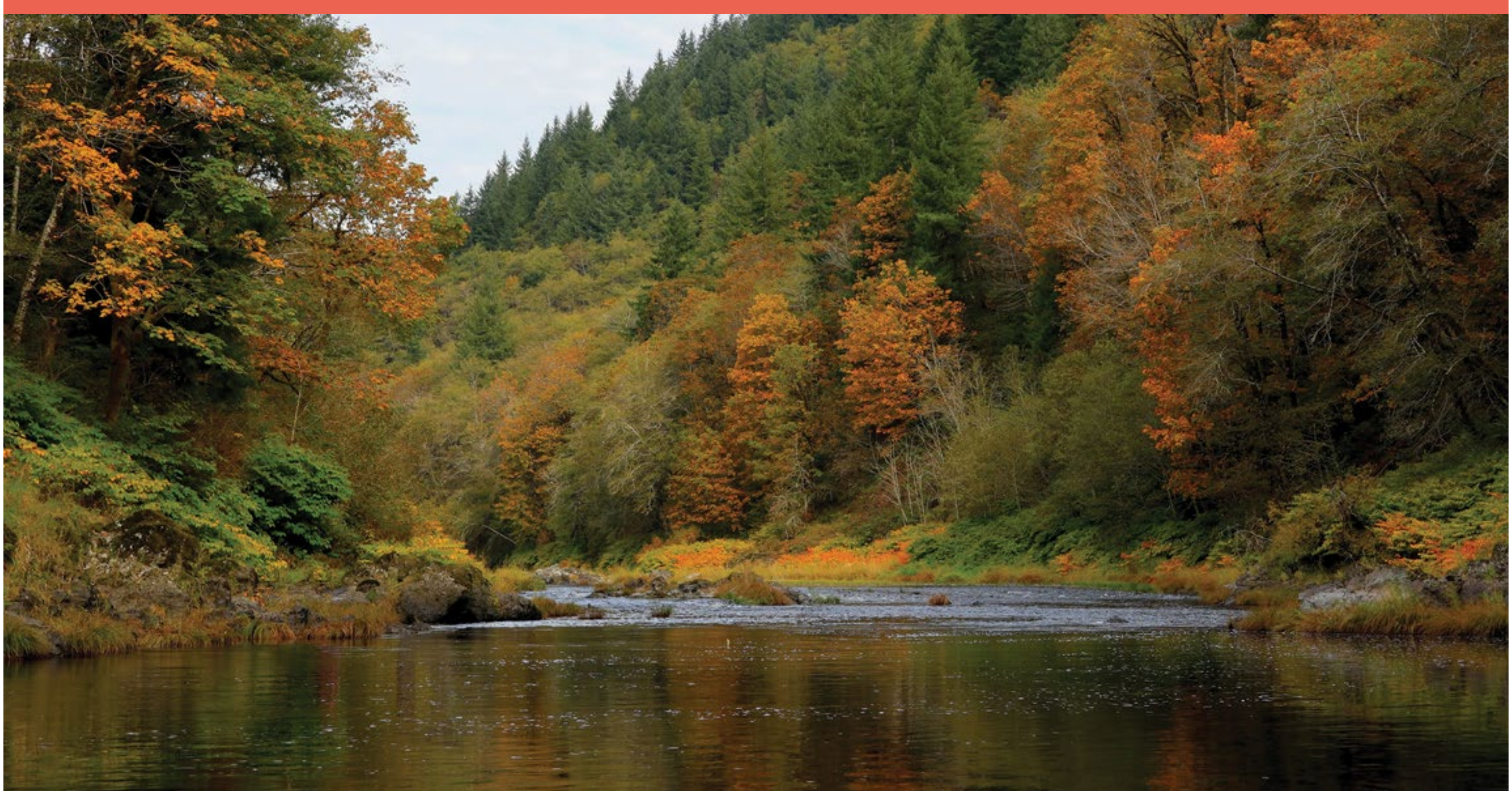
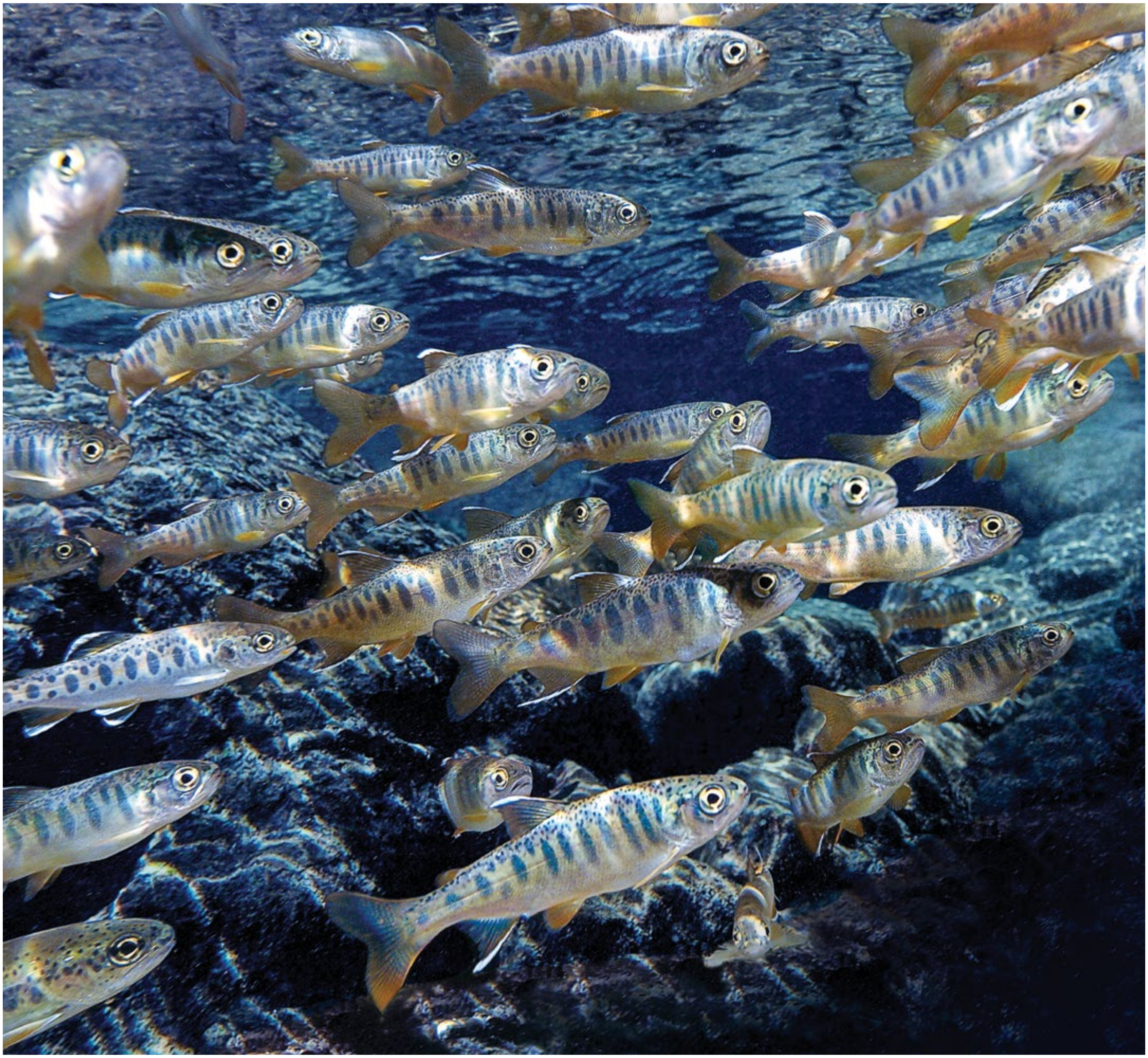
Strategic Action Plan for the Protection & Restoration of Coho Salmon Habitat

~ The Nehalem River ~





Coast Coho juveniles by John McMillan. Cover photos: Coho by iStock and Nehalem River by Wild Salmon Center. Back cover by Alamy.

Contributors and Acknowledgements

The "Strategic Action Plan for the Protection and Restoration of Nehalem River Coho Salmon Habitat" (SAP) was developed by the *Nehalem Basin Partnership* (Nehalem Partnership), a team of dedicated resource managers and conservation professionals, representing the following agencies, organizations, and businesses:

- **Columbia Soil and Water Conservation District (SWCD)**
- **Lower Nehalem Watershed Council (LNWC)**
- **National Oceanic and Atmospheric Administration (NOAA)**
- **Oregon Department of Environmental Quality (DEQ)**
- **Oregon Department of Fish and Wildlife (ODFW)**
- **Oregon Department of Forestry (ODF)**
- **Tillamook Estuaries Partnership (TEP)**
- **Upper Nehalem Watershed Council (UNWC)**
- **Weyerhaeuser**

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Acronyms

AQI	Aquatic Inventories Project
BDA	Beaver Dam Analogue
BLM	Bureau of Land Management
BMP	Best Management Practice
CAP	Conservation Action Plan
CCP	Coast Coho Partnership
CFS	Cubic Feet per Second
CMECS	Coastal and Marine Ecological Classification System
CWA	Clean Water Act
DEQ	Oregon Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FPA	Oregon Forest Practices Act
IP	Intrinsic Potential
KEA	Key Ecological Attribute
LNWC	Lower Nehalem Watershed Council
MDN	Marine Derived Nutrients
NFWF	National Fish and Wildlife Foundation
NGOs	Non-governmental Organizations
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Service
NWFSC	Northwest Fisheries Science Center
OC	Oregon Coast
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OWEB	Oregon Watershed Enhancement Board
OWRI	Oregon Watershed Restoration Inventory
RM	River Mile
SAP	Strategic Action Plan
SWCD	Soil and Water Conservation District
TEP	Tillamook Estuaries Partnership
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
UNWC	Upper Nehalem Watershed Council
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WSC	Wild Salmon Center

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Executive Summary

Prior to European settlement, an estimated quarter million Coast Coho salmon *(Oncorhynchus kisutch)* returned to spawn in the Nehalem River watershed, representing the largest Coho run on the north coast. A century and a half after the initial influx of European settlers – who were drawn to the region's booming timber, fishing, and farming industries – watershed health has declined in the Nehalem basin. These and other land uses have impaired critical watershed processes, leading to the loss and degradation of the habitats that sustain Nehalem Coho and other Pacific Salmon species.

A steady decline in habitat quality and quantity throughout the 20th century – coupled with high hatchery Coho production, high harvest rates, and poor ocean conditions – led to a crash in the Nehalem Coho population in the 1990s. An assessment completed by the Oregon Department of Fish and Wildlife (ODFW) determined that the Nehalem Coho population was no longer viable, primarily due to a lack of stream complexity to support overwintering juveniles. Elevated water temperatures, especially in the mainstem Nehalem River, also limited the quality and quantity of summer rearing habitat.

The decline of Nehalem Coho – and the habitat stressors that caused it – reflected broader, coast-wide trends. As a result, the Oregon Coast (OC) Coho "evolutionarily significant unit" (ESU) was listed as "threatened" under the federal Endangered Species Act (ESA) in 1998. Two plans to rebuild the ESU's 21 independent Coast Coho populations resulted from the ESA listing. First, in March 2007, ODFW published the "Oregon Coast Coho Conservation Plan." Then in December 2016, the National Oceanographic and Atmospheric Administration (NOAA) published the "Final ESA Recovery Plan for Oregon Coast Coho Salmon."

This Strategic Action Plan (SAP) represents a locally led effort to implement the broad recommendations contained in these state and federal recovery plans. In 2015, the Nehalem Partnership convened to develop an SAP that could achieve two long-term goals:

LONG-TERM GOALS	
1	Protect and restore summer, winter, and incubation habitats sufficient to produce a detectable change (i.e., improving trends) in Coho production in high-priority 6th field subwatersheds.
2	Protect and restore watershed processes to ensure sufficient habitat diversity for the expression of multiple life-history strategies within the Nehalem Coho population.

To achieve these goals, the SAP emphasizes restoration of the watershed processes that generate and maintain critical Coho habitats. This process-based approach relies heavily on an "anchor habitat strategy," which seeks to identify, protect, and restore the stream reaches most capable of supporting Coho across the full spectrum of their freshwater residency, including spawning, egg incubation, rearing, and smolting. The primary strategies presented in this plan to restore watershed processes and conserve anchor habitats include:

- protecting selected upland timber stands to safeguard large woody debris (LWD) delivery to anchors;
- installing LWD and promoting dam-building by beavers to increase instream complexity and floodplain interaction in and around anchor habitats;
- enhancing long-term riparian function;
- improving fish passage and longitudinal connectivity; and
- reconnecting tidal wetlands.

The SAP sets forth six long-term outcomes that the Nehalem Partnership seeks to achieve through the implementation of these strategies in 17 "focal areas" (priority subwatersheds where partners have agreed to focus and coordinate restoration efforts). These measurable outcomes are consistent with the state's broad sense recovery goal for the Nehalem Coho population of restoring 311 miles of instream habitat to "high quality habitat."

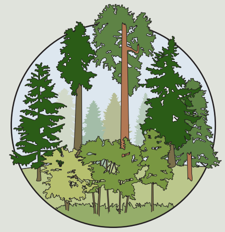

Photo: Lindsey Ray Aspelund

The Nehalem Partnership is confident that these outcomes will lead to achievement of the SAP's two over-arching goals. However, this SAP is not a recovery plan. It does not recommend changes in land use or resource management that may be required to achieve broad sense recovery. In addition, the goals and outcomes contained in the SAP are built on assumptions and imperfect data. Most notably, projected changes in climate will impact the Nehalem Coho population and the effectiveness of habitat restoration in ways that cannot yet be fully understood. Ultimately, the achievement of the Nehalem Partnership's vision – healthy ecological, economic, and social conditions in the watershed that can ensure a sustainable future for native Coho – relies on the adaptive implementation of this plan coupled with the sustained stewardship of resource managers and public and private landowners.

Recognizing the importance of adaptive management, the Nehalem Partnership developed a monitoring framework to assess SAP implementation. The framework provides guidance on how to evaluate both the rate at which the SAP is being implemented and the degree to which it's producing the desired results. The adaptive management chapter concludes with a discussion of several important data gaps, which, once filled, may revise the priorities presented in this plan.

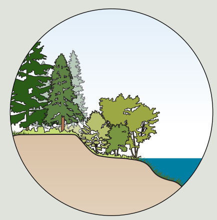
The Nehalem Partnership estimated the costs of all projects presented in the SAP's short-term work plan (2023-2027). To achieve the plan's five-year objectives, partners propose projects with a total estimated cost of $3.44 million. This estimate does not reflect fish passage projects, which will require design and engineering to generate informed cost estimates and likely increase this estimate by several million dollars. Extrapolation of these short-term costs plus fish passage and additional work planned over the life of the plan indicates a total cost of SAP implementation between $45m and $50m.

By 2045 the Nehalem Coho Partnership will achieve the following restoration outcomes:



Upland Forests: **536 acres** of upland timber are protected to ensure long-term delivery of large wood to anchor habitats.

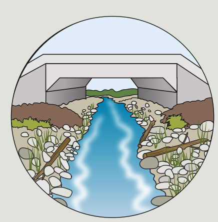
Instream: Instream complexity is restored within **66 miles** of focal area anchor habitats.



Riparian: Riparian function is enhanced along **58 miles** of focal area tributaries.

Off-Channel: Beavers colonize and build dams along an additional **40 miles** of Coho-bearing tributaries, increasing off-channel habitats available for Coho rearing.

Tidal Wetlands: **300 acres** of tidal wetlands and other estuarine habitats are reconnected.



Fish Passage: 52 barriers to fish passage are removed, restoring Coho access to **92 miles** of anchor habitats and cold-water refuge.

Illustrations: Elizabeth Morales

By reaching these six restoration outcomes, the Nehalem Partnership seeks to achieve the SAP's long-term goals and advance the vision of a healthy Nehalem Coho population.

Chapter 1

Introduction: The Nehalem Basin Partnership and the Purpose of this Plan

Scientists estimate that one to two million adult Coho salmon *(Oncorhynchus kisutch)* once returned to the Oregon Coast (OC) Coho Evolutionarily Significant Unit (ESU) (NMFS 2016), which includes populations from Cape Blanco, Oregon north to the Columbia River (ODFW 2007). In the late 19th and early 20th centuries, these runs drove the settlement of small fishing communities and fueled a nascent coastal economy. While the runs began to decline in the early 20th century, Coho and other Pacific Salmon continued to support commercial and recreational fisheries through most of the century, bolstering local economies up and down the coast. The Coho fishery was largely closed following the initial listing of the OC Coho ESU as "threatened" under the Endangered Species Act (ESA) in 1998. For the past 20 years, a recovery effort has been underway focused heavily on the protection and restoration of critical Coho habitats.

As one of 21 independent populations in the OC Coho ESU, the viability of the Nehalem Coho population has mirrored that of the ESU. Once numbering an estimated 240,000 fish in the 1800s (Meengs and Lackey 2005), population abundance declined to less than 3,000 in 2012 (ODFW 2022). Since the passage of the Oregon Plan for Salmon and Watersheds (ODFW 1997), state and federal agencies, local watershed groups, NGOs,

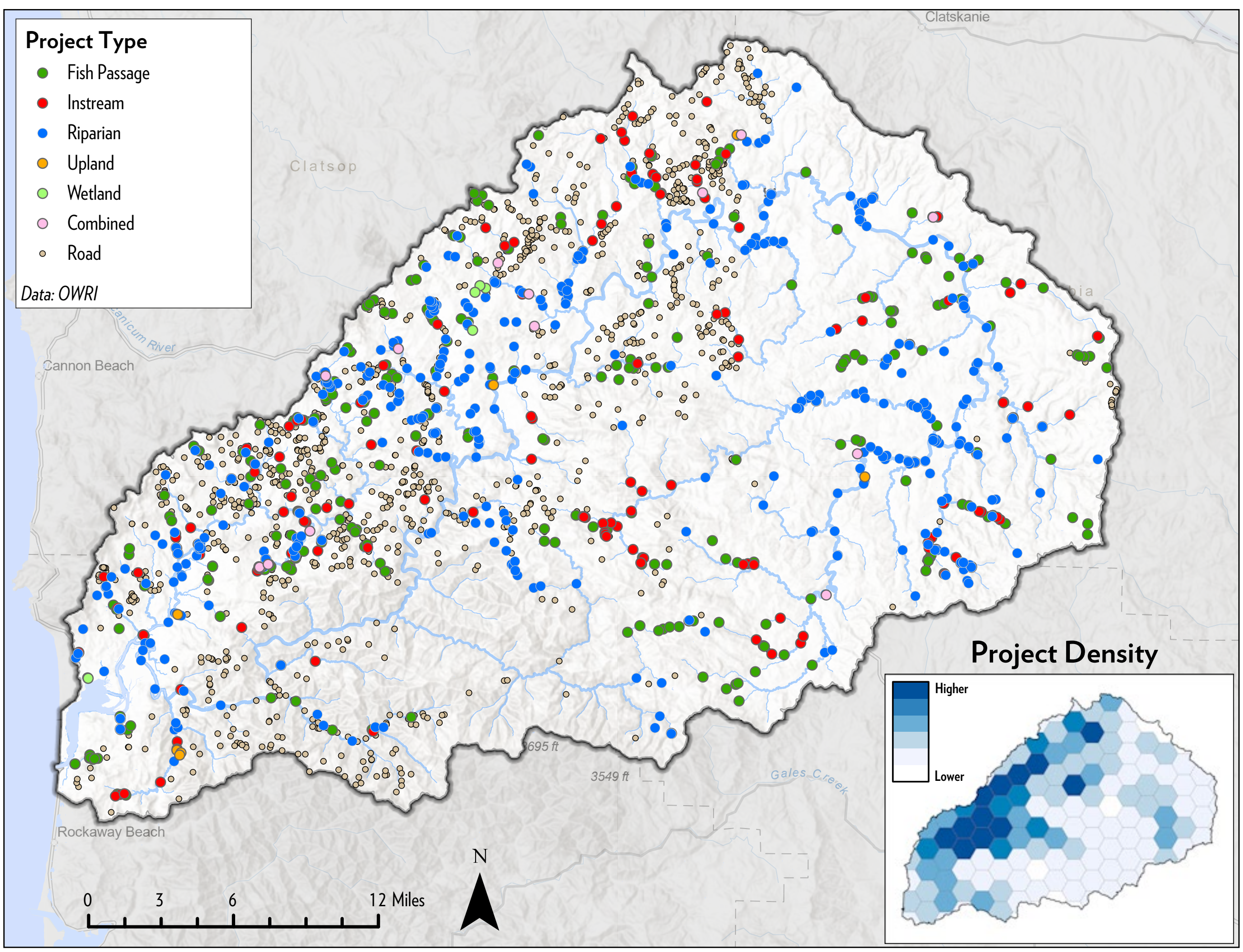


Figure 1-1. Habitat Restoration and Forest Road Maintenance Projects (1995 – 2018).

and public and private landowners have led a substantial local recovery effort. Figure 1-1 shows many restoration projects implemented within the Nehalem watershed over the last two decades.

Along the rural, resource-dependent coast of northwest Oregon, watershed conservation and species recovery require the establishment of strategic partnerships in which a variety of public and private stakeholders work together toward a common vision. This vision must coalesce economic, ecological, and social goals and align the limited social and financial capital available in the region towards solutions that promote sustainable watershed and community health. Development of this Strategic Action Plan (SAP) by the Nehalem Basin Partnership (Nehalem Partnership) intends to meet these needs. Through this plan, the partners listed below seek to engage local stakeholders in developing and implementing habitat protection and restoration actions that will recover the Nehalem Coho population, while sustaining and nurturing the long-term viability of working farms, forests, and communities.

The Nehalem Partnership includes the following federal, state, local, and corporate partners:

- **Columbia Soil and Water Conservation District (SWCD)**
- **Lower Nehalem Watershed Council (LNWC)**
- **National Marine Fisheries Service (NMFS)**
- **Oregon Department of Environmental Quality (DEQ)**
- **Oregon Department of Fish and Wildlife (ODFW)**
- **Oregon Department of Forestry (ODF)**
- **Tillamook Estuaries Partnership (TEP)**
- **Upper Nehalem Watershed Council (UNWC)**
- **Weyerhaeuser**

1.1 The Vision of a Healthy Coho Population

The Nehalem Partnership envisions healthy ecological, economic, and social conditions in the Nehalem basin that ensure a sustainable future for native Coho through highly connected, functional, and productive landscapes.

Through the implementation of this plan, the partners hope to achieve the following long-term ecological goals:

- Protect and restore summer, winter, and incubation habitats sufficient to produce a detectable change (improving trends) in Coho production in high-priority 6th field watersheds, and
- Protect and restore watershed processes to ensure sufficient habitat diversity for the expression of multiple life-history strategies within the Nehalem Coho population.

1.2 Why Coho?

Coho have a unique life cycle among Pacific Salmon that makes them an excellent indicator of watershed health. Adult Coho return from the ocean to the Nehalem River each fall, spawning in the basin's low-gradient tributaries. The resulting offspring emerge from the gravel the following spring, then – unlike other Pacific Salmon – most spend a full year in freshwater before migrating to the ocean. This extended freshwater residency requires a watershed that is functioning sufficiently to maintain a variety of habitat types throughout the year, especially "off-channel" areas such as beaver ponds, oxbows, and

Coho salmon are a "keystone species," which means numerous plant and animal species rely on them to survive.

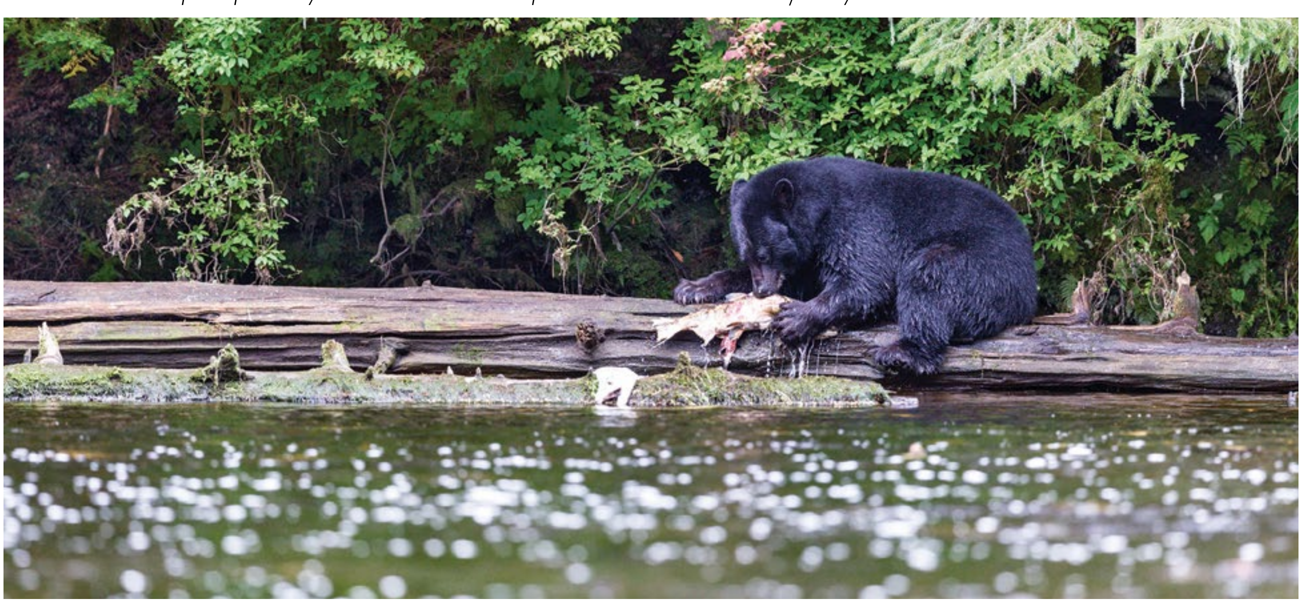
side channels. These habitats allow juvenile Coho to find pockets of cool water when the mainstem heats up in the summer, and resting areas in the winter when peak flows threaten to sweep them downstream. Also, when a watershed can generate and maintain enough complex instream and off-channel habitats to sustain a viable Coho population, the system is likely capable of producing services that communities rely on, such as clean drinking water, flood control, groundwater recharge and recreation.

Restoring Coho habitats also benefits other species. Coho habitats are created by the interaction of complex watershed processes like hydrology, sediment delivery, and riparian (streamside) and floodplain interactions. The protection and restoration of these and other natural processes for Coho help the watershed produce and maintain habitats for Chinook *(Oncorhynchus tshawytscha)*, chum *(O. keta)*, steelhead *(O. mykiss)*, and cutthroat trout *(O. clarki clarki)*, and a range of plant and animal species, many of which Coho require for their survival.

Finally, Coho are a "keystone species," which numerous plants and animals rely on at some point during their lives. All life stages of Coho (egg, fry, smolt, and adult) provide sustenance to aquatic and terrestrial organisms ranging from otter and black bear, which consume returning adults, to the smallest aquatic invertebrates that shred the carcasses of decaying fish after they have spawned.

Forest and plant communities also directly benefit from the decaying fish. Adult Coho return to the watershed after taking up phosphorus, nitrogen, and other nutrients from the ocean. After they spawn, they decompose and release these critical "marine-derived nutrients" (MDN) into the ecosystems where they become available to grasses, shrubs, trees, and other plant life. Studies on MDN have not been conducted in the Nehalem basin, but according to Merz and Moyle (2006), "research over more than three decades has shown that the annual deposition of salmon-borne (MDN) is important for the productivity of freshwater communities throughout the Pacific coastal region." Helfield and Naiman (2001) found "that trees and shrubs near spawning streams derive ~22-24 percent of their foliar nitrogen (N) from spawning salmon." Subsequent research by Naiman et al. (2002) suggests that even in highly modified watersheds in northern California, "robust salmon runs continue to provide important ecological services with

Numerous animal and plant species rely on coho and other salmon for survival. Photo: Tim Plowden / Alamy



high economic value…. Loss of Pacific Salmon can not only negatively affect stream and riparian ecosystem function, but can also affect local economies where agriculture and salmon streams coexist."

1.3 Scope of this Strategic Action Plan

The federal government and the State of Oregon have developed recovery plans for the OC Coho ESU that encompass the Nehalem population, including the Final ESA Recovery Plan for Oregon Coast Coho Salmon (NMFS 2016) and the Oregon Coast Coho Conservation Plan (ODFW 2007). While these ESU-level plans identify population-scale limiting factors and recommend a suite of strategies to recover each population in the ESU, both plans stress that recovery can only be achieved by implementing plans that are locally generated and include finer-scale, targeted conservation actions. Decisions on where and how these actions are implemented must be made in locally convened forums, so input from the landowner community and other stakeholders can be fully integrated into both the long-term habitat restoration strategy and the selection of short-term projects.

This SAP seeks to meet these needs for the Nehalem River community. Chapter 5 presents a long-term "strategic framework" for Coho habitat protection and restoration. This framework describes the habitat restoration strategies that will have the highest potential to restore watershed function and identifies locations throughout the basin where these strategies can generate the greatest benefit. Chapter 6 presents a short-term work plan that maps the specific locations where the social, economic, and regulatory conditions exist to put projects on the ground that advance the long-term strategic framework.

It is important to note that the Nehalem Partnership's ability to achieve the goals described in Section 1.1 is influenced by a variety of threats that cannot be fully addressed by this SAP since it focuses largely on freshwater and estuarine habitat restoration. Over the course of this plan's development, participants considered many of these threats, including predator management (sea lions, cormorants, etc.); the sufficiency of state water quality rules; and fishery, farm, and forest management. Ultimately, the partners opted to limit the scope of this plan to priorities that the Nehalem Partnership has greater control over: namely, where, when, and how Coho habitats can and should be restored in the watershed. Reviewers of this plan are

Decomposing salmon feed riparian forests. Three decades of research shows that trees and shrubs near spawning streams derive an estimated 22-24% of their foliar nitrogen (N) from spawning salmon. Photo: Wild Salmon Center

Photo: Ken Morrish

This SAP does not propose any new regulations or the modification of existing regulations. Implementation of this plan is entirely voluntary.

encouraged to consider the policies governing land use and species/habitat management in the Nehalem basin alongside this plan's restoration goals, and to use existing venues to support policies that align with the vision of Coho recovery as described above.

Finally, the Nehalem Partnership wishes to underscore that implementation of this plan is entirely voluntary. The plan identifies high-quality habitats on both public and private lands to guide outreach to landowners, but the plan's implementation relies entirely on voluntary actions. No new actions will be required of public or private landowners. Consequently, while this plan's maps identify instream and upland habitats on some private lands as a high priority for restoration, the implementation of actions on these lands is up to individual landowners. Likewise, this SAP does not propose any new regulations or the modification of existing regulations.

1.4 SAP Implementation Timeline: Long-Term Outcomes & Short-Term Goals

The Nehalem Partnership projects the implementation of this plan – including new projects identified through the adaptive management process – to run through 2045. Such a long implementation horizon will be necessary to achieve the plan's goals in part because of the time required for the system

Coho salmon have a unique life cycle among Pacific Salmon that makes them an excellent indicator of watershed health. If a watershed can generate and maintain enough complex instream and off-channel habitats to sustain a viable Coho population, the system is likely capable of producing services that communities rely on, such as clean drinking water, flood control, and recreation. Photo: Jim Yuskavitch

to respond to restoration treatments. For example, trees planted in a riparian zone may take a decade or more to begin providing sufficient shade to improve water temperatures. In addition, the Nehalem Partnership recognizes that it will take many years for the implementation of a sufficient number of projects to demonstrate an improvement in subwatershed function.

We hope to reach the goals stated in Section 1.1 by achieving six restoration outcomes by 2045:

- The long-term potential for large wood delivery to anchor habitats is improved through the protection of 536 acres of selected timber stands throughout the Nehalem basin (343 acres in focal areas).
- Instream complexity and stream interaction with off-channel habitats are restored within 66 miles of focal area anchor habitats.
- Riparian function is restored along 58 miles of focal area tributaries, reducing stream temperatures and erosion, increasing macro-invertebrate abundance, and increasing the long-term potential for large wood recruitment.
- Beavers colonize and build dams along an additional 40 miles of Coho-bearing tributaries in the focal areas, increasing the quality and quantity of off-channel habitats available for Coho rearing.
- Three hundred acres of tidal wetlands and other estuarine habitats are reconnected, increasing the quality and extent of tidal rearing habitats and associated freshwater habitats.
- Fifty-two barriers to fish passage are removed, enhancing longitudinal connectivity in focal area tributaries, and restoring Coho access to 92 miles of anchor habitats, cold water refugia, and off-channel habitats.

1.5 Implementing Partners

While this SAP has been developed by the team of partners listed in the introduction to this chapter, a subset of agencies and organizations will lead its implementation on the ground. Table 1-1 lists these partners and the role each will play in implementing this SAP.

IMPLEMENTATION OUTCOMES	
1	**536 acres** of upland timber are protected to ensure long-term delivery of large wood to anchor habitats.
2	Instream complexity is restored within **66 miles** of focal area anchors.
3	Riparian function is enhanced along **58 miles** of focal area tributaries.
4	Beavers colonize and build dams along an additional **40 miles** of tributaries, increasing off-channel habitats available for Coho rearing.
5	**300 acres** of tidal wetlands and other estuarine habitats are reconnected.
6	52 barriers to fish passage are removed, restoring Coho access to **92 miles** of anchor habitats and cold-water refuge.


Photo: Danita Delimont

Table 1-1. Core Implementation Partners

Core Implementation Partners		
Partner	*Experience*	*Anticipated Contributors*
Columbia SWCD	The Columbia SWCD was created in 1946 to support private landowners with stewardship and conservation of working (timber and agriculture) and non-working lands. It has partnered with private landowners throughout Columbia County within the Nehalem watershed on instream and riparian restoration, weed management, and other restoration projects.	The Columbia SWCD will implement the SAP by providing technical assistance to landowners within the parts of the Nehalem watershed that intersect with Columbia County. The SWCD will undertake outreach to landowners, raise implementation funds, manage project implementation, and monitor and report on progress.
Lower Nehalem Watershed Council	The LNWC is dedicated to the protection, preservation, and enhancement of the Nehalem watershed through leadership, cooperation and education. Since its inception in the 1990s, the LNWC has been working with public and private landowners in the watershed to implement habitat restoration, monitoring, and education projects.	The LNWC will be a lead implementer of the SAP in the lower watersheds within their coverage area. It will conduct landowner outreach, raise implementation funding, manage the implementation of habitat restoration projects, and monitor and report on progress.
Oregon Department of Forestry	As the owner and manager of the Tillamook-Clatsop State Forest, ODF is the largest public landowner in the Nehalem basin. The agency has partnered with the watershed councils and other groups on the implementation of the Oregon Plan for Salmon and Watersheds since the 1990s and has decades of experience leading and supporting upland, instream, and riparian habitat restoration projects.	ODF will provide technical support for project implementation, in-kind donation of trees and other project materials as feasible, and access to sites for SAP implementation.
Oregon Department of Fish and Wildlife	ODFW has expertise in regional fisheries, aquatic and terrestrial habitat issues, and supporting and leading state-wide partnerships. Local field staff for the Nehalem have provided technical assistance to the vast majority of the habitat restoration projects implemented in the Nehalem since the development of the Oregon Plan.	ODFW staff will continue to provide technical support for locally led habitat restoration projects, and assist in data management, landowner outreach, public education, and project development.
Tillamook Estuaries Partnership	TEP is a 501 (c) (3) non-profit organization dedicated to the conservation and restoration of Tillamook County's estuaries and watersheds. It has managed habitat restoration, monitoring, and education projects in the Nehalem watershed since 2002, when it expanded its service area beyond just Tillamook Bay.	TEP will implement habitat restoration projects in the Nehalem watershed, while providing technical and financial support to the lead implementers as resources are available.
Upper Nehalem Watershed Council	Founded in 1996, the mission of the UNWC is to foster stewardship and understanding of the natural resources of the Upper Nehalem Watershed among the stakeholders of the watershed communities in order to protect, conserve, restore and sustain the health and functions of the watershed. For over 20 years, it has collaborated with public and private landowners to implement numerous habitat restoration projects, while also supporting local research, monitoring, and education efforts.	The UNWC will be a lead implementer of the SAP in the upper part of the basin within their coverage area. It will conduct landowner outreach, raise implementation funding, manage the implementation of habitat restoration projects, and monitor and report on progress.
Weyerhaeuser	Weyerhaeuser is one of the largest private landowners in the U.S. and offers a diverse suite of resource-based services and products. The company is the largest private landowner in the Nehalem watershed. In addition to ongoing timber operations and other land management activities, it partners with local conservation organizations to restore critical habitats.	Weyerhaeuser will continue to partner with the watershed councils and other stakeholders to implement habitat restoration projects on its lands, as well as support restoration efforts on other lands within the watershed.

Chapter 2

The Nehalem River Watershed

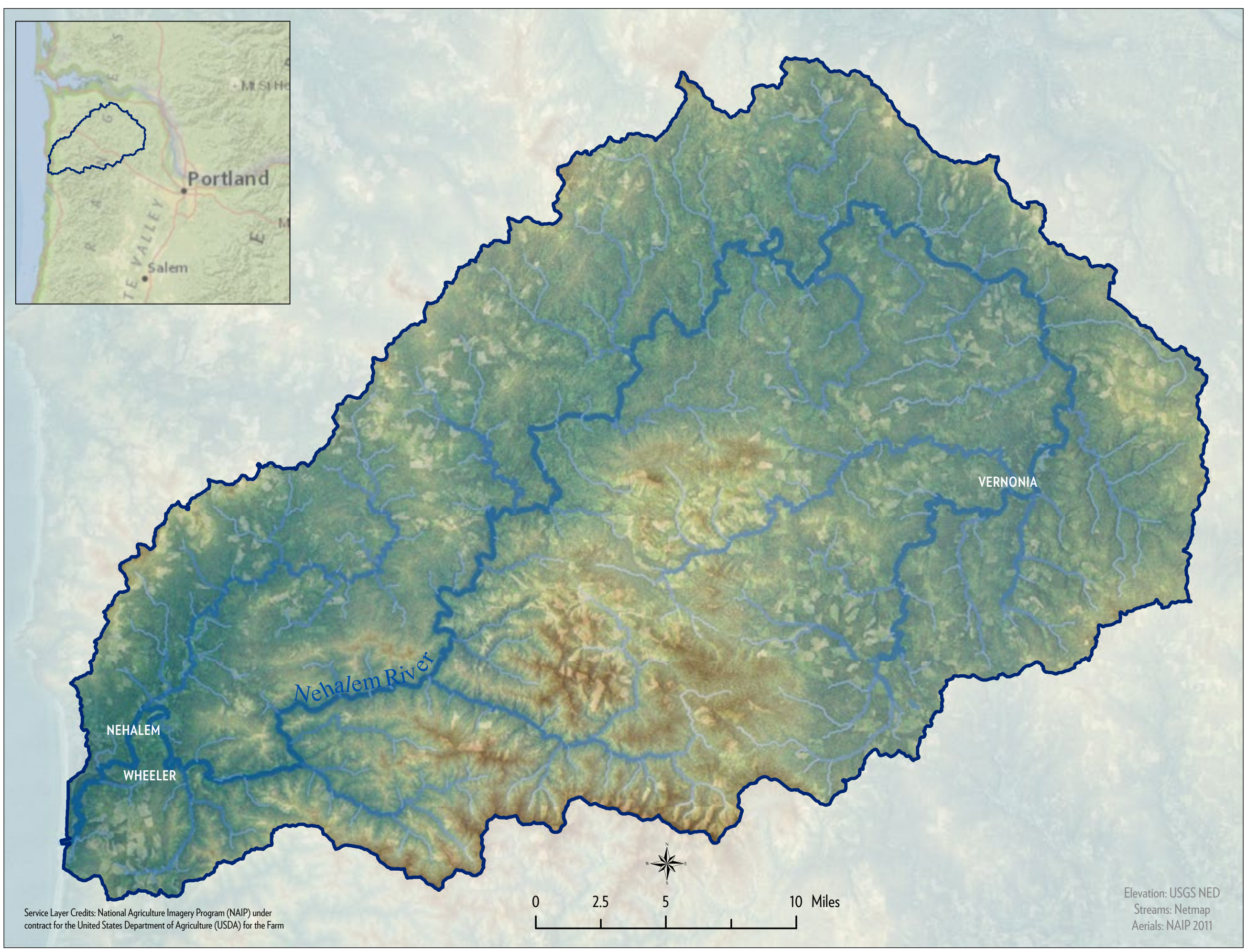
The Nehalem River is the third-longest coastal river in Oregon. Located in the state's northwest corner, the river drains approximately 855 square miles of Washington, Columbia, Clatsop, and Tillamook Counties (Figure 2-1). The Nehalem River flows 118.5 river miles from its source on Giveout Mountain (west of the town of Timber) to Nehalem Bay and the Pacific Ocean. Along the way, the mainstem Nehalem River collects input from over 935 miles of tributaries (Maser 1999).

The Nehalem River watershed is home to an independent population of OC Coho salmon (NOAA 2007; Lawson et al. 2007) that relies on the watershed and its habitat-forming processes for adult spawning, juvenile rearing, and migration to and from the ocean.

The Nehalem River
is the third-longest coastal river
in the state of Oregon.

855	118.5	935
sq mile drainage in 4 counties	river miles long	miles of tributaries

Figure 2-1. The Nehalem River Watershed.



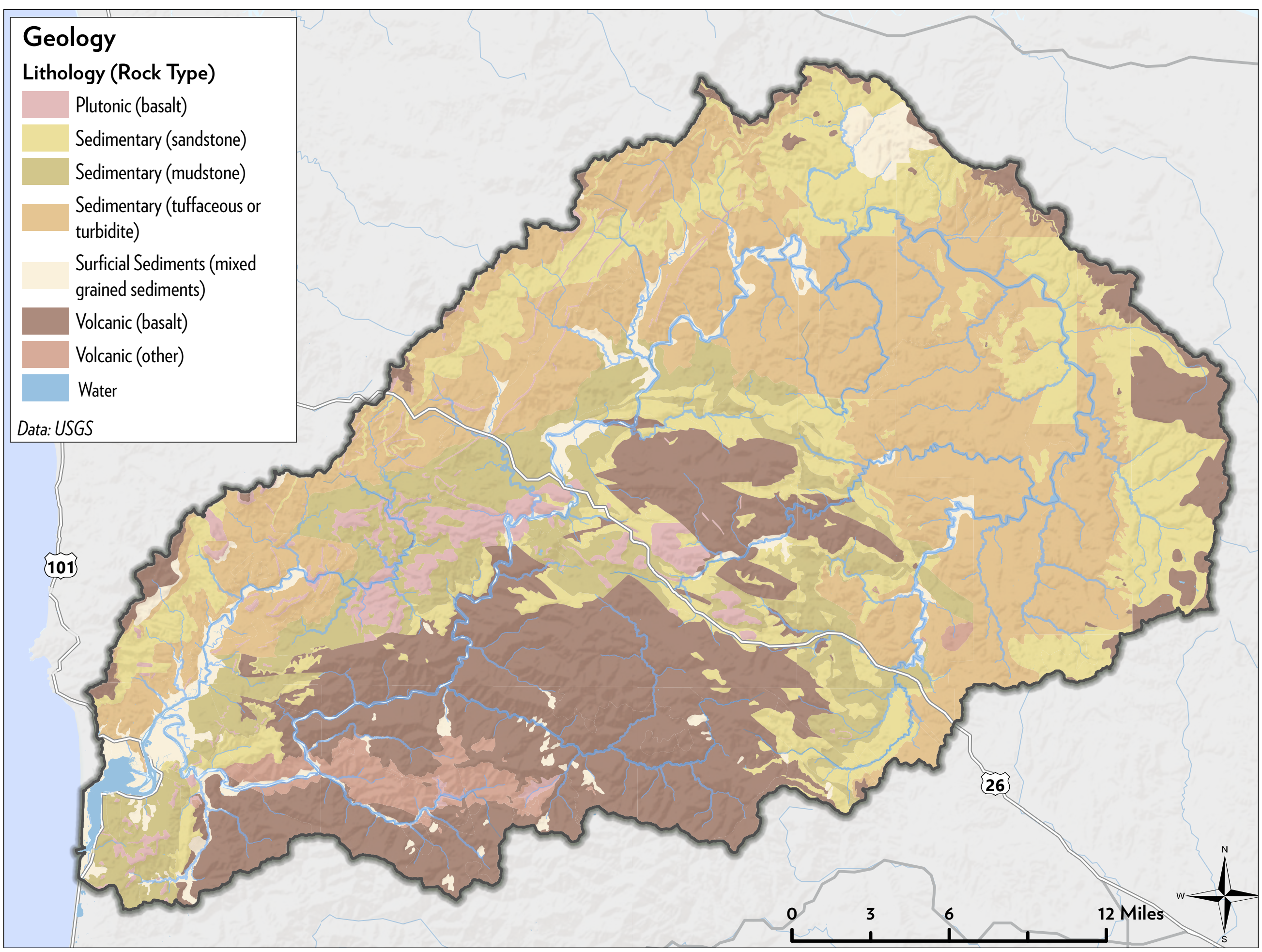
2.1 Geology and Physical Geography

The Nehalem River watershed lies within the Oregon Coast Range Ecoregion. Coniferous forests dominate this region, with 98 percent of the watershed in forest cover (NRCS 2005). Sitka spruce, Douglas-fir, western red cedar, and western hemlock are common in these forestlands (NOAA 2007). Elevation in the watershed ranges from sea level to 4,000 feet, with average temperatures of 50 degrees Fahrenheit and annual rainfalls of 60 to 180 inches.

The watershed contains four EPA Level IV Ecoregions (EPA 2019): coastal lowlands (sea level to 300 feet), coastal uplands (elevations up to 500 feet), volcanics (from 1,000 to 3,200 feet), and Willapa hills. The Nehalem River estuary is a "drowned river mouth estuary" created from the inundation of the lower river mouth and coastal plains resulting from rising sea levels that followed the last ice age. Bounding the coastal lowlands – and the extensive network of marshes, sloughs, and swamps – are coastal uplands. Upland areas in the Nehalem basin include uplifted marine-consolidated and semi-consolidated sandstones and siltstones. Volcanic geology includes Tillamook volcanics in the southern part of the watershed and Columbia Basalt in the northeast (Francisco 2012). Between the volcanic outcroppings lie the Willapa hills, a series of low-lying hills in the western hemlock zone (NOAA 2007). Figure 2-2 provides a map of Nehalem basin geology.

According to Jones et al. (2012), the Nehalem basin is mostly comprised of sedimentary rocks that break down quickly. Stream power is high until the head of tide, where gravel from volcanic rock settles. Sand and

Figure 2-2. Geology of the Nehalem River Watershed.



silts from sedimentary rocks settle mostly in the tidal reaches and on floodplains.

Prior to the arrival of European and American homesteaders and the rise of the commercial timber and agriculture industries, the Nehalem River and its tributaries were a complex mosaic of habitat types providing a variety of functions for aquatic species and sustenance for indigenous cultures. In the upper reaches, large wood (both standing and downed), beaver dams, and boulders promoted interaction between tributary and mainstem channels and their adjacent floodplains. High flows across this complex landscape generated well-connected side channels, oxbows, and ponds of cool, calm water ideal for Coho rearing. High flows also sorted river substrates, creating gravel and cobble riffles well suited to spawning salmon. In the lower reaches of the basin, the floodplain broadened into a connected network of sloughs, marshes, and swamps. Plentiful large wood contributed to the dynamic river as it moved across the floodplain, creating side channels, alcoves, bars, and islands.

Many watershed conditions changed as European settlers moved into the basin. The settlers leveed much of the lower river for flood protection and agriculture, disconnecting the Nehalem River from its historic floodplain and straightening and deepening the mainstem. Marshes and swamps were drained to support agricultural use. Past logging activities – including the use of log drives, slash dams, and diversion dams to float cut logs down the Nehalem River and tributaries to lumber mills – scoured entire reaches of critical spawning substrates. The log drives, along with "river cleaning" to support boating, led to the clearing of habitat-forming large woody debris. Altered hydrology from human management of the landscape also greatly simplified stream habitats. Timber harvest and land clearing for agriculture and development stripped riparian areas of large wood.

Photo: Maggie Peyton

2.2 Water Resources

Rainfall in the Nehalem basin ranges from 55 inches per year near Vernonia to 200 inches in the higher elevations of the Salmonberry subwatershed (Maser 1999). The United States Geologic Survey (USGS) maintains a long-term gage on the Nehalem River near Foss, Oregon. Average discharge during the 1940-1999 period of record was 2,672 cubic feet per second (cfs) with a maximum discharge of 70,300 cfs recorded on February 8, 1996 following a rain-on-snow event. The minimum discharge was 34 cfs from August 29-31, 1967. The average peak flow is 28,776 cfs. Eighty-five percent of the total discharge in the watershed occurs between November and April (Maser 1999).

Water quantity has been identified as a stressor for Coho in the Upper Nehalem River, Middle Nehalem River, and Lower Nehalem River – Cook Creek hydrologic units (Bauer et al. 2008). There are 569 permitted water rights in the Nehalem watershed (OWRD 2023) representing at least 93.25 cfs of cumulative authorized water diversions (Maser 1999), an amount that can have a substantial impact on summer stream temperatures and juvenile fish migration.

2.3 Forest Resources

The vast majority (almost 90%) of the Nehalem River watershed is in state and private forest ownership. The history of the Nehalem forests is one of disturbance, both natural and anthropogenic. Prior to timber harvest by European and American homesteaders, old-growth Douglas fir forests dominated the watershed, with areas periodically disturbed by fire. According to the Nehalem Valley Historical Society (via Maser 1999), the Nehalem Indians regularly managed forestland with fire to allow meadows to persist for deer and elk grazing. Timber harvest by white settlers began in the 1870s with the construction of the Pittsburg lumber mill on the East Fork Nehalem River (Maser 1999; Ferdun 2003). The industry expanded with the construction of the Wheeler sawmill, which operated from 1902 to 1930. With timber production booming, roads and railroads were built to support the industry, and by 1945 virtually all of the Nehalem watershed's timber had been harvested or burned (Sword 1999 via Maser 1999; Ferdun 2003).

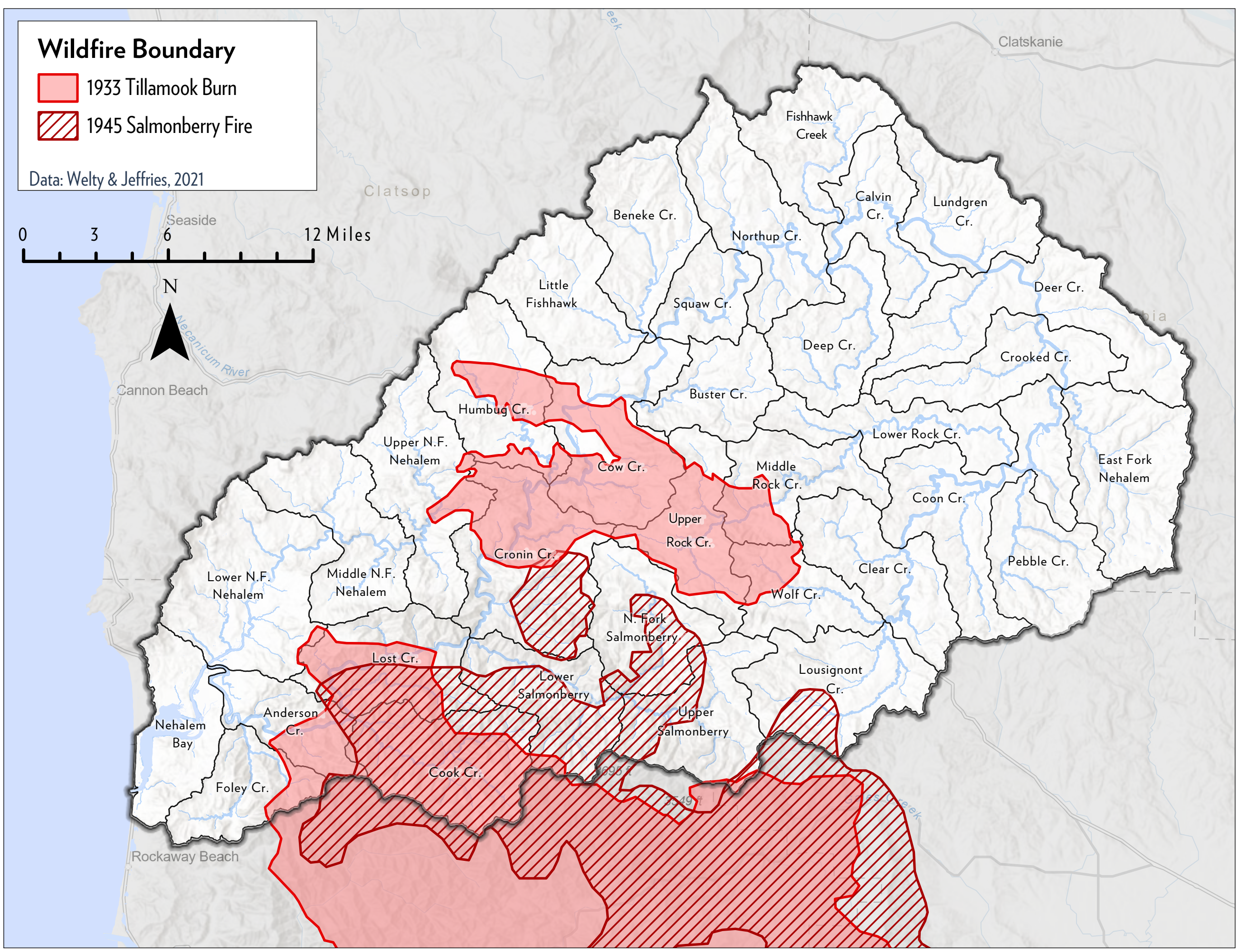
As shown in Figure 2-3, two major fires affected large areas of the Nehalem basin. In 1933, the infamous Tillamook Burn torched 270,000 acres in the Salmonberry River, Cook, Humbug, and Rock Creek drainages, as well as 30 river miles of the Nehalem River mainstem. Twelve years later, in 1945, the Salmonberry Fire burned much of the Salmonberry River and Cook Creek drainages. The damage from these fires stripped the forest of its timber value, forcing many landowners into foreclosure. This loss resulted in land ownership being transferred to the State of Oregon, which initiated a massive reforestation program from 1949 to 1973.

Today, commercial timber harvest occurs on these reforested lands. Tillamook-Clatsop State Forest lands are managed by the Oregon Department of Forestry (ODF) under the Northwest State Forest Management Plan. Private lands are held by small woodlot owners, timber investment management organizations, and logging companies. ODF regulates all of these privately owned forests under the Oregon Forest Practices Act (FPA). Due to this combination of historic clearcutting, catastrophic fire, and ongoing harvest (often 30- or 40-year rotations on private lands), most of the forested land in the watershed is younger than 70 years.

Historic logging photo. By 1945 virtually all of the Nehalem watershed's old-growth timber had been harvested or burned. Photo: Nehalem Valley Historical Society.

Historic logging photo. Photo: Nehalem Valley Historical Society.

Figure 2-3. Extent of the 1933 Tillamook Burn and 1945 Salmonberry Fires.



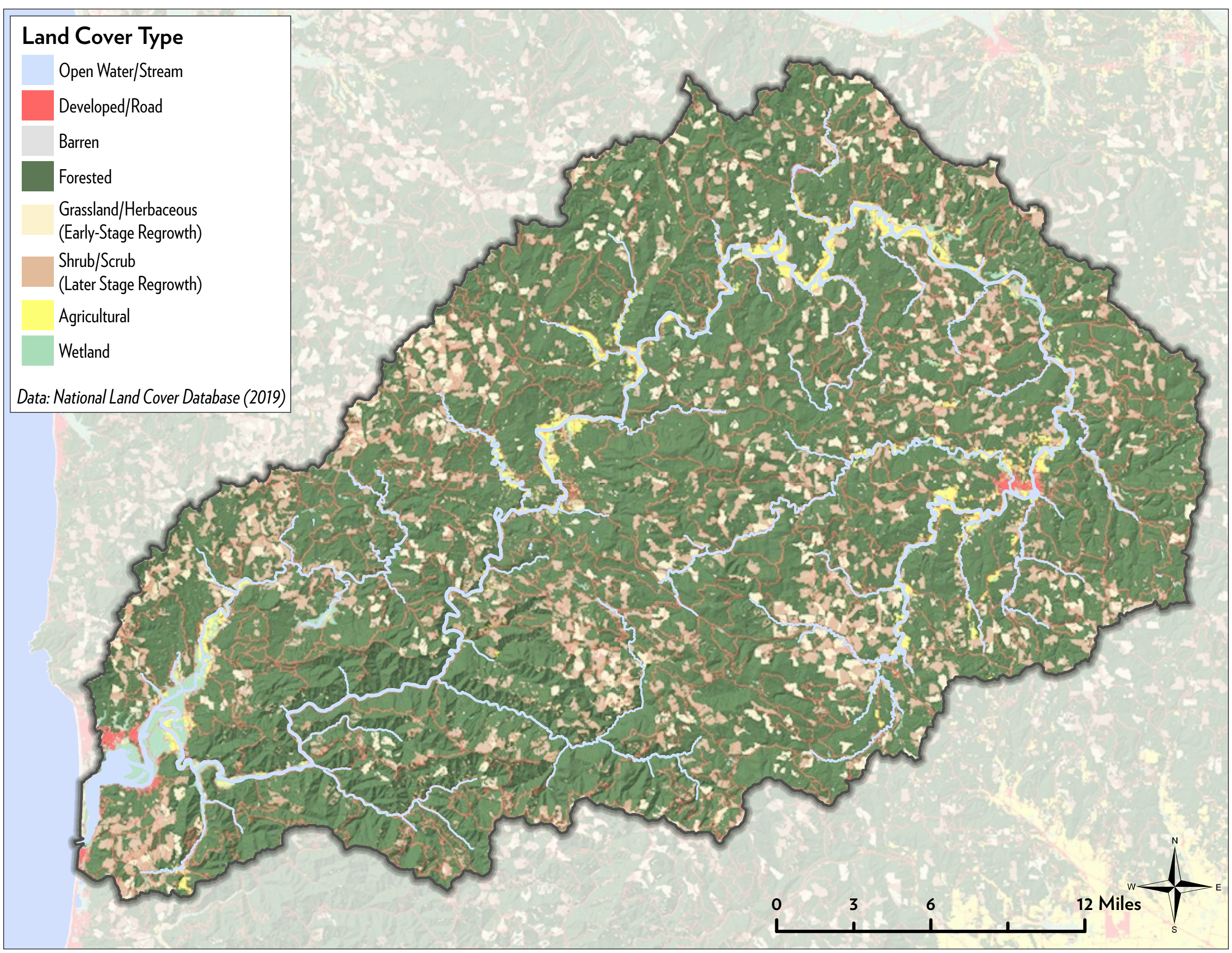
2.4 Biotic Systems

The Nehalem River watershed vegetation structure and composition vary with elevation, proximity to the Pacific Ocean, and timber harvest history (Figure 2-4). The higher elevation areas are dominated by conifer trees, while lower elevation areas, particularly mainstem riparian areas, are dominated by stands of broadleaf species or a mix of broadleaf and conifers (Maser 1999). Within the Nehalem River estuary, habitats include mudflats, aquatic beds, emergent marsh, scrub-shrub, and forested wetlands (Brophy and So 2005).

Coal Creek. Photo: Wild Salmon Center

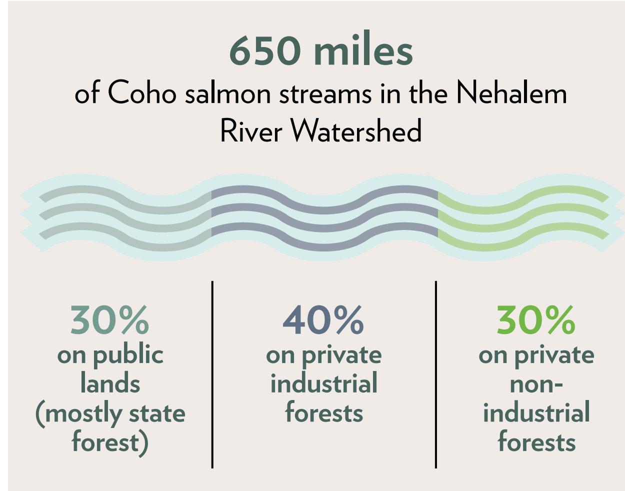
Figure 2-5 shows the distribution of salmon and steelhead throughout the basin. Four salmon and steelhead species – Coho, fall and early-run fall Chinook, chum, and winter steelhead – occur in the mainstem and tributaries of the Nehalem basin. Of these, only Coho are protected under the ESA. Resident and anadromous cutthroat trout, white sturgeon *(Acipenser transmontanus)*, and Pacific lamprey *(Lampetra tridentata)* are also present within the basin (Kavanagh et al. 2005, 2006).

Figure 2-4. Land Cover in the Nehalem River Watershed.



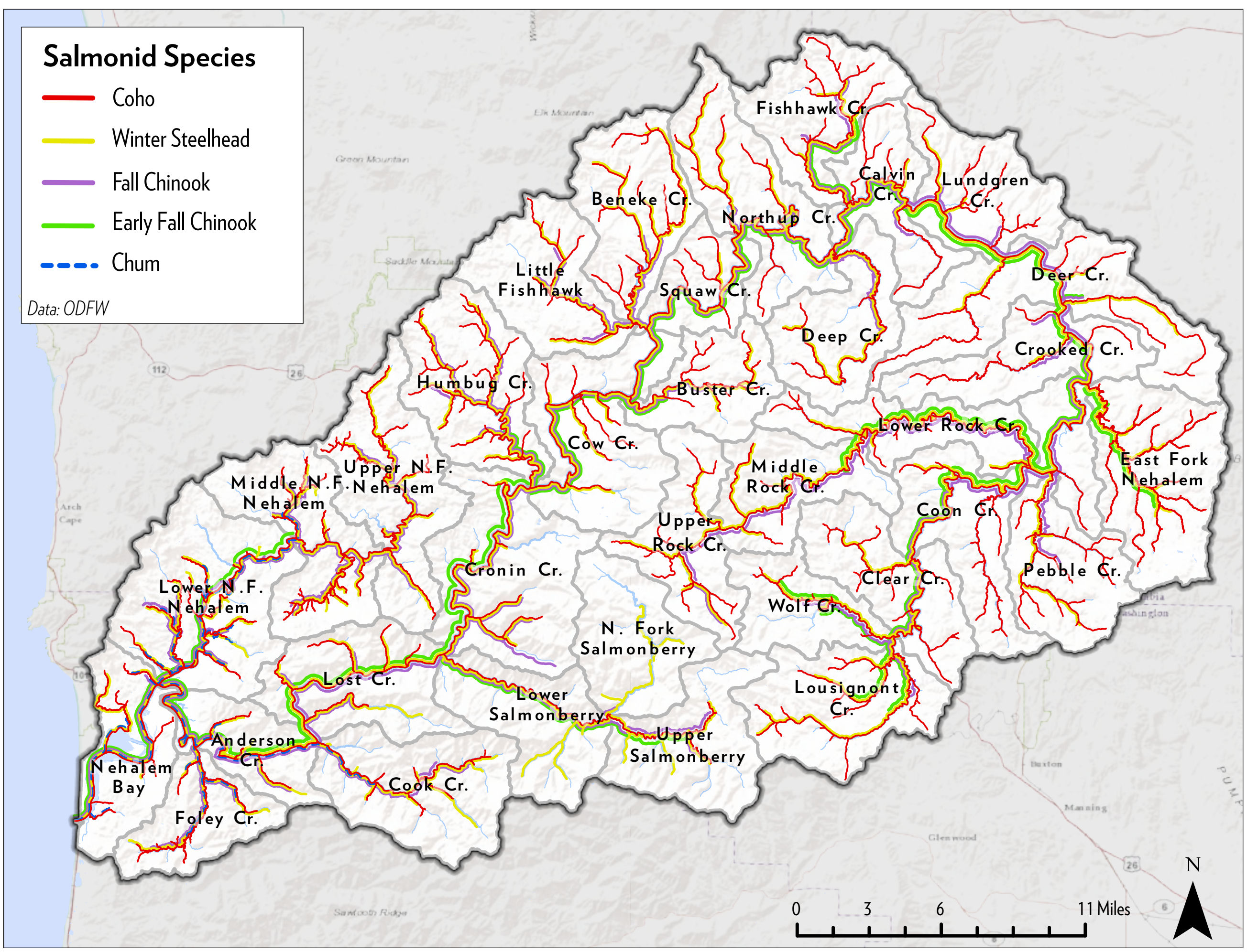
2.5 Human Settlement and Demographics

Today, the Nehalem River watershed has relatively low population growth and economic development compared to its boom period in the early 1900s. The watershed is sparsely populated, with large amounts of forested land. Timber harvest is the dominant land use, with a smaller area supporting agriculture and rural development. Land ownership within the watershed includes 48 percent private industrial timberlands, 40 percent public lands (primarily the Tillamook-Clatsop State Forest), and 12 percent private non-industrial lands (Figure 2-6). Of the approximately 650 miles of Coho streams in the basin, 40 percent of the total length is on private industrial forest lands, 30 percent on public lands, and the remaining 30 percent on private non-industrial forest lands (Watershed Professionals Network 2007).



