Appendix B
Viable Salmonid Population

The restoration objective for the Tucannon River is to improve habitat conditions for Endangered Species Act (ESA)-listed species (spring/summer Chinook salmon, Snake River fall Chinook salmon, Snake River steelhead, and bull trout) for all life history stages within the river. Improving habitat conditions may lead to an increase in the abundance of listed species returning to the river. Increasing abundance could lead to delisting of the species, which is the overall recovery goal for the system.

Throughout this section, spring Chinook salmon are used as an example species to help clarify the discussion and to provide examples for the types of data collected and evaluated in the basin. Similar types of data (where available) are also being evaluated for the other ESA-listed species included in the prioritization framework.

Viable Salmonid Population

To inform habitat restoration actions, spring Chinook salmon in Reach 5 were identified as a species to focus on with the expectation that restoration actions targeted at improving habitat conditions for spring Chinook salmon life stages will also improve conditions for steelhead and other species important to the Tucannon River. Another approach to evaluate the health of Tucannon River spring Chinook salmon is to consider how the population is performing compared to the National Marine Fisheries Service (NMFS) standard of a Viable Salmon Population (VSP), a population biology concept. According to the NMFS, a VSP is an "independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame" (McElhany et al. 2000). McElhany et al. (2000) identified four key population characteristics or parameters for evaluating population viability status:

- Abundance
- Population growth rate or entire lifecycle productivity
- Population spatial structure
- Diversity

The following sections present a brief introduction to each of the VSP parameters and how these apply to the Tucannon River habitat conditions and future restoration planning.

It must be emphasized that any change in risk associated with these population parameters is affected by myriad factors (including in-basin factors; conditions in the Snake and Columbia rivers; predation from avian, mammal, and piscivorous species; and ocean conditions), and consequently is a long-term proposition. Many of these factors (e.g., ocean conditions and marine survival rates) are largely outside of human control. Moreover, changes expected from the types of actions considered in this report are most likely to occur on a generational scale; the likelihood is low that there would be detectable changes in the near future. Also, there is uncertainty associated with the Tucannon River supplemental hatchery program that may affect the spring Chinook salmon population in ways that may not be well understood.

