating pool habitat throughout the lower watershed have remained similar since 2012. Similar to previous years, wood was the dominant factor in the creation of pools below McTaggert Creek in 2016. However, the top forming factor changed from LWD jams in 2012 to roots of standing trees in 2015 and 2016. Prior

to 2008, the mean annual flow in this section of stream was 118 cfs. Streamside vegetation such as red alder (*Alnus rubra*) colonized the margins of the narrowed channel. With the current flow regime, the mean annual flow in this section of river increased to just over 300 cfs, widening the channel margin and submerging many of the alders. Many of these still persist in the stream channel as living trees or snags with roots submerged year-round. Currently, they serve as vertical piles that catch and retain wood and act as anchor points around which single pieces, small conglomerates, and LWD jams of all sizes have been observed. Over time, it is suspected that more will die off and deteriorate, potentially freeing up wood for downstream transport; a process that may have been started before the initial 2012 survey began."

- From 2012 to 2016, the bankfull channel became 9% wider and 7% shallower (some aggradation is occurring downstream of McTaggert Creek). Significant changes in width were observed in Segments 3 and 4 and in depth in Segments 2 and 3.
- True side channel habitat increased 43% from 2012 to 2016. The increase was concentrated in Segment 2.
- Spawning habitat remains plentiful in the lower North Fork. It appears to not be a limiting factor in any manner.
- Riparian vegetation remains efficient at providing adequate stream shading, especially in Segments NFS 3 and 4 and in side channels.
- Wood abundance has fluctuated among sampling years but no trends are evident in the few years of sampling that has been done (Figure 4.13 and Table 4.5). Overall, wood densities are generally considered to be good based on application of the standards in the Washington DNR watershed analysis manual (WDNR 2011), though there is reason to conclude that parts of the lower North Fork are deficient in large, stable jams.
    - LWD data from recent years have shown that existing flows constantly move wood throughout the North Fork. High flows transport wood downstream, move wood out of the survey zones onto the floodplain or vice versa, break what was considered a qualifying piece one year into disqualifying sizes the next year, and create new wood piles on river bends that eventually create jams.

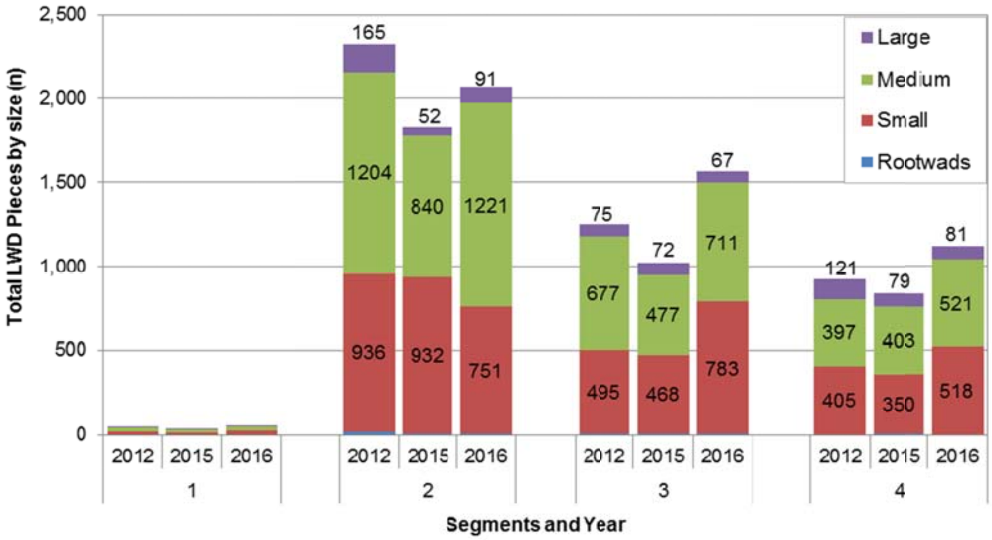



**Figure 4-13. Size distribution of LWD per segment and year in the North Fork Skokomish River, 2012 – 2016. From Tacoma Power (2017b).**

**Table 4-5. LWD pieces per mean bankfull channel width (BFW) per segment and year in the North Fork. From Tacoma Power (2016).**

| Segment | Year | Length (m) | Total LWD pieces | Mean BFW (m) | LWD pieces per BFW | WA DNR Watershed Analysis standard |
|---|---|---|---|---|---|---|
| 1C | 2012 | 443 | 43 | 22.1 | 2.1 | Good |
| | 2015 | | 29 | 26.1 | 1.7 | Fair |
| 2 | 2012 | 4,602 | 2,328 | 28.2 | 14.2 | Good |
| | 2015 | | 1,830 | 26.3 | 10.5 | Good |
| 3 | 2012 | 3,439 | 1,260 | 25.4 | 9.3 | Good |
| | 2015 | | 1,026 | 26.7 | 8 | Good |
| 4A | 2012 | 487 | 155 | 12.5 | 4 | Good |
| | 2015 | | 134 | 13.9 | 3.8 | Good |
| 4B | 2012 | 2,917 | 778 | 16.4 | 4.4 | Good |
| | 2015 | | 707 | 18.6 | 4.5 | Good |

Tacoma Power (2017b) provides evidence that conditions within the lower North Fork channel are not being shaped by releases of Component 2 flows as originally intended when the new flow regime was formulated. The authors noted that instream habitat is shaped by infrequent, high-magnitude flooding and flows at or below bankfull level, citing Leopold et al. (1964). The authors correctly noted that such high magnitude flows have not occurred in the lower North Fork as a result of the Component 2 flows, but rather have occurred since the dams were built in the form of safety spills. The year-round base or Component 1 flows, and low magnitude flood releases (Component 2) were introduced in 2008.

Therefore, the authors concluded that it is likely that the stream already had adjusted to periodic, high-magnitude flooding long before monitoring began and has only been adjusting more recently to low magnitude floods and base component flows. They suggest that it may take years and possibly decades to fully develop new trends and patterns, especially with almost no comparable data prior to 2012.

Tacoma Power (2017b) observed, based on Figure 4.14, that from 2009 to 2015, all flow releases from the dam were at or below 1,000 cfs. During the 2015 surveys, results showed a systematic wood loss in all stream segments, as well as similar types of results in other channel characteristics. In 2016, following an event just over 2,000 cfs (due to a dam safety release), there was a reversal of many factors that brought results back into a pattern similar to those seen in 2012 (e.g., wood count increased to 2012 levels; Figure 4.13). The authors noted that this could be an indication that habitat features could be managed by leveraging high magnitude flows (greater than 2,000 cfs) to shape habitat or activate restoration projects. We note also that Component 3 flows have not been used and will likely not be used in the foreseeable future due to need to avoid greater flooding to the lower Skokomish River valley. Component 3 flows would on some occasions increase flow releases to greater than 2,000 cfs.

License Article 412 requires Tacoma Power to develop a Fish Habitat Enhancement and Restoration Plan (FHER Plan) to guide implementation of projects to restore habitat in the North Fork and McTaggert Creek. Based on the first three years of reporting, several habitat restoration projects have been identified and one is in the process of being implemented (Tacoma Power 2017b). The restoration project involves installing several ELJS in segment NFS 2. It is anticipated that the project will increase the number of large, stable jams in the lower part of lower North Fork, thereby creating deeper pools than currently exist. These pools are expected to provide higher quality holding sites for adult spring Chinook than currently exist there.

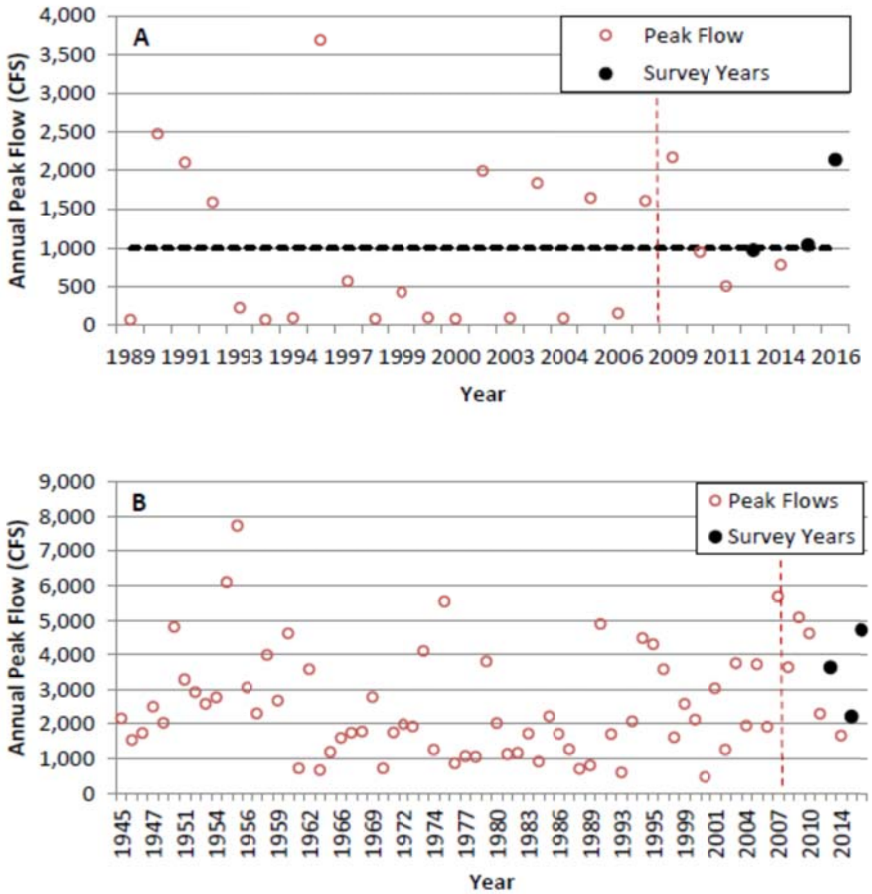



**Figure 4-14. A: Annual peak flow (cfs) recorded immediately downstream of Cushman Dam No.2 in the North Fork Skokomish. The red vertical dashed line represents the initiation of component flow program in 2008 and the black dashed line represents the 1,000 cfs mark which triggers habitat resurveys since 2012. Years 1989-2008 were recorded at retired USGS gage 12058800; years 2009-2016 were recorded at USGS gage 12058790. B: Annual peak flow (cfs) recorded downstream of McTaggert Creek in the North Fork Skokomish at USGS gauge 12059500. The red dashed line represents the initiation of component flows in 2008. From Tacoma Power (2017b).**

It is important to note that the FHER is to be funded through a special fund, the Habitat Restoration Account (HRA), established under the terms of the Cushman Agreement. The purpose of the account is to fund habitat restoration projects in the lower North Fork.

Very extensive water temperature monitoring is required of Tacoma Power as part of the monitoring plan under License Article 413 Section 2.3. Monitoring is required in the upper North Fork (upstream of the upper reservoir), within the reservoirs, and at several sites downstream of the lower dam. Figure 4.15 shows recent years temperatures at RM 13.3 in the lower North Fork (downstream of McTaggert Creek). It is noted that temperatures are cool throughout the summer as a result of cool water discharges from the reservoir, as well as the relatively narrow river channel and dense overhead riparian cover.

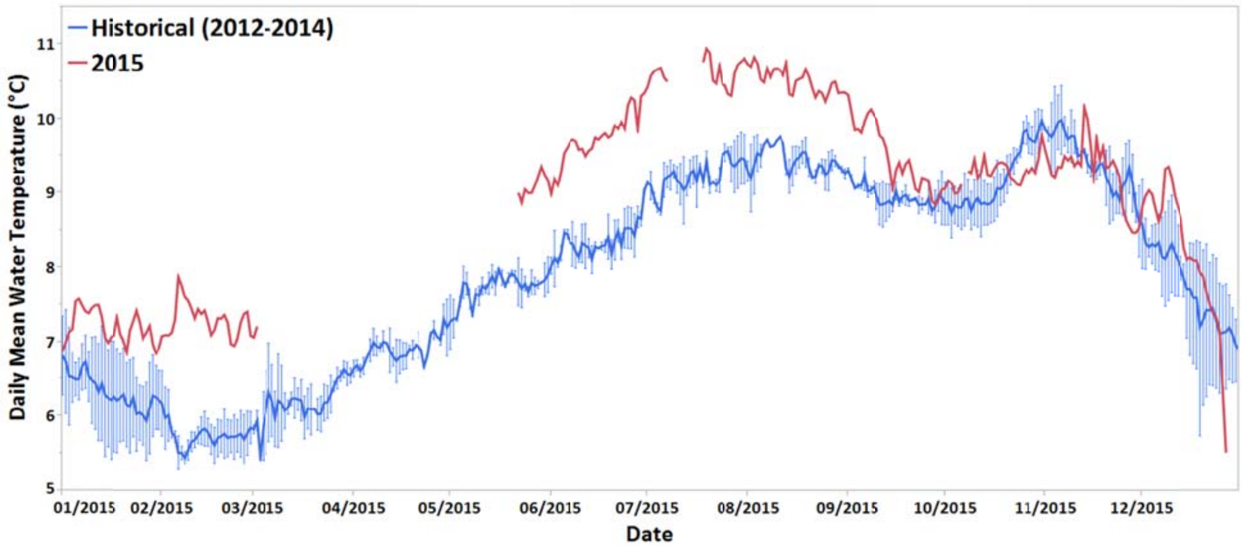



**Figure 4-15. Historical (2012 through 2014) and 2015 daily mean water temperatures at the compliance point (RM 13.3) in the lower North Fork. Blue bars represent the historical range of mean daily flows. From Tacoma Power (2016).**

## 4.2.3 Lower Watershed

Progress in habitat restoration work in the lower watershed since 2010 was primarily achieved by completing the USACE General Investigation (GI) and in related planning to implement locally funded actions. In late 2016, as part of the process to update this recovery plan, a restoration forum was held to obtain additional information to help inform this update. Information presented here also includes results of an assessment made in 2017 of current conditions in the lower South Fork and Skokomish River valley to inform this update.

### 4.2.3.1 General Investigation and other locally sponsored actions

The USACE transmitted its final report on the results of the General Investigation (GI) to Congress in December 2015. The report, entitled "Skokomish River Basin, Mason County, Washington, Ecosystem Restoration - Integrated Feasibility Report and Environmental Impact Statement", is a series of extensive reports that analyzed numerous actions considered for implementing restoration in the lower Skokomish River watershed. The project area for the investigation encompassed the entirety of the lower river valley, including the South Fork downstream of the canyon and the remainder of the valley downstream from there, extending into the river mouth estuary.

The planning objectives for the actions considered were to:

1. Increase the channel capacity of the Skokomish River to allow for restoration of rearing habitat, as well as reduce stranding of ESA-listed salmonid species;
2. Provide year-round passage for fish species around the confluence of the North Fork and South Fork Skokomish River;

3. Restore the side channel and tributary networks in the study area including Hunter and Weaver Creeks; and
4. Improve the quality, quantity, and complexity of native floodplain habitats including riparian and wetland habitats in the Skokomish River mainstem and tributaries.

The purpose of the GI feasibility study was to evaluate the significantly degraded ecosystem in the Skokomish River basin; to formulate, evaluate, and screen potential solutions to these problems; and to recommend a series of actions and projects that have a federal interest and are supported by a local entity willing to provide the necessary items of local cooperation. Mason County and the Skokomish Tribe were the cost-sharing, non-federal sponsors of the feasibility study.

The study was completed under the authority of Section 209 of the River and Harbor Act of 1962, Public Law 87-874. If funded, the Skokomish River Basin Ecosystem Restoration Project would continue under the authority provided by the resolution cited above.

As a result of the study, five major projects were proposed for implementation. Over 60 different projects were considered and evaluated. Many of the projects not selected as part of the federal action were deemed to have substantial benefit to restoration but did not satisfy all of the criteria considered for adoption as part of the federal package. Many of the projects not selected are still being considered or advanced for funding from other funding sources.

The package of five actions proposed as the Skokomish River Basin Ecosystem Restoration Project was authorized for funding by Congress in 2017. The package of actions awaits final funding approval. The estimated total cost for the combined project is approximately $20 million, of which about $13 million would be the federal responsibility. These costs include the monitoring portions of the project.

The specific actions proposed through the GI and other actions outside the USACE's combined package that are still in planning stages are described in Section 4.3 (Strategies, Actions, and Projects).

#### 4.2.3.2 Restoration forum

In October 2016, as part of the process to update this recovery plan, a three-day forum was held to review the status of conditions within the watershed and to consider large-perspective priorities to help guide restoration for Chinook recovery. The purpose was not to re-evaluate actions that had been analyzed as part of the GI effort. Instead it was to take a broader watershed perspective to help improve the understanding of the authors of this plan about the extent that the large watershed issues will have been adequately addressed going forward.

Invited scientists who participated in the forum were individuals with knowledge of the watershed, the issues affecting habitat conditions within the watershed, and the types of actions being implemented to address those issues. Scientists and engineers participated from the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Forest Service, Washington Department of Fish and Wildlife, Mason Conservation District, Tacoma Power, Skokomish Tribe, Puget Sound Partnership, and several consulting companies.

The format for the forum consisted of a field trip through parts of the watershed, and then meetings to address a series of questions to obtain perspectives from the participants on issues affecting habitat conditions.

Two major conclusions emerged from the forum:

1. A critical uncertainty related to the long-term success of proposed restoration efforts is the rate at which sediment is being exported from the upper South Fork to the lower watershed and how this rate will be affected by climate change patterns. Some form of monitoring is needed to help address this matter.
2. The proposed actions for the upper South Fork (more ELJ installations), lower North Fork, and the lower valleys will be effective at substantially improving habitat conditions for Chinook. The long-term sustainability of those actions will be at least partly affected by the rate at which sediment inputs into the lower valley can be stabilized (identified as a critical uncertainty above). Monitoring the effectiveness of actions is vital both for near-term and long-term understanding.

It is noted that Mauger et al. (2015) projected that peak annual flow levels will increase in rivers within the Puget Sound region over the next 80 years. The highest annual river flows are expected to increase by +18% to +55%, on average, for 12 Puget Sound watersheds, of which the Skokomish is one. Flood risk is expected to increase accordingly. Moreover, the study also concluded that these rivers can be expected to experience increases in the frequency of landslides, erosion rates, and sediment transport in winter and spring as a result of increases in frequency and intensity of heavy rain events. It bears noted that a more recent analysis by the U.S. Bureau of Reclamation (USBOR) concluded that while snowpack in Skokomish River watershed is expected to decrease significantly over the next 60 years that winter peak flows will likely significantly increase (McGuire 2017). The fraction of years with annual flow above 2,000 cfs is expected to increase.

In reference to expected effects of climate change, it was emphasized during the forum that installation of more ELJs in the upper South Fork is needed to facilitate stabilization of the active channel there and to decrease the bankfull width to depth ratio of the channel. By doing so, the rate of sediment transport from the upper South Fork should be more effectively slowed and stabilized. Time will be required following ELJ installation for this stabilization to occur prior to the projected increases in peak flows later this century.

#### 4.2.3.3 Current status of habitat in lower watershed

The current status of habitat conditions within lower South Fork and the mainstem river downstream of the forks is described here based on information contained in Tacoma Power (2016 and 2017b) and NSD (2017). Tacoma Power, as part of the Cushman Settlement, is required to monitor changes at several channel cross sections in the mainstem Skokomish River in the vicinity of the North Fork confluence and downstream near Highway 101. This information provides an indicator of how the new flow regime may affect channel conditions downstream of the North Fork. In addition, Natural Systems Design, Inc. (NSD) was requested to provide an assessment of channel conditions based on available LiDAR data and aerial imagery to inform this plan about the current status of habitats.

The NSD (2017) analysis also informed this plan about reasonable near-term (20 years) and longer-term (50-100 years) habitat goals (targets or desired future conditions) for the lower South Fork and the mainstem river. These targets are presented with information contained in USACE (2015) to comprise measurable goals against which progress from restoration actions can be compared (see Section 4.4).

It is helpful here for the reader to have some understanding of how the confluence of the North and South forks has changed locations over about the past 14 years. Prior to 2003, the forks joined at or very near where the confluence exists currently, marked by the label "NF & SF confluence 2012+" in Figure 4.12. Beginning in 2003, the North Fork, at least partially, avulsed into a relic channel, shown as segment NFS 1A in Figure 4.12. Over several years the avulsion progressed until it was completed and the new confluence location was moved downstream about one mile, marked by the label "Former NF & SF confluence 2008-2012" in Figure 4.12. This event moved the mouth of the South Fork downstream, as it followed the path of the former mainstem Skokomish River to the new confluence location. The reach segment labeled as NFS 1A in Figure 4.12 became the lowest reach in the North Fork. The lower reach of the extended South Fork became highly susceptible to dewatering each year in mid-summer, as well as some extension of this effect upstream. In 2012, the South Fork then avulsed to the north and rejoined the North Fork at or near the old site where the forks had joined prior to 2003. The main river channel of the Skokomish River beginning at the forks from that time until now flows through the lower end of what had been the lower part of the North Fork, as it existed between about 2003 and 2012 (Figure 4.12). This section of the river between the new confluence (since 2012) and the older confluence (downstream about one mile) is referred to here as the avulsion reach.

Tacoma Power (2016 and 2017) identified the minimum frequency of flooding in the lower river in recent years based on the number of events that exceeded certain flow or river stage levels (Table 4.6). Both gauges are not considered to be reliable by USGS for assessing flow rates higher than certain levels, 4,000 cfs at the lower South Fork gauge and a stage of 16.4 at the lower Skokomish River gauge. Still, enumeration of the minimum number of events exceeding those levels is a useful indicator of the number of bankfull events that occurred in the lower valley as given by Tacoma Power. Figure 4.16 charts the annual hydrographs for the same four water years listed in Table 4.6. The figures illustrate the kind of variability that occurs among years as well as the intra-annual patterns for flooding (these graphs also inform other parts of this recovery plan).

**Table 4-6. Estimated minimum numbers of bankfull events that occurred in the lower Skokomish valley in water years (WY) 2013-2016, as given by Tacoma Power (2016 and 2017b). See Figure 4.12 for site locations.**

| Water year (WY) | Minimum # bankfull events | |
|---|---|---|
| | Lower South Fork - no. events >4000 cfs (USGS 12060500 ) | Lower Skokomish R - no. events >16.4 ft stage (USGS 12061500) |
| 2013 | 4 | 4 |
| 2014 | 3 | 3 |
| 2015 | 9 | 16 |
| 2016 | 8 | 15 |

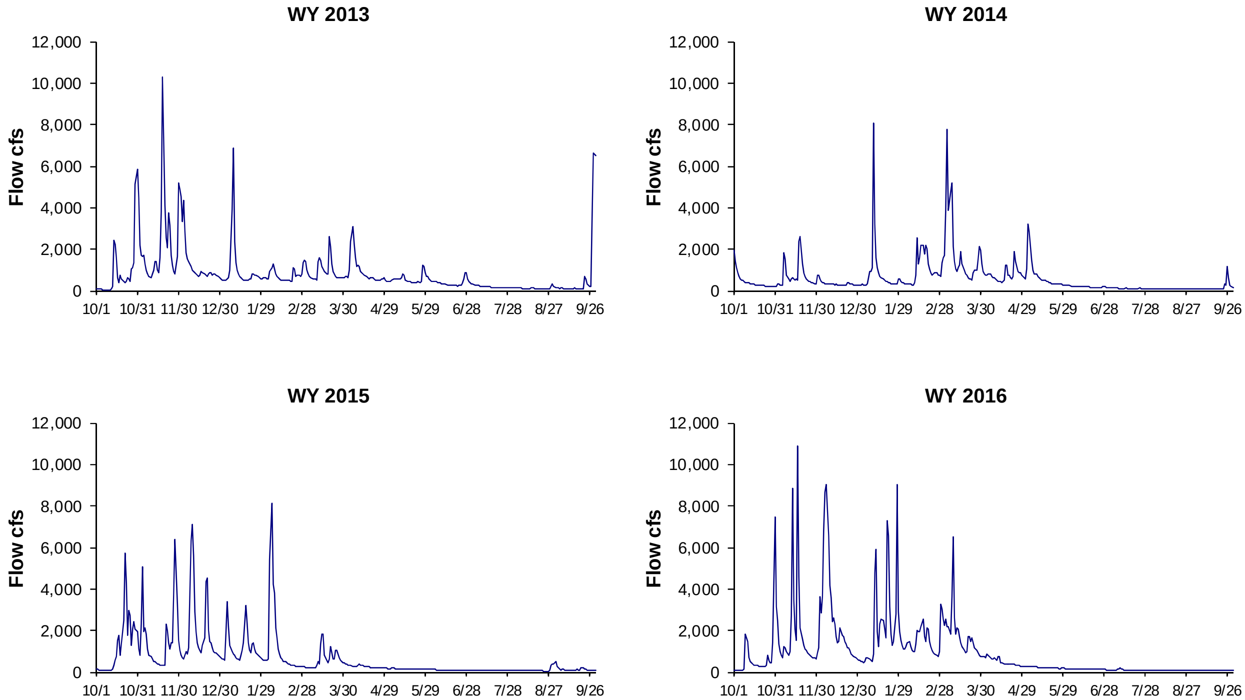



**Figure 4-16. Hydrographs for the South Fork below the gorge for water years (WY) 2013-2016 (USGS 12060500). See Figure 4.12 for location.**

Tacoma Power monitors three cross sections of the river channel in the lower valley as part of its monitoring requirements. Locations of the three sites are shown in Figure 4.12: SFS is in the lower end of the South Fork, SKR 2 is located downstream of the avulsion reach and the previous confluence of the forks, and SKR 1 is located downstream of Highway 101. Observations made by Tacoma Power at these sites over the past several years are informative (Tacoma Power 2016 and 2017b).

1. At site SFS (lower South Fork) – The South Fork channel cross section is by far the most dynamic of the three cross section sites. This site has fluctuated by up to 200 sq. ft. in one year, and overall has increased by over 120 sq. ft. or 15% from 2012 to 2015. The deepest part of the channel shifted almost 100 feet to the south and the gravel bar on the north side increased substantially in width. These observations are consistent with findings reported by NSD (2017), described further below in this section.
2. At site SKR 2 (below avulsion reach) – The site below the confluence of the two forks (SKR 2) has been deepening and increasing in channel area every year since 2012, continuing through 2016. Overall, the channel capacity has increased by at least 17.6% at this site. Other comments by Tacoma Power regarding this site are:
    - The site has continued to degrade (downcut) significantly at an annually increasing rate.
    - One possible reason for this downcutting is the avulsion of the South Fork into the North Fork channel approximately one river mile upstream. That event may have allowed sediment storage into the newly formed channel, which may be serving to reduce bedload from upstream to be transported through the reach to the SKR 2 site. If

this is the case, then the effect seen at SKR 2 would be attributed to a localized effect and not a reach-scale effect.

- Another possible reason for the downcutting would be due to a reach-scale effect. If this is the case, then it would be a welcome sign that the trend may be reversing years of aggradation in the lower South Fork/mainstem. (The findings by NSD 2017 provide further insight into this matter – see below.)

3. At site SKR 1 (below Highway 101) – The downstream-most mainstem cross section at RM 4 has the deepest channel but the smallest cross sectional area, which has varied modestly from 2012 to 2016. The site exhibits some level of aggradation.

Natural Systems Design, Inc. (NSD 2017) assessed channel conditions in the lower valley based on LiDAR data and aerial imagery. The findings are informative to this recovery plan. The assessment also provides metrics that can be used for assessing changes in future conditions due to various factors including restoration actions. The complete assessment is provided in Appendix A of this recovery plan.

NSD employed two separate high-resolution LiDAR datasets (2002 and 2016 datasets) for a geomorphic analysis of the lower valley, combined with an assessment of certain features in the lower valley from the 2016 aerial imagery from Google Earth.

The 2002 dataset from the Puget Sound LiDAR Consortium (PSLC) consists of a topographic bare-earth digital elevation model (DEM) that was collected during March 2002 (GeoEngineers, 2007). The dataset was generated using red-LiDAR technology and thus only consists of ground topography and the water surface during the time of the flight as red LiDAR cannot penetrate water to measure the channel bottom. While the specific date of the flight is unknown, it is assumed to be representative of winter base-flow conditions as the mean flow during March 2002 was 1,426 cfs at the USGS Hwy 101 gage (USGS 12061500).

The 2016 dataset from the Mason Conservation District (Mason CD) and the Skokomish Tribe consists of a topo-bathymetric bare-earth DEM, a water surface DEM, a DEM of the LiDAR first returns, and an intensity image (see Table 1 in Appendix A). The dataset was generated using a combination of red and green LiDAR technology which was able to measure channel bathymetry in addition to ground topography and the water surface. The dataset was acquired on September 28, 2016 with a daily mean flow of 291 cfs at the USGS Hwy 101 gage (USGS 12061500), which is representative of low-flow conditions. The dataset also included an intensity image based on the reflectivity of the object struck by the laser and resembles black and white aerial images.

The complete assessment done by NSD included a terrain analysis using a Relative Elevation Model (REM), riparian condition analysis, low flow channel characteristics for 2016, and an assessment of large wood loading using recent aerial imagery.

NSD identified a set of metrics that could be assessed with the available data and tools deemed to be informative about the condition of factors operative in the lower valley that could potentially affect Chinook performance in various life stages. The metrics recommended by NSD are given in Table 4.7.

**Table 4-7. Recommended geomorphic assessment metrics to evaluate restoration used to address limiting habitat factors affecting Chinook performance in the Skokomish River. From NSD (2017).**

| Limiting factors influencing Chinook | Causes | Geomorphic assessment metrics |
|---|---|---|
| Low flow fish passage and stranding | - De-watering of channel due to aggradation<br>- Depths are too shallow due to over-widened channel | - Width to depth ratio<br>- Pool frequency<br>- Large wood jam frequency (stability of channel) |
| Redd burial and scour | - Channel aggradation<br>- Unstable channel (frequent channel movement) in braided reaches<br>- Channel has not equilibrated to high sediment load from upper watershed and decrease in flow from Cushman dam<br>- in-stability of braid channels and sediment disequilibrium causes extensive scour and deposition within broad active Channel network | - Width to depth ratio<br>- Aggradation and erosion rates<br>- Channel morphology |
| High flow refugia (velocity refuge) | - Active migration within braid channels causes in-stability of available cover along channel margins<br>- Channel confinement (levees) disconnects and limits potential off-channel habitat<br>- Lack of stable large wood jams that provide low velocity refuge | - Large wood jam frequency<br>- Side channel length |
| Low flow refugia (e.g., from temperature and predators) | - Depths are too shallow due to over-widened channel<br>- Lack of shade within over-widened channel increases temperatures<br>- Lack of pools due to channel morphology and lack of stable large wood jams<br>- Pool depths are not deep enough to tap into lower temperature hyporheic water | - Width to depth ratio<br>- Pool frequency<br>- Pool surface area percentage<br>- Pool depth<br>- Large wood jam frequency<br>- Channel morphology |

The assessment was made for each of three geomorphic reaches within the lower valley based on channel morphology and sediment dynamics:

- Lower South Fork reach (RM 8.7-12);
- North Fork confluence reach (or avulsion reach) (RM 7.4-8.7); and
- Mainstem reach (RM 4.9-7.4).

A brief description of each geomorphic reach as given by NSD and overall conclusions about each reach are provided below.

__**Lower South Fork reach:**__

- The South Fork reach consists of a wide braided channel with unvegetated gravel bars dominating the majority of the active channel (see Appendix A in NSD 2017 – Skokomish River Aerial). The reach begins directly downstream from the steep and confined upper South Fork Skokomish and is the first location where the river opens into a broad alluvial valley. There is evidence of a highly dense network of relic channels within the south side (right bank) floodplain (see Appendix A in NSD 2017 – 2016 Relative Elevation Model). This network however, has been cut off from the mainstem river through the development of the floodplain, confinement of the channel, and construction of flood defenses such as levees (GeoEngineers 2007).

- The South Fork reach was previously the site of significant amounts of sediment deposition, which likely contributed to the braided morphology (GeoEngineers 2007).
- Over the past 14 years, the channel appears to be stabilizing (see Appendix A in NSD 2017 – DoD). The DEM of difference between 2002 and 2016 illustrates that there has been between 2-5 ft of scour within the active braid channel with evidence of lateral channel migration illustrated by erosion across the bar surfaces (e.g. RM 9.2). There has been minimal net aggradation (0-3ft) except for areas near the Vance Creek confluence where aggradation of >5ft has been seen. This suggests that sediment supply from the upper basin appears to have been lowered to a magnitude that can be processed (i.e. transported) by the South Fork and that the river may be on a trajectory to recovery and the establishment of a dynamic equilibrium. The active channel is, however, still over-widened with a width-to-depth ratio between 130 (RM 10.6, XS-1) and 160 (RM 9.9, XS-2) and several braid channels dispersing flow.