Breakdown of stream ownership in the Nehalem River Watershed.

Figure 2-5. Fish Distribution in the Nehalem River Watershed.



Chum salmon. Photo; Stock Connection Blue / Alamy

Selected species supported by the freshwater and estuarine reaches of the Nehalem River system.

- Coho salmon
- Fall and early-run fall Chinook salmon
- Chum salmon
- Winter steelhead trout
- Pacific lamprey
- Cutthroat trout
- White sturgeon

The Nehalem River is named for the native people who first inhabited the watershed and have remained for thousands of years (Maser 1999). European explorers began exploring the region that is now Oregon as early as 1579 (Ferdun 2003). The 1770s and 1780s brought more European explorers, and the diseases they brought with them led to the decimation of native populations. Estimates of losses to the native populations range from 75 percent to as high as 90 percent (Maser 1999).

Nearly a century later, in 1866, Hans Anderson was the first European settler in the Nehalem River valley (Maser 1999; Ferdun 2003). Shortly after Anderson's arrival, settlers established the towns of Nehalem and Wheeler just upstream of Nehalem Bay. In 1878, they built a lumber mill in Pittsburg along the East Fork Nehalem River (Maser 1999; Ferdun 2003). With the establishment of towns came industry and development, which led to canneries, lumber mills, and farms.

The resource-dependent economy boomed as settlers continued to move to the Nehalem watershed and establish homesteads. The early 1900's economy was built on timber harvest, dairy farming, and fishing, and all three industries continued to grow through the 1920s as export markets expanded. This period brought the most significant changes to the physical and social environment of the Nehalem watershed to date (Ferdun 2003).

The resource-based economy continued through the 1930s, 40s, and 50s. The commercial fishing industry grew as canneries and hatcheries were constructed. Aggressive logging and the Tillamook Burn significantly altered the forests, and little to no old-growth forest remained in the watershed after 1945 (Maser 1999; Ferdun 2003). Numerous dairy farms operated in the Nehalem River floodplain by this time. These farms leveed wetlands and converted them to pasture for dairy production. In 1960, the Nehalem's remaining cheese factories consolidated under the Tillamook County Creamery Association (Ferdun 2003). Coho runs continued to return in viable numbers to the Nehalem River, and in 1976 managers witnessed the highest recorded harvest rate on OC Coho salmon, at about 90 percent of the run (ODFW 2007).

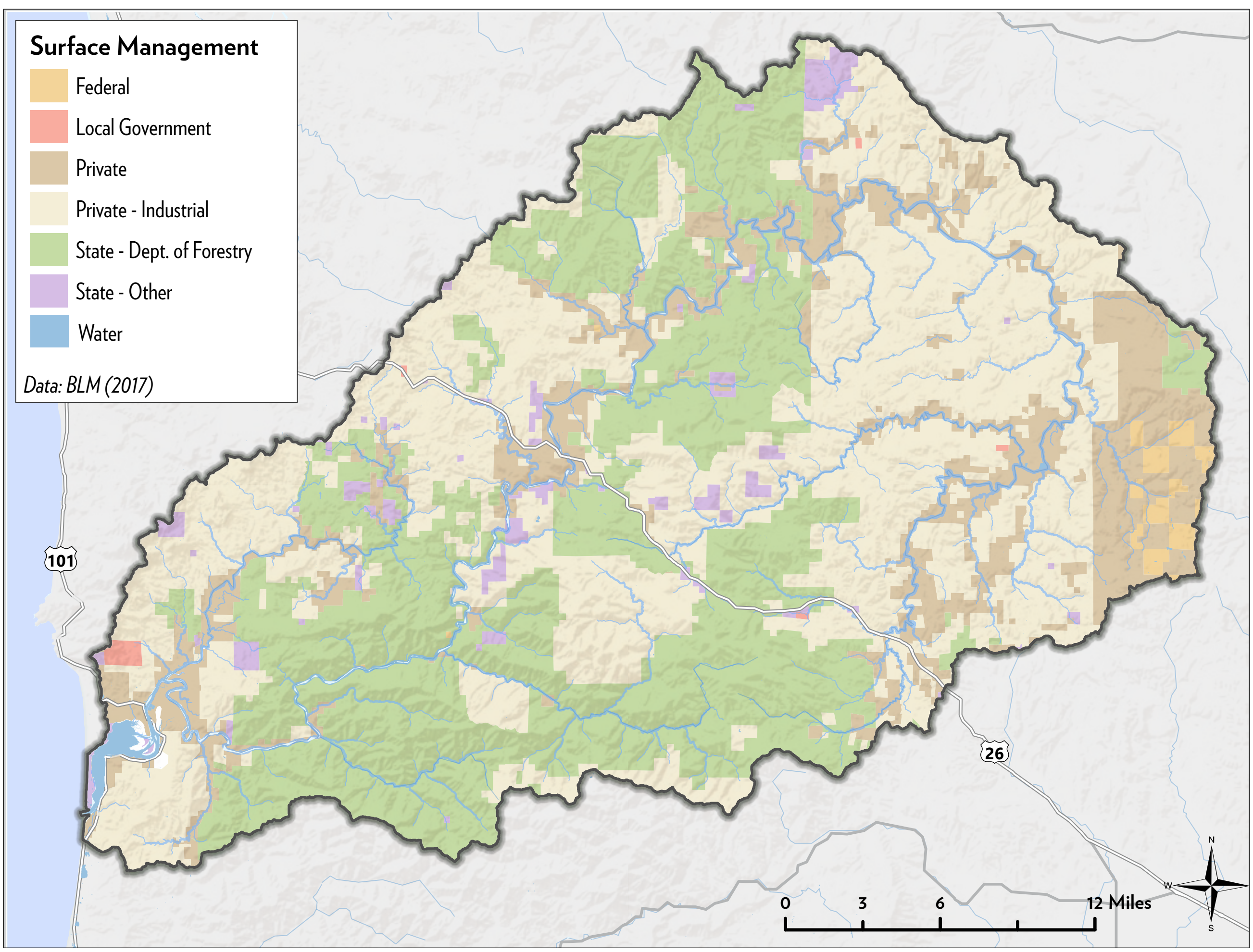
Today, recreation, retirement, and tourism services drive the local economy (Headwaters Economics 2019). Farming continues, with approximately 250 farms in operation (NRCS 2005), as do timber harvest operations. While the river remains closed to commercial fishing, opportunities for recreational fishing persist. The Coho runs are evaluated annually for each population and fisheries depend on annual forecasts that allow abundance goals to be met and protect the weakest stocks. Harvest impact rates to wild OC Coho continue to be managed through the

Pacific Fishery Management Council's Salmon Fishery Management Plan, which NOAA Fisheries found to be consistent with the recovery of OC Coho.

The watershed today supports three main population centers: the towns of Vernonia, Wheeler, and Nehalem. These communities supported a combined population of 3,009 people in 2009 (US Census Bureau, 2010) and 3,079 people in 2019 (US Census Bureau, 2020). Several other smaller towns and isolated farms sit outside of these main population centers. The area's average median income is roughly $38,000, and 42 percent of jobs are in educational, social, and health care services and manufacturing. Agriculture, forestry, fishing/hunting, and mining account for nine percent of the jobs in the towns and five percent in the counties (not including Washington County, since it includes much larger urban areas in the Willamette Valley) (TNC 2012).

Setting a crab ring in Neawanna Creek. Photo: Graham Hardy / Alamy

Figure 2-6. Land Ownership in the Nehalem River Watershed.



Chapter 3

Nehalem Basin Coho and Habitats

3.1 Coho Salmon Life Cycle and Habitat Needs

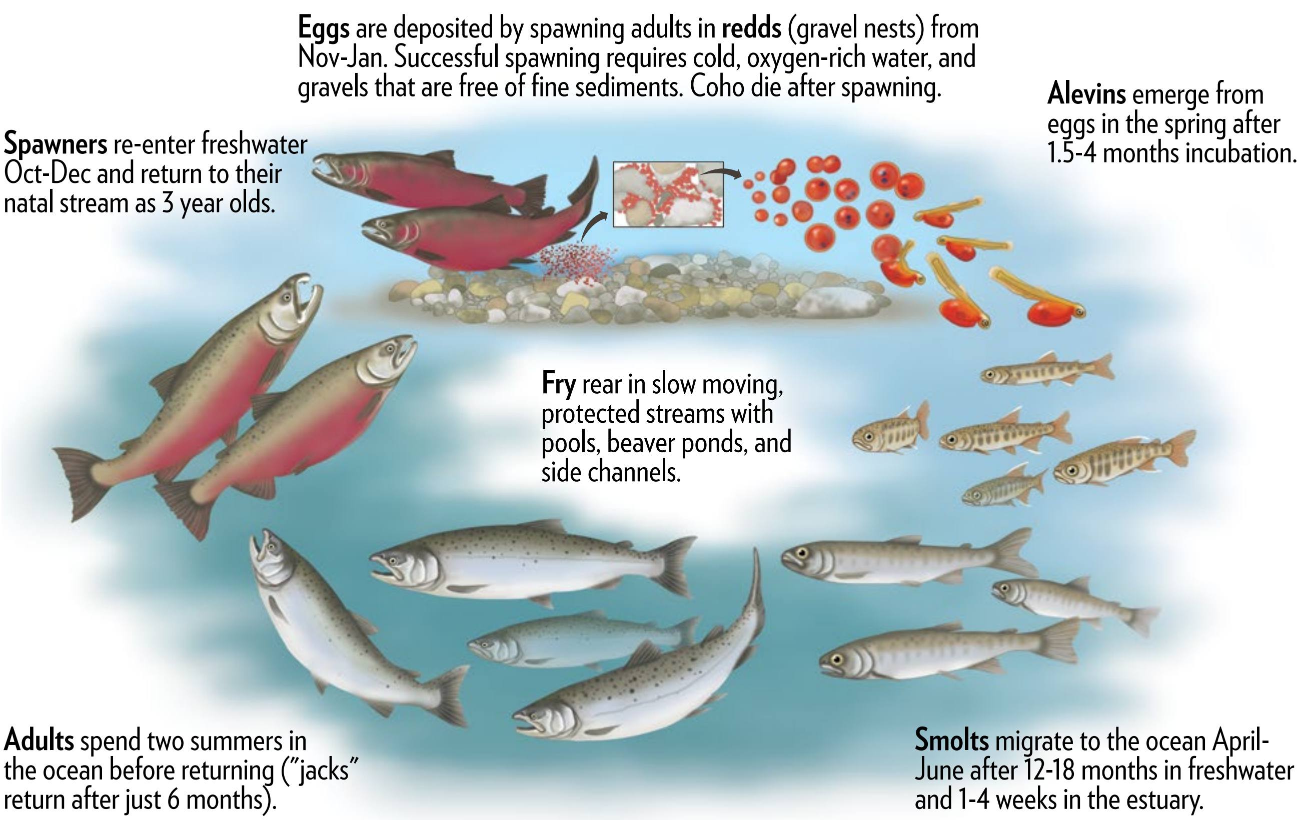
Adult Coho return to the Nehalem River from the ocean and migrate to their natal streams from October through December, spawning between November and January (Kavanagh et al. 2015). Coho preferentially spawn in tributaries but have been observed spawning in the Nehalem's upper mainstem as well (Kavanagh et al. 2005, 2006). Successful spawning requires the appropriate mix of gravels and cobble substrate in stream riffles. Female Coho build redds (gravel nests) and deposit their eggs, which one or more males then fertilize. Adults die soon after spawning, typically within two weeks (Maser 1999). Figure 3-1 depicts the standard Coho salmon life cycle.

Coho redds require a steady flow of oxygenated water to allow eggs and alevins (juveniles that have emerged from the egg but rely on attached yolk sacs for nourishment while they remain within the gravels) to survive (Kavanagh et al. 2005, 2006).

The common understanding of Coho maturation has focused on a "standard" or "conventional" life-history type in which Coho fry rear near their natal stream for a year or so before migrating to the estuary in spring as smolts (juvenile salmon undergoing physiological changes to adapt from freshwater to a saltwater environment) (Sandercock 1991; Nickelson 1998). However, as early as the 1960s, researchers described age-zero (first year of life) fry, which migrate downstream shortly after emergence (Chapman 1962).

The early migration of these individuals, called "nomads," was originally believed to

Figure 3-1. The Coho Salmon Life Cycle. Artwork by Elizabeth Morales.



A smolt is a juvenile salmon undergoing physiological changes to adapt from freshwater to a saltwater environment. Photo: Seth Mead.

be caused by density dependence, a natural population dynamic in which juveniles migrate due to a habitat having reached carrying capacity. Subsequent research into Coho and other Pacific Salmon species indicates that these migrations are not driven by density dependence, high flows, or other sources of displacement; instead, they represent alternative life-history strategies (Reimers 1973; Bottom et al. 2005; Koski 2009; NMFS 2016). The expression of multiple life-history strategies within a population increases the likelihood that the population can persist following sudden or gradual variations in watershed function and the availability of high-quality habitats. This resilience is essential to the viability of Pacific Salmon populations and a key to the species' success (Moore et al. 2014; Koski, K V. 2009).

The component of the Nehalem Coho population expressing this alternative "nomadic" life-history trait represents an unknown, but likely underestimated, percentage of the total population. The contribution of nomads to the total watershed production of Coho smolts can be substantial and may be important in repopulating both natal and non-natal streams.

In addition to the standard and nomadic life-history types, research on juvenile Nehalem Coho migration and residency patterns indicates that several other life-history strategies may be expressed within the population (Bio-Surveys 2011a). During the development of this SAP, the team recognized the presence of six potential unique life-history variations based on a range of environmental and behavioral variables. These life-history types are described in Appendix 2.

Adult Coho generally spend about 18 months in the ocean before returning to their natal streams to spawn in their third year of life (ODFW 2007); however, some males return to freshwater after only one year in the ocean (Mullen 1979). These precocious males, commonly called "jacks," offer another example of the life-history variation observed within Coho populations.

The expression of multiple life-history strategies within a population increases the likelihood that the population can persist following sudden or gradual variations in watershed function and the availability of high-quality habitats.
This resilience is essential to the viability of Pacific Salmon populations and a key to the species' success.

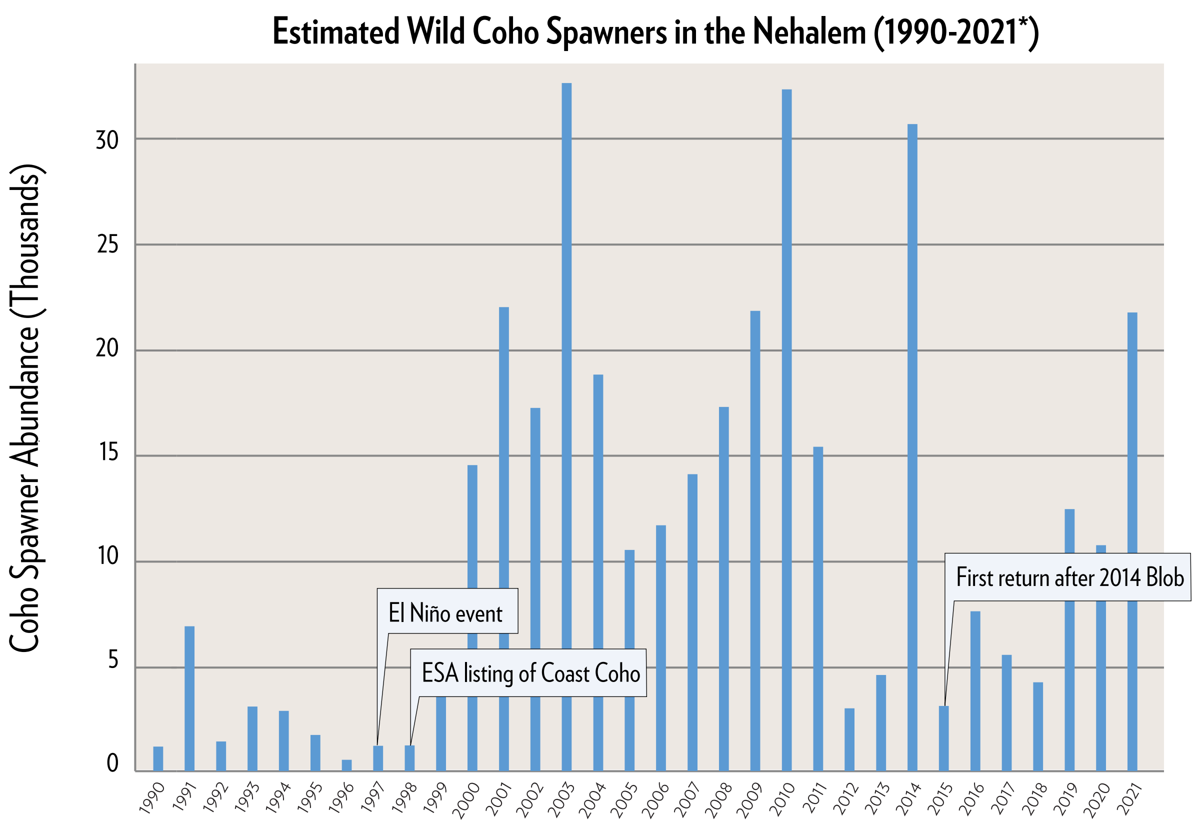
Photo: Eiko Jones

3.2 Coho Salmon Population Abundance

A long-term assessment of Nehalem Coho abundance indicates a steadily declining trend from historical to contemporary estimates (Ferdun 2003). Fisheries catch data from the 1920s and 1930s show an average annual catch of over 50,000 Coho from the Nehalem River, with a severe decline in the catch after 1950. Coho numbers continued to decline steadily from the 1960s through much of the 1990s (ODFW 1993).

Since the mid-1990s, under the Oregon Plan for Salmon and Watersheds, ODFW has utilzized several sampling methods to understand adult spawner abundance, juvenile abundance, and adult escapement. These sampling efforts have been employed at the scale of the North Coast stratum down to the subwatershed, and examined both wild and hatchery Coho. As shown in Figure 3-2, the data indicate large fluctuations in the numbers of natural-origin Coho returning to spawn in the Nehalem watershed in recent years. The Nehalem Coho population bottomed out in 1996 with an estimated abundance of just over 500 natural-origin spawners. This pattern reflected an ESU-wide trend, which led NMFS to list OC Coho under the ESA in 1998, attributing the species' decline to the following factors: high harvest rates, high hatchery production, significantly degraded habitat, and periods of poor ocean conditions. Over the next 15 years, wild spawner abundance estimates ranged from a low of roughly 10,000 natural-origin spawners in 2005 to over 30,000 in 2003 and 2010. Wild spawner abundance dipped to pre-2000 levels in 2012, 2013, 2015, and 2018 (ODFW 2022).

Figure 3-2. Wild Nehalem Coho Salmon Spawner Abundance (1990-2021). **Spawning data for the Nehalem population in 2020 and 2021 are extrapolations based on calculated proportional estimates from 2017-2019. Source: ODFW Salmon and Steelhead Recovery Tracker (ODFW 2022).*

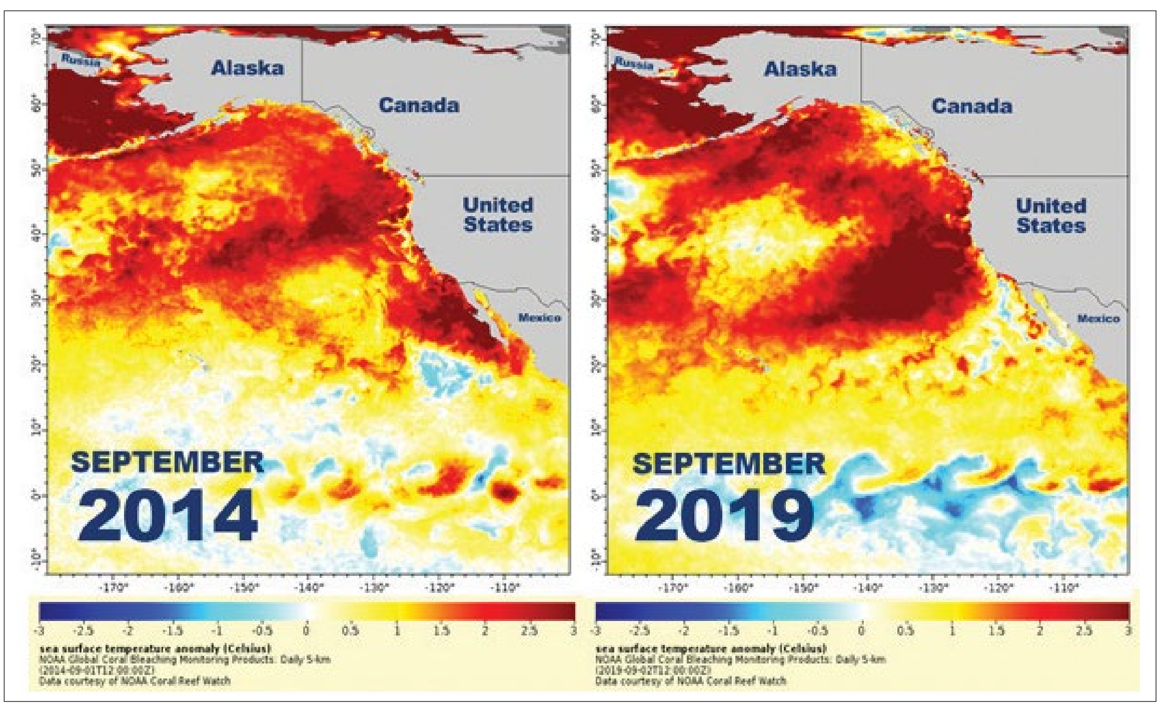


3.3 Ocean Conditions

As previously discussed, Coho spend one to two years in the ocean maturing. During this time, physical conditions of the ocean play a vital role in their growth and survival. El Nino and marine heat wave events cause temperature and salinity changes in the ocean that adversely affect salmonid prey, competition, and predator abundances that directly influence salmon growth potential and survival. In 2014, salmon managers witnessed formation of the largest marine heat wave on record in the North Pacific Ocean. "The Blob" as it became known, limited ocean mixing and spread warm temperatures across the Northeast Pacific Ocean until 2016. This was followed by an El Nino event that sustained abnormally high ocean temperatures.

These events created a significant biological response that was observed at all levels of the marine ecosystem, including a massive die-off of seabirds from a lack of food along the Oregon and Washington coast in 2014, and higher mortality of sea lions and whales in 2015. After the Blob subsided and ocean temperature anomalies returned to neutral, a new marine heat wave developed in 2019 that created additional unfavorable conditions for Coho and other cold-water species. The effects of these events continued for several years (Laurie Weitkamp, NOAA Fisheries), including the low abundance of OC Coho since 2015.

Figure 3-3. Ocean Temperature Anomalies. Image compares sea surface temperature anomalies (how much cooler or warmer the water is compared to normal levels) when the Blob developed in September 2014 and the heat wave started in September 2019. (https://research.noaa.gov/ So-what-are-marine-heat-waves)



3.4 Climate Change

It is well established that the global climate system is warming at an unprecedented rate and subsequently causing ocean warming and acidification (IPCC 2014). There is strong scientific support for projections that the warming will continue through the 21st century and that the magnitude and rate of change will be influenced substantially by the amount of greenhouse gas emissions (IPCC 2014). Ocean acidification is also expected to continue through the end of the century under most greenhouse gas emission scenarios and could accelerate as the ocean's buffering capacity diminishes (Jiang et al. 2019).

In the Pacific Northwest, climate change and the loss of biodiversity represent profound threats to ecosystem function. Research suggests that if greenhouse gas emissions continue at current levels, the average annual air temperature in Oregon will increase by 5°F (2.8°C) by the 2050s and 8.2°F (4.6°C) by the 2080s, with the largest seasonal increases occurring in summer (Dalton and Fleishman 2021). Seasonal changes in precipitation and increased drought frequency are also expected to significantly impact stream flow volume and timing (Dalton and Fleishman 2021). Late fall and winter flows are projected to increase, while spring, summer, and early fall flows are expected to decrease on the Oregon Coast throughout the 21st century.

Because most young Coho spend a full year in freshwater before ocean entry, the juvenile freshwater stage is considered to be highly vulnerable. Photo: Brian Kelley

Summer stream temperatures are expected to increase in the future due to rising air temperatures and decreased base flows. These changes could affect Coho salmon growth and survival through numerous pathways during their life cycle (Wainwright and Weitkamp 2013). High stream temperatures have been linked to reduced Coho parr abundance (Ebersole et al. 2009), higher susceptibility to disease (Cairns et al. 2005), and lower freshwater production (Lawson et al. 2004) in the OC Coho Salmon ESU. The factors limiting the recovery of this species will be amplified by climate change. Currently, poor water quality, including high summer water temperatures and excess fine sediment, is recognized as a secondary limiting factor for most OC Coho populations, including the Nehalem population. If increases in summer stream temperatures outpace actions that increase shade and reduce water temperatures, water quality may become a primary limiting factor (ODFW 2019b). Therefore, instream restoration will need to be coupled with implementing actions to mitigate expected changes in summer temperature and flow.

In most OC Coho populations, low overwinter survival of Coho parr due to a lack of stream complexity will continue to limit smolt production in the near term. However, increasing water temperatures and decreasing base flows in the future could eventually lead to an even more severe reduction in productive summer habitat (ODFW 2019b). Additionally, thermally stressful summer rearing conditions could reduce subsequent overwinter survival, worsening the winter bottleneck that may also be exacerbated by increased flows (Ebersole et al. 2006).

The effect of increasing summer water temperature on juvenile Coho abundance and smolt production will depend on many factors, including temperature heterogeneity and the presence of thermal refuges within stream reaches, food resource availability to support increased metabolic needs, and the quality and quantity of overwinter habitat available to juvenile fish that survive the summer period (ODFW 2019b). Local climate, geomorphology, and riparian conditions differ across the OC Coho Salmon ESU; therefore, Coho populations are likely to be affected by climate change in different ways based on their vulnerability.

Vulnerability is a function of the three following components: 1) *exposure*- the physical, chemical, biological,and other changes occurring in a selected geography due to broader shifts in climate, 2) *sensitivity*- the unique characteristics of watersheds and species that determine the impacts of exposure, and 3) *adaptability*- the capacity of wild populations to change in ways that allow them to survive in changing conditions (IPCC 2007; Crozier et al. 2019). The more vulnerable a species or system is to climate change, the greater the impact. A recent vulnerability assessment of ESA-listed Pacific salmon and steelhead ESUs completed by Crozier et al. (2019) indicates that OC Coho have a high overall vulnerability, high sensitivity and high exposure, and only moderate adaptive capacity. Because most young Coho spend a full year in freshwater before ocean entry, the juvenile freshwater stage is considered to be highly vulnerable. OC Coho salmon also scored high in sensitivity at the marine stage due to expected changes from ocean acidification. These results are consistent with the Wainwright and Weitkamp (2013) climate change assessment and highlight the importance of implementing actions to increase the resilience of these populations.

Projected changes in the ocean environment (sea level rise, increasing sea surface temperature, increased ocean acidification) are largely outside of management control. Therefore, the primary management strategy to minimize the long-term impacts of climate and ocean change on OC Coho centers on the protection, restoration, and enhancement of key freshwater and estuarine habitats (ODFW 2019b). Riparian ecosystems are naturally resilient when not degraded, and may provide adaptive support in mitigating impacts from climate change (Seavy et al. 2009). Riparian areas have higher water content than surrounding upland areas and can absorb heat, buffer air and water temperatures, maintain pockets of cool water, and provide refugia (Seavy et al. 2009). Therefore, salmonids are better able to migrate through temperature-impacted river reaches when there are intact riparian areas creating pockets of cooler water refugia.

Additionally, restoring floodplain connectivity and stream flow regimes, re-aggrading incised channels, restoring riparian vegetation, and promoting beaver and beaver-related pond habitat are most likely to improve stream flow and temperature changes, support biodiversity, increase flood, drought and fire resiliency, bolster carbon sequestration and increase overall resilience to projected climate change impacts (Jordan and Fairfax 2022). Maintaining and restoring diverse and productive rearing habitats will help sustain populations through cycles in ocean productivity, which may become more extreme and unfavorable in the future.

VULNERABILITY TO CLIMATE CHANGE	
1	**Exposure:** The physical, chemical, biological, and other changes occurring in a selected geography due to broader shifts in climate.
2	**Sensitivity:** The unique characteristics of watersheds and species that determine the impacts of exposure.
3	**Adaptability:** The capacity of wild populations to change in ways that allow them to survive in changing conditions.

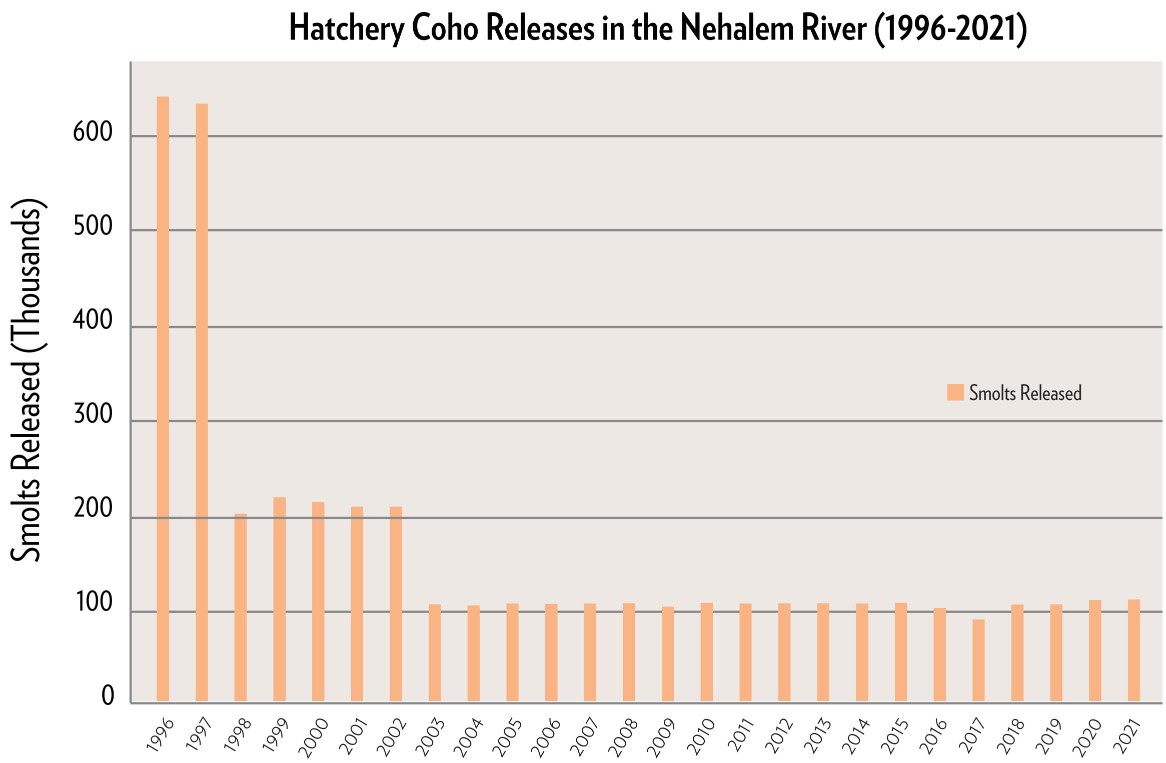
3.5 Hatchery Production

Early 20th-century declines in salmon population abundance and the growth of commercial fishing in the Nehalem River spurred the creation of Nehalem hatchery programs. Hatcheries have influenced the Nehalem fisheries since 1926, when the Foley Creek Hatchery began supplementing wild populations of cutthroat and winter steelhead trout. The Foley Creek Hatchery closed in 1966 and was replaced that year by the North Fork Nehalem Hatchery, which still operates today, producing Coho, fall Chinook, winter steelhead, and rainbow trout.

High hatchery production of Coho was described by NMFS (2016) as adversely impacting Coho populations ESU-wide and was a contributor to the ESA-listing determination. The federal recovery plan points to two impacts: 1) the interaction of wild and hatchery fish on the spawning grounds leading to a reduction in the fitness of the resulting offspring, and 2) inadvertent harvest of natural-origin Coho resulting from recreational angling that targeted the hatchery run (NMFS 2016). The proportion of hatchery Coho found on the spawning grounds in the OC Coho ESU declined from levels of 15-25 percent during 1990-1998 to within established policy guidelines (approximately 9%) as a result of reduced release numbers, reduced release locations, and increased returns of wild Coho.

In the 1980s and early 1990s, the North Fork Nehalem Hatchery released an average of 535,000 Coho smolts per year. Between 1990 and 1995, the average annual release increased to 822,000 before steadily declining over the next decade (Ferdun 2003). As shown in Figure 3-4, since 2003, releases have held steady at roughly 100,000 (ODFW 2019b). This reduction occurred when hatchery managers reduced and eliminated Coho hatchery programs across the Oregon coast starting in the mid-1990s, generating a drop in production from a high of 35 million smolts in 1981 to approximately 260,000 smolts in 2005 across the OC Coho ESU. More recently, the North Fork Nehalem Hatchery has released 100,000 smolts on-site

Figure 3-4. Hatchery Coho Releases. Source: Regional Mark Information System Database, 2022. http://www.rmpc.org



Spawning adult Coho. Alternative life-history pathways contribute to the species' resilience and ability to adapt in a changing environment. Photo: Seth Mead

to "provide fish for sport and commercial harvest in both the ocean environment and the Nehalem Bay and North Fork Nehalem River" (ODFW 2019). Until 2020, the North Fork Nehalem Hatchery reared a stock of varied origin (known as the "32 stock") every two years. In the third year, ODFW reared stock from Fishhawk Lake. Known as the "99 stock," this stock was established in 1978, and smolts return as adults just one year after release (Suring et al. 2015).

Initially, the North Fork Nehalem Coho stocks were managed as an isolated harvest program. Natural-origin fish were not intentionally incorporated into the broodstock since 1986, and only adipose fin-clipped broodstock have been taken since the late 1990s. Because of this, the stock is considered to have substantial divergence from the native natural population and is not included in the Oregon Coast Coho salmon ESU (NMFS 2016). Recently, beginning with the 2020 brood year, the Nehalem Hatchery started converting the Coho hatchery program to a wild broodstock program with naturally produced Coho from the North Fork Nehalem River. The previous lines of long-term hatchery stocks are being phased out, with the transition completed after the 2022 brood year. The first smolt releases occurred in the spring of 2022, and the first adult returns will occur in the fall of 2023 (jacks will return in the fall of 2022). Once the conversion is complete, the program will operate as an integrated stock, with wild Coho incorporated into the broodstock annually at levels specified in the Hatchery Genetic Management Plan (Robert Bradley, personal communications).

3.6 Overview of Habitat Needs and Watershed Components

Coho seek different habitat types during their various life stages, and spatial and temporal use of these habitats varies according to the life-history strategy being expressed by the individual. In order to fully express the range of life-history strategies present within a population, Coho require diverse, complex, and highly connected habitats in freshwater and estuarine ecosystems. During their freshwater residency, juvenile Coho rely on slow-moving water (ideally flows of less than two cfs) with complex in-stream and riparian structure capable of generating and maintaining pools, off-channel rearing areas, and channel-floodplain interaction. Among

LIMITING FACTOR FOR NEHALEM COHO

The limiting factor for Nehalem River coho is a lack of *winter rearing habitat,* driven largely by the **loss of instream complexity.** Instream complexity refers to a suite of instream and off-channel features – like large wood, pools, connected off-channels, alcoves, and beaver ponds – that provide high-quality rearing habitat for juveniles.

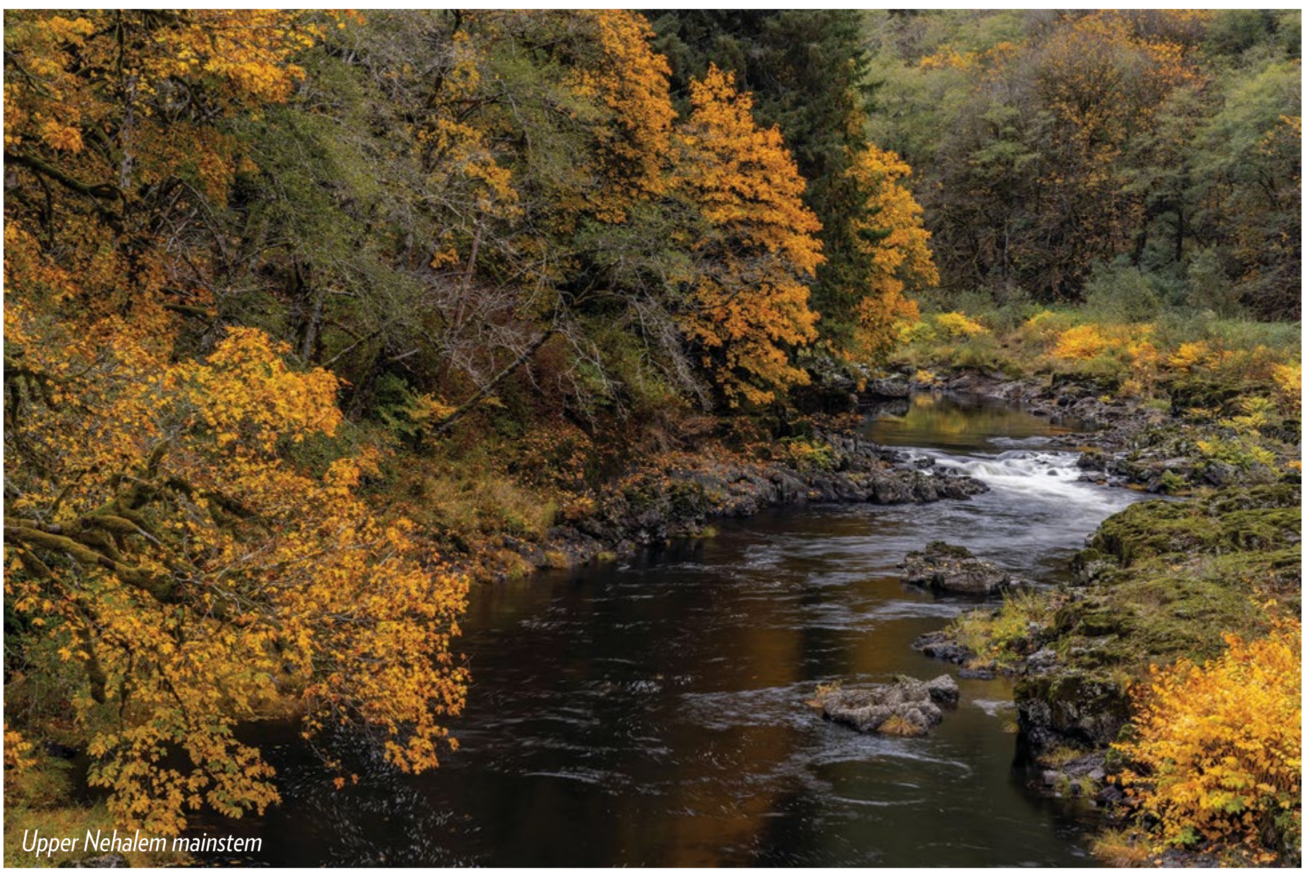
other attributes important to Coho, these conditions generate food, shelter from predators, refuge from high water temperatures in summer, and low velocity resting areas during fall/winter high flows.

While it's described in the Oregon Coast Coho Conservation Plan by the broader term "instream complexity," insufficient winter rearing habitat is the most common factor limiting Coho populations in the OC Coho ESU, including the Nehalem population (ODFW 2007). According to the Oregon Coast Coho Conservation Plan, "high-quality over-wintering habitat for juvenile Coho is usually recognizable by one or more of the following features: large wood, pools, connected off-channels, alcoves, beaver ponds, lakes, connected floodplains, and wetlands" (ODFW 2007). Recently, the planning team has grown increasingly concerned that the extensive spatial range of summer temperature limitations in the mainstem Nehalem River and many tributaries may become the primary factor limiting future OC Coho production.

The specific habitats that Coho require are generated and maintained within a complex, interconnected system of watershed "components." The "Common Framework for Coho Recovery Planning," which the Coast Coho Partnership developed in 2015, standardizes how Coast Coho habitats are defined, classified, and evaluated in plans like this one. The Nehalem Partnership used the Coast Coho Partnership's common framework to develop this SAP but adapted the habitat definitions to fit the characteristics of the Nehalem watershed.

The Nehalem Partnership defined the following watershed habitat characteristics:

Adult Coast Coho use the mainstem river channel to migrate upstream to their natal tributaries, where they will spawn and die. Juveniles use the mainstem to migrate down to the ocean, accessing tributary, off-channel, and estuarine habitats as they go. High flows in winter and hot water in the summer are the major stresses that juveniles encounter on their downstream migration. Cold water tributaries and off-channel habitats provide important sources of refuge from these and other stresses. Photo: Danita Delimont



Upper Nehalem mainstem

- **The Mainstem River** includes portions of rivers above the head of tide (Coastal and Marine Ecological Classification Standard [CMECS] definition); these are typically 5th order, downstream of Coho spawning distribution, and "non-wadeable." The mainstem river component includes associated riparian and floodplain habitats. Mainstem areas support upstream migration for adults, downstream migration for juveniles, summer rearing for the nomadic life history, and limited spawning.
- **Tributaries** include all 1st to 4th order streams with drainage areas > 0.6 km². This includes fish-bearing and non-fish-bearing, perennial and intermittent streams, and the full aquatic network, including headwater areas, and riparian and floodplain habitats. Tributaries support spawning, incubation and larval development, fry emergence, and summer and winter juvenile rearing.
- **Freshwater Non-Tidal Wetlands** include areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support – and under normal circumstances do support – a prevalence of vegetation typically adapted for life in saturated soil conditions. Habitats include depressions, flat depositional areas that are subject to flooding, broad flat areas that lack drainage outlets, sloping terrain associated with seeps, springs and drainage areas, bogs, and open water bodies (with floating vegetation mats or submerged beds). This component is restricted to those wetlands that are hydrologically connected to Coho streams. (Estuarine-associated wetlands are addressed in the estuarine section.) Wetlands are essential to capturing sediment and other contaminants before they enter tributaries and mainstem rivers, and for maintaining and regulating cold water flows. In addition, non-tidal wetlands historically provided thermal refugia for the nomadic coho life-history strategy originating in headwater wadeable streams.

Freshwater wetlands like this near an upper Nehalem tributary provide streams with cold, clean water through underground seeps. Photo: Maggie Peyton

- **Off-channel areas** include locations other than the main or primary channel of mainstem or tributary habitats that provide velocity and/or temperature refuge for Coho. Off-channel habitats include alcoves, side channels, oxbows, and other habitats connected to the mainstem or tributary. These off-channel habitats are essential to the survival of juvenile Coho, providing refuge from high flows in winter and high water temperatures in summer.
- **Estuaries** include areas in tidally influenced lower reaches of rivers that extend upstream to the head of tide and seaward to the mouth of the estuary. Head of tide

Adult Coho spawn and juveniles rear in low gradient tributaries like this one in God's Valley. Photo: Wild Salmon Center

A God's Valley tributary

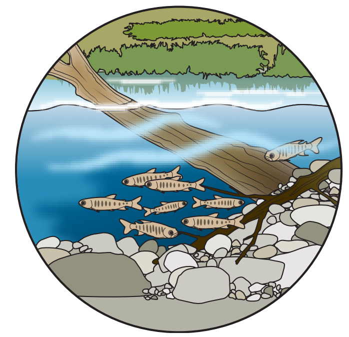
Tidal wetlands like these in the Nehalem estuary are the critical final stop for coho to rear and grow before entering the ocean. Photo: Maggie Peyton

is the inland or upstream limit of water affected by a tide of at least 0.2 feet (0.06 meter) amplitude (CMECS). This includes tidally influenced portions of rivers that are considered to be freshwater (salinity <0.5 parts per thousand). Estuaries are considered to extend laterally to the uppermost extent of wetland vegetation (mapped by CMECS). Estuarine habitats include saltmarsh, emergent marsh, open water, subtidal, intertidal, backwater areas, tidal swamps, and deep channels. This includes the ecotone between salt and freshwater and the riparian zone. Estuary areas have been historically available for feeding, rearing, and smolting Coho. They have also provided summer and winter habitat used by nomadic coho dropping out of headwater reaches as emergent fry.

Off-channel habitats like these found along Sand Lake are essential for rearing coho. Photo: Maggie Peyton.

- **Uplands** include all lands that are at a higher elevation than adjacent water bodies and alluvial plains. They include all lands from where the floodplain/riparian zones terminate, and the terrain begins to slope upward forming a hillside, mountainside, cliff face, or another non-floodplain surface. Uplands provide the majority of wood and gravel resources that are required for maintaining natural processes in a properly functioning ecosystem.
- **Lakes** include inland bodies of standing water. Habitats include deep and shallow waters in the lakes, including alcoves, and confluences with streams. Lakes can provide important rearing habitats for coho, and also help mitigate summer water temperatures through stratification.

Figure 3-5. Components of a Watershed. The map below is a conceptual illustration (not a map of the Nehalem) intended to show: 1) the major "habitat components" of a coastal watershed; and 2) selected "key ecological attributes" (KEAs) that are critical to the health of these components. This is not intended to provide an in-depth explanation of the habitat needs of Coast Coho, but simply highlight several KEAs that this plan is focused on restoring.

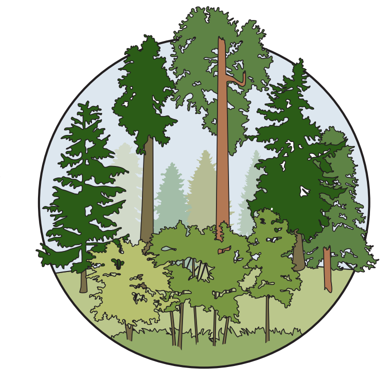


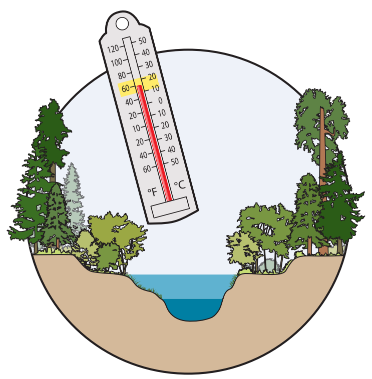
Instream Complexity:

Lack of instream complexity is the primary factor limiting Nehalem Coho (and many other Coast Coho populations). The loss of features that provide instream complexity – like large wood, pools, connected off-channels, alcoves, and beaver ponds – limit the survival of juvenile Coho in both summer and, especially, winter.

Structural Diversity:

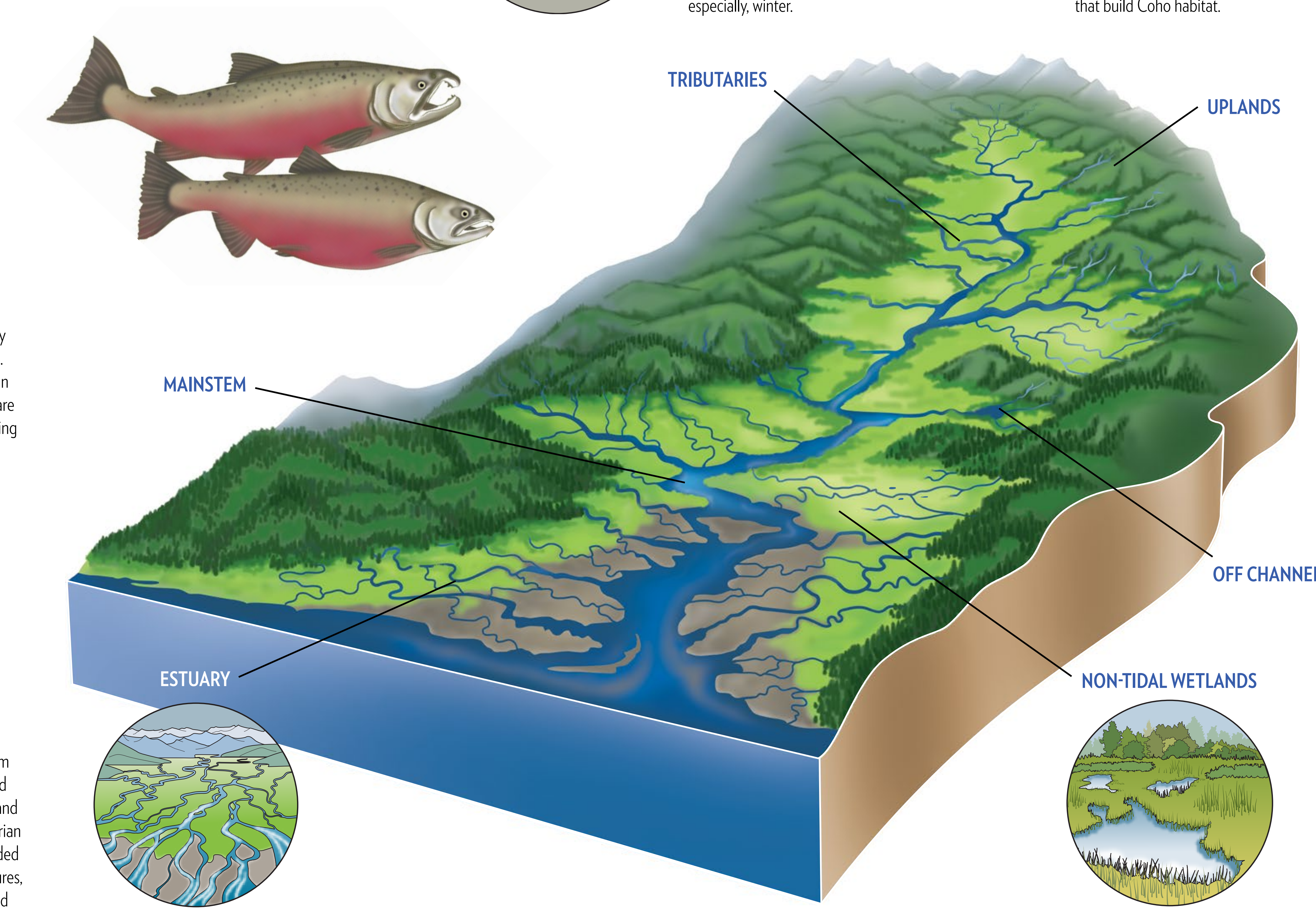
Healthy upland forests contribute large wood, gravel, and other inputs to streams, which enhances the channel's biological and structural complexity. The range and distribution of forest stand size, type, age, and composition determines the extent to which forests can provide the inputs to streams that build Coho habitat.

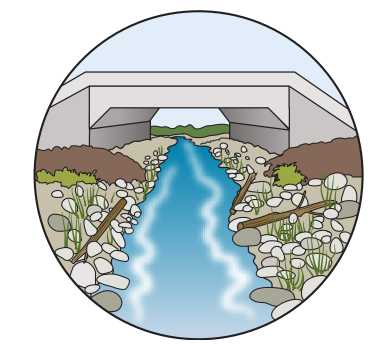




Water Quality:

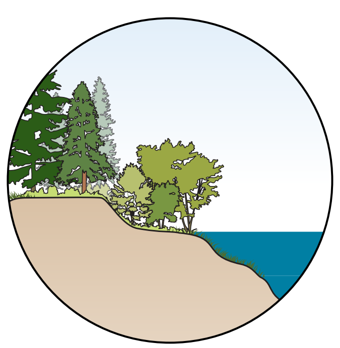
In tributary, mainstem, off-channel, and estuarine habitats, degraded water quality also limits the Nehalem Coho population. Elevated water temperatures (especially in the mainstem Nehalem) and sediments are the primary water quality issues confronting Coho.





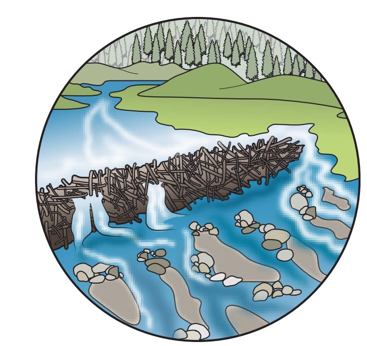
Longitudinal Connectivity:

Inadequate culverts in tributaries and tidegates in estuaries often restrict access for both adult and juvenile Coho to prime spawning and rearing areas. Longitudinal connectivity refers to the degree to which Coho are able to migrate unimpeded up and down stream channels and sloughs.



Riparian Function:

Streamside vegetation along tributaries, off-channel areas, wetlands, and mainstem channels creates shade, provides food and cover for juveniles, filters out pollutants, and provides large wood to the channel. Riparian function in the Nehalem is heavily degraded contributing to elevated water temperatures, reduced instream complexity, and reduced lateral connectivity.

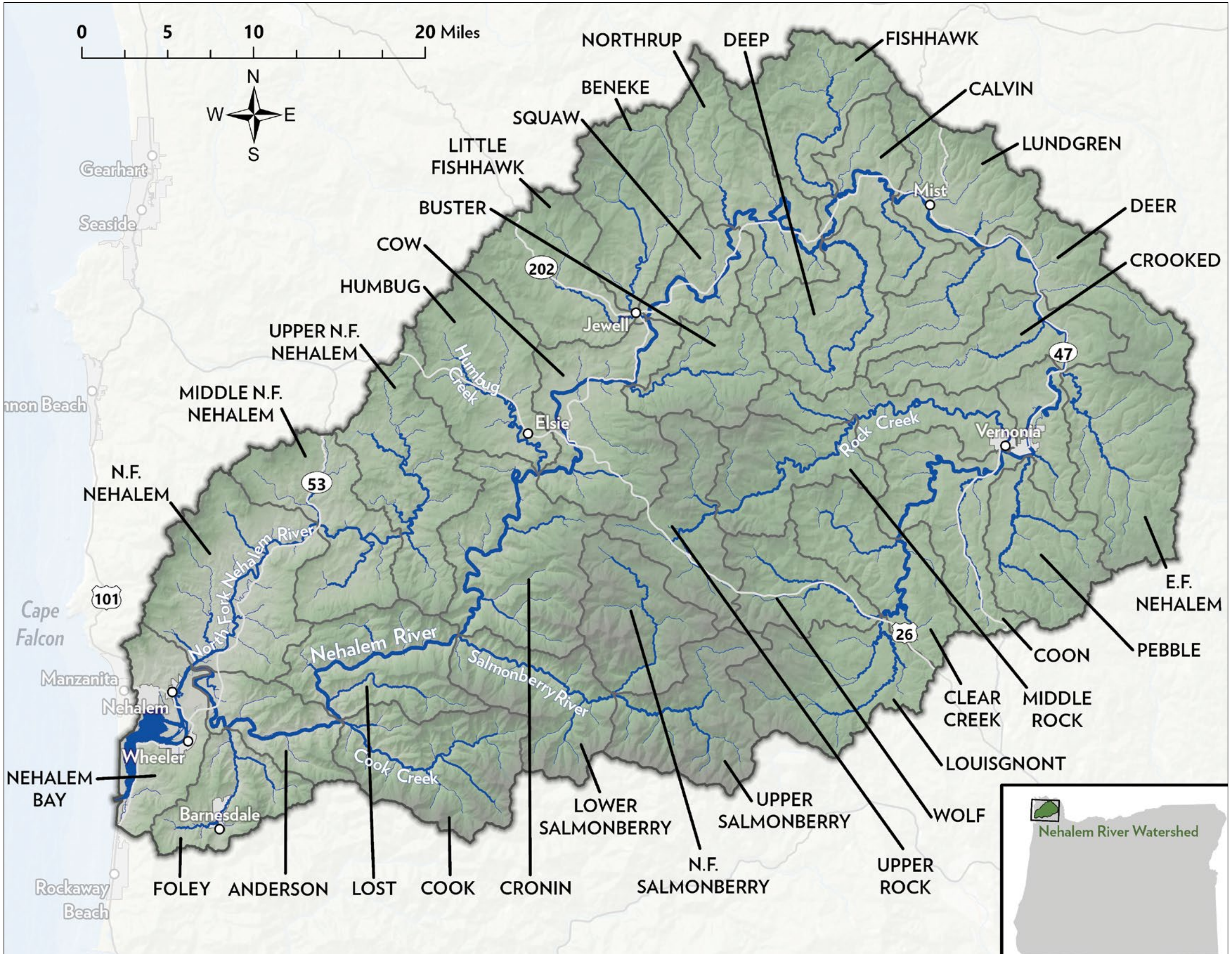


Beaver Ponds:

Beaver ponds are a critical attribute of healthy Coho watersheds. Impounded water behind beaver dams provides juvenile Coho refuge from both high flows in winter and elevated water temperatures in summer. The number of beavers has declined substantially in the Nehalem, significantly reducing available off-channel habitats.

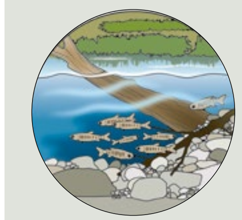
Artwork by Elizabeth Morales.

Figure 3-6. The Nehalem River Watershed.

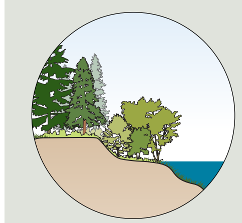


By 2045 the Nehalem Coho Partnership will achieve the following restoration outcomes:

Upland Forests: **536 acres** of upland timber are protected to ensure long-term delivery of large wood to anchor habitats.



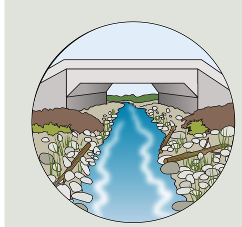
Instream: Instream complexity is restored within **66 miles** of focal area anchor habitats.



Riparian: Riparian function is enhanced along **58 miles** of focal area tributaries.

Off-Channel: Beavers colonize and build dams along an additional **40 miles** of Coho-bearing tributaries, increasing off-channel habitats available for Coho rearing.

Tidal Wetlands: **300 acres** of tidal wetlands and other estuarine habitats are reconnected.



Fish Passage: 52 barriers to fish passage are removed, restoring Coho access to **92 miles** of anchor habitats and cold-water refuge.

Illustrations: Elizabeth Morales

By reaching these six restoration outcomes, the Nehalem Partnership seeks to achieve the SAP's long-term goals and advance the vision of a healthy Nehalem Coho population.

Chapter 4

Development of the Nehalem River Strategic Action Plan

The Nehalem Partnership generated this plan following guidance described in the document, *Components of a Strategic Action Plan for Participation in the Focused Investment Partnerships Program* (OWEB 2017). This process is summarized below.

4.1 Visioning

The Nehalem River SAP process began with a discussion of participant values and priorities that would guide the planning process and generate a long-term vision statement for the Nehalem Basin. The exercise explored ways Coho conservation aligns potentially competing social, economic, and ecological priorities among local stakeholders. In addition to a vision statement, the discussion yielded guiding principles for the planning process, as well as two goal statements, which articulate the Nehalem Partnership's desired long-term results from the implementation of the plan. The discussion also led to the development of outreach documents for team members to share when describing the planning process to landowners, stakeholder groups, and the general public.

4.2 Defining Terms

The Nehalem Partnership used the "Common Framework," a document produced by the Coast Coho Partnership to standardize the terminology used in the development of SAPs for Coho populations up and down the Oregon coast. The Nehalem Partnership tailored the framework to incorporate social and ecological conditions unique to the Nehalem River watershed. The Nehalem common framework: 1) defines the habitat types (called "components") used by the Nehalem

Wild salmon deliver the nutrients derived from their ocean journey back to their natal watersheds, nourishing the ecosystem. Photo: Paul Jeffrey / Alamy

Common Framework Terminology

Key Ecological Attributes: Key Ecological Attributes, or "KEAs", are characteristics of watersheds and specific habitats that must function in order for Coho salmon to persist. KEAs are essentially proxies for ecosystem function. If KEAs like habitat connectivity, instream complexity, water quality, riparian function, and numerous others are in good condition then watershed processes are likely functioning sufficiently to generate and maintain the habitats required to sustain viable Coho populations.

Stressors: Stressors are impaired attributes of an ecosystem and are equivalent to altered or degraded KEAs. They are not threats (defined to the right), but rather degraded conditions or "symptoms" that result from threats. In the common framework, stressors represent the physical challenges to Coho recovery, such as decreased low flows or reduced extent of off-channel habitats.

Habitat Components: Components are the types of habitats that are essential to support the (non-marine) life cycle of Coho salmon. The Nehalem River common framework identifies and defines these habitat types, which are presented in Chapter 3.

Threats: Threats are the human activities that have caused, are causing, or may cause the stressors that destroy, degrade, and/or impair components. The common framework includes a list of threats with definitions and commonly associated stressors. This list is based on threats listed (sometimes using different terms) in existing Coho recovery plans. The definitions are based on previous classifications (IUCN 2001; Salafsky et al. 2008) with minor modifications reflecting the work of the Coast Coho Partnership.

Coho population; 2) identifies the essential functions that these habitats must provide for Coho to persist (called "key ecological attributes" or KEAs); and 3) lists the "stressors" and "threats" that impair or have the potential to impair the KEAs. The framework also provides a list of indicators that can be used to assess and track the KEAs. In aggregate, these indicators signal whether watershed function is improving or declining over time at the watershed or subwatershed scale.

The terminology adopted in the Nehalem common framework is included throughout this plan. The full document is contained in Appendix 3.

4.3 Determining Focal Areas

The Coast Coho Partnership convened, in part, due to recognition among both restoration practitioners and funders of the immense challenges faced in generating benefits from habitat restoration that can be detected beyond just the project scale. This challenge is due partially to restoration organizations working in large geographies and lacking the capacity to implement projects at the pace and scale necessary to produce measurable impacts. In addition, coordination among restoration partners is often undermined by the varying ownerships and land uses present within a basin and the complex funding and regulatory landscape that implementers must navigate to put projects on the ground. Because of these and other factors, it's challenging to focus and coordinate restoration efforts sufficiently to generate a measurable watershed response (e.g., improving trends in abundance or habitat quality) beyond just the project or reach scale.

Partners in the Nehalem sought to address this challenge by focusing this SAP on a limited number of focal areas (or "high-ranked subwatersheds" as they were called during the planning process). The selection of focal areas was driven by the goals and guiding principles generated in step one above.

First, the team applied a stronghold approach, which argues that in the long run, the most cost-effective strategy is to protect and restore habitats that are in good or excellent condition. The stronghold approach adopts a "build from strength" model, which is founded on the belief that expanding areas of functioning habitat is more likely to provide the desired results and show a more immediate return on investment than starting in more highly degraded systems. The approach recognizes that the stressors on highly modified systems are either so numerous (e.g., in urbanized areas) or take so long to reverse (e.g., severe channel entrenchment) that restoration benefits are often uncertain or unrealized. Accordingly, this plan gives priority to subwatersheds that are relatively intact and demonstrate greater ecosystem function than other more degraded systems.

A "6th Field" is a geographic scale established under a hierarchical classification system developed by the USGS that divides river basins into hydrologic unit codes or "HUCs." Commonly referred to as a "sub-watershed," a 6th field HUC is typically between 10,000-40,000 acres or 15-60 square miles.

The process used to assess ecosystem function and habitat productivity across all 34 of the Nehalem basin's 6th field subwatersheds is detailed in Appendix 6. After evaluating a range of criteria to assess function and productivity, the Nehalem Partnership determined that the extent of "anchor habitat" was the most effective indicator of Coho production potential. The anchor habitat approach is described in Section 4.5.