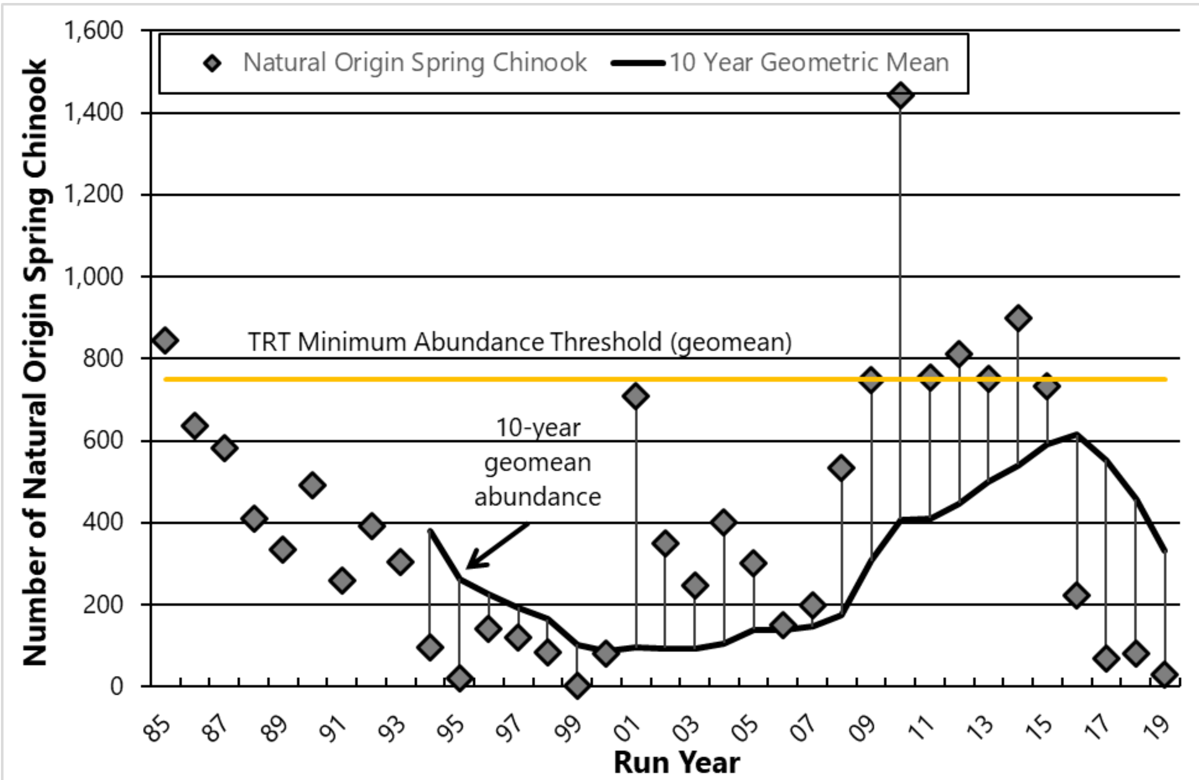
Abundance

Population size is perhaps the most straightforward measure of the VSP parameters and is an important consideration in estimating extinction risk. All other factors being equal, a population at low abundance is intrinsically at greater risk of extinction than is a larger one. The primary drivers of this increased risk are the many processes that regulate population dynamics, particularly those that operate differently on a relatively small population, such as Tucannon River spring Chinook salmon. Examples include environmental variation and catastrophes, demographic stochasticity (intrinsic random variability in population size), selected genetic processes (e.g., inbreeding depression), and deterministic density effects. Although the negative interaction between abundance and productivity may protect some small populations, there is obviously a point below which a population is unlikely to persist (McElhany et al. 2000).

Tucannon River spring Chinook populations spawn exclusively in the mainstem Tucannon River with the majority of spawning occurring from just above the mouth of Sheep Creek (RM 52) downstream to about King Grade (RM 21). Average annual spawning for the past 20 years (1998 to 2018) is 181 redds, with 55% of these being natural spawners and 45% hatchery-origin fish (Gallinat and Kiefel 2019). Average annual spawning for the past 10 years (2009 to 2018) is 211 redds, with 49% of these being natural spawners and 51% hatchery-origin fish (Gallinat and Kiefel 2019). Natural-origin returns have dropped off considerably in the last 4 years and are similar to those experienced in the mid to late 1990s (Figure B-1).

Between 1985 and 2019, the annual returns of natural-origin spring Chinook salmon to the Tucannon River ranged from near zero to approximately 1,450 adults; the high of 1,443 returning adults occurred in 2010 and the low of 3 returning natural-origin spawners occurred in 1999 (Figure B-1; Gallinat and Kiefel 2019; Bumgarner 2019, personal communication). The 10-year geometric mean abundance has varied between approximately 100 and 600 returning adults. The Interior Columbia Technical Recovery Team (ICTRT) estimated that the minimum abundance threshold of returning adults is 750, with the current average of 292 (Gallinat and Kiefel 2019; Bumgarner 2019, personal communication).

Figure B-1
Estimated Abundance of Natural-Origin Spring/Summer Chinook Salmon Adults and 10-year Geometric Mean from the Tucannon River (1986 to 2019 Run Years)