**North Fork confluence reach:**

- The North Fork confluence reach consists of two distinct and contrasting channel morphologies—the braided former mainstem (RM 8.7-7.4) and the anabranching section through the newly formed mainstem (former North Fork) channel (termed the avulsion reach). There is an extensive relic channel network on both sides of the river which includes secondary channels, relic oxbows, and distributary channels, although the south side contains a higher degree of channels and lower lying areas (see Appendix A in NSD 2017 – 2016 Relative Elevation Model). Many of the relic channels along the north side of the river are associated with the North Fork Skokomish alluvial fan, including a forested floodplain surface with a dense network of relict channels.
- The new mainstem channel caused by the levee breach and avulsion consists of a narrow and deep (width to depth = 32, XS-3) that is morphologically complex, has good shade from the adjacent forest, and many deep pools and cover (Figure 4.17). This is in contrast to the former mainstem which was over-widened (width to depth = 287, XS-3), had minimal shade from the unvegetated gravel bars, and limited cover or deep pools. The new channel has greater stability than the old channel because of the surrounding forest, which allows for the maintenance of a more consistent channel planform despite the high sediment loads from upstream. This consistent concentration of flow depth through this channel has improved sediment transport capacity for the overall reach (see Appendix A in NSD 2017 – DoD).
- Comparisons between the 2002 and 2016 LiDAR datasets indicate that there has been net aggradation through this reach, although the net flux is only 60,500 yd3. The erosion is highest within the avulsion location around RM 8.6 and the confluence with the former mainstem around RM 7.4. Deposition ranges between 1-5 feet along gravel bars within the active channel which averages to 0.1-0.4 ft/year of aggradation in these locations. The improvement in sediment transport capacity should likely continue as field observations indicate that red alder is colonizing these gravel bars which would add stability to the channel and maintain a consistent and concentrated width if the channel ever re-occupies these locations.
- The Skokomish River through the avulsion reach provides a site specific restoration template upon which to assess future progress. The new channel through this reach is narrow and deep

and has both a pool frequency and large wood frequency more than double the rest of the project area. The narrow width allows for the retention of relatively small trees capable of spanning the entire channel as well as adequate shade from the surrounding riparian forest. By avulsing into this channel, the river has transitioned from an over-widened braided morphology into the beginning of an anabranching channel network which has dramatically improved the baseline geomorphic conditions. The reach is an example of natural processes working to heal a channel network and provides baseline conditions to assess future restoration efforts within the Skokomish.

**Figure 4-17. Conditions within the North Fork confluence reach (avulsion reach) as seen in June, 2017. This reach is now the mainstem river channel of the lower Skokomish River in this vicinity. It provides a site specific restoration template upon which to assess future progress toward restoration of the river channels within the lower valley. From NSD (2017).**

**<u>Mainstem Skokomish River downstream of avulsion reach:</u>**

- The mainstem Skokomish river downstream from the former North Fork confluence consists of a simple, single thread channel that is confined within a narrow active corridor by splay deposits (i.e., fluvial levees) that are approximately five feet above the 2016 low flow water surface (see Appendix A in NSD 2017 – 2016 Relative Elevation Model). There is low-lying floodplain along both sides of the reach with distinct relict channel networks present on both sides of the river.
- The existing channel is narrower and deeper than the wide braided sections upstream (width to depth = 70 [XS-6] and 35 [XS-7] respectively) although the channel still remains perched above the surrounding floodplain by several feet (XS-6/7, REM). Since 2002, the channel has remained relatively stable with minimal lateral migration, in-channel aggradation or bed erosion (see Appendix A in NSD 2017 – DEM of Difference).

The NSD analysis provided particular insightful data about bankfull width to depth ratios for the Skokomish River valley. Table 4.8 lists the observed ratios based on cross sections from the 2016 LiDAR REM (see Appendix B in NSD 2017 – Potential Avulsion Pathways). The width to depth ratios listed in the table are consistent with those reported by Tacoma Power (2016 and 2017b) at the cross section sites they assessed in the lower South Fork and mainstem river.

**Table 4-8. Bankfull channel width to depth ratios for the Skokomish River valley. Measurements made based off of cross-sections (XS) (see Appendix B in NSD 2017 – Potential Avulsion Pathways) from the 2016 LiDAR DEM.**

| XS | Channel ID | Width (ft.) | Area (ft.$^2$) | Depth (ft.) | Width to depth ratio |
|---|---|---|---|---|---|
| 1-M | MS | 752 | 4,320 | 5.7 | 131 |
| 2-M | MS | 409 | 1,061 | 2.6 | 158 |
| 3-M | Former MS | 491 | 840 | 1.7 | 287 |
| 3-S | Current MS | 132 | 537 | 4.1 | 32 |
| 4-M | Former MS | 532 | 1,778 | 3.3 | 159 |
| 4-S1 | SC | 52 | 175 | 3.4 | 15 |
| 4-S2 | Current MS | 127 | 345 | 2.7 | 47 |
| 4-S3 | Right (Weaver) | 164 | 623 | 3.8 | 43 |
| 5-M | MS | 245 | 1,390 | 5.7 | 43 |
| 5-S1 | Channel C-E | 81 | 248 | 3.1 | 27 |
| 5-S2 | Channel A-E | 93 | 178 | 1.9 | 49 |
| 6-M | MS | 300 | 1,284 | 4.3 | 70 |
| 7-M | MS | 205 | 1,184 | 5.8 | 35 |

Channel ID Codes:
MS = Main Stem
S = Side channel

The bankfull channel width to bankfull channel depth ratio varies between 32-287 for mainstem channels of the Skokomish River and 15-49 for secondary and side channels (Table 4.8; Figure 4.18). The wide range in ratios is characteristic of the variation in channel morphology throughout the valley (braided versus single-threaded) with the wide active channels of the braided reaches having much higher ratios than the remaining channels. The avulsion into the narrower and deeper former North Fork channel helped to dramatically decrease the width to depth ratio within that stretch of the valley from 159 to 32 (XS-3).

Figure 4.18 displays the width to depth ratios in a useful form for this recovery plan. It should be noted that the values seen in the figure are also consistent with findings from the upper South Fork. The figure provides a means of setting Desired Future Condition targets (goals) for restoration in the watershed.

Table 4.9 summarizes the findings of the NSD analysis for the geomorphic-related metrics listed in Table 4.7. Details of the analysis are given in the NSD report (Appendix A of this document).

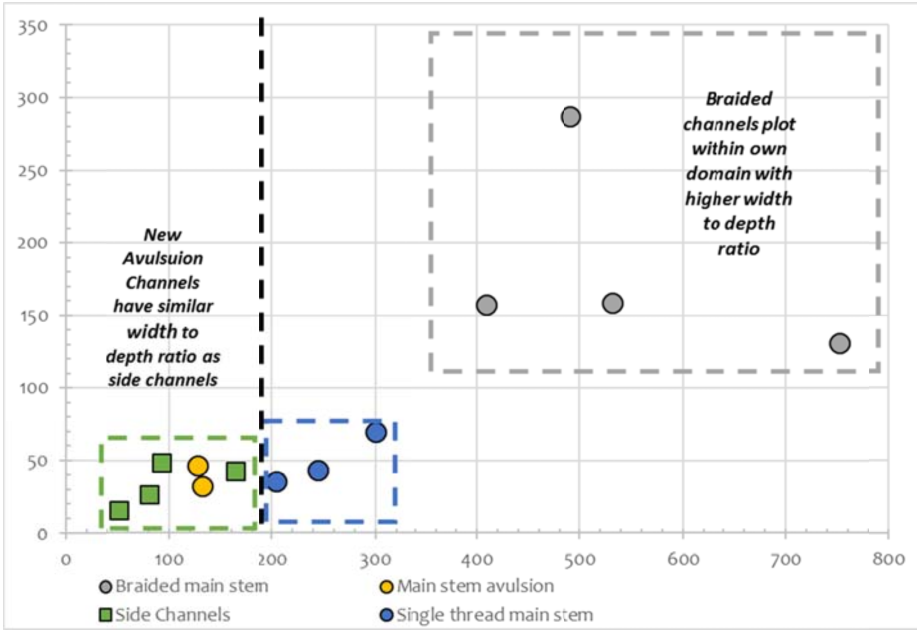



**Figure 4-18. Channel width to depth ratio versus unvegetated channel width. Note the two separate domains in which data group, one for side channels and single thread mainstem channels and one for braided channel reaches. From NSD (2017).**

**Table 4-9. Conditions within the lower South Fork and mainstem Skokomish River as characterized by geomorphic metrics related to limiting factors for Chinook in the river. See Table 4.7 for definitions of metrics.**

| Metric | Units | Average current conditions | | |
|---|---|---|---|---|
| | | South Fork | Avulsion | Mainstem |
| Large wood jam frequency | Jams/mile | 3.3 | 8.2 | 2.1 |
| Pool frequency | Pools/mile | 4.6 | 21.0 | 7.3 |
| Pool surface area percentage | % Total wetted area | 10% | 20% | 20% |
| Pool depth | Average depth (ft.) | 2.8 | 3.7 | 4.1 |
| Width to depth ratio | -- | 144.3 | 39.6 | 49.6 |
| Net Sediment Flux | $Yd^3$ | -259,000 | 60,500 | -80,100 |
| Side channel to main channel ratio | -- | n/a (no side channels) | 0.43 | n/a (no side channels) |
| Channel morphology | % Anabranching | 0 | 55% | 0 |

Water temperatures within the lower Skokomish River valley (Figure 4.8) downstream of the South Fork canyon and the North Fork appear to vary by reach but are generally within optimal or safe ranges for Chinook as given in Bjornn and Reiser (1991). It is notable that water temperatures in lower South Fork appear to be the warmest in the watershed, based on the sites represented in Figure 4.8. Water temperatures in the lower mainstem river (Rocky Beach site RM 7 in Figure 4.8) are much cooler than temperatures in the lower South Fork, probably for two reasons. The lower South Fork lacks good riparian cover and flows through a highly braided and exposed reach. The reach downstream of the North Fork is fed by cool water from the North Fork as well as by substantial groundwater sources and re-emerging water from aggraded streambeds upstream that are subject to dewatering. These sources would be much cooler than surface water in the lower South Fork.

### 4.2.4 Estuary

Significant restoration work has been accomplished in the Skokomish River estuary over the past 12 years.

#### 4.2.4.1 Restoration Phases 1 to 3

During the past 12 years, the Skokomish Tribe has worked effectively with many partners, particularly Mason Conservation District and Tacoma Power, as well as different funding agencies, in a major large-scale, multi-phased effort to restore much of the Skokomish estuary to its historic and natural form and function (Figure 4.19). While the estuary has not been completely restored to its pristine state as it existed 150 years ago, the level of restoration has been very large and comprehensive. Roads and dikes have been removed or breached, fill has been removed, large amounts of sediment have been removed or flushed out to Hood Canal, tidal channels have been opened or reformed, and estuarine marsh and wetlands have been restored (SWAT 2016).

#### 4.2.4.2 Current status of habitat in estuary

The Skokomish estuary has been substantially restored to a more productive state than existed 20 years ago. However, the healing of the habitat complex is still in progress and should continue to improve in the coming years as watershed processes originating upstream are restored to more normative characteristics. Some estuarine restoration work remains in planning stages.

## 4.3 Strategies, Actions, and Projects

The habitat strategies or actions for watershed restoration and Chinook recovery were described in the 2010 Plan under what was referred to as the Framework for Habitat Strategies, shown here as Table 4.10 with several updates incorporated. Many of the actions are in various stages of implementation, as reviewed earlier in this chapter. We focus here on the actions that have been advanced through extensive planning and are soon to be fully implemented once funding is secured. These actions are largely the result of the USACE GI and other planning that went on for related work as part of that process.

As a result of the GI, five major projects were proposed for implementation. Over 60 different projects were considered and evaluated. Many of the projects not selected as part of the federal action were deemed to have substantial benefit to restoration but did not satisfy all of the criteria considered for adoption as part of the federal package. Many of the projects not selected are still being advanced for funding through other funding sources. The five major projects selected through the GI process were authorized for funding by Congress in 2017. That package of actions awaits funding appropriation by Congress.

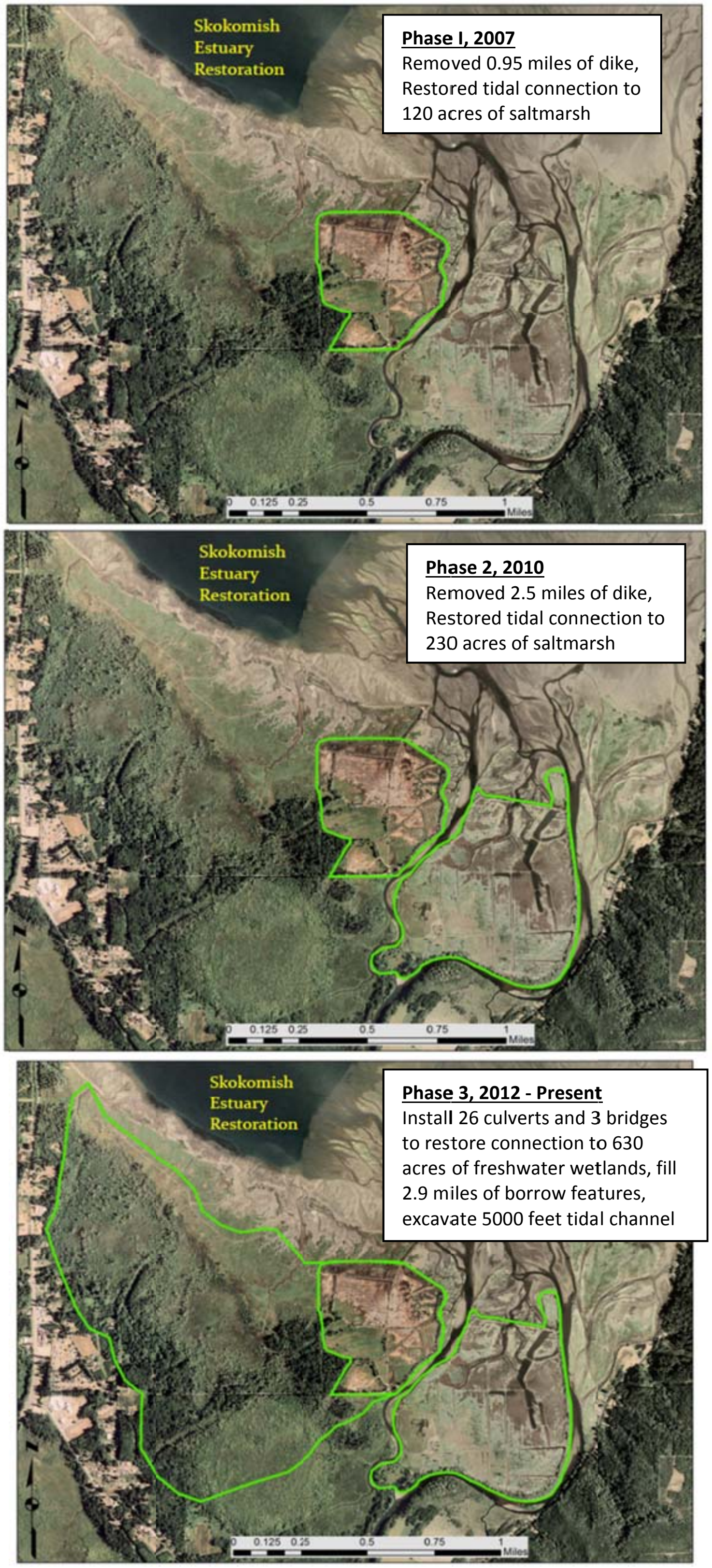



**Figure 4-19. Summary of the three phases of restoration that have been completed in the Skokomish estuary. Source: Geiger (2015).**

Forty restoration sites and associated actions were advanced through a screening process as part of the GI work (Figure 4.20). All of these sites and actions are located in the lower South Fork and mainstem Skokomish River.

The five major projects that have been advanced for federal funding are the following (Figure 4.21):

1. Confluence Levee Removal - Removal of a levee at the confluence of the North and South Forks of the Skokomish River near river mile 9, including other measures related to the levee removal (Figure 4.22);
2. Upstream Large Woody Debris - Installation of large woody debris and engineered logjams on the South Fork Skokomish River between river miles 9 and 11 (Figure 4.23);
3. Wetland Restoration at River Mile 9 - Wetland restoration on the south bank of the Skokomish River between river miles 8.3 and 9.2 (Figure 4.24);
4. Wetland Restoration at Grange – Wetland restoration on the south bank of the Skokomish River between river miles 7.5 and 8 (the Grange site) (Figure 4.25) ; and
5. Side Channel Reconnection - Reconnection of an historical side channel between river miles 4.5 and 5.5 of the Skokomish River (Figure 4.26).

These actions are projected to provide positive benefits to Chinook habitat in the lower valley. These benefits would combine with the more than 1,000 acres of restored estuarine habitat at the downstream end of the project area, as well as the improving forested habitat in the upper watershed and the actions being taken in the lower North Fork. The USACE concluded that the estuarine and upper watershed restoration actions being led by other local, state, or federal entities would complement the USACE's preferred alternative. The reach of river proposed for restoration by the USACE is a critical link between these habitats.

A number of other projects that ranked high for restoration potential were not advanced for federal funding as part of the overall package. A highly ranked project—deemed as important to operate in conjunction with the five projects that were advanced is the Skokomish Valley Road Realignment ("Dips Rd" on Figure 4.20) (Figure 4.27). This project would relocate the (West) Skokomish Valley Road outside of the South Fork Skokomish riparian area, restore approximately one mile of Vance Creek and the South Fork Skokomish River by restoring the right bank and riparian area of the river to include removal of 800 feet of rock bank armor. The project would reconnect up to 60 acres of South Fork Skokomish floodplain.

The full list of actions that were screened in the USACE process, in addition to others that have been added to the list to address needs in Vance Creek and in the upper South Fork, is provided in Appendix B.

**Table 4-10. Framework for habitat strategies.**

| Threat, Issues, Watershed Processes | Relevance to Chinook | Causes | Solutions | Strategies | Objectives | Critical Uncertainties |
|---|---|---|---|---|---|---|
| Degraded Upper Watershed Conditions in South Fork and Vance Creek<br><br><u>Issues:</u> Significantly increased sediment load; unstable sediment and channels; altered in-channel sediment processing; altered hydrologic processes; decreased LWD recruitment; increased solar radiation; loss of channel complexity; reduced accessibility of adult Chinook access to the upper SF at cataracts.<br><br><u>Processes:</u> Geomorphic processes; hydrologic processes; hydraulic processes; sediment delivery; LWD recruitment; thermal inputs; reactivated paraglacial processes | ▪ Aggradation in lower SF and Vance Cr., reduces surface flow, hindering upstream movement of adult Chinook during low to moderate flows and limits spawning site selection<br>▪ Increased sediment load adversely affects egg to fry survival due to degraded channel conditions<br>▪ Loss of channel complexity reduces habitat quality for egg and fry survival<br>▪ Increased sediment loading increases delivery to lower Skokomish valley, compounding habitat issues there<br>▪ Increased thermal loading reduces suitability for spring Chinook performance<br>▪ Reduced spring-time snowmelt pulse reduces passage efficiency at gorge cascades | ▪ High road density and failures, importing coarse and fine materials;<br>▪ Insufficient road maintenance;<br>▪ Large-scale and rapid clearcutting of subbasin;<br>▪ Logging of riparian zone in many areas<br>▪ Stream clearing and channel destabilization;<br>▪ Erosive sub-drainages;<br>▪ More rapid snowmelt and diminishment of the spring snowmelt pulse, possibly due to climate change;<br>▪ Glacial history and re-activation of paraglacial process. | ▪ Reduce anthropogenic sediment inputs<br>▪ Restore sediment sorting processes<br>▪ Re-establish coniferous riparian forests having old-growth characteristics<br>▪ Increase channel stability and complexity<br>▪ Restore floodplain connectivity in response reaches<br>▪ Improve forest hydrologic maturity<br>▪ Arrest paraglacial processes that have been reactivated<br>▪ Improve passage for re-introduced salmonids through gorge cascades | ▪ Decommission roads and maintain remaining road & trail network<br>▪ Stabilize sediment sources<br>▪ Maintain and/or expand riparian reserves<br>▪ Restore riparian conditions<br>▪ Increase woody debris and log jam loading<br>▪ Silviculture treatments to increase hydrologic maturity<br>▪ Remedial measures to improve adult passage at the gorge cascades | ▪ Restore upland landscapes and vegetation that improve and restores watershed form and function<br>▪ Restore the fluvial geomorphic processes in the watershed channels, channel form and function, and sediment movement<br>▪ Restore floodplain function and connectivity in the Skokomish River and tributaries<br>▪ Protect riparian and floodplain corridor, in-channel habitat, water quality, and channel conveyance capacity from further degradation<br>▪ Enhance fish passage effectiveness in the gorge cascades | ▪ Relative impacts between sediment sources (slope versus in-channel);<br>▪ Hydrologic impacts on basin and sub-basin scales from forest management;<br>▪ Time required to arrest re-activated paraglacial processes;<br>▪ Rate of export of coarse sediment from the upper SF to the lower SF and the mainstem Skokomish R.<br>▪ Significance of sub-basin erosion and deposition to geomorphic and biological processes;<br>▪ Adequate levels of woody debris and ELJ loading;<br>▪ Short-term and long-term effects of climate change;<br>▪ Funding levels for restoration and recovery actions. |

**Table 4.10. (continued) Framework for habitat strategies.**

| Threat, Issues, Watershed Processes | Relevance to Chinook | Causes | Solutions | Strategies | Objectives | Critical Uncertainties |
|---|---|---|---|---|---|---|
| Altered Flow Regime in North Fork<br><br><u>Issues:</u> Extreme alterations to natural flow regime, including its magnitude, timing, variation; channel narrowing and aggradation in NF; loss of floodplain storage in NF; promotion of aggradation in lower mainstem with loss of channel flow capacity; habitat simplification in NF (in-channel and off-channel); loss of lateral habitat connectivity in NF.<br><br><u>Processes:</u> Hydrologic processes; hydraulic processes; geomorphic processes | ▪ Characteristics of flow regime in NF over past 80 years not supportive of native Chinook life histories (loss or changes in queues and habitat conditions for adult migration, spawning, and fry migration)<br>▪ Losses in habitat quantity in NF due to extreme reductions in flow<br>▪ Severe aggradation in lower mainstem reduced habitat quantity and quality (creating more unstable conditions for egg incubation) -- effects have extended into the river mouth estuary | ▪ Dam construction and associated hydro-electric operations with water diversion out of basin | ▪ Re-creation of normative flow regime in the NF through change in how flows are regulated at Cushman Dam<br>▪ Regulation of high flows at Cushman Dam to promote channel scour and facilitate return to more normative conditions | ▪ More normative flow regime created by changes in regulation at Cushman Dam<br>– Base flow shape with spring runoff<br>– Variation to mimic freshets<br>– Extended high flows and bankfull flows to promote channel scour | ▪ Restore normative flow regime to promote channel and habitat reformation, channel flow capacity, and re-creation of normative queues for biological responses.<br>▪ Restore floodplain function and connectivity in the Skokomish River and tributaries.<br>▪ Restore the fluvial geomorphic processes in the watershed channels, channel form and function, and sediment movement. | ▪ Effectiveness (extent and rate) of new flow regime to restore channel characteristics and flow capacity in the NF and lower river.<br>▪ Effectiveness of new flow regime to remediate sediment deposits sufficiently or will other strategies be needed?<br>▪ Number of years needed to attain substrate and channel characteristics required to support viable life histories of naturally reproducing Chinook.<br>▪ Channel capacity in the lower Skokomish R. to handle Component 3 flows. |
| Loss of Fish Access to Upper North Fork and Inundation by Reservoir<br><br><u>Issues:</u> Cushman Project isolated anadromous fish habitat by not providing fish passage facilities, as well as inundating high quality stream habitat under the lake for both anadromous and resident fish.<br><br><u>Processes:</u> Watershed connectivity; hydrologic processes; geomorphic processes; hydraulic processes; ecological processes by inundation | ▪ Loss of access resulted in extirpation of spring Chinook in the NF<br>▪ Loss of accessibility for Chinook to re-colonize naturally<br>▪ Loss of a major portion of productive Chinook habitat in the Skokomish basin due to inundation by Cushman reservoirs | ▪ Dam construction without passage facilities<br>▪ Inundation of productive habitat by reservoirs | ▪ Fish passage for migrating spring Chinook<br>▪ Re-introduction and on-going supplementation of spring Chinook using artificial propagation methods | ▪ Trap and haul fish passage facilities for upstream passage of adult spring Chinook at Cushman Dam.<br>▪ Trap and haul fish passage facilities for downstream passage of juvenile spring Chinook at Cushman Dam.<br>▪ Implement sprng Chinook hatchery supplementation program (see Hatchery Chapter) | ▪ Provide for effective upstream and downstream passage of migrant salmonids at the Cushman dam sites<br>▪ Provide for conservation hatchery facilities within the North Fork subbasin to support an integrated population component of spring Chinook (see Hatchery Chapter) | ▪ Migration effectiveness of adult Chinook to base of lower Cushman Dam<br>▪ Trapping effectiveness of adult Chinook at the base of Cushman Dam<br>▪ Downstream passage effectiveness of juveniles through Lake Cushman and through the trapping facility<br>▪ Impact of loss of productive stream habitat through inundation, and ability of re-introduced population to perform with reduced habitat. |

**Table 4.10. (continued) Framework for habitat strategies.**

| Threat, Issues, Watershed Processes | Relevance to Chinook | Causes | Solutions | Strategies | Objectives | Critical Uncertainties |
|---|---|---|---|---|---|---|
| Degraded Lower Floodplain and Channel Conditions (in-channel, off-channel, riparian) (lower South Fork, lower Vance Cr, lower North Fork, mainstem Skokomish R)<br><br><u>Issues:</u> High sediment load; aggradation and shallowing; de-watering; loss of channel complexity; loss of LWD structure; decreased LWD recruitment; unstable sediments and channels; loss of connectivity (in-channel and off-channel); fish stranding; increased thermal loading; decreased biological productivity; reduced riparian functions; increased flood frequency.<br><br><u>Processes:</u> Geomorphic processes; hydrologic processes; hydraulic processes; connectivity; biological productivity; | ▪ Loss of adult migration, spawning, incubation, and juvenile habitat quality and quantity;<br>▪ Loss in Chinook performance at all life stages;<br>▪ Tremendously unstable spawning, egg, and fry habitats;<br>▪ Loss of adult Chinook access to South Fork;<br>▪ Juvenile stranding in dry channels;<br>▪ Loss in food diversity and quantity for juvenile Chinook.<br><br>Note: Instability does not apply to the lower North Fork. | ▪ Land clearing of valley bottoms for farming and settlement;<br>▪ Log-driving and channel clearing of logjams;<br>▪ Flow diversion from Cushman Dams out of basin;<br>▪ Wholesale logging of lower floodplains and uplands with increased sediment delivery;<br>▪ Glacial history and re-activation of paraglacial process;<br>▪ Levee and dike system and loss of channel migration potential;<br>▪ Aggradation of lower river channels;<br>▪ Loss of channel flow capacity. | ▪ Reduce anthropogenic sediment inputs;<br>▪ Restore sediment sorting processes<br>▪ Re-establish coniferous riparian forests having old-growth characteristics;<br>▪ Increase channel stability and complexity;<br>▪ Restore floodplain connectivity in response reaches;<br>▪ Improve forest hydrologic maturity;<br>▪ Arrest paraglacial processes that have been reactivated;<br>▪ Expand available channel migration zone (CMZ);<br>▪ Re-creation of normative flow regime in the North Fork;<br>▪ Regulation of high flows at Cushman Dam to promote channel scour and facilitate return to more normative conditions. | ▪ Extend CMZ through regulatory, incentive, and education programs;<br>▪ Strategically remove impediments to meander, avulsion and channel connectivity;<br>▪ Construct ELJs to restore channel complexity and sediment processes<br>▪ Strategically address key sediment deposits and install log jams to improve channel efficiency;<br>▪ Protect riparian lands through regulatory, incentive, and education programs;<br>▪ Restore effective riparian forest width;<br>▪ Restore riparian forest quality with conifer underplantings;<br>▪ Inventory and control invasives such as knotweed. | ▪ Restore upland landscapes and vegetation that improve and restores watershed form and function;<br>▪ Restore the fluvial geomorphic processes in the watershed channels, channel form and function, and sediment movement;<br>▪ Restore floodplain function and connectivity in the Skokomish River and tributaries;<br>▪ Protect riparian and floodplain corridor, in-channel habitat, water quality, and channel conveyance capacity from further degradation;<br>▪ Restore normative flow regime to promote channel and habitat reformation, channel flow capacity, and re-creation of normative queues for biological responses. | ▪ Sediment delivery rates from the upper South Fork;<br>▪ Amount of sediment and wood loading to come from the North Fork with implementation of new flow regime;<br>▪ Effectiveness of new flow regime to accelerate sediment routing and transport in the lower river valley;<br>▪ Effectiveness of strategies to arrest re-activated paraglacial processes in the South Fork;<br>▪ Appropriate level of channel conveyance and sustainability given how flow regulation will continue to occur and on-going land uses in the basin;<br>▪ Sufficient size of CMZ by reach;<br>▪ Sufficient level of woody debris and ELJ loading;<br>▪ Funding levels for restoration and recovery actions. |

**Table 4.10. (continued) Framework for habitat strategies.**

| Threat, Issues, Watershed Processes | Relevance to Chinook | Causes | Solutions | Strategies | Objectives | Critical Uncertainties |
|---|---|---|---|---|---|---|
| Degraded Estuarine and Near-shore Conditions<br><br><u>Issues:</u> Loss of tidal marshes and channels; decreased primary and secondary productivity; channel aggradation and loss of pool complexity; loss of non-natal estuarine habitats<br><br><u>Processes:</u> Tidal inundation; primary and secondary productivity; geomorphic processes; connectivity; near-shore drift-cell processes. | ▪ Loss of juvenile estuarine habitat quality and quantity;<br>▪ Loss of biological productivity to supply abundant food for young salmon;<br>▪ Reduced distribution and frequency of suitable non-natal estuarine habitats to provide stop-over feeding sites and refuge from predators;<br>▪ Aggradation of the river-mouth estuary and reduced tidal prism contributing to the many changes in channel condition upstream of the estuary (due to “plugging” effect of the estuary by aggradation). | ▪ Levee construction;<br>▪ Filling and road building;<br>▪ Ditching;<br>▪ Vegetation conversion;<br>▪ Increased coarse sediment load;<br>▪ Decreased channel efficiency;<br>▪ All of the factors listed under the other threats associated with sediment routing and delivery, flow regime characteristics, and channel characteristics. | ▪ Increase and improve tidal inundation;<br>▪ Improve local channel complexity and conveyance;<br>▪ See sediment load and delivery solutions listed under the other threats;<br>▪ Restore and protect non-natal estuarine habitats. | ▪ Remove levees and landfill;<br>▪ Fill borrow ditches;<br>▪ Rip compacted road beds;<br>▪ Excavate tidal channels where needed;<br>▪ Strategically address key sediment deposits and install log jams to improve channel efficiency;<br>▪ Restore and protect non-natal stream deltas, tidal embayments, and beaches;<br>▪ Other strategies associated with restoring sediment routing and a normative flow regime. | ▪ Restore nearshore habitat, the estuary, and associated floodplain habitat and function;<br>▪ Restore flow conditions monitor habitat forming flow regimes and channel geometry;<br>▪ Restore the fluvial geomorphic processes in the watershed channels, channel form and function, and sediment movement. | ▪ Sediment delivery rates from the upper South Fork and how these affect aggradation in the estuary;<br>▪ Amount of sediment and wood loading to come from the North Fork with implementation of new flow regime and how these will affect aggradation in the estuary;<br>▪ Effectiveness of new flow regime to accelerate sediment routing and transport in the lower river valley and through the estuary;<br>▪ Appropriate level of channel conveyance and sustainability given how flow regulation will continue to occur and on-going land uses in the basin;<br>▪ Long-term constraints placed on estuary restoration by electric infrastructure;<br>▪ Extent and type of non-natal estuarine habitats needed to be restored. |