The second criterion used to identify focal areas was the degree to which each subwatershed could support unique life-history variations. For example, two subwatersheds selected as focal areas are the Salmonberry River and Cook Creek watersheds. Both are north-flowing tributaries originating in volcanic geology. Due to their geomorphology and large watershed area, the Salmonberry River

Lower Nehalem River above its confluence with the Salmonberry River. Photo: Ken Barber / Alamy

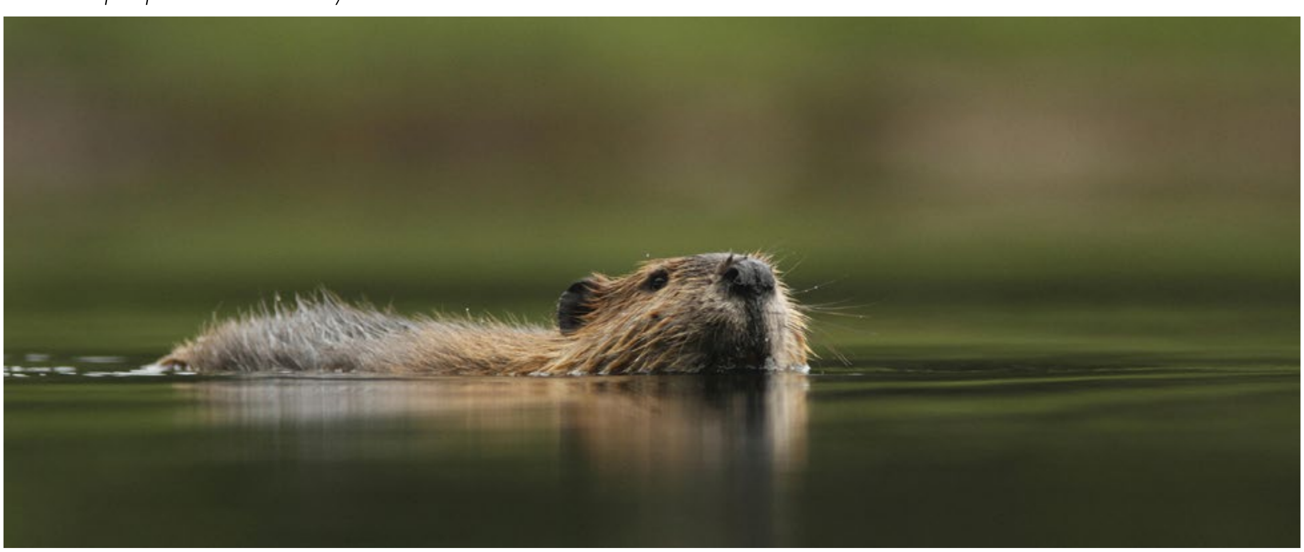
and Cook Creek represent the two most important contributions of both flow and cold water to the mainstem Nehalem (PC Trask 2017; Oregon DEQ 2003), which is temperature limited from the head of tide to RM 112 (Oregon DEQ 2003). Because Coho parr cannot persist in the mainstem during the summer months when temperatures often exceed 80 degrees Fahrenheit (Sullivan et al. 2000), these two drainages provide important thermal refugia and flow volumes that mitigate elevated mainstem temperatures and shorten their duration. Results of ongoing and recently completed juvenile Coho monitoring indicate that the nomadic components of several unique Nehalem Coho life histories depend on these two systems for survival in periods of elevated summer water temperatures (Bio-Surveys 2020).

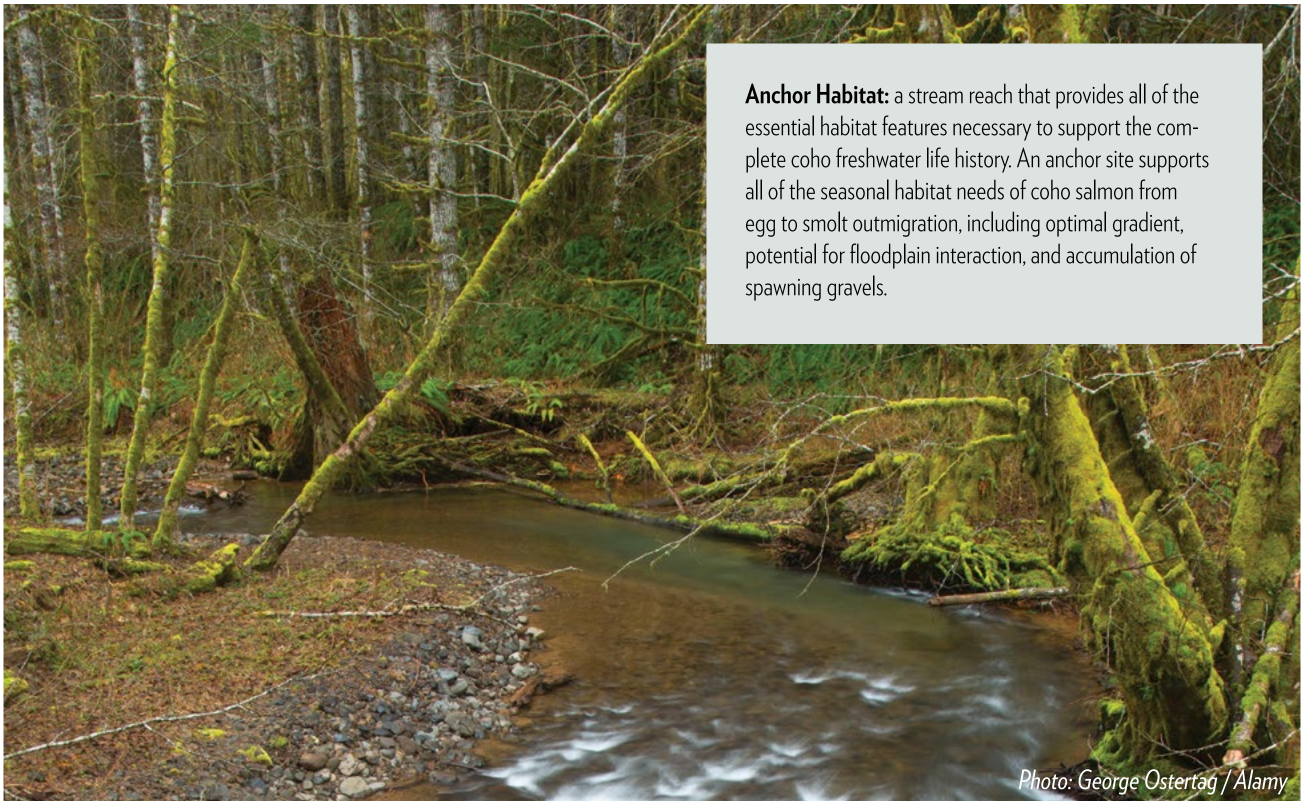
The main purpose of ranking subwatersheds (i.e., selecting focal areas) was to assist the Nehalem Partnership in coming to an agreement on a long-term habitat restoration strategy within the Nehalem basin. The ranking is not intended to recognize one subwatershed as more important than another or to disregard the contributions of subwatersheds that were not identified as focal areas to the productivity of the basin as a whole. **The Nehalem Partnership recognizes the inherent challenges in focusing on discrete pieces of an interconnected system, but participants agree that geographic focus is essential to most effectively invest scarce restoration resources.**

4.4 Determining Restoration Priorities by Focal Area

After identifying focal areas, the team evaluated the major stressors present in each. In the absence of limiting factors analyses in all but the Rock Creek watershed, the planning team agreed that restoration strategies should be determined based on a combination of best professional judgement and modeling. At the outset of the SAP process, NOAA commissioned TerrainWorks to use its Netmap tool to model the optimal locations for restoration strategies best suited to address priority stressors. Netmap is a process based model that develops a "virtual watershed" using a LiDAR digital elevation model (DEM) (with 10m DEMs where LiDAR is unavailable). The virtual watershed enumerates multiple aspects of watershed landforms, processes, and human interactions over a range of scales (Benda et al. 2015; Barquin et al. 2015). NetMap's virtual watershed contains six analytical capabilities to facilitate optimization analyses: 1) delineating watershed-scale

Beavers build ponds that maintain a flow of cold, clean, slow moving water in a river system. These ponds provide homes for juvenille salmon and small invertebrates at the base of the food chain. Photo: Alamy.





Anchor Habitat: a stream reach that provides all of the essential habitat features necessary to support the complete coho freshwater life history. An anchor site supports all of the seasonal habitat needs of coho salmon from egg to smolt outmigration, including optimal gradient, potential for floodplain interaction, and accumulation of spawning gravels.

synthetic river networks using DEMs; 2) connecting river networks, terrestrial environments, and other parts of the landscape; 3) routing watershed information downstream (such as sediment) and upstream (such as fish); 4) subdividing landscapes and land uses into smaller areas to identify interactions and effects; 5) characterizing landforms; and 6) attributing river segments with key stream and watershed information.

The TerrainWorks' analyses included a range of outputs that were considered by the planning team, including prioritized sites for riparian restoration, thermal refugia protection, road maintenance/decommissioning, anchor habitat protection, including their key contributing tributaries, and fish passage improvement. NOAA modelers and the planning team also developed a model using Netmap to prioritize locations for beaver recruitment that built upon existing approaches and applied Nehalem-specific beaver data. Through all of these analyses, Netmap provided managers with modeled priority sites in subwatersheds where data or participant expertise was limited. Chapter 5 provides details on the model runs and the results generated.

The UNWC and LNWC both retain a license to use the Nehalem River Netmap data, as well as access to the Netmap software. Partners are encouraged to continue using Netmap to periodically update the analyses completed during the planning process and run new analyses as TerrainWorks makes them available in updates to the software.

4.5 Identifying Anchor Habitats

ODFW (2007) identified reduced instream complexity as the primary limiting factor for the Nehalem Coho population. While limiting factors analyses have not been completed for each of the 34 Nehalem 6th-field subwatersheds, reduced instream complexity resulting in insufficient over-wintering habitat, is a major stressor in most Nehalem subwatersheds. Accordingly, it is essential that practitioners are able to invest in strategies that enhance complexity with a high degree of confidence that projects are being located in reaches that can deliver the greatest benefit. To facilitate this, the Nehalem Team adopted an anchor habitat approach.

Anchor habitat is a stream reach that provides all of the essential habitat features necessary to support the complete Coho freshwater life history.

Anchor habitat features meet the seasonal habitat needs of Coho from egg to smolt out-migration. They are characterized by an optimum gradient (1-2.5%), high potential for channel-floodplain interaction (brood floodplains and low terraces), and accumulation of spawning gravels (Bio-Surveys 2011a). The protection, restoration, and expansion of sites exhibiting these conditions provide important opportunities to enhance function and increase instream complexity.

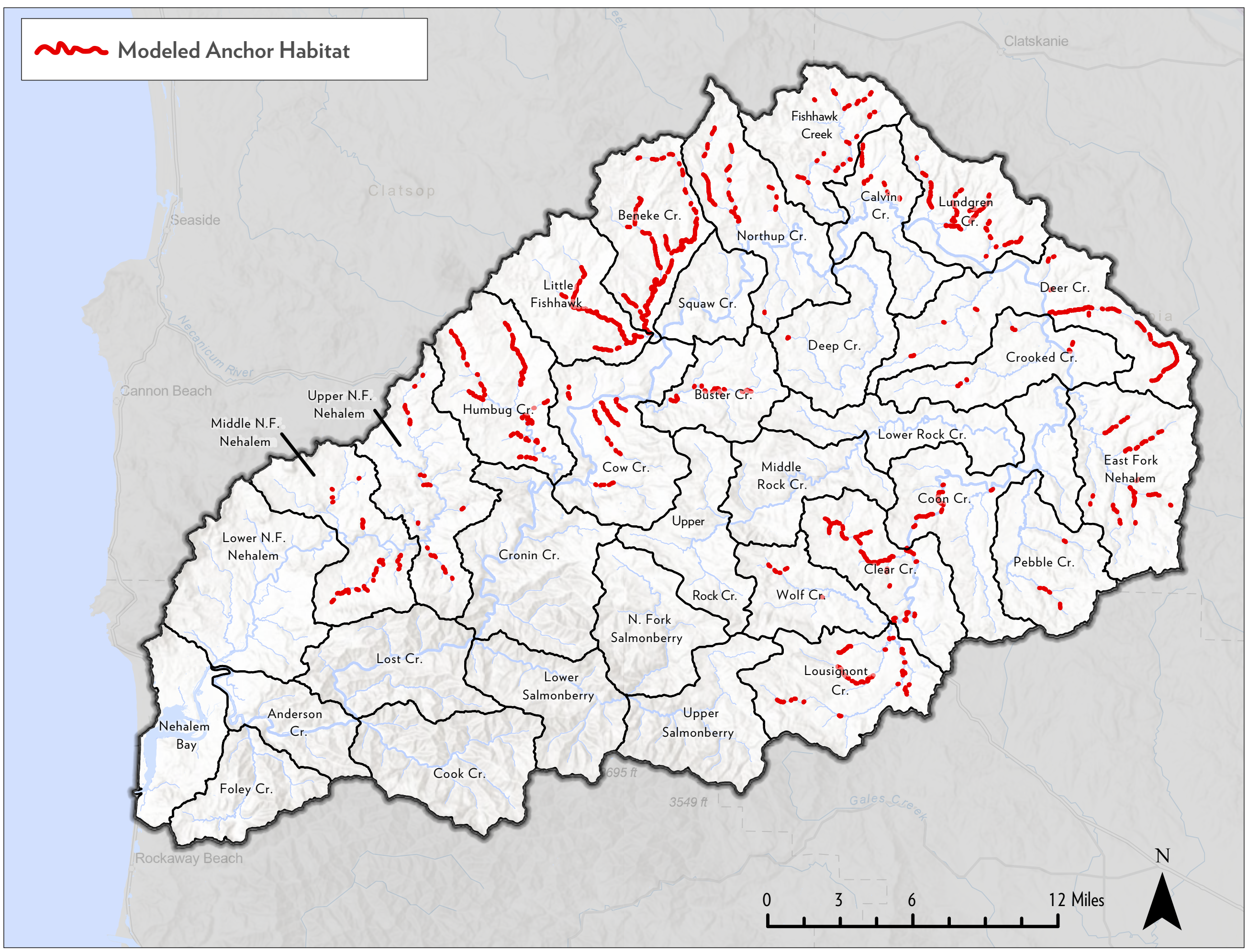
Chapter 5 presents the potential anchor sites where local partners will improve in-stream complexity through floodplain and off-channel habitat reconnection, large wood and beaver dam analogue (BDA) installation, and the protection of upland areas capable of delivering large wood and gravel to anchor habitats.

Appendix 6 contains a detailed description of how Coho anchor habitats are modeled in the Nehalem basin. Figure 4-1 provides the results of this exercise.

4.6 Monitoring and Indicators

Using the common framework, the Nehalem Partnership developed a list of indicators to monitor the pace and effectiveness of

Figure 4-1. Modeled Anchor Habitats in the Nehalem River Watershed. Note: Additional anchor habitats were determined through field data collection. See Figure 5-2.



SAP implementation. This was an important step towards addressing one of the main concerns leading to the development of Coast Coho SAPs: that managers were struggling to detect the cumulative benefits of restoration at a subwatershed or population scale. During the development of the Nehalem common framework, the Nehalem Partnership identified a list of indicators to track through SAP implementation. This list was revisited and revised after the SAP process to incorporate information generated and lessons learned during the process.

Chapter 7 presents the final list of indicators to evaluate the health of Nehalem Basin Coho habitat and watershed function. The Nehalem Partnership is confident that tracking these indicators over time will allow managers to detect changes from ongoing restoration beyond just the reach scale.

4.7 Estimating SAP and Project Costs

The Nehalem Partnership's final step in drafting this SAP was to estimate the anticipated costs of projects selected for the plan. Costs were generated by reviewing the OWEB Oregon Watershed Restoration Inventory (OWRI) database and comparing costs from previous projects implemented in the Nehalem River area by local partners. The OWRI database was queried to focus on projects implemented within the Oregon Coast Coho ESU from 2010 to 2020. These costs were reviewed and modified for use in the Nehalem SAP by partners with extensive experience implementing projects on the north coast. Project costs are presented in Chapter 8.

4.8 Community Outreach

The Nehalem Partnership includes a variety of public and private partners. Throughout the SAP development process, participants maintained consistent communication with the boards and management of the participating groups. Equally important, the managers who work with private landowners provided periodic updates to landowners and industry representatives. This ongoing outreach ensured that questions and concerns raised by local stakeholders were considered by the Nehalem Partnership and acted upon during plan development.

Chapter 5

Impaired Watershed Processes and the Strategies to Restore Them

The previous chapter provided an overview of the Nehalem Partnership's process to develop this SAP. This chapter describes the plan's "Strategic Framework," the long-term restoration road map that resulted from this process. The Strategic Framework includes 1) the protection and restoration strategies that the Nehalem Partnership deems essential to restore watershed function in the Nehalem watershed, and 2) the locations where implementation of these strategies can generate the greatest benefit. Current and future managers and practitioners will use this strategic framework to guide how and where they invest in landowner outreach, habitat assessments, project implementation, and monitoring.

Figures 5-11 through 5-16 map the strategic framework, indicating the locations where specific KEAs will be protected or restored in the focal area watersheds. Tables 5-2 and 5-3 summarize the projected outcomes according to the linear miles and total acres protected or restored in each focal area. Chapter 6 presents the specific locations within these priority areas where partners intend to implement restoration projects through 2027.

The strategic framework presented in this chapter seeks to generate sustainable improvements in the natural processes that create and maintain high-quality rearing habitat for Coho. The planning team considered four principles of 'process-based restoration' (Roni and Beechie 2013) in examining how and where restoration can enhance watershed function. Two of these principles helped guide the Strategic Framework: 1) target the root causes of habitat and ecosystem change, and 2) clearly define expected outcomes, including recovery time. Implementing partners are encouraged to consider the two additional principles when designing the projects listed in Chapter 6: tailor restoration actions to local potential, and match the scale of restoration to the scale of physical and biological processes targeted.

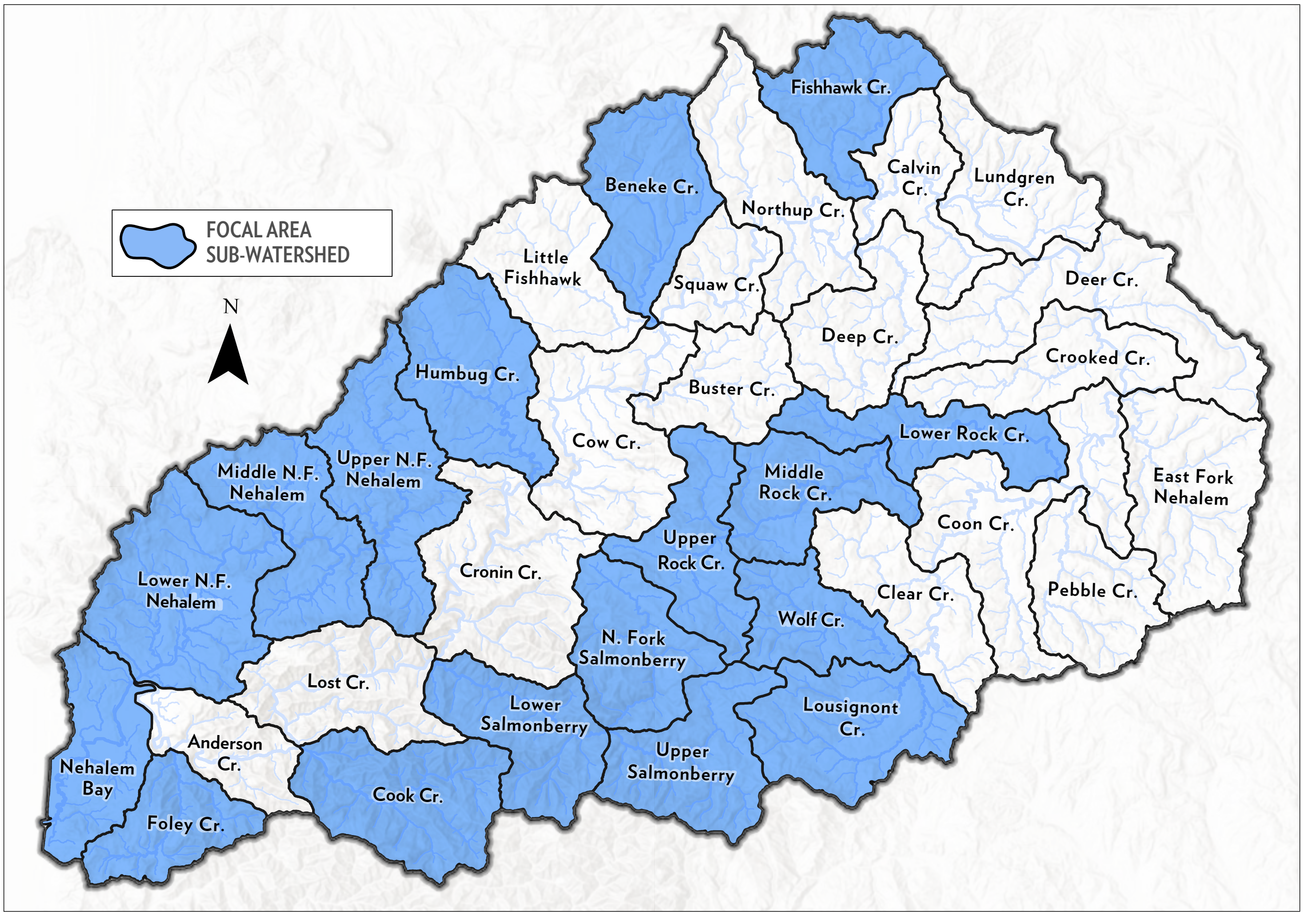
It should be noted that the strategies presented in this chapter are limited to those that local restoration partners have the authority and capacity to implement. To fully address the root causes of historic and ongoing habitat loss and more fully restore long-term watersthed function, state and federal partners are encouraged to examine the adequacy of current resource management policies and regulations. **Habitat restoration provides a net benefit only when the policies governing resource use sufficiently protect remaining watershed function.**

5.1 Focal Areas: Ranking the Subwatersheds

Through the process described in Chapter 4, the planning team ranked the following subwatersheds as high restoration priorities in the near term. These focal areas, shown in Figure 5-1, include 17 6th field subwatersheds and the mainstem Nehalem River.

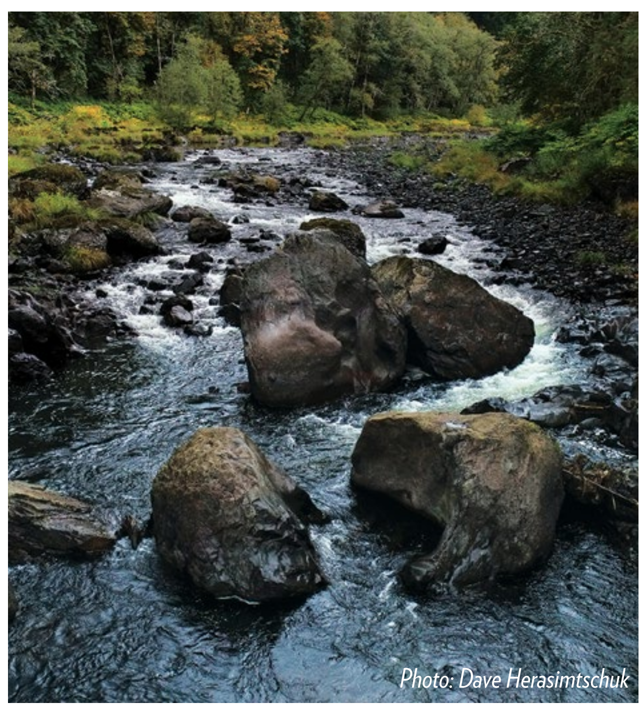
- Nehalem Bay
- Foley Creek
- North Fork Nehalem (lower, middle, and upper)
- Humbug Creek
- Beneke Creek
- Fishhawk Creek
- Rock Creek (lower, middle, and upper)
- Wolf Creek
- Lousignont Creek
- Salmonberry River (lower, upper, and north fork)
- Cook Creek

Figure 5-1. Focal Areas in the Nehalem River Watershed.



As described in Chapter 4, the Nehalem Partnership's purpose for identifying focal areas is not to characterize one subwatershed as more or less important than another but rather to focus and coordinate restoration investments among multiple stakeholders. This focus is intended to concentrate efforts in parts of the Nehalem watershed that are most likely to generate a positive signal (i.e., a quantifiable benefit) from the implementation of protection and restoration actions.

Additionally, these subwatersheds were selected to ensure that ongoing restoration efforts serve multiple life-history types present in the watershed. While this SAP relies heavily on a limiting factors approach to prioritization, the Nehalem Partnership recognizes that the spatial distribution and diversity of habitat types available are essential to life-history diversity and long-term population resilience. Ensuring restoration is carried out across a broadly distributed network of focal areas, regardless of their influence on basin-scale production, helps advance this priority.



5.2 Habitat Stressors, Limiting Factors, and the Anchor Habitat Approach

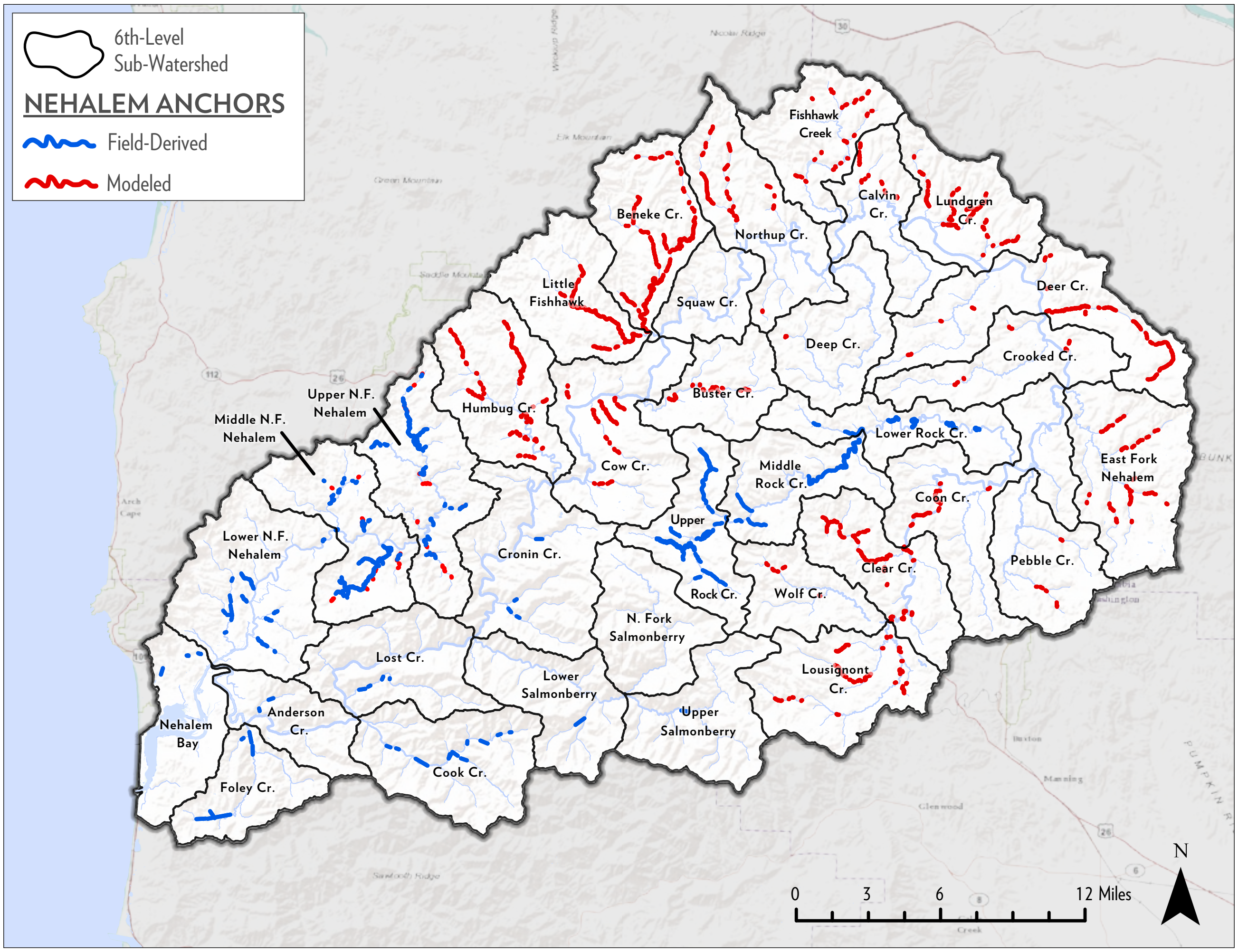
According to the Oregon Coast Coho Salmon Recovery Plan, "loss of stream complexity, including connected floodplain habitat, is the primary limiting factor for many Coho populations, and overwinter rearing of juvenile Coho is especially a concern. This instream habitat is critical to produce high enough juvenile survival to sustain productivity, particularly during periods of poor ocean conditions" (NMFS 2016). The ODFW defines stream complexity as "habitat of sufficient quality to produce over-winter survival at rates high enough to allow Coho spawners to replace themselves at full-seeding during periods of poor ocean conditions (3% smolt to adult survival)" (ODFW, 2007). "High quality over-winter rearing habitat for juvenile Coho salmon typically includes features such as large wood, pools, connected off-channel alcoves, side channels, beaver ponds, lakes, connected floodplains, and wetlands" (ODFW, 2007; NMFS, 2016).

The lack of instream complexity throughout the watershed is the primary factor limiting the production of Nehalem Coho. While evaluating KEAs in each focal area, the Nehalem Partnership consistently identified reduced wood delivery, lack of pools, bed coarsening, decreased lateral connectivity, and/or decreased beaver ponds as primary stressors. A limiting factors analysis (LFA) undertaken in Rock Creek identified instream complexity as the primary stressor limiting Coho production in all three subwatershed units (Bio-Surveys LLC 2011a). More recent "Rapid Bioassessments," which were used to generate "LFA lights" in the entire LNWC coverage area, also found a lack of instream complexity resulting from inadequate wood to be limiting production (Bio-Surveys LLC 2020).

In addition to the loss of physical habitat complexity, reduced water quality – especially increased summer water temperature – was also identified as a major stressor in several focal areas. Improving water temperatures during summer rearing will improve egg-to-smolt survival and increase the expression of

Improving water temperatures during summer rearing will improve egg-to-smolt survival. Photo: Wild Salmon Center

Figure 5-2. Anchor Habitats in the Nehalem River Watershed.



life histories now limited by thermal barriers in the mainstem and lower tributaries.

This chapter presents several protection and restoration strategies to address reduced instream complexity and water quality impairments, including protecting upland timber stands; adding large wood in anchor habitats; enhancing riparian vegetation; encouraging dam-building by beaver colonies; and removing physical barriers to fish passage.

To assist in prioritizing locations for upland habitat protection, instream restoration, and floodplain/off-channel reconnection, the Nehalem Partnership identified anchor habitats within all of the Nehalem's subwatersheds. These areas are shown in Figure 5-2. Many anchor habitats were identified through habitat assessments and surveys of Coho distribution and density collected during several rapid bioassessments. These field-determined anchors are shown in blue. Where field data was not collected, the team used Netmap to model anchors, which are shown in red. The process used to model anchors is summarized in Chapter 4 and detailed in Appendix 6.

Anchor habitats provide – or have the potential to provide if restored – all of the essential habitat features necessary to support the complete Coho freshwater life history for the "standard" life history strategy. Thus, the protection and restoration of these sites provides a unique opportunity to deliver a sustained increase in Coho production. Projects that improve key habitat features by augmenting instream complexity, reconnecting floodplains, restoring off-channel habitats, and improving riparian function in

Table 5-1. Lost or Altered Tidal Wetland Habitats by Type. Source: Nehalem Conservation Action Plan, 2012.

Habitat	Current Acres	Historic Acres	Acres Lost	% Loss
Spruce swamp	426	1326	900	68%
Salt marsh	441	880	439	50%
Shrub swamp	0	56	56	100%
Total	**867**	**2262**	**1395**	**62%**

these areas can increase the functionality of an existing anchor and collectively restore stream function at the subwatershed scale. The anchor habitat strategy gives local partners a high degree of confidence that the strategies presented in this chapter represent the best opportunities to generate the greatest return on future restoration investments.

The final strategy presented in this chapter is the reconnection and restoration of tidal wetlands and associated freshwater habitats. In addition to reduced instream complexity and impaired water quality in tributaries and the Nehalem mainstem, the loss of tidal connectivity in the estuary is also a major stressor on the Coho population. Since European settlers moved into the watershed, modification of tidal processes has substantially reduced the availability and quality of estuarine rearing habitat for Nehalem Coho. A variety of anthropogenic practices – including agriculture, urbanization, and rural residential development – have led to the construction of barriers that have substantially reduced the connectivity of estuarine habitats, both spatially and temporally. Channel form and connections to side channels, overflow channels, tidal marshes and swamps, alcoves, backwater ponds, and floodplains have all been heavily altered or disconnected in the tidally influenced areas of the lower Nehalem River and estuary. The Nehalem Conservation Action Plan estimates that 62 percent of spruce swamp, salt marsh, and shrub swamp habitat have been altered or lost due to development. (See Table 5-1.)


Photo: Broken Banjo Photography

Estuarine habitats are essential to facilitate the physiological changes that occur in adult and juvenile Coho as they migrate between salt and freshwater. Suitable tidal exchange, water flow, salinity, and water quality are all required to support the acclimation of down-river migrating Coho smolts. Juvenile growth and maturation also require good to excellent water quality, forage, and cover. Forage includes aquatic invertebrate and fish species that support growth and maturation. Cover includes aquatic vegetation, side channels, undercut banks, brush and trees providing shade, large wood and log jam complexes, large rocks and boulders, beaver ponds, and freshwater wetlands (NMFS 2016). Key off-channel estuarine habitats include sloughs, side channels, overflow channels, tidal marshes and swamps, alcove or ponds, groundwater channels, and seasonally flooded wetlands (Lestelle 2007.)

5.3 Strategies to Conserve Critical Coho Habitats in the Nehalem Watershed

The Strategic Framework presented in this chapter is intended to guide landowner outreach, project implementation, and habitat monitoring over the long term (two or more decades). Of course, the strategies presented here do not represent all of the restoration opportunities present in the Nehalem watershed. They simply represent those within the Nehalem Partnership's purview and have the highest likelihood of improving watershed function and increasing Coho habitat production over the long term. As these strategies are implemented, the Strategic Framework will be evaluated and priorities may change as monitoring data becomes available. This is discussed further in Chapter 7: Evaluation and Adaptive Management.

Strategy 1. Protect selected timber stands to promote large wood delivery to anchor habitats within debris-flow prone Type-N tributary corridors.

__2045 Outcome #1__: The long-term potential for large wood delivery to anchor habitats is improved through the protection of 536 acres of selected timber stands throughout the Nehalem basin (343 acres in focal areas).

While the installation of large wood in selected stream reaches can significantly increase stream complexity, these projects typically provide benefits for a relatively short term (one to two decades). Protecting carefully selected stands of large diameter timber can increase the natural recruitment of large instream wood continuously and over a longer horizon. Passive

Figure 5-3. Upland Sites with the Highest Potential to Deliver Large Wood into Anchor Habitats.

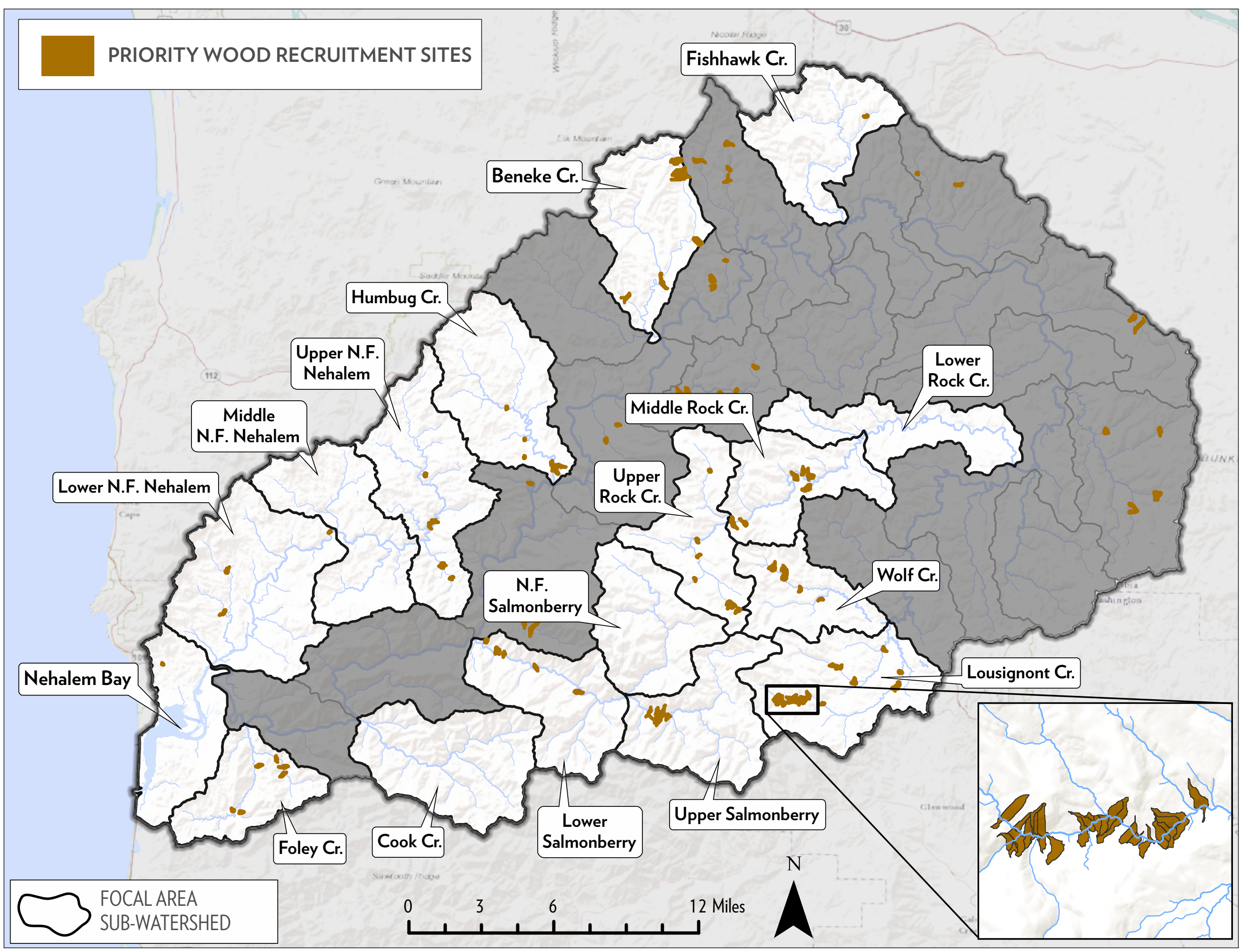


Table 5-2. Acres of Upland Wood Recruitment Sites Recommended for Permanent Protection in the Nehalem River Basin.

Tributary Name	Acreage	Tributary Name	Acreage
Lousignont Creek-Nehalem River	113	Northup Creek-Nehalem River	13
Foley Creek	61	Cow Creek-Nehalem River	12
Anderson Creek-Nehalem River	53	Deep Creek	12
Lost Creek-Nehalem River	46	Middle North Fork Nehalem River	10
Cook Creek	43	Upper Salmonberry River	8
Wolf Creek	36	Humbug Creek	7
Lower North Fork Nehalem River	33	Lower Rock Creek	6
Buster Creek	29	East Fork Nehalem River	6
Cronin Creek-Nehalem River	22	Fishhawk Creek	5
Lower Salmonberry River	21	**Total**	**536**

large wood delivery provides a sustainable and cost-effective approach to increasing and maintaining habitat complexity over the long term.

The Nehalem Partnership used NetMap to locate and map areas with the greatest opportunity to provide for natural recruitment of large wood into or above anchor habitats through delivery from upland sources. Areas highlighted in Table 5-2 and Figure 5-3 contain large, old trees that grow (or may be downed) on steep slopes and have a high likelihood of sliding and delivering wood into identified anchor habitats. Methods to identify these locations are detailed in Appendix 7.

Large wood significantly increases stream complexity. Photo: Wild Salmon Center

It should be noted that managing selected timber stands under longer rotations supports this plan's goal of delivering large wood into anchor habitats. Although this plan does not recommend specific forest management prescriptions, the recently approved Private Forest Accords call for reducing harvest on steep slopes found on private timberlands. Regulations currently under development to implement the Accords are anticipated to increase the long-term availability of large wood to streams.

The modeling approaches developed through this SAP were adopted and modified for use in the Accords. Managers are encouraged to update the maps generated in this SAP to further prioritize locations to protect upland habitats in the Nehalem Basin. Additionally, the Nehalem Partnership encourages ODF to use the debris flow and anchor habitat models in development of the Western Oregon State Forests Habitat Conservation Plan.

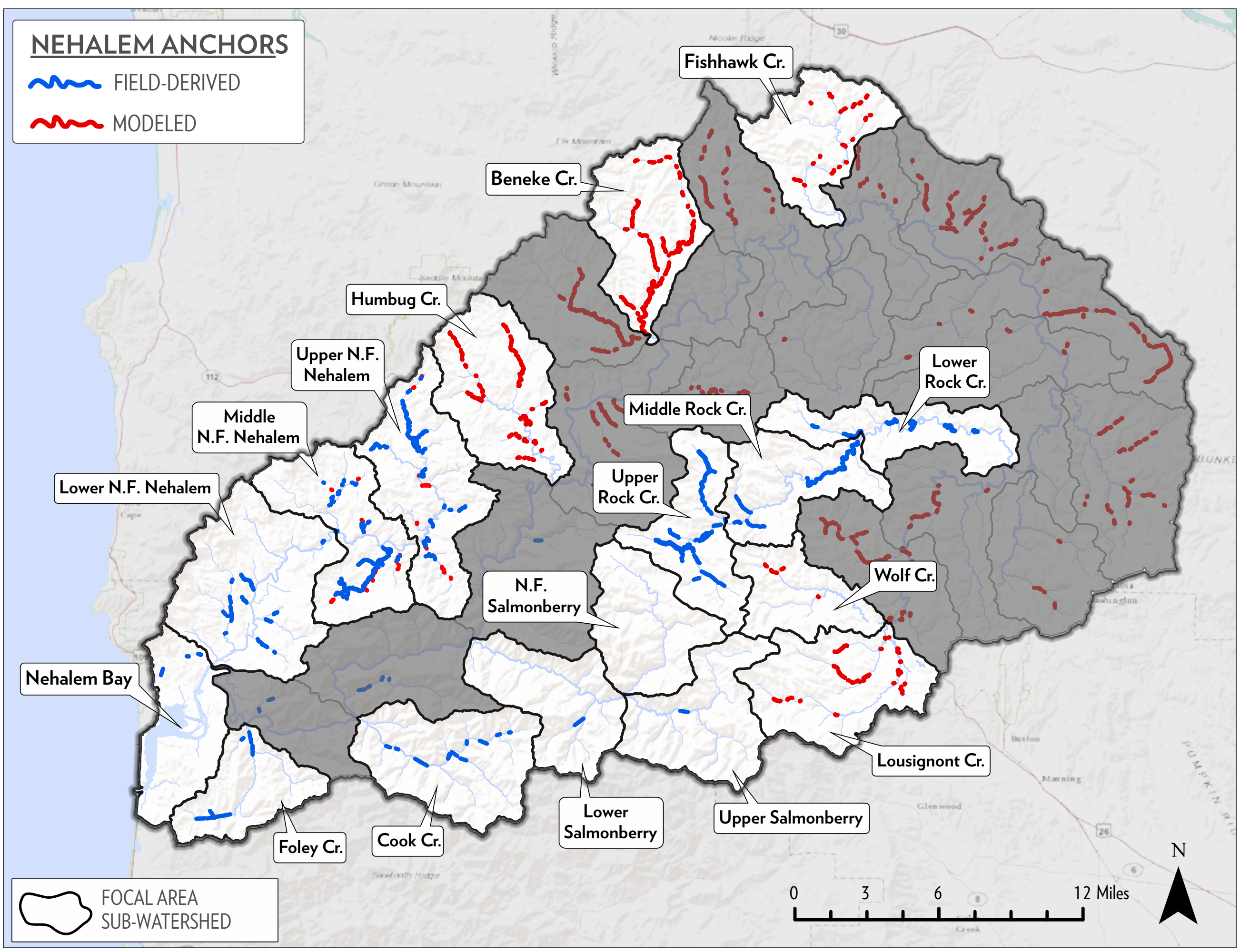
Strategy 2. Add large wood to identified anchor habitats and priority reaches of cold water refugia.

<u>2045 Outcome #2</u>: Instream complexity and stream interaction with off-channel habitats are restored within 66 miles of focal area anchor habitats.

Stream complexity results from several factors, including (but not limited to) geology, valley slope and width, the degree of streambank hardening, and the presence of large trees and other instream structure. Large, downed trees can change the morphology of rivers and streams, creating hydrogeomorphic conditions suitable to providing velocity refuge and other important aspects of high-quality juvenile rearing habitat. According to the Oregon Coast Coho Conservation Plan, "high quality over-wintering habitat for juvenile Coho is usually recognizable by one or more of the following features: large wood, pools, connected off-channel alcoves, beaver ponds, lakes, connected floodplains and wetlands" (ODFW 20007).

Following decades of stream cleaning (in which large wood was removed from streams to enhance mainstem transportation and fish migration) and extensive clearcutting (which reduced passive wood delivery to streams), tributaries in the Nehalem are now well below the desired benchmarks for wood. As a complement to Strategy 1, which supports long-term, passive wood delivery into Nehalem River tributaries, this strategy calls for the targeted placement of large wood. The installation of large wood can boost short-term

Figure 5-4. Anchor Habitats Identified in the Focal Areas.



Coho production while enhancing watershed function in anchors and other priority reaches.

Wood placement locations called for in Chapter 5 are focused largely in areas with significant amount of anchor habitat, shown in Figure 5-4. Criteria considered in determining priority locations included:

1) whether the reach is an identified anchor habitat (i.e., the site can support the full range of seasonal habitat requirements for Coho, including spawning, incubation, and summer/winter rearing);

2) the current level of connectivity (i.e., the site is currently accessible to juvenile salmonids); and

3) the estimated proportion of the 6th field's Coho production that is generated by a site (i.e., the site is highly productive – or capable of being highly productive with restoration).

In addition to applying the anchor strategy, the planning team prioritized locations to increase instream complexity through a review of tributary confluences that provide cold water inputs to the lower mainstem Nehalem. These tributary nodes may serve as life boats for juvenile salmonids seeking refuge from lower mainstem water temperatures that reach over 25 degrees Celsius in the summer (Bio-Surveys 2020). Juveniles seeking to ride out the summer in these cold water plumes are likely subject to high predation due to the limited availability of cover caused by reduced instream complexity.

Bio-Surveys (2020) prioritizes the cold water confluences from the estuary upstream to Humbug Creek (RM 34.7). The following tributaries were identified as high priorities for restoration at their confluences with the Nehalem mainstem based on field work conducted in 2018. These include (in order of priority): Fall Creek, Cook Creek, Heloff Creek, Spruce Run Creek, Candyflower Creek, Foley Creek, Salmonberry River, Lost Creek, George Creek, an unnamed tributary, and Buchanan Creek. A review of data gaps provided in Chapter 7 recommends further refining this list through additional data collection and undertaking a similar assessment in the upper basin.

The installation of large wood can boost short-term Coho production and enhance watershed function. Photo: Dave Herasimtschuk

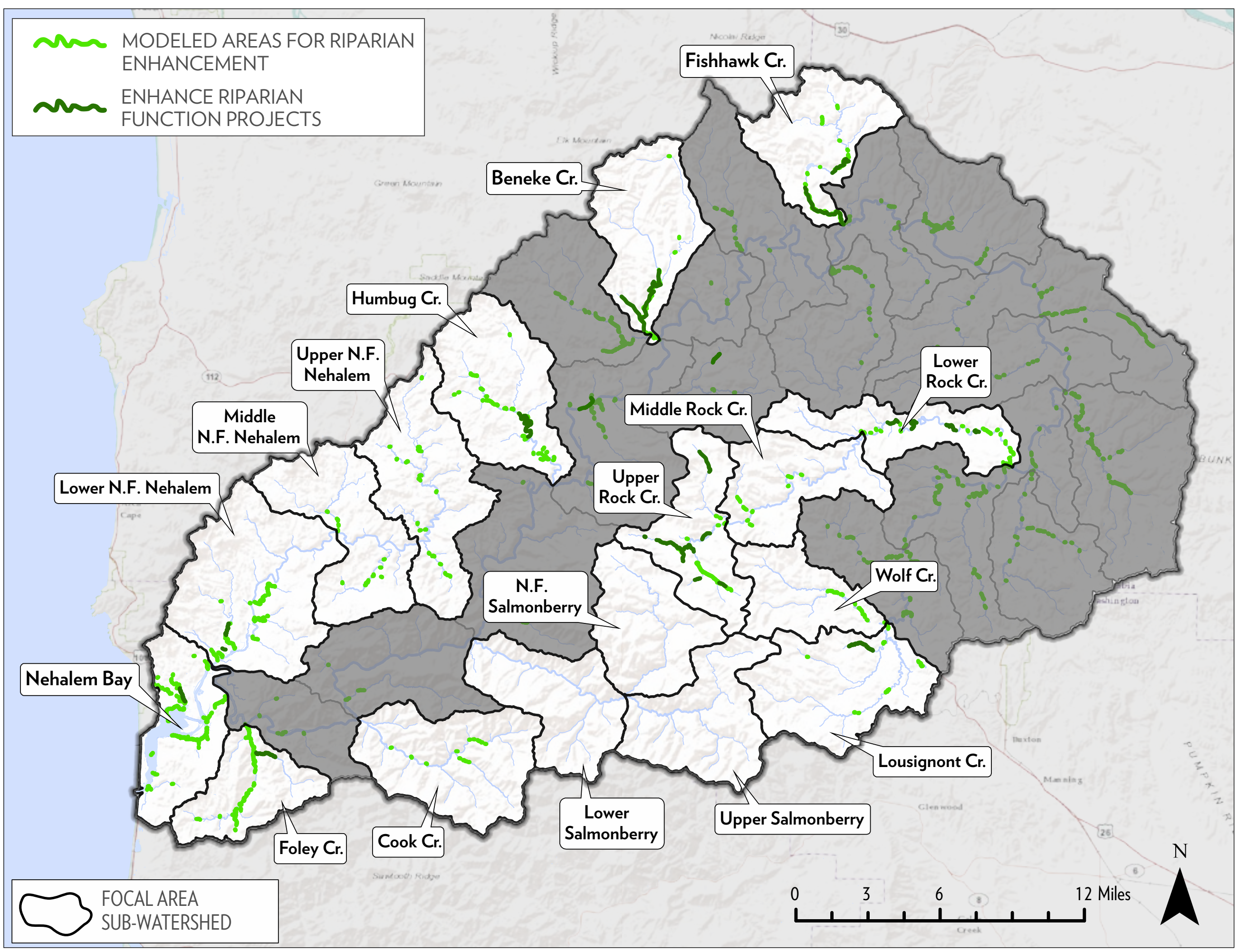
Strategy 3. Enhance riparian habitats along tributaries through native plantings and the management of invasive species.

2045 Outcome #3: Riparian function is restored along 58 miles of focal area tributaries, reducing stream temperatures and erosion, increasing macro-invertebrate abundance, and increasing the long-term potential for large wood recruitment.

Both the state's Oregon Coast Coho Conservation Plan and the federal recovery plan establish that healthy riparian areas are a key component of high-quality rearing habitat for juvenile Coho. Functioning riparian habitats maintain channel connectivity to floodplains, wetlands, and side channels; provide shading; generate large wood and litter; retain sediments; support macro-invertebrate communities and provide other important aspects of a healthy stream ecosystem. These functions have been lost or reduced in many parts of the Nehalem Basin from the headwaters to the bay due to forest and pasture management, rural residential and urban development, and the proliferation of non-native species.

The restoration of riparian areas also serves as a critical buffer to climate change. Elevated summer temperatures in the mainstem Nehalem and many lower tributaries already create a thermal barrier to juvenile migration in summer, shown in Figures 5-6 and 5-7. In addition to limiting access to critical habitats and diminishing overall habitat availability, the impaired migration of juveniles also threatens

Figure 5-5. Modeled Priority Reaches for Riparian Enhancement and Proposed Near-term Projects.



the expression of alternative life-history strategies like the nomadic Coho. Loss of life history diversity threatens the viability and resilience of the Nehalem Coho population. The restoration of riparian zones presents a tool to combat the impacts of climate change on thermal regimes in the Nehalem, supporting juvenile migration and access to critical cold water habitats in summer. Figure 5-5 shows priority reaches for riparian habitat enhancement.

The riparian enhancement activities in this plan focus primarily on removing non-native vegetation and planting native vegetation. Where necessary, managers may also incorporate livestock exclusion through fencing and off-channel watering. Additionally, the LNWC proposes to form a regional working group to enhance riparian silvicultural approaches and establish "pockets" of mid to late-successional conifers in the riparian zone near large wood placement sites, in debris-flow source areas, and adjacent to beaver dam analogue installations.

Healthy riparian zones are essential to maintaining cold water, recruiting large wood to the stream, and filtering out fine sediments and other contaminants.

Figure 5-6. Modeled Stream Temperatures in the Nehalem River Watershed.

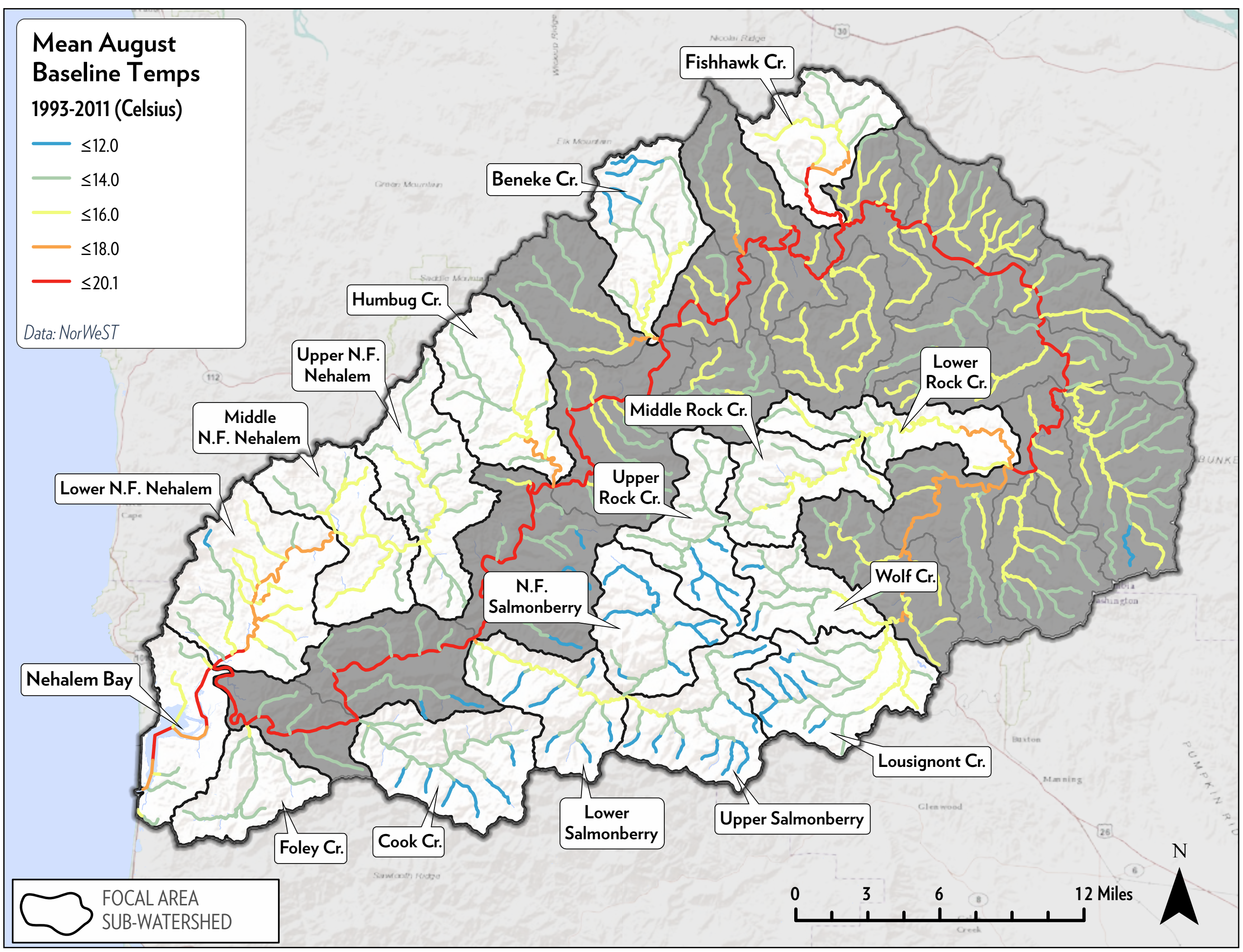
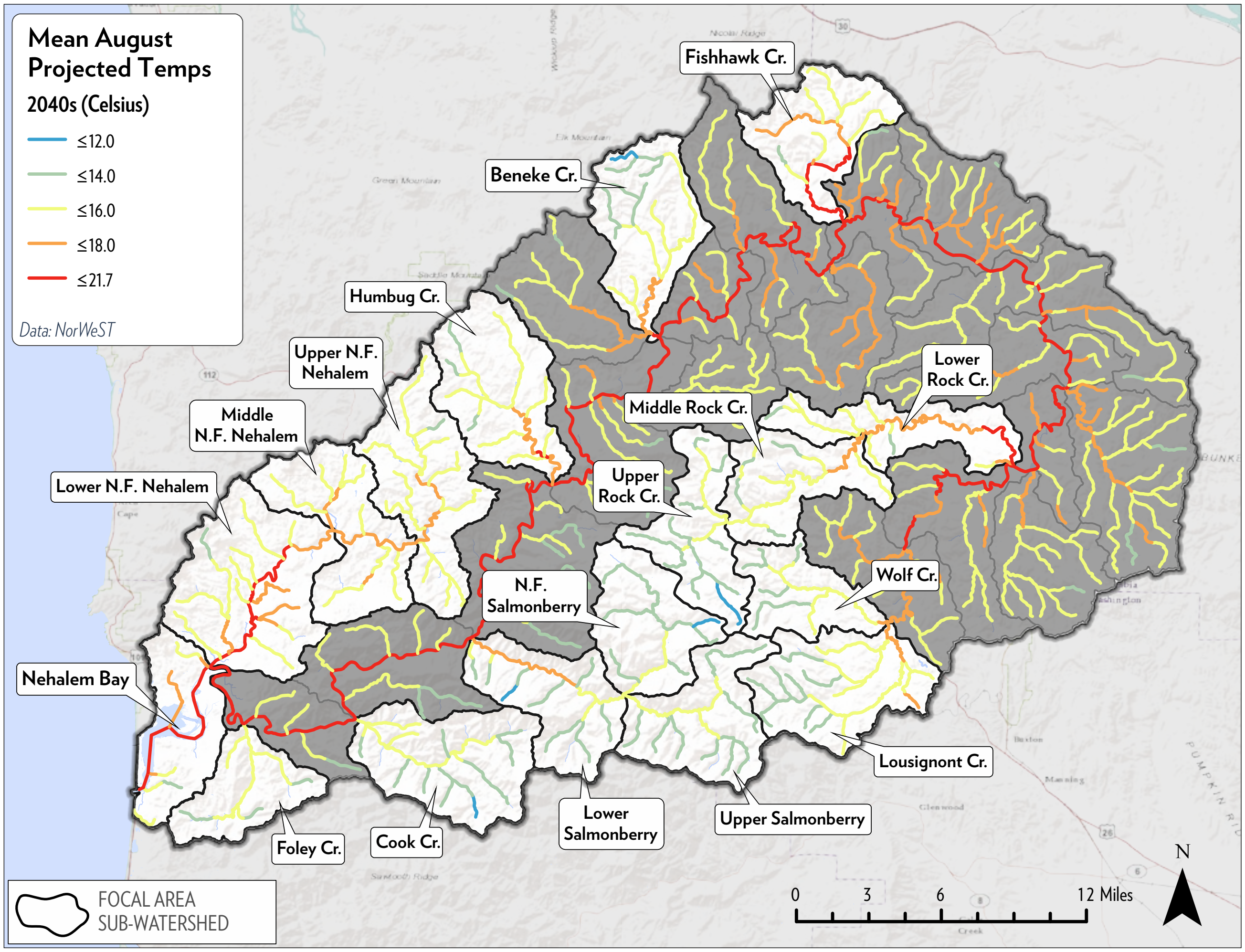


Figure 5-7. Modeled 2040 Stream Temperatures in the Nehalem River Watershed.



Strategy 4. Recruit and promote beaver colonization and encourage dam-building in selected 1st - 3rd order tributaries.

<u>2045 Outcome #4</u>: Beavers colonize and build dams in an additional 40 miles of Coho- bearing tributaries in the focal areas, increasing the quality and quantity of off-channel habitats available for juvenile rearing.

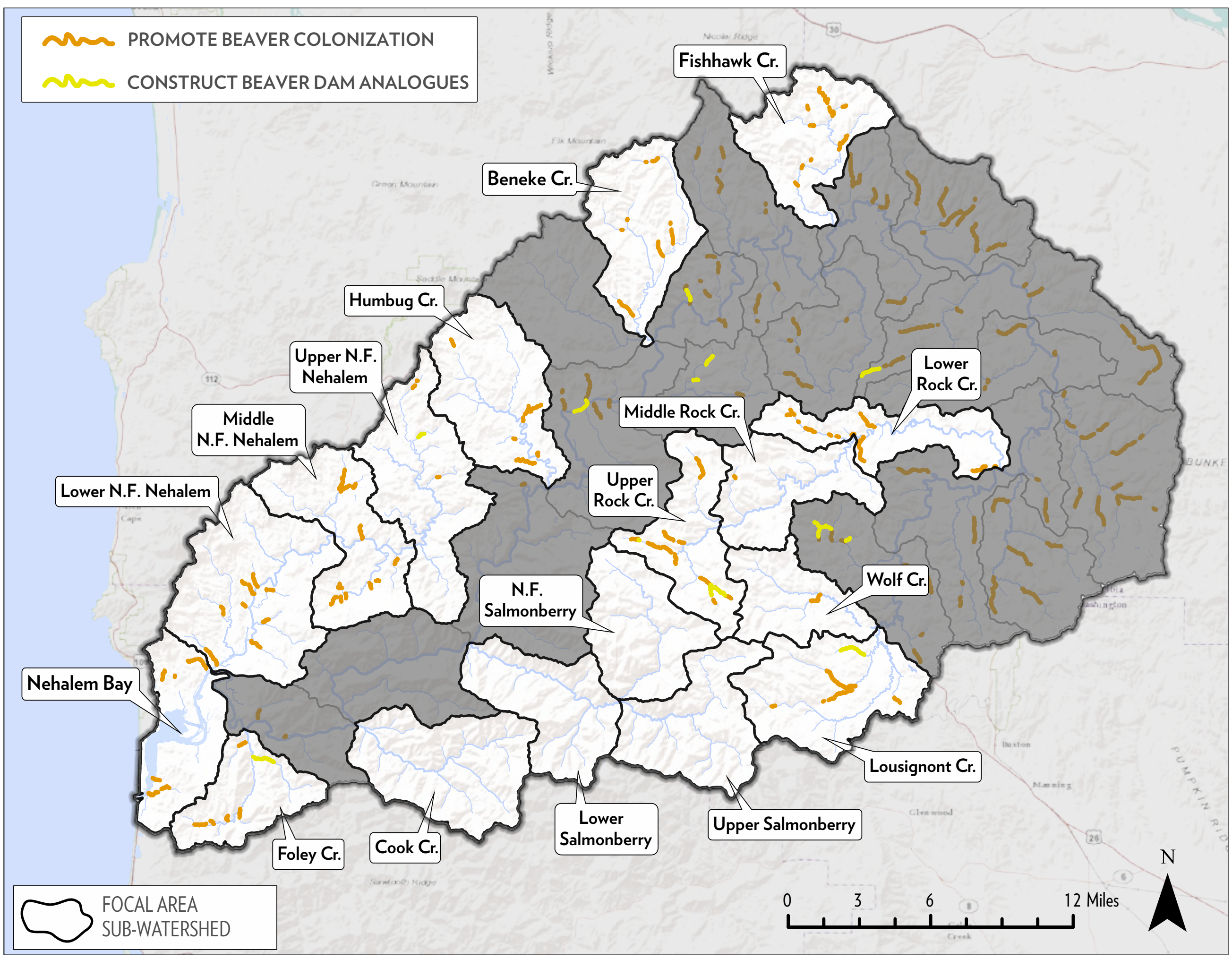
As detailed in the Beaver Restoration Guidebook (USFWS, Castro et al. 2015), beaver ponds provide excellent habitat for Coho and other fish species because they slow stream flow and generate abundant off-channel and edge habitat. Among other benefits, these conditions offer refuge from flood flows in winter and from high water temperatures found in the mainstem and many tributaries during the summer months. They also provide cover from predators and abundant food, which requires substantially less energy to find than in higher velocity tributary habitats.