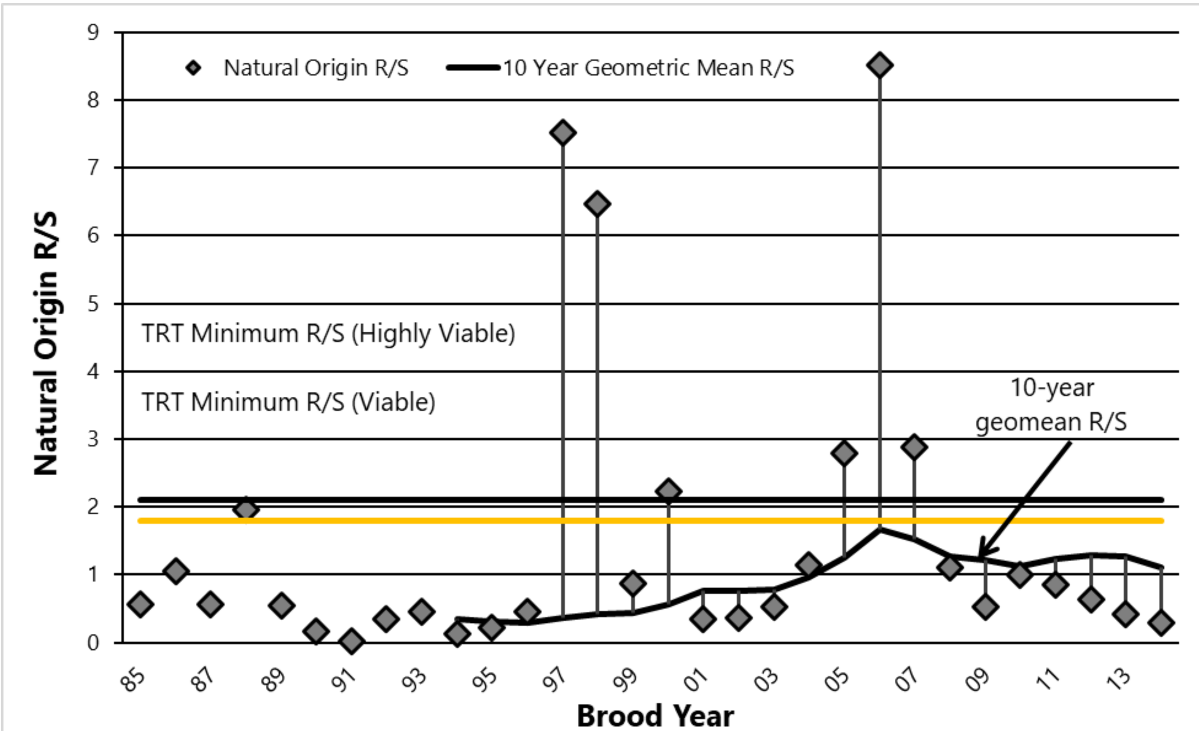


Sources: Gallinat and Kiefel 2019; Bumgarner 2019, personal communication

Lifecycle Productivity

Population growth rate (λ) or productivity over the entire lifecycle is a key measure of population performance in a species' habitat. In simple terms, it describes the degree to which a population is replacing itself. A population growth rate of 1 (λ = 1.0) means that a population is exactly replacing itself (one spawner produces one spawner in the next generation), whereas a λ = 0.71 (the λ value determined in the Tucannon River for spring Chinook salmon) means that the population is declining at a rate of 29% annually—a trend that is obviously not sustainable in the long term (Figure B-2). Recruits per spawner are often less than one, with 19 of 30 (63%) years below the replacement level (Gallinat and Kiefel 2019). The population has experienced brief periods of high productivity in the late 1990s and mid-2000s, but only 5 of the last 30 years (17%) have been above both TRT minimum threshold values. The Technical Review Team estimated that an R/S of 1.8 is needed for an extinction risk of less than 5% and an R/S of 2.1 is needed for an extinction risk of less than 1% (highly viable criteria) (SRSRB 2011).

Figure B-2
Estimated Productivity of Natural-Origin Spring/Summer Chinook Salmon Adults and 10-year Geometric Mean from the Tucannon River (1985 to 2014 Brood Years)



Source: Gallinat and Kiefel 2019

The causes for the low R/S are not precisely known and likely include multiple factors that are difficult to quantify, such as potential effects from habitat conditions and habitat capacity (WDFW 2011). Hatchery supplementation, the Columbia and Snake rivers, predation, harvest, and ocean conditions are also factors of the R/S value.

Spatial Structure

Spatial structure, as the term suggests, refers to the geographic distribution of individuals in a population unit and the processes that generate that distribution. Distributed populations that interact genetically are often referred to as a metapopulation. Although the spatial distribution of a population, and thus its metapopulation structure, is influenced by many factors, none are perhaps as important as the quantity, quality, and distribution of habitat. One way to think about the importance or value of a broad geospatial distribution is to consider that in the presence of such a distribution, a population is less likely to go extinct from a localized catastrophic event or localized environmental perturbations (McElhany et al. 2000).

Spatial distribution (of spawning and summer rearing) of spring Chinook salmon in the Tucannon River is primarily restricted to the area upstream of Marengo (RM 25) to the headwaters, yet historically it is presumed that spring Chinook salmon spawned and reared at least down to Pataha Creek, near RM 12.5 (Gallinat and Ross 2011).