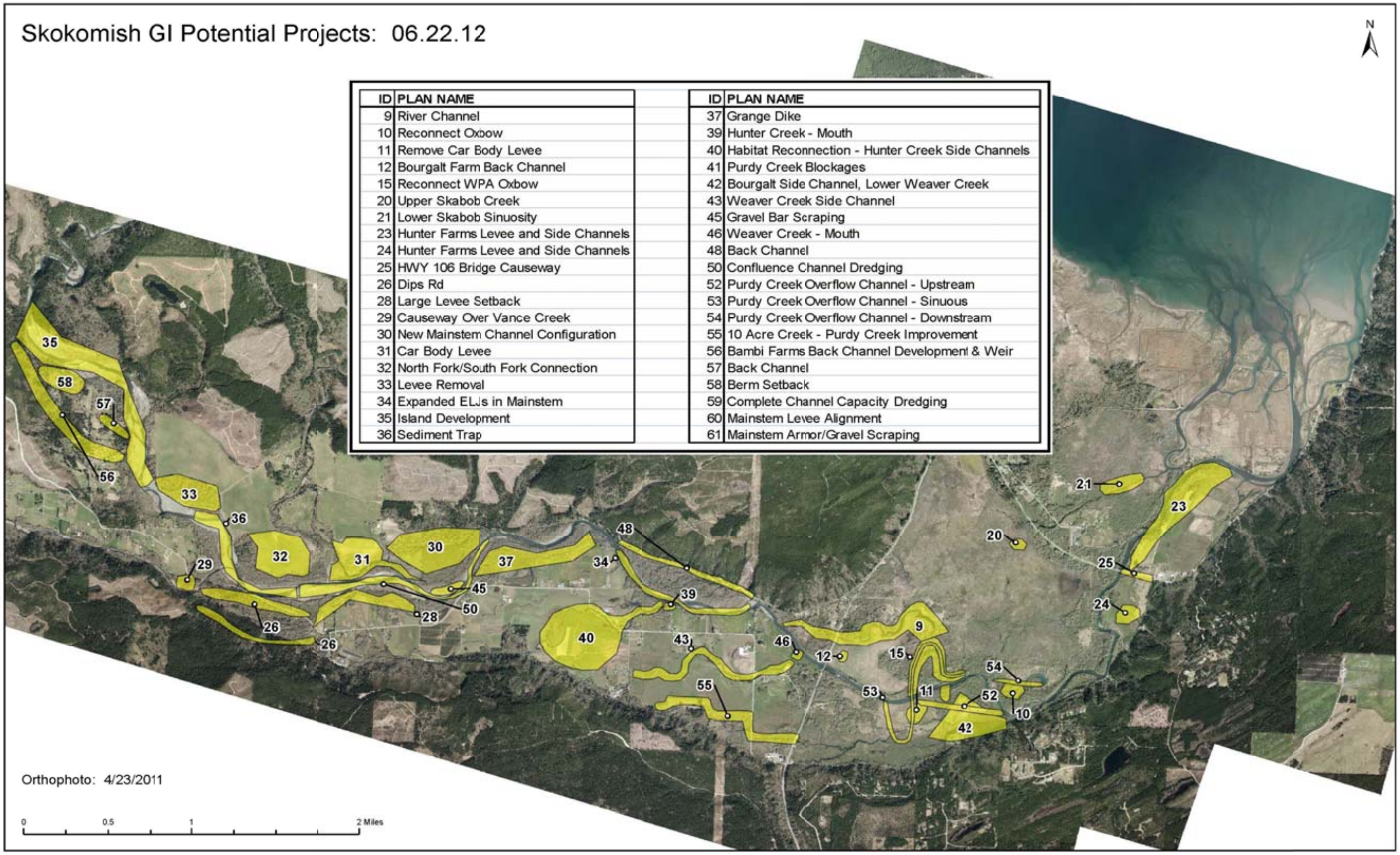



**Figure 4-20. The top forty sites and actions that were analyzed for costs and benefits as part of the USACE General Investigation (GI).**

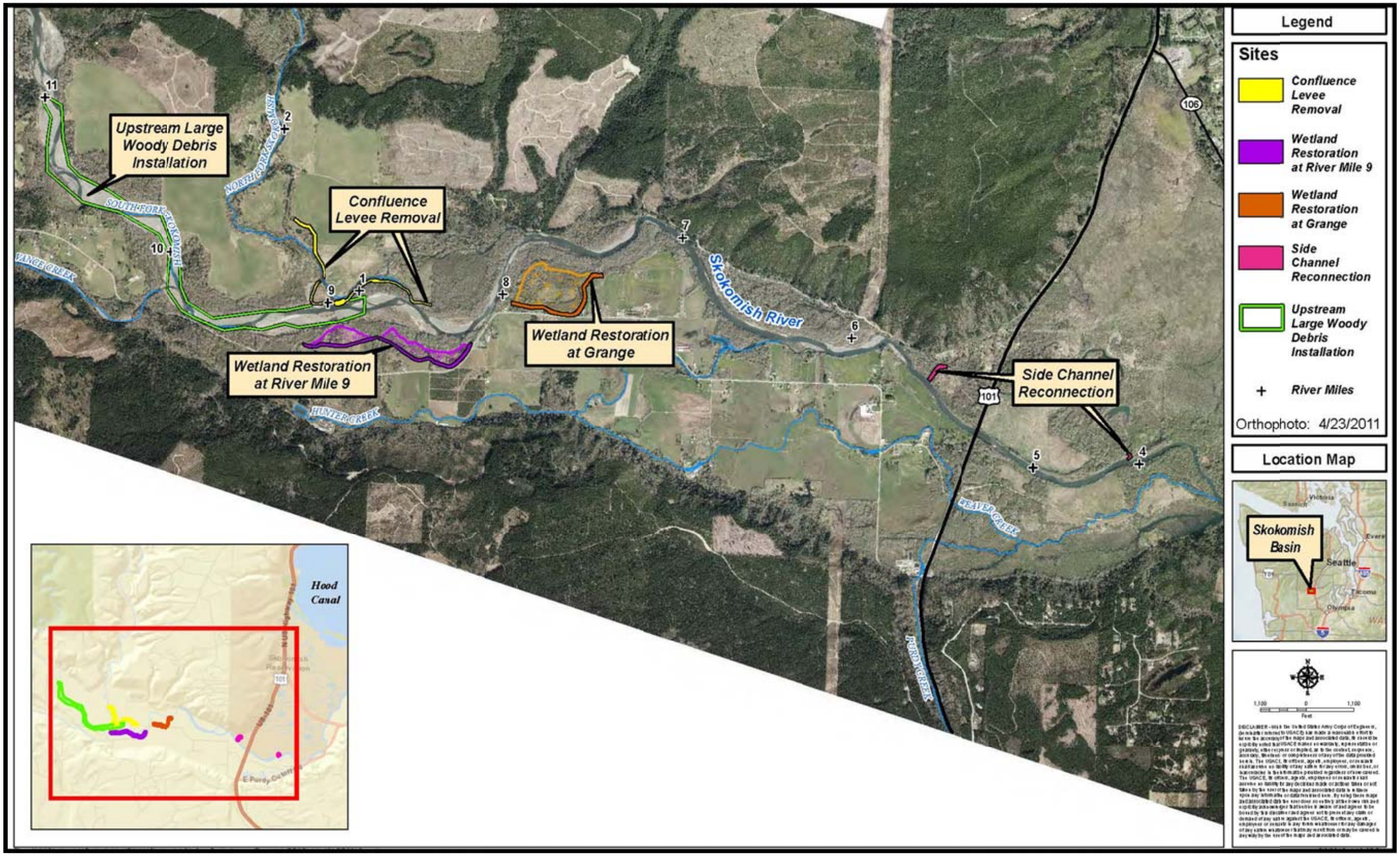



**Figure 4-21. The top five sites and actions that were analyzed for costs and benefits as part of the USACE General Investigation (GI). These five projects are being advanced for congressional funding.**

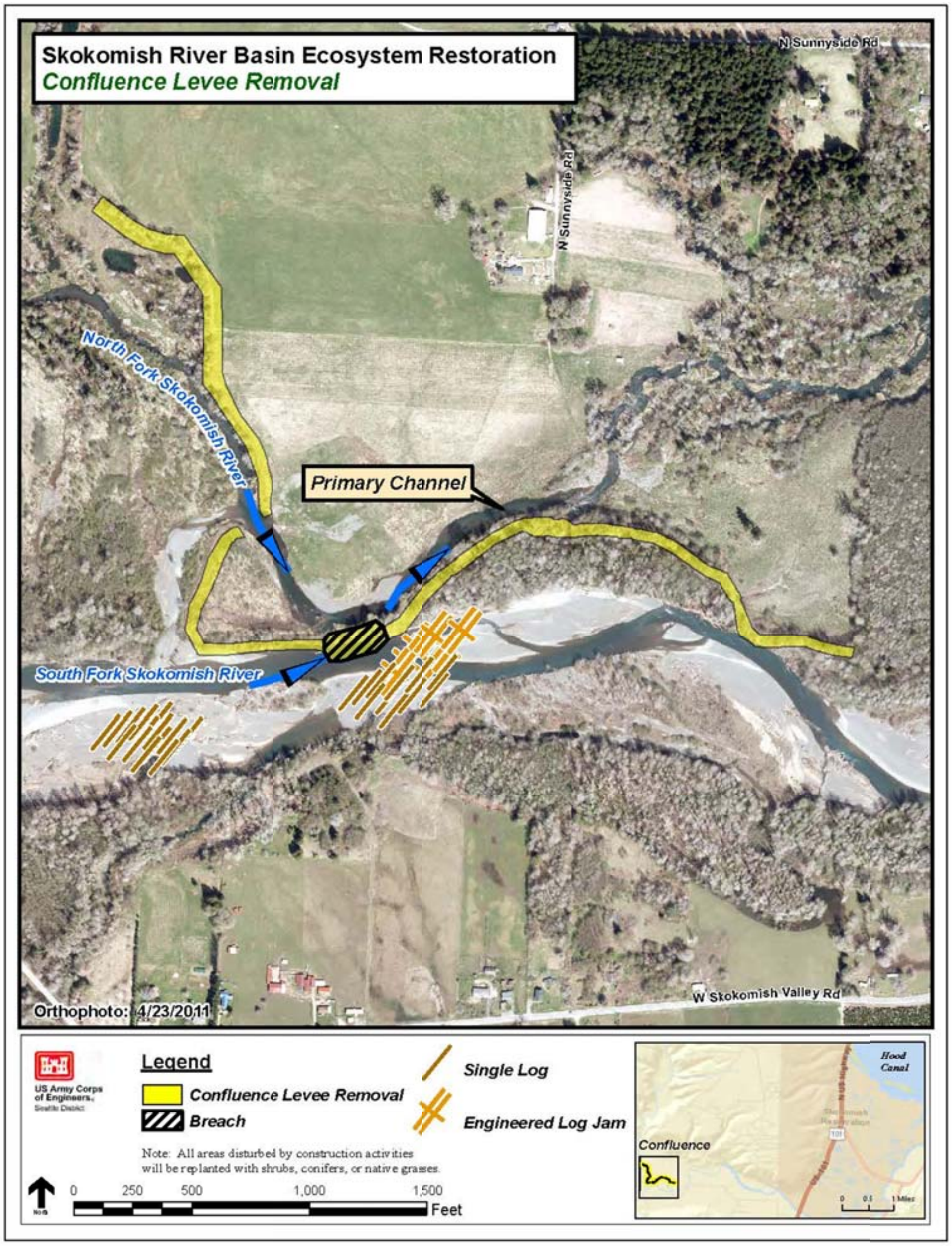



**Figure 4-22. Confluence Levee Removal action.**

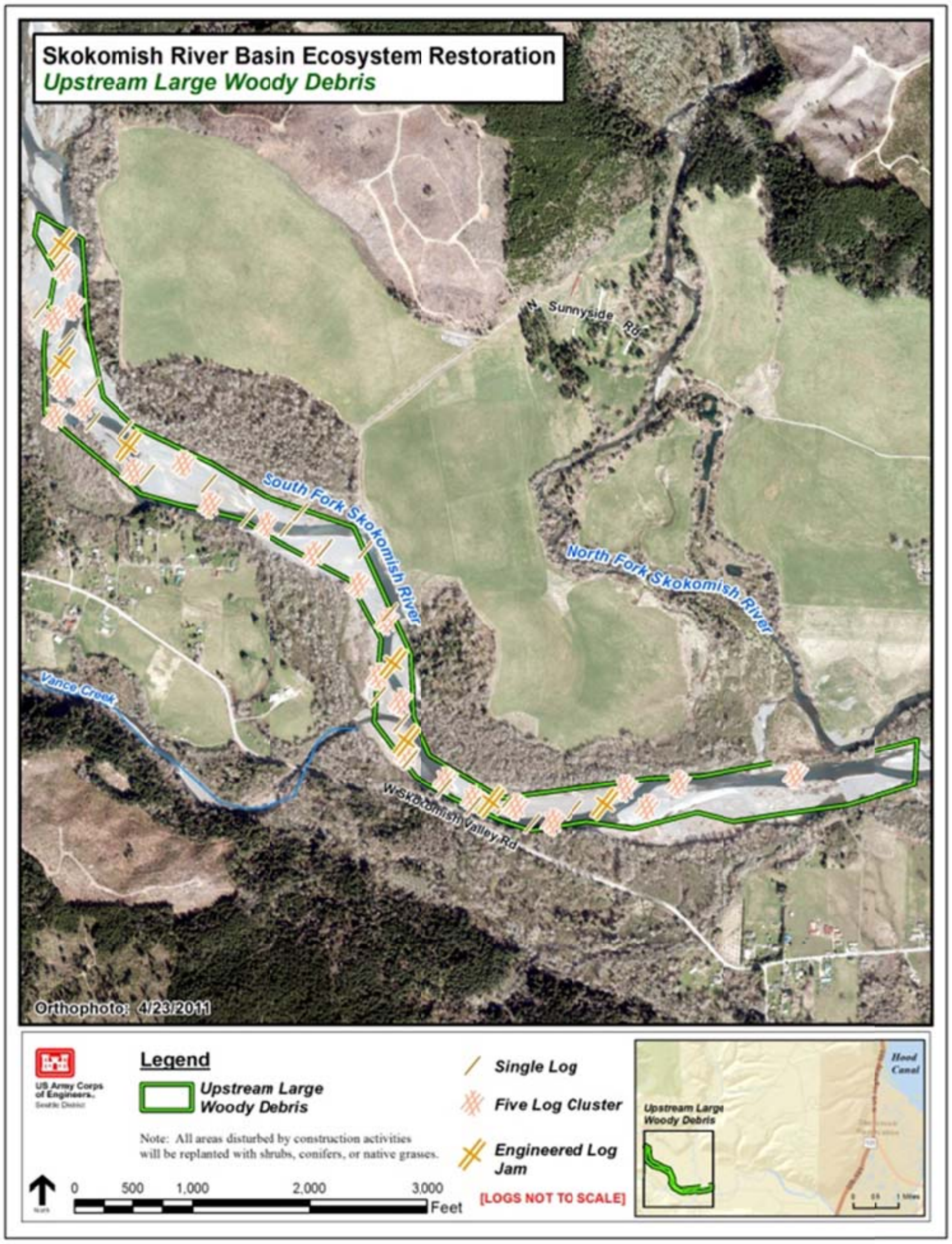



**Figure 4-23. Upstream Large Woody Debris action.**

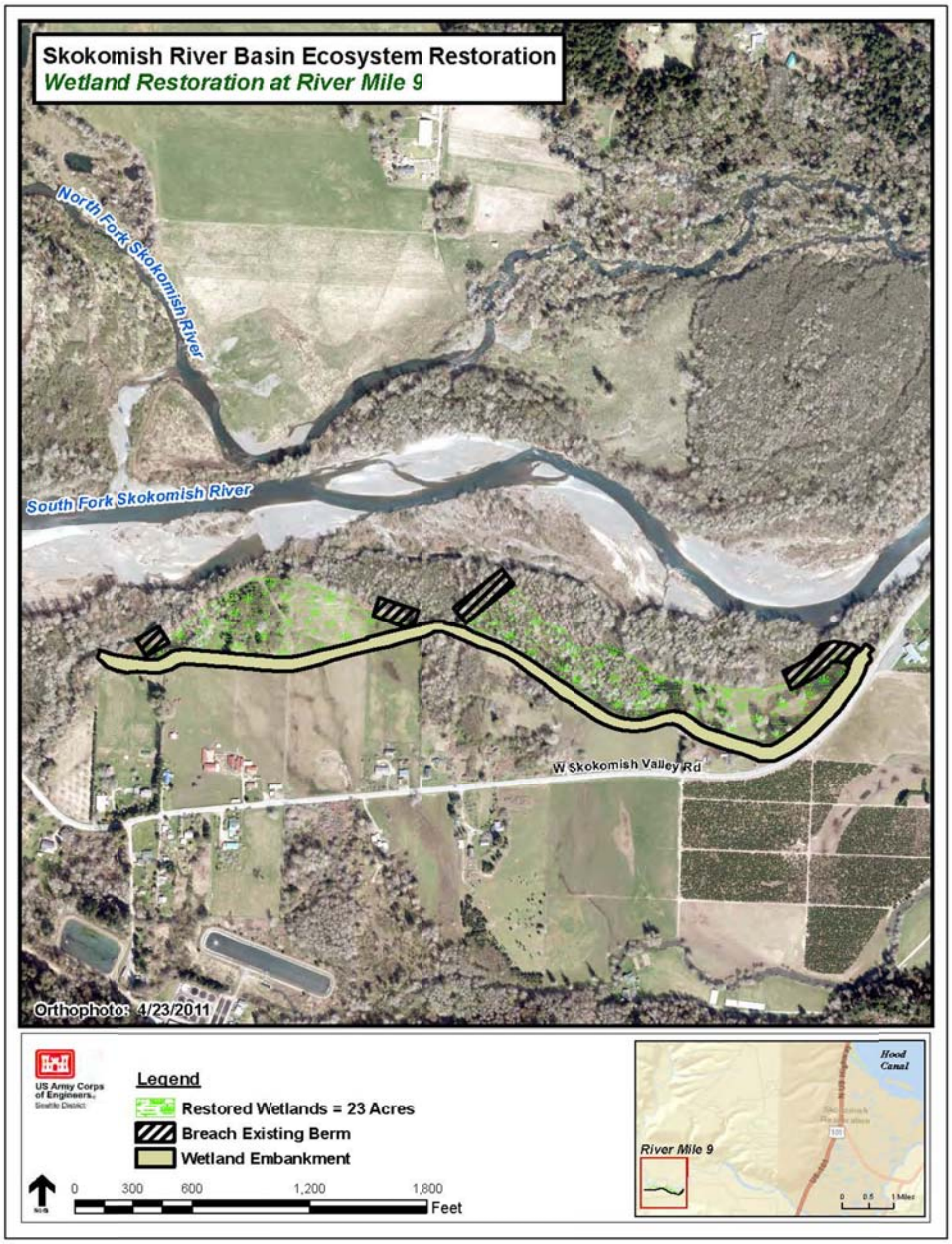



**Figure 4-24. Wetland Restoration at River Mile 9 action.**

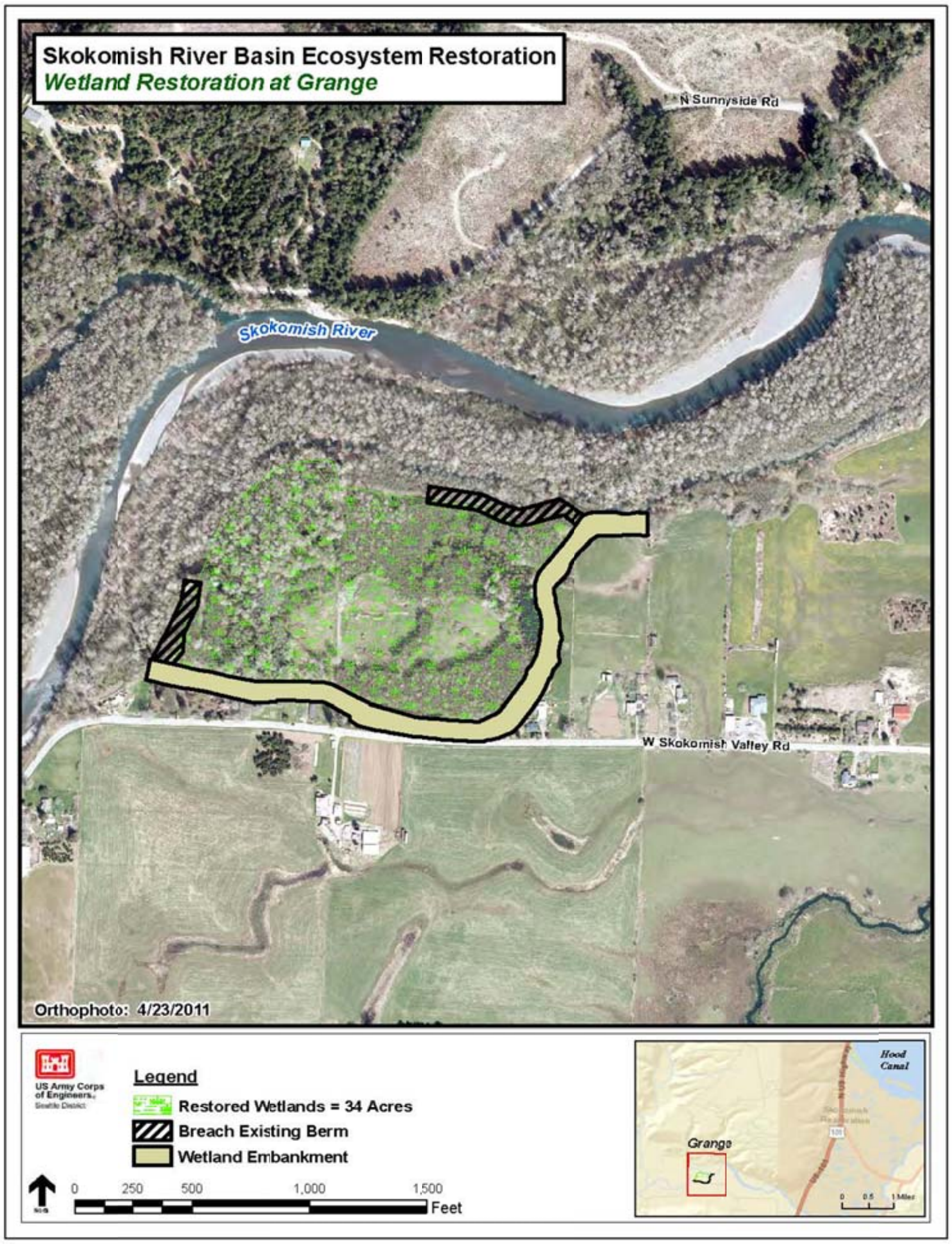



**Figure 4-25. Wetland Restoration at Grange action.**

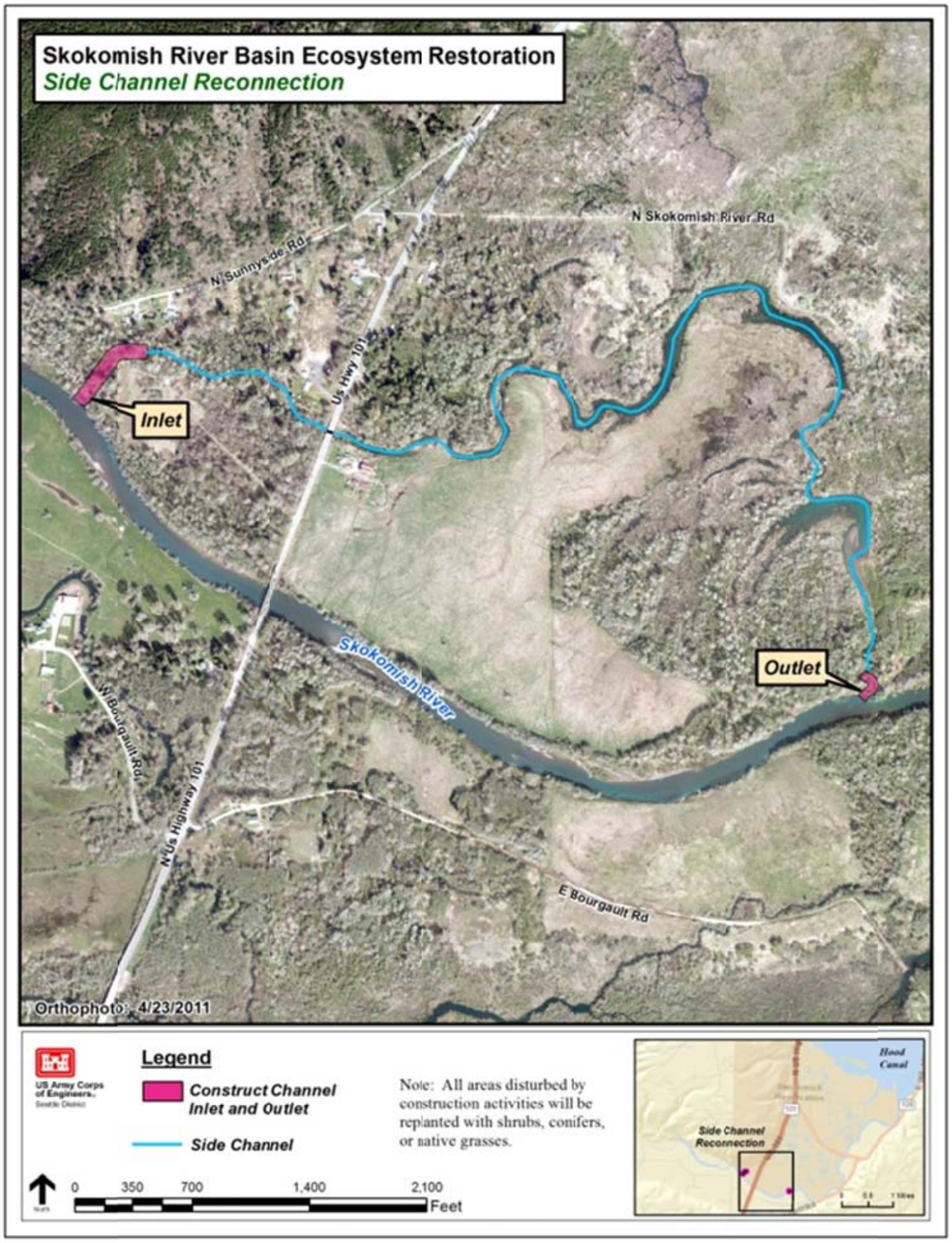



**Figure 4-26. Side Channel Reconnection action.**

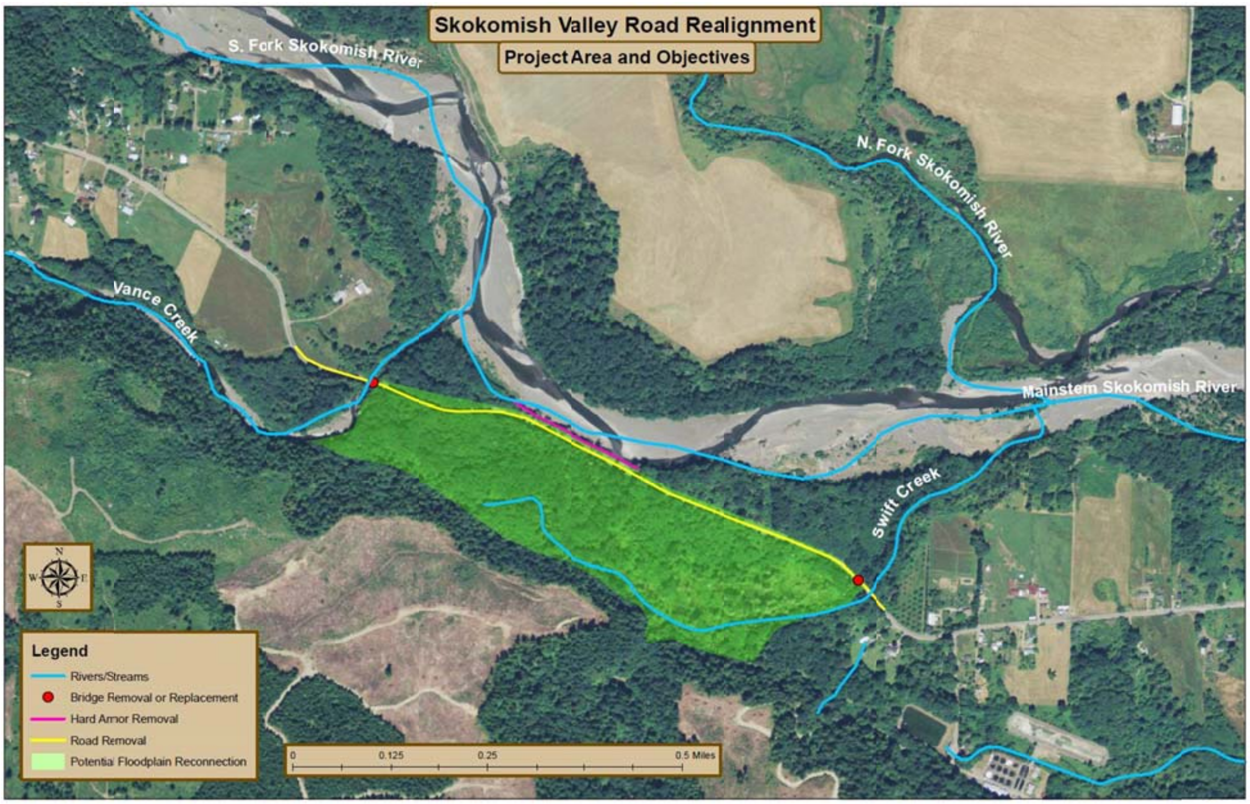



**Figure 4-27. West Skokomish Valley Road Relocation project, a high ranking project that needs local funding to move forward.**

## 4.4 Habitat Goals

Desired future condition targets for habitat characteristics provide measureable objectives for the watershed restoration. Properly Functioning Conditions (PFC) were used in Chapter 3 to identify ambitious goals that the recovery plan should ultimately strive for. Across the Puget Sound ESU, where PFC has been applied in EDT modeling, the resulting Chinook performance averages about 70-80% of the estimated historic abundance, which may be overly ambitious in many rivers. For the Skokomish watershed, we considered two analyses to set habitat targets.

As part of the General Investigation, the USACE performed an ecosystem services analysis to evaluate the 60 actions considered as part of the overall evaluation (Klimas et al. 2015). Habitat metrics and target conditions used in the analysis are shown in Table 4.11. The actions under consideration were scored by the team doing the analysis against these targets based on expert judgment and a modeling procedure. The targets served as a set of reference conditions against which the actions could be uniformly scored, but it was recognized that they were overly ambitious to serve as realistic targets for the restoration plan as it was being developed (Nancy Gleason, USACE, *personal communications*). We conclude that the targets in Table 4.11 are comparable to PFC goals—they reflect broad-sense goals for habitat conditions that the co-managers would ideally like to achieve. But these goals are likely overly ambitious as realistic targets within the foreseeable future on a watershed scale, particularly in light of climate change projections.

**Table 4-11. Habitat assessment metrics and target conditions used by the USACE in evaluating actions as part of the General Investigation (from Klimas et al. 2015).**

| Assessment metric | Parameters or other notes | Baseline condition (overall) | Target condition |
|---|---|---|---|
| **Pool habitat 1/** | Number of pools greater than 1-meter depth, good cover, and cool water | Less than 35% of surface area is pool habitat | Pool to riffle ratio of 1:1, or 40-60% surface area in pools |
| **Large woody debris 2/** | Pieces of LWD per meter of channel length | Less than 0.2 pieces of LWD per meter | 75th percentile of natural conditions; 0.6 LWD pieces per meter |
| **Riparian cover 3/** | Species composition, average stand diameter, density, width | High impact (poor) conditions for 62% of the mainstem and 32% of Vance Creek; riparian buffers less than 66 feet wide; 30-70% canopy cover | 150-foot riparian buffer width, with 100% canopy cover |
| **Floodplain connectivity / access 4/** | Percentage of aquatic habitat remaining connected to the mainstem | General floodplain access has less than 50% connection; certain sites have no connection | 100% connection |
| **Channel capacity 5/** | Frequency of overbank flow at specific discharge return interval; fish survival | Overbank flows typically four times per year; correlation between aggradation and reduced egg-to-migrant survival with likely 33% reduction in Skokomish | Two-year flow capacity within bankfull width (suggested to be 17,000 cfs) |

1/ Peters et al. (2011)
2/ Peters et al. (2011) and Fox et al. (2003)
3/ WDFW and PNPTC (2000)
4/ Correa (2003)
5/ Beamer et al. (2005)

We requested that Natural Systems Design, Inc. (NSD) formulate a set of target conditions for the Skokomish river based on its analysis presented in NSD (2017) (see Appendix A in this plan). The target conditions needed to be defined using metrics that could be evaluated with the types of monitoring that will likely be available or could readily be available at a specified future date. The targets were to be developed to address the limiting factors identified in the 2010 Plan (as also seen in Table 4-10 in this document). The targets were to be formulated for two time horizons: 20 years and 100 years from now.