In addition to the physical habitats created, beaver ponds drive watershed processes that recruit and retain spawning gravels and forest nutrients, increase hyporheic flow, elevate local water tables, and generate lateral connectivity between the stream channel and floodplain. This capacity to restore watershed function and enhance habitats beyond just a reach scale makes their damming activity particularly effective at increasing over-winter survival (often the limiting factor) at a subwatershed scale. In addition, beaver colonization and dam building can benefit every Coho life-history type present in the Nehalem Basin, while also benefiting the full range of Coho life stages. **Therefore, the recruitment of beavers and restoration of beaver pond habitats represents one of the most impactful and economical restoration strategies available to the recovery effort.**

The Oregon Coast Coho Conservation Plan states, "Increasing the number of beaver dams in areas where dams are limited.... will create stream complexity and increase the Coho smolt capacity of populations and the ESU, which will help the populations and ESU build towards desired status." Similarly, the federal recovery plan recommends increasing the number of beavers and beaver ponds as a range-wide strategy.

The Nehalem Partnership's primary strategy to increase the number of beaver ponds focuses on installing Beaver Dam Analogues (BDAs), wood structures that can mimic and potentially catalyze dam construction. The BDAs proposed in the SAP will be designed and constructed to provide salmon habitat at sites chosen to avoid conflict with humans. Three years of monitoring results from recently implemented BDAs in the upper Nehalem watershed demonstrate that BDAs may encourage beaver colonization and increase over-winter Coho habitat where dams are constructed. Additional long-term monitoring is needed to capture the cyclical nature of beaver site colonization. Food availability is a critical factor for site utilization; therefore, evaluating if the site has sufficient food resources and augmenting food availability through planting will be an important component.

Figure 5-8. Modeled Stream Reaches with the Highest Potential for Beaver and Locations Proposed for Beaver Dam Analogues in the Near-term.



Beaver Dam Analogues are wood structures that can mimic beaver dam construction. Photo: Maggie Peyton

To identify the best sites for installing BDAs, the team developed an intrinsic potential model for beaver and ran it with Netmap. The model is driven by the identification of geomorphology conducive to persistent beaver dam habitat. After ground-truthing the model and locating several potential sites, the team invited a group of BDA expert scientists and agency personnel to visit the locations and offer feedback on site selection, design, and construction techniques. The preferred locations for testing BDAs were on public property where there was little or no risk of harming roads, buildings, or private property.

Figure 5-8 presents the results of the Beaver Intrinsic Potential model. This map does not represent all of the sites that beaver may occupy. It simply shows the locations where the most suitable geomorphic conditions exist for site establishment. Successful implementation of BDAs has already occurred on several of these sites. Additional sites proposed for near-term BDA construction are also shown in Figure 5-8.

While this plan seeks to promote beaver colonization and dam-building, the Nehalem Partnership recognizes that some beaver management strategies may undermine and diminish the benefits of beaver establishment. In addition, maintaining existing colonies of beavers is a more cost-effective strategy to generate Coho habitat than restoring these habitats once beaver have been removed. Currently, the only mandatory reporting is for recreational harvest of beaver on public lands through the furtaker report. The Partnership encourages state and federal managers and policy makers to consider the following changes in beaver management and policy:

- Require mandatory reporting of beaver trapping across all land ownership;
- Collect baseline data on current population status;
- Provide support to private landowners seeking to implement non-lethal management strategies;
- Support regional efforts to create “quick response teams” that can remove and relocate beavers when necessary due to human conflict;
- Increase awareness of the role of beavers in generating high-quality salmon habitat; and
- Remove beaver as a predatory rodent on private lands under the jurisdiction of ODA to a managed furbearer by ODFW.

Strategy 5. Reconnect and restore tidal wetlands and sloughs and associated freshwater habitats.

***2045 Outcome #5**: Three hundred acres of tidal wetlands and other estuarine habitats are reconnected, increasing the quality and extent of tidal rearing habitats and associated freshwater habitats.*

Drowned-river mouth estuaries like the Nehalem Bay generate a variety of habitats that are important to Coho rearing, including saltmarsh, emergent marsh, open water, subtidal, intertidal, backwater areas, tidal swamps, mudflats, tidal channels, scrub-shrub, and deep channels. Collectively, these habitats provide important and diverse opportunities for juvenile Coho to feed, grow, and smolt before entering the ocean. Under the standard life-history strategy for Nehalem Coho, smolts typically spend less than a month in the estuary feeding, growing, and adapting to saline environments before entering the Pacific Ocean.

Ongoing studies of Coho use of the Salmon River estuary (about 60 miles south of the Nehalem Bay) show estuaries are more than simply short-term stopovers for Coho on the way to the ocean. The habitat complexity and connectivity within and between the freshwater and estuarine environments enable young salmon to express a variety of alternative life-history strategies (Bisson et al. 2009; Moore et al. 2015; Flitcroft et al. 2019). Jones et al. 2011 describes "a wide range of sizes and times of juvenile Coho migration to the estuary and ocean, including many nomads that successfully rear and grow in the estuary for extended periods."

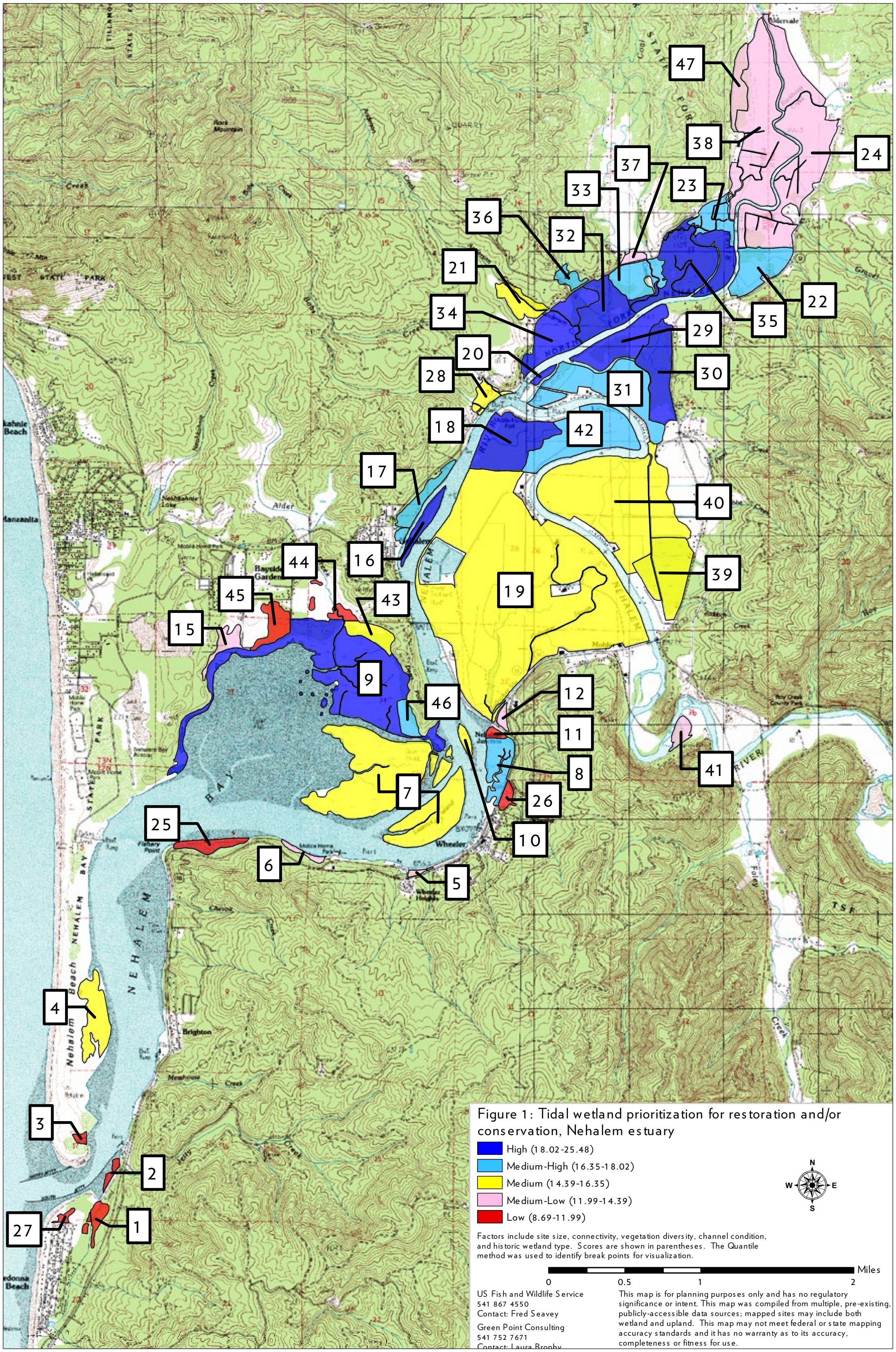

Neahkanie Farm Wetland

More recent research details the diverse temporal and spatial use of these habitats by Coho. Some juvenile cohorts enter tidal areas as fry in spring within months of emerging from the gravel; others as parr in the fall after a short summer in spawning-adjacent habitats; and many more enter the estuary as yearlings headed out to the ocean (Jones et al. 2021).

Jones et al. (2014) describes the importance of reconnecting tidal habitats, explaining "estuary restoration has re-established a variety of habitats capable of rearing juveniles that were not supported by stream habitats in the upper [Salmon] basin. Under the environmental conditions experienced during this survey, estuarine wetlands accounted for as much as 30 percent of the adult *O. kisutch* that now return to spawn in Salmon River. These results suggest that life-history diversity and the habitat opportunities that sustain it are fundamental to the productivity as well as the resilience of Salmon River *O. kisutch*."

Findings by Jones et al. (2021) provide further evidence that "estuary-focused" life-history strategies can comprise an important component of an OC Coho run. In one of seven years of the study, alternate (estuary-focused) strategies represented the majority of returning adults (58%). Following an assessment of juvenile Coho distribution in the lower Nehalem tributaries, Bio-Surveys (2020) described a similar finding; "Coho found rearing in lower mainstem thermal refugia and estuarine habitats represent an important subset of the population."

Figure 5-9. Tidal Wetland Restoration Priorities in the Nehalem Bay (Brophy et al. 2005).



Tidal wetlands in Nehalem Bay. Photo: Wild Salmon Center

Finally, monitoring in the lower Salmon River indicates that some cohorts of rearing Coho retreat to estuary-adjacent streams in fall and winter before re-entering the estuary in spring (Jones et al. 2014). These streams, which are often small and not easily recognized as critical habitat, provide a source of cold water refugia and freshwater for juveniles not yet ready to enter the more saline habitats. These contributions strongly point to estuary-adjacent streams as a key habitat component for Coho and a priority for protection and restoration.

Brophy et al. (2005) prioritized tidal wetlands in the Nehalem Bay, and the Nehalem Partnership has incorporated the priorities recommended in that report into this SAP (Figure 5-9). The study highlights land areas in the Nehalem River estuary where tidal wetland restoration or other conservation action can offer the greatest ecosystem benefit for the cost. Criteria for prioritization included the size of the site, tidal channel condition, wetland connectivity, salmonid habitat connectivity, historic vegetation type, and diversity of current vegetation types. The report identified 1,350 hectares (ha) (3,336 acres) of current and former tidal wetlands in the Nehalem River estuary. Over 70 percent of the estuary's historic tidal wetlands (970 ha) have undergone major site alterations that greatly restrict or alter tidal flows, such as diking and ditching. Roughly 3 percent (37 ha) have undergone minor alterations like culverted drainages and road crossings, and 25 percent (340 ha) are relatively undisturbed.

In addition to this report, local partners recently completed an inventory of Nehalem Bay tide gates. The data generated from this work will support the prioritization of tide gate replacements using the Opti-Pass model developed by The Nature Conservancy. Local partners may overlay the results from the Opti-Pass analysis on the Brophy (2005) prioritization and SAP focal area and anchor habitat maps to inform a long-term tidal wetland reconnection strategy.

In addition to this work, the Nehalem Partnership recommends three additional priorities for restoring the Nehalem River estuary and its tributaries:

1) Enhance fish passage and/or reconnect tidal areas and floodplains containing 1st – 3rd order tributaries draining into the estuary. These tributaries provide important salinity refuges for 0+ age nomads, which cannot yet tolerate elevated salinity.

2) Prioritize tributaries on the south side of the bay (north-flowing creeks) because of their capacity to serve as thermal refugia.

3) Protect landward migration zones.

Strategy 6. Replace or remove culverts and other barriers to fish passage.

2045 Outcome #6: Fifty-two barriers to fish passage are removed, enhancing longitudinal connectivity in focal area tributaries, and restoring Coho access to 92 miles of anchor habitats, cold water refugia, and off-channel habitats.

The ODFW fish passage barrier list contains numerous culverts, tide gates, dams, and other barriers to fish migration in the Nehalem River basin. Several other assessments also prioritize barriers within selected subwatersheds, including a culvert inventory and Rapid Bioassessment completed in the lower basin and the Rock Creek LFA from the upper basin. The Nehalem Partnership reviewed these sources and identified 52 high-priority barriers to OC Coho. These barriers are mapped in Figure 5-10. In Chapter 6, the Partnership presents the barriers that it intends to eliminate in the next five years. In addition to providing juvenile and adult access to anchor habitats, cold water refugia and other key habitats, the removal of these barriers will enhance longitudinal connectivity, improving the transport of gravel and wood through the system.

5.4 Outcomes by Restoration Strategy in SAP Focal Areas

Tables 5-3 and 5-4 summarize the outcomes sought in the upper and lower Nehalem focal areas from implementing the strategies described above through 2045. The focal area maps in Figures 5-11 through 5-16 show the locations where partners seek to implement these strategies.

Figure 5-10. Fish Passage Reconnection Priorities in the Focal Areas.

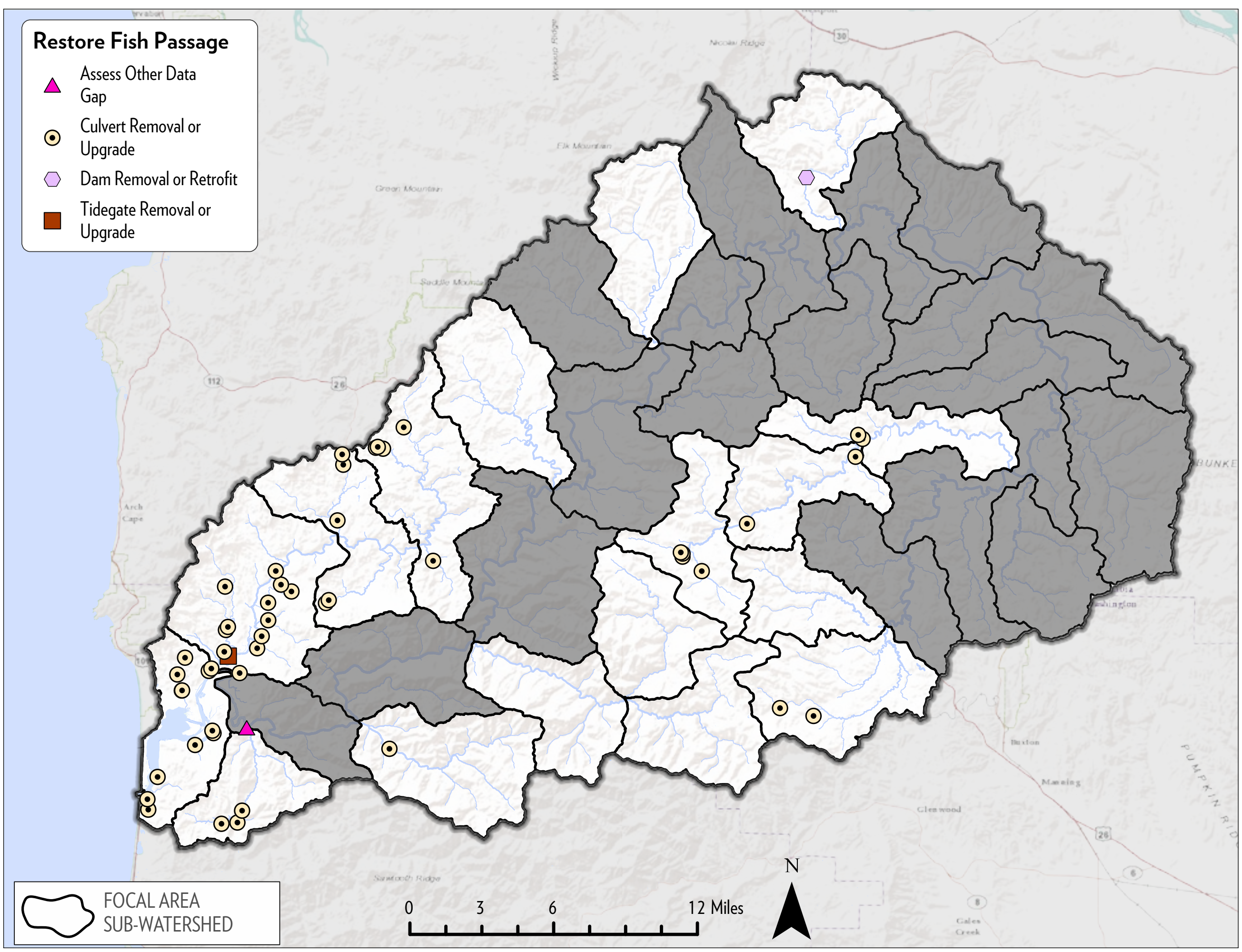


Table 5-3. Projected Outcomes in the Lower Nehalem Focal Areas (2023 - 2045).

KEY ECOLOGICAL ATTRIBUTES RESTORED OR ENHANCED	Focal Areas					
	Foley Creek	Nehalem Bay	North Fork Nehalem	Cook Creek	Salmon-berry	Total
Stands of selected large timber protected (acres)	61	0	43	43	29	**176**
Increased instream complexity in anchor habitats from large wood (miles)	2.6	.3	6.3	2.4	.8	**12.4**
Instream complexity increased by beaver enhancement activities (miles)	2	3	9.5	0	0	**14.5**
Enhanced riparian function along tributaries (miles)	5.8	10.2	8.5	.9	0	**25.4**
Fish passage barriers replaced (number)	4	13	23	1	0	**41**
Longitudinal connectivity increased in tributaries (miles of habitat reconnected)	7	21	36	1	0	**65**
Increased tidal connectivity in priority areas (acres)	N/A	High priority	Highest priority	N/A	N/A	**300**

Table 5-4. Projected Outcomes in the Upper Nehalem Focal Areas (2023 - 2045).

KEY ECOLOGICAL ATTRIBUTES RESTORED OR ENHANCED	Focal Areas						
	Humbug Creek	Beneke Creek	Fishhawk Creek	Rock Creek	Wolf Creek	Lousignant Creek	Total
Stands of selected large timber protected (acres)	7	0	5	6	36	113	**167**
Increased instream complexity in anchor habitats from large wood (miles)	7.3	13	2.1	26.1	.5	4.1	**53.1**
Instream complexity increased by BDAs and beaver colonization dam-building (miles)	3.1	2.7	3.4	11.1	.6	3.6	**24.5**
Enhanced riparian function along tributaries (miles)	5.5	5.7	4.7	13.1	1.4	2.4	**32.8**
Fish passage barriers replaced (number)	0	0	1	8	0	2	**11**
Longitudinal connectivity increased in tributaries (miles of habitat reconnected)	0	0	2	21	0	4	**27**

5.5 Priority Reaches by Restoration Strategy in the Focal Areas

The following maps in Figures 5-11 to 5-16 present the river reaches and upland locations identified as the highest priorities for implementing the strategies presented in this chapter. These locations represent the areas where investment in protection and restoration projects will provide the greatest benefit and highest return on investments made in Nehalem Coho recovery. Chapter 6 presents a short-term (5-year) work plan, which identifies specific locations within these priority areas where landowners are prepared to implement projects, or outreach is underway, and partners have a high degree of confidence that a project can be implemented in the foreseeable future.

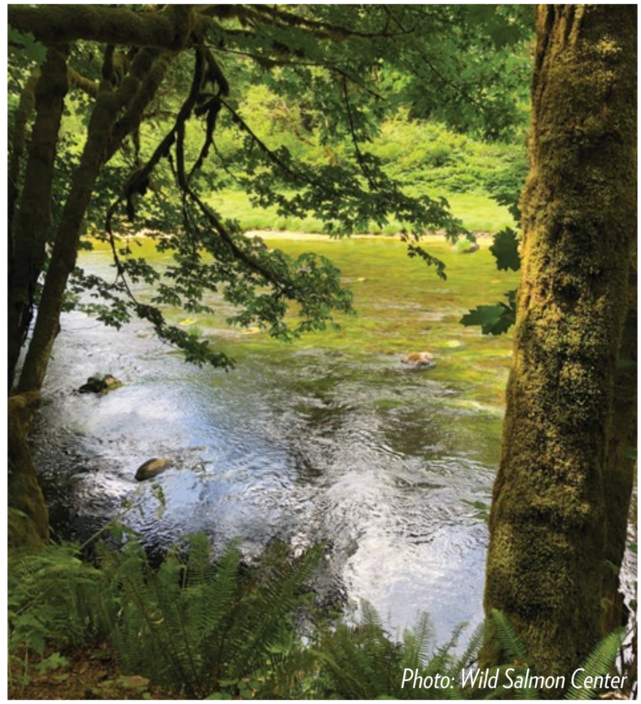


Figure 5-11. Priority Reaches by Restoration Strategy in the Tidally Connected Focal Areas, including Foley Creek, Nehalem Bay, and the lower North Fork Nehalem Watersheds.

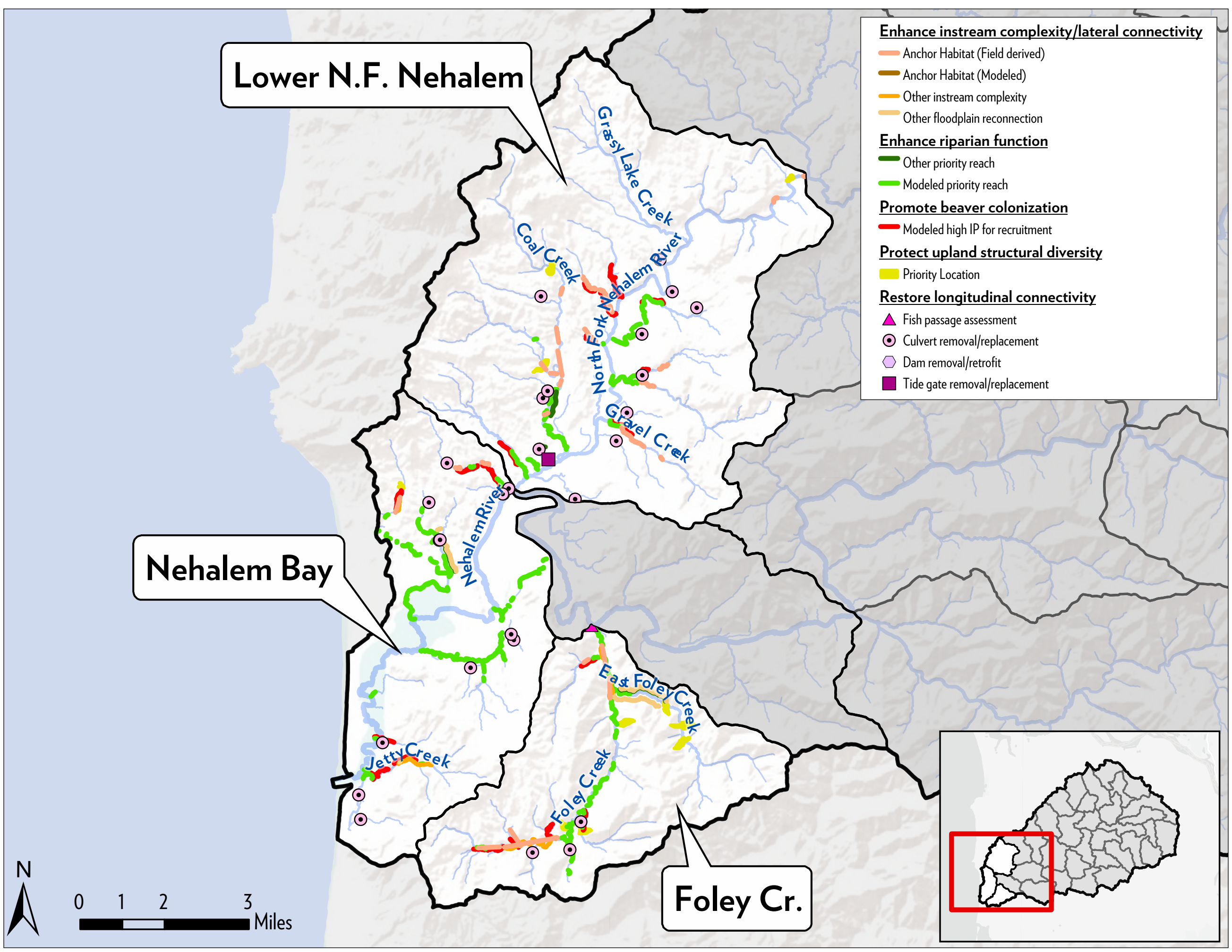


Figure 5-12. Priority Reaches by Restoration Strategy in the Middle and Upper North Fork Nehalem and Humbug Creek Focal Areas.

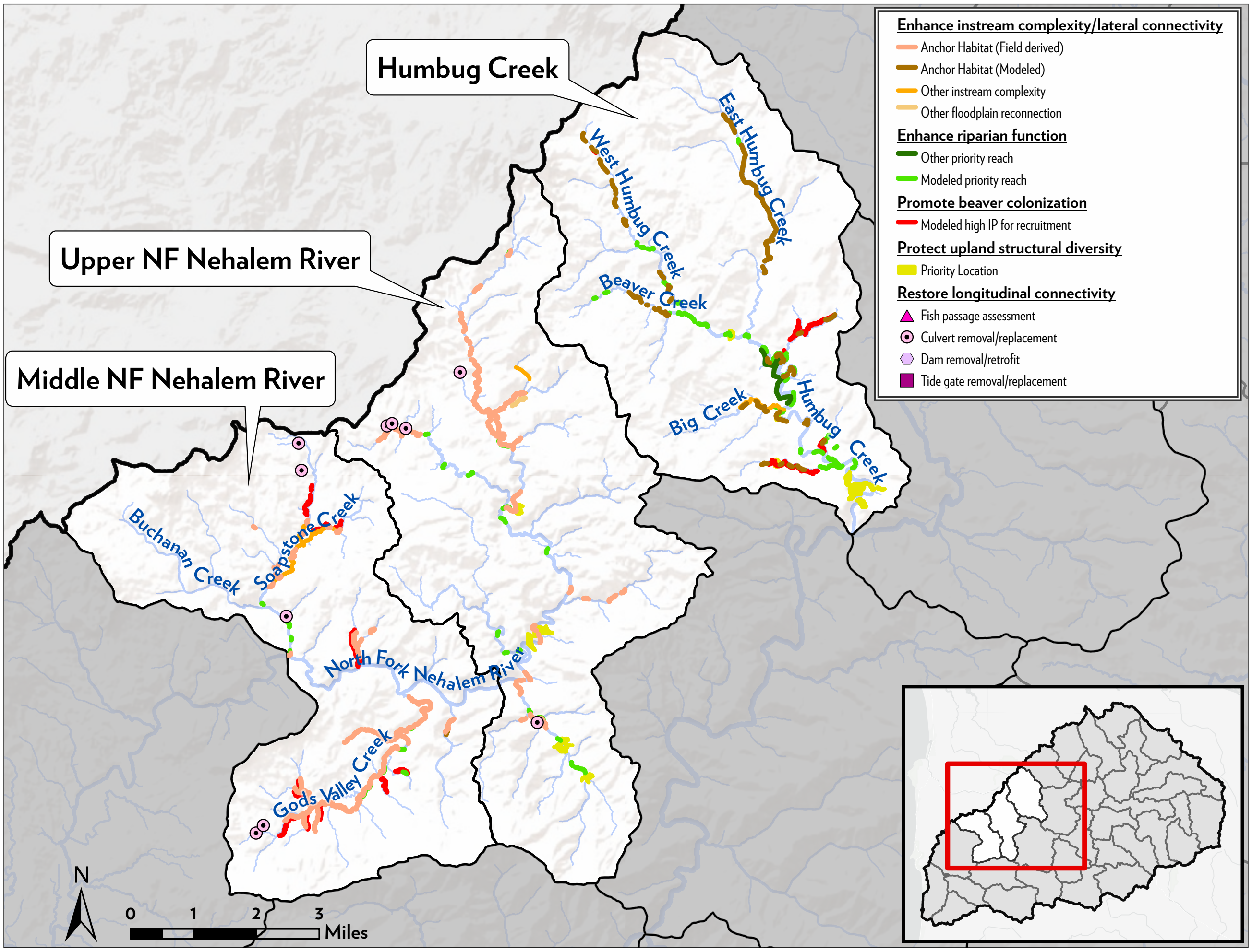


Figure 5-13. Priority Reaches by Restoration Strategy in the Beneke and Fishhawk Creek Focal Areas.

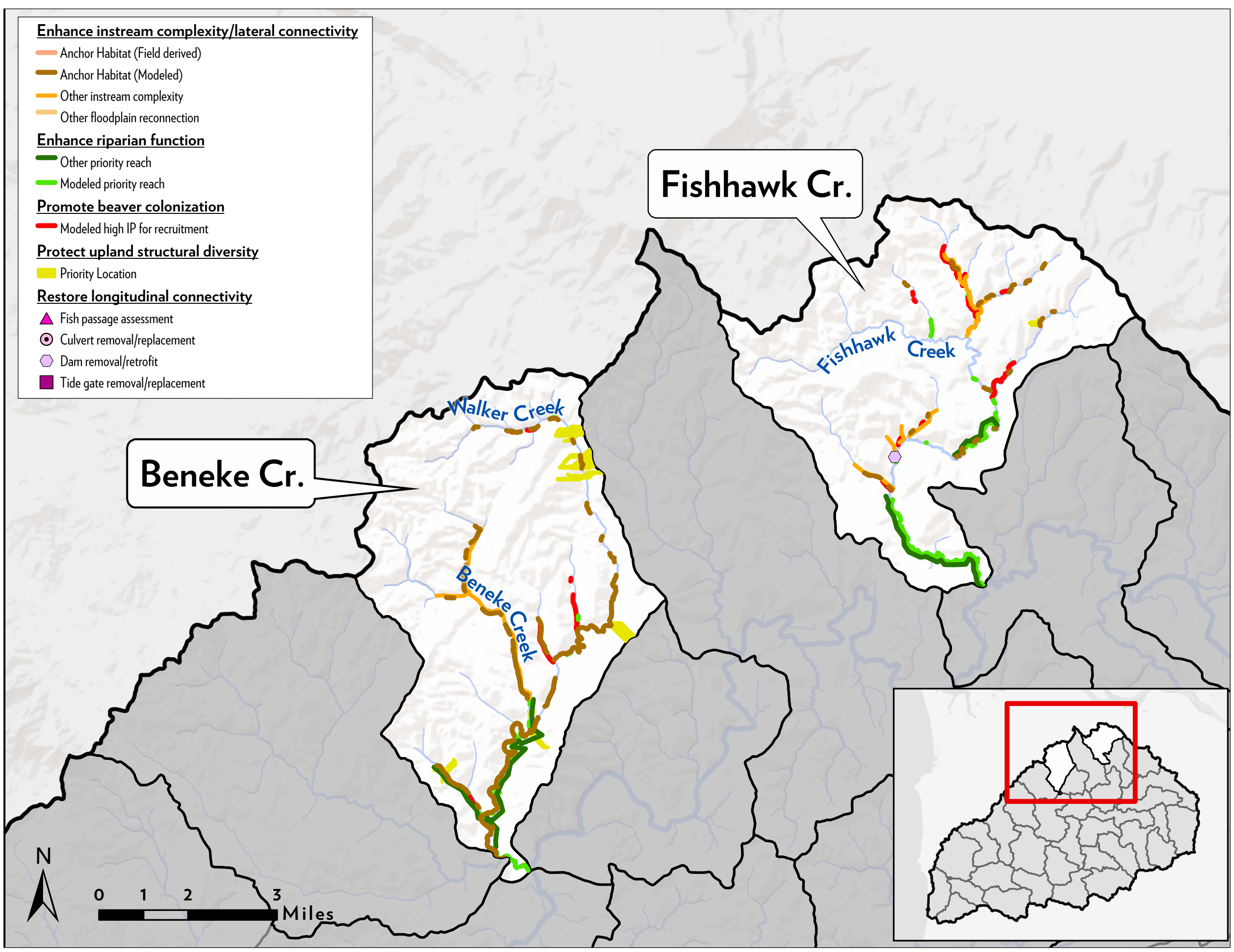


Figure 5-14. Priority Reaches by Restoration Strategy in the Lundgren, Deer, Crooked, Pebble Creek, and East Fork Nehalem Sub-watersheds. Note: these watersheds were not selected as short-term focal areas, but all provide high-quality habitat and reaches with high-restoration potential.

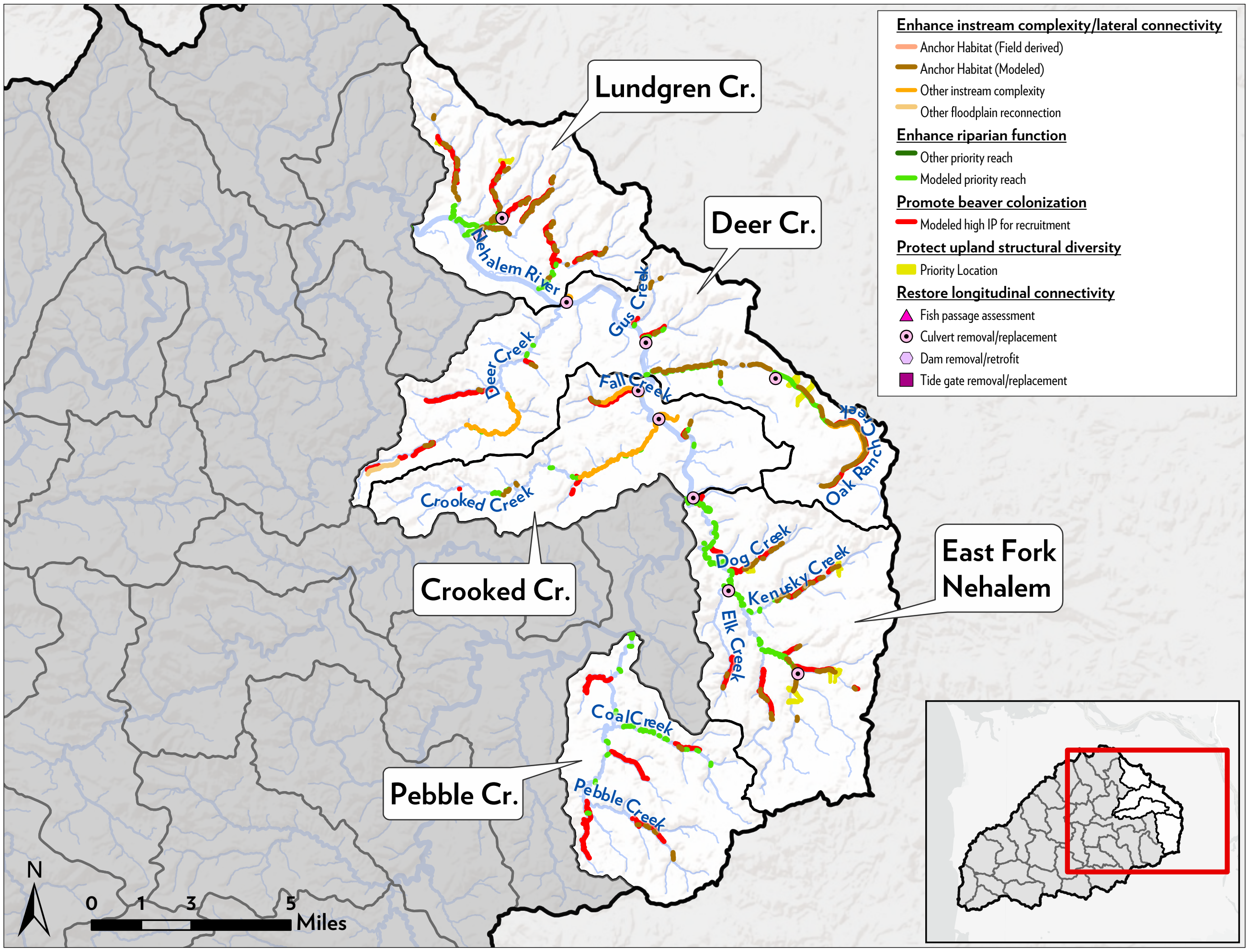


Figure 5-15. Priority Reaches by Restoration Strategy in the Rock, Wolf, and Lousignont Creek Focal Areas. Note: this map includes the priorities presented in the Rock Creek Limiting Factors Analysis (see Figures 6-1 and 6-2) and subsequent modeling on potential beaver colonization sites and priority upland areas for large wood recruitment.

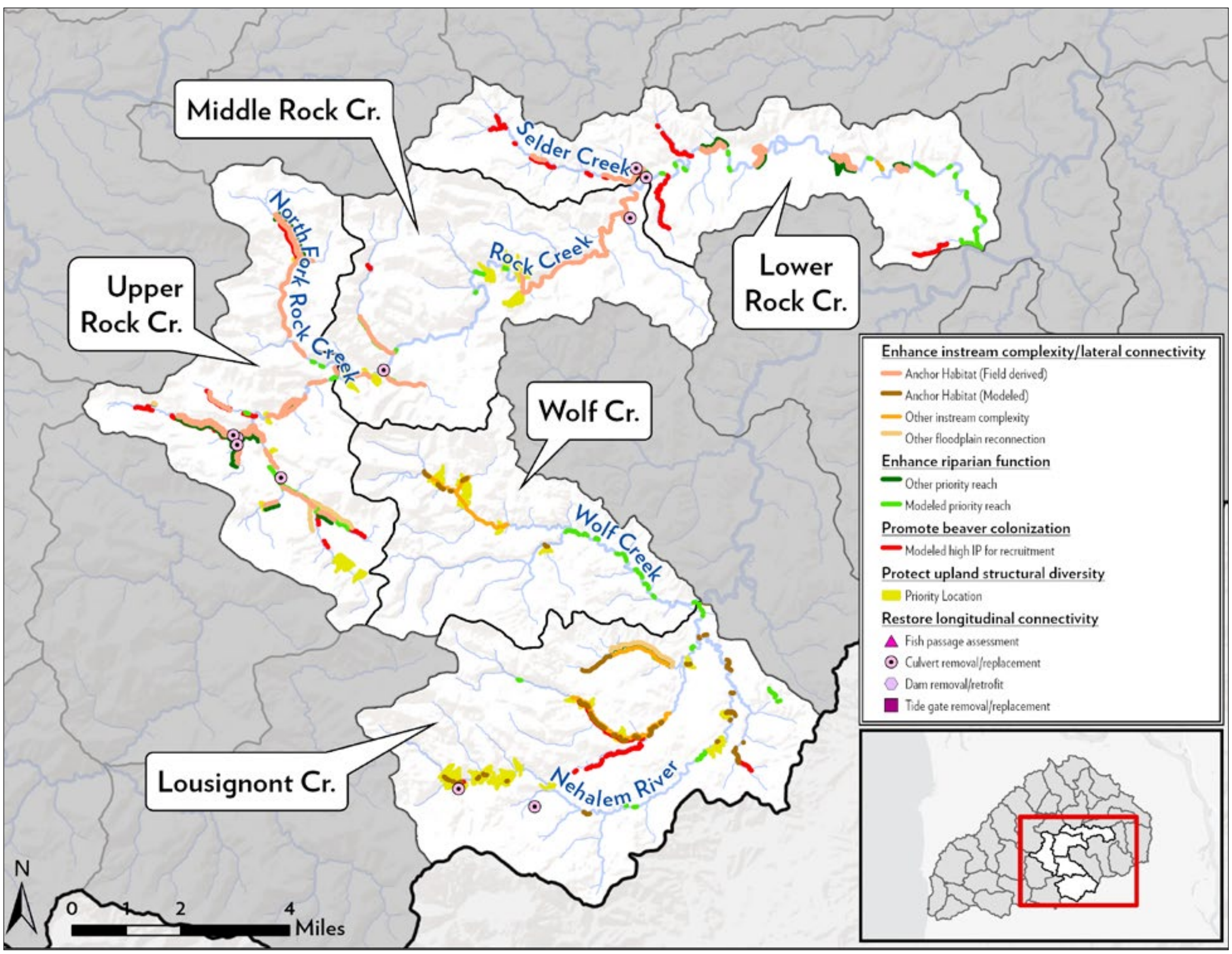
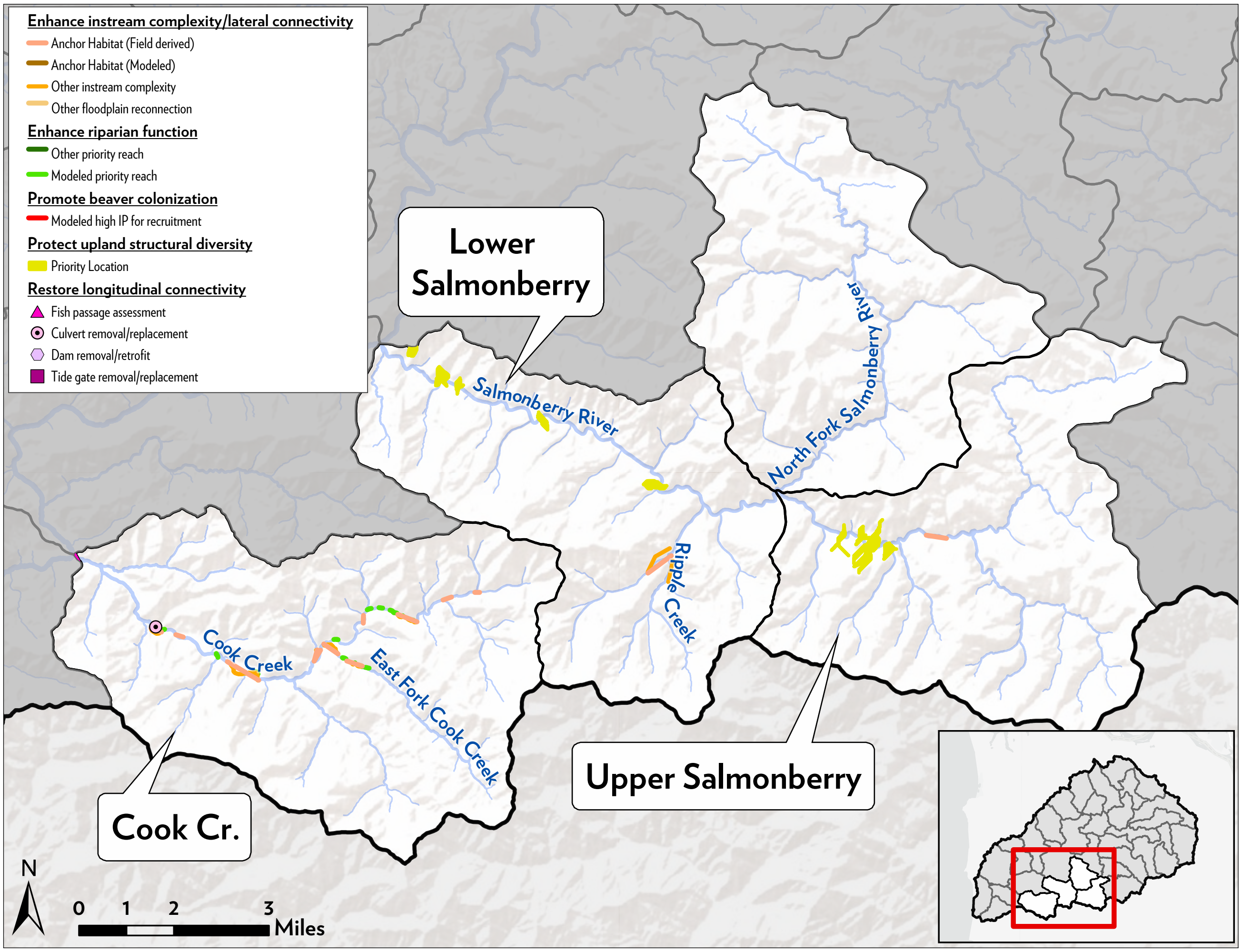


Figure 5-16. Priority Reaches by Restoration Strategy in the Cook Creek, Upper Salmonberry, and Lower Salmonberry Focal Areas.



Chapter 6

Project Implementation Plan: 2023 – 2027

Chapter 5 describes the protection and restoration strategies that the Nehalem Partnership will employ over the long term and the locations where the coordinated implementation of these strategies can generate the greatest benefit. The following chapter outlines a short-term work plan in which a subset of locations have been selected from these priority areas for implementation of projects within the next five years. The projects presented below reflect the locations where the scientifically determined priorities shown in Chapter 5 align with the conditions necessary for project implementation (willing landowners, high potential for funding, permits feasible, etc.). In short, these are the locations where science and opportunity meet.

6.1 Emerging Opportunities

While this SAP identifies focal areas in which to focus investment and coordinate implementation, the Nehalem Partnership recognizes the contributions of the other subwatersheds to the basin-wide dynamics that have made the Nehalem such a highly productive Coho system. To that end, the Partnership agrees that focusing implementation in the focal areas does not restrict any participating partners from undertaking projects in the other subwatersheds.

However, to be recognized as a funding priority, projects outside of the focal areas should meet one or more of the following criteria: 1) demonstrate the application of new conservation incentives or techniques; 2) engage an influential landowner or partner who can accelerate work in the focal areas; 3) exploit a finite window of opportunity; and/or 4) advance a large-scale project with a high cost-benefit. Partners developing this SAP agreed to an 80-20 guideline, where each partner will seek to direct 80 percent of its investments in project implementation and landowner outreach within this plan's focal areas. In addition to meeting one or more of the criteria above, projects undertaken outside the focal areas should also adhere to the anchor strategy presented in this SAP.

6.2 Near-Term Actions and Objectives

The Nehalem Partnership proposes the following actions for implementation from 2023 to 2027. These SAP proposed near-term actions are listed according to the long-term outcomes that they support.

2045 Outcome #1: The long-term potential for large wood delivery to anchor habitats is improved through the protection of 536 acres of selected timber stands throughout the Nehalem basin (343 acres in focal areas).

Objective 1.1 – By 2025, engage all public and private landowners in the focal areas with lands containing habitats modeled as high priority for future wood recruitment.	
Action 1.1 – A	Overlay SAP maps of 'priority upland sites to protect' (Figure 5-3 and Appendix 7) on debris flow and steep slope maps generated under the Forest Accords to determine which SAP priority areas are now protected under the revised FPA. Collaborate with private industrial forest landowners to determine the feasibility and costs of protecting upland sites that are not protected. Develop an initial list of sites deemed as opportunities for protection.
Action 1.1 – B	Review map of priority timber stands with ODF to support protection priorities generated under the Western Oregon State Forests Habitat Conservation Plan.
Action 1.1 – C	Support voluntary protection of priority upland stands through implementation of the Forest Accords in the Nehalem Basin.

2045 Outcome #2: Instream complexity and stream interaction with off-channel habitats are restored within 66 miles of focal area anchor habitats.

Objective 2.1 – By 2029, add LWD to 32.6 miles of focal area anchor habitats.	
Action 2.1 – A	Add LWD to 4.1 miles of anchor habitats on upper mainstem Beneke Creek - GIS 100.
Action 2.1 – B	Add LWD to 2.4 miles of anchor habitat on ODF lands on NF Wolf Creek - GIS 101.
Action 2.1 – C	Add LWD to 1.3 miles of anchor and cold water refugia habitats on Fishhawk and Boxer Creeks – GIS 106.
Action 2.1 – D	Add LWD to 2.9 miles Hamilton Creek - GIS 900.
Action 2.1 – E	Add LWD and re-meander 0.8 miles of Dass Creek – GIS 904.
Action 2.1 – F	Add LWD to 0.3 miles of O'Black Creek - GIS 902.
Action 2.1 – G	Add LWD to 1.4 miles of Fall Creek (Olympic: Crooked sub).
Action 2.1 – H	Add LWD to 1 mile of anchor habitats on Big Creek - GIS 109.
Action 2.1 – I	Add LWD to 2.8 miles of Upper Lousignont Creek – GIS 400.
Action 2.1 – J	Add LWD to 0.7 miles of Jetty Creek – GIS 920.
Action 2.1 – K	Add LWD to 2.2 miles of Foley Creek – GIS 401.
Action 2.1 – L	Add LWD to 0.3 miles of Upper Neah-Kah-Nie Creek – GIS 21.
Action 2.1 – M	Add LWD to 2.6 miles of Soapstone Creek – GIS 22.
Action 2.1 – N	Add full spanning LWD to 0.3 miles of Spruce Run Creek – GIS 34.
Action 2.1 – O	Add LWD to 0.4 of Grand Rapids Creek – GIS 600.
Action 2.1 – P	Add LWD to 0.7 miles of Gravel Creek – GIS 910.
Action 2.1 – Q	Add LWD to 0.2 miles of the Little North Fork Nehalem– GIS 911.
Action 2.1 –R	Add LWD to 1.7 miles of Upper Oak Ranch Creek on ODF lands in Deer Creek – GIS 402.
Action 2.1 – S	Add LWD to 0.1 miles of Bob's Creek (Anchor 1 & 2) – GIS 40.
Action 2.1 – T	Add LWD to 1.5 miles of East Foley Creek – GIS 11 (.5) and 14 (1).
Action 2.1 – U	Add LWD to 2.5 miles of Gods Valley Creek (mainstem).
Action 2.1 – V	Add LWD to 0.85 miles of Gods Valley Creek Trib A.
Action 2.1 – W	Add LWD to 0.5 miles of Gods Valley Creek Trib C.
Action 2.1 – X	Add LWD to 0.8 miles of Gods Valley Creek Trib D.
Action 2.1 – Y	Add LWD to 0.25 miles of Gods Valley Creek Trib E.
Action 2.1 – Z	Add LWD to the confluence of the Salmonberry and the mainstem Nehalem River.
Action 2.1 – AA	Add LWD to the confluence of Cook Creek and the mainstem Nehalem River.
Action 2.1 – BB	Add LWD to the confluence of Spruce Run Creek and the mainstem Nehalem River.

Objective 2.2 – By 2025, initiate implementation of the LWD recommendations in the Rock Creek Limiting Factors Analysis (LFA).	
Action 2.2 – A	Identify and engage all landowners containing priority reaches in the Rock Creek LFA (Figures 6-1 and 6-2).
Action 2.2 – B	Determine an implementation schedule based on the project prioritization contained in the LFA (Appendix 9) and landowner willingness.
Action 2.2 – C	Support voluntary protection of priority upland stands through implementation of the Forest Accords in the Nehalem Basin.
Objective 2.3 – By 2025, add 7 miles of LWD to anchor habitats in selected locations outside of the focal areas (see Section 6.1 Emerging Opportunities).	
Action 2.3 – A	Add LWD to 0.9 miles of Buster Creek – GIS 116.
Action 2.3 – B	Add LWD to 3.3 miles of Crooked Creek (Olympic) – GIS 907.
Action 2.3 – C	Add LWD to 1.4 miles of Upper Northrup Creek (ODF) – GIS 403.
Action 2.3 – D	Add LWD to 1.2 miles of Clear Creek – GIS 125.
Action 2.3 – E	Add LWD to 0.2 miles of lower North Fork Clear Creek – GIS 126.

<u>2045 Outcome #3</u>: Riparian function is restored along 58 miles of focal area streams, reducing stream temperatures and erosion, increasing macro-invertebrate abundance, and increasing the long-term potential for large wood recruitment.

Objective 3.1 – By 2027, plant 14.4 miles of riparian vegetation in locations modeled as highest priority within the focal areas.	
Action 3.1 – A	Plant 3.9 miles of riparian vegetation on Fishhawk Creek above and below dam – GIS 104.
Action 3.1 – B	Plant 2.3 mile of riparian vegetation on ODFW Wildlife Refuge along Humbug Creek – GIS 108.
Action 3.1 – C	Augment riparian plantings on 5 miles of Beneke tract of Jewell Meadows – GIS 110.
Action 3.1 – D	Plant riparian vegetation on 0.9 miles of Tweedle Creek – GIS 128.
Action 3.1 – E	Plant 0.6 miles of riparian vegetation on Coal Creek – GIS 601.
Action 3.1 – F	Plant 0.7 mile of riparian vegetation on Alder Creek and tributary downstream of Hwy 101 – GIS 20.
Action 3.1 – G	Plant 1 mile of conifer understory on East Foley Creek (along anchor 1) – GIS 14.
Objective 3.2 – Enhance riparian vegetation adjacent to all instream and off-channel habitat projects.	
Action 3.1 – A	Plant native species at selected LWD installation sites.
Action 3.2 – B	Plant beaver-preferred forage at selected BDA sites (see 4.1 - E).

2045 Outcome #4: Beavers colonize and build dams on an additional 40 miles of Coho-bearing tributaries in the focal areas, increasing the quality and quantity of off-channel habitats available for Coho rearing.

Objective 4.1 – By 2027, construct, augment, and/or maintain 58 BDAs in focal area reaches modeled as high beaver intrinsic potential.	
Action 4.1 – A	Construct BDA on Tweedle Creek - GIS 129.
Action 4.1 – B	Construct BDAs on Crawford Creek – GIS 410.
Action 4.1 – C	Construct BDAs (3) on Grand Rapids Creek (GIS 699; 600 is LWD).
Action 4.1 – D	Augment and maintain as needed BDAs installed in 2018 and 2019 in Lousignont (GIS 120 - BDA/130 – riparian), Buster/Walker Creeks (GIS 119 & 123 /131 – riparian), Rock Creek (GIS 121), Bear Creek (GIS 411), and Deer Creek (GIS 122).
Action 4.1 – E	Plant beaver preferred forage at completed BDA sites.
Action 4.1 – F	Determine the feasibility of BDA sites on upper mainstem Beneke Creek and ODF lands on Wolf Creek.
Objective 4.2 – By 2023, initiate outreach to private landowners and the general public on the role of beaver in restoring Coho habitats and improving watershed function.	
Action 4.2 - A	Host "living with beaver" forums with the industrial timber owners, including Weyerhaeuser, Stimson, and Olympic Resource Management.
Action 4.2 - B	Ground truth Netmap-modeled High Beaver IP for sub-watersheds that were not completed in this SAP.
Action 4.2 - C	Implement a local outreach campaign focused on public education regarding the role of beavers.

2045 Outcome #5: 300 acres of tidal wetlands and other estuarine habitats are reconnected, increasing the quality and extent of tidal rearing habitats and associated freshwater habitats.

Objective 5.1 – Complete two tidal reconnection projects by 2026.	
Action 5.1 – A	Create tidal sloughs and freshwater wetlands near mouth of Alder Creek on the Alder Creek Farm property (GIS 20).
Action 5.1 – B	Enhance tidal connectivity of McCoy (GIS 850) and Zimmerman (GIS 851) wetlands.
Action 5.1 – C	Use 2021 tide gate inventory and TNC Opti-Pass model to identify additional priorities for tidal wetland and estuarine reconnection and restoration.

<u>2045 Outcome #6</u>: 52 barriers to fish passage are addressed, enhancing longitudinal connectivity in focal area tributaries, and restoring Coho access to 92 miles of anchor habitats, cold water refugia, and off-channel habitats.

Objective 6.1 – By 2026, address nine high-priority fish passage barriers impeding access to anchor habitat in the focal areas.	
Action 6.1 – A	Improve passage through Fishhawk dam and implement temperature abatement measures – GIS 107.
Action 6.1 – B	Replace Harliss culvert #407 (high) on Cook Creek Road (assess feasibility of decommissioning Cook Creek Road) – GIS 2.
Action 6.1 – C	Replace culverts to Coal Creek tributary under Anderson Road (#188: 1.15 miles habitat, #189: .34 miles of habitat) – GIS 413.
Action 6.1 – D	Replace culvert #371 on Batterson Creek to reconnect summer refugia – GIS 701.
Action 6.1 – E	Replace culvert #285 on McPherson Creek to reconnect summer refugia – GIS 702.
Action 6.1 – F	Replace Little Rackheap culvert – GIS 700.
Action 6.1 – G	Remove/replace culvert on Fall Creek on Olympic Resources property – GIS 905.
Action 6.1 – H	Remove/replace culvert #3 (Weyerhaeuser) on Clear Creek – GIS 908.
Objective 6.2 – By 2035, partner with ODOT to upgrade ten priority culverts under state highways in SAP focal areas.	
Action 6.2 - A	Assess the feasibility of upgrading priority culverts under: <u>Highway 53</u> • culvert #529 – high priority (GIS 529) • culvert #606 – high priority (GIS 606) • culvert #562 – medium priority (GIS 562) • culvert #565 – medium priority (GIS 565) <u>Highway 101</u> • Alder Creek culvert #293 – high priority (GIS 19) • culvert #462 – medium priority (GIS 19) • culvert #175 – medium priority (GIS 415) <u>Highway 47</u> • Dass Creek culvert – high priority (GIS 903) • O'Black Creek culvert – high priority (GIS 901) Highway #26 • Rock Creek culvert and trash rack – high priority (GIS 823)

Figure 6-1. Project Recommendations in the Limiting Factors Analysis, Upper Rock Creek.

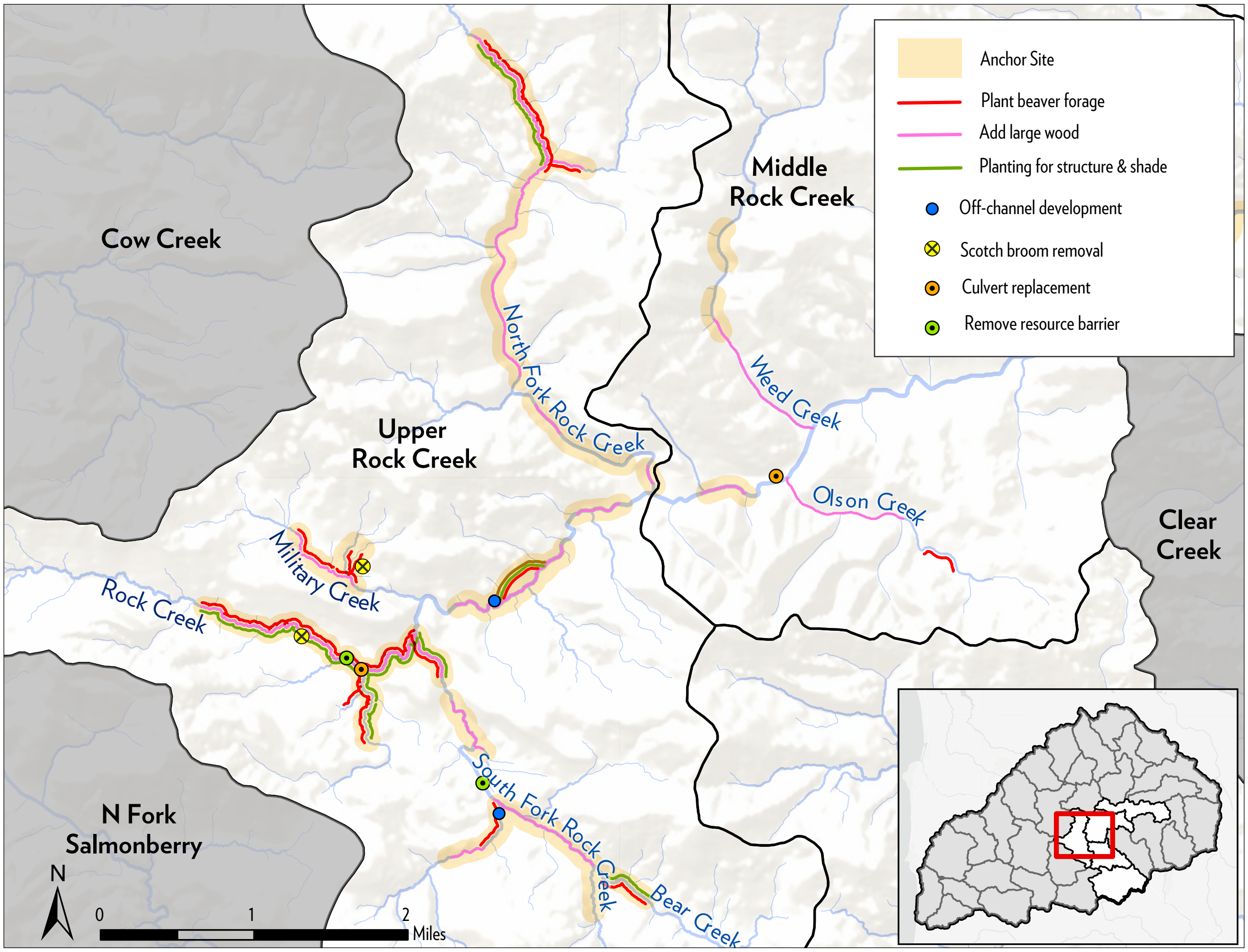
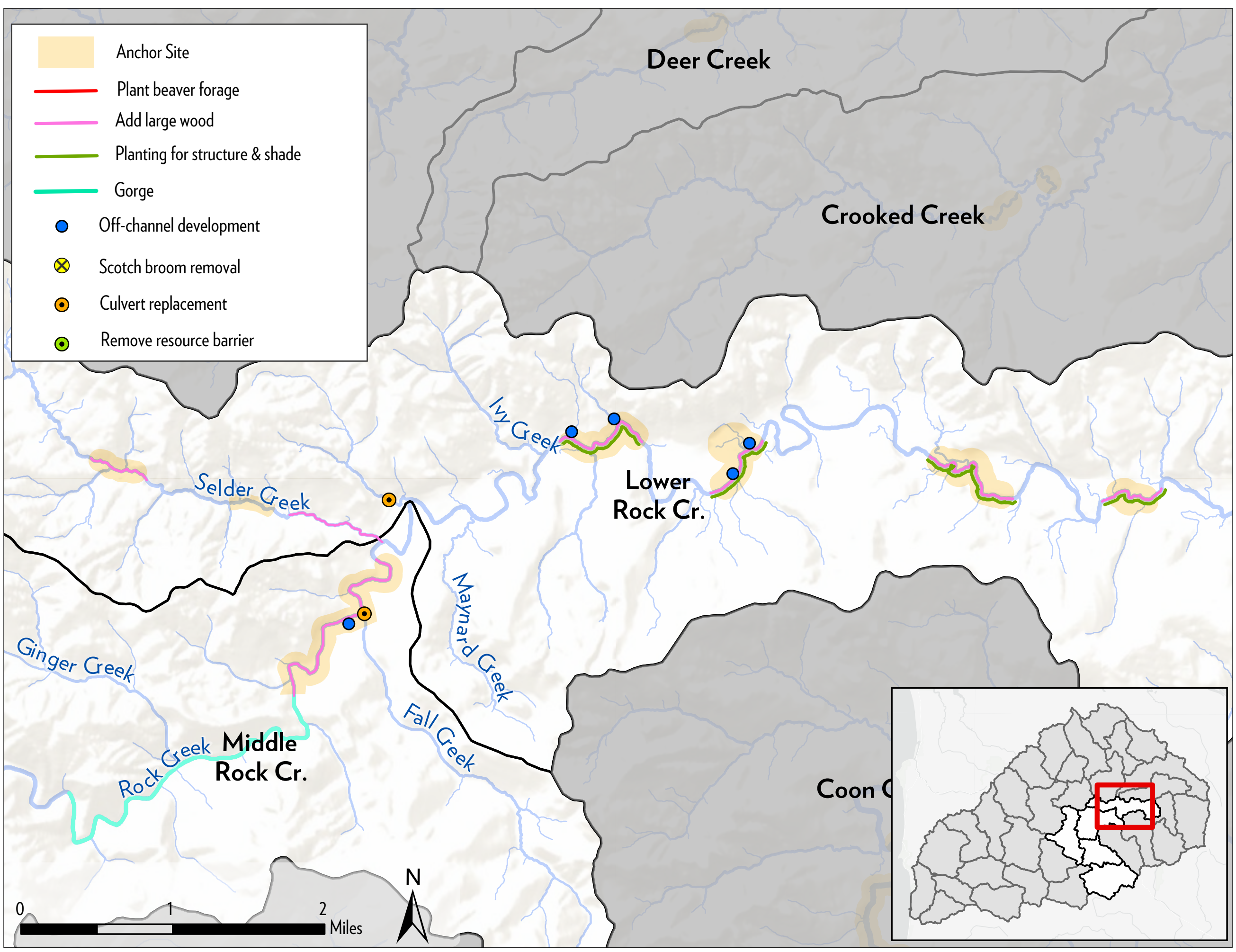


Photo: Paul Jeffrey / Alamy

Figure 6-2. Project Recommendations in the Limiting Factors Analysis, Lower Rock Creek.