Per Table B-1, it is noteworthy that approximately 97% of the spring Chinook salmon spawning documented over the past 30 years occurs between RM 26.9 (Marengo Bridge) and RM 58.3 (about 3 miles above Sheep Creek), recognizing that spawning near the headwaters may have occurred historically at a higher density than is currently occurring (WDFW 2011). This is like due to the implementation of the hatchery program in the mid-1980s, which removed wild-origin spawners to begin the program, and likely shifted the overall spawning distribution because of hatchery fish homing to either the Tucannon Fish Hatchery or Curl Lake acclimation pond where hatchery fish have been released.

Table B-1
Spring/Summer Chinook Redd Distribution in the Tucannon River (1985 to 2019)

Section	River km (Rkm)	River mile (RM)	Percent of Total Redds	Average Redds	Redds per Rkm	Redds per RM
Mouth to Marengo (Lower)	0–20.1	0–13.6	1.7	2.7	0.1	0.2
Marengo	20.1–39.9	13.6–26.9	1.0	1.6	0.1	0.1
Hartsock	39.9–55.5	26.9–37.5	19.2	31.0	2.0	2.9
HMA	55.5–74.5	37.5–50.3	64.0	103.2	5.4	8.1
Wilderness	74.5–86.3	50.3–58.3	14.1	22.7	1.9	2.7

Notes:

1. 1985 to 2018 data are from Gallinat and Kiefel (2019). Data from 2019 were added in by Joe Bumgarner (WDFW), personal communication.
2. Rkm and RM differ slightly; RM shown were developed for the current scope of work and have been compared to Rkm primarily based on landmarks (bridges, property boundaries) for consistency.
3. Local biologists believe that all or most of the redds found in the lowest section are likely strays from other Snake River spring/summer populations that come into the river late as spawning time is near its end, and do not necessarily represent "true" Tucannon River stock returns. However, few carcasses have ever been recovered to document this.

Life History Diversity

Biological diversity within and among populations of salmon is generally considered important for three reasons (McElhany et al. 2000):

- Diversity of life history patterns is associated with the use of a wider array of habitats.
- Diversity protects a species against short-term spatial and temporal changes in the environment.
- Genetic diversity is the so-called raw material for adapting to long-term environmental change.

The latter two reasons are often described as nature's way of hedging its bets—a mechanism for dealing with the inevitable fluctuations in environmental conditions—in the long and short terms. With respect to diversity, more is better to minimize the risk of extinction.

Current life history diversity of Tucannon River spring Chinook salmon is presumed to reflect historical life history diversity, with the majority of juveniles emerging from the gravel in spring, rearing for one summer and one winter, and then out-migrating as 1-year-old smolts in the spring. Of interest is the apparent lack of winter-rearing habitat and channel complexity (e.g., side channels, back water, and pools) that support juvenile fish. Existing data demonstrate that the largest mortality occurs between egg and smolt, with the majority of the mortality occurring between egg and parr; it is alarming that, from brood year 1983 to brood year 2003, on average less than 6% of spring Chinook salmon survived from egg to smolt (Gallinat and Ross 2010).

Restoration Expectations Related to Viable Salmonid Population Goals

Abundance

Population abundance is a key parameter used to assess the status of a stock and evaluate trends in stock improvement or decline. Abundance is also useful in identifying critical population dynamics that can be used to identify success in restoring a stock or levels at which extinction risk is high and the level of attention given to restoration be increased. Collectively proposed restoration actions in the Tucannon River are intended to improve abundance holistically; hence, no restoration action proposed in this report is targeting abundance specifically.

Lifecycle Productivity

As presented and referenced in this document, previous studies have identified degraded habitat conditions and juvenile carrying capacity as primary causes for the low R/S ratio currently observed in the Tucannon River. Therefore, proposed restoration actions are highly focused on addressing limitations to productivity. The largest mortality occurs between egg and smolt, with the majority of the mortality occurring between egg and parr (SRSRB 2006). In addition, WDFW data indicate that smolt production generally increases with an increase in adult returns in the basin, although a carrying capacity issue may exist above approximately 200 female spawners (Gallinat and Ross 2010). Spawning and incubation for spring Chinook salmon begins in late August and continues through March, with fry developing to parr through June. This timeline represents a large range in hydrologic conditions and habitats used by Chinook salmon; prioritizing specific time periods and associated habitats is necessary to target critical lifecycle periods affecting productivity (ISRP 2011a).