The 20-year time horizon is consistent with the planning horizon that guides this plan with respect to the summer/early fall Chinook population (George Adams hatchery derived).

Table 4-12 summarizes the habitat goals for physical attributes of the natural environment to be used as targets for this plan. These targets are useful for the lower river, South Fork, lower North Fork, and Vance Creek.

Water temperature goals are to at least maintain the temporal and spatial patterns seen in Figure 4.8, that is, water temperatures should not increase to levels higher than those shown in the figure. Climate change is projected to increase air temperatures significantly before the end of the century (Mauger et al. 2015). The actions that are proposed as part of this plan, if implemented fully, should serve to offset those increases.

The passage goal for the South Fork gorge is to achieve passage with minimal injuries or mortality for spring Chinook during their upstream adult migration window.

Goals for upstream and downstream passage at the Cushman Dams are to fully achieve the standards set forth in the license articles for the dams.

**Table 4-12. Twenty and 100-year planning targets for habitat conditions in the Skokomish watershed. From NSD (2017) (Appendix A in this plan).**

| Metric | Units | Average current conditions | | | 20 year targets | | 100 year targets | |
|---|---|---|---|---|---|---|---|---|
| | | South Fork | Avulsion | Mainstem | Target | Rationale | Target | Rationale |
| Large wood jam frequency | Jams/mile | 3.3 | 8.2 | 2.1 | **8** | Comparable to avulsion reach<br>20% of reference | **22.5** | 75% of Queets Reference |
| Pool frequency | Pools/mile | 4.6 | 21.0 | 7.3 | **20** | Comparable to avulsion reach | **34.6** | Additional pools from stable wood jams |
| Pool surface area percentage | % Total wetted area | 10% | 20% | 20% | **20%** | Comparable to avulsion reach | **29%** | Same ratio as current avulsion reach (17%/21 pools/mile) |
| Pool depth | Average depth (ft.) | 2.8 | 3.7 | 4.1 | **4** | Comparable to avulsion reach | **4** | Comparable to avulsion reach |
| Width to depth ratio | -- | 144.3 | 39.6 | 49.6 | **40** | Comparable to avulsion reach | **40** | Comparable to avulsion reach |
| Net Sediment Flux | $Yd^3$ | -259,000 | 60,500 | -80,100 | **n/a** | Unknown given continued re-establishment of equilibrium and change in channel form | **0** | Sediment equilibrium reached within valley |
| Side channel to main channel ratio | -- | n/a<br>(no side channels) | 0.43 | n/a<br>(no side channels) | **1** | At least 2 dominant flow pathways | **2** | At least 3 dominant flow pathways |
| Channel Morphology | % Anabranching | 0 | 55% | 0 | **55%** | Comparable to avulsion reach | **75%** | Almost full recovery of relic morphology |

# Chapter 5. Hatchery Recovery Strategies

Hatchery technology is an essential tool for recovering Chinook life histories adapted to the environmental conditions being restored to the Skokomish watershed. Habitat restoration and hatcheries, operating in unison, are mutually necessary to achieve both the short- and long-term recovery goals for the watershed. Hatchery actions are needed to re-establish spring Chinook in the watershed, redevelop a later returning population segment of the extant summer/early fall Chinook population to aid in potentially recovering a fall-timed population, and to help ensure the maintenance of treaty-protected and non-treaty fisheries. This chapter describes the ways in which hatcheries will be employed to achieve these goals.

Three primary hatchery facilities relevant to this chapter are located in the Skokomish watershed or nearby vicinity, in addition to several other smaller facilities that have had some role in the operations either in the recent past or continuing into the future. The primary facilities are:

- George Adams Hatchery (WDFW facility);
- Hoodsport Hatchery (WDFW facility); and
- North Fork Skokomish Hatchery (City of Tacoma facility).

This chapter is organized into the following sections:

5.1 The role of hatcheries in recovery;

5.2 Hatcheries – past and present;

5.3 Hatchery management objectives;

5.4 Strategy implementation; and

5.5 Benefits and risks of hatchery strategies.

## 5.1 The Role of Hatcheries in Recovery

A fundamental hypothesis of this plan is that restoration of habitat forming processes will provide the habitat needed for the re-expression of successful Chinook life histories, allowing the species to recover to viable levels (Chapter 1). No indigenous, locally adapted Chinook Salmon exist in the Skokomish watershed currently (Myers et al. 1998, Ruckelshaus et al. 2006). Consequently, just as active restoration of habitat forming processes is necessary, active restoration of demographic processes using artificial production[13] can increase the likelihood and pace of re-establishing adapted Chinook life histories compared to passive management, which relies entirely on natural recolonization and adaptation. To be successful, however, the appropriate sequencing, timing, location, and magnitude of hatchery actions combined with habitat recovery needs to occur. Success also means providing ecosystem services, such as harvest, and other benefits to the people investing in these choices.

Habitat restoration is the cornerstone to Chinook recovery, but rehabilitating degraded natural processes that create and sustain critical habitat may take 50 to 100 years or more to attain full

[13] / Tools of artificial production include translocation and reintroduction; choice and control of brood stock and spawning; management of fish parasites and diseases, growth, and behavior through rearing conditions; time, location, size and status of fish released into the wild; and monitoring.

benefits. While habitat-forming processes and associated habitat functions are being restored, hatcheries can continue to have an essential role in managing and protecting the resources of the watershed (Figure 1.3, Chapter 1). Hatcheries provide ways of maintaining or increasing abundance and distribution of salmon, reintroducing stocks or species, and providing for harvest. Salmon can respond quickly to hatchery actions but the results may not be sustainable without continued hatchery production. In contrast, habitat recovery can restore ecosystem processes that form and sustain salmon life histories and salmon populations, but the results often require long periods of time to achieve. Using hatcheries and habitat recovery in unison can be an efficient and successful approach to achieving the short- and long-term goals for the watershed than using either one alone.

Using hatcheries in salmon recovery requires a fundamental reassessment of how habitat restoration, harvest, and hatcheries are managed and sequenced as a whole. Chapter 8 of this plan briefly reviews these concepts and how these different sectors might be adaptively managed to avoid the pitfalls of the past.

## 5.2 Hatcheries – Past and Present

In Hood Canal and the Skokomish River, as in many other areas, hatcheries were both a response to and a cause of the decline in wild salmon. Beginning in the late 19th century, increased fishery harvest on the populations, which had not been heavily exploited before, combined with an escalating loss of salmon habitat in watersheds resulted in the decline of wild salmon. Hatchery production appeared to provide an easy way to mitigate for lost natural production, and many new hatcheries were constructed to supplement fisheries (Lichatowich 1999). A pattern of increasing hatchery production accelerated the extinction of locally adapted wild populations as hatchery fish replaced wild fish in the rivers. Releases of large numbers of hatchery fish compared to lower abundances of wild fish, for example, led to harvest rates focused on the more abundant hatchery fish, resulting in the over harvest of wild populations (Hilborn 1985; Kope 1992). Where harvest rates were less aggressive, large numbers of hatchery fish escaped the fisheries and exacerbated genetic and ecological effects on wild populations.

Large numbers of hatchery produced juvenile Chinook have been released into the Hood Canal basin since the early 1950s (Myers et al. 1998). Releases have been made into most of the major rivers and streams of the basin. Although locations of releases included areas that did not historically support Chinook populations, most releases were focused on the Skokomish River and mid-Hood Canal (Figure 5.1) where historical populations of Chinook Salmon existed (Ruckelshaus et al. 2006).

Sources for brood stock for fish released in the Hood Canal basin have varied, including stocks from the Trask River (Oregon), Elwha, and Dungeness rivers and hybrid stocks, one from Soleduck Hatchery and a second derived from interbreeding Nooksack, Cowlitz, and Umpqua River (Oregon) stocks (Myers et al. 1998, Fuss and Ashbrook 1995). The large majority of releases into Hood Canal streams, however, have been of Green River-origin (Puget Sound) Chinook, which was originally a late-returning stock (fall-timed) that has been under culture since 1901. This hatchery stock has been used throughout large parts of Puget Sound, although often under different names (Fuss and Ashbrook 1995). Green River-origin Chinook are now a much earlier returning stock than the original source population due to long-term domestication effects (Quinn et al. 2002; Chapter 2 in this plan).

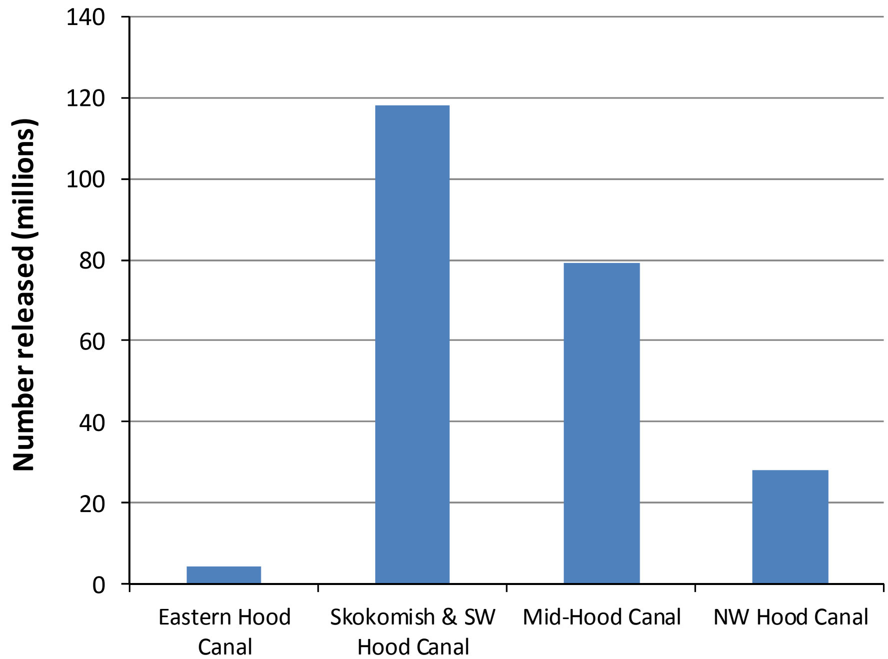



**Figure 5-1. Numbers of Chinook released into Hood Canal rivers and streams prior to listing under the Endangered Species Act. Data are from Myers et al. (1998). Note: Hoodsport Hatchery releases are grouped with Mid-Hood Canal in the figure.**

The major hatchery facilities that have had or currently have a significant role in the artificial production of Chinook in the Hood Canal region are described briefly here. Detailed descriptions of goals, objectives, operational practices, and monitoring associated with the major facilities are contained in the associated hatchery and genetic management plans (HGMPs 2002); the HGMP is in review for the North Fork Hatchery.

*George Adams Hatchery.* WDFW owns and operates the George Adams Hatchery located at RM 1.0 on Purdy Creek, a tributary to the lower Skokomish River. The facility was constructed in 1960 and enlarged to its current size in 1977. The physical layout spans 31 acres and relies on raceways and rearing and release ponds for production. The facility produces around 3.8 million Chinook subyearling fingerlings annually by collecting and spawning returning George Adams brood stock, incubating the eggs, rearing the juveniles, and then releasing them into Purdy Creek. The George Adams Fall Chinook Program uses an integrated production strategy (HSRG 2014). The brood stock was originally derived from Green River origin Chinook Salmon. As explained later in this chapter, the program now includes a component to experimentally extend the latest segment of returning fish later into September and October.

*Hoodsport (Finch Creek) Hatchery*. The Hoodsport Hatchery is located at the mouth of Finch Creek in Hoodsport, approximately five miles north of the Skokomish River estuary. This WDFW facility covers slightly over 4 acres situated on the shoreline of Hood Canal. It contains an incubation building and 17 raceways of different sizes. The program has been rearing and releasing Chinook Salmon fingerlings since 1953 and yearlings of the same stock since 1995. Like the George Adams Hatchery, the brood stock at the Hoodsport facility was originally derived from Green River origin stock. The hatchery is operated as a segregated hatchery program and therefore no natural-origin returns are incorporated into the brood stock. The program releases 3.0 million subyearling fingerlings and 120,000 yearlings directly to Hood Canal to provide harvest opportunities. Releases occur after April 1 to minimize predation or competition with ESA-listed wild Hood Canal summer chum salmon. The program is able to meet the expected standards of a segregated (isolated) harvest program. It bears noting that the timing of adult returns back to the facility is approximately the same as the adult return timing to the George Adams facility. The Hoodsport Hatchery does not have a role in the recovery of Chinook in the Skokomish River, though it has an important purpose in supporting both treaty and non-treaty fisheries in Hood Canal and areas beyond Hood Canal.

*North Fork Skokomish River Salmon Hatchery*. In 2016 Tacoma Power completed construction of a new hatchery facility along Lake Kokanee, the reservoir formed by the lower Cushman Dam. The hatchery is operated by Tacoma Power, in cooperation with WDFW and the Skokomish Tribe. A primary purpose of the hatchery is to support the re-establishment of spring Chinook to the North Fork upstream of the Cushman Dams. The facility has a key role in the reintroduction of the species first to the North Fork, then subsequently to the South Fork. As the program becomes established with the return of both hatchery-origin and natural-origin fish, it will evolve to become an integrated program as defined by the HSRG, incorporating returning natural-origin fish into the broodstock and controlling the proportion of hatchery fish spawning naturally in the upper North Fork. The donor stock being used to begin the program was derived originally from wild Skagit River spring Chinook, which is now being propagated at Marblemount Hatchery in the Skagit River system. The first release of juveniles into the North Fork occurred in summer 2016 with the release of yearling smolts (brood year 2014). The on-going program calls for an annual release of 300,000 subyearling fingerlings and 70,000 yearlings.

*Other Hatchery Facilities*. Two other hatchery facilities warrant mention here: the Long Live the Kings (LLTK) facility on lower Lilliwaup Creek and McKernan Hatchery on Weaver Creek in the lower Skokomish River valley. The facility on Lilliwaup Creek, owned and operated by the nonprofit organization LLTK, is located approximately nine miles north of the Skokomish River estuary. The hatchery was used for egg incubation and juvenile rearing for the spring Chinook donor stock eggs and fry from brood years 2014 and 2015 while the North Fork Skokomish River Hatchery was still under construction. The McKernan Hatchery is a satellite facility to George Adams Hatchery and is located two miles to the west on Weaver Creek, a tributary of the Skokomish River. The McKernan facility has a role in supporting hatchery production of the late-timed segment of the George Adams Chinook population to be used in extending the run timing of this segment.

## 5.3 Hatchery Management Objectives

This chapter focuses on four objectives for hatcheries for achieving the goals for Chinook recovery in the Skokomish watershed:

1. Reintroduce spring Chinook sequentially to the upper North Fork and then into the upper South Fork of the Skokomish River;
2. Maintain genetic diversity and abundance of spring Chinook in the river system while promoting local adaptation of the introduced fish in the basin using conservation hatchery principles and tools;
3. Manage genetic diversity and composition of the extant, George Adams Hatchery summer/early fall Chinook population to achieve the following:

a. Reduce or eliminate the continued advance of run entry and spawning timing of the population, particularly reducing or eliminating the June and July run entry segment of the population;

b. Stabilize the core run entry timing mode to maintain an August run entry timing; and

c. Extend and enhance the latest run entry timing segment of the population, i.e., the September and October segment, and facilitate increased natural spawning of this segment into the lower North and South forks and Vance Creek.

4. Continue providing for harvest even after such time as natural production produces a stable, self-sustaining population.

### Objective 1: Reintroduce spring Chinook Salmon

This objective provides for reintroducing a true spring-run Chinook stock into the watershed, first into the upper North Fork, then into the upper South Fork. The reintroduction program is being managed under a four-phased framework as outlined in Chapter 3.

Re-establishing spring Chinook to the Skokomish River is intended to increase the diversity, abundance, and spatial distribution of Chinook in the watershed, the region, and the ESU. Historically, annual returns of Chinook to the Skokomish River included both spring and fall Chinook, each having distinctive river entry timing patterns and spawning distributions in the watershed (see Chapter 2). Although both racial components with life history characteristics as they historically existed have been extirpated from the river, the extant summer/early fall population was derived from a fall-timed run from Green River—hence that genetic stock, albeit altered by hatchery domestication, is now well established in the lower watershed. In contrast, the spring-timed population component that existed in the upper watershed historically was completely extirpated—until now. In 2016 and 2017, hatchery produced juveniles of a true spring-timed run (Skagit River stock) were released into the North Fork as part of Phase 1 of the reintroduction program. The reintroduction will continue for enough years to establish a return of fish back to the North Fork Hatchery to develop a locally adapted brood stock. The effort will then focus on reintroducing fish into the upper North Fork for natural spawning, and subsequently to reintroduce fish to the upper South Fork.

### Objective 2: Maintain genetic diversity and abundance of spring Chinook Salmon

This objective focuses on ensuring that the abundance and characteristics of spring Chinook used for reintroductions in the North and South forks remain adequately supported to continue progress towards the recovery goals. Although reintroduction of Pacific salmon and trout to areas where they have been extirpated is a goal of many recovery plans throughout western United States, it has yet to be tried in enough places for general concepts, tools, and strategies to be tested, proven, and refined. Uncertainty is high and setbacks are likely. Genetic diversity is essential to allow populations to adapt to new and changing environmental conditions. The choice of a donor stock with the genetic diversity for life history traits (e.g., migration-timing, disease resistance, size, etc.) that will most likely succeed in the new environment is a critical decision in the process. Also, reintroduction is usually not a single event but a phased process that necessarily continues to rely on hatchery technology for a prolonged period. Consequently, continued hatchery operations are an important part of maintaining genetic diversity and sufficient abundance. Therefore, continued hatchery production in the North Fork will be necessary to sustain the reintroduction efforts and develop an integrated (incorporation of natural-origin fish) brood stock. It is recognized that sufficient hatchery production will be needed to compensate for difficulties that may be encountered due to fish passage issues through the dam and reservoir and the limited amount of available habitat upstream of the upper reservoir. The reintroduction effort in the Skokomish River is a four-phased program (outlined in Chapter 3).

#### Objective 3: Manage genetic diversity and composition of the extant summer/early fall Chinook Salmon population to minimize conflicts with spring Chinook, support harvest, and facilitate potential recovery of late-timed natural production

This objective calls for 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/early 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) experimentally 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 population.

#### Objective 4: Continue to provide for harvest

This objective recognizes that appropriate management of the extant, non-native George Adams and Hoodsport hatchery stocks can maintain harvest in the Skokomish River and Hood Canal, while minimizing potential risks to recovery of spring Chinook Salmon and facilitating an extension of the latest river entry timing segment to foster improved natural production.

Hatcheries can provide salmon for harvest benefits when the ecosystem has been too degraded to provide those services or while the rehabilitation of the ecosystem to provide necessary natural production for harvest progresses. In this regard hatcheries are especially important in meeting tribal treaty obligations. The 1974 landmark court case *United States* v. *Washington* established that without salmon the treaty rights established between the tribes and the United States government cannot be met and that hatchery fish must be included in meeting treaty rights. In the Skokomish watershed, for example, a conscious decision was made to compensate for the dramatic loss of habitat and natural production, especially on the North Fork Skokomish, by introducing a non-native stock and using artificial propagation to provide fish for harvest.

Because of treaty obligations, hatchery and harvest management is now the shared responsibility of the tribal and Washington state co-managers. The co-managers may choose to use the tools of harvest and hatchery management to help natural salmon populations, but until these populations recover to levels that meet treaty and other legal obligations for harvest, hatchery production will fill that role in a way that complements salmon recovery efforts.

## 5.4 Strategy Implementation

Hatchery strategies/actions are grouped according to how they address the strategic objectives. We treat them, therefore, as four separate strategies aimed at achieving the objectives identified above. Some aspects of these strategies depend on what is learned in earlier phases. In these cases, the chapter describes the steps and analyses. Details of other actions are included in other planning documents such as hatchery and genetic management plans (HGMPs) and the Cushman Settlement Agreement.

### Strategy 1: Reintroduce spring Chinook Salmon

This strategy is a program to re-establish spring Chinook in the North and South forks of the Skokomish River. The reintroduction program is being managed under a four-phased framework as outlined in Chapter 3.

Reintroduction using translocation is a key tool in conserving and recovering many species worldwide (IUCN 1998). Efforts to reintroduce salmon to parts of their historic range are underway in many regions of the Pacific Northwest, including large rivers and tributaries of the Columbia River, the Puget Sound, and the upper Klamath and San Joaquin rivers in California.

The initial focus of the program is to reintroduce spring Chinook Salmon in the North Fork. After re-establishment is underway and clearly progressing, reintroduction will expand to the South Fork to increase overall spatial structure and carrying capacity in the watershed. The North Fork is the first focus because it historically provided the most suitable hydrology and habitat for spring Chinook in the watershed (SIT and WDFW 2010), and the Cushman Settlement provided the initiative, funding, fish passage provisions, and a new hatchery facility to move forward in the North Fork.

To address this objective, Tacoma Power completed the new hatchery facility along Lake Kokanee in 2016, just upstream from the lower Cushman Dam. After five years of planning and construction of the facility, spring Chinook from the Skagit River were released into the North Fork in 2016 (brood year 2014) as part of the initial reintroduction.

While the North Fork effort is underway, habitat and fish passage actions in the mainstem Skokomish River and South Fork (Chapter 4) will continue to improve conditions in those areas in advance of the reintroduction effort to occur in the upper South Fork. The upper South Fork, having more than 15 miles of available habitat, has not been used by Chinook since the indigenous spring run was extirpated from the drainage.

Although there is no way of knowing whether South Fork Chinook were historically a different independent population than those in the North Fork (Ruckelshaus et al. 2006), the production in both the North and South forks is important for recovery of spring Chinook in the Skokomish watershed. The North Fork alone is unlikely to support a viable population by itself even with restored normative conditions downstream of the dams. A large proportion of the historical spawning and rearing habitat will remain inundated by reservoirs for at least the next 30 years. Lentic conditions could impede passage and outmigration of salmon. Also, the reservoirs may hold large numbers of predators. The remaining habitat in the upper North Fork is at the upper end of the historic distribution and is unlikely to be as productive as the habitat that was inundated. Consequently, South Fork habitat is needed to sustain the recovered population and mitigate for some of the historical habitat in the North Fork lost to inundation by reservoirs.

The overall reintroduction strategy is based on IUCN guidelines (IUCN 1998). Table 5.1 outlines key issues for implementation of this strategy, status of the issue, and expected sequencing in approximate time frames, e.g., 1-5 years, 5-10 years, 10-20 years, and >20 years. Key implementation issues as part of this strategy have been and/or continue to be the following:

- Selection of appropriate brood stock for reintroduction;
- Establish reliable operation of hatchery facilities in the North Fork;
- Size the program for reintroduction; and
- Develop and implement monitoring strategies.

### Strategy 2: Maintain genetic diversity and abundance of spring Chinook Salmon

The hatchery operations for the North Fork Hatchery are designed to minimize loss of genetic diversity from (1) founder effect and genetic drift, (2) introgression with the extant summer/early fall Chinook population in the watershed, and (3) inadvertent selection to the hatchery environment. To be successful, however, habitat must be restored and protected to provide the opportunity for natural production and adaptation. Details of hatchery operations are given in the North Fork Skokomish River Spring Chinook Hatchery and Genetic Management Plan (HGMP). To minimize loss from founder effects (e.g., using eggs from a small number of Marblemount Hatchery Chinook females that does not represent all the genetic diversity in the stock), eggs from approximately 105 females, fertilized by 105 males, will be transferred annually until the abundance of returning adults to the North Fork Hatchery is large enough to maintain production and genetic diversity without transfers. The chance of inadvertently interbreeding spring-run fish with the extant summer/early fall stock in the watershed, at either the North Fork or George Adams facilities, will be minimized by the temporal and spatial separation between the two stocks as well as using genetic identification and appropriate tags to identify origin. Inadvertent selection to the hatchery environment will be managed by identifying appropriate proportions of natural-origin fish for the brood stock and hatchery fish on the spawning grounds for the phase of recovery (HSRG 2014).

**Table 5-1. Key implementation issues for hatchery strategies involving reintroduction of spring Chinook beginning with 2010.**

| Issue | Sequencing and status |
|---|---|
| *Selection of an appropriate brood stock to reestablish early-timed Chinook.*<br>This step began in 2010. Ten of the 22 Puget Sound Chinook Salmon populations have life history traits associated with early migration timing but not all were appropriate donors. Abundances of many populations were too low to sustain mining brood stock for reintroduction elsewhere. After examining life-history, genetic, demographic, and logistic considerations, the Marblemount Hatchery population was chosen as a donor stock. This population was begun from spring-run fish in the Suiattle River and has been managed to provide information on migration patterns, timing and distribution of spring Chinook. | 1 to 5 years (Issue has been addressed) |
| *Establish operation of hatchery facilities in the North Fork.*<br>The Lilliwaup Hatchery, a conservation hatchery operated by LLTK conservation organization on Lilliwaup Creek, was the initial home of transfers of pathogen-free Chinook eggs from Marblemount Hatchery in 2015 while Tacoma Public Utilities completed construction of the North Fork Skokomish Hatchery. The North Fork Skokomish Salmon Hatchery, which is also operated by Tacoma Public Utilities, opened in 2016 with objectives of releasing 300,000 subyearling and 75,000 yearling Chinook annually. The Skokomish Tribe, WDFW, and Northwest Indian Fisheries Commission provide technical support to the program. | 1 to 10 years (In progress) |
| *Determining the appropriate size of the program over time.*<br>Licensing agreements for the hydropower dam on the Skokomish River provide legal commitments for supporting levels for production. Numbers of fish to be released have been established for the initial phase of the program. Actual production will change over time as the program moves through different recovery phases, including phases of establishing the founder stock (preservation), recolonization, local adaptation, and recovery (HSRG 2014) in the North and later in the South Fork. The Skokomish Tribe and WDFW have developed and are continuing to refine quantitative objectives, metrics of success, and monitoring for the hatchery, natural production, and habitat restoration for each phase. | 10 to 30 years |
| *Implementing release strategies to minimize possible negative interactions with other species.*<br>On-going discussions will occur to identify possible adverse interactions between the reintroduction fish and other species. | 5 to 20 years |
| *Initiate monitoring strategies.*<br>Technical planning discussions are underway on parts of this, including marking strategies. | 5 to 10 years |
| *Identify the appropriate locations, size, and strategies for reintroduction of Chinook to the North and South fork.*<br>Reintroduction to the South Fork will occur in Phase 2 (recolonization). It will occur when some of level of natural production in the North Fork becomes evident and sufficient broodstock are available at the North Fork hatchery to initiate. The Skokomish Tribe and WDFW have developed and are continuing to refine quantitative objectives and metrics of success for this stage (see Chapter 3). | 10 to 20 years |
| *Initiate monitoring strategies.* | 1 to 10 years (In progress) |

### Strategy 3: Manage genetic diversity and composition of the extant summer/early fall Chinook Salmon population to minimize conflicts with spring Chinook, support harvest, and facilitate potential recovery of natural production

This strategy consists of an updated program for managing the summer/early fall Chinook population produced at George Adams Hatchery. It involves a number of significant changes to the way the population has been managed in the past—these are necessary due to the following:

1. A need to minimize fishery and breeding interactions between the spring Chinook reintroduction program and the on-going summer/early fall Chinook program at George Adams Hatchery;
2. A need to stabilize the central mode of river entry of George Adams Hatchery returns to a time period that will reduce potential conflicts with other conservation objectives (i.e., objectives for both Chinook and summer chum); and
3. A need to attempt to extend and enhance the late-timed segment of the summer/early fall population to facilitate later spawning and a re-emergence of life history traits more similar to historic life history timing traits.

These changes to the program constitute sub-strategies to Strategy 3, and each is described below.

As part of a strategy to improve the potential for recovering fall Chinook in the Skokomish River, WDFW and the Skokomish Tribe have implemented a program at George Adams Hatchery to evaluate the development of a late spawning segment from the extant hatchery Chinook population. We hypothesize that the river entry and sexual maturity timing of the latest timed segment would be more adapted to the environmental conditions in the Skokomish River than the earlier segments of the existing hatchery stock. The late-timed fall Chinook hatchery program currently provides for 330,000 eggs to be taken after October 1 with the peak of the late egg take being approximately five weeks later than the hatchery summer/fall peak in the second week of September.

The operating assumption in implementing this objective is that migration and spawn timing can be genetically managed to promote two timing modes, an earlier returning and spawning mode similar to the current hatchery program and a later returning and spawning mode that would be more likely to be successful spawning in the wild. This is expected to be possible by spawning a separate group of Chinook Salmon selected from fish that are ready to spawn after October 1 in addition to the current hatchery spawning that peaks in early to mid-September. Genetic analyses indicate that the stock likely has adequate genetic diversity to respond to selection, with genetic effective population sizes near 1,000 and evidence of heritability for migration and spawn timing.

Preliminary genetic modeling (Warheit 2016) suggests that achieving two timing modes in the run is likely to take at least four or five generations (approximately 20 years). The greater the separation between the spawning times for the two groups and the more fish that can be spawned later, the more likely this is to be successful. Because of unknown factors, such as heritabilities (a statistical measure of how much change might occur because of selection) and correlations of return timing and spawn timing or annual variation in smolt-to-adult survival rates, progress will not necessarily be the same each year. Consequently, the Skokomish Tribe and WDFW plan to make adjustments to the hatchery program and harvest as needed. In some years, for example, too few late-spawning fish may return to provide desired number of brood stock. In other years, harvest may need to be adjusted.

The contribution of the late-timed program to the ultimate goal of recovery will depend on the ability of these fish to colonize properly functioning natural spawning habitat and produce natural-origin returns at sustainable levels. In order to achieve success in the long term, naturally spawning late-timed fish must exhibit population productivity rates that exceed replacement in excess of a minimum viable population size.

Significant challenges exist in establishing a fall-timed Chinook population in the Skokomish River, such that adaptive management will be essential to reconciling multiple goals and objectives. Since an appropriately timed fall Chinook life history can only be successful where properly functioning freshwater habitat exists, information developed during the implementation of this evaluation will be used to assess habitat function and to guide the future direction of this program. The late-timed fall Chinook supplementation plan was initiated in 2014 with the collection of eggs from late-returning Chinook salmon at George Adams Hatchery. Tasks and products associated with implementation of the program are described here and elsewhere in this recovery plan and will be reported on in future Puget Sound Chinook Harvest Management plans and in an updated Hatchery and Genetic Management Plan.

A detailed discussion of appropriate program size and potential strategies for achieving a minimum of 10% natural spawners from the late-timed program are given in the 2015 addendum to the 2014 Skokomish Fall Chinook Late-timed Program Plan (PSIT and WDFW 2015). Reliance on passive colonization through straying would require a program size as high as 550,000 to 750,000 eggs (see Task 1-4 of the 2015 Addendum late-timed fall Chinook Program Plan). Such a program would result in large surplus returns of adults to the hatchery with no role in the broodstock program. Moreover, passive colonization would be likely to occur on a timescale inconsistent with objectives for the numerical expansion of the late-timed stock.

The co-managers are therefore implementing a more direct approach through active supplementation, based on other supplementation models in Hood Canal (summer chum, steelhead and Mid-Hood Canal Chinook (PSIT and WDFW 2015) with a program release size of 300,000. This program will bolster hatchery late-timed program strays with active seeding of key habitats through a combination of off-station juvenile releases and transport of adult hatchery returns to the spawning grounds (Table 5.2). The program return to the hatchery will initially be supported with a release of 200,000 fingerlings (SRG) from later timed parents. Additionally, both adult and juvenile releases may be used to recruit additional adults to the natural spawning grounds as appropriate. Adult release groups (ARG) will be derived from excess immature broodstock when available at the hatchery.

**Table 5-2. Current releases sizes programmed for the Skokomish late-timed Chinook program.**

| Program component | Release location | Release strategy | Release number | Release size | Timing | Mark |
|---|---|---|---|---|---|---|
| On-station | Purdy Creek | Fingerling (SRG) | 200,000 | 70 fpp | May | Unclipped, GA Late cwt |
| Off station | North Fork (RM 13.3) | Fingerling (SRG) | 50,000 | 80 fpp | April | Unclipped, NF Late cwt |
| Off-station | South Fork (RM 2.2) | Adult (ARG) [a/] | 200 | 0.1 fpp | Oct | Site-specific Floy |
| | Vance Creek (RM 3.0)[b/] | Fingerling (SRG) | 50,000 | 80 fpp | April | Unclipped, Vance Late cwt |
| | | Adult (ARG) [a/] | 200 | 0.1 fpp | Oct | Site-specific Floy |
| | | **Total release** | **300,000** | | | |
| | | **Egg take goal** | **330,000** | | | |

[a/] Adult releases are planned from hatchery adult surpluses from late maturing fish and will be dependent on availability

[b/] Up to three locations have been identified for ARG and SRG releases in Vance Creek below RM 3.0 to distribute spawners

The on-station late-timed Chinook releases to support the program are to release smolts at the same time and size as used for main production program at the George Adams facility, i.e., to release the fish into Purdy Creek at 70 fish per pound (fpp) in May. Given the volatility of the South Fork and the mainstem river, the co-managers had originally identified Vance Creek and the North Fork as the best locations for both adult and smolt releases. However, further consideration of the spring Chinook reintroduction program and other supplementation programs currently underway in the North Fork led to a decision to focus all adult releases of late-timed Chinook into Vance Creek and the lower South Fork (Figure 5.2).