6.3 Schedule of Near-Term Restoration Projects by Focal Area

Table 6-1. Implementation Schedule for Near-Term Projects (2023-2027) in the Nehalem Basin Focal Areas.

FOCAL AREA	RESTORATION PROJECT	LEAD (LANDOWNER)	Project Start		
			2023	24-25	26-27
Rock - Lousignont - Wolf	Upper Lousignont LWD	UNWC (ODF)	X		
	Wolf Creek LWD	UNWC (ODF)		X	
	BDA augmentation	UNWC (ODF)		X	
	Highway 26 culvert (feasibility)	UNWC (ODF)			X
Humbug - Fishhawk - Beneke	Fishhawk dam passage	UNWC (private)		X	
	Big Creek LWD	UNWC (Weyerhauser)		X	
	Fishhawk and Boxler Creek LWD	UNWC (ODF)		X	
	Beneke Creek LWD / riparian	UNWC (ODF)	X		
	Fishhawk riparian	UNWC (multiple)			X
	Humbug Creek (ODFW refuge)	UNWC (ODFW)			X
Small mainstem / estuary tribs	Tweedle Creek BDA, LWD, riparian (private)	UNWC (private)	X		
	Jetty Creek LWD	LNWC (Greenwood Res)	X		
	Upper Oak Ranch Creek LWD	UNWC (ODF)	X		
	Crawford Creek BDA – direct	UNWC (ODF)	X		
	Spruce Run Creek LWD	LNWC (ODF)		X	
	Fall Creek LWD	UNWC (ORM Timber)		X	
	Neah-Kah-Nie Creek LWD	LNWC (private)		X	
	Spruce Run Confluence LWD	LNWC (ODF)			X
	Cook Creek confluence LWD	LNWC (State Parks)			X
	Fall Creek fish passage	UNWC (ORM Timber)			X
	Hamilton Creek LWD	UNWC (ODF)			X
	O'Black Creek LWD	UNWC (private)			X
	Dass Creek LWD	UNWC (private)			X
	Highway 47 culverts (feasibility)	UNWC (private)			X

FOCAL AREA	RESTORATION PROJECT	LEAD (LANDOWNER)	Project Start		
			2023	24-25	26-27
North Fork Nehalem	Grand Rapids Creek LWD & BDA	LNWC (Greenwood Res)	X		
	Coal Creek riparian planting	LNWC (private)	X		
	Gravel Creek LWD	Stimson Timber			X
	Soapstone Creek LWD	LNWC (ODF)		X	
	Cold water confluence pilot	LNWC (multiple)		X	
	Little North Fork LWD	LNWC (private)			X
	Bob's Creek LWD	Stimson Timber			X
	Little Rackheap culvert replacement	LNWC (private)			X
	Coal Creek (Anderson Rd) culvert replacements	LNWC (Tillamook County Public Works)			X
	Highway 53 culverts (feasibility)	LNWC (multiple)			X
	God's Valley Creek LWD	LNWC (multiple)			X
Foley - Cook and Nehalem Bay	Harliss Creek culvert removal	LNWC (ODF)		X	
	East Foley Creek LWD and riparian planting	LNWC (ODF)			X
	Foley Creek LWD and riparian	LNWC (private)			X
	Batterson and McPherson Creek culvert replacements	LNWC (ODF, OPRD)	X		
	Zimmerman and McCoy tidal wetland reconnection	LNWC (LNCT)		X	
	Alder Creek wetland and riparian restoration	LNWC (LNCT)		X	
	Highway 101 culverts (feasibility)	LNWC (ODOT)			X
Priority anchors outside of focal areas	Upper Northrup Creek LWD	UNWC (ODF)	X		
	Buster Creek LWD	UNWC (ODF)		X	
	Crooked Creek LWD	(ORM Timber)		X	
	Clear Creek LWD & fish passage	UNWC (Weyerhauser)		X	
	LNF Clear Creek LWD	UNWC (Weyerhauser)		X	

6.4 Maps of Near-Term Actions (Projects) by Focal Area

Figures 6-3 through 6-8 map the locations of near-term (2023-2027) projects proposed in the focal areas (shown in white) and neighboring subwatersheds (light gray) (note: dark gray watersheds are contained in another figure). These projects represent the initial steps towards implementing the priorities described in Chapter 5, as mapped in Figures 5-12 through 5-16.

Figure 6-3. Near-term Projects Proposed in the Foley Creek, Nehalem Bay, and Lower North Fork Nehalem Focal Areas, and Neighboring Anderson Creek Subwatershed.

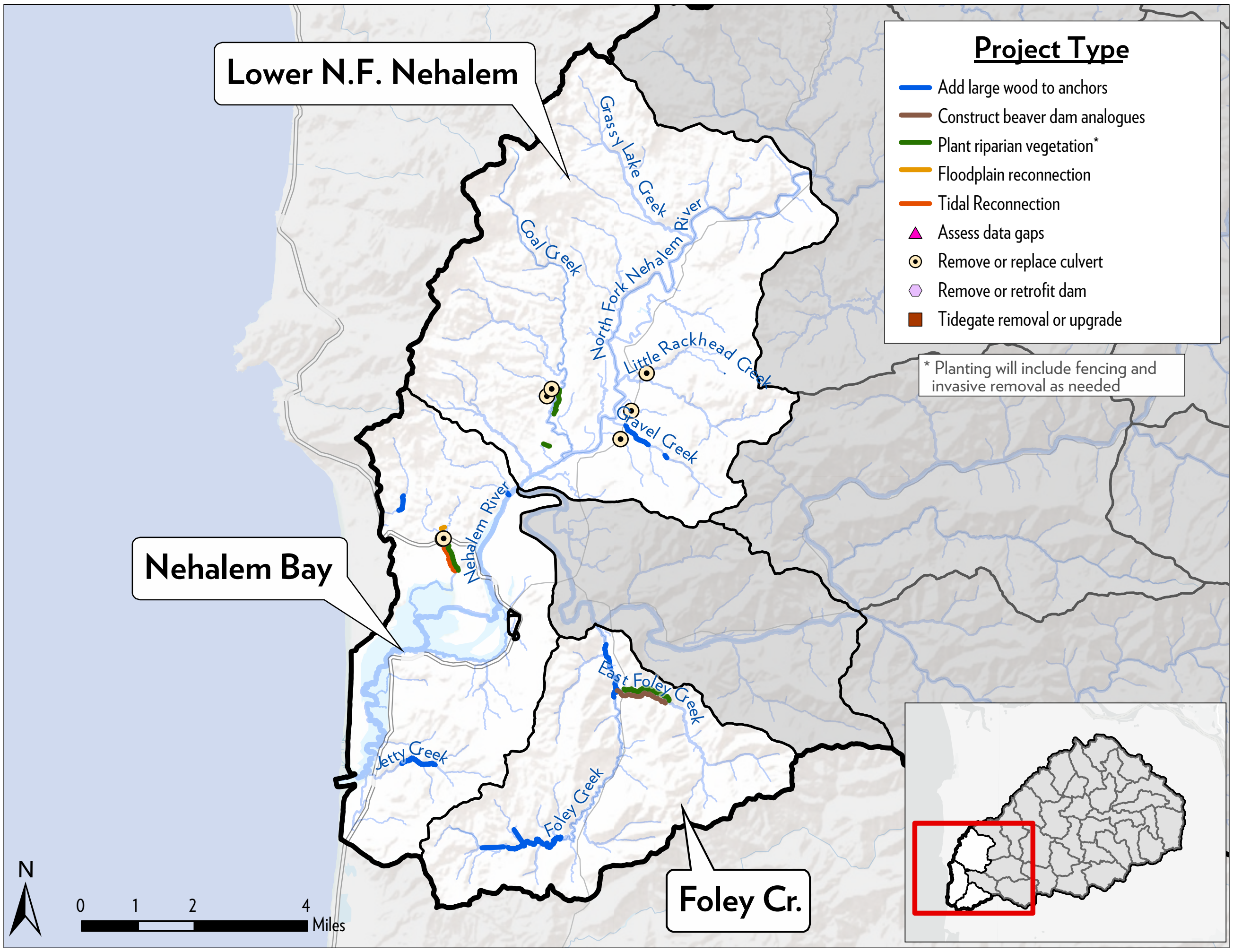


Figure 6-4. Near-term Projects Proposed in the Middle and Upper North Fork Nehalem and Humbug Creek Focal Areas, and Neighboring Cow, Cronin, and Lost Creek Subwatersheds.

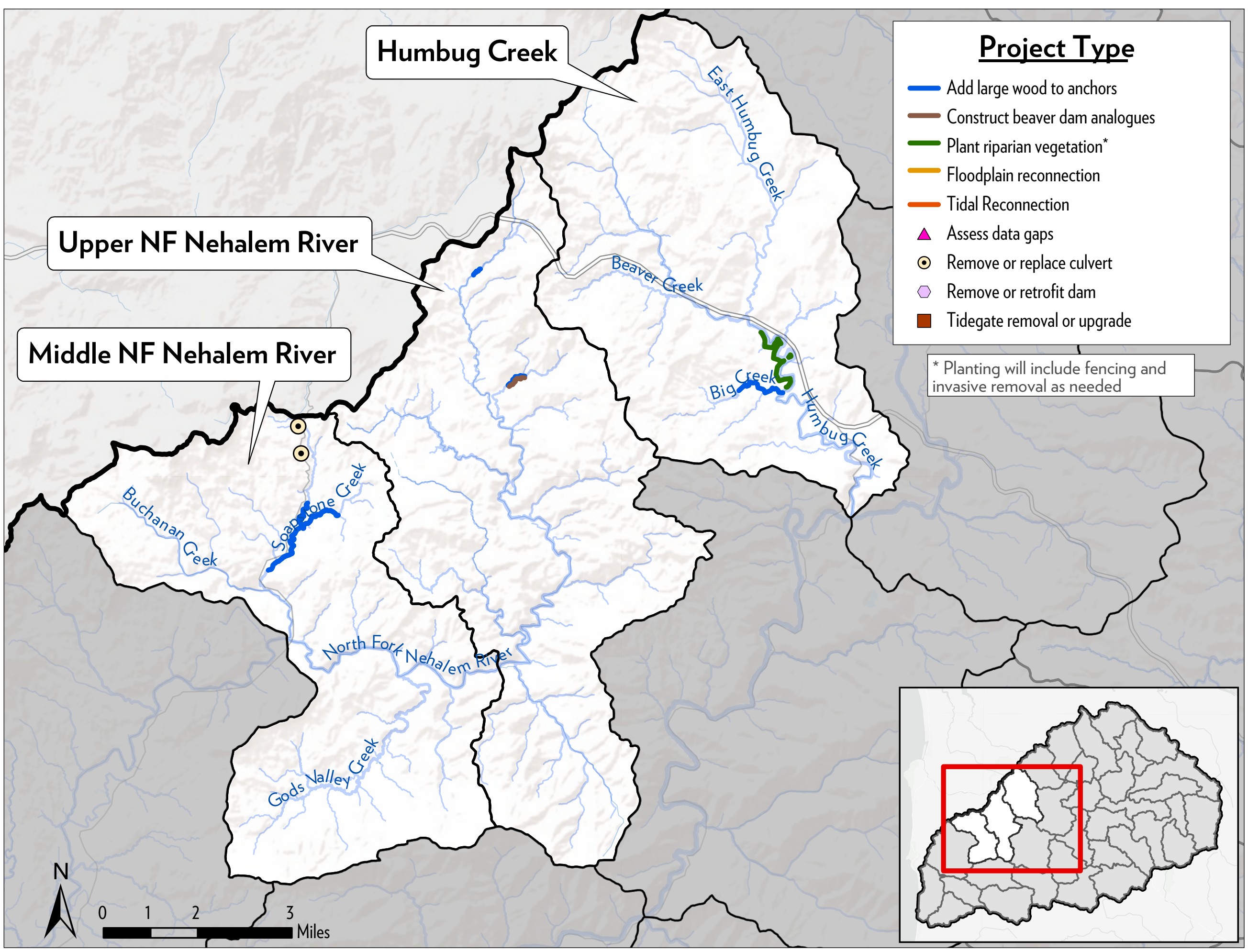


Figure 6-5. Near-term Projects Proposed in the Beneke Creek and Fishhawk Creek Focal Areas, and Neighboring Subwatersheds.

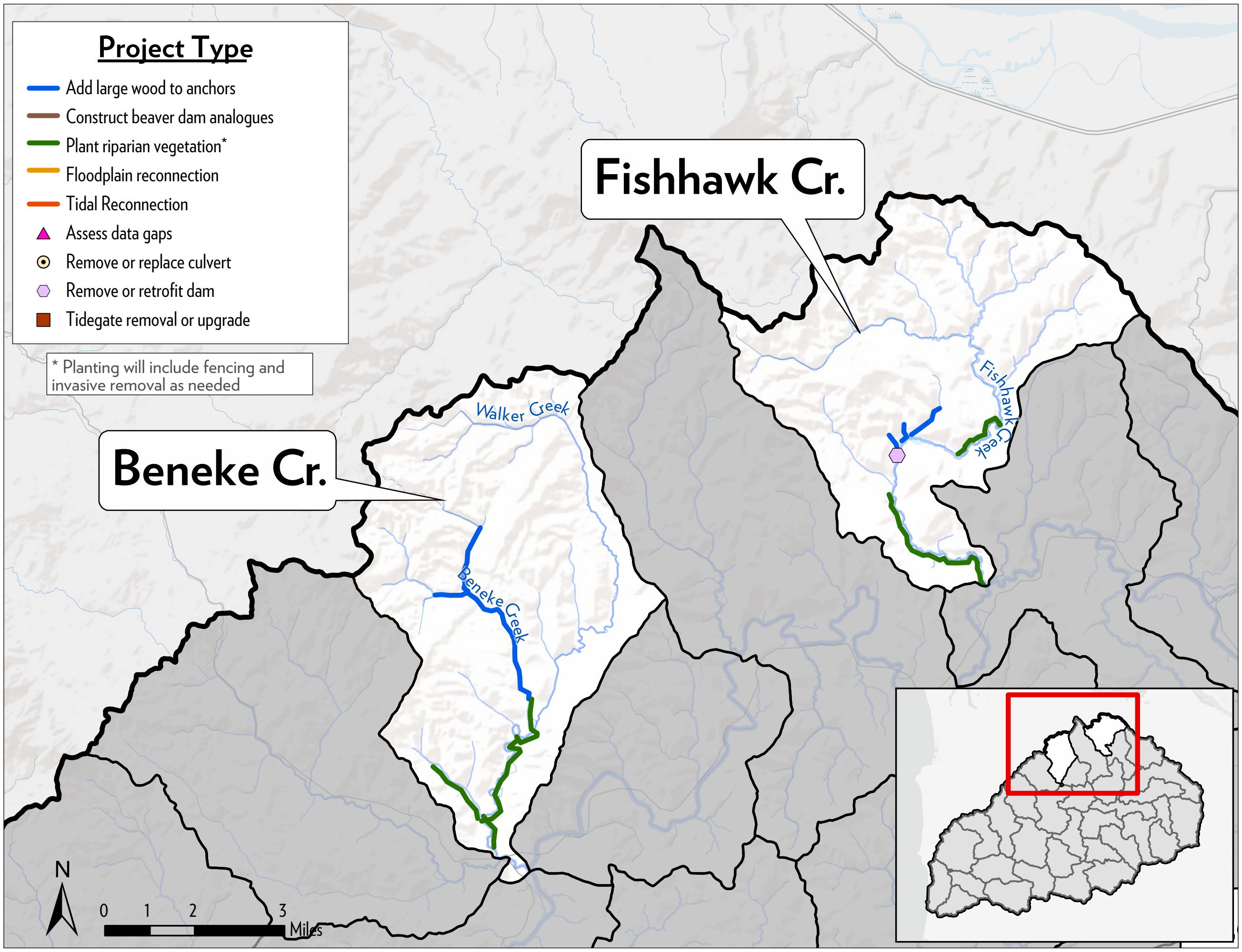


Figure 6-6. Near-term Projects Proposed in the Deer Creek and Crooked Creek Subwatersheds.

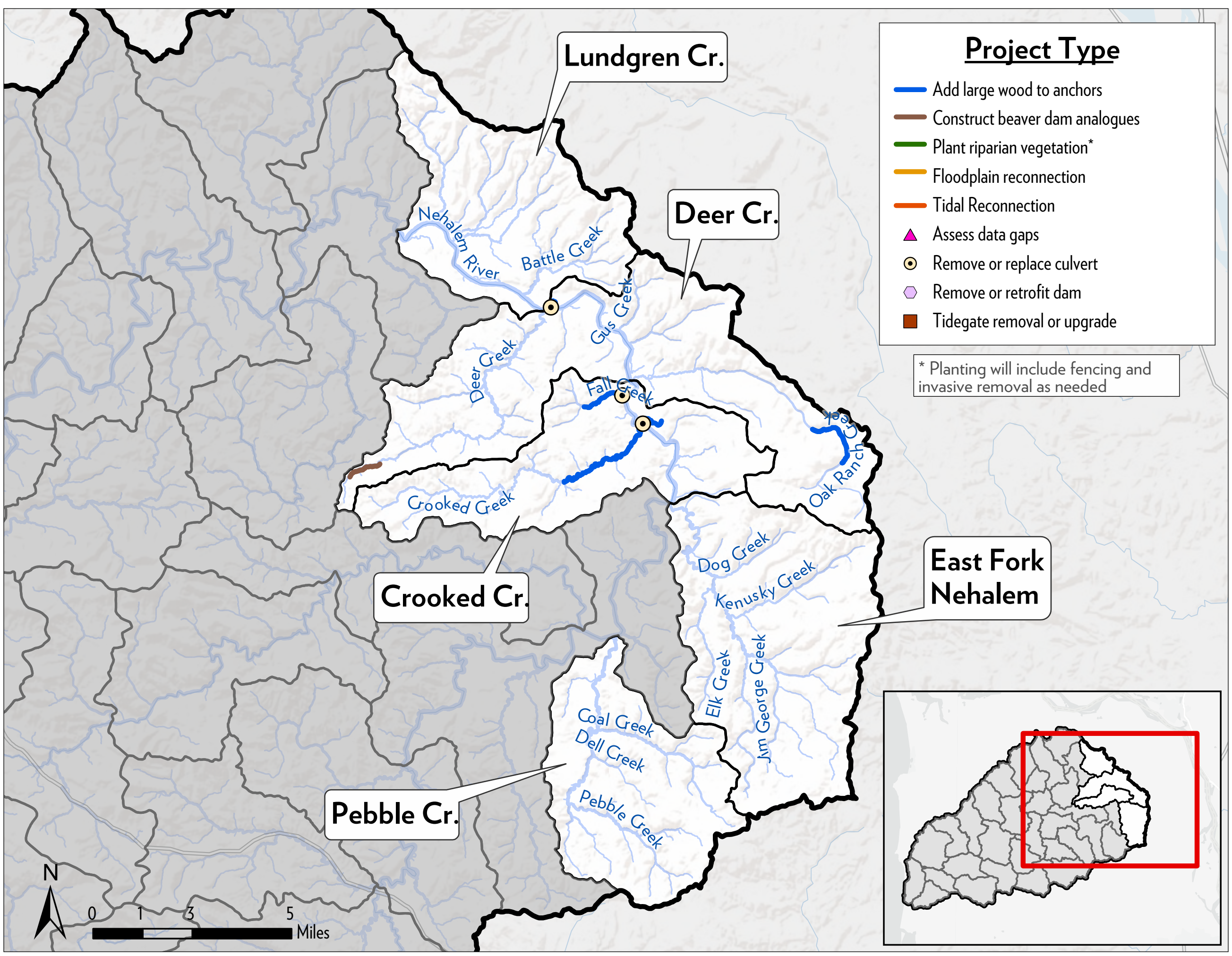


Figure 6-7. Near-term Projects Proposed in the Lower, Middle, and Upper Rock Creek, Wolf Creek, and Lousignont Creek Focal Areas, and Neighboring Clear Creek and Coon Creek Sub-watersheds.

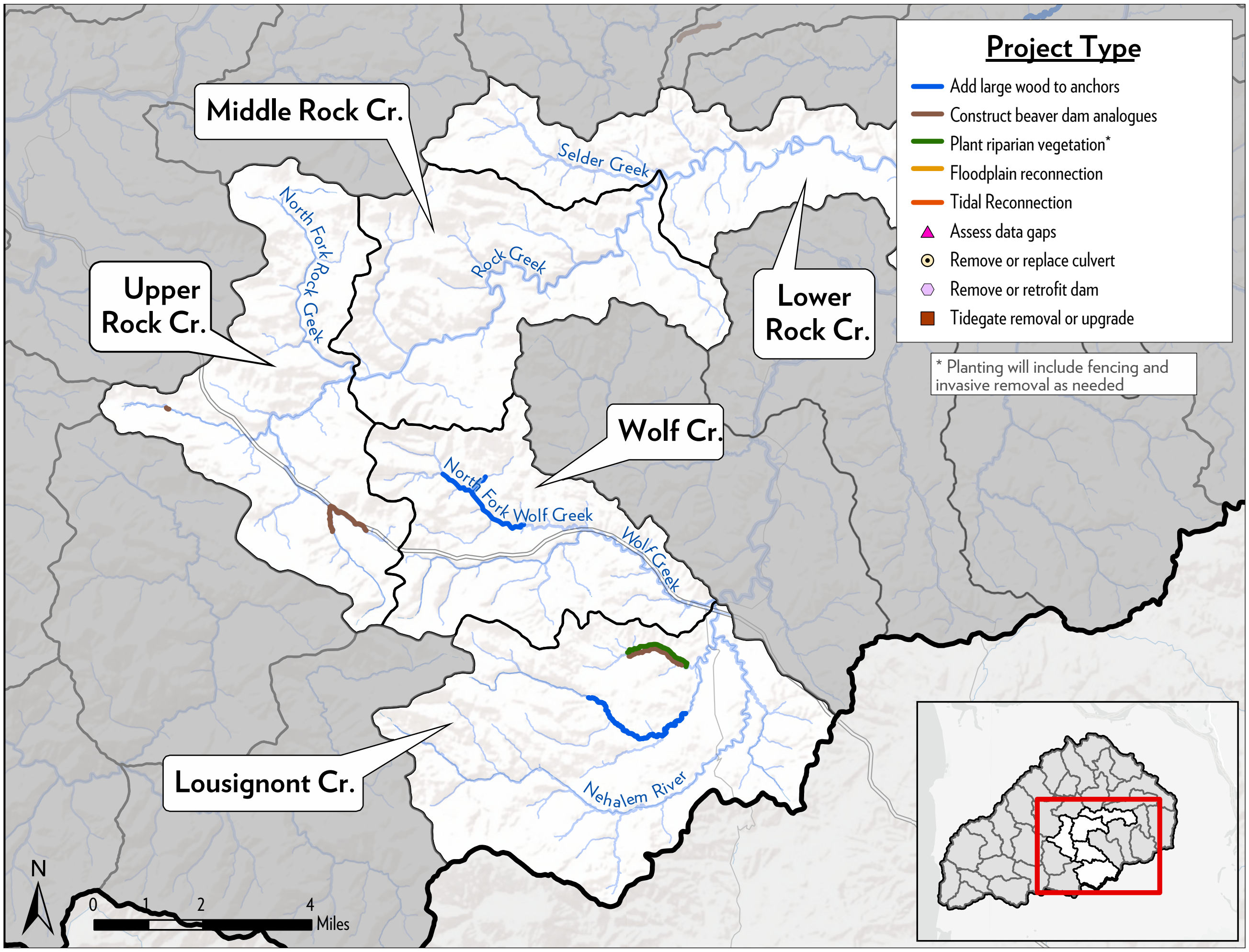
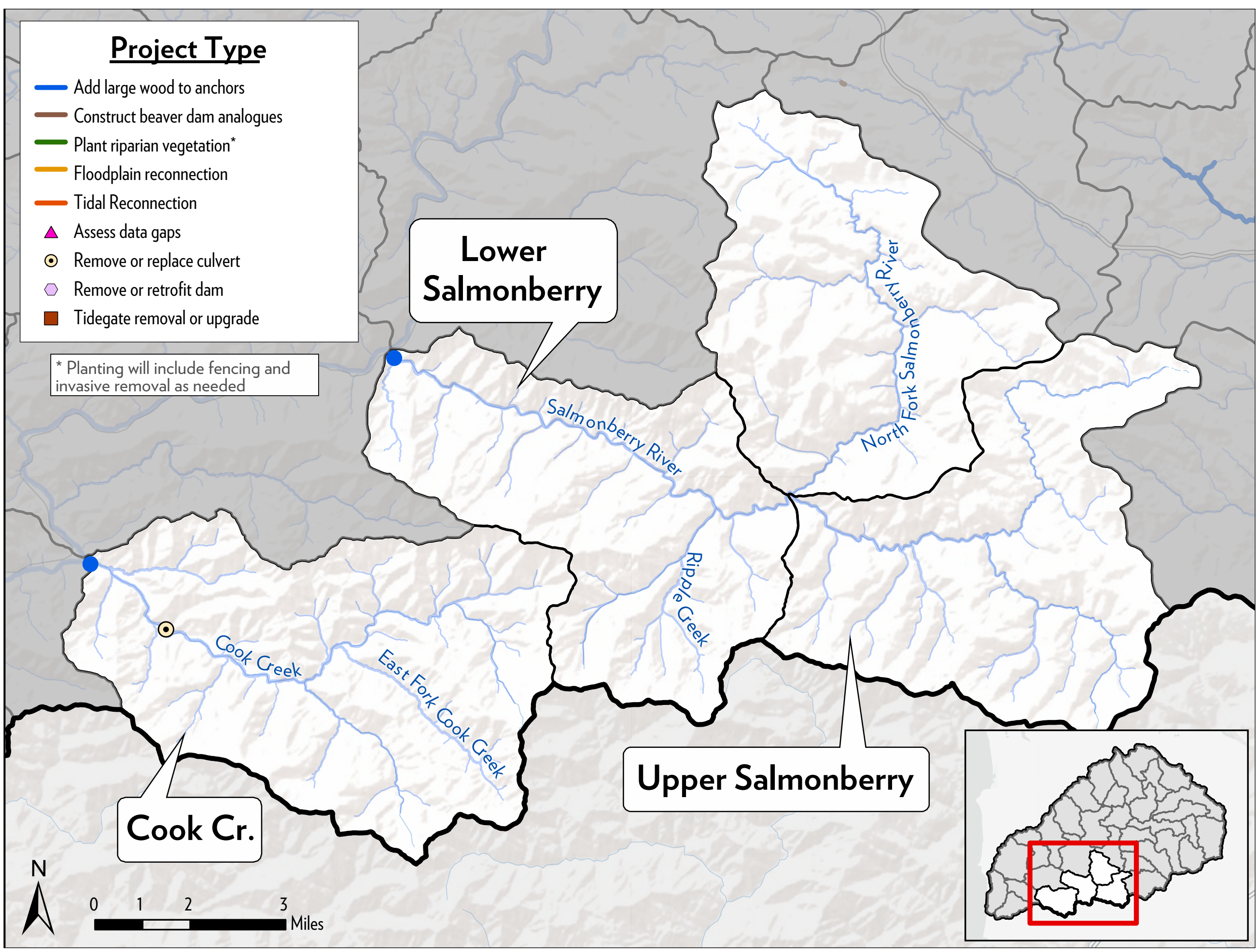


Figure 6-8. Near-term Projects Proposed in the Cook Creek-Salmonberry Focal Area.



Chapter 7

Evaluation and Adaptive Management

The Nehalem Partnership recognizes that an adaptive management approach is essential to the long-term success of this plan. Section 7.1 presents a Monitoring Framework that partners will use to evaluate: 1) the rate at which the SAP is implemented, and 2) whether implementation is generating the anticipated benefits. This chapter concludes with a list of critical data gaps that, as filled, can support the adaptive implementation of this plan.

7.1 The Monitoring Framework

Table 7-1 below presents the Monitoring Framework for the Nehalem Partnership to monitor SAP implementation and effectiveness. This framework is constructed around the SAP's six outcomes. Next to each outcome statement, the table defines the two types of monitoring, implementation monitoring and effectiveness monitoring, that should be conducted.


Photo: Ronald Hope

Implementation monitoring seeks to assess the rate at which the SAP is being implemented. The columns on the left side of the goal statement list priority project locations and project tracking metrics that partners can use to evaluate the degree to which SAP implementation is occurring. Broadly, these metrics are intended to answer the question, "Is the SAP being implemented at the desired pace and scale?"

Effectiveness monitoring aims to assess whether SAP implementation is producing the desired benefits. The columns to the right of the goal statements show: 1) the KEAs that partners seek to improve for a particular habitat component; 2) the indicator(s) used to assess the KEA; and 3) related notes. Evaluation of these KEAs using the selected indicators helps answer the question, "Are we moving towards our stated goals and desired outcomes?"

Note: many of the KEAs and indicators presented in Table 7-1 were derived from the common framework, but represent only those deemed by the Planning Team as the highest priority and most likely to reflect improving (or declining) watershed conditions for Coho. For a complete list of KEAs and indicators considered in this process, please refer to the 'Common Framework' in Appendix 3.

Currently, the Nehalem Partnership's capacity to apply the Monitoring Framework below is limited. Consequently, the purpose of this chapter is not to present a full monitoring plan (which is unlikely to be implemented), but to suggest a framework that aligns with SAP goals and can be selectively developed over time. The Nehalem Partnership recognizes the considerable limitations on funding now available for monitoring and will develop specific plans for each of the KEAs as priorities dictate and funds allow.

Table 7-1. Nehalem Monitoring Framework.

SAP Monitoring Framework					
Implementation Monitoring – *Are the SAPs being implemented?*			Effectiveness Monitoring – *Is SAP implementation having the intended effects? Are we moving towards our goals?*		
SAP Priority Locations for Projects	**Implementation Metric**	**SAP 2045 OUTCOMES**	**Key Ecological Attribute (component)**	**Effectiveness Indicator (preferred in bold)**	**Location to Monitor & Notes**
Priority timber stands in focal areas	• Number of sites placed under easement or administrative protection (review at 10-year increments) • Acres or lineal distance of high priority runout zones acquired or placed under easement • Acres of high priority stands harvested (if any)	**2045 Outcome #1** ***The long-term potential for large wood delivery to anchor habitats is improved through the protection of 536 acres of selected timber stands throughout the Nehalem basin (343 acres in focal areas).***	Landscape array of structural diversity (uplands) Habitat complexity (tributary)	• Amount of large wood available to be recruited to rivers and streams through watershed processes. • Amount of large wood remaining in rivers and stream that is effectively increasing complexity and high quality habitat. • **% of anchor habitats with increasing trends in extent of spawning gravel (m2).** • **% total channel area represented by secondary channels (CAP) in anchor habitats** • **% of treated anchor habitats with improving width: depth ratio (use AQI protocol)** [1,2]	Anchor habitats and identified upland debris flow areas within Rock Creek and NF Nehalem. Anchor habitats and identified upland debris flow areas within Rock Creek and NF Nehalem.
Anchor sites in focal areas	• Lineal feet of anchor habitats treated with LWD. • Lineal feet of areas treated outside of anchors.	**2045 Outcome #2** ***Instream complexity and stream interaction with off-channel habitats are restored within 66 miles of focal area anchor habitats.***	Habitat complexity (tributary)		

[1] Nehalem Monitoring Framework included the following list of AQI metrics:

- Miles of high-quality habitat: produce 2,800 smolts/mile.
- % stream reach that is pool habitat
- % of stream reach that is slack water pool habitat
- % pools greater than 1 meter in depth
- # of wood pieces per 100m of stream
- # of key wood pieces (>12m long, 0.60 m dbh)
- Volume of LWD per 100 m
- # alcoves per reach

[2] Entrenchment indicator references:

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SAP Monitoring Framework					
Implementation Monitoring – *Are the SAPs being implemented?*			**Effectiveness Monitoring –** *Is SAP implementation having the intended effects? Are we moving towards our goals?*		
SAP Priority Locations for Projects	**Implementation Metric**	**SAP 2045 OUTCOMES**	**Key Ecological Attribute (component)**	**Effectiveness Indicator**	**Location to Monitor & Notes**
Priority sites identified in focal areas	• Acres planted • % of anchor sites planted when LWD treatments occur • % of sites planted that were identified (by Netmap) as high priority to improve temperature	**2045 Outcome #3** ***Riparian function is restored along 58 miles of focal area tributaries, reducing stream temperatures and erosion, increasing macro-invertebrate abundance, and increasing the long-term potential for large wood recruitment.***	Water temperature (mainstem and tributaries)	**• Total # of days where monitoring locations exceed temperature standards (DEQ 7day running Average Max)** **• Number of consecutive days exceeding 18°C temperature** **• Presence of a thermal barrier in the mainstem that prevents migration of fish during warm periods (7-day moving mean of daily summer max temp is < 20°C) (CAP)**	1) all focal areas; 2) key tribs and mainstem (to further determine where the problem tribs are); and 3) small 1st and 2nd order tribs offering thermal refugia (to further determine locations of these unique habitat types. *Note: Fly FLIR to find thermal barriers at low flow)*
All focal areas	• lineal feet of riparian areas treated in priority beaver recruitment areas (assumes beaver-friendly species planted) • # of BDA or dam- building support structures added to priority beaver areas	**2045 Outcome #4** ***Beavers colonize and build dams on an additional 40 miles of Coho-bearing tributaries in the focal areas, increasing the quality and quantity of off-channel habitats available for Coho rearing.***	Beaver ponds (off-channel)	**• % of areas identified as 'high potential for beaver' that have beaver impoundments present** *(Note: impoundments must be >12inches high and with different water elevations up and down-stream of dam)*	Monitor for presence/ absence and count impoundments. Baseline data in Upper Nehalem. Gather baseline data in other beaver priority areas and continue monitoring. Data should be collected in February when dams are likely to blow out.

SAP Monitoring Framework					
Implementation Monitoring – *Are the SAPs being implemented?*			Effectiveness Monitoring – *Is SAP implementation having the intended effects? Are we moving towards our goals?*		
SAP Priority Locations for Projects	**Implementation Metric**	**SAP 2045 OUTCOMES**	**Key Ecological Attribute (component)**	**Effectiveness Indicator**	**Location to Monitor & Notes**
• Anchor habitat in tribs in focal areas • Entire mainstem • All tidal areas contained in Lower NF Nehalem, Foley, Cook, & Nehalem Bay	• Number of floodplain reconnection projects completed • Acres of wetlands acquired or placed under easement (review at 10-year increment). • Acres of tidal wetland / slough and nontidal areas reconnected • Acres of wetlands converted to other uses (if any) – use DSL permits • Percentage of high priority sites reconnected (Brophy et al 2005, Figure 5-9)	**2045 Outcome #5** ***300 acres of tidal wetlands and other estuarine habitats are reconnected, increasing the quality and extent of tidal rearing habitats and associated freshwater habitats.***	Tidal connectivity (estuary)	• **Acres of wetland relative to historic condition** • **% of wetlands subject to disrupted hydrologic connectivity** • **% of identified high priority refugia areas restored and/or protected** • **Distribution of habitat types relative to historic condition (per HGM)** [3]	*Review/conduct aerial surveys for lowland areas.* *Review Coastal and Marine Ecological Classification (CMECS) and Coastal Change Analysis Program (C-CAP) data*
• Anchor habitats in focal areas • Entire mainstem • All tidal areas contained in Lower NF Nehalem, Foley, Cook, & Nehalem Bay	• # of barriers addressed and crossings made accessible to fish passage (e.g. tide gates and culverts). • Acres of tidal wetland / slough and non-tidal areas reconnected	**2045 Outcome #6** ***52 barriers to fish passage are addressed, enhancing longitudinal connectivity in focal area tributaries, and restoring Coho access to 92 miles of anchor habitats, cold water refugia, and off-channel habitats.***	Longitudinal connectivity (tributaries) Off-channel habitat (tributaries) Extent of habitat (estuary)	• **Coho distribution above baseline**	All focal areas

[3] Hydrogeomorphic (HGM) Assessment Guidebook, a Rapid Assessment Guidebook for Tidal Wetlands. A method that may be applied during a single visit to assess indicators of the functions and condition of a particular tidal wetland relative to others of its subclass. http://www.oregon.gov/dsl/WW/Documents/tidal_HGM_pt1.pdf

The Planning Team recognizes the magnitude of the challenge faced in detecting habitat responses at the subwatershed scale from the implementation of actions contained in this SAP. As stated in the Oregon Coast Coho Conservation Plan (ODFW 2007), "restoration of ecological processes that support high-quality habitat requires time and is constrained by patchwork landownership patterns, different regulatory structures, and historical land use practices. Even given an expected increase in the level of non-regulatory participation in habitat improvement work, it will take time to: (1) produce detectable improvements in habitat quality, and (2) restore the biological and ecological processes across the ESU." This Monitoring Framework will serve as a blueprint that local partners can use to build incremental and scalable monitoring plans that track both SAP implementation and progress towards its goals.

7.2 Data Gaps

During the course of developing this SAP, the planning team identified several data gaps that the Nehalem Partnership will work to fill through the development of future monitoring plans. The following summarizes the highest priority data gaps.

1) Life history diversity. This SAP is the first restoration plan developed in the Nehalem Basin that considered the multiple life history types believed to be present in the population (Appendix 2). The plan identifies focal areas and recommends restoration strategies based on six unique life history types, which were derived largely from assessments of watershed lithology, habitat features, and juvenile habitat use. Partners should refine this list by collecting otolith samples and water chemistry to test these hypothesized life history types. The Coast Coho Partnership is working with partners on the mid and south coasts to collect and analyze otoliths to more fully understand Coho life histories. The Nehalem Partnership

Photo: Danita Delimont / Alamy

will review the results of these pilot projects and will consider implementing a similar or modified program.

2) Water temperature. Temperature data reviewed in the development of the SAP indicates that elevated water temperatures in the mainstem Nehalem and the lower reaches of many tributaries limit juvenile migration, eliminating access to critical habitats. The projected impacts of climate change will exacerbate this problem. A Salmon Trout Enhancement Program (STEP) report on temperature monitoring in the Salmonberry undertaken between 1994 - 1997 and 2007 - 2018 indicates that climate-driven increases in water temperature are already underway. Findings show a trend of increasing summer average daily high temperatures at a rate of .068° C ± .04° C annually (p=.002) (Fergusson 2019).

The trends found in the Salmonberry River indicate that both the extent of cold water refugia and access to key areas will become increasingly limited. While the locations of many of the SAP's restoration strategies (e.g., riparian enhancement, anchor habitat restoration, and fish passage reconnection) are driven by temperature considerations, additional data is needed to refine these priorities. Temperature data collection priorities include the following.

First, review temperature data collection recommendations and identify priorities. During the development of this SAP, WSC hired PC Trask to review existing temperature data and make recommendations on additional data collection priorities. The Nehalem Partnership will begin the development of a temperature monitoring program with a review of these recommendations, which focus largely on: 1) validating relationships between elevated mainstem temperatures and tributary contributions of warm water, and 2) potential locations of thermal refugia. These outputs, which may refine some of the priorities presented in this SAP, will rely on

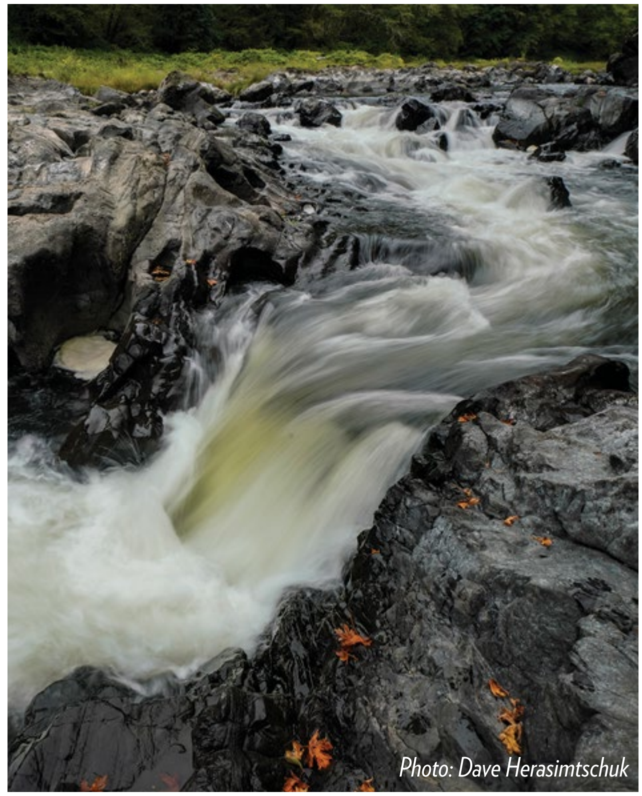

Photo: Dave Herasimtschuk

a basin-wide inventory of flow and temperature contributions basin-wide.

Second, identify and monitor cold water refugia throughout the entire Nehalem watershed. Bio-Surveys LLC (2020) identified tributaries in the lower Nehalem watershed that provide critical cold water contributions or thermal refugia to juveniles. Ongoing monitoring of identified locations should be undertaken to refine the list. This project should also be expanded to include the upper Nehalem watersheds.

Third, continue to support and expand, as needed, annual temperature surveys conducted in the Salmonberry River. Characterized by steep slopes underlain with erosion-resistant volcanic rock, the Salmonberry River is the largest source of cold water in the basin. The tributary's cold water contributions in summer are essential to maintaining the temperature of the lower mainstem. Increasing water temperatures in the Salmonberry and a potential reduction in cold water habitat are important indicators of thermal challenges throughout the basin. STEP data from the Salmonberry provides one of the longer records of collected temperature data in the basin. It's important to maintain and expand these data sources.

3) Fish passage priorities. Extensive efforts have been made to identify and prioritize fish passage barriers in the Nehalem River basin. In addition to the ODFW fish passage barrier list, the Upper and Lower Nehalem Watershed Councils have completed culvert inventories, tide gate inventories, and identified barriers in Rapid Bioassessments and Limiting Factor Analyses. Important data gaps remain, however, that should be addressed.

First, survey mainstem Type N tributaries in winter, and identify culverts with restricted fish passage. Many small mainstem tributaries are disconnected from juvenile fish passage in the summer and, therefore, identified as non-fish bearing (Type N) following summer habitat surveys. Many of these tributaries are reconnected to the mainstem in high water and offer important flow refuge in winter. However, impassable culverts (often just upstream from the confluence with the mainstem) limit juvenile access to flow refuge. According to one ODFW biologist, "these tributaries that are a trickle in summer may have dozens of juveniles sitting in pools below culverts in winter. There is ideal winter habitat upstream, but juveniles are not able to pass through the culvert due to high water velocity." These Type N mainstem tributaries should be re-surveyed in winter flow conditions. Where fish are present and culverts are blocking upstream migration, pipes should be added to the ODFW inventory.

Photo: Barrie Kovish

Second, prioritize tide gates in the lower watershed using the TNC OptiPass model. In 2021, the LNWC and TNC completed an inventory of tide gates in the Nehalem Bay and its tidal sloughs and tributaries. Application of the TNC OptiPass model can help prioritize replacement or removal of these gates. Modelers are encouraged to consider the priorities established in this plan alongside the OptiPass results when prioritizing tide gate upgrades. These include such factors as the extent of anchor habitat available upstream, access to cold water refugia in summer, tidal wetland priorities (Figure 5-9), and riparian restoration priorities.

Third, prioritize barriers that restrict juvenile access to cold water tributaries. As described in this plan, access to cold water refuge is going to be increasingly important to ensure the viability of the Nehalem Coho population. The fish passage barriers presented in this plan for replacement were driven largely by assessments of fish use below the barriers and the extent of anchor habitat potentially accessible upstream. While access to cold water refugia was considered, limited data did not allow for a basin-wide assessment of barriers to cold water refuge. As TEP, DEQ, and the watershed councils partner on temperature data collection, it is essential that the data generated are used to update the fish passage barriers presented in this plan.

Chapter 8

Costs

This chapter estimates the costs associated with executing the projects proposed in Chapter 6. The estimated project costs shown in Tables 8-1 through 8-6 are organized by outcome. Table 8-7 summarizes the overall estimated costs in the upper and lower watersheds according to restoration project type.

These costs were generated by reviewing comparable costs in the Oregon Watershed Restoration Inventory (OWRI) database and those associated with implementing similar projects in the Nehalem River area by local restoration practitioners. Several data points for maximum costs were left out of the OWRI results because they were not relevant to the Nehalem River watershed.

Where projects were far enough along in the planning process to have verified cost estimates, these cost estimates were used in the cost summary. Where project-specific cost estimates were not available, estimates were made based on project type. For floodplain reconnection and off-channel restoration projects, estimates from other projects with a similar level of complexity were scaled to the size of the proposed project. For instream complexity projects, estimates were generated by multiplying mileage calculated from GIS by an average cost per mile. For riparian enhancement projects, estimates were made by multiplying acreage by a mid-range cost per acre estimate. The riparian enhancement acreages were estimated by multiplying stream miles (calculated using GIS) proposed for treatment times 50 feet, which approximates the average buffer width treated watershed-wide over the last several years.

Table 8-1. Short-Term Project Costs for Outcome 1: Upland Sites to Protect (2023-2027).

Action	Lead	Project	Cost
1.1 – A	UNWC & LNWC	Review map of priority timber stands with ODF and Weyerhaeuser to determine feasibility and cost of protection. Develop initial list of sites deemed opportunities for protection.	$ 25,000
1.1 – B	UNWC & LNWC	Review map of priority timber stands with all other public and private forest owners. Identify protection opportunities.	15,000
1.1 – C	WSC	Support voluntary protection of priority upland stands through implementation of the Forest Accords in the Nehalem Basin.	100,000
		Total	**$140,000**

Table 8-2. Short-Term Project Costs for Outcome 2: Increased Instream Complexity (2023-2029).

Action	Lead	Project	Cost
2.1 – A	UNWC	Add LWD to 4.1 miles of Beneke Creek LWD	$ 164,000
2.1 – B	UNWC	Add LWD to 2.4 miles of NF Wolf Creek	96,000
2.1 – C	UNWC	Add LWD to 1.3 miles of Fishhawk and Boxer Creeks	52,000
2.1 – D	UNWC	Add LWD to 2.9 miles Hamilton Creek	116,000
2.1 – E	UNWC	Add LWD and re-meander 0.8 miles of Dass Creek	32,000
2.1 – F	UNWC	Add LWD to 0.3 miles of O'Black Creek	12,000
2.1 – G	UNWC	Add LWD to 1.4 miles of Fall Creek	56,000
2.1 – H	UNWC	Add LWD to 1 mile of anchor habitats on Big Creek	40,000
2.1 – I	UNWC	Add LWD to 2.8 miles of Upper Lousignont Creek	112,000
2.1 – J	LNWC	Add LWD to 0.7 miles of Jetty Creek	28,000
2.1 – K	LNWC	Add LWD to 2.2 miles of Foley Creek	88,000
2.1 – L	LNWC	Add LWD to 0.3 miles of Upper Neah-Kah-Nie Creek	12,000
2.1 – M	LNWC	Add LWD to 2.6 miles of Soapstone Creek	104,000
2.1 – N	LNWC	Add full spanning LWD to 0.3 miles of Spruce Run Creek	12,000
2.1 – O	LNWC	Add LWD to 0.4 miles of Grand Rapids Creek	16,000
2.1 – P	LNWC	Add LWD to 0.7 miles of Gravel Creek	28,000
2.1 – Q	LNWC	Add LWD to 0.2 miles of the Little North Fork Nehalem	8,000
2.1 – R	UNWC	Add LWD to 1.7 miles of Upper Oak Ranch Creek	68,000
2.1 – S	LNWC	Add LWD to 0.1 miles of Bob's Creek	4,000
2.1 – T	LNWC	Add LWD to 1.5 miles of East Foley Creek	60,000
2.1 U-Y	LNWC	Add LWD to 4.9 miles of Gods Valley Creek and tributaries	296,000
2.1 – Z	LNWC	Add LWD to the Salmonberry-mainstem	450,000
2.1 – AA	LNWC	Add LWD to the Cook Creek-mainstem	250,000
2.1 – BB	LNWC	Add LWD to the Spruce Run-mainstem confluence.	300,000
2.2 – A-B	UNWC	Engage Rock Creek landowners and determine implementation schedule	25,000
2.3 – A	UNWC	Add LWD to 0.9 miles of Buster Creek	36,000
2.3 – B	UNWC	Add LWD to 3.3 miles of Crooked Creek	132,000
2.3 – C	UNWC	Add LWD to 1.4 miles of Upper Northrup Creek	56,000
2.3 – D	UNWC	Add LWD to 1.2 miles of Clear Creek	48,000
2.3 – E	UNWC	Add LWD to 0.2 miles of lower North Fork Clear Creek	8,000
		Total	**$2,709,000**

Table 8-3. Short-Term Project Costs for Outcome 3: Enhanced Riparian Function (2023-2027).

Action	Lead	Project	Cost
3.1 – A	UNWC	Plant 3.9 miles of riparian vegetation on Fishhawk Creek	$ 70,200
3.1 – B	UNWC	Plant 2.3 miles of riparian vegetation on Humbug Creek	41,400
3.1 – C	UNWC	Augment riparian plantings on 5 miles of Beneke tract of Jewel Meadows Wildlife Area	62,500
3.1 – D	UNWC	Plant riparian vegetation on 0.9 miles of Tweedle Creek	16,200
3.1 – E	LNWC	Plant 0.6 miles of riparian vegetation on Coal Creek	10,800
3.1 – F	LNWC	Plant 0.7 miles of riparian vegetation on Alder Creek and tributary	25, 000
3.1 – G	LNWC	Plant 1 mile of conifer understory on East Foley Creek	18,000
3.2 – A - B	LNWC / UNWC	Plant native species at BDA and LWD sites – Costs included in LWD/BDA estimates	0
		Total	**$219,100**

Table 8-4. Short-Term Project Costs for Outcome 4: Increased Beaver Colonization (2023-2027).

Action	Lead	Project	Cost
4.1 – A	UNWC	Construct BDA on lower Tweedle Creek	$ 10,000
4.1 – B	UNWC	Construct BDAs on Crawford Creek	20,000
4.1 – C	LNWC	Construct BDAs on Grand Rapids Creek	20,000
4.1 – D	UNWC	Augment BDAs installed in Lousignont, Buster/Walker, Bear, Rock, and Deer Creeks	30,000
4.1 – E	UNWC	Plant beaver preferred forage at BDA sites	50,000
4.1 – F	UNWC	Determine the feasibility and locations of BDAs for upper mainstem Beneke Creek and ODF lands on Wolf Creek	5,000
4.2 – A	UNWC	Host beaver forum with major timber owners, including Weyerhaeuser, Stimson, and Olympic Resource Management	10,000
4.2 – B	UNWC	Ground truth Netmap-modeled High Beaver IP for sub-watersheds that were not completed in this SAP	7,500
4.2 – C	UNWC	Implement a local outreach campaign focused on public education regarding the role of beavers	20,000
		Total	**$172,500**

Table 8-5. Short-Term Project Costs for Outcome 5: Reconnected Tidal Habitats (2023-2027).

Action	Lead	Project	Cost
5.1 – A	LNCT	Create tidal sloughs and freshwater wetlands near mouth of Alder Creek on the Alder Creek Farm property (design/engineering/feasibility costs only)	$ 75,000
5.1 – B	LNCT	Reconnect Bott's, McCoy, and Zimmerman wetlands (design/engineering/feasibility costs only)	100,000
5.1 – C	LNWC	Use recently completed tide gate inventory to identify additional priorities for tidal wetland and estuarine reconnection and restoration	20,000
		Total	**$195,000**

Table 8-6. Short-Term Project Costs for Outcome 6: Increased Longitudinal Connectivity (2023-2027).

Action	Lead	Project	Cost
6.1 – A	Fishhawk Lake Team	Improve passage through Fishhawk dam and implement temperature abatement measures	Site assessments and initial designs required for cost information
6.1 – B	ODF	Replace Harliss culvert #407 (high) on Cook Creek Road (explore feasibility of decommissioning Cook Creek Road)	
6.1 – C	LNWC	Replace culverts to Coal Creek tributary under Anderson Road (#188: 1.15 miles habitat, #189: .34 miles of habitat)	
6.1 – D	LNWC	Replace culvert #371 on Batterson Creek to reconnect summer refugia	
6.1 – E	LNWC	Replace culvert #285 on McPherson Creek to reconnect summer refugia	
6.1 – F	LNWC	Replace Little Rackheap culvert	
6.1 – G	UNWC	Remove/replace culvert on Fall Creek on Olympic Resource Management property	
6.1 – H	UNWC	Remove/replace culvert #3 on Clear Creek	
6.2 – A	UNWC and LNWC	Partner with ODOT to assess the feasibility of upgrading culverts under state highways in focal areas	$200,000
		Total	**N/A**

Table 8-7. Short-Term Project Objectives and Costs by Outcome.

	Long-Term Outcomes (2045)	Short-Term Objectives (2023-2027)	Short-Term Cost
1	Large wood delivery to anchor habitats is safeguarded through the protection of 536 acres of selected timber stands throughout the Nehalem basin (343 in focal areas).	• Engage all landowners in protection of priority areas	$ 140,000
2	Instream complexity and stream interaction with off-channel habitats are restored within 66 miles of focal area anchor habitats.	• Add large wood to anchors (33 miles) and other priority areas (6 miles) • Complete Rock Creek LFA outreach	2,709,000
3	Riparian function is restored along 58 miles of focal area streams, reducing stream temperatures and erosion, increasing macro-invertebrate abundance, and increasing the long-term potential for large wood recruitment.	• Plant 14 miles of priority riparian areas • Enhance riparian function at all BDA and LWD sites	219,100
4	Beavers colonize an additional 40 miles of Coho-bearing tributaries in the focal areas, building dams and increasing the quality and quantity of off-channel habitats available for Coho rearing.	• Install and/or maintain 58 BDAs (51 complete and not included in cost) • Initiate outreach campaign on "living with beavers"	172,500
5	300 acres of tidal wetlands and other estuarine habitats are reconnected, increasing the quality and extent of tidal rearing habitats, and associated freshwater habitats.	• Complete two tidal reconnection projects (design costs only) • Update prioritization with 2021 tide gate inventory	195,000
	Total Cost of SAP Implementation (2023 – 2027)*		**$3,435,600**
6	52 barriers to fish passage are removed, enhancing longitudinal connectivity in focal area tributaries, and restoring Coho access to 92 miles of anchor habitats, cold water refugia, and off-channel habitats.	• Replace nine high priority fish passage barriers • Determine feasibility of replacing priority culverts on major state highways	N/A

** Total costs do not include fish passage projects.*

Sustainability

Because all of the restoration strategies called for in this SAP are intended to enhance watershed processes, the Nehalem Partnership is confident that the results of our cumulative efforts will be sustained over time through the slow but steady improvement of watershed function. The functional benefits resulting from anchor habitat enhancements from LWD and beaver recruitment, for example, will: 1) increase channel-floodplain interaction, promoting greater habitat complexity and off-channel rearing for Coho in winter, while 2) elevating the water table and establishing more instream and off-channel temperature refugia in summer. As more and more anchor habitats are enhanced through beaver colonization, LWD installation, riparian enhancement, and selected barrier replacements, we are confident that the hydrologic, geomorphic, riparian, and biological processes that generate and maintain critical Coho habitats will improve at scales beyond just the reach at which each project was implemented. Once these benefits can be realized at scale, much of our work can be sustained naturally, with minimal future intervention.

The restoration of watershed function is at the core of our long-term approach to sustaining the benefits of SAP implementation. Ultimately, however, the goal of restoring function can only be achieved if the local partners are coordinated and have sufficient capacity to sustain on-the-ground project implementation year after year. To ensure these conditions exist, the Nehalem Partnership has established a Memorandum of Understanding (MOU) that secures commitments from public and private partners to sustain SAP implementation (Appendix 11). At the time of SAP printing, the following partners have signed on to the MOU: UNWC, LNWC, TEP, ODFW, DEQ, Columbia SWCD, Clatsop SWCD, USFWS, Weyerhaeuser, The Beaver Coalition, ODF, and Trout Unlimited.

Maggie Peyton of the Upper Nehalem Watershed Council and Wild Salmon Center's Mark Trenholm on the Nehalem River. Photo: Dave Herasimtschuk

Commitments from several other partners are anticipated following the final review of the completed plan. Core Partners who have signed on to the MOU have agreed to spend at least 126 hours over three years on partnership-building efforts like the creation of governing agreements, development of short and long-term work plans, and ongoing review of priorities established in the SAP. These and other commitments are intended to create a durable yet flexible implementation structure that can thrive for decades.

Private and public partners have a long history of collaboration in the Nehalem basin. Since 1997, the basin's two watershed councils have collaborated extensively with these and other stakeholders, resulting in numerous public and private landowners, researchers, consultants, contractors, and volunteers collaborating on efforts to improve watershed health and recover wild salmon populations. In addition to extensive community education and landowner outreach, this partnership has undertaken watershed health assessments, limiting factors analyses, rapid bioassessments, data syntheses, and water quality and quantity monitoring. These activities have led to the implementation of over 20 years of on-the-ground restoration projects. This extensive history of collaboration has built a strong foundation upon which to sustain SAP implementation.

In addition to the MOU, the Nehalem Partnership has acquired funding to hire a contract Coordinator, who will facilitate the administrative work of the Partnership and coordinate project planning and implementation activities. Specifically, the Coordinator will: facilitate quarterly meetings during which time the partners will review (and revise, as needed) the SAP implementation schedule; develop an annual implementation work plan; coordinate on-the-ground work to leverage resources and promote economies of scale; and support the implementation needs of participating partners (permit and grant writing, etc.).


Photo: Dave Herasimtschuk

9.1 Updating the SAP

The UNWC and LNWC convened the team to develop this SAP and will serve as long-term stewards of the plan. The boards of these two organizations will receive regular updates on project implementation. All partner organizations will also be reminded to update their boards and members on progress at regular increments. The two councils will also continually update the public on SAP implementation through outreach to print media, social media posts on their Facebook accounts, annual reports to the Tillamook, Clatsop, and Columbia boards of county commissioners, and ongoing outreach to numerous local agencies and organizations.

Finally, ensuring adaptive management of the plan will be a critical function of the two councils. The monitoring framework in Chapter 7 will, as funded, generate a steady stream of data that can be used to evaluate SAP implementation and re-assess priorities. This is particularly important in the case of BDA installation in anchor locations because the effort now underway as a result of this SAP represents the first of its kind in the Oregon coast range. The two councils will hold a joint annual meeting with the members of the core planning team to evaluate data generated from BDA monitoring, research aimed at the data gaps identified in Chapter 7, and any other research/monitoring efforts underway.

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Photo: Ronald Hope

Appendix 1

Glossary of Terms and Definitions

Nehalem Bay SAP
Glossary of Terms and Definitions

Abundance	The number of fish in a population. See also population.
Adaptive Management	Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. It is a process for adjusting actions and/or direction based on new information. A plan for monitoring, evaluation, and feedback is incorporated into an overall implementation plan so that the results of actions can become feedback on design and implementation of future actions.
Anadromous Fish	Species that are hatched in freshwater, migrate to and mature in salt water, and return to freshwater to spawn.
Anchor Habitat	a stream reach that provides all of the essential habitat features necessary to support the complete Coho freshwater life history. An anchor site supports all of the seasonal habitat needs of Coho salmon from egg to smolt outmigration, including optimal gradient, potential for floodplain interaction, and accumulation of spawning gravels.
Barrier	A blockage such as a waterfall, culvert, or rapid that impedes the movement of fish in a stream system.
Beaver Dam Analogues	Human-made, channel-spanning structures that mimic or reinforce beaver dams (Pollock et al. 2015).
Broad Sense Recovery	Goals defined in the recovery planning process, in this case by the state of Oregon, that go beyond the requirements for delisting under the ESA, to address, for example, other legislative mandates or social, economic, and ecological values. The state's Oregon Coast Coho Conservation Plan describes broad sense recovery as a desired future condition in which "Populations of naturally produced fish comprising the ESU are sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) that the ESU will: a) be self-sustaining, and b) provide ecological, cultural, and economic benefits."
Channel Gradient	The slope of a stream reach.
Critical Habitat	Critical habitat includes: (1) specific areas within the geographical area occupied by the species at the time of listing, on which are found those physical or biological features that are essential to the conservation of the listed species and that may require special management

	considerations or protection, and (2) specific areas outside the geographical area occupied by the species at the time of listing that are essential for the conservation of a listed species. If a species is listed or critical habitat is designated, ESA section 7(a) (2) requires federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of such a species or to destroy or adversely modify its critical habitat (NMFS 2008).
Delisting	Removing a species from the endangered species list.
Delisting Criteria	Criteria incorporated into ESA recovery plans that define both biological viability (biological criteria) and alleviation of the causes for decline (listing factor criteria based on the five listing factors in ESA section 4[a] [1]), and that, when met, would result in a determination that a species is no longer threatened or endangered and can be proposed for removal from the Federal list of threatened and endangered species. These criteria are a NMFS determination and may include both technical and policy considerations.
Dependent Populations	Populations that rely on immigration from surrounding populations to persist. Without these inputs, dependent populations would have a lower likelihood of persisting over 100 years.
Diversity	All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy vs. lifelong residence in freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.
Ecosystem	A complex system, or group, of interconnected elements and processes and functions, formed by the interaction of a community of organisms with their environment
Endangered Species Act	Passed by Congress in 1973, its purposes include providing a means to conserve the ecosystems on which endangered species and threatened species depend. See also **endangered species** and **threatened species**.
Escapement	Usually refers to adult fish that escape from fisheries and natural mortality to reach the spawning grounds.

Estuarine Habitat	Areas available for feeding, rearing, and smolting in tidally influenced lower reaches of rivers. These include marshes, sloughs and other backwater areas, tidal swamps, and tide channels.
Evolutionarily Significant Unit	An Evolutionarily Significant Unit (ESU) represents a distinct population segment of Pacific salmon that (1) is substantially reproductively isolated from conspecific populations and (2) represents an important component of the evolutionary legacy of the species. Equivalent to a distinct population segment (DPS) and treated as a species under the Endangered Species Act.
Factors for Decline	Factors identified that caused a species to decrease in abundance and distribution and become threatened or endangered.
Floodplain	A nearly flat plain along the course of a stream or river that is naturally subject to flooding, or using geological terms, a depositional landform in alluvial basins.
Hydrologic units	In the U.S. Geological Survey, hydrologic units have been divided at different scales. The area of a fourth-field hydrologic unit is 440,000 acres and a fifth-field hydrologic unit is between 40,000 and 250,000 acres.
Focal Area	Focal areas represent locations in the watersheds where partners have agreed to focus and coordinate restoration efforts. They were selected using a stronghold approach, which evaluated the potential for coordinated action to restore watershed function and boost habitat productivity. Additionally, the selection process also considered the degree to which each subwatershed is capable of supporting unique life-history strategies.
Freshwater Habitat	Areas available for spawning, feeding, and rearing in freshwater.
Fry	Young salmon that have emerged from the gravel and no longer have a yolk sack.
Full Seeding	In general, full seeding refers to having enough spawners to fully occupy available juvenile habitat with offspring. As applied in fisheries management for Oregon Coast Coho salmon, it refers to habitat quality sufficient for spawners to replace themselves when marine survival is 3 percent and is based on early models of juvenile rearing capacity.
Goals	Broad, formal statements of the long- term condition we seek to achieve.