The life stage between egg and parr coincides with late summer low flow, winter storm flows, and the spring runoff period. Summer low flows are unpredictable, and other efforts in the basin are focused on improving water quality and quantity. Winter storm events are stochastic and vary greatly in the effect that they may have on growth and productivity. For example, several consecutive years of minor peak flows, where impacts to fish are also minor, may occur between larger, less frequent flood events that have the ability to scour redds, resulting in significant losses to the run. Spring runoff flows occur each year and are relatively predictable in their magnitude and their effect on the habitat types required by juvenile salmonids; these habitats are currently lacking in the system. Data from smolt trapping in the lower river indicate that parr are arriving in the lower basin throughout the spring runoff period, long before their genetic signal should be initiating movement downstream (WDFW 2011). It is speculated that this may be occurring either because they are being flushed downstream and are not able to find suitable refuge habitat or because juvenile fish are actively seeking out habitats in the lower river because of the lack of refuge areas (carrying capacity) in the preferred rearing areas upstream.

Based on high egg-to-parr mortality and uncertainty related to much of the hydrologic cycle during the egg-to-parr timeline, improving habitat conditions for juveniles during the spring runoff period was determined to be of high priority and to provide the greatest certainty of success with respect to improving growth and productivity for the ESA-listed species collectively. Therefore, restoration actions that will provide hydraulic complexity; will improve or create side channels, alcoves, or hydraulic refuge and cover; or will improve low-lying floodplain connectivity will be considered to have high biological benefit when developing conceptual projects.

Installing necessary instream structure to provide adequate cover and complexity, while designing within the basin and reach-scale geomorphic context, will be critical to achieving both an immediate biological benefit and long-term restoration success. Hydraulic complexity and off-channel habitat projects will provide hydraulic refuge and rearing habitat for juvenile salmonids during moderate to high flows and will also provide more desirable habitat during lower flow conditions. LWD placements will provide refuge and cover and will be used to initiate a geomorphic response in many locations where natural channel development and floodplain connectivity can be achieved. Levee and riprap removal will remove stressors in the system, allowing for more natural geomorphic processes and promoting habitat recovery. See Appendix A for more details on specific restoration actions proposed for the Tucannon River.

Collectively, these improvements can re-establish natural "processes of material and energy transfer across the watershed that enables the formation and maintenance of productive habitat," identified by the Independent Scientific Review Panel (ISRP) for the Tucannon River (ISRP 2011b). It is expected that these improvements will promote the re-establishment of natural processes, which will increase habitat diversity and total rearing area available for juveniles and will improve their survival and productivity. The habitat improvements should also increase spawning and emergence conditions over time through improved energy dissipation from increases in channel complexity, improved temperature conditions, and improved distribution of nutrients and fine sediment across the floodplain.

Spatial Structure

Improving the population spatial structure relates to improving habitat conditions throughout the river corridor such that habitat needs are met across the various life stages and hydrologic regimes, and the health of the population is not jeopardized by local environmental effects. The restoration approach for the Tucannon River does not focus exclusively on one reach or segment of the study area, but values both areas of the river currently experiencing high fish use, as well as areas with high restoration potential should a "full build out" of restoration opportunity be realized. This approach is further described below and in Section 4 of the main report.

In general terms, the restoration strategy for the Tucannon River is a holistic basin-scale approach that values both immediate and long-term biological benefits. Implementation of restoration projects will likely occur in high-use areas early to maximize growth and productivity in areas of current use. In addition, projects with high benefit and low cost will be highly recommended regardless of location to maximize the growth and productivity of the segment of the population currently using those areas. Projects implemented on the fringes of the current high-use areas will expand the linear extent of high-quality habitat throughout the river corridor, increasing the distribution and carrying capacity for fish using those areas. Projects removing stressors on habitat will allow for natural recovery of the system and better habitat continuity through the river in the long term.

This restoration strategy will improve the spatial distribution of the stock by improving existing high-use areas, implementing high-benefit/low-cost projects in non-high-use areas, expanding the size of high-use areas by implementing projects on the fringes of those areas, removing stressors affecting natural processes for long-term improvement of quality habitat throughout the river corridor production, and improving the spatial distribution of the stock.

Life History Diversity

None of the proposed restoration actions will specifically target improving life history diversity within the target species.

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