Two smolt release groups (SRG) of 50,000 each are to be produced for two locations in the Skokomish River basin where environmental conditions are most conducive to successful natural production. These groups will be reared at the McKernan facility on well water in order to reduce their imprinting to Purdy Creek and to maximize imprinting to release sites. They will be released just prior to smolting in order to allow some degree of acclimation and imprinting to the potential spawning locations. These releases will therefore occur slightly earlier and potentially at smaller size due to their stage of development, which is currently expected to be in April at approximately 80 fpp. All three juvenile release groups will be unclipped and uniquely coded wire tagged.

Program goals must be achieved in the following order. The 330,000 egg take for the hatchery and SRG portions of the program must be met before any adults are surplused and transported to release sites. Moreover, the 220,000 egg take must also be met before eggs can be set aside for smolt releases. As surplus adults and eggs in excess of those needed to produce the 220,000 are acquired, release sites would be prioritized in the following order: (1) South Fork, (2) Vance Creek, and (3) North Fork, up to the total program size outlined in Table 5.2.

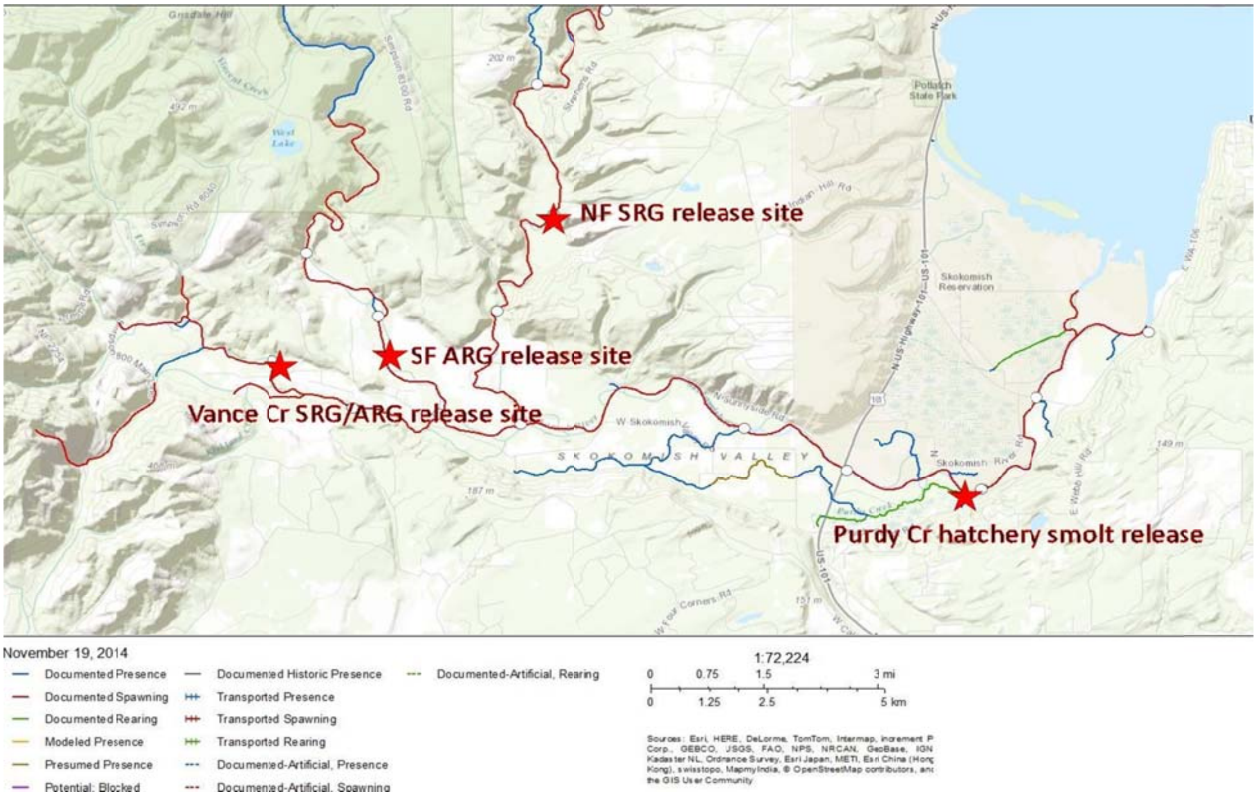



**Figure 5-2. Locations for off-station and on-station releases of the later-timed Chinook in the Skokomish Basin. The George Adams Hatchery is located on Purdy Creek.**

The success of the late-timed Chinook program returns to George Adams hatchery will be based primarily on coded wire tag (CWT) returns of the uniquely coded 200,000 hatchery release. Assessments of off-station smolt release groups (SRG's) will also employ recovery of tagged returns from uniquely CWT releases. Each of these three groups, in addition to the main hatchery program's double index tag (DIT) groups, will be recovered at the hatchery, on the spawning grounds, and in fisheries providing critical information on differential survival, release site fidelity, and susceptibility to fisheries. An external mark will be used to monitor behavior and distribution of any adult releases, which will be marked with floy tags, color-coded based on release site and uniquely numbered for each individual. Both live fish observations and carcass recoveries will be used to assess the effectiveness of this release strategy.

Success of the late timed program on the spawning grounds will be evaluated by expanding monitoring efforts in the following ways:

1. <u>Extended survey season (temporal coverage)</u>: Spawning surveys in the past were completed when live fish were no longer observed and when redd counts fell to single digit numbers. Although Chinook redd construction is increasingly rare in the mainstem river in October, extended temporal coverage will better measure late spawning. Index reaches of Vance Creek and the North Fork will be monitored weekly through the months of October and November at flows under 800 cfs on the South Fork gauge (USGS # 12060500). Based on the period of historical flow record (1931 – 2014), mean daily flow has exceeded this threshold 17% of the time in October and 42% of the time in November.

2. Expanded geographic coverage: Chinook spawning indexes have been developed in the Skokomish River to detect increases in later spawning Chinook. These include extending monitoring of existing coho indexes in Vance Creek, Hunter Creek, and the North Fork, locations where flows are most stable during October and November. Extended monitoring of the lower South Fork and mainstem indexes as supplemental reaches will also occur, where conditions are highly dynamic, as weather and flows allow.
3. Increased frequency of carcass recovery surveys: Carcass surveys have historically been combined with spawner surveys. After periods of peak spawning, spawning survey frequency from every 7 to 10 days will be supplemented with specialized carcass surveys every 3 to 5 days as flows permit. Increases in carcass survey frequency will be made from one to two or three times a week where evidence of late spawning is detected, and as flows (under 800 cfs at the South Fork gauge) and weather allow. Carcasses will be sampled to identify mark status, spawn date, sex, fork length, to collect scales for age determination, and to collect DNA samples from carcasses in acceptable sampling condition for parentage analysis.
4. Repositioning of Tacoma Power's screw trap: Efforts will be made to reposition Tacoma Power's smolt trap to lower in the North Fork to encompass the majority of Chinook spawning habitat in that stream. This will increase the catch of outmigrating juvenile Chinook by the trap. Increasing the catch of juvenile Chinook is important for two reasons. First, in order to evaluate the overall productivity of Chinook in the basin, juvenile production estimates must represent a large proportion of the spawning habitat used by the naturally spawning population. Second, higher catch numbers will be needed to increase the accuracy and precision of mark-recapture methods of abundance estimation. Additional site options to monitor smolt outmigration in the Skokomish system include the lower South Fork, the mainstem Skokomish River, and Vance Creek. Criteria for selection of an additional smolt trapping site would include (a) hydraulic conditions at the site conducive to high catch rates and (b) a location downstream of habitats where we expect late-timed naturally spawning Chinook to have a survival advantage over earlier spawners. However, no additional juvenile trapping can occur without significant additional funding and staffing levels.

Given the challenges of monitoring and sampling during the late-time fall period, a progressive range of metrics will be employed in order to assess VSP parameters of late-timed Chinook under variable conditions.

1. Benchmark 1: Numerical increases in live Chinook observations in late September and redds constructed in October over two to three brood cycles will provide indications of successful returns to the spawning grounds. The co-managers have intensively sampled Chinook in the Skokomish Basin for a number of years and have extensive baseline information with which to evaluate these parameters for returns of summer/fall Chinook. Such increases will need to be considered in the context of increased flows from Cushman under the new license and any trends in hydrological conditions associated with climate change.
2. Benchmark 2: Beginning in 2022 with the first return of naturally spawned 4-year olds from progeny of brood year 2014 late-timed hatchery releases, we hypothesize increasing numbers of natural-origin fish spawning after October 1. However, we explicitly avoid pHOS benchmarks during the first two brood cycles (eight years) because the goal of the plan is to increase late-timed fish spawning in the river via hatchery production.

3. Benchmark 3: Interannual variation in median spawn timing for natural-origin Chinook in the Skokomish River and tributaries should trend towards a later date as the late-timed hatchery program progresses through subsequent generations. This result would be consistent with the hypothesis that late-timed spawners encounter more favorable spawning conditions than earlier timed spawners and that later timed fish will be more successful in producing adult progeny. We expect late-timed spawners to have higher reproductive success than earlier timed spawners, and as a result the median spawn date should shift later over time.
4. Benchmark 4: A spatial expansion in Chinook redd site distribution should result from the advantages of later spawning timing due to seasonal changes in flow regimes and improved reproductive success. Three mechanisms might provide advantages for later spawning Chinook salmon. First, spawning reaches selected by late-timed spawners may be inaccessible to earlier timed spawners due to low water or intermittent river flows. Second, spawning sites selected by late-timed spawners may be less vulnerable to hydrologic disturbance (i.e., scour), and thus promote higher survival to returning adults, which would home to natal sites. Third, improved reproductive success (fitness related) of later spawning fish should result in a greater spawning distribution.

Productivity-based benchmarks are the preferred means of assessing the success of late-timed Chinook. However, substantial challenges exist with collecting the data needed to assess productivity in the Skokomish system. The Skokomish is one of the most flood-prone rivers in Washington State, capable of reaching flood stage with any major rain event. Often such rain events occur during the fall spawning period in October and November when salmon are inclined to move up onto the spawning grounds. Although flows from the North Fork are regulated by the Cushman Hydro-electric project, the South Fork is volatile in comparison. It is not uncommon for flows in the South Fork to rapidly jump from several hundred cfs, which is surveyable by salmon survey crews, to several thousand cfs which is not. Such flows are often accompanied by dramatic increases in turbidity, which can interfere with survey visibility for days after flows have declined.

Across a 15 year period from 1999 through 2014, averages of daily flows illustrate the survey window extending from August through the first half of October, after which flow averages rise above 1,100 cfs in the mainstem Skokomish River (Table 5.3, USGS gauge 12061500). Over the same time period, the percentage of non-surveyable days based on flows was less than 1% for the months of August and September, and then increased to 17% for October and 54% for November (Table 5.4).

**Table 5-3. Means of mean daily flow values for the Skokomish River across a 15 year period from 1999 through 2014 (USGS gauge 12061500). Green cells are surveyable based on flow conditions, red cells are not.**

| | Mean daily values for 11 - 15 years of record in, ft3/s (1999- 2014) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 1 | 1,570 | 1,810 | 1,230 | 1,440 | 985 | 716 | 460 | 297 | 268 | 620 | 865 | 1,610 |
| 2 | 3,270 | 1,780 | 1,300 | 1,470 | 929 | 804 | 442 | 294 | 265 | 538 | 1,230 | 1,630 |
| 3 | 3,060 | 1,460 | 1,350 | 1,430 | 987 | 771 | 432 | 290 | 261 | 522 | 1,330 | 2,920 |
| 4 | 2,600 | 1,900 | 1,240 | 1,330 | 912 | 707 | 421 | 287 | 258 | 640 | 1,580 | 2,590 |
| 5 | 2,900 | 1,580 | 1,080 | 1,390 | 1,230 | 690 | 412 | 285 | 253 | 565 | 1,440 | 1,970 |
| 6 | 3,650 | 1,410 | 1,040 | 1,260 | 1,300 | 680 | 410 | 286 | 254 | 463 | 2,510 | 1,940 |
| 7 | 5,260 | 1,400 | 1,070 | 1,420 | 1,150 | 676 | 401 | 296 | 264 | 516 | 3,490 | 1,560 |
| 8 | 5,160 | 1,270 | 1,090 | 1,420 | 1,030 | 651 | 398 | 282 | 258 | 528 | 2,530 | 1,460 |
| 9 | 3,700 | 1,200 | 1,170 | 1,300 | 944 | 616 | 400 | 276 | 254 | 541 | 1,770 | 1,280 |
| 10 | 3,510 | 1,220 | 1,240 | 1,250 | 885 | 611 | 386 | 272 | 253 | 500 | 1,510 | 2,200 |
| 11 | 3,370 | 1,250 | 2,430 | 1,310 | 841 | 593 | 379 | 268 | 293 | 632 | 1,570 | 2,610 |
| 12 | 3,060 | 1,160 | 2,810 | 1,370 | 827 | 578 | 376 | 265 | 269 | 619 | 2,590 | 2,440 |
| 13 | 3,500 | 1,270 | 2,960 | 1,500 | 808 | 570 | 371 | 263 | 264 | 539 | 2,490 | 2,460 |
| 14 | 3,140 | 1,190 | 2,440 | 1,660 | 828 | 561 | 365 | 257 | 264 | 527 | 2,060 | 3,130 |
| 15 | 2,440 | 1,300 | 1,820 | 1,320 | 875 | 542 | 359 | 254 | 273 | 596 | 2,640 | 3,090 |
| 16 | 1,970 | 1,510 | 1,600 | 1,420 | 915 | 527 | 356 | 251 | 278 | 1,110 | 2,900 | 3,270 |
| 17 | 2,800 | 1,550 | 1,580 | 1,350 | 883 | 524 | 352 | 249 | 293 | 1,970 | 1,820 | 2,980 |
| 18 | 2,790 | 1,270 | 1,520 | 1,290 | 923 | 520 | 344 | 249 | 288 | 1,320 | 2,920 | 1,890 |
| 19 | 2,050 | 1,250 | 1,450 | 1,160 | 957 | 507 | 337 | 249 | 297 | 1,250 | 3,510 | 1,620 |
| 20 | 1,600 | 1,500 | 1,880 | 1,180 | 937 | 491 | 334 | 256 | 296 | 2,310 | 2,460 | 1,660 |
| 21 | 1,510 | 1,630 | 1,870 | 1,110 | 892 | 483 | 348 | 262 | 280 | 1,970 | 2,630 | 1,900 |
| 22 | 1,790 | 2,320 | 2,170 | 1,040 | 900 | 480 | 606 | 351 | 275 | 1,400 | 2,400 | 2,500 |
| 23 | 1,930 | 1,650 | 1,640 | 1,030 | 857 | 474 | 424 | 358 | 290 | 1,130 | 1,540 | 2,150 |
| 24 | 1,790 | 1,350 | 1,670 | 1,190 | 800 | 468 | 364 | 329 | 297 | 823 | 1,290 | 2,750 |
| 25 | 2,020 | 1,360 | 1,550 | 1,140 | 772 | 464 | 344 | 313 | 288 | 745 | 1,720 | 3,140 |
| 26 | 2,240 | 1,320 | 1,600 | 1,110 | 763 | 471 | 333 | 310 | 351 | 704 | 1,390 | 2,680 |
| 27 | 1,710 | 1,150 | 1,580 | 1,160 | 790 | 486 | 324 | 291 | 341 | 682 | 1,210 | 2,320 |
| 28 | 1,490 | 1,100 | 1,570 | 1,120 | 822 | 506 | 312 | 280 | 438 | 818 | 1,560 | 1,970 |
| 29 | 1,580 | 1,110 | 1,510 | 1,050 | 809 | 532 | 307 | 276 | 331 | 864 | 1,980 | 1,590 |
| 30 | 2,960 | | 1,500 | 1,020 | 737 | 487 | 303 | 278 | 384 | 758 | 1,460 | 1,690 |
| 31 | 2,130 | | 1,480 | | 724 | | 297 | 270 | | 1,110 | | 1,750 |

**Table 5-4. Number of days (all years in record combined) in August, September, October, and November with mean daily values above and below 1,100 cfs, flows considered surveyable for spawning Chinook salmon.**

| | Total | < 1100cfs | > 1100cfs | Not Surveyable |
|---|---|---|---|---|
| **August** | 466 | 463 | 3 | 0.6% |
| **September** | 446 | 443 | 3 | 0.7% |
| **October** | 450 | 372 | 78 | 17.3% |
| **November** | 413 | 189 | 224 | 54.2% |

Obtaining adequate sample sizes under varying flow regimes for producing age composition estimates needed for productivity will be problematic. Moreover, all analyses requiring data collected on the spawning grounds (i.e., abundance trends, productivity, spatial distribution, and spawn timing) may be biased by differential conditions (flow, visibility, presence of other salmonid species) encountered within the basin during October and November. We advance the following benchmarks 5 – 7 as additional monitoring metrics but acknowledge that river conditions may prevent us from achieving robust estimates of each respective metric.

5. Benchmark 5: Spawner to spawner measures of productivity (λ) would be assessed for the combined summer/fall Chinook population (early and late components). By combining samples of earlier and later natural spawners, we are more likely to have sufficient sample sizes to measure spawner to spawner productivity. Moreover, this approach would maintain continuity with existing estimates of productivity to determine if there is a trend towards greater λ. Improvement in λ for the combined earlier and later timing segments is contingent upon a sufficiently large late timed hatchery program such that late timed fish account for a significant proportion of the total adult return. Even if 10 % of fish spawning naturally are late timed, it may not be sufficient to enhance λ for the combined earlier and later natural spawners. See Table 2-3 for a summary of λ values estimated for brood years 1999 to 2012.
6. Benchmark 6: Spawner to spawner productivity (λ) values for the early portion of the spawning escapement would be compared to values for the late-timed segment. We hypothesize that λ should be greater for spawners from the late-timed segment compared to spawners from the earlier timed segment of the summer/early fall population. This comparison would require many years to accumulate sufficient data, i.e., at least five years following the first measurable observations of late-timed fish spawning in the river. Furthermore, it may require assumptions about age class structure for late-timed fish depending on carcass recoveries. However, it would provide a direct test of the hypothesis that late-timed fish spawning in the river are more successful than early-timed fish spawning in the river.
7. Benchmark 7: Interannual variation in juvenile productivity (smolts per spawner) would be assessed using estimates of juvenile outmigrants at the smolt trap. Estimates of juvenile productivity for the combined naturally spawning summer/early fall Chinook population (all timing segments) should trend toward higher productivity values through time. Measuring aggregate Chinook productivity will allow for pooling of samples to provide more precise juvenile abundance estimates. Here, we assume that a higher productivity, if observed, would be a function of the addition of a late-timed segment to the spawning aggregate. Furthermore, segregating juvenile offspring as produced by earlier and later spawners would require genetic methods and a near census sample of adult carcasses, neither of which are currently available with existing resources or possible under prevailing river conditions.

**Strategy 4: Continue Providing for Harvest**

WDFW raises or supports the release of nearly 7 million summer/early fall Chinook in Hood Canal and the Skokomish River watershed to provide for harvest and escapement for natural spawning (Table 5.5). This production consists of two hatcheries that manage the hatchery and natural spawning components through either an *integrated production strategy* or an *isolated production strategy*. The integrated strategy allows artificially propagated fish to spawn in the wild and incorporates natural-origin fish into the brood stock to minimize genetic divergence. In contrast, the fish produced by the segregated strategy are not intended to reproduce in the wild and are intended only for harvest.

**Table 5-5. Current production of summer/early fall Chinook for the purpose of harvest augmentation and experimental efforts to extend the spawning timing of the late timing segment.**

| Production facility | No. of summer/early fall Chinook | | Watershed of release |
|---|---|---|---|
| | Fingerling | Yearling | |
| George Adams | 3,800,000 | | Skokomish River |
| Hoodsport | 3,000,000 | 120,000 | Finch Creek |
| Combined | 6,800,000 | 120,000 | |

## 5.5 Benefits and Risks of Hatchery Strategies

The four strategies described in this plan should provide immediate short-term and long-term benefits to salmon and the people who depend on them. These benefits are not without risks. A large body of scientific literature documents potentially negative genetic effects on natural production associated with artificial production over time, although the actually reported effects are variable by species, location, and program type (Busack and Currens 1995; Naish et al. 2008; RIST 2009). Other concerns about hatchery fish focus on the potential of disease amplification, predation, and increased competition with wild populations. Such issues could affect the results of recovery activities to reestablish and rebuild natural populations in this watershed.

Experience has shown that these risks cannot be eliminated, but they can be controlled. These lessons have been hard ones learned and an important part of the overall strategy is to use existing tools and advances in hatchery science to maximize the benefits possible by hatcheries while minimizing the potential risks. In 1999, Congress established the Hatchery Scientific Review Group (HSRG) to catalyze review and advocate for the best science that would allow hatcheries to provide fish for harvest while, at the same time, reducing risks to natural populations and contributing to achieving conservation goals for Pacific salmon and steelhead. Incorporating these scientific principles is an important part of developing this recovery plan. Co-managers reviewed all of their hatchery programs internally for consistency with the Endangered Species Act, participated in an independent review of hatcheries by the Hatchery Scientific Review Group (HSRG), and developed hatchery and genetic management plans (HGMPs) to minimize risk to natural populations and comply with Section 4(d) of ESA.

# Chapter 6. Harvest Management Recovery Strategies

The fundamental purpose of fisheries management is to ensure sustainable production of fish stocks, while promoting the economic and social well-being of fishermen and industries that rely on that production (Hilborn and Walters 1992). Harvest of depleted populations must be managed so as not to impede their recovery. There is no doubt that past overharvest contributed, in concert with other factors such as habitat loss, to the demise of the indigenous Chinook life history types produced in the Skokomish watershed. This chapter describes harvest management-related strategies that will promote the recovery of Skokomish spring Chinook and improve the potential for recovery of a fall-run Chinook population.

The best prospect for recovering a Skokomish Chinook population, at least in the near-term, has been determined to be for the spring-run racial group. Recovery necessitates a re-introduction of a suitable spring-timed stock to the watershed. As the plan goes forward, and as progress is made in restoring key habitats in the lower valleys, the potential for expanding the recovery efforts to include a late-timed or fall-run racial group is to be evaluated.

During the past century, Skokomish Chinook were harvested throughout their migration pathway, in mixed-stock fisheries operating in coastal marine waters between California and Southeast Alaska, as well as in the Puget Sound. Total harvest rates exceeded 70% during the late 1970s and early 1980s. Since then, harvest management has evolved to consider broadly declining abundance and to protect individual stocks, particularly those listed under the ESA.

Drawing from many strategies to conserve weakened salmon stocks, this plan defines harvest management objectives and strategies for Skokomish Chinook that are consistent with recovery and suited to their distinct life histories.

This chapter is organized into the following sections:

- 6.1 The fisheries – past and present;
- 6.2 Harvest management processes;
- 6.3 Harvest management objectives; and
- 6.4 Harvest management strategies.

## 6.1 The Fisheries – Past and Present

This section presents a short overview of the fisheries that have affected indigenous Skokomish Chinook and fisheries that are operative today as context for understanding current status and management.

### 6.1.1 Pre-Treaty Era

In times past, fish and fishing were the lifeblood of the aboriginal peoples of the Puget Sound region. The salmon was most important. In the Hood Canal region fishing occurred in marine and freshwater areas, but principally in the Skokomish River (Elmendorf and Kroeber 1992). The Skokomish group of the Twana people used weirs, traps, nets, and spears to harvest fish at various places. As noted in Chapter 1, the two waterfalls on the North Fork (Figure 1.2) were favored places to harvest spring Chinook as the fish gathered there to make their ascent to the upper reaches (James 1980).

Tribal customs, ceremonies, myths, and taboos defined their management of harvest and limited the scale of fishing (Lichatowich 1999). Cohen (1986) described Puget Sound tribal practices:

> "Indian practice, enforced by belief, would not permit fishermen to catch more salmon than they needed. When the fish were running, the fishermen periodically opened their traps and weirs to let spawners escape upstream. Traps sometimes washed out, as well, allowing more fish through. Perhaps most important, once the Indians had met their needs, they stopped fishing."

Tribal fisheries recognized clearly defined property rights. In some cases, these rights resided in the tribe as a whole; in other cases in families or individuals; sometimes in a mixture of the two (Barsh 1977; Higgs 1982). This system maintained consistency in how the fisheries operated over time.

Salmon were highly productive in pristine watersheds, and in most years, abundant, but freshwater and marine survival undoubtedly varied (Lichatowich 1999; Montgomery 2003). Lichatowich (1999) concluded that while the tribes possessed the skills, technology, and knowledge to more fully exploit the salmon runs, their form of management led them to live within the productive limits of the resource. An ecological balance existed between people and salmon.

### 6.1.2 Post-Treaty Era

The signing of treaties between the Puget Sound tribes and the Federal Government in the mid 1850s coincided with the onset of rapid changes in the Skokomish and other Puget Sound watersheds, as described in Chapter 4. For several decades following the signing of the treaties, Indian people continued to harvest fish for themselves and for trade with the growing number of immigrants.

In the late 1800s, canneries and related business enterprises proliferated in Puget Sound and their production peaked in 1913. There were indications that salmon stocks were in decline by this time, due to high harvest rates and habitat deterioration (Netboy 1973). Chinook catch in Puget Sound peaked in 1918 (Crutchfield and Pontecorvo 1969).

As innovations in commercial fishing gear and boats developed in the early 20th century, and recreational fisheries expanded in the 1920s, harvest rates on salmon populations increased. Fishery groups competed with one another, resulting in much controversy and political maneuvering (Crutchfield and Pontecorvo 1969; Higgs 1982). This led to passage of Initiative Measure No. 77 in 1934, which banned all fixed gear (traps) in Puget Sound and closed certain areas to commercial salmon fishing, including Hood Canal.

By mid-century, it was believed that Skokomish Chinook were in severe decline (WDF 1957b). The Skokomish Tribe's in-river commercial fishery for Chinook was closed in 1946 and remained so for a number of years (Smoker et al. 1952). The Cushman Project was believed to be the primary reason for loss of Chinook production (WDF 1957b), though hindsight shows that several factors contributed. In the 1950s, WDF and the City of Tacoma reached agreement to construct a new hatchery at Purdy Creek in the lower Skokomish River to help mitigate the loss in salmon production. The George Adams Hatchery began operation in 1961 using Chinook broodstock of Green River lineage.

Between 1950 and the mid 1970s, commercial and recreational fishing effort in marine waters from California to Alaska increased. During the mid-1950s, the Canadian troll fishery off the west coast of Vancouver Island expanded rapidly, taking large numbers of U.S.-origin Chinook and coho. Soon after, sport fisheries in marine waters increased in both U.S. and Canadian waters. Exploitation rates on some Puget Sound Chinook populations, including Skokomish Chinook, exceeded 70% during the period from 1970 through the early 1990's, based on analysis of George Adams Hatchery CWTs (PSC 2009).[14] These high harvest rates likely contributed to the demise of indigenous Chinook stocks in the Skokomish River.

Harvest rates were probably at their highest level at the same time that habitat quality was rapidly deteriorating in the streams utilized by various life stages of native spring and fall Chinook. During the mid-1900s, the Skokomish watershed was undergoing an enormous transformation as the forests were cut, the North Fork was dammed and diverted, and the floodplains and delta were diked. Alterations to the upper South Fork associated with timber harvest were occurring at their most rapid rate in the 1960s and 1970s. The rates of aggradation and flooding in the lower river were increasing during this period.

Hatchery Chinook production at Hood Canal hatcheries increased during the period to offset lost natural production and to meet the increasing demand for fishing opportunity.[15] Hood Canal was re-opened to commercial salmon fishing to enable the affected treaty tribes to once again exercise their right to harvest salmon there. Non-treaty commercial fishing was also re-initiated. Treaty and non-treaty fisheries expanded in Hood Canal during the mid-1970s and into the 1980s.

### 6.1.3 Current Harvest Management

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, PST 2010 Chinook Annex).

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, establishing management units and escapement goals to guide annual management of fisheries. Hood Canal hatchery Chinook stocks were designated as the "primary" management units by the HCSMP, so commercial Chinook 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 stocks were designated as "secondary" management units in the HCSMP, so fisheries were not managed to achieve a specific number of natural spawners.

Terminal-area fisheries in the marine areas of Hood Canal (primarily in Areas12C and 12H) and in the Skokomish River target Chinook fish produced in the George Adams Hatchery and Hoodsport Hatchery. Treaty commercial and non-treaty sport fisheries occur in the lower mainstem of the river. The fisheries that

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[14]/ It cannot be known with certainty what the ocean distribution and exploitation rates were for the native Skokomish Chinook. Total exploitation rates in all fisheries combined exceeded 70% on George Adams Hatchery Chinook from the late 1970's until the early 1990's (PSC 2009).

[15] / It is noted that hatchery practices during much of the 20th century, which usually relied on non-indigenous stocks, did not consider the risk to indigenous populations. This is especially evident when viewed in the light of current understanding of the ecological and genetic interactions of natural and hatchery production. The primary goal of those hatchery practices was to enhance fisheries, most frequently to mitigate for lost production due to severe habitat constraints that had developed.

have targeted summer/ early fall Chinook have operated from mid-July through early September, but in recent years Chinook fishing has been closed in late August. Terminal fisheries directed at coho have commenced in mid-September.

The Puget Sound Chinook ESU was listed as threatened under the Endangered Species Act in 1999 (NMFS 1999). Pursuant their authority to implement the ESA, the NMFS established conservation standards in the salmon 4(d) rule, specific to harvest, to ensure the likelihood of survival and recovery of the ESU would not be significantly reduced (NMFS 2004). The original listing was subsequently revised to include the George Adams hatchery production, and more recently, the North Fork hatchery production of spring chinook.

Consequent to the listing, the Puget Sound co-managers developed the Harvest Management component of the Puget Sound Comprehensive Chinook Management Plan (PSCCMP), which specified harvest objectives for each of the fourteen natural chinook populations comprising the ESU. The Fisheries Regulation Assessment Model (FRAM), the primary tool for pre-season harvest planning, was substantially revised to account for this higher resolution of harvest mortality. The PSCCMP departed from managing regional stock groups under escapement goals, instead to implementing exploitation rate (ER) ceilings relative to all fisheries or fisheries in southern U.S. waters. More restrictive ER ceilings were specified to implement more conservative fisheries if projected escapement fell below the low abundance threshold (LAT).

The PSCCMP was initially implemented in 2001, and has undergone several subsequent revisions, the last of which was implemented in 2010 (PSIT and WDFW 2010). This PSCCMP is consistent with the Puget Sound Salmon Management Plan and, for Hood Canal management units, the Hood Canal Salmon Management Plan.

Notwithstanding the ESA mandate to conserve the naturally produced Chinook in the Skokomish River, it is generally recognized that indigenous Skokomish life histories are extinct (Ruckelshaus et al 2006). Natural spawners are genetically indistinguishable from the George Adams hatchery stock (Marshall 2000) and their migratory timing and life history patterns mirror those of the hatchery fish (see Chapter 2). Estimates of escapement since 1988 indicate the large majority of naturally spawning Chinook in the river are first-generation hatchery strays (C. Gray, Skokomish Tribe, and M.Downen, WDFW, 2017 *personal communications*)

For the Skokomish Chinook summer-fall management unit, the versions of the PS Harvest Plan implemented from 2001 to 2009 established normal and critical exploitation rate ceilings on southern United States (SUS) pre-terminal fisheries, and coincided with the implementation of 100% marking programs, with terminal fishery constraints designed to achieve a natural spawning escapement of at least 1,200 to the Skokomish River.

The 2010 Harvest Plan (PSIT and WDFW 2010) established a total exploitation rate ceiling of 50%, (i.e. relevant to all fisheries in the U.S. and British Columbia. If predicted escapement fell below the low abundance threshold of 800, a more constraining critical ER ceiling (CEREC) would be imposed on pre-terminal SUS fisheries, but terminal area fisheries could also be further reduced so that the total ER would not exceed 50%.