Gradient	The slope of a stream segment.
Habitat Quality	The suitability of physical and biological features of an aquatic system to support salmon in the freshwater and estuarine system.
Hatchery	A facility where artificial propagation of fish takes place.
Historical Abundance	The number of fish produced before the influence of European settlement.
Independent Population	A collection of one or more local breeding units whose population whose dynamics or extinction risk over a 100-year period is not substantially altered by exchanges of individuals with other populations (migration). **Functionally independent populations** are net donor populations that may provide migrants for other types of populations. This category is analogous to the independent populations of McElhany et al. (2000).
Intrinsic Potential	The estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, valley constraint, and mean annual discharge of water. Intrinsic potential in this report refers to a measure of potential Coho salmon habitat quality. This index of potential habitat does not indicate current actual habitat quality.
Juvenile	A fish that has not matured sexually.
Keystone Species	A species that plays a pivotal role in establishing and maintaining the structure of an ecological community. The impact of a keystone species on the ecological community is more important than would be expected based on its biomass or relative abundance.
Limiting Factors	Impaired physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity).
Listed Species	Species included on the List of Endangered and Threatened Species, authorized under the Endangered Species Act and maintained by the U.S. Fish and Wildlife Service and NMFS.
Lowland Habitat	Low-gradient stream habitat with slow currents, pools, and backwaters used by fish. This habitat is often converted to agricultural or urban use.
Marine Survival Rate	The proportion of smolts entering the ocean that return as adults.

Metrics	Something that quantifies a characteristic of a situation or process; for example, the number of natural-origin salmon returning to spawn to a specific location is a metric for population abundance.
Morphology	The form and structure of an organism, with special emphasis on external features.
Naturally Produced Fish	Fish that were spawned and reared in natural habitats, regardless of parental origin. See also **wild fish**.
Objectives	We use the term objectives to refer to formal statements of the outcomes (or intermediate results) and desired changes that we have identified as necessary to attain the goals. Objectives specify the desired changes in the factors (direct and indirect threats and opportunities) that we would like to achieve in the short and medium-term "A good objective meets the criteria of being *results oriented, measurable, time limited specific, and practical*.[1]"
Parr	The life stage of salmonids that occurs after fry and is generally recognizable by dark vertical bars (parr marks) on the sides of the fish.
PDO	For *Pacific Decadal Oscillation*. A long-term pattern of Pacific Ocean climate variability, with events lasting 20 to 30 years and oscillating between warm and cool regimes.
PIT Tag	For *passive integrated transponder tag*. An injectable, internal, radio-type tag that allows unique identification of a marked fish passing within a few inches of a monitoring site.
Population	A group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group. See also **abundance**.
Population Dynamics	Changes in the number, age, and sex of individuals in a population over time, and the factors that influence those changes. Five components of populations that are the basis of population dynamics are birth, death, sex ratio, age structure, and dispersal.
Production	The number of fish produced by a population or in a particular location in a year.
Productivity	The rate at which a population is able to produce fish, such as the average number of surviving offspring per parent. Productivity is used as

[1] Open Standards for the Practice of Conservation.

	an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population production over an entire life cycle. Can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.
Recovery	The reestablishment of a threatened or endangered species to a self-sustaining level in its natural ecosystem (i.e., to the point where the protective measures of the ESA are no longer necessary).
Recovery Plan	A document identifying actions needed to make populations of naturally produced fish comprising the OCCS ESU sufficiently abundant, productive, and diverse so that the ESU as a whole will be self-sustaining and will provide environmental, cultural, and economic benefits. A recovery plan also includes goals and criteria by which to measure the ESU's achievement of recovery, site-specific management actions as may be necessary to achieve the plan's goal, and an estimate of the time and cost required to carry out the actions.
Redd	A nest constructed by female salmonids in streambed gravels where eggs are fertilized and deposited.
Resilience	A measure of the ability of a population or ESU to rebound from short-term environmental or anthropogenic perturbations.
Run Timing	The time of year (usually identified by week) when spawning salmon return to the spawning beds.
Salmonid	Fish belonging to, or characteristic of, of the family Salmonidae, which includes salmon, steelhead, trout, char, and whitefish.
Smolt	A life stage of juvenile salmon that occurs just before the fish leaves freshwater. Smolting is the physiological process that allows salmon to make the transition from freshwater to salt water.
Smolt Capacity	The maximum number of smolts a basin can produce. Smolt capacity is related to habitat quantity and quality.
Spawner	Adult fish on the spawning grounds.
Spawner Survey	Effort to estimate the number of adult fish on spawning grounds. It uses counts of redds and fish carcasses to estimate escapement and identify

	habitat. Annual surveys can be used to compare the relative magnitude of spawning activity between years.
Species	Biological definition: A group of organisms formally recognized by the scientific community as distinct from other groups. Legal definition: refers to joint policy of the USFWS and NMFS that considers a species as defined by the ESA to include biological species, subspecies, and DPSs. In this Plan, 'the species' refers to the Oregon Coast Coho salmon ESU.
Stakeholders	Agencies, groups, or private citizens with an interest in recovery planning, or those who will be affected by recovery planning and actions.
Sustainable Population	A population that, in addition to being persistent, is also able to maintain its genetic legacy and long-term adaptive potential for the foreseeable future. "Sustainable" implies stability of habitat availability and other conditions necessary for the full expression of the population's (or ESU's) life history diversity into the foreseeable future. As used in this plan, sustainable and sustainability are the same, or nearly the same, as viable and viability. For clarity, after we introduce both terms, we use the term sustainable in place of viable, except where it used in a quote or other specific application of the TRT or BRT such as viable salmonid population.
Threats	Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, and volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.
Threatened Species	A species not presently in danger of extinction, but likely to become so in the foreseeable future. See also **endangered species** and **ESA**.
Valley Constraint	The valley width available for a stream or river to move between valley slopes.
Viable, Viability	The likelihood that a population will sustain itself over a 100-year time frame. As used in this plan, viable and viability are the same, or nearly the same, as sustainable and sustainability.
Viable Salmonid Population	A viable salmonid population (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 (random or directional) over a 100-year time frame.

Wild Fish Fish whose ancestors have always lived in natural habitats, that is, those with no hatchery heritage. See also **naturally produced fish**.

Appendix 2

Potential Unique Life History Types of Nehalem Coho

<u>Potential Unique Life History Types for Nehalem Basin Coho</u>

updated August 2016

1) 6th Field Spawners upstream of Humbug Cr confluence (including mainstem Nehalem above RM 90 at Vernonia).

<u>Unique Features</u>:

- Tuffaceous siltstone and sandstone / Marine sedimentary
- High IP
- Exhibits the unique capability of surviving extremely high colloidal concentrations of suspended sediment year round (Crooked Cr)

<u>Complex variations known to exist within each general Life History pattern:</u>

- Overwinter in 6th field
- Mainstem nomads that rear in estuary (spring, summer, winter)
- Mainstem nomads that do not reach estuary (summer rear in 2nd / 3rd order thermal refuge in tribs to mainstem / broad distribution)

2) 6th Field Spawners in Salmonberry (Cronin Cr / Cook / Lost)

<u>Unique features:</u>

- Tillamook volcanics
- Low IP
- North slope contributions (cooler stream temps)
- Cronin Cr stock exhibits high c. shasta resistance. Indications from other hatchery studies conducted at the NF Nehalem hatchery suggest c. shasta resistance may be a genetic trait broadly distributed in wild Nehalem coho (Trask hatchery stock crosses w/ Fish hawk Lake stock)

<u>Complex variations known to exist within each general Life History pattern:</u>

- Overwinter in 6th field
- Mainstem nomads that rear in estuary (spring, summer, winter)
- Mainstem nomads that do not reach estuary (summer rear in 2nd / 3rd order thermal refuge in tribs to mainstem / broad distribution)

3) 6th Field Spawners in NF Nehalem

<u>Unique features:</u>

- High potential for exposure to genetic dilution from hatchery stocks
- Differential fitness, productivity, hidden benefits
- Tuffaceous siltstone / sandstone (lower basin, unique from similar upper basin geologies because of varying temporal access that can dramatically effect run timing)
- High IP

Complex variations known to exist within each general Life History pattern:

- Overwinter in 6th field
- Mainstem nomads that rear in estuary (spring, summer, winter)
- Mainstem nomads that may seek summer thermal refuge in tributaries of the mainstem Nehalem associated with the intertidal ecotone (Jetty Cr, Foley Cr, Alder Cr, Bobs Cr, Anderson North, Anderson South, Roy, Peterson Cr /narrow distribution). May exhibit upstream migration patterns as summer parr in an effort to moderate salinity.

4) 6th Field Spawners Fishhawk Cr

Unique Features:

- Significant Lake rearing
- Exhibit c.shasta resistance (Lichatowich, 1985)
- Combined tuffaceous siltstone / sandstone and marine sedimentary

Complex variations known to exist within each general Life History pattern:

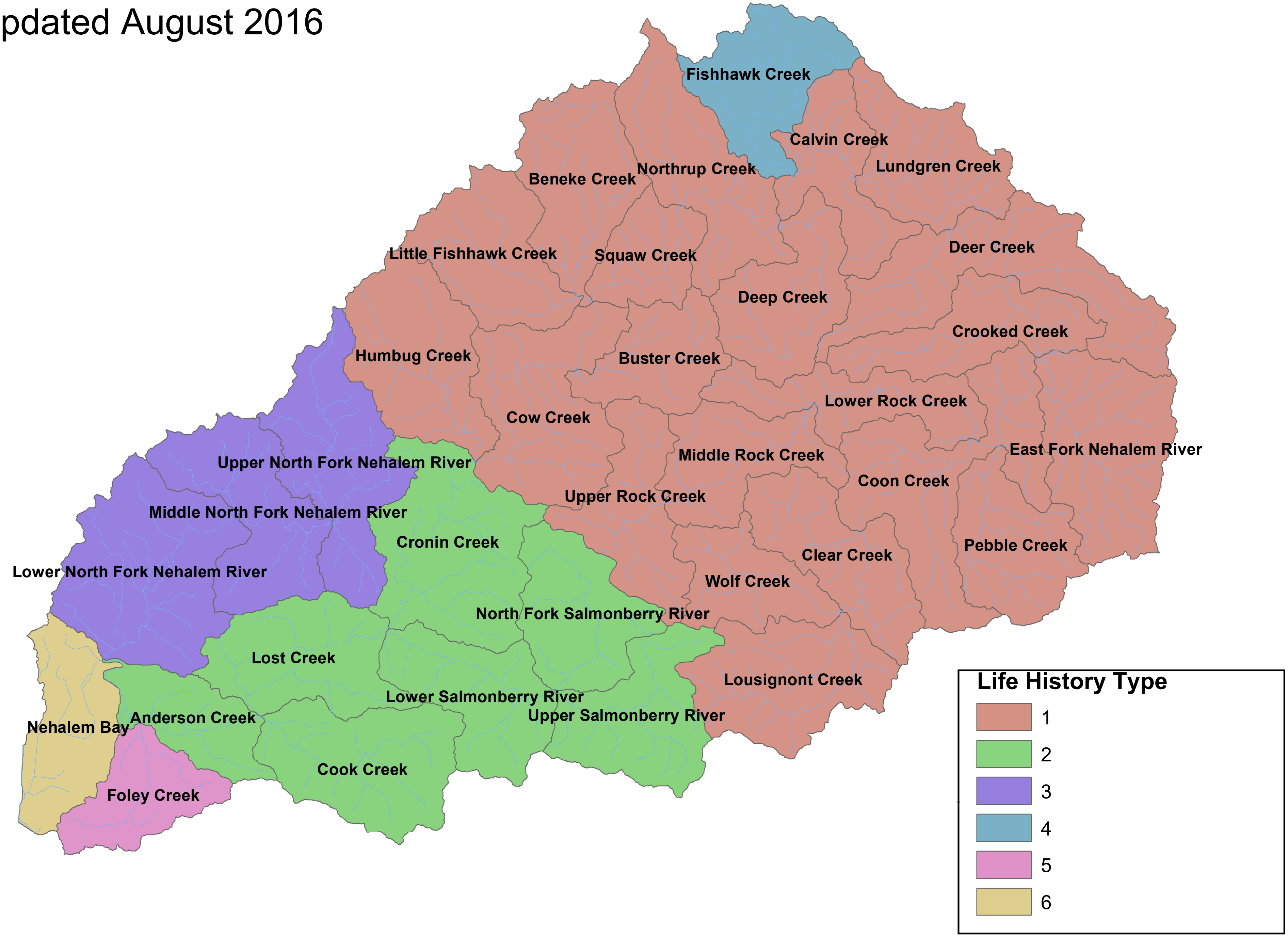
- Overwinter in 6th field
- Over winter in Fish Hawk Lake
- Mainstem nomads that rear in estuary (spring, summer, winter)
- Mainstem nomads that do not reach estuary (summer rear in 2nd / 3rd order thermal refuge in tribs to mainstem / broad distribution)

5) 6th Field Spawners of the lower 5th Field, Foley Cr

Unique Features:

- Lower Basin
- North Slope (spring fed, extremely unique temperature profiles)

Appendix 2
Potential Unique Life History Types for Nehalem Basin Coho
Updated August 2016



- Potential for unique survival, growth rates and migration patterns associated w/ nomadic strategy when compared to the Upper Nehalem basin nomadic life history
- High potential for temporal differences in spawning and fry emergence
- Coevolution with viable chum salmon population
- Combined tuffaceous siltstone / sandstone and mafic intrusive rock

Complex variations known to exist within each general Life History pattern:

- Overwinter in 6^{th} field
- Nomads that rear in estuary (spring, summer, winter)
- Nomads that may seek summer thermal refuge in tributaries of the mainstem Nehalem associated with the intertidal ecotone (Jetty Cr, Alder Cr, Bobs Cr, Anderson North, Anderson South, Roy, Peterson Cr / narrow distribution). May exhibit upstream migration patterns as summer parr in an effort to moderate salinity.

6) 6^{th} Field Spawners in minor tributaries of the estuary (Nehalem Bay) extending to the upper end of the intertidal ecotone. (Primaries include Jetty Cr, Alder Cr, Bobs Cr, Anderson North, Anderson South, Roy Cr, Peterson Cr)

Unique Features:

- Combined Tuffaceous sandstone / siltstone and Alluvial deposits
- Lower basin, Includes dunal front
- High potential for temporal differences in spawning and fry emergence
- Potential for unique survival, growth rates and migration patterns associated w/ nomadic strategy when compared to the Upper Nehalem basin nomadic life history
- Coevolution with viable chum salmon population

Complex variations known to exist within each general Life History pattern:

- Overwinter in 7^{th} field
- Nomads that rear in estuary (spring, summer, winter)
- Nomads that may seek summer thermal refuge in other tributaries of the mainstem Nehalem associated with the intertidal ecotone (Foley

Cr, Jetty Cr, Alder Cr, Bobs Cr, Anderson North, Anderson South, Roy, Peterson Cr / narrow distribution). May exhibit upstream migration patterns as summer parr in an effort to moderate salinity.

General environmental and biotic factors that have the capacity to influence life history diversity in freshwater

Thermal barriers that develop in relation to changes in climactic conditions. An appropriate example is where low winter flow scenarios create both a temperature barrier (too cold) and a hydrologic barrier (low flows limiting access to natal 6^{th} fields) for spawning migration. This scenario results in creating a survival advantage for both late run timing that produces adults with a high condition factor capable of holding for long periods in mainstem habitats before initiating spawning migrations and for spawners entering lower estuary tributaries.

Adult size that has the capacity of influencing escapement targets (stream size) and capitalizing on variable gravel sorts. Jacks and Jennys may be more effective at utilizing very small streams for spawning and incubation.

The proliferation of healthy beaver colonies that are dam builders likely creates a unique coho life history strategy (pond reared). Exceptional growth rates that alter outmigrant size and timing. This scenario results in higher marine survival rates and differential rates of survival associated with fresh water predation.

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Appendix 3

Coast Coho Partnership - SAP Common Framework

A summary of terms and definitions used in the development of Strategic Action Plans for Coast Coho Habitat Restoration in Oregon

Coast Coho Common Framework, V 2.6

Coast Coho Partnership

Updated: October 15, 2019

1. Introduction and Purpose

The following document has been developed by the Coast Coho Partnership (Partnership), a group of state and federal agencies and non-profit organizations leading development of the "Oregon Coast Coho Business Plan" (Business Plan). The Business Plan is intended to leverage financial support for the implementation of high priority projects contained in locally developed, population scale recovery plans called "Strategic Action Plans."

This document advances a Partnership goal to establish a common language for coast coho recovery that links federal, state, and local recovery planning by consistently describing the habitats that coast coho rely on; the ecosystem processes that generate and maintain these habitats; and a suite of indicators that can be used to assess trends in habitat quantity and quality. In addition, the Partnership seeks to establish consistent terminology for partners to describe the factors that limit coho production, and the human activities that give rise to these limiting factors.

The Partnership includes: the Oregon Department of Fish and Wildlife (ODFW), National Fish and Wildlife Foundation (NFWF), National Oceanic and Atmospheric Administration (NOAA) Fisheries, NOAA Restoration Center, Wild Salmon Center (WSC), and Oregon Watershed Enhancement Board (OWEB).

1.1 Common Framework

The Partnership drafted this Common Framework to provide a uniform approach for describing and classifying ecosystems, processes, species, and associated human-induced threats important to coho recovery. The initial draft was created by the Partnership working with consultants who had developed and employed a similar approach to support recovery planning for Puget Sound Chinook. Following creation of a draft framework, the Partnership convened a two-day workshop with scientists and resource managers with extensive experience in coastal watersheds to review and refine the document. The resulting framework was then further refined by partners working on population scale recovery and the development of three pilot SAPs in the Nehalem, Siuslaw, and Elk Rivers.

The common framework is intended for use at a variety of scales (reach, sub-watershed, watershed, ESU) and will allow information and planning efforts to be shared and communicated consistently up and down the coast. The Framework builds on several interrelated categories of information, or "elements," which are defined as follows:

- **Components** –Habitats that if conserved can support the continued viability or recovery of coho (example: tributaries).

- **Key ecological attributes (KEAs) –** Aspect of a component's biology or ecology that if present, defines a healthy component and, if missing or altered, would lead to the outright loss or extreme degradation of that component over time (example: water quality).

- **Indicators** – Metrics that can be tracked to assess the condition of KEAs (example: temperature).

- **Stresses** – Symptoms that a component is degraded; similar to a limiting factor but often more specific (example: reduced riparian wood vs. limited instream complexity).

- **Threats –** Human activities that stress and degrade the health of components (example: roads).

At the start of the SAP planning process, watershed teams will use the Common Framework to select the components, KEAs, indicators, stresses, and threats relevant to their understanding of what limits coho populations in their watershed. This customization of the Common Framework reflects individual watershed conditions and the context for recovery that drive the selection of actions and strategies.

The Partnership drafted this Common Framework using existing ODFW and NMFS terminology and standardized concepts taken from a planning tool called *Open Standards for the Practice of Conservation (Open Standards)*[1]. The *Open Standards* are scalable, adaptable, and widely used to design, manage, and monitor conservation projects around the world.

2. Components, KEAs, Indicators

The characterization of watersheds through the identification of components, stresses, and key ecological attributes (KEAs) is critical for consistently describing the current physical and biological context for coho recovery in the watershed. This information also clearly defines the elements being improved or protected by the strategies and actions in the forthcoming SAPs.

2.1 Components

Components are the things we care about conserving. They can be individual species, habitat types, ecological processes, or ecosystems chosen to encompass the full breadth of conservation objectives for a specific project. In the Common

[1] Additional information regarding the Open Standards may be found at http://www.conservationmeasures.org

Framework, components are *priority habitats for coho recovery*, such as mainstem river and off-channel habitats. In the SAP, the "Conservation/Restoration targets" section will reference both the habitat components from the Common Framework relevant to the watershed and the coho population(s).

Coast Coho Habitat Components and Definitions

Component	Definition
Mainstem River	Portions of rivers above head of tide (Coastal and Marine Ecological Classification Standard (CMECS) definition); typically 4th order, downstream of coho spawning distribution, non-wadeable. The mainstem river component includes riparian and floodplain areas.
Tributaries	All 1st – 3rd order streams with drainage areas > 0.6 km2. This includes fish-bearing and non-fish-bearing, intermittent streams, and the full aquatic network including headwater areas. The tributary component includes riparian and floodplain areas.
Off-channel	Any area other than the main or primary channel of mainstem or tributary habitats that provides a velocity refuge for coho. This includes slack water habitats such as alcoves, side channels, and oxbows. This includes riparian and floodplain areas.
Freshwater Non-Tidal Wetlands	Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Habitats include depressions, flat depositional areas that are subject to flooding, broad flat areas that lack drainage outlets, sloping terrain associated with seeps, springs and drainage areas, areas associated with bogs, and open water bodies (with floating vegetation mats or submerged beds). This component is restricted to those wetlands that are hydrologically connected to coho streams. Estuarine associated wetlands are addressed in the estuarine section.

Estuaries	The areas historically available for feeding, rearing, and smolting in tidally influenced lower reaches of rivers that extend upstream to the head of tide and seaward to the mouth of the estuary. Head of tide is the inland or upstream limit of water affected by a tide of at least 0.2 foot (0.06 meter) amplitude (CMECS). This includes tidally influenced portions of rivers that are considered to be freshwater (salinity <0.5 ppt). We are extending the definition laterally to the uppermost extent of wetland vegetation (mapped by CMECS). Habitats include saltmarsh, emergent marsh, open water, subtidal, intertidal, backwater areas, tidal swamps, and deep channels. This includes the ecotone between saltwater and freshwater and the riparian zone.
Uplands	All lands that are at a higher elevation than adjacent water bodies and alluvial plains. They include all lands from where the floodplain/riparian zones terminate and the terrain begins to slope upward forming a hillside, mountain-side, cliff face, or other non-floodplain surface.
Lakes	Inland bodies of standing water; for purposes of OC coho salmon recovery. Habitats include deep and shallow waters in the lakes, including alcoves, and confluences with streams.

2.2 Key Ecological Attributes (KEAs)

KEAs are the characteristics of a component that, when present, support a viable component but, if missing or altered, lead to loss or degradation of the component over time. KEAs can be used to assess the status of a component, develop protection and restoration objectives for conservation, and focus monitoring and adaptive management programs. In the Common Framework, KEAs are *characteristics necessary for coho recovery*, such as riparian function and habitat complexity. The core KEAs that every watershed team should include in their local framework are indicated in the table below.

KEAs by Component

Component	Key Ecological Attributes (definitions below)
Mainstem River	Water Quality Flows (high and low) Habitat complexity Riparian Function Geomorphic processes Lateral connectivity Longitudinal connectivity
Tributaries	Water quality Flows (high and low) Habitat complexity Beaver ponds Riparian Function Geomorphic processes Lateral connectivity Longitudinal connectivity
Freshwater Non-tidal wetlands	Water Quality Hydrologic Regime Landscape arrays of habitats Riparian function (relevant to wetland type) Beaver ponds Hydraulic Connectivity
Off-channel	Habitat complexity Riparian Function Beaver ponds Geomorphic processes Lateral connectivity Longitudinal connectivity
Estuary	Water Quality Landscape array of habitats Sediment dynamics Channel morphology Inundation regime Connectivity (lateral and longitudinal)
Uplands	Connectivity Landscape Array of Structural Diversity (upland forests)

KEAs by Component

Component	Key Ecological Attributes (definitions below)
Lakes	Habitat complexity Connectivity (lateral and longitudinal) Water quality

KEA Definitions

Water Quality: The biological, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses (EPA, CWA). In tributary and mainstem habitats of coastal watersheds good water quality reduces potential health impacts to coho adult and juvenile life stages. Poor water quality can have direct mortality impacts, make them more susceptible to disease, impair their swimming ability, create a tendency for avoidance of habitat, alter the timing of migration, and delay hatching and emergence and rate of maturation.

High Flows: In mainstem, tributary, and off-channel habitats, peak high flows for channel maintenance are important to create diversity of habitat and move sediments through the system. Sustained high flows reconnect the stream to floodplain and trigger adults to return to freshwater to spawn. High flows provide physical access to smaller tributaries to spawn. In tributary and mainstem habitats spring high flows are important for smolt survival. Wetlands need high flows to maintain their health and recharge the associated groundwater. High flow transfers nutrients and food sources from the wetlands into stream habitats.

Low Flows: In tributary, mainstem, and off-channel habitats it is important that low flows are sufficient to allow access to habitats and sustain good water quality. When flows are too low, fish are concentrated and density issues are created in available habitats. Low flows create conditions where wetlands are able to discharge their stored water and are important for bug production. In wetland habitats, low flows create conditions where wetlands are able to discharge their stored water and are important for bug production.

Habitat Complexity: Stream complexity is important for wintering habitat for juveniles in some areas of the mainstem and in tributaries, wetlands, and off-channel habitats. Complexity includes one or more of the following features: large wood, a lot of wood, pools, connected off-channel alcoves, beaver ponds, lakes, connected floodplains and wetlands. In tributary streams and off-channel habitats, complexity is also important for juveniles in the summer.

Riparian Function (overlaps with connectivity): Streamside vegetation in tributaries, off-channel habitats, and some mainstem and wetland habitats can provide shade to regulate stream temperature, create cover for coho rearing, provide a source of food and nutrients, help stabilize sediment supply, filter out pollutants including pesticides and nutrients, and provide a source of in-stream complexity.

Beaver ponds: off-channel habitats resulting from the impoundment of surface water and hyporheic flow by beavers.

Geomorphic processes: The land forming aspects of erosion and deposition. In the estuary, this includes the movement of sediment and wood.

Lateral connectivity: The periodic inundation of the floodplain and the resulting exchange of water, sediment, organic matter, nutrients, and organisms. This is the lateral extent of the streams connectivity to the adjacent riparian, floodplain, and off-channel habitats.

Longitudinal connectivity: the pathways along the entire length of a stream.

Hydrologic Regime: Patterns of seasonal and inter-annual hydrology changes. Wetlands need water inputs to maintain their health and recharge the associated groundwater. High stream flow transfers nutrients and food sources from the wetlands into stream habitats.

Landscape Array of Habitats: A range of functioning wetland and estuary habitat types appropriate to the landscape that provide biologically productive areas for coho to rear, find refuge, and go through physiological changes before migrating to the ocean.

Hydraulic Connectivity: The extent to which surface water bodies interact with adjacent wetlands through lateral surface and/or subsurface connections.

Sediment Dynamics: In estuaries, the movement of sediments throughout the system is an important component of what helps create and maintain tidal channels. When sediment processes are impaired it can reduce the connectedness and amount of tidal channel habitat available to coho salmon. Retention of sediment by marshes also is important to the productivity of subtidal estuarine waters. Sediments not stabilized by marshes remain suspended in the water column, especially in estuaries characterized by persistent upwelling currents and waves. Suspended sediments reduce available light and consequently reduce the primary production essential to estuarine food webs (Adamus 2005).

Habitat Diversity: A mosaic of functioning habitat types that provide biologically productive areas for coho to rear, find refuge, and go through physiological changes before migrating to the ocean. The combination of appropriate habitat types is unique to each estuary but will likely include beaches, mudflats, tidal marsh, and tidally influenced riverine habitats.

Channel morphology: Channels systems created through tidal action. Length, width to depth ratios, and sinuosity are important features of tidal channel morphology.

Inundation regime: The frequency, duration, and depth of tides flowing into estuarine habitats.

Connectivity (uplands): The lateral extent of uninterrupted physical pathways that facilitate the transport of organic and inorganic materials from an upland area into a surface water body, and/or its riparian zone and floodplain.

Landscape Array of Structural Diversity (upland forests): The range and distribution of forest stand size, type, age, and composition within a defined uplands area.

Shoreline habitat complexity (lakes): TBD

Hydraulic connectivity to wetlands (lakes): TBD

2.3 Status Indicators

Defining and tracking status and condition information is a critical step in developing an SAP, and will allow recovery partners to assess progress toward recovery status and goals up and down the coast. Ecosystem status information will be used to track changes in the current and future status of habitat features and processes over time as SAPs are implemented. Ecosystem indicators will provide information about the relationship between the effects of strategies or actions and current and desired future status.

Common Framework Definition

Status indicators are specific units of information measured over time that document changes in the status of a KEA or another element (e.g., a threat). Indicators can be measured directly or computed from one or more directly measured variables. Indicators should be measurable, precise, consistent, and sensitive. In the Common Framework, indicators are *metrics to assess coho recovery*, such as the number of pools present in off-channel habitat. Other indicators, such as implementation metrics, should be added in to the local framework later in the process (e.g. miles of levees removed or acres of riparian plantings installed).

The list below is not an exhaustive list of all potential indicators but represents a sampling of indicators that are broadly applicable and a good place from which to start a discussion. This process will be iterative, and new status information will be integrated as it becomes available.

2.4 Indicators by Component and KEA

Component	Key Ecological Attributes	Indicators (metrics) for this KEA Local teams will annotate each as…. **Bold = Sufficient data exists to evaluate the indicator with a reasonable/replicable amount of analysis**. *Italics = Aspirational indicator.* *1) Data is not readily available (i.e no monitoring program exists or is planned); OR* *2) current sampling is not sufficient to characterize at appropriate scale; OR* *3) available data requires extensive (not easily replicated) analysis to assess.*
Mainstem River	Water Quality	• Temperature: % of monitored stream reaches meeting temperature criteria • Average DEQ ambient site condition • Turbidity • Disease/pathogens
	Flows (high and low)	• Number of days reach not meeting instream flow • Number of days/year that flow levels in the mainstem fall below in-stream flow rights (5 year running mean) • Amount of water allocated • % of historic flow • Trends in peak hydrograph (system flashiness)
	Habitat complexity	• % pool habitat • Amount and volume of wood • Number of large pieces of wood • Reaches with connected off-channel alcoves, flood plains and wetlands • Spawning gravel density • Depth to width ratio
	Riparian Function	• Riparian road density (mi road/mi stream) in one site potential buffer (e.g. 164" in Nehalem) • % of forest riparian areas with conifers > 20" dbh in one site potential tree buffer • % of 6^{th} fields basins with > 50% of riparian area in late seral • % of open lands with wooded buffers along streams • % of riparian area with diverse, healthy native vegetation appropriate to site potential • Proportion of riparian areas containing invasive species

		• Width • Percentage of sites that have reached max potential or are demonstrating improving trends for effective shade
	Geomorphic processes	• % fine sediment in pools • Fast water units • Pool tailouts • % gravel • % bedrock in stream reach • Geological composition of reaches • Lineal distance of side channel habitat • Ratio of side channel to mainstem length
	Lateral connectivity	• % of the potential fish use stream length with entrenchment ratio > 2.2
	Longitudinal connectivity	• Presence of a thermal barrier in the lower mainstem that prevents migration/movement of fish during warm periods (7 day moving mean of daily summer max temp is < 20°C) • Number of fish passage barriers
Component	**Key Ecological Attributes**	**Indicators (metrics) for this KEA**
Tributaries	Water quality	• # of days where monitoring locations exceed standards • % of monitored stream reaches meeting temperature criteria • Average DEQ ambient site condition • Turbidity • % of macro-invertebrate sampling sites in "most disturbed" DEQ condition class
	Flows (high and low)	• Percentage of water allocated verses capacity • Number of days not meeting instream flow
	Habitat complexity	• Miles of high quality habitat (produce 2,800 smolts/mile) • % of stream reaches with HabRate model rating of "good" for winter rearing, summer rearing, spawning and emergence. • % stream reach in pool habitat • % of stream reach in slackwater pool habitat • % pools greater than 1 meter in depth • # of wood pieces per 100m of stream • # of key wood pieces (>12m long per 100 meters stream length, >60 cm dbh • Volume of LWD per 100 m • # alcoves per reach

		• % of riffle that is sand/silt/ organics (from geomorphic processes in off-channel) • % fine sediment across stream reach (from geomorphic processes in OC) • % fine sediment in fast water habitat (from geomorphic processes in OC) • Fast water units (from geomorphic processes in OC) • Pool tailouts (from geomorphic processes in OC) • % gravel within a reach (from geomorphic processes in OC) • % bedrock in stream reach (from geomorphic processes in OC) • Summary indicator: % of stream reaches, suitable for key life stages, with HabRate model rating of "good"* (Incorporates the following Aquatic Inventory Attributes: % gradient, unit width, active channel width, floodprone width, % pools, scour pool depth, riffle depth, large boulders/100m, % fines, % gravel, % cobble, % boulder, pieces of large woody debris (LWD)/100m, % undercut, residual pool depth, average pieces LWD in pools, average key pieces LWD in pools, and average % sheltered pools)
	Beaver ponds	• # and area of beaver ponds • % of potential beaver habitat occupied by beaver sign
	Riparian Function	• Riparian road density (mi road/mi stream) in one site potential tree buffer (e.g. 164' in the Nehalem) • % of forest riparian areas with conifers > 20" dbh in 164' buffer • % of 6^{th} fields basins with > 50% of riparian area in late seral • % of open lands with wooded buffers along streams • % of riparian area with diverse, healthy native vegetation appropriate to site potential • Percentage of sites that have reached max potential or are demonstrating improving trends for effective shade • Proportion of riparian areas containing invasive species • Width
	Geomorphic processes	• % of riffle that is sand/silt/ organics • % fine sediment across stream reach • % fine sediment in fast water habitat • Fast water units • Pool tailouts • % gravel within a reach • % bedrock in stream reach • Geological composition of reaches

	Lateral connectivity	• % total channel area represented by secondary channels • % of the potential fish use stream length with entrenchment ratio > 2.2 • Lineal distance of side channel habitat • Ratio of side channel to trib length • % of historic aquatic habitats still connected • % of the historical floodplain area that has been excluded from overbank inundation
	Longitudinal connectivity	• Incidence of blocked passage due to low flows or high temperature in the summer • % of total basin stream length blocked by road crossings, dams, culverts, or other artificial blockages • # of fish passage barriers • % of historic aquatic habitats still connected

Component	Key Ecological Attributes	Indicators (metrics) for this KEA
Freshwater Non-Tidal Wetlands	Water Quality	• % of wetlands that meet water quality standards ($H_2$0 temp, sediment, nutrients, and DO)
	Hydrologic Regime	• Duration of soil saturation within rooting zone (NWI and hydric soil mapping)
	Landscape Array of Habitats	• Change in wetland acres (hydric soil mapping (NRCS) compared to NWI) • Acres of wetland • Distribution of different wetland types compared to historic (NWI) • Number of seasonally or year round connected freshwater wetlands • Secondary channel area as a % of total channel area
	Riparian Function (relevant to wetland type)	• Plant community diversity • Large wood • Width • Dominant over story
	Beaver ponds	• % of potential beaver habitat occupied by beaver sign • # and area of beaver ponds
	Hydraulic Connectivity	• Frequency of floodplain wetland inundation • Subsurface connectivity • Fish presence (% accessible to fish)

Component	Key Ecological Attributes	Indicators (metrics) for this KEA
Off-channel	Habitat complexity	• % total channel area represented by secondary channels • % pools greater than 1 meter in depth • #of wood pieces per 100m of stream • # Key wood pieces (>12m long, 0.60m dbh) • Volume of LWD per 100 m • # alcoves per reach • Diversity and abundance of off-channel habitat types.
	Riparian Function	• Riparian road density (mi road/mi stream) in one site potential tree buffer (e.g. 164' in the Nehalem) • % of forest riparian areas with conifers > 20" dbh in 164' buffer • % of 6th fields basins with > 50% of riparian area in late seral • % of open lands with wooded buffers along streams • % of riparian area with diverse, healthy native vegetation appropriate to site potential • Percentage of sites that have reached max potential or are demonstrating improving trends for effective shade • Proportion of riparian areas containing invasive species • Width
	Beaver ponds	• % of potential beaver habitat occupied by beaver sign • # and acres of beaver ponds
	Geomorphic processes	• % fine sediment across stream reach • % fine sediment in fast water habitat • Fast water units • Pool tailouts • % gravel within a reach • % bedrock in stream reach
	Connectivity (lateral and longitudinal)	• Fish presence/absence • Miles/acres of off-channel area connected to mainstem or tributary

Component	Key Ecological Attributes	Indicators (metrics) for this KEA
Estuary	Water Quality	• Indicator for salinity patterns • % of monitored Bay sites meeting bacteria or other WQ criteria
	Landscape Array of Habitats	• Acres of connected tidal wetland • Acres of wetland relative to historic condition (use Coastal and Marine Ecological Classification (CMECS) and Coastal Change Analysis Program (C-CAP) data) • Distribution of habitat types relative to historic condition (CMECS/C-CAP data) • Riparian condition (use Coastal Landscape Analysis Modeling Study (CLAMS) or C-CAP data) • % of historic native wetland habitats lost or altered • % of total estuary area not impacted by levees, dikes, or roads • Amount of large wood, open water, deep channels, salt pans • Acres of beaver ponds
	Sediment dynamics	• Length of connected tidal channels • Width to depth ratios and sinuosity of tidal channels • Channel density • Feet of tidal channels per acre
	Channel morphology (geomorphic processes)	• Length of connected tidal channels • Width to depth ratios and sinuosity of tidal channels • Channel density
	Inundation regime	• Acres of tidal wetlands relative to historic (CMECS) • Number of flow barriers restricting water flow within estuary(dikes, tidegates, and restrictive culverts, roads, railroads, and fill material) (CMECS)
	Connectivity (lateral and longitudinal)	• Number of culverts and tide gates restricting water flow within the estuary

Component	Key Ecological Attributes	Indicators (metrics) for this KEA
Uplands	Connectivity	• % of the watershed that contains steep slope clearcuts (> 65% slope) • % of CLAMS delivery-weighted debris torrent model high-risk areas potentially impacted by timber harvest • Road density • % high debris flow areas intersected by roads • % riparian corridors intersected by roads • % of roads in the watershed where BMPs for the maintenance of designed drainage features are applied (or meet Forest Service road criteria) • % sediment delivery (fine, coarse) over historic
	Landscape Array of Structural Diversity (upland forests)	• % steep slope in clearcut • % of forest classified as: regeneration, closed single canopy; understory; layered; older forest. • Proportion of area in different seral stages (early, mid, late, plantation) • % of the watershed with an OGSI (Old Growth Structural Index) value > 50 (see Spies et al. 2007) • % high risk landslide areas with forest stands in layered or older forest structure. • % high risk landslide areas with forest stands in understory or layered structure.

Component	Key Ecological Attributes	Indicators (metrics) for this KEA
Lakes	Habitat complexity	• Amount of LWD at the Edge (#s of logs by size category: large and not large) • % natural shoreline • riparian composition may not be available
	Connectivity	• % of potential wetlands that are connected subsurface or surface • Barrier inventory (indicator of extent of fish passage)
	Water quality	• Water quality in lakes (H_20 temp, sediment, nutrients, toxics, and DO)

3. Stresses and Threats

The next step in customizing the Common Framework is to describe the primary stresses and threats causing degraded habitat conditions within your watershed. Using consistent terms and methods to describe the effects of different stresses and threats on different components is helpful for prioritizing recovery strategies, actions, and monitoring both within your watershed and across coastal watersheds. After completing this section of the Toolkit, your watershed team will have a documented understanding of relations between threat-stress-components. These relationships will be important later as you select strategies to address threats and build logic models.

3.1 Stresses

Stresses are impaired attributes of an ecosystem. Stresses are equivalent to altered or degraded KEAs. Stresses are not threats, but rather degraded conditions or "symptoms" that result from threats, such as increased water temperature or decreased longitudinal connectivity.

Stresses by Component

Component	Associated Stresses
Mainstem	Increased water temperature
	Increased toxins
	Increased turbidity
	Increased nutrients
	Reduced DO
	Reduced flows (habitat availability)
	Increased flashy flows
	Lack of natural storage
	Increased velocity (that reduces winter rearing habitat)
	Decreased longitudinal connectivity (fish Passage)
	Reduced riparian wood inputs (frequency and size/composition of wood in streams, recruitable wood)
	Lack of pools
	Altered riparian function (species of complexity, age complexity, width of buffer)
	Decreased lateral connectivity
	Increased fine sediment
	Bed coarsening
	Loss of sediment supply
	Reduced extent of habitat
	Increased velocity (that reduces winter rearing habitat)

Tributary	Increased water temperature
	Increased toxins
	Increased turbidity
	Increased nutrients
	Reduced DO
	Reduced flows (habitat availability)
	Increased flashy flows
	Lack of natural storage
	Increased velocity that reduces winter rearing habitat
	Decreased longitudinal connectivity (fish Passage)
	Lack of pools
	Decreased beaver ponds
	Reduced riparian wood inputs (frequency and size/composition of wood in streams, recruitable wood)
	Altered riparian function (species of complexity, age complexity, width of buffer)
	Decreased lateral connectivity
	Increased fine sediment
	Bed coarsening
	Loss of sediment supply
	Reduced extent of habitat
Freshwater Non-tidal Wetlands	Increased water temperature
	Increased nutrients
	Reduced DO
	Reduced quantity for access
	Reduced forage habitat availability
	Lack of natural storage
	Reduced frequency of wood
	Reduced size of wood
	Altered species complexity
	Altered age complexity
	Decreased connectivity
	Decreased beaver ponds
	Reduced extent of habitat
Off-channel	Increased water temperature
	Increased toxins
	Increased turbidity
	Increased nutrients
	Reduced DO
	Reduced flows (habitat availability)
	Increased flashy flows
	Lack of natural storage
	Increased velocity (that reduces winter rearing habitat)
	Decreased longitudinal connectivity (fish Passage)
	Decreased beaver ponds

	Lack of pools
	Reduced riparian wood inputs (frequency and size/composition of wood in streams, recruitable wood)
	Altered riparian function (species of complexity, age complexity, width of buffer)
	Decreased lateral connectivity
	Increased fine sediment
	Bed coarsening
	Loss of sediment supply
	Reduced extent of habitat
Estuary	Increased water temperature
	Increased toxins
	Increased nutrients
	Reduced DO
	Increase estuarine acidification
	Reduced habitat diversity
	Reduced bar area (gravel bar or mud flats)
	Increased velocity that reduces winter rearing habitat
	Reduced frequency of wood in estuary
	Reduced size of wood in estuary
	Reduced riparian width (buffer size)
	Reduced riparian species complexity
	Altered riparian age complexity
	Decreased riparian connectivity
	Increased fine sediment (loss of eel grass)
	Reduced extent of habitat
	Loss of sediment supply (loss of sand)
	Modified salinity regime
	Altered marine mixing
	Reduced tidal wetland connectivity (includes subsidence)
	Reduced forage
	Altered freshwater hydrology
Uplands	Fragmentation
	Loss of connectivity to stream networks
	Altered forest composition
	Increased sediment and hydrology delivery
Lakes	Increased water temperature
	Increased toxins
	Increased nutrients
	Reduced DO
	Reduced quantity for access
	Reduced for habitat availability
	Reduced frequency of wood
	Reduced size of wood
	Reduced riparian wood

	Altered riparian species complexity
	Decreased longitudinal connectivity
	Invasive species/altered species composition
	Reduced extent of habitat

3.2 Threats

Threats are defined as human activities that have caused, are causing, or may cause the destruction, degradation, and/or impairment of components and/or their KEAs. Threats deliver stresses directly to components. The Common Framework includes a list of threats with definitions and common stressors. This list is based on threats listed (sometimes using different terms) in existing coho recovery plans (NOAA, ODFW). The definitions are based on previous classifications (IUCN 2001; Salafsky et al, 2008) with minor modifications reflecting the work of the Partnership.

Common Framework Threats and Definitions

Code (not order of priority)	**Threat**	**Definition**
1	Levees, dikes and bank armoring	These threats refer to shoreline hardening practices and the creation of hard linear surfaces along a beach or stream bank. Erosion and flooding in these areas are reduced, but an unnatural riparian area is created that reduces habitat use by salmonids. These structures disrupt shoreline processes, flow regimes, and reduce habitat extent.
2	Gravel mining (placer, suction dredge, other)	The mining of gravel or mineral deposits in a stream bed can lead to degradation to salmonid habitat through the production of effluents that pollute waters, create sediment and toxic chemical runoff, and can cause major changes in stream structure. Sedimentation is common as is a loss of spawning gravel where mining takes place.
3	Tidegates, culverts and other fish passage impairments	These threats taken together refer to structures that impede the movements and migrations of fish. These can include structures in, along-side, and across water bodies. Structures that impede fish movements cause habitat fragmentation resulting in loss of rearing habitat and prevent successful spawning. Dams are included in a different category of threats.
4	Removal of beavers and beaver ponds	The loss of ponds created by beaver dams has resulted in significant loss of rearing habitat for coho salmon. The removal of beavers and beaver ponds

		can alter stream flow, raise water temperature, and removes important feeding and resting habitat.
5	Conversion	Conversion represents changes in land management or development to practices and uses that are less compatible with healthy salmon ecosystems than those that existed previously. Conversion may be viewed as a spectrum with intact and functioning ecosystems on one end and heavily modified areas (such as urban areas, industrial feedlots etc) on the other. As conversion takes place and lands move down this spectrum, watershed health declines due to increased impervious surfaces, altered flow regimes and stream structure, increased pollutant and effluent loading, and/or other adverse impacts to habitat and water quality. Conversion typically reduces both the extent and quality of habitats, while impairing the processes that can restore and create them.
6	Incompatible/poorly managed roads/railroads	Both paved and unpaved roads including logging roads can all be considered threats to salmon habitat. The general expansion of roads causes terrestrial habitat fragmentation, increased fine sediment, impervious surfaces, and causes debris and pollution impacts.
7	Water withdrawals (urban, ag and potential for future water storage)	Water withdrawals can create a threat to salmonid populations by reducing stream flow, changing stream structure, and increasing water temperature. All types of water withdrawals fit into this category, which includes water for private use, agricultural use, and water storage. Water withdrawals from groundwater can also impact surface water availability. This category also includes future water storage projects (dams to store water in winter for use by communities during the summer) which will alter hydrology and water availability.
8	Incompatible/poorly managed stormwater/wastewater	Stormwater and wastewater become threats to salmon populations when they cause toxins and other pollutants to enter salmon habitats. These can be from both point and non-point sources and includerunoff, wastewater discharge, persistent chemical cycling, historic (legacy) sources, non-persistent toxics, and discharge through stormwater conveyance systems. The threat from stormwater and wastewater generally depends on the toxicity and quantity of the discharge or runoff that enters habitats.

9	Dredging	Activities that excavate or remove substrate from estuaries, sloughs, and tidally-influenced river reaches to maintain channels for navigation, prepare an area for development, and support other economic uses. Dredging can cause sedimentation and reduce habitat availability and complexity.
10	Dams and off-channel water storage	Dams and off-channel water storage fall under the same threat category. These threats deal with water storage concerns and are similar in impact to water withdrawal in that flow regimes are modified. Dams and water storage threats can also impede the movements and migrations of fish. Flashy flow regimes can also be caused by dams and off-channel water storage.
11	Incompatible/poorly managed agricultural practices	Incompatible/poorly managed agricultural practices include ongoing and historic agricultural practices that result in higher water temperature, increased effluents, simplified stream structure, and other adverse impacts on habitats and watershed function.
12	Fertilizers/pesticides	Threats from fertilizers and pesticides can impact water quality and introduce pollutants into salmonid habitat.
13	Incompatible/poorly managed timber practices	Incompatible/poorly managed timber practices includes current and legacy (especially splash damming) silvicultural practices that result in higher water temperature, increased effluents, simplified stream structure, and other adverse impacts on habitats and watershed function.
14	Invasive species	Plants, animals, or pathogens that are non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause harm. Invasive aquatic species can cause increased predation and competition for salmonid populations, as well as displacement of native fish and the introduction of non-native genetic material. Invasive non-native plants can negatively impact riparian habitat by displacing native species.
15	Climate change	Climate change can threaten salmon populations by contributing to sea level rise, increased water temperatures, changes in the patterns of upwelling events, changes in nutrient and oxygen levels, pH decreases, and precipitation changes.

16	Recreation	Recreation includes activities that rely on the passive or active use of natural resources. Such activities are many and varied and may produce a variety of impacts such as wood removal, disturbance to flora and fauna, degraded water quality and others.

3.3 Threat-Stress-Component Linkage

The linkages between threats, stresses and habitat components will help watersheds better articulate and come to a common understanding of what is causing the specific degradation to specific coho habitats. The following table includes the Partnership's assumption of links between components, stresses and threats for the whole Oregon coast. These may or may not be relevant in your watershed.

Component	Key Stresses associated with the component	Threats associated with the stress
Mainstem River	Increased water temperature	1,4,5,6,7,8,10,11,13,15
	Increased toxins	5,8,11,12
	Increased turbidity	1,2,4,5,6,8,9,11,13,15
	Increased nutrients	5,8,11
	Reduced DO	3,5,11,12
	Reduced flows (habitat availability)	4,5,7,10,13
	Increased flashy flows	1,2,3,4,5,6,8,11,13,15
	Lack of natural storage	1,3,4,5,6,7,9,10,11,13
	Increased velocity that reduces winter rearing habitat	1,2,3,4,5,6,8,9,11,13
	Decreased longitudinal connectivity (fish Passage)	2,3,9,11,13
	Lack of pools	1,2,3,4,5,6,9,11,13
	Reduced frequency of wood in streams	1,2,3,5,9,11,13
	Reduced size of wood in streams	13
	Reduced riparian width (buffer size)	1,2,3,5,6,9,11,13
	Reduced riparian wood	1,5,6,9,11,13
	Altered riparian species complexity	1,4,5,6,11,13,14
	Altered riparian age complexity	1,4,5,6,11,13
	Decreased lateral connectivity	1,2,3,4,5,6,9,11,13
	Increased fine sediment	2,4,5,6,8,9,11,13
	Bed coarsening	1,2,4,5,8,9,11,13
	Loss of sediment supply	1,2,3,4,5,6,9,10,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15
Tributaries	Increased water temperature	1,4,5,6,7,8,10,11,13,15

	Increased toxins	5,8,11,12
	Increased turbidity	1,2,4,5,6,8,9,11,13,15
	Increased nutrients	5,8,11
	Reduced DO	3,5,11,12
	Reduced flows (habitat availability)	4,5,7,10,13
	Increased flashy flows	1,2,3,4,5,6,8,11,13,15
	Lack of natural storage	1,3,4,5,6,7,9,10,11,13
	Increased velocity that reduces winter rearing habitat	1,2,3,4,5,6,8,9,11,13
	Decreased longitudinal connectivity (fish Passage)	2,3,9,11,13
	Lack of pools	1,2,3,4,5,6,9,11,13
	Reduced frequency of wood in streams	1,2,3,5,9,11,13
	Reduced size of wood in streams	13
	Reduced riparian width (buffer size)	1,2,3,5,6,9,11,13
	Reduced riparian wood	1,5,6,9,11,13
	Altered riparian species complexity	1,4,5,6,11,13,14
	Altered riparian age complexity	1,4,5,6,11,13
	Decreased lateral connectivity	1,2,3,4,5,6,9,11,13
	Increased fine sediment	2,4,5,6,8,9,11,13
	Bed coarsening	1,2,4,5,8,9,11,13
	Loss of sediment supply	1,2,3,4,5,6,9,10,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15
Freshwater Non-Tidal Wetlands	Increased water temperature	1,4,5,6,7,8,10,11,13,15
	Increased nutrients	5,8,11
	Reduced DO	3,5,11,12
	Reduced quantity for access	1,2,3,4,5,6,7,8,9,10,11,13
	Reduced for habitat availability	1,2,3,4,5,6,7,8,9,10,11,13
	Lack of natural storage	1,2,3,4,5,6,7,9,10,11,13
	Reduced frequency of wood	1,2,3,5,9,11,13
	Reduced size of wood	13
	Altered species complexity	1,4,5,6,11,13,14
	Altered age complexity	1,4,5,6,11,13
	Decreased connectivity	1,2,3,4,5,6,9,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15
Off-Channel	Increased water temperature	1,4,5,6,7,8,10,11,13,15
	Increased toxins	5,8,11,12
	Increased turbidity	1,2,4,5,6,8,9,11,13,15
	Increased nutrients	5,8,11
	Reduced DO	3,5,11,12
	Reduced flows (habitat availability)	4,5,7,10,13
	Increased flashy flows	1,2,3,4,5,6,8,11,13,15
	Lack of natural storage	1,3,4,5,6,7,9,10,11,13

	Increased velocity that reduces winter rearing habitat	1,2,3,4,5,6,8,9,11,13
	Decreased longitudinal connectivity (fish Passage)	2,3,9,11,13
	Lack of pools	1,2,3,4,5,6,9,11,13
	Reduced frequency of wood in streams	1,2,3,5,9,11,13
	Reduced size of wood in streams	13
	Reduced riparian width (buffer size)	1,2,3,5,6,9,11,13
	Reduced riparian wood	1,5,6,9,11,13
	Altered riparian species complexity	1,4,5,6,11,13,14
	Altered riparian age complexity	1,4,5,6,11,13
	Decreased lateral connectivity	1,2,3,4,5,6,9,11,13
	Increased fine sediment	2,4,5,6,8,9,11,13
	Bed coarsening	1,2,4,5,8,9,11,13
	Loss of sediment supply	1,2,3,4,5,6,9,10,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15
Estuary	Increased water temperature	1,4,5,6,7,8,10,11,13,15
	Increased toxins	5,8,11,12
	Increased nutrients	5,8,11
	Reduced DO	3,5,11,12
	Increase estuarine acidification	15
	Reduced habitat diversity	1,2,3,4,5,6,9,11,13,15
	Reduced bar area (gravel bar or mud flats)	1,2,3,5,9,11,13
	Increased velocity that reduces winter rearing habitat	1,2,3,4,5,6,8,9,11,13
	Reduced frequency of wood in estuary	1,2,3,5,9,11,13
	Reduced size of wood in estuary	13
	Reduced riparian width (buffer size)	1,2,3,5,6,9,11,13
	Reduced riparian species complexity	1,4,5,6,11,13,14
	Altered riparian age complexity	1,4,5,6,11,13
	Decreased riparian connectivity	1,2,3,4,5,6,9,11,13
	Increased fine sediment (loss of eel grass)	2,4,5,6,8,9,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15
	Loss of sediment supply (loss of sand)	1,2,3,4,5,6,9,10,11,13
Uplands	Fragmentation	1,3,4,6,13
	Loss of connectivity to stream networks	1,3,6,11,13
	Altered forest composition	13,14
Lakes	Increased water temperature	1,3,4,5,6,7,10,11,13,15
	Increased toxins	5,6,8,11
	Increased nutrients	5,8,11,13,15

	Reduced DO	1,3,4,7,11,12,13,14
	Reduced quantity for access	1,3,4,5,6,7,10,11,13
	Reduced for habitat availability	1,3,4,5,6,7,11,13,14,15
	Reduced frequency of wood	1,2,3,5,9,11,13
	Reduced size of wood	13
	Reduced riparian wood	1,5,6,9,11,13
	Altered riparian species complexity	1,4,5,6,11,13,14
	Decreased connectivity	1,3,4,5,6,7,8,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15

Appendix 4

ODFW Nehalem Life Cycle Monitoring Project Summary

Nehalem River Life Cycle Monitoring
Summary Report

Introduction

In 1998, as part of the Oregon Plan for Salmon and Watersheds, the Oregon Department of Fish and Wildlife (ODFW) Life-Cycle Monitoring project (LCM) began monitoring survival and migration of salmonid fishes (*Oncorhynchus spp.*) in the North Fork (NF) Nehalem River basin (Suring et al. 2014). The two primary goals of the NF Nehalem LCM project are to estimate abundance of returning adult salmonids and downstream migrating juvenile salmonids and estimate freshwater and marine survival rates of coho salmon.

The NF Nehalem River, a 4th order tributary that joins the mainstem Nehalem River at river mile (RM) 2.8, has annual returns of wild coho salmon (*Oncorhynchus kisutch*), fall Chinook salmon (*Oncorhynchus tshawytscha)*, winter steelhead (*Oncorhynchus mykiss)*, and coastal cutthroat trout (*Oncorhynchus clarkii clarkii*). Nehalem Fish Hatchery, located approximately 2 RM downstream of the LCM site, also releases two stocks of hatchery coho salmon and one stock of winter steelhead into the NF Nehalem River. Nehalem stock hatchery coho salmon are of varied origin and have had no wild inputs since the 1960s. Fishhawk stock hatchery coho salmon are derived from wild fish from Fishhawk Creek, a tributary to the upper Nehalem River. During the three year coho salmon brood-cycle, the Nehalem stock is released as smolts and return as adults in two years and the Fishhawk stock in one year.

Adult and Juvenile Salmonid Abundance Estimation

Adult fish are collected from September through May at a fish trap on Waterhouse Falls, 12 RM upstream of the confluence with the mainstem Nehalem River, and at a fish trap on Fall Creek Falls, 4 RM upstream of Waterhouse Falls (Figure 1). Both waterfalls are partial migration barriers to upstream anadromous migration. Wild fish are tagged with Floy tags and a Petersen mark-recapture methodology (Ricker 1975) modified for tag loss (Caughely 1977) is employed to estimate total wild spawners upstream of both falls. Live visual and carcass recoveries from the Fall Cr Falls adult trap and spawning surveys where tag detection can be evaluated are used for mark-recapture estimation. Stray hatchery coho salmon caught at both traps are euthanized and used for stream enrichment or donated to the local food bank and assisting living facilities. The number of hatchery coho salmon spawners upstream of both falls is estimated by multiplying the wild coho salmon spawner estimate by the hatchery:wild ratio of coho caught at each adult trap and then subtracting the number of hatchery coho euthanized at each trap.

Juvenile fish are collected from February through June at rotary screw traps installed in the vicinity of Waterhouse and Fall Cr Falls (Figure 1). In 2017, an additional rotary screw trap was also installed at the mouth of Gods Valley Cr, an important spawning and rearing tributary upstream of Waterhouse Falls (Figure 1). Rotary screw traps are checked daily and capture efficiency determined by marking up to 50 fish from a variety of species size-class categories and counting new fish and recaptures each day. Juvenile out-migrant estimates for each trap site are made using the Bayesian Time-Stratified Population Analysis (BTSPAS; Bonner and Schwarz 2014) in R (R Core Team 2017) from weekly-stratified mark-recapture estimation.

Monitoring in the LCM study basin began at the lower screw trap site (i.e. near Waterhouse Falls) in spring of 1998, with trapping at the Waterhouse and Fall Cr Falls adult traps commencing in 1999, and juvenile monitoring at the upper screw trap site (i.e. near Fall Cr Falls) in 2000. We defined the total basin as the area upstream of Waterhouse Falls, the lower sub-basin as the area between Waterhouse and Fall Cr Falls, and the upper sub-basin as the area above Fall Cr Falls. The NF Nehalem lower (38.6 km) and upper (38.5 km) sub-basins contain 77.1 km of coho salmon rearing and spawning habitat (Figure 1).

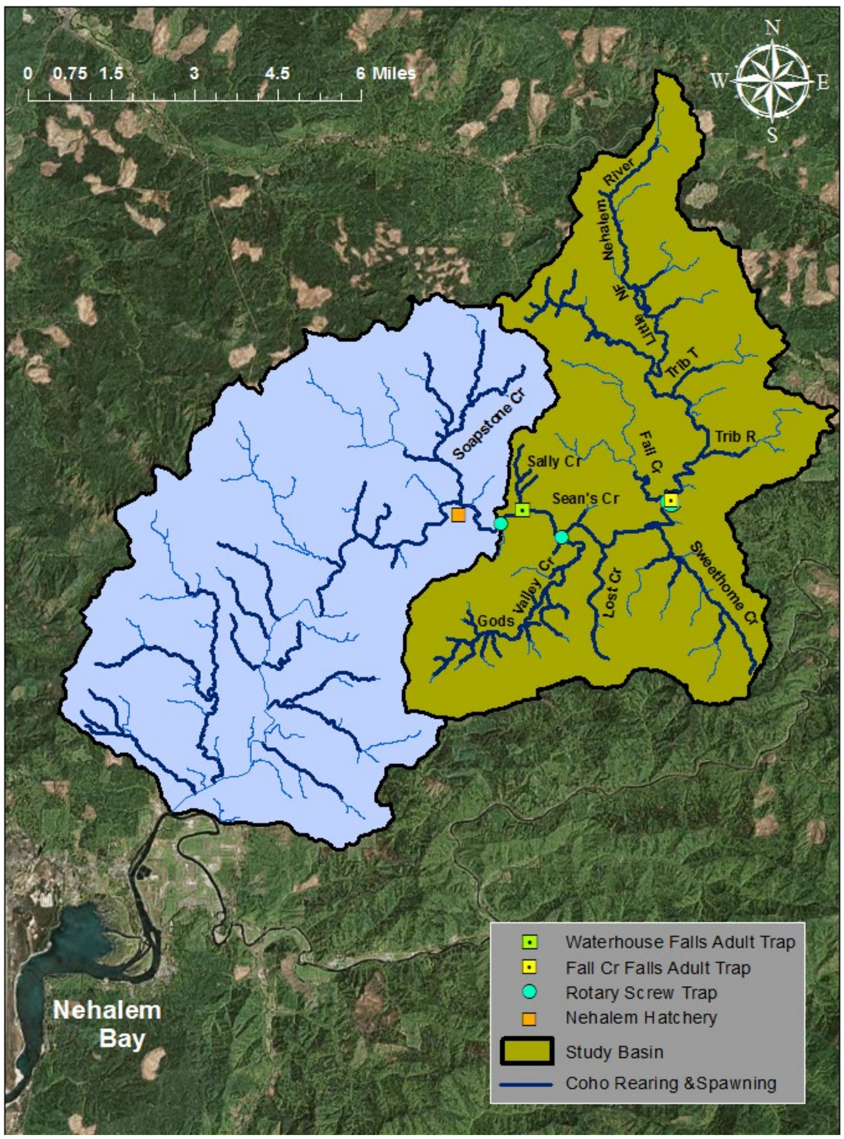

Figure 1. The NF Nehalem River basin including the Life-Cycle Monitoring (LCM) study area, Nehalem Hatchery, adult and juvenile fish trapping locations, and extent of coho salmon spawning and rearing habitat.

In figures that follow, bounds around population estimates are 95% confidence intervals. For the results below, the following terms and definitions are used to describe the chronology of coho salmon life history types and parameters:

Return Year: represents the year most adult fish are collected at a trap or observed upstream of a trap (October or December) although coho may spawn in January and February of the subsequent year. Composed of age-3 adults and age-2 jacks (i.e. 1996 Brood Year adults and 1997 Brood Year jacks form the 1999 Return Year).

Brood Year: represents the first year that eggs are deposited for a Return Year (e.g. fish of the 1996 Brood Year were derived from the 1996 Return Year. This brood will return as adults to form the 1999 Return Year).

Sample Year: the year juvenile coho were collected at a screw trap (February-June).

Percent Freshwater (FW) Survival: the number of coho smolt out-migrants divided by the estimated number of eggs deposited in the corresponding Brood Year.

Egg Deposition: the estimated number of eggs deposited by female adult coho spawners in a Return Year using the following equation from (Johnson 1998):

$$(7.9556 * [\text{average coho female length}] - 2854.07) * \text{total female spawners}$$

Percent Marine Survival: the number of female wild coho adults returning to spawn divided by half the coho smolts produced from the corresponding Brood Year.

Adult and Juvenile Coho Salmon Timing

Coho salmon adults usually begin to ascend the NF Nehalem River beginning in early September to early October with the arrival of fall rains and higher river flows. Coho salmon usually arrived at the Waterhouse Falls adult trap by early to mid-October and at the Fall Cr Falls adult trap by late October, with peak catches of hatchery fish occurring earlier than wild fish. A significant number of wild coho salmon were caught at both the Waterhouse Falls and Fall Cr Falls adult traps, with run-timing usually continuing through December and, sometimes, into January. Few hatchery coho salmon were caught after mid-November at the Waterhouse Falls adult trap or at any time during the trapping season at the Fall Cr Falls adult trap. Accurate estimates of coho fry were not possible at the rotary screw traps due to large storms and high flows in February and early March precluding safe operation of the traps when large numbers of coho fry were typically migrating. Peak coho smolt out-migration typically occurred between mid-April and mid-May when conditions were more favorable for trapping.

What we have Learned

The number of wild adult coho salmon spawners in the NF Nehalem River basin upstream of Waterhouse Falls varied widely over the monitoring period, with large fluctuations in run size sometimes occurring over a short time period. For instance, we observed our third highest spawner estimate in the 2011 return year (2,706 spawners), and our lowest number of wild adult coho spawners in 2012 (389 spawners). Similarly, the 2014 return year saw the highest number of wild adult coho spawners return to the basin (6,690 spawners) followed by our fourth lowest number of spawners in 2015 (783 spawners). No significant relationship was observed between wild adult coho spawners upstream of Waterhouse Falls and the number of coho smolt out-migrants, out-migrant peak or season length, or freshwater survival for the corresponding brood. However, there was a significant relationship between wild adult coho spawners and marine survival estimates ($R^2 = 0.93$; $p < 0.05$). The lower sub-basin had a higher number of wild adult coho spawners annually ($\bar{x}$ = 1,163 spawners) compared to the upper sub-basin ($\bar{x}$ = 793 spawners).

Significant straying of hatchery coho salmon occurred upstream of Nehalem Hatchery, with 35% of the adult hatchery coho return (i.e. Nehalem Hatchery catch and LCM estimate) estimated to reach Waterhouse Falls. We found no consistent relationship between the number of smolts released from the hatchery and subsequent number of returning hatchery adults, nor the percentage of hatchery spawners that strayed to Waterhouse Falls. The percentage of all hatchery coho adults that strayed to Waterhouse Falls was significantly higher for Fishhawk stock hatchery coho than Nehalem stock (45% compared to 31%, respectively). The majority of adult hatchery coho spawned in the lower sub-basin and few fish were observed at Fall Cr Falls or estimated to have spawned in the upper basin. Over all years of this study, hatchery strays comprised 26% of all adult coho salmon spawners upstream of Waterhouse Falls. Euthanizing hatchery coho at the adult traps for stream enrichment or donation to local food banks and assisted living facilities significantly reduced stray rates (23% - 87% reduction, $\bar{x}$ = 53%) while providing a vital protein source for local communities.

The number of coho smolt out-migrants varied widely over the monitoring period and was significantly higher in the upper sub-basin ($\bar{x}$ = 18,079 smolts) than lower sub-basin ($\bar{x}$ = 9,738 smolts). Similarly, coho smolts/female spawner was significantly higher in the upper basin (73 smolts/female spawner) than lower sub-basin (18 smolts/female spawner). Lower sub-basin coho smolt production varied over a wide range of female spawner densities, while upper sub-basin production was less variable over a much narrower range of female spawner densities. In both sub-basins, the number of coho smolts per female decreased as the number of female spawners increased. Similarly, freshwater survival decreased as the number of female spawners increased in both sub-basins. We did not find a significant relationship between female spawner numbers and smolt abundance or between freshwater survival and smolt abundance.

Over nineteen years of trapping we have monitored nearly 7 brood cycles of the three coho brood lines (i.e. 1996, 1997, 1998 broods). Although not statistically significant, the 1997 brood has consistently produced fewer returning adult spawners ($\bar{x}$ = 1,098 adults) than the 1996 ($\bar{x}$ = 2,444 adults) and 1998 broods ($\bar{x}$ = 1,895 adults). Similarly, the 1996 brood produces significantly fewer ($p = 0.009$) coho smolts ($\bar{x}$ = 20,761 smolts) than the 1998 ($\bar{x}$ = 32,329 smolts) and 1996 broods ($\bar{x}$ = 30,913 smolts).

Water temperature monitoring in the NF Nehalem River basin began in 2006 at Waterhouse Falls and 2011 at Fall Cr Falls. Additional water temperature monitoring was implemented in all major NF Nehalem tributaries in 2015 and all tributaries in the Gods Valley Creek watershed in 2016. Hourly water temperature readings at Waterhouse Falls show temperatures regularly exceeding 18°C during the summer months. Data from Fall Creek Falls also shows temperatures exceeding the same threshold but to a lesser extent and duration. Preliminary data from tributary monitoring indicates some tributaries may supply cold water refugia, but continued monitoring is necessary to better understand thermal patterns in the basin.

A Closer Look at the Numbers

1. The number of returning coho salmon spawners was highly variable (Figures 2 and 3)
    - Total adults = 411 - 9,081 spawners, ($\bar{x}$ = 2,566 spawners)
    - Wild Adults = 389 - 6,690 spawners, ($\bar{x}$ = 1,817 spawners)
    - Hatchery Adults = 22 - 3,332 spawners, ($\bar{x}$ = 749 spawners)
    - Wild Adults (Lower, $\bar{x}$ = 1,163 spawners, Upper, $\bar{x}$ = 793 spawners)
2. Marine survival, smolt production, and freshwater survival also highly variable
    - Marine survival = 1.7% - 21.1%, ($\bar{x}$ = 6.6%; Figure 4b)
    - Smolt production = 19,228 - 43,260 smolts, ($\bar{x}$ = 28,229 smolts; Figure 4c)
    - Freshwater survival = 0.2% - 3.9%, ($\bar{x}$ = 1.3%; Figure 4d)
3. Significant straying of hatchery coho salmon occurs upstream of Nehalem Hatchery
    - 35% of hatchery adult coho salmon stray to Waterhouse Falls (Figure 5)
    - Fishhawk stock hatchery coho salmon have a higher stray rate than Nehalem stock (45% compared to 31%, respectively; Figure 5)
    - Hatchery strays comprise a significant percentage of all adult coho salmon spawners upstream of Waterhouse Falls (26% strays, Figure 6)
4. The majority of hatchery adult coho salmon spawn in the lower sub-basin (22 - 2,401 spawners, $\bar{x}$ = 734 spawners) than in the upper sub-basin (0 - 931 spawners, $\bar{x}$ = 79 spawners; Figure 7)

5. Removal of hatchery coho salmon at LCM adult traps significantly reduces strays on spawning grounds (23% - 87% reduction, ($\bar{x}$ = 53%; Figure 8)
6. The number of coho salmon smolts and coho smolts/female spawner is significantly lower in the lower sub-basin than the upper sub-basin (Figures 9 and 10) despite similar rearing capacity
   - Lower sub-basin = 2,667 - 21,753 smolts, ($\bar{x}$ = 9,738 smolts)
   - Upper sub-basin = 10,474 - 22,815 smolts, ($\bar{x}$ = 18,079 smolts)
   - Lower sub-basin = 1 - 67 smolts/female spawner, ($\bar{x}$ = 18 smolts/female spawner)
   - Upper sub-basin = 17 - 200 smolts/female spawner, ($\bar{x}$ = 73 smolts/female spawner)
7. The number of coho smolts/female spawner decreased as the number of female spawners increased in both the lower and upper sub-basins (Figure 11)
8. Coho salmon freshwater survival (%) decreased as the number of female spawners increased (Figure 12)
9. Although not significant (p=0.34), more wild adult coho salmon spawners typically return from the 1996 and 1998 broods than the 1997 brood (Figure 13a)
   - 1996 brood = 745 - 6,690 adults; ($\bar{x}$ = 2,444 adults)
   - 1997 brood = 612 - 2,094 adults; ($\bar{x}$ = 1,098 adults)
   - 1998 brood = 657 - 5,026 adults; ($\bar{x}$ = 1,895 adults)
10. Significantly more coho smolts (p=0.009) are produced from the 1996 and 1998 broods than the 1997 brood (Figure 13b)
    - 1996 brood = 21,405 - 43,260 smolts; ($\bar{x}$ = 32,329 smolts)
    - 1997 brood = 19,228 - 24,158 smolts; ($\bar{x}$ = 20,761 smolts)
    - 1998 brood = 26,905 - 37,852 smolts; ($\bar{x}$ = 30,913 smolts)
11. Hourly water temperature readings during summer in the NF Nehalem River regularly exceed 18ºC at Waterhouse Falls (Figure 14)

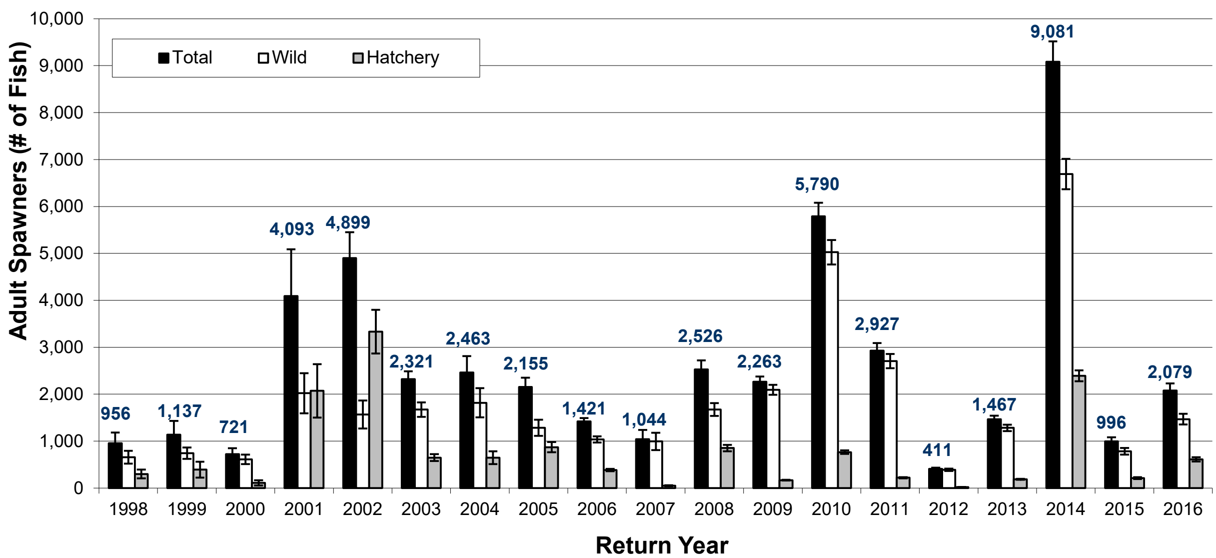

Figure 2. Annual number of total, wild, and hatchery coho salmon spawners in the NF Nehalem River basin upstream of Waterhouse Falls for the 1998 - 2016 return years. The total number of coho salmon spawners for each return year is shown above the black bar.

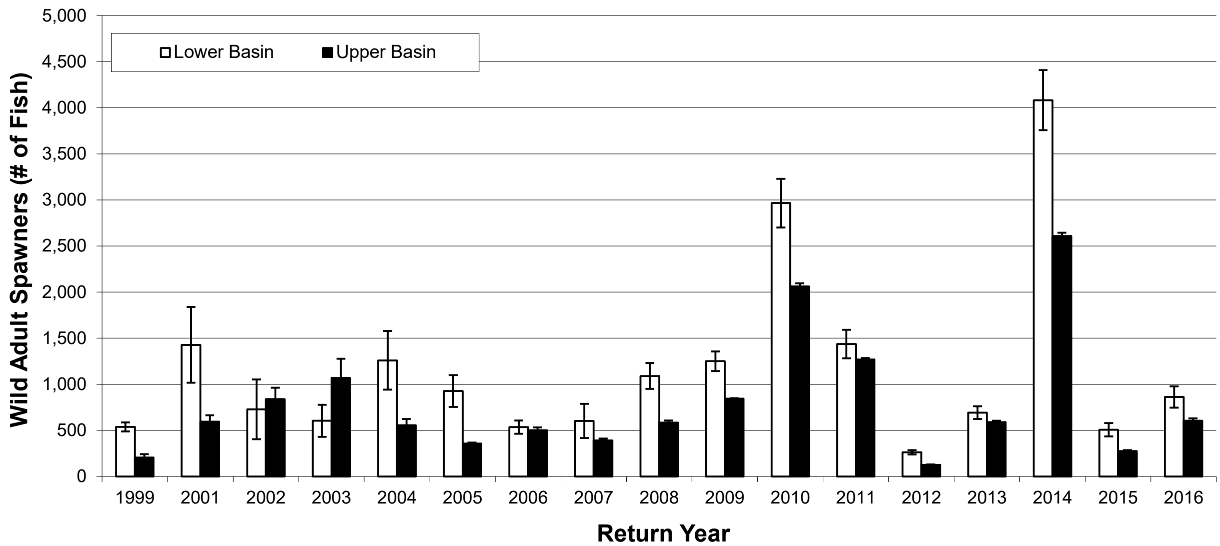

Figure 3. Annual number of wild adult coho salmon spawners in the lower (white bars) and upper (black bars) sub-basins of the NF Nehalem River basin for the 1999 and 2001- 2016 return years.

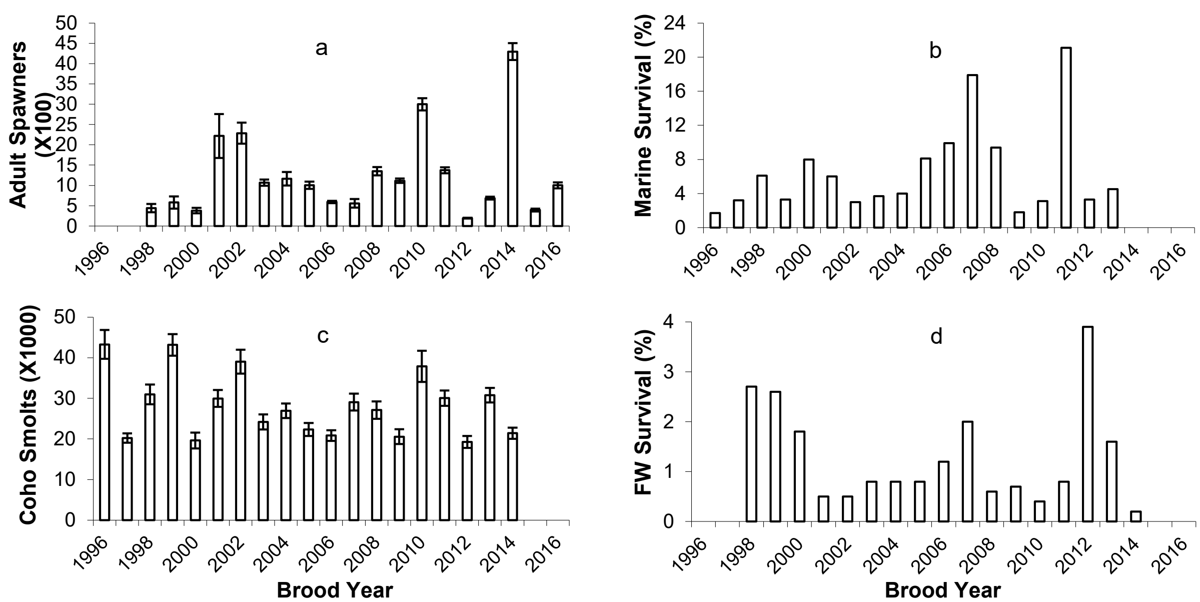

Figure 4. Annual trends in the (a) parental female spawner estimate, (b) percent marine survival, (c) smolt production estimate, and (d) percent freshwater survival for coho salmon in the NF Nehalem River upstream of Waterhouse Falls for the 1998 - 2016 brood years.

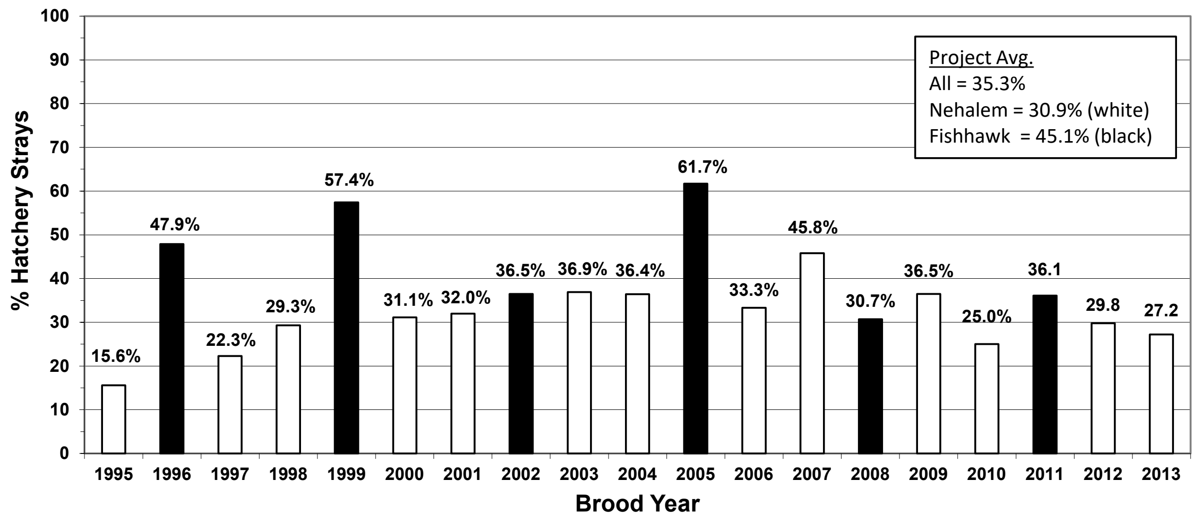

Figure 5. Percentage of all returning hatchery coho salmon adults that strayed to Waterhouse Falls for the 1995 - 2013 brood years. Brood years with white bars indicate Nehalem stock hatchery coho returns and black bars indicate Fishhawk stock hatchery coho returns.

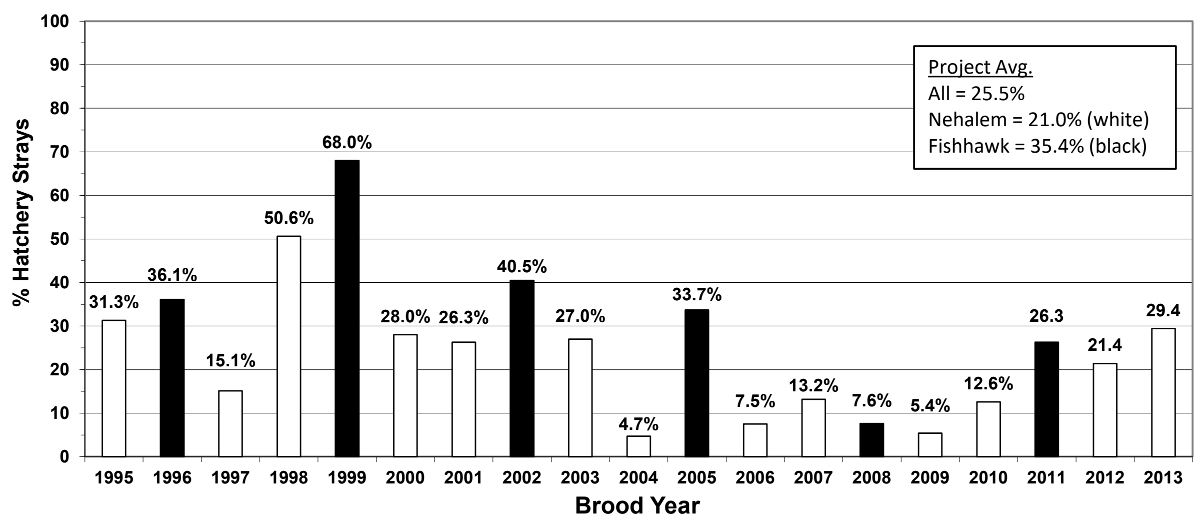

Figure 6. Percentage of hatchery adult coho salmon strays among all adult coho salmon spawners upstream of Waterhouse Falls for the 1995 - 2013 brood years. Brood years with white bars indicate Nehalem stock hatchery coho returns and black bars indicate Fishhawk stock hatchery coho returns. No hatchery coho salmon were removed at the Waterhouse Falls adult trap during the 1999 - 2003 brood years.

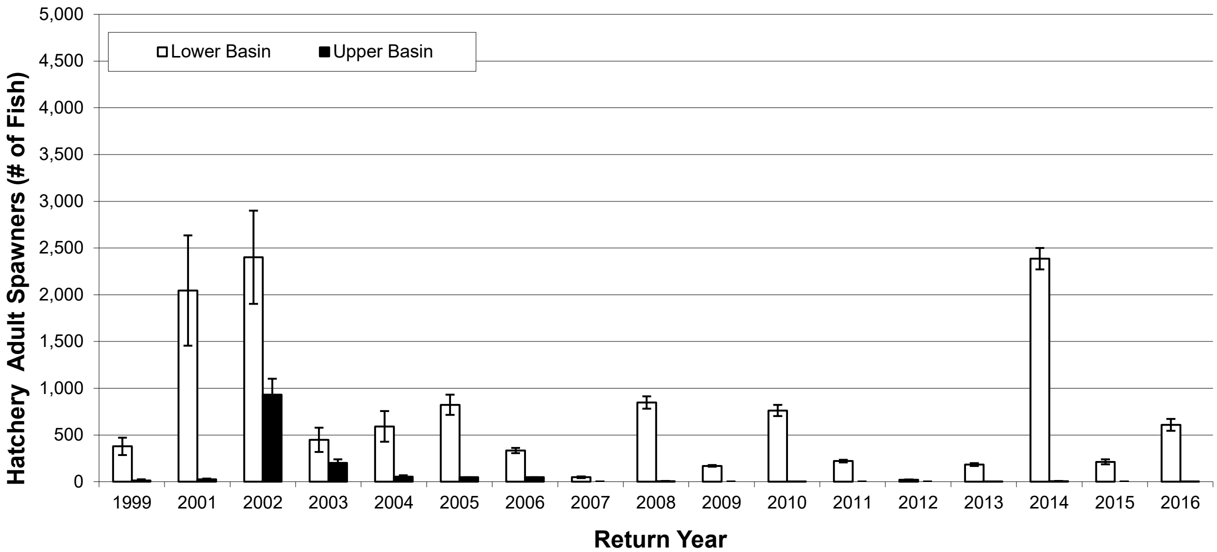

Figure 7. Annual number of hatchery adult coho salmon spawners in the lower (white bars) and upper (black bars) sub-basins of the NF Nehalem River basin for the 1999 and 2001- 2016 return years. No hatchery coho salmon were removed at the Waterhouse Falls adult trap during the 2002 - 2006 return years.

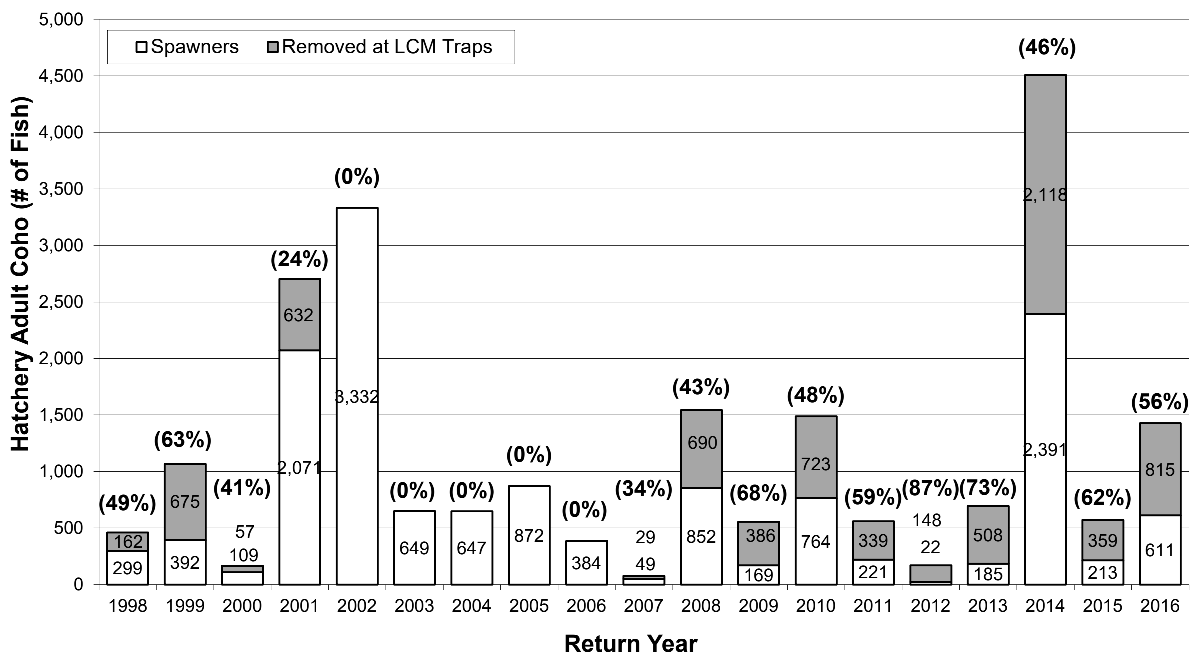

Figure 8. Annual number of hatchery adult coho salmon removed at the Waterhouse Falls and Fall Cr Falls adult traps (gray bars) and spawners upstream of Waterhouse Falls (white bars) for the 1998 - 2016 return years. No hatchery coho salmon were removed at the Waterhouse Falls adult trap during the 2002 - 2006 return years. The percentage reduction in hatchery adult coho

salmon spawners upstream of Waterhouse Falls from removal at LCM adult traps is shown above each bar in parantheses.

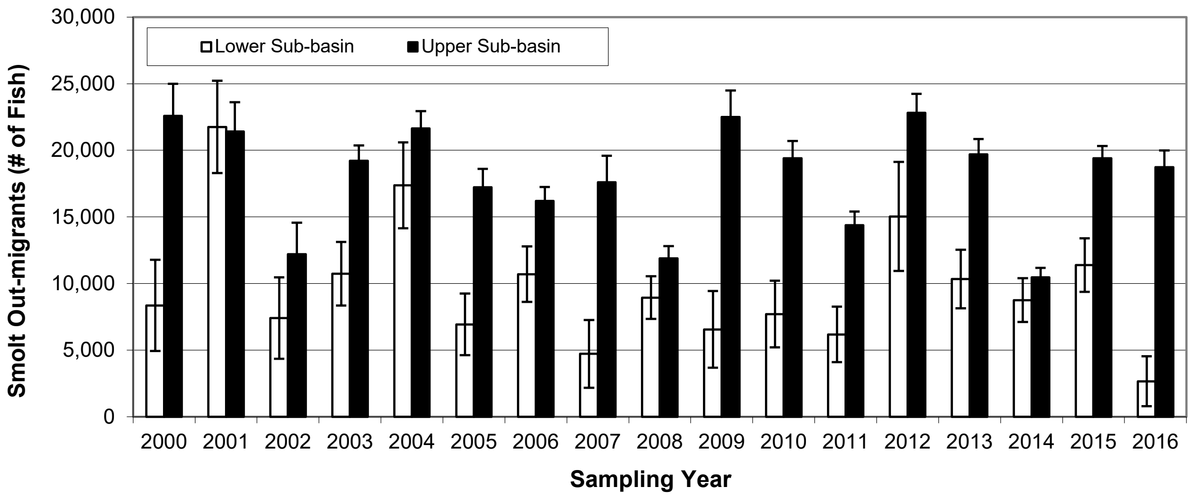

Figure 9. The estimated number of coho smolt out-migrants in the lower (white bars) and upper (black bars) sub-basins of the NF Nehalem River for the 2000 - 2016 sampling years.

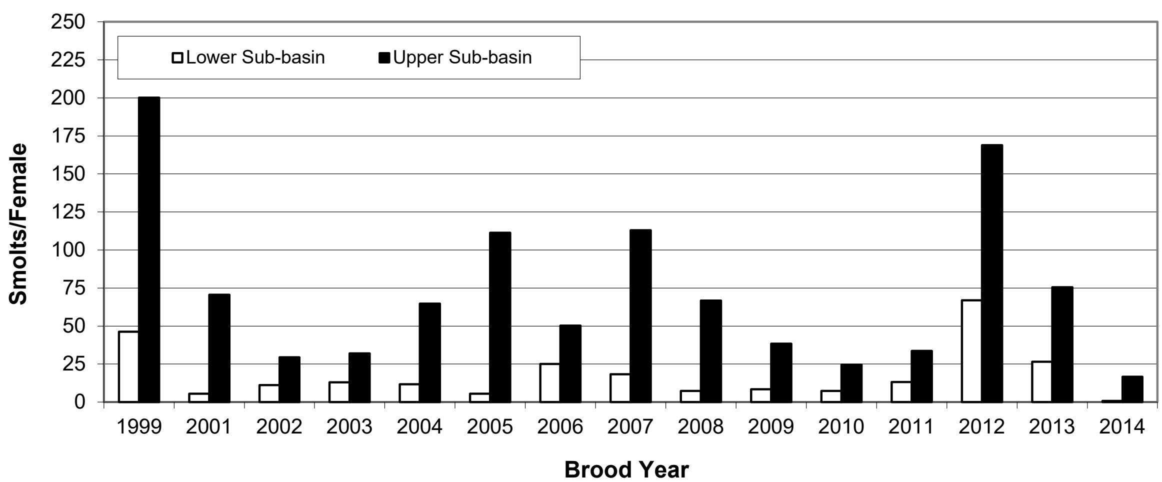

Figure 10. The estimated number of coho smolts/female spawner in the lower (white bars) and upper (black bars) sub-basins of the NF Nehalem River for the 1999 and 2001 - 2014 brood years.

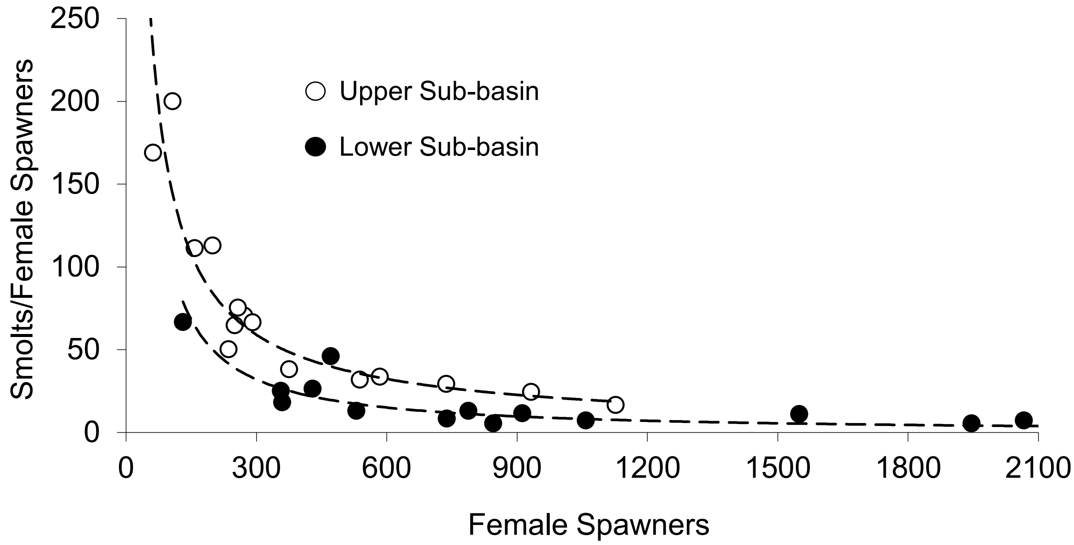

Figure 11. The relationship of coho salmon smolts per female spawner to total female spawners in the lower and upper sub-basins of the NF Nehalem River.

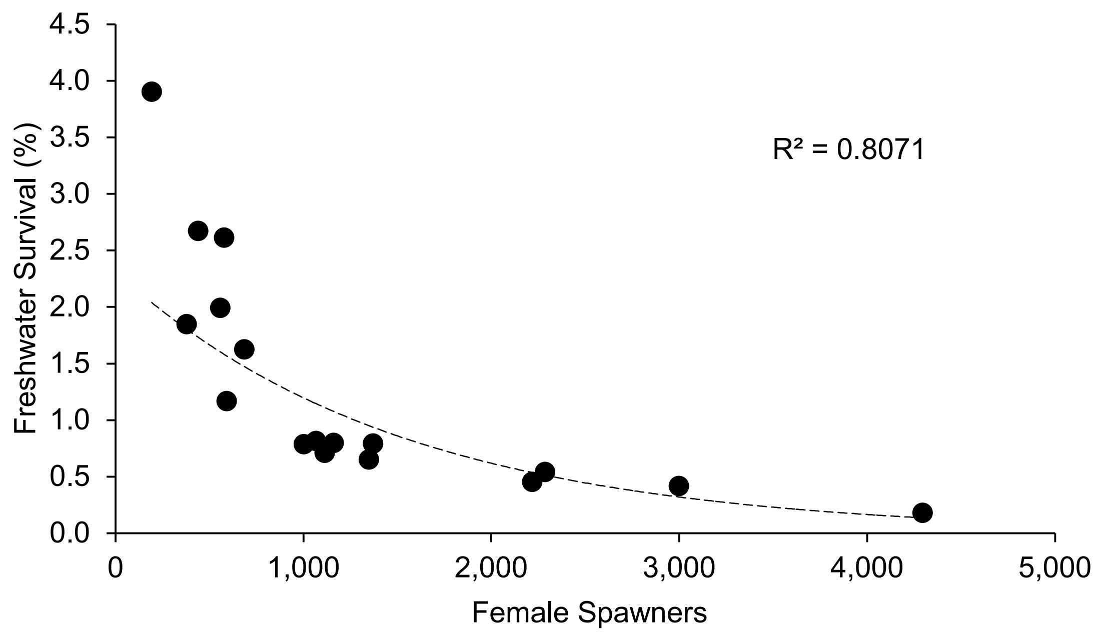

Figure 12. The relationship between coho salmon freshwater survival (%) and number of female coho spawners in the NF Nehalem River basin upstream of Waterhouse Falls for the 1998 - 2014 brood years.

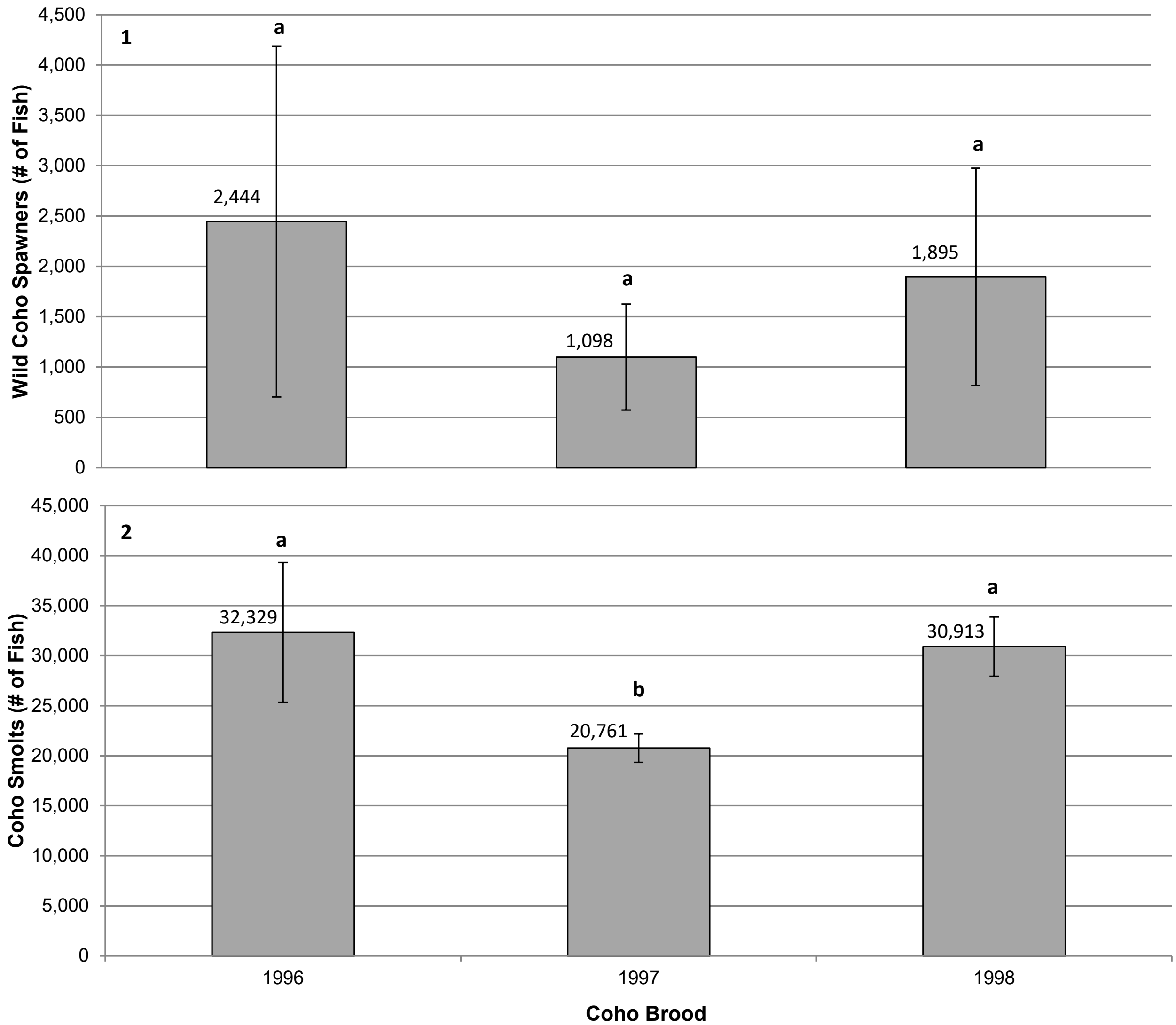

Figure 13. Number of (1) wild coho salmon adult spawners and (2) number of coho smolt out-migrants by coho brood line for the 1996 - 2016 brood years. Coho broods with difference letters are significantly different ($p < 0.05$).

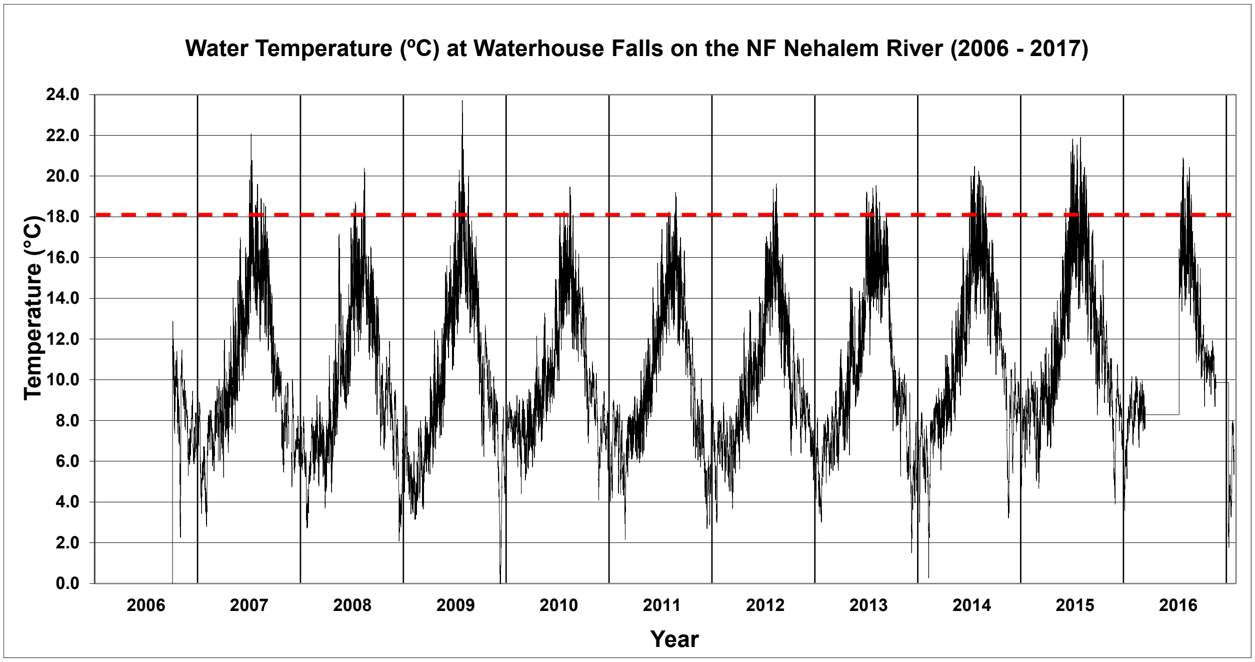

Figure . Hourly water temperature readings (°C) recorded at Waterhouse Falls on the NF Nehalem River from 2006 - 2017. The red dotted line highlights temperatures exceeding the 18°C threshold critical for salmon.

Data Gaps (Opportunities for Future Study)

1. Information lacking on alternative life history strategies for wild coho in NF Nehalem
    - 2016 was first year of otolith collections from adult coho carcasses
    - Otolith microchemistry analyses currently being performed at OSU (40 samples)
    - More coho carcasses found at NF Nehalem LCM site than any other site
    - Continuation of NF Nehalem LCM project will provide opportunity for future study
2. Information lacking on thermal refugia in the NF Nehalem LCM basin
    - NF Nehalem mainstem water temperatures exceed 18°C every summer
    - Water temperature loggers deployed in all major tributaries to NF Nehalem (2015) and Gods Valley Creek watershed (2016) to better understand thermal patterns
    - Continuation of NF Nehalem LCM project will provide opportunity for future study
3. Insufficient understanding of why coho smolts/female spawner is higher in upper sub-basin than lower sub-basin
    - Continuation of adult and juvenile monitoring in basin can evaluate this pattern
    - Updated winter habitat surveys and water temperature monitoring needed to evaluate habitat availability and quality and thermal patterns in the upper and lower sub-basins as possible reasons
    - Hatchery coho impacts to sub-basin smolt production unknown

4. Insufficient understanding of coho brood line effect
    - Continuation of adult and juvenile monitoring in basin can evaluate this pattern
5. Evaluate future restoration actions in upper sub-basin using FW survival and coho smolts/female spawner
    - High confidence in wild adult coho estimation
    - Very few hatchery coho strays
    - Long term data on FW survival and coho smolts/female spawner
    - Significant, inverse relationship between female spawners and FW survival and coho smolts/female spawner indicates habitat limitations
6. Evaluate future restoration actions in upper sub-basin and Gods Valley Creek using overwinter parr to smolt survival
    - Requires summer snorkel surveys or PIT tagging to acquire parr counts
    - Requires pre-restoration data for comparison
    - Screw traps likely to provide high confidence in coho smolt estimation for evaluation

Other Issues

7. Removal of hatchery coho salmon strays at adult traps
    - LCM staff have euthanized hatchery coho salmon at adult traps in most years
    - Euthanizing hatchery coho at adult traps significantly reduces proportion of hatchery origin spawners on spawning grounds with wild fish (pHOS)

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Appendix 5

Annotated Bibliography

Nehalem Annotated Bibliography

Bangs, Brian, Emily Alvis, and Andrew Bradley. 2007. "ODFW AQUATIC INVENTORY PROJECT East Fork Nehalem River Stream Report." Oregon Department of Fish and Wildlife.

The East Fork Nehalem River Stream Report was produced in 2007 as part of the Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventory Project. The East Fork Nehalem River habitat survey began at the Scaponia Recreation Site and extended 4,199 meters. Second growth timber and mature timber were the dominant land use types. Riffles (48%) were the dominant instream habitat type. Fines (40%) were the dominant substrate type. The trees found most frequently in the riparian zone were 3 – 15 cm dbh hardwoods. The inventory included 5 reaches. The crew observed coho fry through unit 108 (2,853 m); however, the upper fish distribution was not determined. There were potential barriers to upstream fish migration at unit 116 (2,974 m) which was a 2.2 m high step into a culvert and at unit 148 (3,673 m) which was a 2.5 m high step into a culvert. Reach 3 was unsurveyed due to a land owner access denial. The crew noted culvert crossings at unit 45 (830 m), unit 117 (3,021 m) and at unit 149 (3,711 m). The unnamed tributary at unit 35 was surveyed during the summer of 2007 as East Fork Nehalem River Tributary. Two tributaries of this creek named Floeter Pond Creek and Gunners Lakes Creek were also surveyed in the summer of 2007. The crew noted salmon spawning ground survey signs at unit 34 (685 m) and at unit 114 (2,967 m). Beaver activity and beaver dams were noted in reaches 2 through 5. Channel morphology, characteristics, and dimensions were cataloged for each reach, as well as riparian, bank, and wood summaries.

Bangs, Brian, Emily Alvis, and Andrew Bradley. 2007. "ODFW AQUATIC INVENTORY PROJECT East Fork Nehalem River Tributary Stream Report." Oregon Department of Fish and Wildlife.

The East Fork Nehalem River Tributary Stream Report was produced in 2007 as part of the Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventory Project. The East Fork Nehalem River habitat survey began at its confluence with the East Fork Nehalem River and extended 2,359 meters to the confluence with Gunners Lakes Creek. Mature timber and young timber were the dominant land use types. Rapids (45%) was the dominant instream habitat type. Stream substrate was a mixture of cobble (34%), fines (29%) and gravel (23%). The trees found most frequently in the riparian zone were 3 – 15 cm dbh hardwoods. The crew did not observe fish during the survey. The upper fish distribution was not determined. There were no barriers to upstream fish migration in the surveyed length. Floeter Pond Creek and Gunners Lakes were named tributaries of East Fork Nehalem River Tributary, and both were surveyed during the summer of 2007. Spawning ground survey signs were noted at unit 1 (13 m) and at unit 93 (1,464 m). Beaver activity was present in a high number of units in reach 1. The crew noted several units in reach 3 with stabilized earthflows on the hillslopes. Channel morphology, characteristics, and dimensions were cataloged for each reach, as well as riparian, bank, and wood summaries.

Bangs, Brian, Emily Alvis, and Andrew Bradley. 2007. "ODFW AQUATIC INVENTORY PROJECT Floeter Pond Creek Stream Report." Oregon Department of Fish and Wildlife.

The Floeter Pond Creek Stream Report was produced in 2007 as part of the Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventory Project. The Floeter Pond Creek habitat survey began at its confluence with the East Fork Nehalem River Tributary and extended 3,450 meters. Young timber was the dominant land use type. Scour pools was the dominant instream habitat type. Fines was the dominant substrate type. The trees found most frequently in the riparian zone were 15 – 30 cm dbh conifers. The crew did not observe fish during the surveyed length. The upper fish distribution was not determined. There was a potential artificial barrier to the upstream migration of fish at unit 143 (3243 m). This potential barrier was at a 0.8-meter-high step into a culvert. The crew noted beaver activity in two units in reach 2. The crew noted culvert crossings at unit 17 (224 m) and at unit 144 (3,264 m). Channel morphology, characteristics, and dimensions were cataloged for each reach, as well as riparian, bank, and wood summaries.

Bangs, Brian, Emily Alvis, and Andrew Bradley. 2007. "ODFW AQUATIC INVENTORY PROJECT Gunners Lakes Creek Stream Report."

The Gunner Lakes Creek Stream Report was produced in 2007 as part of the Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventory Project. The Gunners Lakes Creek habitat survey began at the confluence with East Fork Nehalem River Tributary and extended 2,087 meters to the first large pond. The channel was hillslope constrained within a steep, V-shaped valley. The average valley width index was 1.2 (range: 1 – 2). Land uses for the reach were mature timber and young timber. The average unit gradient was 8.9 percent. Stream habitat was dominated by rapids (56%). Stream substrate was a mixture of cobble (27%), boulders (24%), fines (24%) and gravel (23%). Wood volume was 23.7 m3/100m. The trees found most frequently in the riparian zone were 3 – 15 cm dbh conifers and deciduous species (based on 3 riparian transects). The crew observed fish through unit 32 (464 m); however, the upper fish distribution was not determined. There was a potential natural barrier (PN) to upstream fish migration at unit 27 (355 m). This potential barrier was a 2.3 m high step over boulders. The crew noted that in unit 109 (2,062 m) they used the bedrock substrate type to denote the presence of hardpan clay. The crew noted beaver activity at unit 61 (1,033 m) and at unit 62 (1,065 m). The crew also observed game trails and an unidentified species of frog during the survey. Culvert crossings were noted at unit 48 (834 m) and at unit 112 (2,087 m). Channel morphology, characteristics, and dimensions were cataloged for each reach, as well as riparian, bank, and wood summaries.

Bauer, Steve, Ed Salminen, Paul Hoobyar, and John Runyon. 2008. "Summary of the Watershed Health Indicators for the Oregon Coast Coho ESU."

This report identifies factors limiting watershed health within selected Oregon watersheds draining to the Pacific Ocean. The goal of this project was to summarize Watershed Health Indicators that are limiting the health of watersheds, with a primary focus on the Oregon Coast Coho ESU. This report fulfills the Oregon Watershed Enhancement Boards legislative mandate to establish priorities that will help guide funding decisions. Limiting factors were identified for fifth field hydrologic unit codes. Limiting factors identified for the Nehalem aquatic and instream watershed health indicators included water temperature, water quality, water quantity (Upper and Middle Nehalem River and Lower Nehalem River – Cook Creek), winter rearing habitat complexity (Upper Nehalem River, Salmonberry River, North Fork Nehalem River), summer rearing habitat complexity (North Fork Nehalem River), large wood (Upper Nehalem River, Salmonberry River, North Fork Nehalem River, Lower Nehalem River – Cook Creek), channel modification (Upper and Middle Nehalem River), and hatchery impacts (Lower Nehalem River, Salmonberry River, North Fork Nehalem River, Lower Nehalem River – Cook Creek). Limiting factors for riparian areas included stand condition (Upper and Middle Nehalem River, North Fork Nehalem River), roads (Upper, Middle, and Lower Nehalem River, Lower Nehalem River – Cook Creek), and invasive species (Lower Nehalem River, Lower Nehalem River – Cook Creek). Limiting factors for freshwater wetlands included habitat loss in Lower Nehalem River – Cook Creek and connectivity in the Upper Nehalem River. Other freshwater wetland watershed health indicators and other areas represent a major data gap. Upland limiting factors include hydro modification (Upper Nehalem River, Salmonberry River, Lower Nehalem River – Cook Creek), fine sediment sources (Upper Nehalem River), habitat fragmentation (Upper Nehalem River, North Fork Nehalem River), and large wood recruitment (Upper Nehalem River, North Fork Nehalem River, Lower Nehalem River – Cook Creek). Limiting factors for tidelands represents a major data gap, but did provide some information pertaining to watershed health in the North Fork Nehalem River and Lower Nehalem River – Cook Creek watersheds. Tidal wetland limiting factors were identified as hydro modification, vegetation modification, and tidal wetland loss. Tidal flats limiting factors were identified as hydro modification and sediment regime.

Bio-Surveys LLC. 2008. "East Fork Nehalem Rapid Bio-Assessment 2008." Alsea, OR: Upper Nehalem Watershed Council.

This rapid bio-assessment provides detailed information on habitat conditions and coho abundance in a relatively small geographic area, the East Fork Nehalem River subwatershed. The intent of the project was to gather information on the status of juvenile salmonid summer rearing distributions and densities. Several fish passage barriers, both juvenile and adult, were identified and beaver activity was cataloged. A total expanded estimate of 38,495 Coho summer parr were present during the summer inventory of 2008. Adding the standard 20% visual bias for Coho snorkel sampling would raise this estimate to a total of 48,119 summer parr. Most juveniles were found summer rearing in the EF mainstem (44%), Jim George (19%), and Kenusky (15%). Recommendations for the subwatershed included increased riparian tree plantings, preservation of riparian canopy along tributaries to the East Fork, and increase access to habitat by removing fish passage barriers.

Bio-Surveys LLC. 2011. "Upper Nehalem Rapid Bio-Assessment 2011." Alsea, OR: Upper Nehalem Watershed Council.

This rapid bio-assessment provides detailed information on habitat conditions and coho abundance in a larger geographic area, the Upper Nehalem River watershed. The intent of the project was to describe and quantify the distribution and abundance of juvenile salmonids during summer flow regimes. A large amount of site specific reach and subwatershed information is presented in this document, as well as summary statistics for the larger study area. Distribution, density, and abundance data for 2009, 2010, and 2011 are compared, particularly productive reaches and habitats are highlighted, limiting factors like temperature and habitat access are mentioned, as well as habitat forming processes like beaver activity are cataloged.

Bio-Surveys LLC, Trask Design and Construction, and Sialis Company. 2011. "Limiting Factors Analysis and Restoration Plan Rock Creek Basin." Limiting Factors Analysis. Upper Nehalem Watershed Council.

This document identifies the dominant processes and habitat characteristics that currently limit the production of Coho salmon smolts in Rock Creek. The analysis combines three separate 6th field HUC subdivisions (Lower, Middle and Upper Rock Cr) into a single natural geographic subdivision. The analysis area includes all of mainstem Rock Cr and its tributaries above its confluence with the mainstem Nehalem at RM 91 in the town of Vernonia. The primary attributes evaluated are fish distribution, the abundance and distribution of aquatic habitats, spatial differences in thermal water quality, and historical upslope management activities. Gravel and mainstem thermal limitations are the dominant issues affecting smolt production in the sub basin. The results of the limiting factors analysis prescribe a mix of strategies involving the recovery of riparian canopies, culvert removal or improvement, securing headwater wood and substrate recruitment corridors, instream wood placement, road assessment/removal, easement acquisition and cooperative planning strategies. The report describes conditions and constraints that control channel functionality at each anchor site, and establishes what actions are necessary to relieve these constraints in ways that contribute to the expansion of the core area and to improvements in whole-system health and functionality.

Brophy, Laura, and Khemarith So. 2005. "Tidal Wetland Prioritization for the Nehalem River Estuary." Green Point Consulting, US Fish and Wildlife Service, Pacific Coast Joint Venture.

This prioritization provides a strategic approach for tidal wetland conservation and restoration actions undertaken in partnership with willing landowners. The study highlights land areas in the Nehalem River estuary where tidal wetland restoration or conservation action may offer the most ecosystem benefit for the cost– that is, those locations that may offer the highest potential to protect or increase estuary functions. This study provides a basis for working with interested landowners to develop site-specific action plans. The study uses an ecosystem perspective, prioritizing wetland areas rather than specific restoration projects. Criteria for prioritization included size of site, tidal channel condition, wetland connectivity, salmonid habitat connectivity, historic vegetation type, and diversity of current vegetation types. The Nehalem River Estuary is considered drowned river mouth shallow draft development estuary with all of the major types of tidal wetlands common to Oregon. The study identified 1,350 hectares (ha) (3,336 acres) of current and former tidal wetlands in the Nehalem River estuary. The results show that 72% of the estuary's historic tidal wetlands (970 ha) have undergone major site alterations that greatly restrict or alter tidal flows, such as diking and ditching. About 3% (37 ha) have undergone minor alterations like culverted drainages and road crossings; and 25% percent (343 ha) are relatively undisturbed.

Boswell, Todd, and Gareth Ferdun. 2002. "Juvenile Coho Winter Habitat Priorities for Large Wood Placement and Fish Passage Barriers." Sponsored by the Lower Nehalem Watershed Council and Oregon Watershed Enhancement Board.

Oregon Department of Fish and Wildlife Aquatic Inventory protocols were used to survey 37.25 miles of stream habitat in the Nehalem basin. The survey identified 31 stream reaches that should receive priority for large wood placement. The authors chose to give priority to streams that: already had Coho present, were in a valley wide enough that large wood could create off channel habitat (Valley Width Index greater than 3), had a channel width small enough for wood to stay in place after periods of heavy rain. (Active Channel Width less than 12 meters) and, did not currently have adequate large wood (key large wood per 100 meters less than 2). The survey evaluated 17 culverts, four of which block passage to suitable Coho habitat. The authors used ODFW aquatic benchmarks supplemented with information on stream gradient and fish presence to assess the value of the habitat in stream reaches above culverts. Snorkel surveys were conducted in 151 pools, of which 93 contained Coho (fry in 64 pools, pre-smolts in 82 pools).

Boswell, Todd, and Gareth Ferdun. 2003. "Juvenile Coho Winter Habitat Priorities for Large Wood Placement." Sponsored by the Lower Nehalem Watershed Council and Oregon Watershed Enhancement Board.

Oregon Department of Fish and Wildlife Aquatic Inventory protocols were used to survey 24.63 miles of stream habitat in the Nehalem basin. The survey identified 26 stream reaches that should receive priority for large wood placement. The authors chose to give priority to streams that: already had Coho present, were in a valley wide enough that large wood could create off channel habitat (Valley Width Index greater than 3), had a channel width small enough for wood to stay in place after periods of heavy rain. (Active Channel Width less than 12 meters) and, did not currently have adequate large wood (key large wood per 100 meters less than 2). The survey also evaluated nine large woody debris placement projects. Three of the nine LWD projects were considered ineffective (two in Cook Creek, one in Piatt Canyon). Snorkel surveys were conducted in 117 pools, of which 74 contained Coho (fry in 32 pools, pre-smolts in 74 pools).

Boswell, Todd, and Gareth Ferdun. 2005. "Juvenile Coho Winter Habitat Priorities for Large Wood Placement." Sponsored by the Lower Nehalem Watershed Council and Oregon Watershed Enhancement Board.

Oregon Department of Fish and Wildlife Aquatic Inventory protocols were used to survey 60 miles of stream habitat in the Nehalem basin. The survey identified 35 stream reaches that should receive priority for large wood placement. The authors chose to give priority to streams that: already had Coho present, were in a valley wide enough that large wood could create off channel habitat (Valley Width Index greater than 3), had a channel width small enough for wood to stay in place after periods of heavy rain. (Active Channel Width less than 12 meters) and, did not currently have adequate large wood (key large wood per 100 meters less than 2). The survey evaluated riparian condition, with 26 stream reaches identified as priority for riparian enhancement. Fish passage barriers were identified, including 15 culverts and two concrete dams that impede adult and/or juvenile Coho passage. Snorkel surveys were conducted in 130 pools, of which 126 contained Coho.

Boswell, Todd, and Gareth Ferdun. 2007. "Juvenile Coho Winter Habitat Priorities for Large Wood Placement." Sponsored by the Lower Nehalem Watershed Council and Oregon Watershed Enhancement Board.

Oregon Department of Fish and Wildlife Aquatic Inventory protocols were used to survey 150.5 miles of stream habitat in the Nehalem basin. The survey identified 148 stream reaches that should receive priority for large wood placement. The authors chose to give priority to streams that: already had Coho present, were in a valley wide enough that large wood could create off channel habitat (Valley Width Index greater than 3), had a channel width small enough for wood to stay in place after periods of heavy rain. (Active Channel Width less than 12 meters) and, did not currently have adequate large wood (key large wood per 100 meters less than 2). The survey evaluated riparian condition, with 107 stream reaches identified as priority for riparian enhancement. Fish passage barriers were identified, including 25 culverts and five concrete dams that impede adult and/or juvenile Coho passage. Snorkel surveys were conducted in 445 pools, of which 293 contained Coho.

Clearway Environmental. 2016. "Culvert Assessment and Fish Passage Prioritization Report for the Lower Nehalem Watershed." Lower Nehalem Watershed Council.

This document provides a comprehensive, up-to-date watershed scale assessment of culverts in the Lower Nehalem watershed. The study area includes four 5th field Hydrologic Unit Code watersheds: Salmonberry River, Lower Nehalem River, North Fork Nehalem River, and Middle Nehalem River. The report ranks and prioritizes culverts for replacement while documenting methods of data collection and analysis. The results of field work and analysis are meant to supplement existing culvert data and help the Lower Nehalem Watershed Council and its partners strategically approach the replacement or removal of culverts and fish passage barriers.

Clearway Environmental. 2016. "Culvert Assessment and Fish Passage Prioritization Report for the Lower Nehalem Watershed Appendix 2.1 Salmonberry River Basin Culverts." Lower Nehalem Watershed Council.

This appendix provides detailed information about the surveyed culverts and fish passage barriers in the Salmonberry River watershed. The appendix provides maps and detailed location information, culvert measurements, channel gradient and width, and prioritization information.

Clearway Environmental. 2016. "Culvert Assessment and Fish Passage Prioritization Report for the Lower Nehalem Watershed Appendix 2.2 Lower Nehalem River Basin Culverts." Lower Nehalem Watershed Council.

This appendix provides detailed information about the surveyed culverts and fish passage barriers in the Lower Nehalem River watershed. The appendix provides maps and detailed location information, culvert measurements, channel gradient and width, and prioritization information.

Clearway Environmental. 2016. "Culvert Assessment and Fish Passage Prioritization Report for the Lower Nehalem Watershed Appendix 2.3 North Fork of Nehalem River Basin Culverts." Lower Nehalem Watershed Council.

This appendix provides detailed information about the surveyed culverts and fish passage barriers in the North Fork Nehalem River watershed. The appendix provides maps and detailed location information, culvert measurements, channel gradient and width, and prioritization information.

Clearway Environmental. 2016. "Culvert Assessment and Fish Passage Prioritization Report for the Lower Nehalem Watershed Appendix 2.4 Middle Nehalem River Basin Culverts." Lower Nehalem Watershed Council.

This appendix provides detailed information about the surveyed culverts and fish passage barriers in the Middle Fork Nehalem River watershed. The appendix provides maps and detailed location information, culvert measurements, channel gradient and width, and prioritization information.

Demeter Design. 2008. "East Fork Nehalem Watershed Assessment." Upper Nehalem Watershed Council.

This report provides a detailed assessment of the East Fork Nehalem Watershed, including the historical conditions and disturbances, channel habitat type classification, hydrology and water use, riparian area and wetland condition, sediment sources, channel modifications, water quality, fish habitat and distribution, overall watershed condition, and monitoring plan. According to a stakeholder meeting, the most pertinent natural resource issues within the watershed are: aquatic and riparian habitat degradation and loss; upland habitat degradation and loss; urban and rural impacts; land management impacts; and federal and state laws. The report pulls together a lot of useful, detailed information from multiple data sources, but is limited in its geographic scope.

Ferdun, Gareth. n.d. "Habitat Survey Data Synthesis Summary." Summary.

This brief data synthesis summary distills the habitat survey work completed by Oregon Department of Fish and Wildlife and Todd Boswell. The data synthesis summary focuses on large wood and riparian enhancement work. According to Watershed Professionals Network, 356 miles of stream would benefit from large wood (about 54% of stream miles identified as coho habitat) and about 136 miles of stream are in need of improved riparian buffers. The upper Nehalem has five times as many miles of stream in need of large wood as the lower Nehalem (296.3 vs. 59.5) and 3.25 times as many miles in need of riparian enhancement as the lower Nehalem (104.3 vs. 32.0). Associated costs and estimated cost-shares are presented to address the current need for large wood and riparian enhancement projects.

Ferdun, Gareth, Gwendolyn Endicott, and Mark Beach. n.d. "Nehalem Estuary and Associated Wetlands."

Ferdun et al describe the Nehalem estuary and associated wetlands in clear, easy to understand language that is engaging to a wide audience. The document is written as a mix of personal experience and the collation and synthesis of data collected over the years. The document is broken into seven chapters. Chapter one includes information on the structure of the Nehalem estuary, including the influence of human development. Chapter two delves into wetland vegetation found in the Nehalem estuary. Chapter three provides a historical timeline of human influence, helping the reader understand how the estuary changed over time to what it is today. Chapter four focuses on flooding. Chapter five outlines preservation priorities. Chapter six and seven examine two specific sites within the estuary, Bott's Marsh and Alder Creek Farm.

Ferdun, Gareth. 2003. "Historical Time Line." In *Understanding the Nehalem Watershed*.

The historical timeline starts in 25 B.C., skips to the late 1500's and skips over the 1600's. There is a large amount of detail from the 1800's through 2003. 1900-1920 is considered the Nehalem's boom period, with increases in farming and dairy production, salmon canneries, and timber production. The contemporary historical recounting includes information about the development of towns and infrastructure, the decline of the extractive resource economy (and rise of tourism/retirement economy), changes in salt marsh habitat, Coho hatchery releases, and the creation of several environmentally focused groups.

Ferdun, Gareth. 2003. "Looking to the Future." In *Understanding the Nehalem Watershed*.

This chapter of Understanding the Nehalem Watershed provides suggestions and speculation on trends concerning Coho salmon and the habitats and habitat processes they rely on to survive. The author provides suggested direction for data collection and study of topics including carrying capacity of streams, fine sediment, Coho fry migration, riparian and old growth structure, eelgrass, estuarine habitat use by salmonids, and counting fish other than Coho. This short section is somewhat editorial.

Ferdun, Gareth. 2003. "Nehalem Estuary." In *Understanding the Nehalem Watershed*.