The 2010 Harvest Plan, in the Skokomish Management Unit profile, and now this recovery plan, focus on restoring spring Chinook, while also recognizing the need to maintain future options for recovery of the summer/early fall population. Improving the potential for recovery of a fall-run population depends initially on shifting the timing of the George Adams run to enhance the potential for natural productivity.

## 6.2 Harvest Management Processes

The annual harvest management process includes pre-season planning, in-season implementation of fisheries, and post-season assessment. Each step of the process reflects defined elements of the Puget Sound Chinook Harvest Management Plan, and the Puget Sound Salmon Management Plan.

### 6.2.1 Forecasting

Harvest planning is based on forecasts of the abundance of each stock which generally inform harvest strategies and comprise inputs to the fisheries simulation model (FRAM), during the pre-season planning process (North of Falcon forum).

Forecasting the abundance of the Skokomish summer/early fall natural stock is based on a recent historical average of terminal abundance, i.e. the number of fish returning to Hood Canal. The annual abundances used for this average are reconstructed 'retroactively' from the annual total natural escapement – including natural- and hatchery-origin fish. Annual hatchery returns are forecasted separately, based on recent year catches of hatchery fish in the terminal area, from age-specific, recent average adult returns per pound of fingerlings released for age 3+, 4+, and 5+ returns. For hatchery and natural stocks, terminal abundance is the estimated catch in each terminal fishery added to spawning escapement. Catch in each fishery is based on the relative abundance of all contributing stocks, i.e., George Adams and Hoodsport hatchery recruits and Mid-Hood Canal natural chinook. Predictions obtained by these methods may at the discretion of local technical staff be adjusted to account for recent forecast error, expected marine survival conditions affecting the forecasted return, or other factors.

The abundance of Hood Canal wild coho is based on a linear regression model that relates the return of tagged natural jack coho at Big Beef Creek (BBC) to Hood Canal December Age 2 (DA2) recruits in the subsequent run year. Skokomish River hatchery coho abundance is predicted from recent recruitment rates for the George Adams stock applying historic marine survival rates estimated from CWT-based cohort reconstruction of December Age-2 recruits, as were those of natural coho. Because there are several enhancement facilities in Hood Canal, and tag data were not available for all facilities for all years, marine survival rates were estimated from reconstructed cohorts, using the assumption that untagged releases contributed to pre-terminal fisheries in a way that maintained the same ratio to tagged releases, as estimated by the RRTERM run reconstruction model to have entered the Hood Canal terminal area.

### 6.2.2 Pre-season Planning

Pre-season planning develops the fishing regime in Washington waters for the forthcoming season. Negotiation is informed by FRAM runs that incorporate the proposed fisheries and forecasted abundance of all coastal Chinook stocks originating in California, Oregon, Washington, and B.C. and expected catch in Alaska and British Columbia. The model accounts for all fisheries-related mortality, including incidental Chinook mortality that occurs in fisheries directed at sockeye, pink, coho, and chum salmon.

During the initial phase of the program to establish a spring Chinook population, pre-season planning will qualitatively consider constraining fisheries likely to have direct impacts, based primarily on migration characteristics of the donor stock. Quantitative methods for managing fisheries for the spring Chinook population, such as forecasting abundance and incorporating time and area distributions into harvest simulation modeling, will be developed as requisite time series of exploitation patterns and escapement information accumulates.

Salmon fisheries in Puget Sound (i.e., which in this context include those in the Strait of Juan de Fuca, Georgia and Rosario Straits, and all associated terminal marine and freshwater areas) are planned concurrently with coastal fisheries, which are managed under the jurisdiction of the Pacific Fisheries Management Council. Since the PSCHMP has been authorized by the NMFS as compliant with the conservation standards of the ESA, the Council approves coastal fisheries regimes after assessing compliance with harvest guidelines for Puget Sound Chinook (stated in the PSCHMP) using the FRAM simulation model. However, southern U.S. ocean fisheries exert relatively small impacts on Puget Sound Chinook; exploitation rates estimated for Skokomish Chinook in recent seasons have been only 2-3%.

Post-season harvest management performance is assessed annually, and involves comparison of expected and observed catch and escapement for all stocks, and periodic, retrospective assessment of stock status trends and the effectiveness of management measures implemented by the co-managers. Related information about harvest and abundance of Skokomish spring Chinook will be incorporated in these reports as it becomes available.

## 6.3 Harvest Management Objectives

The purpose of the harvest-related strategies presented in this plan is to (1) ensure that fishery-related mortality will not impede recovery of spring Chinook in the watershed and (2) help evaluate the potential for recovering a late-timed (fall run) Chinook population. As the plan goes forward, the potential for expanding recovery efforts to include the late-timed racial group will be evaluated based on progress of experimental work to adjust important life history characteristics and at recovering the spring Chinook population (see Chapters 1 and 3).

Fisheries will be planned and implemented to achieve the following objectives related to spring Chinook and summer/early fall Chinook:

1. Protect and conserve the abundance and life history diversity of a locally adapted, self- sustaining spring Chinook population during and after its recovery;
2. Recognizing the advance in run timing that has occurred on the summer/early fall Chinook over time, shape terminal area fisheries to better utilize the early and mid-portions of returning hatchery fish and give greater protection from harvest mortality to the late-returning segment of the run to facilitate an increase in natural reproductive rates of natural spawners.
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, re-introduced sockeye, hatchery-origin and wild coho, and fall chum).
4. Recognizing the importance of ceremonial and subsistence (C&S) tribal fisheries, prioritize C&S fisheries over any other fisheries targeting the Skokomish River spring Chinook during all phases 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 among treaty and non-treaty fishers.

6. Monitor abundance, productivity, and spawning distribution of spring and summer/early fall Chinook populations, which will include estimating catch distribution, age composition, and mortality in all fisheries.

Harvest objectives and guidelines for Skokomish spring Chinook will be incorporated in subsequent revisions of the Puget Sound Chinook Harvest Management Plan.

## 6.4 Harvest Management 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 early and summer-fall Chinook, and fisheries for sockeye, coho, and fall chum that involve indirect impacts on either Chinook stock.

### 6.4.1 Spring Chinook

Management of the initial fisheries for spring Chinook will refer to the pre-terminal catch distribution and exploitation rate ceiling for Skagit spring Chinook. A program will be implemented to collect stock-specific information on the run timing, distribution, and fishery-specific harvest mortality of the Skokomish spring-run population, to better inform future harvest management. Terminal harvest will be more certain, due to the unique run timing of spring Chinook and the ability to identify hatchery-origin returns. In the interim, management objectives for terminal harvest will be implemented and monitored. Ultimately, harvest objectives will be revised to reflect the productivity and abundance of spring Chinook as they colonize and adapt to habitat in the North Fork, and later, the South Fork. This Plan 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.

In order to maximize spawning escapement in the early phases of recovery, except for limited ceremonial and subsistence harvest, terminal fisheries targeting spring Chinook will not be implemented. As abundance increases, opportunities for expanding terminal fishing opportunities will be evaluated and implemented if consistent with management objectives. Additional commercial fishing opportunities will occur when the population recovers.

During the Phase 1 of recovery (Establish Founder Stock), limited C&S fisheries may occur in the lower Skokomish River 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 6.1). 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 and returns exceed broodstock requirements of the North Fork Hatchery program (see Chapter 3).

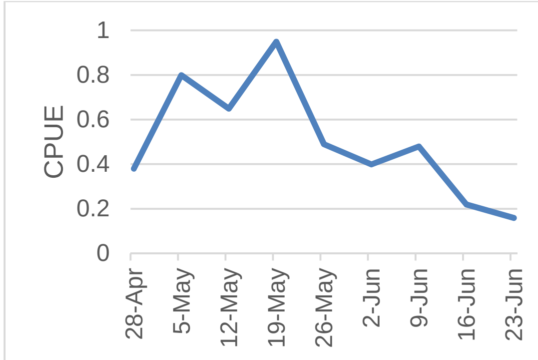


**Figure 6-1. River entry timing for Skagit spring Chinook (C. Ruff Skagit River Coop, personal communication 2016).**

Pre-terminal fisheries will involve incidental mortality of spring Chinook returning to the Skokomish River. It is expected that recent constraints on pre-terminal fisheries in Washington, which have been driven by concern for weak Puget Sound Chinook stocks, will be sufficient to meet the conservation and protection objectives of this Plan for Skokomish spring Chinook.

When sufficient information has been collected to characterize fisheries mortality and distribution, the Skokomish 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.

### 6.4.2 Summer/Early Fall Chinook

Terminal-area fisheries for summer/early fall Chinook target a mixture of Hoodsport Hatchery and George Adams Hatchery production in Marine Area 12C, and George Adams production in the Skokomish River. The terminal fishing regime is planned to maximize harvest opportunity, while achieving conservation objectives for the natural component, as specified in the Puget Sound Chinook Harvest Plan and clarified in this plan (see Chapter 3). This plan envisions a transition to later run timing for the George Adams stock, which involve changes in terminal harvest strategy. In recent years George Adams Chinook have exhibited more and more advanced 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 begin in late July and peak in mid-August. For a period of at least two brood cycles (seven years starting in 2018) fishing pressure will increase in the river and Area 12C during the month of July to remove early George Adams returns. Fisheries directed at summer/early fall Chinook will occur in Area 12C and the Skokomish River through the fourth week of August. Skokomish River fisheries will include openings in the mainstem below SR 106, between SR 106 and US 101, and in Purdy Creek. River fisheries will commence the first week of July, with regulations for use of hook & line, dipnet, gillnet, and beach seine gear. Fisheries in Area 12C and the Skokomish River will be closed at the end of August, continuing through September. Coho directed fisheries will begin October 1 in Area 12C and in early October in the Skokomish River

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. However the hiatus in terminal fisheries 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. The terminal harvest rate on this later-timed component will be managed consistent with the total ER ceiling of 50%, though it is expected that the total ER on fish returning after August will be much reduced.

The higher fishing pressure during July, to assist the shift in run timing, and continuing through August, will increase the terminal harvest rate on the early and mid-portion of the return and the total exploitation rate on the aggregate summer/early fall management unit. It is important to recognize, however, that the total ER on the late-timed segment will be significantly reduced.

Based on the return timing of Marblemount spring Chinook 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. Therefore, we expect that incidental harvest of spring Chinook will be very low during the summer/early fall Chinook fisheries in July and August. However, the timing and migration behavior of spring Chinook returning to the Skokomish will be monitored with supplemental data from CWT recoveries in fisheries to determine the extent of run timing overlap and locations where spring Chinook hold in the lower river that might expose them to harvest.

### 6.4.3 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. Yearling juvenile sockeye produced at the Hood Canal hatchery are released into the North Fork; subyearling sockeye are released into Cushman Reservoir from where they will emigrate, primarily as yearlings.

Sockeye fisheries, beyond minimal C&S opportunity, will not be initiated until returns exceed hatchery broodstock requirements. 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.

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 6.2). Ruff et al. (2015) estimated that migration timing in the Skagit River, from Skagit Bay to the Baker River trap, was 14.5 days ( a distance of approximately 56 river miles). Based on these Baker River data that river entry of sockeye will begin in late May and continue through the end of July, we estimate that migration to the North Fork trap may take about a week, considering the shorter path in the Skokomish system. If the Hood Canal hatchery sockeye stock and the North Fork spring Chinook stock exhibit behavior similar to the Skagit donor stocks, we would expect some overlap in the latter part of spring Chinook entry with sockeye. But incidental harvest of spring chinook will be kept low during sockeye fisheries, primarily through harvest regulations that specify use of smaller mesh (5 3/4" or smaller) gillnets that target sockeye. A gill-net test fishery will be implemented in Area 12C and the lower Skokomish River to determine the entry and migration timing of sockeye. Incidental Chinook catch in the sockeye test fishery will be carefully monitored. Ceremonial and subsistence removals of spring

Chinook could be taken by the test fishery. The test fishery may be interrupted or terminated if spring Chinook catch exceeds a threshold percentage (to be set) of the projected terminal abundance of Chinook.

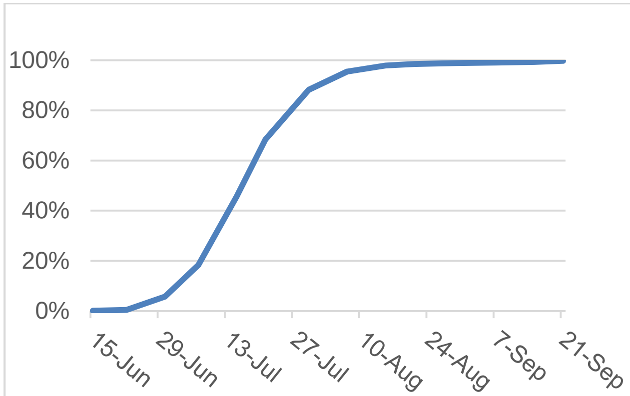


**Figure 6-2. The timing of arrival of sockeye salmon at the Baker River trap (E. Eleazer, WDFW, personal communications 2016)**

### 6.4.4 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 sub-populations in the Little Quilcene River, Big Quilcene River, Hamma Hamma River, Duckabush River, Dosewallips River, Union River, and Lilliwaup Creek. The abundance of the Hood Canal population has increased dramatically (Fig 6.3) since the listing, aided by re-introduction and hatchery supplementation programs, a harvest management strategy, and habitat restoration. Escapement goals are being achieved or exceeded in most rivers. Summer chum have been observed in increasing numbers in the lower Skokomish River and the run is now considered to be robust (Lestelle et al. 2018). Surveys since 2010 have estimated a peak live count of 1,600 summer chum in the lower mainstem (below the SR 206 bridge) in late August and September (M. Downen, WDFW personal communications Sept 21, 2016).

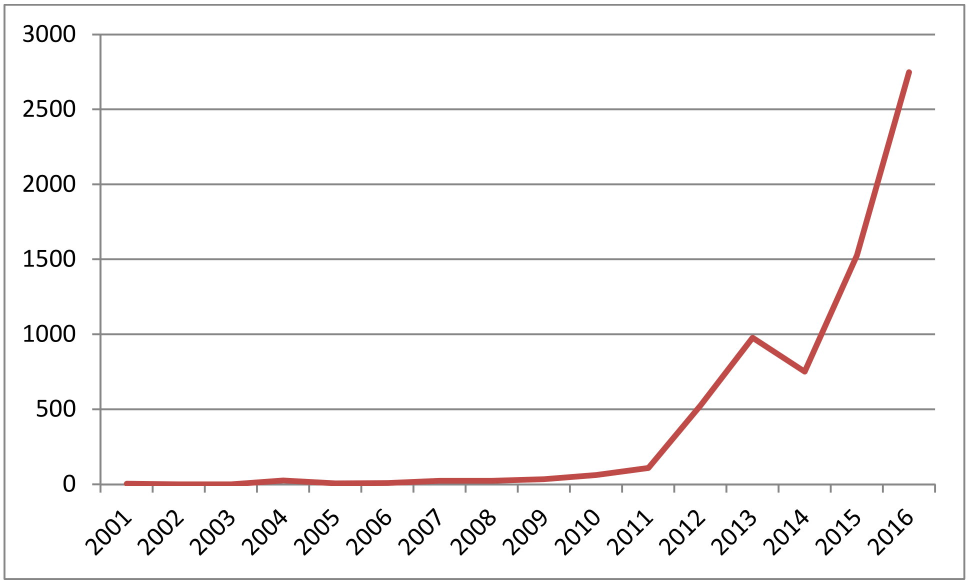


**Figure 6-3. Estimated spawning escapements of summer chum in the Skokomish River, 2001 - 2016. (WDFW SaSI 2017, M. Downen, L. Lestelle personal commications June 6, 2017)**

For harvest management in the Skokomish River, though Skokomish summer chum returns have not been delineated within the Hood Canal population for conservation under the ESA, terminal fisheries will be shaped such that the extreme terminal (in-river) harvest rate does not exceed 10%. The summer/early fall Chinook fishing regime outlined above, including the hiatus in fishing from late August through September, will minimize incidental impacts on summer chum. The Union River summer chum sub-population has been consistently strong since the listing in 1999 and the run is considered robust (Lestelle et al. 2018). It is noted that summer chum begin entering the Skokomish River in late August and their major entry timing occurs in September, when the river will be closed to fishing under the harvest plan described here.

### 6.4.5 Coho

Fisheries directed at coho salmon in Puget Sound have been managed in accordance with the Comprehensive Coho Plan developed by the co-managers in the 1990s (though this plan was not formally agreed by all parties). Harvest of wild coho 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 has been 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 in the Skokomish River (82G). Also, limited dip-net coho fisheries occur in the Quilcene River.

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 occur in October. In previous years the coho fishery in the river began earlier (mid-September). Recent year catch data indicate that incidental catch of summer/early fall Chinook is very low during the opening of coho-directed fisheries in 12C and the Skokomish River, as the peak of the hatchery return to George Adams has already passed. Wild coho continue to return at relatively lower abundance from October to January, but fishery encounters with Chinook have been consistently very low (ranging from 7 to 80 landed annually) through the coho and fall chum management period.

### 6.4.6 Fall Chum

There is substantial production of fall chum at Hoodsport Hatchery and McKernan / George Adams Hatcheries, with a smaller Skokomish tribal program at Enetai (near Potlatch) and Little Boston Hatchery in Port Gamble. 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 escapements of sufficient broodstock to perpetuate the hatchery programs. Natural escapement to the Skokomish River and numerous other river systems throughout Hood 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. These fisheries incur very low incidental mortality on summer/early fall Chinook.

### 6.4.7 Winter Steelhead

Fisheries for winter steelhead have been highly constrained in recent decades because the wild populations have been severely depressed. Hatchery production has been terminated, but limited experimental production operated by the NMFS / co-managers continues in the South Fork Skokomish, 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.

### 6.4.8 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 overlaps that of summer/early fall Chinook in September, which can further complicate estimation of Chinook escapement. No terminal area fisheries targeting pink salmon returns to the Skokomish River are envisioned, but incidental harvest of pinks is expected in Chinook fisheries in August.

# Chapter 7. Hydropower Recovery Strategy

This plan documents how various threats and related issues have influenced the physical and biological processes of the Skokomish watershed over the past 150 years. The cumulative effect of all of these changes caused the extinctions of the aboriginal life histories of Skokomish Chinook. The single most influential event on the watershed and its processes was the construction of the Cushman Hydroelectric Project. It has had a major role in shaping the watershed's environment, salmon resources, and human communities over the past 80 years (see Chapter 4 for details).

This chapter presents the strategy that will employ the Cushman Project to help achieve recovery. The chapter is organized into the following sections:

This chapter is organized into the following sections:

7.1 The role of hydropower management in recovery;

7.2 History of events leading to the Cushman Settlement and a new license; and

7.3 Components of the strategy.

## 7.1 The Role of Hydropower Management in Recovery

The Cushman Project will continue to have a major role in the Skokomish watershed over at least the next 40 years. On July 15, 2010, the Federal Energy Regulatory Commission (FERC) issued a new license to the City of Tacoma to operate the Cushman Project. License articles call for the implementation of a variety of measures aimed at restoring normative watershed functions and salmon life histories adapted to the watershed, as spelled out in the Cushman Settlement. Tacoma is required to fund and implement these measures over the life of the license.

As Tacoma had a role in the demise of the aboriginal salmon life histories, it now has an important role in their recovery. The actions specified in the new license call for the re-establishment of early-timed Chinook in the upper North Fork, which is a foundational part of the rest of this recovery plan.

## 7.2 History of Events Leading to the Cushman Settlement and A New License

This section provides an overview and chronology of the major events that led to the Cushman Settlement. It serves to give context for understanding the important role that it has in the recovery plan.

In 1926 the City of Tacoma completed the construction of a hydroelectric dam on the north fork of the Skokomish River to provide electricity to the people of the City of Tacoma. The dam was built without any fish passage facilities and the lake formed by the dam inundated 9.6 miles of prime spawning and rearing habitat. In 1930, Tacoma completed the construction of a second dam on the North Fork 2 miles downstream of the upper dam. The powerhouse for the lower dam was located along the shore of Hood Canal. The North Fork flows were diverted completely out of the watershed through pipes to the powerhouse. Together these dams and associated facilities are known as the Cushman Hydroelectric Project. It operated from 1926 through 1996 without any mitigation requirements for the damage caused to the habitat and the fish and wildlife that live there.

As early as 1915, members of the Skokomish Tribe had opposed the construction of the Cushman Project for fear that it would damage tribal resources and the Skokomish Reservation, which is located downstream. The Tribe sought help from the Bureau of Indian Affairs (BIA), the U.S. Department of Interior (DOI) and the U.S. Department of Justice. The Federal Government debated this issue between agencies and ultimately decided not to take any legal action to stop or otherwise limit construction or operation of the Project. The Tribe filed suit against Tacoma in the Federal District Court but the Court ruled that the Tribe did not have standing to bring the suit itself. If the case was to go forward, the Federal Government would have to pursue it on behalf of the Tribe and the suit was then dismissed. Intervention was not pursued by the Federal Government. The Cushman Project was allowed to go forward.

The original license for the operation of the Project expired in 1974. FERC allowed Tacoma to keep operating the Project on annual licenses until a new license was issued in 1998 and amended in 1999. During this period, the Skokomish Tribe, DOI, Federal and State natural resource agencies intervened in the license proceedings. Legal and administrative appeals were filed by the Tribe and the agencies seeking to have mitigation actions imposed by FERC on Tacoma. In 1996 the DOI developed license conditions designed to mitigate for damages caused by the nearly 75 years of operation of the Project. These conditions were developed under section 4(e) of the Federal Power Act. FERC did not accept these conditions and developed their own set of conditions, which were less restrictive, that were attached to the new license issued in 1998. The Tribe, Tacoma and the agencies then appealed the license issuance, each for various reasons. The Tribe then filed suit in Federal District Court against Tacoma and the Federal Government for damages caused by the Project. The District and Ninth Circuit Court of Appeals ruled against the Tribe and dismissed its claims against Tacoma but transferred the Tribes claims against the Federal Government into the Federal Court of Claims.

In 2006, the D.C. District Court issued a ruling in the appeal of the 1998 license. In that decision the Court determined that under the Federal Power Act only DOI has the authority to develop license conditions to protect the Skokomish Reservation and to mitigate for damage to the Skokomish River caused by the operation of the Project, and that FERC could not reject those conditions. The Court remanded the case back to FERC for modifications to the new license to include the conditions developed by DOI. The Tribe then filed a request with the District Court to amend language in its decision in the damages case to be consistent with language in the Ninth Circuit’s decision. When the District Court refused, the Tribe appealed to the Ninth Circuit. The Ninth Circuit offered to provide a mediator if the Tribe and Tacoma were willing to try and settle this latest dispute. Mediation was accepted by the parties.

The Tribe and Tacoma reached agreement on the principal elements of an agreement that would settle all of the disputes between them. DOI and the State and Federal natural resource agencies were then brought in to the process to help craft the language for the license conditions for submittal to FERC. Provisions for a license were agreed to by the Tribe, Tacoma, BIA, NOAA Fisheries, U.S. Forest Service, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife and the Washington Department of Ecology. The agreement was then signed in a ceremony in Tacoma in January of 2009.

This settled disputes over license conditions, damages, water rights, illegal trespass, and the Coastal Zone Management Act.

The license conditions to be submitted to FERC were developed with two primary objectives: (1) to restore normative flows to the North Fork, and (2) to restore salmon species and their life histories that had been extirpated or reduced by the operation of the Project. Together, the license conditions are designed to restore the form and function of the North Fork, restore the channel capacity in the lower Skokomish River, restore access for fish to the upper reaches of the North Fork, and re-establish fish runs in the North Fork. The length of the license period would be 40 years. Tacoma would be required to implement the mitigation measures in the license over the license period. In July, 2010, FERC accepted all of the articles for inclusion into the new license.

## 7.3 Components of the Strategy

This section provides an brief overview of the major license conditions that were developed to improve the aquatic habitat and fish populations in the Skokomish River. Details of the license pertaining to this recovery plan are contained in Appendix C. Elements of these conditions as they will affect habitat, including flow, and the use of hatcheries in recovery are described further in Chapter 4 (habitat) and Chapter 5 (hatcheries).

### 7.3.1 Normative Flow Regime

The new flow regime to be implemented has three components: base flows governed by a water budget, channel formation flows and sediment transport flows. Together these components are designed to help restore normative fish habitat characteristics and the channel flow conveyance capacity in the Skokomish River.

### 7.3.2 Fish Passage

A fish passage program and facilities are to be designed and implemented to provide fish passage upstream and downstream of the Cushman dams. The effectiveness of the passage facilities is to meet NMFS fish passage standards.

### 7.3.3 Habitat Restoration

A fund will be established with an initial deposit of $3.5 million to be used for aquatic and riparian habitat restoration projects in the North Fork.  Tacoma will add $300,000 each year beginning in year 5 for the remainder of the length of the 40 year license.

### 7.3.4 Fish Supplementation and Re-Introduction Program

A program will be developed and operated to re-establish early-timed Chinook in the North Fork through re-introduction using a donor stock. Hatchery technology is to be employed. Other species to be re-introduced using similar technologies are sockeye, coho, and steelhead. Indigenous coho and steelhead from the Skokomish watershed are to be used. A donor stock for sockeye will be required. On-going supplementation technology will be required due to the limitations of the upper North Fork habitat as a result of inundation by the reservoir.

### 7.3.5 Monitoring and Evaluation

The license requires a significant amount of monitoring to assess how the mitigation measures are performing over the life of the license. Tacoma is to develop the monitoring plans with the help of the Tribe, DOI and the Federal and State agencies. Tacoma will be responsible for implementing the plans. Data collected from the monitoring plans will be used to evaluate the effectiveness of mitigation and the various restoration actions in the watershed. Modification and improvements can be made to the actions using an adaptive management approach in conjunction with monitoring. These monitoring plans will be designed to complement monitoring work being conducted in the South Fork and estuary of the Skokomish River through the efforts of the Tribe and other entities. A brief list of the monitoring elements to be addressed by Tacoma is provided below. A more detailed description of monitoring requirements is contained in the new Cushman license (Appendix C).

Operational and Flow Monitoring Plan - This plan will document how Tacoma Power will: (1) monitor impoundment water surface elevations in Lake Cushman; (2) monitor stream flows in the Skokomish River downstream of the Project; (3) ensure compliance with the minimum flow requirements; and (4) improve mainstem flow and flood forecasting.

Fish Habitat and Monitoring Plan – This plan is to address the following elements:

- Sediment transport and channel morphology in the lower North Fork and mainstem
- Fish habitat composition and distribution in the North Fork and lower Skokomish River
- Productivity of Lake Cushman
- Water temperatures
- Fish population abundance in the North Fork
- Juvenile production, distribution, and habitat utilization in the lower North Fork
- Fish distribution and habitat utilization in the upper North Fork
- Resident fish in Lake Kokanee
- Genetic monitoring of specific populations.

Fish Passage Monitoring Plan – This plan is to address the following elements:

- Juvenile emigrant survival through the reservoir, fishways and transport mechanisms
- Adult passage effectiveness
- Compliance with survival standards and passage effectiveness as stipulated by NMFS

Hatchery Monitoring Plan – This plan is to address the following elements:

- Best management practices for supplementation facilities
- Size at release, growth rates and survival in hatcheries
- Disease profile
- Spawn timing and condition
- Homing/straying
- Coded-wire tagging program
- Stock inventory
- Number of fish released
- Water temperature at facilities
- Water quality parameters required by permits

# Chapter 8. Integration of Habitat, Hatchery, & Harvest Strategies

This chapter describes the need to integrate the various parts of the plan into a cohesive, internally consistent plan and the major steps to accomplish that.

This chapter is organized into the following sections:

8.1 Challenges of integrating habitat, harvest, and hatchery strategies;

8.2 Sequencing, duration, location; and

8.3 Next Steps in integration.

## 8.1 Challenges of Integrating Habitat, Harvest, and Hatchery Strategies

Integration is the coordinated combination of actions among all the different management sectors (habitat, harvest, hatcheries, and hydroelectric) that together work to achieve the goal of recovering self-sustaining, harvestable salmon runs. Because many actions in these sectors fundamentally require tradeoffs between what people want and what salmon need, "H-integration" involves balancing biological effectiveness in moving towards salmon recovery (e.g. the greatest sustainable improvements in the shortest amount of time) and fairness in providing competing benefits for people. (It should be noted that we have considered the hydroelectric strategy as being contained in the habitat and hatchery strategies for simplification.)

The most biologically effective combination of activities is unlikely to be successful, for example, because it may require costs to communities that are perceived as unfair and therefore are not politically sustainable. These actions would likely not get implemented and consequently are not useful for restoration. Likewise, trying to please everyone may be ineffective and costly in recovering salmon (Figure 8.1).

## 8.2 Sequencing, Duration, Location

Practically, integrating the different actions in habitat, hatchery managements, and fishery management means implementing the actions at the best time, in the appropriate sequence, in appropriate locations, and at the necessary levels to be most effective. Figure 8.2 illustrates likely sequences, durations, and magnitudes of actions and their predicted effects for Skokomish River Chinook.

The most important step is beginning the habitat restoration strategy and activities that will allow improve the productivity of naturally spawning Chinook. To protect the investments in habitat restoration, habitat protection likewise needs to increase. Hatchery Strategy No. 1, reintroducing early-timed Chinook to the North and South Forks, depends not only on gaining adequate flows and passage in the watershed but also on choice of an appropriate strategy for the brood stock and enough time for local adaptation to occur. Reintroduction will occur sequentially, first in the North Fork and later in the South Fork. Closely related is Hatchery Strategy No. 2, maintaining genetic diversity and abundance in the North Fork, which is a key foundation for monitoring and adapting the reintroduction efforts early in Strategy 1 and in allowing time for habitat to respond to restoration and protection in the different forks. Hatchery Strategy No. 3, in contrast, allows for harvest and provides a possible contingency source for use of later-returning production in the watershed.

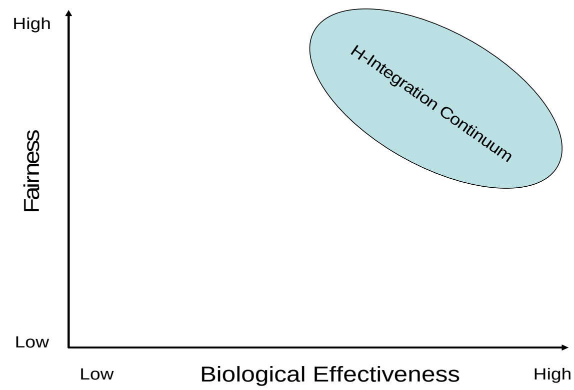


**Figure 8.1. Achieving integration of actions in different management sectors (habitat, fisheries, hatcheries, and hydroelectric power) is a balance between fairness and the continuum of biological effectiveness in achieving salmon recovery goals.**

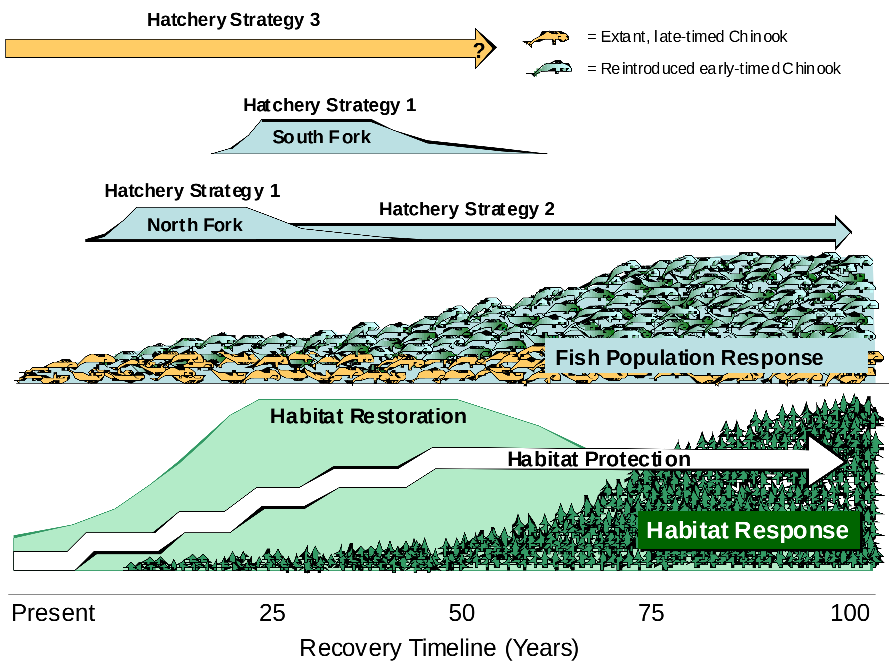


**Figure 8.2. Conceptual illustration of sequencing of hatchery strategies in the Skokomish River in relation to habitat restoration and protection actions and the response of the fish populations. The height of the strategies and fish and habitat responses over time indicates the expected magnitude.**

Using or developing the appropriate scientific tools to help inform these choices is also an important part of the sequencing. For example, as natural production increases in response to habitat and hatchery strategies, harvest management will need to have adequate tools and data to continue to provide for harvest while protecting natural-origin fish.

## 8.3 Next Steps in Integration

As illustrated above, integration involves four key steps

1. Using the best available information and analyses to understand and predict the combined effects of the individual H-sector actions on VSP characteristics of the population. This begins with comparing the effects of the actions for their directionality (+ or -), magnitude, time lag, and persistence.
2. Choosing actions that are complementary in their effects.
3. Implementing the actions.
4. Utilize monitoring and adaptive management to address probabilities and uncertainties (see Chapter 9)

Recovery planning for Skokomish Chinook has focused on qualitative analyses of these steps and this has provided the general direction and priorities for integration in this recovery plan. Quantitative analyses provide an additional way of refining these analyses and testing for unexpected results that may not be apparent in qualitative analyses. Quantitative analyses require gathering appropriate data and selecting or developing appropriate models for the analysis and this is just beginning for Skokomish Chinook.

An important use of these analyses will be to set the framework for adaptive management (Chapter 9). For example, Table 8.1 shows how results from the analyses can be organized. The major actions from one time period (e.g., current) have expected outcomes at other time periods (e.g., 5, 10, and 20 years), which in turn suggest whether actions need to change at those time periods. The expected outcomes also become the triggers for adaptive management. For example, if the expected outcome does not occur at 5 years, it makes sense to ask why. Were these the right actions? Were they implemented? Was the monitoring inadequate to detect the response? Did something else unexpected happen in the watershed to explain the results? Does the model need to be refined? Answering these questions then leads to refining the sequence, location, timing and duration of the next set of restoration actions.

**Table 8.1. Summary of integrated restoration actions.**

| | Time Frame for Actions | | | |
|---|---|---|---|---|
| **Management Sector** | **Current** | **5 yr** | **10 yrs** | **20 yr** |
| Habitat | Major Actions | Major Actions | Major Actions | Major Actions |
| Harvest | Major Actions | Major Actions | Major Actions | Major Actions |
| Hatcheries | Major Actions | Major Actions | Major Actions | Major Actions |
| Hydroelectric | Major Actions | Major Actions | Major Actions | Major Actions |
| **VSP Characteristic** | **Expected Effects of Actions** | | | |
| Abundance | Results from modeling (including uncertainty) | Results from modeling | Results from modeling | Results from modeling |
| Productivity | Results from modeling | Results from modeling | Results from modeling | Results from modeling |
| Spatial Structure | Results from modeling | Results from modeling | Results from modeling | Results from modeling |
| Diversity | Results from modeling | Results from modeling | Results from modeling | Results from modeling |

# Chapter 9. Adaptive Management and Monitoring

Adaptive management is a science-based management approach of adjusting management actions and/or directions based on new information. It is an essential part of managing salmon recovery to address uncertainties about the future, including the responses of the environment and the biota to recovery actions. Adaptive management is not managing by trial and error—it requires that purposeful actions be taken, then monitored and scientifically evaluated so that policy, management, and actions become more effective in salmon recovery over time (Joint Natural Resources Cabinet 1999).

Adaptive management and monitoring are linked. Without monitoring, there is no scientifically valid way of assessing progress and knowing whether investments in actions are beneficial. Well-designed monitoring should (1) indicate whether the restoration measures were designed and implemented properly, (2) determine whether the restoration results met the objectives, and (3) give us new insights into ecosystem function and response (Kershner 1997). Hence, besides measuring progress of the plan, monitoring also serves a research role in addressing critical uncertainties.

This chapter describes the major elements of the adaptive management and monitoring components of this recovery plan. These elements will be part of the larger adaptive management effort being developed for the Puget Sound Chinook ESU.

This chapter is organized into the following sections:

9.1 The adaptive management cycle; and

9.2 Monitoring and Evaluation Framework.

The elements of monitoring contained in this chapter do not in themselves constitute a monitoring plan for recovery. Instead, they would be woven into monitoring efforts either already underway, soon to be implemented, or to be undertaken in the future as funding becomes available. The Cushman Settlement, for example, calls for long-term, comprehensive monitoring of various environmental and biological responses in the North Fork and, to some degree, in the lower Skokomish River. While the components of that monitoring plan have been agreed upon, specific details are still developing (see Chapter 4). The General Investigation (GI) being carried out by the USACE in the lower valleys of the Skokomish River and South Fork also will provide important monitoring and research information. It is expected that one benefit of the GI will be to continue to provide an important monitoring function in the lower river valleys for years to come. Other monitoring efforts are also underway in the basin, as noted in this chapter.

## 9.1 The Adaptive Management Cycle

Will habitat, harvest, hatchery, and hydroelectric strategies recover Chinook salmon in the Skokomish River? The answer hinges on many things that are still uncertain. For example, do we understand the physical and biological processes operating in the watershed that limit salmon recovery well enough to make effective choices? Will there be enough funds to implement the most effective actions? Will the goals, objectives, and strategies outlined in the recovery plan be successfully implemented? Will agencies with regulatory authorities use them to protect existing watershed functions so that recovery actions can provide net improvements?

Adaptive management is a tool for managing these types of uncertainty. It refers to an explicit process of making decisions based on the best available information, implementing them, learning from the results of the implementation, and adjusting the decisions as necessary to achieve a goal.  This process can be seen as a management cycle comprised of four key steps (Figure 9.1):

1. Develop goals and objectives;
2. Develop a framework for assessing progress in recovery;
3. Prepare and implement a plan to get the important information;
4. Decide how to use the new information.

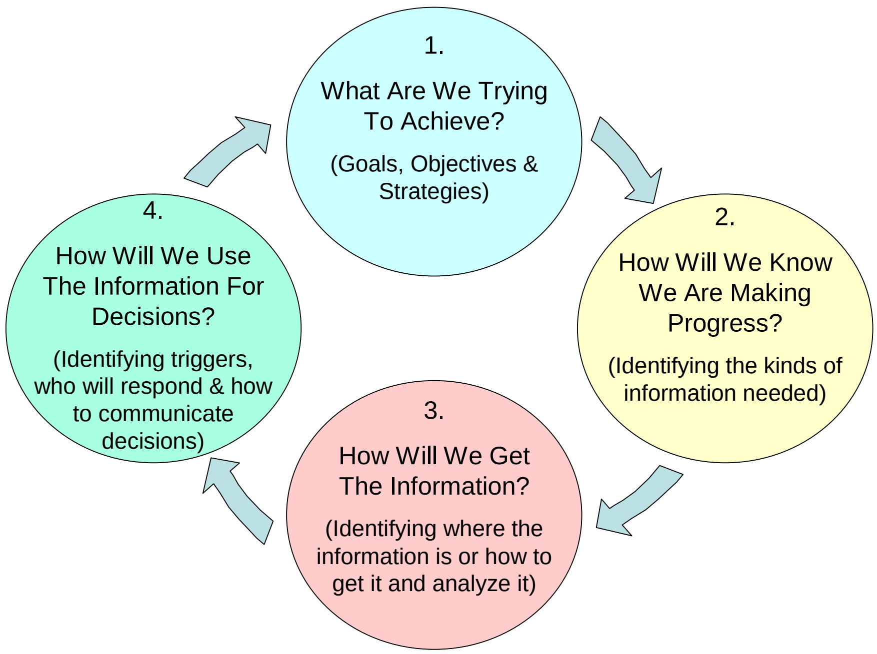


**Figure 9.1.  The adaptive management cycle (adapted from the Ecosystem Management Initiative Evaluation Cycle, University of Michigan).**

An important characteristic of this cycle is that improvements can and should occur in all the steps of the evaluation cycle over time.  This allows us to begin taking actions without waiting for a perfect monitoring or decision making system, because through the evaluation process monitoring, analyses, and strategic decision making are examined for how they can be refined and improved.

The scale and scope of this plan are extensive; therefore, it is imperative that the participants in the adaptive management cycle be broadly defined. Watershed-scale protection and restoration involve multiple specialists, including tribal and non-tribal agency personnel, and non-agency partners. Taking an interdisciplinary approach and utilizing multiple agencies and other entities will help integrate the four H's. All of the involved agencies and personnel should actively participate in setting objectives, study design, and analysis.

The adaptive management cycle envisioned in this plan is not another management process being added to an already full slate of management activities involving the Skokomish River, its resources, and the many active personnel. To be useful in a timely manner, we envision that its elements need to be integrated into as many of the various management processes that already exist or will be soon.

## 9.2 Monitoring and Evaluation Framework

This section presents the monitoring and evaluation framework around which the adaptive management cycle will be structured. The framework encompasses the four primary types of monitoring that will need to occur to assess progress toward recovery (Figure 9.2). It is adapted from the status decision framework formulated by NMFS in its guidance document to help recovery planners address monitoring (NMFS 2007).

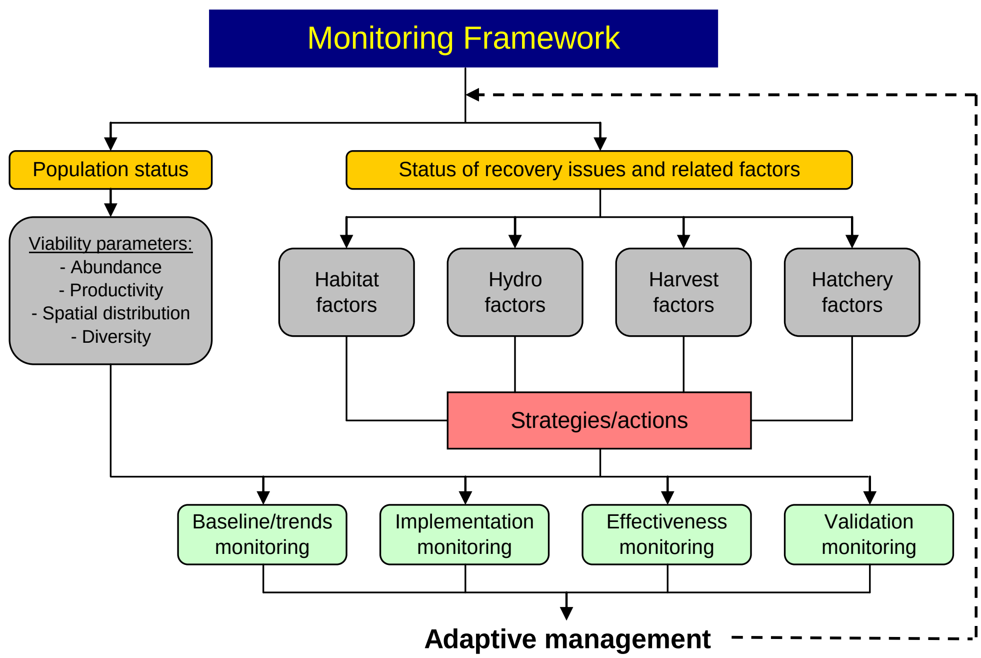


**Figure 9.2. Monitoring and evaluation framework (adapted from NMFS 2007).**

Definitions of the four types of monitoring, adapted from Joint Natural Resources Cabinet (1999), Botkin et al. (2000), and NMFS (2007), are given below:

> *Baseline/trends monitoring* involves tracking changes in fish populations and habitat conditions over time. This monitoring is critical to the interpretation of effectiveness and validation monitoring activities. It includes establishing a baseline for future comparisons.
>
> *Implementation monitoring* determines progress in implementing the planned recovery strategies/actions. Has an action been implemented? This monitoring is generally carried out as an administrative review, which can include site visits. It does not directly link restoration actions to physical, chemical, or biological responses, as none of these parameters are measured.
>
> *Effectiveness monitoring* assesses how effective actions are in achieving their objectives. The effectiveness of actions directed at affecting the physical environment is usually most directly

assessed by determining whether targeted watershed processes or habitat characteristics are altered. For example, did a flow regime action facilitate sediment transport through the lower river? Monitoring directed at answering this question will often yield useful information in a few years. In contrast, the effectiveness of such an action in improving salmon performance can often only be determined over a much longer period of monitoring (Lichatowich and Cramer 1979) and may be best considered as validation monitoring (Botkin et al. 2000). Variability in biological response to altered environmental characteristics is usually much greater than variability in habitat metrics, making it more difficult to conclude cause and effect in biological response (Lestelle et al. 1996; Botkin et al. 2000). However, some effectiveness monitoring directed at certain habitat issues, such as providing fish passage at dams or natural falls, is measured by directly assessing fish response, which, in this case, can normally be determined relatively rapidly.

*Validation monitoring* seeks to validate basic assumptions about how actions contribute to the recovery of the target population (Botkin et al. 2000). Because the ultimate goal of this plan is to re-establish a natural population of early-timed Chinook, then the best measure of the success of various actions toward achieving this goal is the number of naturally-produced, self-sustaining fish produced as a result of those actions. The contributions of some actions toward recovery, particularly those aimed at restoring watershed processes, can be extremely difficult to validate in the short-term (Lestelle et al. 1996). In these cases, modeling can be useful to help validate underlying assumptions contained in the recovery plan until longer-term monitoring results become available.

The elements of the monitoring framework are described below within the context of each of the four steps in the adaptive management cycle (Figure 9.1). Many of the monitoring elements are defined through the use of two terms, *benchmarks* and *triggers*, which were applied by the Shared Strategy in its presentation of the recovery plan for the ESU. The terms have the same meaning herein. Benchmarks define how progress or change is to be measured for each type of monitoring associated with specific strategies. For implementation monitoring, for example, the benchmarks identify targets against which progress is to be measured to verify actual implementation. Triggers are meant as a type of checklist to help gauge the rate of progress. In implementation monitoring, the triggers can indicate when actions should be initiated or when progress might be occurring too slowly consistent with other aspects of the plan.

**<u>Step 1.</u> Develop goals and objectives**

This step establishes clear goals and objectives. The objectives define a strategy's or specific project's purpose and determine the type and extent of restoration/protection that is desired. Objectives need to be measurable or quantifiable in some manner, and are defined by indicators to be assessed through monitoring. It is important to define the temporal and spatial scale so monitoring objectives can be identified and prioritized. When the temporal and spatial scales are clearly defined, the study design and sampling protocols can be developed.

**<u>Step 2.</u> How will we know if we are making progress?**

This step involves designing monitoring to detect change. Utilizing standard principles for conducting environmental or biological field studies, information should be collected on physical, biological, or chemical characteristics before implementing actions or before altering actions, such as altering the flow regime, so changes resulting from the restoration/protection can be documented.

We will know if we are making progress toward recovery if we know that recovery actions are being implemented, and if we see expected changes in watershed processes and the performance of the target salmon population. Chapters 4 to 7 identified recovery strategies for each of the threat categories or other recovery issues. Chapter 8 outlined a way of organizing the expected, combined effects of all of the strategies.

Four kinds of information, corresponding to each of the monitoring types, are needed for Step 2:

1. <u>Baseline and trends information for relevant indicators.</u> Information on relevant environmental indicators is needed to define the baseline set of conditions throughout the watershed or within specific restoration areas, as well as to monitor trends over time. Some of the environmental indicators are miles of moderate/high risk roads by stream drainage, significant sediment sources that need to be addressed, miles and locations of streams by riparian condition, density of LWD by stream reach, habitat type composition, streambed scour/stability indices, among many others. Relevant indicators are the same as those listed in Tables 9.1 and 9.2.

   Information on salmon performance is also essential. Indicators of salmon performance that are critical for status and trends monitoring are spawners abundances, juvenile production, and survival indices measured at key locations in the watershed as well as in the marine environment.

2. <u>Progress in achieving implementation benchmarks.</u> Monitoring will occur to assess progress in implementing the strategies as defined by the implementation benchmarks and corresponding indicators identified in Table 9.1. The table also identifies triggers to help gauge the rate of progress in implementation or status of the strategies. The benchmarks, indicators, and triggers combined provide the means of evaluating implementation progress.

3. <u>Assessment of action effectiveness.</u> Monitoring will occur to assess the effectiveness of recovery strategies and actions in meeting objectives as defined by the effectiveness benchmarks in Table 9.2. Some of the benchmarks identified in Table 9.2 measure effectiveness as changes in key environmental indicators, while others focus directly on changes in salmon performance during one or more life stages. Examples of environmental changes due to actions include reductions in rates of mass wasting, channel stability indices increasing in the upper South Fork, channel flow capacity increasing in the lower river valleys, increases in stable log jams, and indices of riparian quality improving, among many others. Examples of improved performance of Chinook due to action effectiveness include improved ability of adults to navigate cataracts in the South Fork gorge, achievement of NOAA fish passage standards both upstream and downstream at the Cushman Dams, post-release survival of early-returning hatchery produced Chinook in the North and South forks, successful natural breeding of hatchery-produced Chinook in the North and South forks and normative survival of their progeny, among other benchmarks.

4. <u>Validation of key assumptions and assessment of changes in population performance.</u> Monitoring activities will occur to validate the basic assumptions that underlie this plan and to assess changes in population status as the plan goes forward. Both near-term and longer-term validation benchmarks are identified in Table 9.3. Near-term benchmarks are meant to provide information in the early years of the plan about how well the various strategies might be contributing to recovery. Use of modeling is expected to help validate the plan during the early

years. EDT is one model that can be used in this manner (Blair et al. 2009; Thompson et al. 2009). To actually validate that the plan is indeed making significant progress toward recovery will require relatively long-term collections of empirical data due to environmental variability and related survivals in both fresh and salt water. Ultimately, monitoring of status and trends for both the population and the threats (recovery issues) will be used to validate the plan and recovery.

**Step 3. How will we collect information?**

Various agencies and non-agency partners will participate in collecting the information needed to monitor the progress of this plan. Key aspects of baseline and trends monitoring useful for this plan have been occurring for several years and will soon expand as the Cushman Settlement is implemented. Some of these monitoring activities also will be the basis for implementation, effectiveness, and validation monitoring. New efforts directed at implementation, effectiveness, and validation monitoring is also expected to soon be initiated, though other efforts will need to wait funding.

The Skokomish Tribe and WDFW annually assess spawner abundance and composition for all salmon species in key areas of the watershed, including the lower North Fork, lower South Fork, and mainstem river. Upon re-introduction of early-timed Chinook into the upper South Fork, the survey effort will be expanded to cover that area.

Tacoma's new operating license for the Cushman Project requires a significant amount of monitoring to assess the effects of the license conditions on the watershed and on its fish and wildlife populations. To do this, specific monitoring plans have been developed through the Fisheries and Habitat Committee (FHC), which is charged with monitoring oversight. The FHC is made up of representatives from the various agencies who participated in the settlement process. Monitoring details have been developed, and continue to be refined, into statistically sound monitoring components. Some of the elements contained in those plans are listed in Table 9.2. It is worth noting the level of biological monitoring that is aimed at assessing salmon response in the North Fork. Tacoma is responsible to fund annual assessments of spawners and juvenile production in the North Fork subbasin—both in the upper North Fork and lower North Fork.[16] Those efforts include operations of fish passage facilities at the Cushman Dams. The facilities are to be used to annually assess the number of Chinook adults that return to the base of the lower dam and then that will be passed into the North Fork Hatchery or taken to the upper North Fork. The fish will be identified as being hatchery or naturally-produced. The facilities will also assess the number of juveniles that successfully pass downstream out of Lake Cushman.

Much environmental baseline information has been collected in recent years, including channel characteristics and habitat composition in the lower North Fork by Tacoma and in the upper South Fork by the USFS. Additional baseline and on-going trends monitoring information on channel and habitat characteristics will be performed by Tacoma in the lower North Fork and mainstem Skokomish River under provisions of the new Cushman license. Key characteristics of the lower South Fork and mainstem Skokomish River have been assessed, or are currently being assessed, by the U.S. Bureau of Reclamation and U.S. Army Corps of Engineers as part of the General Investigation. Effectiveness monitoring on environmental indicators will be performed by Tacoma and the USACE as part of activities associated with the Cushman license and the GI, respectively. Also, the USFS will perform effectiveness monitoring in the upper South Fork as part of restoration actions that it is implementing (e.g., USFS 2010).

[16] / Annual assessments are to occur for the life of the Cushman Project license, i.e., 40 years.

Agencies or entities known or expected to be involved in some form of monitoring by geographic area within and beyond the watershed are listed below:

- Upper South Fork and associated tributaries
  - USFS
  - Skokomish Tribe
  - Washington State agencies
  - HCCC
- Lower South Fork and associated tributaries
  - Mason County
  - Skokomish Tribe
  - Washington State agencies
  - HCCC
  - Green Diamond Resource Company
- Cushman Project related
  - City of Tacoma
  - Skokomish Tribe
  - WDFW
  - NMFS
  - USFWS
- Lower North Fork and associated tributaries
  - City of Tacoma
  - Skokomish Tribe
  - Washington State agencies
  - Green Diamond Resource Company
  - Mason County
  - HCCC
- Mainstem Skokomish River
  - Skokomish Tribe
  - Washington State agencies
  - City of Tacoma
  - USCOE
  - Mason County
  - HCCC
- Skokomish estuary
  - Skokomish Tribe
  - Washington State agencies
  - USCOE
  - Mason County
  - HCCC
- Hood Canal marine areas
  - Washington State agencies
  - Skokomish Tribe
  - Point No Point Treaty Tribes
  - Mason County
  - Kitsap County
  - Jefferson County
  - HCCC

- Pre-terminal fisheries
  - Co-Managers

**<u>Step 4.</u> How will the information be sued for making decisions?**

Information collected through the monitoring elements described above will be used in a variety of management processes that concern the Skokomish watershed and its fish populations. Many different groups, ranging from individual landowners, county and state regulatory agencies, Skokomish Tribe, other tribes, City of Tacoma, and federal land and natural resource agencies, make or influence decisions through these processes that affect the Skokomish watershed or its fish. To be effective, the elements of this recovery plan need to be integrated into the relevant management processes and related forums. As the primary authors of this plan, the Skokomish Tribe and WDFW are committed to providing leadership in this regard.

**Table 9.1. Implementation monitoring elements: implementation benchmarks, triggers, and indicators.**

| Recovery issue | Strategy | Implementation benchmark | Implementation triggers | Indicator |
|---|---|---|---|---|
| Degraded Upper Watershed Conditions in South Fork and major tributaries | Decommission roads and maintain remaining road & trail network | All moderate and high risk roads decommissioned, stabilized or upgraded to prevent sediment delivery by 2015. | Plans for decommissioning and maintenance on USFS lands and Green Diamond lands agreed on by relevant parties; completed plans being implemented as per RMAP on private lands and the 2000 Road Management Strategy (RMS) and the 2003 Access and Travel Management Plan (ATM) on USFS lands; decommissioning targets not being met on annual or specified schedule; Green Diamond lands targets not being met on specified schedule. | Miles of road decommissioned annualized |
| | Stabilize sediment sources | Significant sediment sources stabilized with routing and rate of inputs to channels reduced. | High risk or significant sediment sources identified; plans for stabilization by 2015; proposals submitted for funding; funding secured; progress in reducing # of sites or lack thereof. | # of sites identified with plans for stabilization completed; # of sites stabilized |
| | Expand high quality riparian reserves along mainstem South Fork and tributaries. | Amount of riparian areas preserved by voluntary or regulatory/statutory programs increasing through 2020. | South Fork subbasin-wide riparian targets established by land ownership and subdrainage; comprehensive riparian mgmt plan completed; progress in miles of streams with reserves; steady improvement in quality of riparian forests made evident or lack thereof. | Miles of stream where high quality riparian zones either exist or have been reserved to be established |
| | Restore riparian conditions | Quality and quantity of riparian areas restored through riparian management programs increasing by 2015, then continuing to improve incrementally thereafter until PFC condition reached. | South Fork subbasin-wide riparian targets established by land ownership and subdrainage; comprehensive riparian mgmt plan completed; progress in miles of streams with reserves; steady improvement in quality of riparian forests made evident or lack thereof | Miles of stream where high quality riparian zones either exist or have been reserved to be established |
| | Increase woody debris and log jam density | Density of woody debris increasing by 2015 as a result of both passive and active restoration planning, then continuing to improve incrementally thereafter until PFC conditions reached. | Progress or the lack thereof on elements of the HCCC's Three-Year Watershed Implementation Priorities; approval/permitting attained for the South Fork Skokomish Large Wood Enhancement Project on USFS lands in the upper South Fork; South Fork subbasin-wide LWD and logjam targets established by mainstem reach and subdrainage; comprehensive LWD mgmt/restoration plan completed; proposals submitted for actions; funding secured; actions submitted according to plan; progress or lack thereof in density of stable LWD and jams. | Density of LWD by size class and number of stable jams established |

| Recovery issue | Strategy | Implementation benchmark | Implementation triggers | Indicator |
|---|---|---|---|---|
| | Silviculture treatments should increase hydrologic maturity on public lands with incentives for doing the same on private lands. | Watershed and sub-basin hydrologic maturity on public lands on an increasing trajectory through 2050. | South Fork subbasin-wide targets for hydraulic maturity of stands established for all public lands; plan to achieve targets completed; agreements reached for plan implementation; steady progress in increasing average stand age. | Average stand age; stand age composition steadily increasing. |
| | Assessment of fish passage conditions within the South Fork gorge for spring Chinook. | Assessment study completed by 2020. | Results of assessment to be used in developing guidance for needed remedial action. | Results of assessment. |
| | Remedial measures taken to improve adult passage at the gorge cascades based on assessment work to be done prior to return of spring Chinook and further indications of problems based on observed passage effectiveness. | Action to improve passage at each cataracts determined to be impeding spring Chinook passage in the SF gorge – actual benchmark will be determination that returning adult passage is being impeded. | Cataracts scoped, evaluated; correction actions identified, proposed for action; proposals for funding; funding secured; engineering completed; actions implemented. Spring Chinook supplementation effort into North Fork implemented and progress on returning fish provides signal for how progress on passage facilities should be progressing. | Evidence that passage effectiveness is being impeded by returning fish. Progress on site evaluation; proposal for funding; funding secured; engineering; construction. |
| Altered Flow Regime in North Fork | More normative flow regime created by changes in regulation at Cushman Dam | Component 1 of normative regime implemented; establishes base flow pattern. | FERC license issued 2010; Fisheries and Habitat Committee established and specifics of implementation established. | Flow release magnitude and timing at lower Cushman Dam. |
| | | Component 2 of normative regime implemented; establishes variation in intramonthly flows corresponding to flows at Staircase. | FERC license issued 2010; Fisheries and Habitat Committee established and specifics of implementation established; release triggers at Staircase achieved that signal Component 2 releases. | Flow release magnitude, timing, and variation at lower Cushman Dam. |
| | | Component 3 of normative regime implemented initially in 2011-2018 - channel forming and bed scouring flows corresponding to flood events in lower river. | FERC license issued 2010; Fisheries and Habitat Committee established and specifics of implementation established; release triggers at Potlatch gauge achieved that signal Component 3 releases. | Flow release magnitude and timing at lower Cushman Dam.<br>*NOTE: Component 3 flows have been suspended indefinitely – see Chapter 4.* |
| Loss of Fish Access to Upper North Fork | Trap and haul fish passage facilities for upstream passage of adult early-timed Chinook at Cushman Dam. | Deployment of fully functional upstream passage facilities at lower Cushman Dam. | FERC license issued 2010; Fisheries and Habitat Committee established; design and engineering completed; facility testing and evaluation; facility upgrades until NOAA criteria achieved. | Design and engineering; construction; testing; monitoring and evaluation. |
| | Trap and haul fish passage facilities for downstream passage of juvenile early-timed Chinook at Cushman Dam. | Deployment of fully functional downstream passage facilities at upper and lower Cushman Dam. | FERC license issued 2010; Fisheries and Habitat Committee established; design and engineering completed; facility testing and evaluation; facility upgrades until NOAA criteria achieved. | Design and engineering; construction; testing; monitoring and evaluation. |

| Recovery issue | Strategy | Implementation benchmark | Implementation triggers | Indicator |
|---|---|---|---|---|
| Degraded Lower Floodplain Conditions, including in-channel, off-channel, and riparian. | Extend CMZ through regulatory, incentive, and education programs | Increases in CMZ as a result of regulatory, incentive, and education programs. | Implementation and progress in Component 3 flows as part of restored normative flow regime; results of evaluation of the same between 2011-2018; progress and completion in the ACOE's General Investigation Study and applicable findings; adoption of measures promoting appropriate CMZs to promote normative channel function and reduce flooding. | Progress in promoting/advancing regulatory, incentive, and education programs for extending CMZ in Skokomish Valley; progress in extending CMZ in the valley. |
| | Strategically remove impediments to meander, avulsion and channel connectivity | Progress in removing identified impediments to meander, avulsion, and channel connectivity in the lower valleys. | Implementation and progress in Component 3 flows as part of restored normative flow regime; results of evaluation of the same between 2011-2018; progress and completion in the ACOE's General Investigation Study and applicable findings and conclusions regarding measures to achieve normative channel function for Chinook habitat while reducing flooding. | Identification of key impediments that inhibit normative channel function; formulation of plans to correct; securing of funding; implementation of actions. |
| | Construct ELJs to restore channel complexity and sediment processes | Placement of strategically-located ELJs in the lower valleys to promote island formation, channel complexity, and sediment processes. | Implementation and progress in Component 3 flows as part of restored normative flow regime; results of evaluation of the same between 2011-2018; progress and completion in the ACOE's General Investigation Study and applicable findings and conclusions regarding measures to achieve normative channel function for Chinook habitat while reducing flooding. | Identification of strategic sites for placement of ELJs to promote normative channel function; formulation of plans for construction; securing of funding; implementation of actions. |
| | Strategically address key sediment deposits and install log jams to improve channel efficiency | Reduction/removal of key sediment deposits in the lower valleys that inhibit normative sediment routing | Implementation and progress in Component 3 flows as part of restored normative flow regime; results of evaluation of the same between 2011-2018; progress and completion in the ACOE's General Investigation Study and applicable findings and conclusions regarding measures to achieve normative channel function for Chinook habitat while reducing flooding. | Identification of sediment deposits that inhibit channel function and sediment routing; formulation of plans for addressing the deposits; securing of funding; implementation of actions. |
| | Protect riparian lands through regulatory, incentive, and education programs | Improved protection of riparian lands through regulatory, incentive, and education programs. | Comprehensive riparian mgmt plan completed for lower river valleys; progress in miles of streams with expected improvements in protection measures; steady improvement in quality of riparian forests or lack thereof made evident. | Miles of stream increasing with measures in place that will help ensure improved protection of riparian zones. |
| | Restore effective riparian forest width | Quality and quantity of riparian areas restored through riparian management programs increasing by 2015, then continuing to improve incrementally thereafter until PFC condition reached. | Comprehensive riparian mgmt plan completed for lower river valleys; progress in miles of streams with expected improvements in protection measures; steady improvement in quality of riparian forests or lack thereof made evident. | Miles of stream where high quality riparian zones either exist or have been secured through various programs to be established. |

| Recovery issue | Strategy | Implementation benchmark | Implementation triggers | Indicator |
|---|---|---|---|---|
| | Restore riparian forest quality with conifer underplantings | Measured progress in restoring riparian structure and species composition through underplantings of conifers. | Comprehensive riparian mgmt plan completed for lower river valleys; progress in miles of streams with expected improvements in protection measures; steady improvement in quality of riparian forests or lack thereof made evident. | Acres of underplantings with conifers. |
| | Inventory and control invasives such as knotweed | Measured progress in controlling invasives (such as knotweed) within the riparian corridors. | Comprehensive riparian mgmt plan completed for lower river valleys; progress in miles of streams with expected improvements in protection measures; steady improvement in quality of riparian forests or lack thereof made evident. | Miles of stream corridor or riparian acres treated for controlling invasives. |
| Degraded Estuarine and Nearshore Conditions | Remove levees and landfill | Progress in the percentages of remaining levees removed or sufficiently breached (as % of the total levees that had been created). | Updating of estuarine restoration plan to incorporate provisions of Cushman Settlement and projects completed through 2010; Another update to be made based on findings and recommendations in the ACOE's General Investigation Study. | Acres or length of levees removed. |
| | Fill borrow ditches | Progress in reducing the percentage of borrow ditches previously created (as % of the total borrow ditches that were created). | Updating of estuarine restoration plan to incorporate provisions of Cushman Settlement and projects completed through 2010; Another update to be made based on findings and recommendations in the ACOE's General Investigation Study. | Acres of borrow ditches restored. |
| | Rip compacted road beds | Progress in the percentages of remaining roadbeds removed (as % of total roadbeds that had been created). | Updating of estuarine restoration plan to incorporate provisions of Cushman Settlement and projects completed through 2010; Another update to be made based on findings and recommendations in the ACOE's General Investigation Study. | Acres or length of roadbeds removed. |
| | Excavate tidal channels where needed | Progress in excavating or restoring tidal channels. | Updating of estuarine restoration plan to incorporate provisions of Cushman Settlement and projects completed through 2010; Another update to be made based on findings and recommendations in the ACOE's General Investigation Study. | Acres or length of tidal channels created or restored. |
| | Strategically address key sediment deposits and install log jams to improve channel efficiency | Reduction/removal of key sediment deposits within the estuarine zone that inhibit normative sediment routing. | Updating of estuarine restoration plan to incorporate provisions of Cushman Settlement and projects completed through 2010; Another update to be made based on findings and recommendations in the ACOE's General Investigation Study. | Identification of sediment deposits that inhibit channel function and sediment routing; formulation of plans for addressing the deposits; securing of funding; implementation of actions. |
| | Restore and protect non-natal stream deltas, tidal embayments, and beaches | Progress in the number of sites (by type) restored along the length of Hood Canal. | Progress or lack thereof in protecting or restoring non-natal nearshore habitats used by juvenile salmonids as prioritized in HCCC recovery documents and PNPTC Technical Report 06-1. | # of sites restored and protected. |

| Recovery issue | Strategy | Implementation benchmark | Implementation triggers | Indicator |
|---|---|---|---|---|
| Hatcheries | Reintroduce spring Chinook to North Fork and South Fork. | Numbers of spring-run returning fish released to North Fork and South Fork | Donor stock identified; hatchery facilities in North Fork completed; operational plans developed and hatchery & genetic management plan completed; juvenile fish released. All consistent with phases described in Chapter 3. | Numbers of spring Chinook released to North Fork and South Fork consistent with phases described in Chapter 3. |
| | Maintain genetic diversity and abundance of spring Chinook in the North Fork | Number of adults, sources (hatchery and wild), & sex ratios used in spawning | Brood stock management objectives identified – all consistent with phases described in Chapter 3. | Number of adults, sources (hatchery and wild), & sex ratios used in spawning |
| | Maintain genetic diversity of extant Chinook stock to provide harvest and as a contingency | Number of adults, sources (hatchery and wild), & sex ratios used in spawning | Brood stock management objectives identified – all consistent with phases described in Chapter 3. | Number of adults, sources (hatchery and wild), & sex ratios used in spawning |
| | Manage broodstock of the summer/early fall stock to facilitate (1) significant reduction in the pre-August 1 segment, (2) stabilize the core segment to August, and (3) extend and enhance the segment that enters after September 1. | Numbers of adults that enter the George Adams Hatchery trap prior to and after specified dates associated with presumed times of river entry. | Brood stock management objectives identified for the three timing segments of the summer/early fall hatchery run. See Chapter 3. | Numbers and timing of adults associated with the three timing segments of the summer/early fall run. Number of returning Chinook in the early segment should significant decline by 2028; timing and numbers in the middle segment should stabilize with a peak river-entry timing of mid-August; numbers of returning adults in the late segment should increase with river-entry extending into mid-October by 2030. |
| | Continue providing for harvest | Production objectives achieved (numbers of fish at size released and marked) | Production objectives defined and implemented. | Production objectives achieved (numbers of fish at size released and marked) |
| Harvest | Develop and apply a guideline exploitation rate ceiling, based on the expected harvest distribution and run timing of the donor spring Chinook stock. | Provisions for harvest protections applied in formulating various pre-terminal and terminal fisheries. | Year of first return of 3-yr olds and thereafter - consistent with phases described in Chapter 3. | Modeled impacts using surrogate indicator stock for initial impact assessment; CWT contributions to all fisheries for hatchery produced fish used to assess actual harvest impacts once CWTs available. |
| | Pre-terminal fisheries scenarios formulated during pre-season planning will take into account expected impacts on the re-introduced population to minimize potential impacts. | Provisions for harvest protections considered in formulating annual pre-terminal. | Year of first return of 3-yr olds and thereafter - consistent with phases described in Chapter 3. | Modeled impacts using surrogate indicator stock for initial impact assessment; CWT contributions to all fisheries for hatchery produced fish used to assess actual harvest impacts once CWTs available. |
| | Provide for treaty C&S fisheries in the Skokomish River during all stages of recovery as a recognized high priority in ensuring Indian treaty rights, taking into account the stage of recovery, expected return, and the guideline ER ceiling. | C&S fisheries implemented by Skokomish Tribe beginning with the first return of 3-year old spring Chinook. | Year of first return of 3-yr olds and thereafter - consistent with phases described in Chapter 3. | Agreed-upon criteria/guidelines for implementing C&S fisheries; performance of C&S fisheries. |

| Recovery issue | Strategy | Implementation benchmark | Implementation triggers | Indicator |
|---|---|---|---|---|
| | Develop and implement criteria for expanding opportunity to harvest spring Chinook, or other stronger populations having harvestable numbers, as significant progress is made toward recovery of the spring-run population. | Criteria established and implemented for expanding fishing opportunity corresponding to progress in recovery of early-timed Chinook. | Year of first return of 3-yr olds and thereafter - consistent with phases described in Chapter 3. | Agreed-upon criteria/guidelines for implementing expanded fishery opportunity as a function of progress toward recovery of early-timed Chinook. |
| | Develop and implement guidelines to limit incidental fishery impacts on spring Chinook in extreme terminal fisheries that target harvestable numbers of other populations. | Guidelines established for regulating incidental fishery impacts on spring Chinook in in-river fisheries targeting other populations. | Year of first return of 3-yr olds and thereafter - consistent with phases described in Chapter 3. | Agreed-upon guidelines for limiting incidental fishery impacts on spring Chinook while targeting other populations. |
| | Implement separate harvest strategies for each of the three timing segments of the summer/early fall population as they currently exist (e.g., 2012-2017): (1) entry prior to August 1 – increase ER to maximum level to eliminate this timing component for significantly diminish it; (2) entry August 1 to August 30 – harvest at suitable ER to utilize these fish at a full and reasonable rate while ensuring genetic diversity of the run and adequate broodstock; (3) entry after August 31 – eliminate to the extent practical and feasible harvest on this segment within the terminal and extreme terminal areas. | For southern U.S. fisheries, agreed-upon fishery regimes by co-managers as part of the annual North of Falcon process. | Strategies to be implemented as quickly as possible to safeguard returning overlapping spring Chinook, provide for efficient harvest of available harvestable hatchery fish, and protect the late timing segment - consistent with objectives for timing segments given in Chapter 3. | Agreed-upon fisheries for all fisheries managed by co-managers in southern U.S. areas to address the objectives for each of the three timing segments of the summer/early fall population. ER on the early segment should be maximized to the extent practical; stabilized at 50-65% on the mid segment of the population and reduced to much less than 50% on the late segment. |

**Table 9.2. Effectiveness monitoring elements: effectiveness benchmarks and indicators.**

| Recovery issue | Strategy | Effectiveness benchmarks | Indicator |
|---|---|---|---|
| Degraded Upper Watershed Conditions in South Fork and major tributaries | Decommission roads and maintain remaining road & trail network | Rate of mass wasting by major drainage being reduced; channel stability indices improving; intragravel fines improving; sediment delivery to lower watershed stabilized, then reducing. | # of mass wasting events associated with roads; active channel width; bed scour and channel stability indices; channel cross-sectional changes; intragravel fines. |
| | Stabilize sediment sources | Progress in stabilizing sediment sources; channel stability indices improving; intragravel fines improving; sediment delivery to lower watershed stabilized, then reducing. | Active channel width; bed scour and channel stability indices; channel cross-sectional changes; intragravel fines. |
| | Expand high quality riparian reserves along mainstem South Fork and tributaries. | Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stabilization, active channel width reduced, side channel stabilization, island formation and stabilization, and habitat composition, and habitat composition; channel stability indices improved, sediment delivery to lower watershed stabilized, then improved. | Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability. |
| | Restore riparian conditions | Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stabilization, active channel width reduced, side channel stabilization, island formation and stabilization, and habitat composition; channel stability indices improved, sediment delivery to lower watershed stabilized, then improved. | Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability. |
| | Increase woody debris and log jam density | Indices of terrace and streambank stabilization, active channel width, side channel stability, island formation and stability; mainstem channel stability show steady improvement; sediment delivery to lower watershed stabilized, then improved. | LWD stability; terrace and streambank stability; active channel width; side channel creation and stability; island formation and stability; in-channel habitat type composition; channel stability. |
| | Silviculture treatments should increase hydrologic maturity on public lands with incentives for doing the same on private lands | Channel stability indices in upper South Fork mainstem improving; sediment delivery to lower watershed stabilized, then reducing. | LWD stability; terrace and streambank stability; active channel width; side channel creation and stability; island formation and stability; in-channel habitat type composition; channel stability. |
| | Remedial measures taken to improve adult passage at the gorge cascades | Willingness/ability of spring Chinook adults to pass gorge cataracts; lack of significant delays at the cataracts and injury of returning chinook at those sites. | Passage of adult spring Chinook at the gorge cataracts; rate of injury to Chinook that pass upstream of the gorge. |

| Recovery issue | Strategy | Effectiveness benchmarks | Indicator |
|---|---|---|---|
| Altered Flow Regime in North Fork | More normative flow regime created by changes in regulation at Cushman Dam | Base flow pattern that mimics natural flow pattern with sufficient spring-time/early summer pulse for adult early-timed chinook passage over Little Falls and return to base of dam. | Similarity of flow regime shape to natural flow pattern with adequate spring pulse; passage of spring Chinook through the entirety of the lower North Fork and return to the base of dam. |
| | | Normative-type variation introduced into release discharge from Cushman that provides stimuli for salmon migration and in-channel habitat maintenance. Consideration to be given to frequency of events and whether criteria should be changed. Other factors: coordination of flow releases, timeliness of releases to match storm events, not compounding flooding, habitat structure composition in North Fork. | Similarity of flow variation during fall and winter to natural flow regimes in the watershed; reformation and maintenance of normative habitat characteristics in the lower North Fork. |
| | | Component 3 flows implemented as channel capacity maintenance/improvement flows. Evaluation criteria: increases in channel flow capacities of North Fork and lower Skokomish R, amount of bed scour and sediment movement in North Fork and main Skokomish R, habitat structure and composition. | Channel flow capacities of the lower North Fork and mainstem Skokomish River; channel depth; sediment transport rates; frequency of flooding in the lower Skokomish River.<br><br>*NOTE: Component 3 flows have been suspended indefinitely – see Chapter 4.* |
| Loss of Fish Access to Upper North Fork | Trap and haul fish passage facilities for upstream passage of adult spring Chinook at Cushman Dam. | NOAA criteria for upstream passage as specified in the FERC license; specific measures to be monitored. | Upstream passage effectiveness over the Cushman Dams of spring Chinook. |
| | Trap and haul fish passage facilities for downstream passage of juvenile spring Chinook at Cushman Dam. | NOAA criteria for upstream passage as specified in the FERC license; specific measures to be monitored. | Downstream passage effectiveness over the Cushman Dams of spring Chinook. |
| Degraded Lower Floodplain Conditions, including in-channel, off-channel, and riparian. | Extend CMZ through regulatory, incentive, and education programs | Indices of normative channel complexity, bank stability, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity should increase over time. | Channel complexity; streambank stability; sediment transport and routing; channel flow capacity; flood frequency. |
| | Strategically remove impediments to meander, avulsion and channel connectivity | Indices of normative channel complexity, bank stability, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity should increase over time. | Sediment transport and routing; channel flow capacity; flood frequency; habitat type composition. |

| Recovery issue | Strategy | Effectiveness benchmarks | Indicator |
|---|---|---|---|
| | Construct ELJs to restore channel complexity and sediment processes | Indices of normative channel complexity, bank stability, sediment routing, and flood frequency shown to be improving over 5-year increments. | Channel complexity; streambank stability; sediment transport and routing; channel flow capacity; flood frequency; frequency and stability of large logjams; island formation and stability; width to depth ratio (to drop); number of secondary channels; number and quality of pools. |
| | Strategically address key sediment deposits and install log jams to improve channel efficiency | Indices of normative channel complexity, bank stability, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity should increase over time. | Sediment transport and routing; channel flow capacity; flood frequency; habitat type composition. |
| | Protect riparian lands through regulatory, incentive, and education programs | Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, streambank stabilization, side channel stabilization, island formation and stabilization; channel stability indices improved. | Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability. |
| | Restore effective riparian forest width | Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, streambank stabilization, side channel stabilization, island formation and stabilization; channel stability indices improved. | Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability. |
| | Restore riparian forest quality with conifer underplantings | Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, streambank stabilization, side channel stabilization, island formation and stabilization; channel stability indices improved. | Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability; width to depth ratio (to drop); number of secondary channels; number and quality of pools. |

| Recovery issue | Strategy | Effectiveness benchmarks | Indicator |
|---|---|---|---|
| | Inventory and control invasives such as knotweed | Indices of riparian effectiveness improving, including species composition, stand age, stand structure, shading, LWD contributions, streambank stabilization, side channel stabilization, island formation and stabilization; normative channel stability characteristics more evident consistent with more normative avulsion characteristics. | Riparian forest indicators, including species composition, stand age, stand structure, shading, LWD contributions, terrace and streambank stability, active channel width, side channel stability, island formation and stability; in-channel habitat type composition; channel stability. |
| Degraded Estuarine and Nearshore Conditions | Remove levees and landfill | Changes in size of the tidal prism; indices of normative channel complexity, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity should increase over time. | Size and distribution of tidal prism; channel complexity; sediment routing; channel flow capacity; flood frequency. |
| | Fill borrow ditches | Changes in size of the tidal prism; indices of normative channel complexity, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity should increase over time. | Size and distribution of tidal prism; channel complexity; sediment routing; channel flow capacity; flood frequency. |
| | Rip compacted road beds | Changes in size of the tidal prism; indices of normative channel complexity, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity should increase over time. | Size and distribution of tidal prism; channel complexity; sediment routing; channel flow capacity; flood frequency. |
| | Excavate tidal channels where needed | Changes in size of the tidal prism; indices of normative channel complexity, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity should increase over time. | Size and distribution of tidal prism; channel complexity; sediment routing; channel flow capacity; flood frequency. |
| | Strategically address key sediment deposits and install log jams to improve channel efficiency | Changes in size of the tidal prism; indices of normative channel complexity, sediment routing, and flood frequency shown to be improving over 5-year increments; channel flow capacity should increase over time. | Size and distribution of tidal prism; channel complexity; sediment routing; channel flow capacity; flood frequency. |
| | Restore and protect non-natal stream deltas, tidal embayments, and beaches | Percentage of restoration of pristine condition (based on PNPTC Technical Report 06-1) or that achieve full function based on ratings in the same. | # of non-natal habitats and beaches with habitat rating values reflecting PFC conditions (as inferred from PNPTC Technical Report 06-1). |
| Hatcheries | Reintroduce spring Chinook to North Fork and South Fork. | Demonstrating that released individuals survive (post-release survival of spring Chinook into the North Fork and South Fork); breeding by the released generation and their offspring (number of fish returning to North and South Forks to spawn (wild and in hatchery) | Numbers of spring Chinook released to North and South fork; numbers of returning fish; post-release survivals; reproductive success (in hatchery and natural environments) levels. |

| Recovery issue | Strategy | Effectiveness benchmarks | Indicator |
|---|---|---|---|
| | Maintain genetic diversity and abundance of spring Chinook in the North Fork | Indices of genetic diversity (heterozygosity; allelic diversity; genetic effective population size); life history trait variation (returning timing and juvenile age at migration); and desired gene flow rates maintained | Numbers of spring Chinook released to North and South fork; numbers of returning fish; post-release survivals; reproductive success (in hatchery and natural environments) levels; sex ratios; age structure. |
| | Maintain genetic diversity of extant summer/early fall Chinook stock to provide harvest and as a contingency | Indices of genetic diversity (heterozygosity; allelic diversity; genetic effective population size); life history trait variation (returning timing and juvenile age at migration); and desired gene flow rates maintained | Numbers of George Adams fish at hatchery; numbers of returning fish; post-release survivals; reproductive success; sex ratios; age structure. |
| | Manage broodstock of the summer/early fall stock to facilitate (1) significant reduction in the pre-August 1 segment, (2) stabilize the core segment to August, and (3) extend and enhance the segment that enters after September 1. | Numbers of adults that enter the George Adams Hatchery trap prior to and after specified dates associated with presumed times of river entry. Spawning timing of each segment of the run. Fry emergence timing of fish produced from naturally spawning stock in the river. | Numbers and timing of adults associated with the three timing segments of the summer/early fall run. Number of returning Chinook in the early segment should significant decline by 2028; timing and numbers in the middle segment should stabilize with a peak river-entry timing of mid-August; numbers of returning adults in the late segment should increase with river-entry extending into mid-October by 2030. Spawning timing of each segment. Fry emergence timing of fish produced from naturally spawning stock in the river. |
| | Continue providing for harvest | See Harvest Monitoring | Harvest contributions based on CWT analysis, catch accounting; projections using harvest models. |
| Harvest | Develop and apply a guideline exploitation rate ceiling, based on the expected harvest distribution and run timing of the donor spring Chinook stock. | CWT contributions to all fisheries with consideration as done for other tagged populations in the ESU. | Total exploitation rate on the spring Chinook stock measured by CWT analysis and/or projections based on modeling. |
| | Pre-terminal fisheries scenarios formulated during pre-season planning will take into account expected impacts on the re-introduced population to minimize potential impacts. | CWT contributions to all fisheries with consideration as done for other tagged populations in the ESU. | Harvest impact estimates on the spring Chinook stock measured by CWT analysis and/or projections based on modeling. |

| Recovery issue | Strategy | Effectiveness benchmarks | Indicator |
|---|---|---|---|
| | Provide for treaty C&S fisheries in the Skokomish River during all stages of recovery as a recognized high priority in ensuring Indian treaty rights, taking into account the stage of recovery, expected return, and the guideline ER ceiling. | Thorough accounting of C&S fisheries; performance of C&S fisheries compared to pre-season projections of how fisheries would be performed. | Catch records documenting C&S impact levels. |
| | Develop and implement criteria for expanding opportunity to harvest spring Chinook, or other stronger populations having harvestable numbers, as significant progress is made toward recovery of the early-timed population. | CWT contributions to all fisheries with consideration as done for other tagged populations in the ESU. | Harvest impact estimates on the spring Chinook stock measured by CWT analysis and/or projections based on modeling. |
| | Develop and implement guidelines to limit incidental fishery impacts on spring Chinook in extreme terminal fisheries that target harvestable numbers of other populations. | Thorough accounting of all incidental fishery impacts occurring during fisheries targeting other populations returning to the Skokomish River. | Catch records and creel census data documenting impacts on spring Chinook in extreme terminal areas. |
| | Implement separate harvest strategies for each of the three timing segments of the summer/early fall population as they currently exist (e.g., 2012-2017): (1) entry prior to August 1 – increase ER to maximum level to eliminate this timing component for significantly diminish it; (2) entry August 1 to August 30 – harvest at suitable ER to utilize these fish at a full and reasonable rate while ensuring genetic diversity of the run and adequate broodstock; (3) entry after August 31 – eliminate to the extent practical and feasible harvest on this segment within the terminal and extreme terminal areas. | Modeling using FRAM or other agreed upon tools; CWT contributions to all fisheries with consideration as done for other tagged populations in the ESU. | Agreed-upon fisheries for all fisheries managed by co-managers in southern U.S. areas to address the objectives for each of the three timing segments of the summer/early fall population. ER on the early segment should be maximized to the extent practical; stabilized at 50-65% on the mid segment of the population and reduced to much less than 50% on the late segment. |

**Table 9.3. Validation monitoring elements: validation benchmarks in near and long-term time periods and indicators.**

| Recovery issue | Strategy | Validation benchmarks - near-term | Validation benchmarks - long-term | Indicator |
|---|---|---|---|---|
| Degraded Upper Watershed Conditions in South Fork and major tributaries | Decommission roads and maintain remaining road & trail network | Modeled (EDT) spawner (egg) to juvenile emigrant survival levels consistent with performance needed to achieve recovery goals for spring Chinook. | Empirical spawner (egg) to smolt survival levels consistent with performance needed to achieve recovery goals for spring Chinook. May need independent measure of stock fitness. | Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions. |
| | Stabilize sediment sources | Modeled (EDT) spawner (egg) to juvenile emigrant survival levels consistent with performance needed to achieve recovery goals for spring Chinook. | Empirical spawner (egg) to smolt survival levels consistent with performance needed to achieve recovery goals for spring Chinook. May need independent measure of stock fitness. | Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions. |
| | Expand high quality riparian reserves along mainstem South Fork and tributaries. | Modeled (EDT) spawner (egg) to juvenile emigrant survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for spring Chinook. | Empirical spawner (egg) to emigrant juvenile and pre-spawning survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for spring Chinook; May need independent measure of stock fitness. | Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions. |
| | Restore riparian conditions | Modeled (EDT) spawner (egg) to juvenile emigrant survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for spring Chinook. | Empirical spawner (egg) to emigrant juvenile and pre-spawning survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for spring Chinook; May need independent measure of stock fitness. | Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions. |
| | Increase woody debris and log jam density | Modeled (EDT) spawner (egg) to juvenile emigrant survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for spring Chinook. | Empirical spawner (egg) to emigrant juvenile and pre-spawning survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for spring Chinook; May need independent measure of stock fitness. | Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions. |
| | Silviculture treatments should increase hydrologic maturity on public lands with incentives for doing the same on private lands | Modeled (EDT) spawner (egg) to juvenile emigrant survival levels, and juvenile abundance levels, consistent with performance needed to achieve recovery goals for spring Chinook. | Empirical spawner (egg) to smolt and pre-spawning survival levels consistent with performance needed to achieve recovery goals for spring Chinook. May need independent measure of stock fitness. | Natural spawner abundance; hatchery/natural composition of spawners; juvenile emigrant abundance; modeled estimates of spawners and juvenile emigrants with updated environmental attribute conditions. |

| Recovery issue | Strategy | Validation benchmarks - near-term | Validation benchmarks - long-term | Indicator |
|---|---|---|---|---|
| | Remedial measures taken to improve adult passage at the gorge cascades | Modeled (EDT) passage effectiveness values consistent with performance needed to achieve recovery goals for spring Chinook. | Willingness/ability of spring Chinook adults to pass the gorge cataracts; lack of significant delays at the cataracts and injury of returning Chinook at those sites. | Passage effectiveness over cataracts; modeled population performance with and without passage improvements. |
| Altered Flow Regime in North Fork | More normative flow regime created by changes in regulation at Cushman Dam | Modeled (EDT) migration effectiveness values consistent with performance needed to achieve recovery goals for early-timed Chinook. | Willingness/ability of early-timed chinook adults to migrate through the lower North Fork to the base of the lower dam, including ability to ascend Little Falls. | Passage effectiveness through the lower North Fork by returning adults; modeled population performance with and without effective passage to the lower dam. |
| | | Modeled (EDT) juvenile and adult survival and abundance levels in the lower North Fork and lower Skokomish River consistent with performance needed to achieve recovery goals for early-timed Chinook. | Habitat utilization rates and patterns of utilization in lower North Fork and lower Skokomish River by juvenile and adult migrant early-timed Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant early-timed Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | | Modeled (EDT) juvenile and adult survival and abundance levels in the lower North Fork and lower Skokomish River consistent with performance needed naturally spawning Chinook (fully fit fish). | Habitat utilization rates and patterns of utilization in lower North Fork and lower Skokomish River by juvenile and adult migrant Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| Loss of Fish Access to Upper North Fork | Trap and haul fish passage facilities for upstream passage of adult early-timed Chinook at Cushman Dam. | Modeled (EDT) adult passage values (projected) consistent with performance needed to achieve recovery goals for spring Chinook. | NOAA criteria for upstream passage as specified in the FERC license; specific measures to be monitored. | Upstream passage effectiveness over the Cushman Dams of spring Chinook. |
| | Trap and haul fish passage facilities for downstream passage of juvenile spring Chinook at Cushman Dam. | Modeled (EDT) juvenile passage values (projected) consistent with performance needed to achieve recovery goals for spring Chinook. | NOAA criteria for downstream passage as specified in the FERC license; specific measures to be monitored. | Downstream passage effectiveness over the Cushman Dams of spring Chinook. |
| Degraded Lower Floodplain Conditions, including in-channel, off-channel, and riparian. | Extend CMZ through regulatory, incentive, and education programs | Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | Strategically remove impediments to meander, avulsion and channel connectivity | Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |

| Recovery issue | Strategy | Validation benchmarks - near-term | Validation benchmarks - long-term | Indicator |
|---|---|---|---|---|
| | Construct ELJs to restore channel complexity and sediment processes | Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | Strategically address key sediment deposits and install log jams to improve channel efficiency | Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | Protect riparian lands through regulatory, incentive, and education programs | Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | Restore effective riparian forest width | Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | Restore riparian forest quality with conifer underplantings | Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | Inventory and control invasives such as knotweed | Modeled (EDT) juvenile and adult survival and abundance levels in the lower Skokomish River consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| Degraded Estuarine and Nearshore Conditions | Remove levees and landfill | Modeled (EDT) juvenile and adult survival and abundance levels in the estuarine zone consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |

| Recovery issue | Strategy | Validation benchmarks - near-term | Validation benchmarks - long-term | Indicator |
| --- | --- | --- | --- | --- |
| | Fill borrow ditches | Modeled (EDT) juvenile and adult survival and abundance levels in the estuarine zone consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | Rip compacted road beds | Modeled (EDT) juvenile and adult survival and abundance levels in the estuarine zone consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | Excavate tidal channels where needed | Modeled (EDT) juvenile and adult survival and abundance levels in the estuarine zone consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | Strategically address key sediment deposits and install log jams to improve channel efficiency | Modeled (EDT) juvenile and adult survival and abundance levels in the estuarine zone consistent with performance needed to achieve performance standards for naturally spawning Chinook (fully fit). | Habitat utilization rates and patterns of utilization in the lower Skokomish River by juvenile and adult migrant naturally spawning Chinook consistent with those observed in healthy rivers. | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| | Restore and protect non-natal stream deltas, tidal embayments, and beaches | | | Habitat utilization patterns and rates by juvenile and adult migrant Chinook; modeled performance of juveniles and adult migrants with updated environmental attribute conditions. |
| Hatcheries | Reintroduce spring Chinook to North Fork and South Fork. | Modeled persistence (e.g. probability of extinction) meets desired levels | Persistence a re-established run to desired to North Fork and South Fork | Numbers of spring Chinook released to the North and South fork; numbers of returning fish; post-release survivals; reproductive success (in hatchery and natural environments) levels. |
| | Maintain genetic diversity and abundance of spring Chinook in the North Fork | Heterozygosity; allelic diversity; genetic effective population size; key life history traits such as returning timing and juvenile age at migration | Indices of genetic diversity; life history trait variation; and desired gene flow rates maintained | Numbers of spring Chinook released to the North and South fork; numbers of returning fish; post-release survivals; reproductive success (in hatchery and natural environments) levels; sex ratios; age structure. |

| Recovery issue | Strategy | Validation benchmarks - near-term | Validation benchmarks - long-term | Indicator |
|---|---|---|---|---|
| | Maintain genetic diversity of extant Chinook stock to provide harvest and as a contingency | Heterozygosity; allelic diversity; genetic effective population size; key life history traits such as returning timing and juvenile age at migration | Indices of genetic diversity; life history trait variation; and desired gene flow rates maintained | Numbers of George Adams fish at hatchery; numbers of returning fish; post-release survivals; reproductive success; sex ratios; age structure. |
| | Manage broodstock of the summer/early fall stock to facilitate (1) significant reduction in the pre-August 1 segment, (2) stabilize the core segment to August, and (3) extend and enhance the segment that enters after September 1. | Numbers of adults that enter the George Adams Hatchery trap prior to and after specified dates associated with presumed times of river entry.<br><br>Increased number of naturally spawning Chinook in the river in late September, October. | Numbers of adults that enter the George Adams Hatchery trap prior to and after specified dates associated with presumed times of river entry.<br><br>Increased number of naturally spawning Chinook in the river in late September, October.<br><br>Fry emergence timing in the hatchery and river from fish in the late –timed segment pushed later, particularly for fish spawning in the river (pattern for later emergence should become evident).<br><br>Evidence for increasing number of NORs returning to the river. | Numbers and timing of adults associated with the three timing segments of the summer/early fall run. Number of returning Chinook in the early segment should significantly decline by 2028; timing and numbers in the middle segment should stabilize with a peak river-entry timing of mid-August; numbers of returning adults in the late segment should increase with river-entry extending into mid-October by 2030. Spawning timing of each segment. Fry emergence timing of fish produced from naturally spawning stock in the river. |
| | Continue providing for harvest | See Harvest Monitoring | See Harvest Monitoring | Harvest contributions based on CWT analysis, catch accounting; projections using harvest models. |
| Harvest | Develop and apply a guideline exploitation rate ceiling, based on the expected harvest distribution and run timing of the donor spring Chinook stock. | Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals. | CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals. | Total exploitation rate on the spring Chinook stock measured by CWT analysis and/or projections based on modeling. |
| | Pre-terminal fisheries scenarios formulated during pre-season planning will take into account expected impacts on the re-introduced population to minimize potential impacts. | Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals. | CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals. | Harvest impact estimates on the spring Chinook stock measured by CWT analysis and/or projections based on modeling. |
| | Provide for treaty C&S fisheries in the Skokomish River during all stages of recovery as a recognized high priority in ensuring Indian treaty rights, taking into account the stage of recovery, expected return, and the guideline ER ceiling. | Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals. | CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals. | Catch records documenting C&S impact levels. |

| Recovery issue | Strategy | Validation benchmarks - near-term | Validation benchmarks - long-term | Indicator |
|---|---|---|---|---|
| | Develop and implement criteria for expanding opportunity to harvest spring Chinook, or other stronger populations having harvestable numbers, as significant progress is made toward recovery of the spring population. | Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals. | CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals. | Harvest impact estimates on the spring Chinook stock measured by CWT analysis and/or projections based on modeling. |
| | Develop and implement guidelines to limit incidental fishery impacts on spring Chinook in extreme terminal fisheries that target harvestable numbers of other populations. | Modeled (EDT) life cycle performance with projected productivity and abundance parameters (given habitat characterizations with actions) and expected harvest rates is consistent with achieving recovery goals. | CWT contributions to all fisheries consistent with sustainable harvest regimes developed under the plan, resulting in building run size to river and achievement of recovery goals. | Catch records and creel census data documenting impacts on spring Chinook in extreme terminal areas. |
| | Implement separate harvest strategies for each of the three timing segments of the summer/early fall population as they currently exist (e.g., 2012-2017): (1) entry prior to August 1 – increase ER to maximum level to eliminate this timing component for significantly diminish it; (2) entry August 1 to August 30 – harvest at suitable ER to utilize these fish at a full and reasonable rate while ensuring genetic diversity of the run and adequate broodstock; (3) entry after August 31 – eliminate to the extent practical and feasible harvest on this segment within the terminal and extreme terminal areas. | Estimated ERs consistent with objectives of the plan for each timing segment over the next 20 years. Timing of returning fish from each segment consistent with objectives. | Estimated ERs consistent with objectives of the plan for each timing segment over the next 20 years. Timing of returning fish from each segment consistent with objectives.<br><br>Increased number of naturally spawning Chinook in the river in late September, October.<br><br>Fry emergence timing in the hatchery and river from fish in the late –timed segment pushed later, particularly for fish spawning in the river (pattern for later emergence should become evident).<br><br>Evidence for increasing number of NORs returning to the river. | Agreed-upon fisheries for all fisheries managed by co-managers in southern U.S. areas to address the objectives for each of the three timing segments of the summer/early fall population. ER on the early segment should be maximized to the extent practical; stabilized at 50-65% on the mid segment of the population and reduced to much less than 50% on the late segment.<br><br>Numbers and timing of adults associated with the three timing segments of the summer/early fall run. Number of returning Chinook in the early segment should significantly decline by 2028; timing and numbers in the middle segment should stabilize with a peak river-entry timing of mid-August; numbers of returning adults in the late segment should increase with river-entry extending into mid-October by 2030. Spawning timing of each segment. Fry emergence timing of fish produced from naturally spawning stock in the river. |

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# Chapter 11. Appendices

## Appendix A

### Skokomish River Geomorphic Assessment Metrics

## Appendix B

### Comprehensive List of Actions Proposed for Skokomish River

## Appendix C

### License Articles for the Cushman Hydroelectric Project -- FERC No. 460