This chapter of Understanding the Nehalem Watershed focuses on the estuary and provides similar content to Ferdun et al (no date) above. The chapter describes the variety of estuarine habitat types found within the Nehalem estuary. There is also mention of habitat conditions, including water quality. Ferdun et al also provide site specific conservation and restoration opportunities within the estuary.

Ferdun, Gareth. 2003. "Nehalem State Forests." In *Understanding the Nehalem Watershed*.

In this chapter, Ferdun summarizes the process established in 2001 by the Tillamook District of the Oregon Department of Forestry that engaged a focus group to review a draft Tillamook State Forest 10-year management plan. The goal of the management plan is to provide the "greatest permanent value" from state lands. The key approach to this goal provided in the plan was the harvest technique of mimicking older forest structure. The focus group provided 16 recommendations, of which five were the focus of this chapter. Topics included old growth (two recommendations), planning for wildlife, Swiss needle cast, and recreation. In the planning for wildlife section, salmon are mentioned. The chapter quotes the Environmental Protection Agency, National Marine Fisheries Service, and U.S. Fish and Wildlife Service opinion "a substantial body of scientific literature demonstrating that the Oregon forest practices likely adversely affect water quality and threatened species of salmonid. . ."in terms of shade and temperature, large wood recruitment, sediment and landslides, and roads. Specific to Coho, the chapter states the three federal agencies do not believe the Oregon Forest Practices Act leave enough trees on stream banks to supply the large wood needed in Coho streams.

Ferdun, Gareth. 2003. "Nehalem Watershed." In *Understanding the Nehalem Watershed*.

Understanding the Nehalem watershed provides and introduction to basic background information about the Nehalem River and its surrounding watershed. This chapter gives a basic watershed profile and coho habitat concerns. The Nehalem watershed chapter covers physical geography, land ownership, local economy and demographic information, as well as coho specific information like general life cycle, juvenile and adult habitat needs, historic run estimates, hatchery impacts, and limiting factors.

Fergusson, Ian. 2009. "Distribution of Spawning Coho Salmon, Salmonberry River (Nehalem Basin)."

During a 2009 Coho spawning survey in the Salmonberry River, Fergusson and others verified Coho spawning distribution from roughly the South Fork Salmonberry River to the barrier just upstream of Pennoyer Creek. Adult Coho, carcasses, and/or redds were observed in the mainstem Salmonberry from the South Fork to above Wolf Creek, as well as in the South Fork, North Fork, and Kinney Creek. Verifying wild versus hatchery fish was impossible in most cases, but when the distinction was possible, intact adipose fins were observed.

Fergusson, Ian. 2011. "Effects of Debris Torrents on Summer Water Temperatures: Salmonberry River (Nehalem Basin), Oregon."

The Salmonberry River supports several trout and salmon species including Coho salmon. Severe rainstorms and landslides occurred in February 1996 and December 2007. These events caused damage to instream and riparian habitat. The Oregon Department of Fish and Wildlife Salmon Trout Enhancement Program has been monitoring water temperatures in the Salmonberry River since 1994. This period of record provides the opportunity to explore potential impacts of debris torrent damage on steam temperatures. Results from the analysis showed significant increases in average daily maximum and mean temperatures between control and treatment streams. Literature and observations from the analysis suggest a period of approximately 15 years after riparian vegetation removal is needed to reestablish canopy closure in first-order streams.

Francisco, Cristina. 2012. "Geologic Setting of the Nehalem Watershed: Framework for Geomorphic Analysis and Habitat Assessment." Undergraduate Research. Western Oregon University.

This undergraduate research provides an overview of the physiographic and geologic setting of the Nehalem River basin. A summary of geologic events over several epochs is provided along with information on soils, climate, topography, and location. The geologic setting of the Nehalem watershed is strongly influenced by active tectonic associated with the Cascadia Subduction Zone and Oregon Coast Range. Surface elevations range the sea level to over 3,000 feet. Bedrock stratigraphy includes several formations ranging in age from Eocene up to middle Miocene, in addition to Quaternary terrace gravel and alluvium.

Jones, Krista, Mackenzie Keith, Jim O'Connor, Joseph Mangano, and Rose Wallick. 2012. "Preliminary Assessment of Channel Stability and Bed- Material Transport in the Tillamook Bay Tributaries and Nehalem River Basin, Northwestern Oregon." USGS, USACE, ODSL.

This report summarizes a reconnaissance study of channel condition and bed-material transport in the Tillamook Bay Tributaries and the Nehalem River Basin. The study included a review of existing datasets (such as channel cross sections and instream gravel mining records), delineation of bars and wetted channels from aerial and ortho-photographs spanning 1939–2009, and field observations and bed-material measurements made in October 2010. From these efforts, key datasets and issues relevant to understanding channel condition, bed-material transport, and the potential effects of instream gravel mining on both were identified; vertical and lateral channel stability were assessed; and preliminary conclusions regarding the relation between sediment supply and transport capacity were made. The mapping results for the Fluvial Nehalem Reach indicated that unit bar area declined 45.6percent from 1939 to 1967 and then fluctuated from 1967 to 2009, resulting in a net unit bar area reduction of 49.8 percent from 1939 to 2009. Nearly two–thirds of the net loss in bar area occurred from RKM 26.6–24.6, which is a broad unconfined segment of the floodplain where the channel transitions from fluvially to tidally influenced. This reduction is attributable to the lateral channel migration between 1939 and 1967 and subsequent vegetation establishment. Downstream in the Tidal Nehalem Reach, unit bar area increased a net 14.7 percent from 1939 to 2009 despite a small decrease from

1939 to 1967. This increase in unit bar area occurred within the Nehalem Bay (RKM 9.6–0) as more tidal mud flats and bars were mapped in 2009 relative to 1939. Despite the overall increase in bar area over the analysis period, bar area declined a net 17 percent from RKM 24.6–19.2.

Kavanagh, Peggy, Kim Jones, and Charlie Stein. 2006. "Fish Habitat Assessment in the Oregon Department of Forestry Lower Nehalem and Necanicum Study Area." Corvallis, OR: Oregon Department of Fish and Wildlife.

This project summarizes the condition of stream habitat, the distribution and abundance of salmonids, and the potential for restoration in the Lower Nehalem River. The ODFW Aquatic Inventories Project conducted stream habitat surveys with the goal of documenting the status and trends of stream conditions in coastal drainages. These surveys in conjunction with fish distribution, fish presence, potential barriers to passage, past restoration activities, habitat limiting factors modeling, and HabRate form the basis of the analyses. This document provides useful information on geology and stream structure, different Coho life histories habitat use and abundance, the identification of salmon anchor habitats, pool habitat and the watershed processes that create pool habitat, large wood and habitat forming processes, and overall condition of habitat in the study area.

Kavanagh, Peggy, Kim Jones, Charlie Stein, and Paul Jacobsen. 2005. "Fish Habitat Assessment in the Oregon Department of Forestry Upper Nehalem and Clatskanie Study Area." Corvallis, OR: Oregon Department of Fish and Wildlife.

This project summarizes the condition of stream habitat, the distribution and abundance of salmonids, and the potential for restoration in the Upper Nehalem River. The ODFW Aquatic Inventories Project conducted stream habitat surveys with the goal of documenting the status and trends of stream conditions in coastal drainages. These surveys in conjunction with fish distribution, fish presence, potential barriers to passage, past restoration activities, habitat limiting factors modeling, and HabRate form the basis of the analyses. This document provides useful information on geology and stream structure, different Coho life histories habitat use and abundance, the identification of salmon anchor habitats, pool habitat and the watershed processes that create pool habitat, large wood and habitat forming processes, and overall condition of habitat in the study area.

Maser, Joseph. 1999. "Nehalem River Watershed Assessment Introduction." http://web.pdx.edu/~maserj/project/project1/project1.htm.

The introduction to Maser's Nehalem River Watershed Assessment provides useful information about the watersheds general characteristics. General location, orientation, size statistics, population, geology, land use, vegetation, and potential limiting factors are introduced. This information will be useful in writing chapter eight of the strategic action plan. Other chapters of this report should go into more detail on the topics in the introduction.

Maser, Joseph. 1999. "Nehalem River Watershed Assessment Channel Habitat Typing." http://web.pdx.edu/~maserj/project/project1/project1.htm.

There are several stream types that provide Coho spawning and rearing habitat in the Nehalem River watershed. These stream types having varying structure and characteristics that make them sensitive to natural and human-made disturbance. Of the 935 linear miles of streams mapped at a 1:100,000 scale in the watershed, 440.9 miles (47.1%) were rated highly sensitive to changes. This category includes much of the mainstem Nehalem River and the major tributaries. Moderately sensitive reaches comprised 278.6 miles (29.8%) and reaches with low sensitivity comprised 215.7 miles (23.1%).

Maser, Joseph. 1999. "Nehalem River Watershed Assessment Channel Modifications." http://web.pdx.edu/~maserj/project/project1/project1.htm.

The land use practices that impacted the rivers early in the 1900s have been altered by the availability of resources (trees), modernization of techniques (logging trucks) and changes in government policy (Oregon Forest Practices Act). The most common channel modifications found are culverts placed at road crossings and debris flows due to road construction in close proximity and upslope from streams. According to ODFW (1993), some illegal, unpermitted removal of small amounts of instream gravel occurs in the mainstem Nehalem River. The historical modifications identified through interviews occurred mainly on the mainstem Nehalem River, Cook Creek, North Fork of the Nehalem River, Salmonberry River and Fishhawk Creek. There is thought to have been many small-scale diversions, dredging and instream structures that occurred in the Nehalem Watershed during the late1800's and early 1900s during heavy logging and railroad and road building. Log drives, splash dams, levees, roads, and railroads have all affected the stream and river channels of the Nehalem watershed.

Maser, Joseph. 1999. "Nehalem River Watershed Assessment Fish and Fish Habitat." http://web.pdx.edu/~maserj/project/project1/project1.htm.

The purpose of the fish and fish habitat section was to compile available information on fish populations, in-stream habitat, and migration barriers in the watershed in order to evaluate potential impacts to important areas of current fish use and habitat. This majority of this section was completed by synthesizing available information from a variety of sources. Topics include Coho salmon life history description, population estimates (historical and contemporary), habitat needs for spawning and juvenile Coho, potential limiting factors (lack of large wood and spawning gravel), and hatchery practices and impacts. For the habitat condition evaluation, ODFW surveys were used for the streams which have been surveyed recently (since 1993). Individual parameters for pools, riffles, riparian species and large woody debris were identified as either desirable or undesirable according to ODFW benchmarks.

Maser, Joseph. 1999. "Nehalem River Watershed Assessment Historical Conditions." Chapter. http://web.pdx.edu/~maserj/project/project1/project1.htm.

Historical narrative and key dates of formative natural and anthropogenic events affecting the Nehalem watershed provide important context to the current state of the watershed. The timeline and historical narrative outline the rise of the natural resource based economy, which logged all the old growth timber out of the Nehalem by 1945. This intensive logging caused major ecological damage, including impacts to stream morphology, instream complexity, and riparian areas. The Tillamook Burn and the Salmonberry Burn also caused significant damage to the forests of the Nehalem watershed. Commercial fishing was abundant until 1956, when commercial gill netting was banned. By this time, the salmon and steelhead runs were greatly depleted. To offset the salmonid decline, hatchery programs began in 1926 on Foley Creek. The Foley Creek hatchery was a trout hatchery, replaced by the North Nehalem Hatchery in 1966, which raised Coho, Chinook, and winter steelhead. Historical forest harvest and commercial fishing practices have changed the landscape and stream characteristics of the Nehalem River watershed. The cumulative effects of these activities have degraded Coho habitat and therefore may be a major reason for the decline of Coho populations.

Maser, Joseph. 1999. "Nehalem River Watershed Assessment Hydrology and Water Use." http://web.pdx.edu/~maserj/project/project1/project1.htm.

This chapter provides basic information about hydrology in the Nehalem River watershed and the land uses and water rights that impact in stream flows. Watershed characteristics like amount of river miles, stream miles, and drainage area are useful for creating a profile of the watershed. Precipitation is summarized. Mean annual precipitation in the Nehalem Basin is approximately 113 inches. Little snow falls in the watershed, so snowmelt and rain on snow events are not common contributors to peak stream flow. Discharge is also summarized. Average discharge at the Foss gage (59-year period of record) is 2,672 cfs. The peak flood of record occurred in February 1996. Land use related stressors to Coho and Coho habitat are minor. Forestry is the largest land use category in the watershed, encompassing approximately 92 percent of the watershed area. However, the potential risk of peak flow enhancement associated with timber harvest is low.

Maser, Joseph. 1999. "Nehalem River Watershed Assessment Riparian Conditions." http://web.pdx.edu/~maserj/project/project1/project1.htm.

In accordance with the GWEB manual, this assessment evaluates the potential for the riparian zone to provide large woody debris and its ability to provide shade to the basin's streams. Beyond large wood and shade, riparian vegetation also influences fish habitat by providing cover, reducing erosion, filtering fine sediments, providing habitat for macroinvertebrates and providing detritus to the larger system. Riparian condition is summarized by subwatershed. The Cook Creek subwatershed has suprisingly little riparian area in poor condition. The riparian buffers in the Salmonberry subwatershed are generally in good condition. The Upper Nehalem subwatershed has two significant reaches with poor riparian conditions. Both Weed Creek and the South Fork Rock Creek have grass on both banks. The riparian buffer in the Upper Nehalem subwatershed has the most variability in the watershed. There is a concentration of riparian buffer in poor condition along Fishhawk Creek and the North Fork Fishhawk Creek. There is only one small reach at the headwaters of Walker Creek which is in poor condition in the Lower Nehalem subwatershed. Riparian buffers are typically continuous and wide. The North Fork Nehalem subwatershed has some areas of riparian buffer in poor condition. The headwater areas of Boykin and Rackheap Creeks, all of God's Valley Creek, and the North Fork Nehalem River between Soapstone Creek and Sweet Home Creek are all in poor condition. Current levels of large woody debris are generally low, especially large pieces of woody material which can significantly increase the quality of fish habitat. Seventy-six percent of the watershed has good potential for recruitment of large woody debris. However, it is important to consider that the majority of the riparian vegetation in the watershed consists of young hardwood species. Generally, the larger the trees the better they will perform in-stream functions.

Maser, Joseph. 1999. "Nehalem River Watershed Assessment Sediment Sources." http://web.pdx.edu/~maserj/project/project1/project1.htm.

For this assessment, potential sources of sediment were evaluated. Rural road instability, slope instability (not related to roads), and rural road runoff were identified as potential sediment sources. It was determined that surface erosion from range land and crop land was not an issue since all the areas of these land uses are located in low sloped areas (all less than 50% slope). The total urban area in the watershed is only 0.5% and no major tributaries receive drainage mostly from urban sources. Urban runoff was determined as very low priority and not an issue for this assessment. The Cook Creek and Salmonberry subwatersheds have the greatest potential for landslide occurrence. None of the subwatersheds have particularly high densities of roads within 200 feet of a stream. However, Cook Creek has both the highest density of roads near streams and the highest density of roads near streams with steep sideslopes.

Maser, Joseph. 1999. "Nehalem River Watershed Assessment Watershed Condition Summary." http://web.pdx.edu/~maserj/project/project1/project1.htm.

This section gives a brief summary of the results of each assessment component (historical conditions, channel habitat types, hydrology and water use, riparian conditions, sediment sources, channel modifications, and water quality). Data gaps are identified, including information which will require further assessment and monitoring. Additionally, recommendations for potential restoration activities are discussed. Recommendations include improving riparian conditions, identifying and removing barriers, to fish passage, and increasing the amount of large wood in streams.

Maser, Joseph. 1999. "Nehalem River Watershed Assessment Water Quality." http://web.pdx.edu/~maserj/project/project1/project1.htm.

The purpose of this analysis was to identify obvious areas of water quality impairment by comparing selected measurements of water quality to evaluation criteria. The analysis included collecting information about beneficial uses, 303(d) listed reaches, and other water quality data collected by the Department of Environmental Quality and the Nehalem Watershed Councils. Impairments due to temperature, dissolved oxygen, pH, nutrients, bacteria, and turbidity were identified. The mainstem Nehalem River from the mouth to Rock Creek is 303(d) listed as water quality limited due to elevated temperature in the summer. The upper and lower Nehalem Bay is also listed due to elevated bacteria levels. Dissolved oxygen, pH, total phosphorus, bacteria, and turbidity levels were in accordance with Oregon Water Quality Standards. There was no data for contaminants such as pesticides, herbicides or metals. Temperature and total nitrate occurred at levels shown to cause impairment to water quality. Temperature exceeded standards in the summer months, while nitrate was high in the fall, winter, and spring.

Natural Resources Conservation Service. 2005. "NRCS Nehalem 8 Digit Hydrologic Unit Profile." USDA.

The hydrologic unit profile for the Nehalem subbasin is a quick reference for basic information including physical description, land use, precipitation, demographics and census data, resources and resource concerns, and amount of conserved land in the subbasin. The focus of the profile is mainly on resource management, which consists mostly of dairy farming and pasture and timber and forestry. By acreage, the subbasin is 98 percent forestland (41 percent public, 57 percent private). The profile notes soil loss by water erosion as a resource concern for the subbasin as well as stream temperature and fecal coliform.

NOAA Fisheries. 2007. "Final Assessment of NOAA Fisheries' Critical Habitat Analytical Review Team (CHART) For the Oregon Coast Coho Salmon Evolutionarily Significant Unit." Portland, OR: NOAA Fisheries Protected Resources Division.

NOAA relates human activities to limiting factors, includes information about Coho life histories, and information specific to the Nehalem Coho population among other Oregon coast estuaries. Major human actions that impact Coho habitat include: forestry, grazing, agriculture, road building/maintenance, channel modifications/diking, urbanization, sand and gravel mining, mineral mining, dams, irrigation impoundments and withdrawals, river, estuary, and ocean traffic, wetland loss/removal, beaver removal, and exotic/invasive species introductions. These activities have impacts on stream hydrology, flow and water-level modifications, fish passage, geomorphology and sediment transport, temperature, dissolved oxygen, vegetation, soils, nutrients and chemicals, physical habitat structure, and stream/estuarine/marine biota and forage. Most issues in the Nehalem are related to forestry or agriculture.

Oregon Department of Environmental Quality. 2003. "North Coast Subbasins TMDL Appendix D North Coast Subbasins Water Quality Management Plan." Management Plan. ODEQ.

The Oregon Department of Environmental Quality created a water quality management plan in 2003 to address the issues of 303(d) listings of streams and bodies of water suffering from water quality limitations for temperature and bacteria. The Nehalem has several stream reaches that are water quality limited for temperature and a few limited for bacteria (Fecal Coliform). The majority of this document is focused on providing clear direction for a planning and implementation process to address 303(d) listed water bodies. The document does provide some useful information including a general watershed description, population data, a list of 303(d) listed water bodies, and a list of point source pollutant discharges and dischargers.

Oregon Department of Fish and Wildlife. 1993. "Draft Nehalem Basin Plan." Oregon Department of Fish and Wildlife.

The draft Nehalem Basin Plan is an amalgamation of several documents regarding salmonid species in the Nehalem Basin. The document is truly a draft with meeting notes and agendas, sections of a fish management plan, and handwritten notes and drawings. A large amount of the document concerns Nehalem Chinook and steelhead, but there is also valuable Coho information as well. The plan provides historical fish community production and escapement numbers, as well as hatchery and wild Coho information. Wild Coho life history and population status information is provided, as well as hatchery contributions to fisheries and the management considerations when dealing with wild and hatchery Coho. The document estimates the rate of Coho smolts released from the Nehalem Hachery at 800,000-900,000 a year.

Oregon Department of Fish and Wildlife North Coast Watershed District. 2008. "Fish Runs and Fisheries of the Salmonberry River." Tillamook, OR: Oregon Department of Fish and Wildlife.

Oregon Department of Fish and Wildlife provide a detailed accounting of fish populations and habitat conditions for the Salmonberry River watershed. This report includes information on streams and geology, land ownership, temperature, sediment, and benthic communities. The report summarizes Aquatic Habitat Inventories, hatchery practices and releases, and significant fire and flood events in the Salmonberry. Coho salmon are thought to be present in the Salmonberry River during some years, but the Salmonberry contains very little habitat that would be suitable for Coho spawning and rearing. Coho salmon abundance in the Salmonberry River is thought to be very low.

R2 Resource Consultants, and Lee Benda and Associates. 2005. "Upper Nehalem Watershed Analysis Chapter 2. Watershed Overview." Oregon Department of Forestry.

The Watershed Overview includes information about Oregon Department of Forestry lands specifically, with some more general watershed scale information as well. Topics include physical setting, biological setting, social context, and forest management. The physical setting section is heavy on geology and description of the ecoregions, with more concise information on climate and hydrology. The biological section is mainly focused on trees and vegetation. Social context focuses on population and demographics information as well as the economy's transition from dairy farming and timber to service based. Forest management outlines the current conditions and future goals of the different ODF management basins.

R2 Resource Consultants, and Lee Benda and Associates. 2005. "Upper Nehalem Watershed Analysis Chapter 3. Historical Overview." Oregon Department of Forestry.

This chapter summarizes historical events affecting the project area for the watershed analysis (ODF lands in the Upper Nehalem basin). Detailed timelines from three OWEB watershed assessments were collated and new information from cadastral survey notes and historical maps and documents were included in the chapter. In addition, a discussion of the natural disturbance regime is provided, based on information developed through modeling of other similar northwest landscapes. Information on the natural disturbance regime is critical for interpreting current watershed conditions and for developing sound management strategies. Topics covered include historical natural resources and fish populations, early settlement and land us trends, and natural disturbance regimes.

R2 Resource Consultants and Lee Benda and Associates. 2005. "Upper Nehalem Watershed Analysis Chapter 4. Stream Channel." Oregon Department of Forestry.

This chapter provides a description of the morphologic characteristics of channel habitat types in the Upper Nehalem basin, depicting channel confinement, channel sensitivity, and channel habitat type distribution. The goal of this chapter was to build on existing channel habitat type data to support more intensive analysis regarding evaluation of habitat and restoration potential. Information was gathered to describe the following key morphologic attributes and geomorphic functions: bedform, pool formative factors, large wood recruitment mechanism, large wood distribution and role in habitat formation, sediment storage, and substrate mobility. Field data and geomorphic theory were used to develop a description of the sensitivity of each channel type to changing inputs of large wood, coarse sediment, fine sediment and peak flows. Geomorphic characteristics were then used to predict aquatic habitat attributes of each channel habitat type, and to describe how those attributes would be affected by changing inputs of wood, sediment and water.

R2 Resource Consultants and Lee Benda and Associates. 2005. "Upper Nehalem Watershed Analysis Chapter 5. Hydrology and Water Use." Oregon Department of Forestry.

This section of the watershed analysis characterizes the hydrology and water uses within the ODF management areas. Specific information includes streamflow characteristics, water yield and peak flows, instream water rights and low flows, consumptive water uses, and water withdrawals and storage. A majority of the Nehalem watershed is classified as forestry in terms of land use. Overall, the probability of peak flow enhancement from timber harvest in the Upper Nehalem Basin would be low due to the infrequency of rain-on-snow events and the small portion of forestry roads. The Middle Nehalem River subwatershed had 4.6 percent area in roads and thus, a moderate risk of enhancing peak flows.

R2 Resource Consultants and Lee Benda and Associates. 2005. "Upper Nehalem Watershed Analysis Chapter 6. Riparian/Wetlands." Oregon Department of Forestry.

This chapter consists of a remote assessment of riparian vegetation conditions along streams in the Upper Nehalem watershed. It also includes available information concerning the type, extent and location of wetlands and noxious weeds in the watershed. The water quality and fish habitat sections of this report (Chapters 9 and 10) discuss how resources may be influenced as a result of the current or future potential riparian conditions. The purpose of the riparian assessment was to assess the current riparian situations in the watershed and determine how existing conditions compared to typical conditions present along various stream channel types for the ecoregions encompassing the watershed. An additional purpose was to organize the riparian areas in accordance with appropriate restoration/enhancement opportunities. The purpose of the wetlands assessment was to assess the current locations and general characteristics of wetlands in the watershed and determine if opportunities exist to restore degraded wetland conditions. Very limited information is available for the noxious weed assessment in the upper Nehalem watershed.

R2 Resource Consultants and Lee Benda and Associates. 2005. "Upper Nehalem Watershed Analysis Chapter 7. Non-Road Sources of Erosion." Oregon Department of Forestry.

Landslides, debris flows, and non-road sources of erosion do not seem to me a major limiting factor to Coho habitat in the Upper Nehalem. The highest values (areas of the highest density of debris flow-prone channels) occur toward the western margin of the upper Nehalem watershed and decrease eastward. It is important to stress the landslide modeling results indicated that the majority of the area encompassed by the Nehalem watershed analysis has a relatively low risk of landslides and debris flows. This result was due to the lack of very steep and highly convergent topography. Consequently, the risk posed by shallow landslides and debris flows to aquatic resources and water quality was low throughout much of the Nehalem study area. Fishhawk, Quartz, and Northup Management basins had the highest probabilities of shallow landslides and debris flows. Based on 2005 road surveys of forest roads in the project area, gullies and other forms of surface erosion are not a significant issue in the Upper Nehalem.

R2 Resource Consultants and Lee Benda and Associates. 2005. "Upper Nehalem Watershed Analysis Chapter 8. Road Related Sediment Sources." Oregon Department of Forestry.

Erosion near streams and surrounding areas occurs through various natural and human-induced processes. The focus of this section is to identify portions of road networks that currently affect or are prone to affect stream channel morphology, fish habitat, and fish passage due to road position or delivery of fine sediment to streams. There are approximately 607 miles of active forest road managed by ODF within the project area. Of this total length, approximately 53.8 miles (8.8%) are stream adjacent. Drainage for approximately 96 miles (15.8%) of forest road within the project area was assessed to have direct hydrologic connection to streams. The majority (67.4%) of forest roads in the project area were identified as perfectly functioning road drainages. Critical road locations identified within the project area included roads with sidecast/fill slides, fill slides, stream in ditch, stream parallel roads, wetland adjacent roads, roads with steep fill, and roads with steep full-bench. Canyon fill, channel fill, deep active slide and deep inactive slide road types were not observed in the project area. The total length of critical roads identified in the project area is 33.6 miles, or approximately 5.5 percent of the total road length (Table 8-6). The vast majority of roads (94.4%) in the project area were designated non-critical during 2005 RIMS surveys. A total of five road sections in the Upper Nehalem Project Area, totaling approximately 0.26 mile, are located in sidecast/fill or fill slides (Table 8-7). Approximately 67 percent of road prisms in the project area were assessed to be stable. A total of 720 stream crossings were identified within the Upper Nehalem Project Area. Of this total, three stream crossings identified as barriers occur on known fish bearing streams, while 559 crossings were assessed to have no fish passage restriction. Of the 720 stream crossings within the project area, eight were determined to be at high risk of washout while 484 were assessed to be at low risk of washout.

R2 Resource Consultants and Lee Benda and Associates. 2005. "Upper Nehalem Watershed Analysis Chapter 9. Water Quality." Oregon Department of Forestry.

This chapter consists of a water quality assessment along fish-bearing streams in the upper Nehalem watershed. It should be regarded as supplemental to the PSU water quality assessment prepared by Johnson and Maser (2000). The primary purpose of this effort was to perform a remote assessment of riparian vegetation conditions to estimate the radiation-blocking angles along stream corridors and to make projections of potential stream temperatures based on current, historical and future riparian conditions. Within this assessment, vegetation heights, topographic blocking elements and reasonably achievable surface water temperatures are estimated for eleven management basins within the Upper Nehalem basin. Overall, water quality data from the sampled waters were rated good for summer fish rearing and they were consistent with biological use criteria. Dissolved oxygen levels in streams were not generally a concern due to high re-aeration rates in turbulent flowing water. pH levels in the surface waters of the watershed were expected to comply with the state standard throughout the stream network. The pH levels monitored to date were not anticipated to have an adverse effect upon aquatic biota in the watershed. All of the reported results on and near ODF lands in the watershed for ammonia-nitrogen and un-ionized ammonia remained within recommended concentrations for aquatic life. Data from the upper basin indicate a low level of nitrates, suggesting the nutrient concern was more likely an issue in the lower portions of the basin. Turbidity measurements in the watershed ranged from <1 to 8 NTU. These levels were low, but likely did not represent the full range of turbidity levels throughout the year.

R2 Resource Consultants and Lee Benda and Associates. 2005. "Upper Nehalem Watershed Analysis Chapter 10. Aquatic Resources and Their Habitats." Oregon Department of Forestry.

This habitat section describes the aquatic environment within the upper Nehalem watershed and how that environment affects the distribution and abundance of aquatic resources in the watershed. Several factors have been identified as likely contributing to the population decline of coho salmon. These factors of decline include habitat destruction, overfishing, artificial propagation, and poor ocean conditions (Weitkamp et al. 1995). As in-channel habitat complexity, structure, and abundance of pool habitats are important for freshwater survival of coho salmon, reduction of these habitat characteristics may limit coho production (Nickelson et al. 1992). In general, densities of spawners increased from 1 to 5 wild adult coho per mile in 1998 to more than 200 per mile in 2002 and 2003 (Kavanagh et al. 2005). Estimates of abundance suggest that this ESU is currently at a level of 5 to 10 percent of historical abundance (Weitkamp et al. 1995). Overall streams surveyed by ODFW Aquatic Habitat Inventory program were reported to have habitat in fair to good condition. Nehalem streams had fewer high gradient reaches and more reaches with a narrower active channel width than Reference streams. The Upper Nehalem streams showed similar habitat ratings for 6 attributes including: percent gravel in riffles, percent bedrock, density of deep pools, percent pool habitat, percent secondary channel area, percent channel shading. Dissimilarities between the upper Nehalem and reference conditions were evident for percent fine sediments and riparian attributes (Kavanagh et al. 2005). Large wood was relatively rare in upper Nehalem streams.

R2 Resource Consultants and Lee Benda and Associates. 2005. "Upper Nehalem Watershed Analysis Chapter 11. Limiting Factors." Oregon Department of Forestry.

The Limiting Factors chapter investigates instream large woody debris, sediment deposition, and surface water stream temperatures as limiting factors for properly functioning habitat conditions in the Upper Nehalem watershed. From a watershed perspective, the wood levels in the upper Nehalem appeared to be within the natural variation of unmanaged systems, and thus all subwatersheds were classified as functioning. Individual reaches were highlighted as having lower amounts of large wood than reference streams, however. A comparison of the statistical distributions of the reach data indicated that the ODF streams in the upper Nehalem River Project Area were similar to unmanaged references streams and conditions with respect to substrate composition. From a watershed perspective, the substrate composition in the upper Nehalem appeared to be within the natural variation of unmanaged streams, given the geology of the watershed. Some areas could benefit from substrate enhancement, however. There are 58 reaches with high levels of fines that could be affecting the habitat value to native fishes. These reaches have more than 30 percent fines in riffles and represent sufficient amounts of fine sediments by volume to fill the pore spaces in riffle gravels and diminish the suitability of these substrates for salmonid fish spawning. The current riparian situations on ODF lands in the watershed are anticipated to meet properly functioning habitat conditions along 93 percent of the fish-bearing streams in the watershed. Approximately 17 miles and 2 miles of ODF fish-bearing streams are anticipated to have a moderate and high risk of limiting the achievement of properly functioning habitat conditions, respectively.

Suring, Erik, Ronald J. Constable Jr., Chris M. Lorion, Bruce A. Miller, and Derek J. Wiley. 2012. *Salmonid Life-Cycle Monitoring in Western Oregon Streams 2009-2011, The Oregon Plan for Salmon and Watersheds*. Oregon Department of Fish and Wildlife. https://nrimp.dfw.state.or.us/CRL/Reports/2007-06.pdf.

This report provides monitoring results for North Fork Nehalem River adult spawner and juvenile out-migrant abundance and (freshwater and marine) survival rates of Coho salmon. Estimates of wild adult Coho spawners in the total basin upstream of Waterhouse Falls were considerably lower in the first three monitoring years (x = 671 adults) than in the last ten years (x = 1,919 adults). Numbers were lowest in 2000 (612 adults) and highest in 2010, with the two highest spawner estimates occurring in the last two years (2,094 and 5,026 adults, respectively). Total estimated numbers of Coho spawners (wild plus hatchery) were also lowest in 2000 (721 adults) and greatest in 2010 (5,790 adults). Marine survival has varied over the course of monitoring, ranging from 1.7% (1996 brood) to 17.4% (2007 brood), with the highest marine survival estimates occurring in the last three years. The annual number of out-migrating juvenile Coho also varied annually, but there is a trend of decreased freshwater survival at higher spawner densities, presumably related to density dependent effects like lack of winter habitat.

Thom, Barry A, and Kelly Moore. 1997. "North Coast Stream Project Guide to Instream and Riparian Restoration Sites and Site Selection Phase II Necanicum River, Nehalem River, Tillamook Bay, Nestucca River, Neskowin Creek and Ocean Tributary Drainages." Funded by Oregon Wildlife Heritage and Foundation Oregon Department of Forestry Oregon Department of Fish and Wildlife.

This guide highlights potential stream habitat enhancement projects along the North Coast, including the Nehalem River drainage. The guide predominantly outlines streams that are of a proper size and gradient for instream enhancement work, and is meant to be supplemental to the Phase I document. Potential instream and riparian enhancement sites were identified using GIS and prioritized using field verification where possible. In the Upper Nehalem River basin, 86 miles of streams have been selected as potential instream enhancement sites. The six miles of high priority sites are within Upper Rock Creek and Robinson Creek drainages. In channel enhancement has been conducted on North Fork of Rock Creek, Weed Creek, North Fork Wolf Creek, and Lousignont Creek. The Upper Nehalem River above Robinson Creek and Upper Rock Creek drainages are core areas for Coho salmon. In the Middle Nehalem River basin, 103 miles of streams are of a potential size and gradient for instream enhancement work, with 13 of these miles at a high priority. High priority areas for enhancement include Battle Creek, Oak Ranch Creek, and the upper tributaries of Pebble Creek. Fall Creek is also an excellent area for enhancement pending the removal of an impassable culvert in the lower reaches of the stream. Instream enhancement work has been conducted on Deer Creek, Dog Creek and Kenusky Creek. Oak Creek and Deer Creek serve as core areas for Coho salmon within this subbasin. In the North Fork Nehalem River basin, 43 stream segments have been selected as potential instream enhancement areas. Of these 43 sites, 8 miles have been listed as a high priority. High priority enhancement areas include the Upper North Fork Nehalem, and Little North Fork Nehalem rivers as well as Gods Valley Creek. The Jewell area of the Nehalem River basin includes all tributaries from Beaver Creek downstream to Humbug Creek. Approximately 12 miles of streams in this area have been selected as high priority enhancement areas with another 116 miles of streams having at least some potential for instream enhancement. High priority enhancement areas include the East Humbug Creek, Buster Creek, Beneke Creek and Fishhawk Creek (Birkenfeld) drainages. In the Lower Nehalem River basin, 46 segments were selected that were an adequate size and gradient for instream work for a total length of 48 miles of potential stream habitat enhancement work. The only core Coho salmon area that occurs in the drainage is Foley Creek, which has also been selected as a potential enhancement area. Foley Creek, Upper Cook Creek, and Lost Creek appear to be very good locations for enhancement work.

The Nature Conservancy. 2012. "Voluntary Conservation Action Plan for Nehalem River Watershed."

This plan describes the results of a partnership of local community groups, landowners, and public agencies who met to create a Conservation Action Plan that developed voluntary conservation strategies and actions for the Nehalem River Watershed. For this exercise, particular attention was given to the freshwater system, riparian, and estuary and associated ecoystems sections. The report rates the health of the freshwater system as fair overall.

However, stream temperature, amount of high quality habitat, and the status of Coho are in poor condition. Characterizing the state of riparian areas represents a major data gap at the time of this report. The estuary and associated ecosystems were rated as fair as well, but is at risk of habitat loss, sea level rise due to climate change, large wood removal, invasive species, flood control infrastructure, and shoreline development. This report presents baseline data for existing conditions as well as goals and strategies for achieving those goals, demonstrating a clear conservation and restoration need.

Unknown. 2005. "Annual Estimates of Wild Coho Spawner Abundance in Coastal River Basins within the Oregon Coastal ESU, 1990-2004." Table.

This table provides annual estimate of wild Coho spawner abundance in coast river basins within the Oregon Coastal ESU from 1990-2004, including the Nehalem River. The table has an unknown origin, but provides important information about abundance of wild spawners in the Nehalem River. From 2000-2004, wild spawner estimates are much higher each year than estimates for each individual year in the 1990's.

Watershed Professionals Network, and Jones & Stokes. 2007. "Final Report Nehalem Data Synthesis Project: OWEB # 208-922-6488."

This data synthesis was conducted with a focus on prioritizing restoration projects and public outreach. The report provides information on Intrinsic Potential, large woody debris placement, and riparian improvement. Background information on the watershed is useful but brief. The eight priority subwatersheds identified in the report include Foley Creek, Lower North Fork Nehalem River, Middle North Fork Nehalem River, Upper North Fork Nehalem River, Fishhawk Creek, Lower Rock Creek, Middle Rock Creek, and Upper Rock Creek. There are currently identified 831 total miles of medium (.5-.8) to high (.8-1.0) Coho Intrinsic Habitat Potential (IP) stream, 372 miles of that total are high IP (.8 to 1.0) stream. There are 355.79 total miles of LWD Priority stream reach currently identified in the Nehalem system. There are approximately 136.33 total miles of Riparian Enhancement Priority stream reach currently identified in the Nehalem system.

Appendix 6

Methods - Subwatershed Ranking and Anchor Habitat Identification

The Nehalem Strategic Action Plan
Summary of Methods to Rank Subwatersheds and Identify Anchor Habitats
Map Version 3.0 (Document Revised August 16, 2016)

The following is intended to summarize the process used to rank sub-watersheds to guide development of the Nehalem Strategic Action Plan (SAP). The purpose of ranking sub-watersheds is to assist the planning team (Team) in sequencing on-the-ground habitat protection and restoration projects in the Nehalem basin. The ranking is not intended to recognize one watershed as "more important" than another, or disregard the contributions of lower ranked sub-watersheds to the basin-wide dynamics that make the Nehalem such a productive coho system. The Team recognizes the inherent challenges in subdividing an inter-connected system, but believes this geographic focus is essential if success is to be demonstrated in a large basin with limited financial resources available to the groups that work there.

Guiding Principles

The sub-watershed ranking is guided by several principles.

1. Follow the stronghold approach. Because watershed function is more likely to be altered within highly degraded systems, the return on restoration investment is less assured and may take significantly longer to be realized than in less impaired watersheds. Protecting and restoring habitats in largely intact sub-watersheds is more likely to provide the expected results and show a more immediate return on investment. Accordingly, the ranking gives priority to sub-watersheds that exhibit remnant attributes of a functional system and demonstrate the capacity for recovery through restoration.

2. Recognize multiple life stages. The ranking gives priority to sub-watersheds that contain the greatest number of stream miles with habitats capable of supporting the complete freshwater life history of Oregon Coast Natural (OCN) coho. This principle seeks to align the SAP with the approaches used in the Rock Creek Limiting Factors Analysis (LFA, Bio-Surveys, 2010) that identified key anchor habitats for OCN coho to identify the sub-watersheds where future LFAs – or targeted baseline assays would have the greatest value for guiding and prioritizing future restoration actions.

3. Recognize the importance of life history diversity. Life history diversity is essential to promote resilience within a population in the face of changing climactic and watershed conditions. This principle seeks to ensure that a broad range of unique life history strategies are recognized for Nehalem coho and this inherent diversity is captured in all aspects of restoration and recovery planning within the SAP.

4. Aggregate sub-watersheds. Utilizing 6th field hydrologic units for comparing and prioritizing restoration actions is challenging because the hydrologic unit (HUC) can be an incomplete description of a biologically functional sub watershed. This creates inconsistencies in habitat comparisons across the range of 6th field HUCs that require

normalization where large stream order subbasins included multiple 6th field delineations. In the sub-watershed ranking process, 6th fields were combined that resulted in describing a biologically functional stream segment that included its headwaters and its lowlands extending to the confluence of the next larger stream order.

Methods

Guided by the principles above, the Steering Committee (Committee) identified several criteria to evaluate each of the Nehalem's 6th field watersheds. Criteria included:

- potential high quality rearing habitat;
- existing high quality rearing habitat;
- existing spawning habitat;
- distribution;
- forest stand maturity; and
- the presence of Oregon Department of Forestry (ODF) anchors.

To assess each of these criteria, the Committee compiled existing data and scored each sub-watershed according to data ranges (condition bins) that it established. Both the raw data and scores are shown on the spreadsheet that accompanies this summary. It should be noted that the criteria, raw data, and scores contained in this spreadsheet are designed for decision support, and can be filtered and weighted in numerous ways. The ultimate decision for how – or whether – to use these data are determined through a collaborative process between the local Team and Committee, which is described below.

Data sources used to assess each of the criteria include the following:

- *Potential High Quality Rearing* was evaluated using the miles of high and medium Intrinsic Potential (IP) available. Intrinsic Potential is a modelling approach that analyzes several immutable features of the landscape to assess the potential for a watershed or stream reach to host a particular species. High IP areas for coho are identified using a model developed by the US Forest Service CLAMS project and the Oregon Department of Fish and Wildlife (ODFW). IP was assessed largely using data derived from LIDAR, though 10m digital elevation models (DEMs) were applied where LIDAR data was unavailable.

- *Existing High Quality Rearing* was evaluated using several criteria, including ODFW's Habitat Limiting Factors Model (HLFM) and HabRate model, snorkel surveys, and Netmap-modeled anchor habitat sites.

    - The HLFM is used to determine the potential production of winter fry from existing survey habitat. The data used in this model is the physical habitat data collected by the ODFW Aquatic Inventories Project (AQI) program and is limited to wadeable streams.

- The HabRate model evaluates the current condition of habitat based on the AQI habitat surveys and any whole basin surveys that may have occurred in the target watersheds. This model uses the same wadeable-streams-only data set that HLFM uses.
- The Netmap-modeled Anchor Sites (see below).
- Snorkel surveys included in the spreadsheet were conducted as part of a three year series of rapid bio-assessments (RBAs) completed in the summers of 2009, 2010, and 2011. Among other data collected, the RBAs assessed juvenile density by sampling every 5th pool. Because sampling was not conducted across all of the sub-watersheds, data was not translated into scores. The data is included in the spreadsheet because it is useful for decision support.

- *Existing Spawning Habitats* were assessed using HabRate. As stated above, the HabRate model evaluates the current condition of habitat based on the AQI habitat surveys and any whole basin surveys that may have occurred in the target watersheds.

- *Distribution* was assessed using ongoing ODFW field data. Maps were updated in 2014.

- *Forest Stand Structure and Maturity* was evaluated using stand height and vegetation class data. The percentage of stand height/veg class per HUC 6 binned as "high" was calculated to compare sub-watersheds to determine which have the highest percentage of taller and older forests.

- *Aquatic Anchor Watersheds* were identified by the ODF in 2001 and recognized in State Forest Implementation Plans in 2003. The ODF designated anchor watersheds to provide additional protections to a suite of drainages identified as possessing strong wild salmon populations and relatively intact habitats.

- *Unique life history group* information was provided by Steve Trask of Bio-Surveys in a document titled "Potential unique coho life histories of the Nehalem Basin. " The document divides the Nehalem Basin sub-watersheds into 6 unique history groups and describes the attributes of each life history subdivision.

Preliminary Results

The Committee used the guiding principles combined with the criteria and information sources described above to develop a draft list of twelve high ranked sub-watersheds. First, data were entered into the spreadsheet and binned (scored) into high (3), medium (2), and low (1) for each data source. The binned scores were summed into an aggregate score, and the sub-watersheds were then sorted by highest aggregate score. This first filter was intended to incorporate the guiding principles related to capturing the stronghold sub-watersheds (#1). These sub-watersheds provide the most extensive areas of high quality habitats capable of supporting multiple life stages (#2).

To incorporate the guiding principle related to life history diversity (#3), the Committee then selected the highest-scored sub-watershed for each life history group that was not captured by the aggregate scoring approach described above. These included Fishhawk and the estuary. This step ensured that at least one sub-watershed from each of the unique life history groups would be included among those that were given a high ranking. We should note that Cook, Cronin, and Lost Creek all had the same aggregate score, and so all were considered equally important for inclusion in the final prioritization process. Cook Creek contained the added value of being identified as an ODF Aquatic Anchor Watershed, and Cronin Cr is known to be a source of c.shasta resistant OCN coho.

The Upper and Lower North Fork ranked high in the analysis. The Middle North Fork Nehalem River was added to the high ranked list in order to recognize the role of this 6th field HUC as a necessary functional component of complete biological unit (principle #4). The three sub-watersheds that comprise the Rock Creek drainage – including the Upper, Lower, and Middle – were similarly clustered to capture a complete subbasin subdivision.

Team Review and Recommendations: January 20 meeting

These results were presented to the Nehalem SAP Team on January 20, 2016, and several challenges discussed, primarily related to the adequacy of existing data. These included:

- HLFM and HabRate rely on AQI data, which is collected only in wadeable streams. In addition, not all basins are surveyed at the same density, and some basins have few or no survey sites. These conditions limit the applicability of AQI data and these models in an exercise that seeks to compare sub-watersheds.
- Sufficient data is not available on spawning gravel to characterize existing spawning habitat.
- The Nehalem RBA was not conducted in all of the sub-watersheds.
- ODF Anchor Habitats only point to priority areas on ODF land. It is, therefore, not a complete comparative analysis tool for this exercise.
- Intrinsic Potential is incapable of evaluating key habitat conditions such as water quality (temperature limitations) and available spawning gravel. In addition, false positives are common in the HIP model due to the use of 10 meter DEM data, which is unable to detect deep channel entrenchment that renders significant stream reaches as low IP (mainstems).

After extensive review and discussion, the Team recommended several revisions to the methodology, which may be summarized as follows:

- Intrinsic Potential is too heavily weighted in the draft analysis. First. the High IP score is doubled, and, second, IP criteria are incorporated into the Netmap Modeled Anchor Site analysis (discussed below). The Team recommended reducing the emphasis on IP modeling.

- Recognize the function of small 2nd and 3rd order mainstem tributaries in providing thermal refuge, which is particularly important for sustaining the known nomadic life histories.
- To more accurately identify "remnant attributes" of a functional system (principle #1), undertake analyses of forest cover, stand structure, and large wood recruitment potential. Also try to identify areas of cold water refugia. If data are not available, highlight this as a key data gap.
- Present the full spreadsheet in the SAP, but use the Netmap Modeled Anchor Site as the primary filter to sort results (rather than aggregate score).

The Netmap-modeled Anchor Sites

In addition to considering the data described above, the Team also conducted a watershed-wide analysis of potential anchor habitats by modeling an approach applied in three Rock Creek sub-watersheds (Bio-Surveys 2011). This effort began with an evaluation of whether Netmap modelling could produce a similar set of anchor sites for OCN coho as biologists who had collected and analyzed field data. If the modeled approach could produce similar results, Netmap could be applied throughout the entire Nehalem drainage to produce a collection of anchor sites with a reasonable assurance of accuracy.

The Committee initiated the project by interviewing Bio-Surveys' Steve Trask, whose crews conducted the field work for the LFA, to identify the key parameters used in the determination of anchor sites. From conversations with Mr. Trask, the Team created a list of four parameters used to determine anchor sites, including: terrace height, channel gradient, floodplain width relative to average floodplain widths and temperature.

These parameters were analyzed in GIS as follows, to determine the highest ranked areas:

- *Terrace heights*: NetMap's Valley Floor Index tool was used to calculate a raster of elevations above the channel on the Valley Floor. The resulting raster was reclassified so that anything under 2 feet (0.6096 meters) was assigned a value of 1. All other data received a "no data" value. The purpose of this step was to find all the pixels that were potential high value terraces (i.e. terraces under 2 feet in elevation above the stream channel). For each drainage area that drained into each reach (defined by NetMap as "drainage wings"), the model then determined the area of potential high value terraces. This helped approximate the total amount of potentially high value terraces and compare reach by reach.

- *Channel gradient* was binned into three categories and received the following scores:
  - < 1 % = 3 points,
  - between 1 and 4% = 5 points, and
  - greater than 4% = 1 point.

- *Floodplains* were binned into five categories using natural breaks (Jenks method) in GIS. The widest floodplains received a score of 5, and the narrowest received a score of 1.

- *Temperature* was incorporated into the analysis at the population scale (i.e. the entire Nehalem basin) by filtering out all streams greater than 17.8° degrees and only running the analysis on those streams that met this temperature criteria.

Finally, scores for each bin were added (Terrace + Gradient + Floodplain Width) to determine the total score. Reaches receiving values of 9 or greater were considered to have the potential to serve as anchor sites.

To compare the Netmap modelled results with the results generated in the Rock Creek LFA, the field derived anchor habitat polygons were overlaid with the Netmap modeled high ranking stream reaches. There was only one substantial area of divergence, where Netmap ranked a stream reach as likely being an anchor site and the Rock Creek LFA did not. Conversations with Mr. Trask determined that while this was an area that may have fit the Netmap back cast criteria for an anchor site, the absence of functional spawning gravel disqualified it in the LFA field review (spawning gravel being a required component within the LFA Methodology for classification as a functional Anchor Site).

Netmap's inability to quantify or model the presence and abundance of spawning gravel was noted as a limitation of the tool's use in identifying functional anchor sites. The Team agreed that the Netmap results based on the Rock Cr LFA back cast produced some signal in most ground truthed anchor sites in 3rd and 4th order stream corridors. The results did a poor job of delineating the physical upstream and downstream boundaries of those anchor sites but produced a viable target for final field verification. Because of the considerable limitations of the data used to assess the selected criteria (especially the lack of any data for spawning gravel), the Team further agreed that this approach should be used as the primary filter for ranking sub-watersheds and focusing final field reviews. While extensive "ground-truthing" of the modeled results is unlikely during development of the SAP, the Team recognized the importance of field-verifying the results below and may explore ways to expedite a verification process.

Updated Results

Using these Netmap Modeled Anchor Sites analysis as the primary filter produced the following high ranked watersheds:

- Beneke Creek
- Lower North Fork Nehalem
- Humbug Creek
- Middle Rock Creek
- Clear Creek
- Upper Rock Creek
- Middle North Fork Nehalem

In order to fully capture the range of life history diversity present in the Nehalem (principle #3), the Team recommended adding the following sub-watersheds to the priority list:

- Foley Creek
- Fishhawk Creek
- Nehalem Bay
- Lower Salmonberry River

The Lower Salmonberry River was added instead of the higher ranked sub-watersheds in that life history diversity group to recognize the Salmonberry's critical contribution of cold water to the mainstem downstream.

To reflect the final guiding principle used in this process (aggregating sub-watersheds, #4), the Team also added the following watersheds to the priority list:

- Upper North Fork Nehalem (to the Lower North Fork and Middle North Fork Nehalem)
- Lower Rock Creek (to Upper and Middle Rock Creek)
- Upper Salmonberry River and North Fork Salmonberry River (to Lower Salmonberry River)

The Team also added the full mainstem Nehalem to capture critical contributing areas (CCA) of cold water refugia for the nomadic life history and ensure that high water temperatures in the mainstem, a key limiting factor basin-wide, can be sufficiently addressed in the SAP.

Finally, the Team overlaid these results with the results of the *Nehalem Data Synthesis Project.* The Data Synthesis identified eight priority sub-watersheds. In the lower Nehalem the priorities included the three sub-watersheds in the North Fork Nehalem and Foley Creek. In the Upper Nehalem the three Rock Creek sub-watersheds and Fishhawk Creek were identified as the priorities.

Team Review and Recommendations: March 30 meeting

The resulting map (version 2.0) was presented to the Nehalem SAP Team at its March 30 meeting, along with a Netmap analysis of Forest Stand Structure. This analysis was intended to more fully inform the group's first guiding principle: applying a stronghold approach (guiding principle #1 above). Based on this analysis and subsequent discussion, the Team reached consensus on three final revisions:

1. Add Cook Creek because it represents a LHD cluster that is not currently represented in the list of high ranked watersheds.
2. Add Lousignont Creek because: 1) stand composition is old and intact (LEMMA); 2) it is triple the production of Clear and Wolf (RBA); and 3) it includes the highly productive upper mainstem Nehalem.
3. Replace Clear Creek with Wolf Creek because Wolf Creek: 1) generates cold water in its headwaters; 2) contains extensive old and intact forest stands (LEMMA); and 3) is highly productive (RBA).

The Team agreed to use the resulting map (version 3.0) of high ranked sub-watersheds to prioritize projects for inclusion in the draft SAP.

References

Bio-Surveys 2011. Limiting Factors and Restoration Plan: Lower, Middle, and Upper 6th Fields Rock Creek Basin Tributary to the Nehalem River.

Appendix 7

Methods - Evaluating Upslope Large Wood Delivery Potential to Anchor Habitats

The Nehalem Strategic Action Plan
Summary of Methods to Evaluate the Potential for Large Wood Delivery from Upslope Sources into Anchor Habitats

The Netmap model was used in order to determine what upslope areas in the Nehalem watershed have the greatest potential to deliver wood and gravel to coho habitat and should be protected. To analyze likelihood to slide and deliver, Netmap results were combined with Landscape Ecology, Modeling, Mapping & Analysis (Lemma) GNN 2012 Structure Data to answer the following questions:

1) Where is there high potential for debris flows and shallow landslides?
2) Where is late seral vegetation (i.e. large and giant trees) present?
3) Where do the intersection of the above drain directly into areas with high priority coho anchor habitat?

Based on the GIS analysis results for the above 3 questions, areas where preservation should occur can be determined. These areas will need further validation and field ground-truthing.

Analysis of intersection slopes likely to fail and late seral vegetation for 1st – 2nd order streams

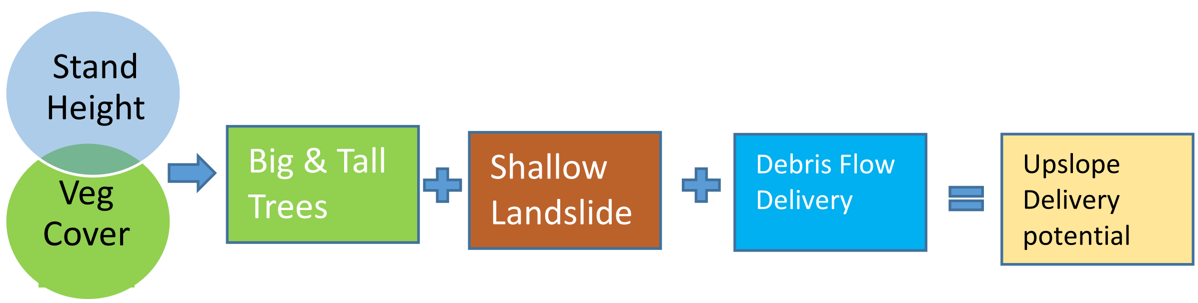


Figure 1: Mapping intersection of slopes likely to fail and late seral vegetation

Step 1: Map late seral vegetation

Vegetation data was compiled using the Landscape Ecology, Modeling, Mapping & Analysis (Lemma) GNN 2012 Structure Data provided with Netmap outputs.

The purpose of the analysis of the vegetation data is to find areas of old growth and mature forests. Data mapped included stand height and vegetation class.

To conduct this analysis the Lemma Vegetation Classification (VEGCLASS) field was used. Data in this field that captured mixed, large and old-growth categories (values 4, 7, 10, and 11) was selected. More info on the vegclass categories we chose, is available at: http://lemma.forestry.oregonstate.edu/data/structure-maps

Stand height (STNDHGT) data (average stand height) was binned into 5 categories, and received 1 point for the lowest average heights and 5 points for the highest average stand heights. After being binned, data was reclassed so that the lower (1-3) average stand heights received a value of 0, and the higher average stand heights received a value of 1. These values were assigned so that when stand height was multiplied by Veg Class only the veg class with taller average stand heights would remain.

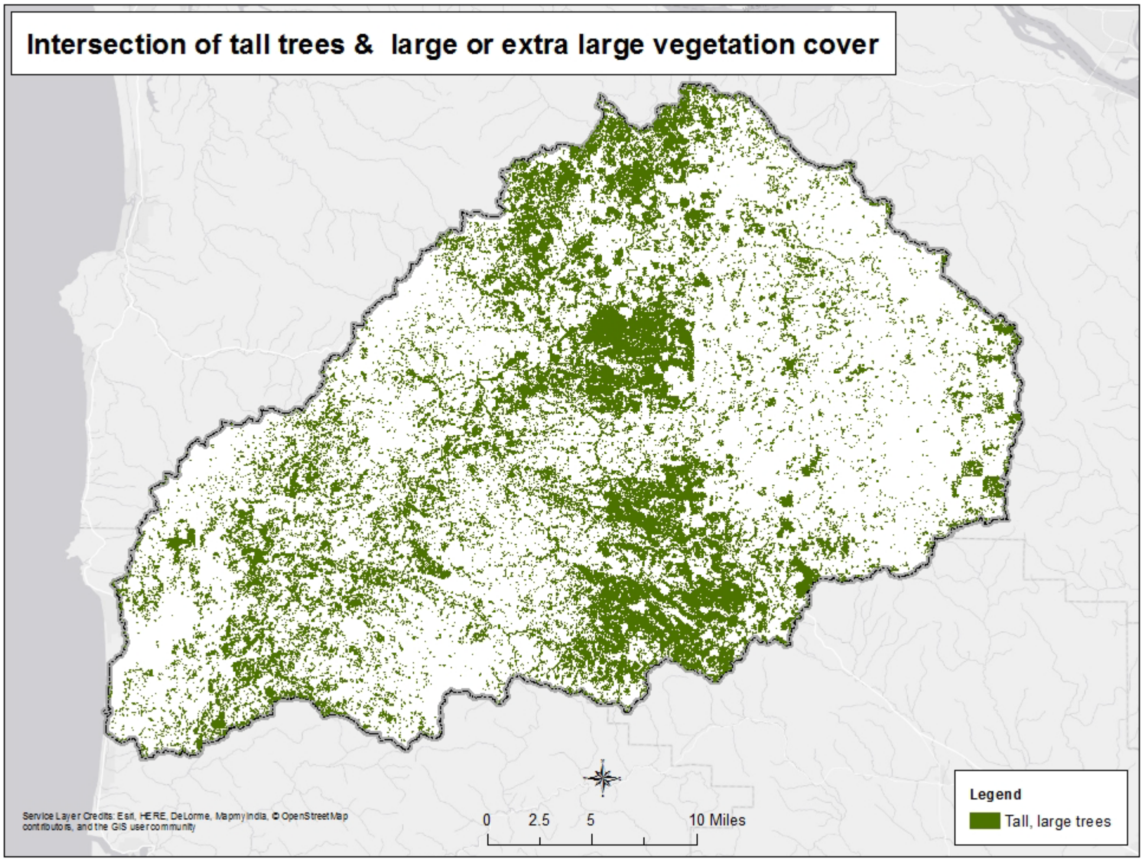


Figure 2: Location of large, tall trees based on intersection of stand height and veg class.

Because the LEMMA data is in pixel format, in order to associate it with netmap reaches, a percent of high ranking stand height/veg class per drainage wing was calculated. A netmap drainage wing is the area that drains into any given 100 meter reach. Each of the drainage wings was assigned a value based on a percentage of large/tall trees in the drainage wing (Figure 3). This percent was then assigned to its associated reach. A binned score was created binning the results into 5 categories from 1 – low percentage of large/tall trees to 5 high percentage of big and tall trees.

Step 2: Map shallow landslide and debris flow potential

Netmap tools were modified by Terrainworks, to allow for calculation of landslide initiation and debris flow delivery to a given set of reaches. Using this new Netmap capability, we were able to locate areas with a high likelihood of a shallow landslide traveling down a debris flow track and delivering to a potential anchor habitat [Refer to Page XX for anchor habitat definition]. The Netmap tool generates three rasters: One of likelihood of shallow landslide initiation; one of debris flow tracks to streams; and one that is a combination of both - with the area of landslide initiation buffered. We used this later raster, called “proportions” to depict the areas likely to slide and deliver to streams. This raster was reclassified to filter out all but the top 20% of the areas likely to initiate and deliver debris flows to streams (figure 3).

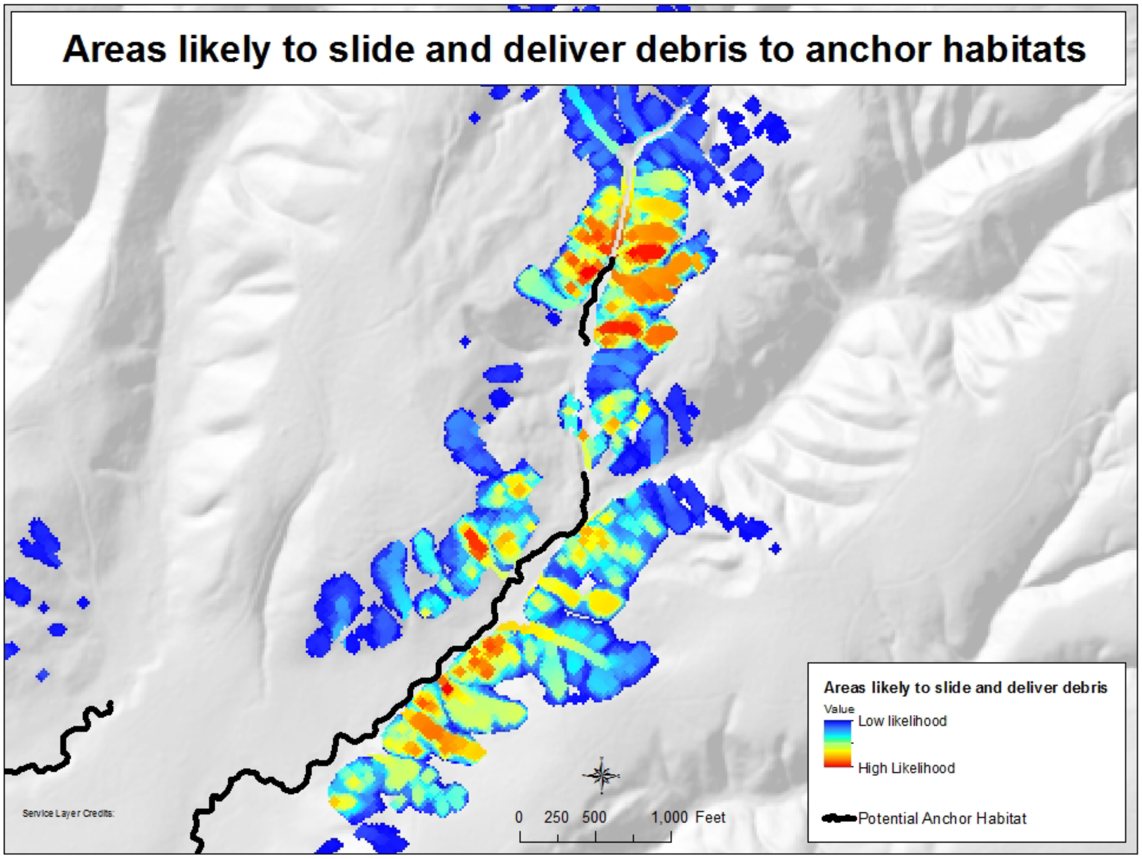


Figure 3: Areas likely to slide and deliver debris to anchor habitats

Step 3: Combined Results to highlight areas with large trees and a high likelihood of shallow landslides and debris flows delivering to anchor habitats

Each drainage wing (i.e. the area draining into each reach) was reviewed to find reaches that had a combination of high debris flow likelihood with large trees draining into it.

This analysis was done using the 'zonal statistics by table' tool in spatial analyst on both the large/tall tree raster and on the top 20% of the proportions raster and joining the results of both analysis to the drainage wings feature class.

Drainage wings that had a score for large/tall trees of at least 4500 rose to the top as having both a high likelihood to slide and deliver and a significant amount of large vegetation.

Results were joined from drainage wings to their accompanying Netmap stream reaches.

Figure 4 displays an example area. Reaches (in brown) are those likely to receive debris flows/landslides (depicted in light brown) that are in areas of large, late seral vegetation (depicted in green).

In addition, the fish biologist advising us on this work, suggested reviewing potential slide areas likely to deposit into 3rd order anchor habitat streams. While in a prior version of this upslope analysis, we analyzed this component separately, in this current analysis, these streams seemed to be accounted for as high priorities and thus were not accounted for separately.

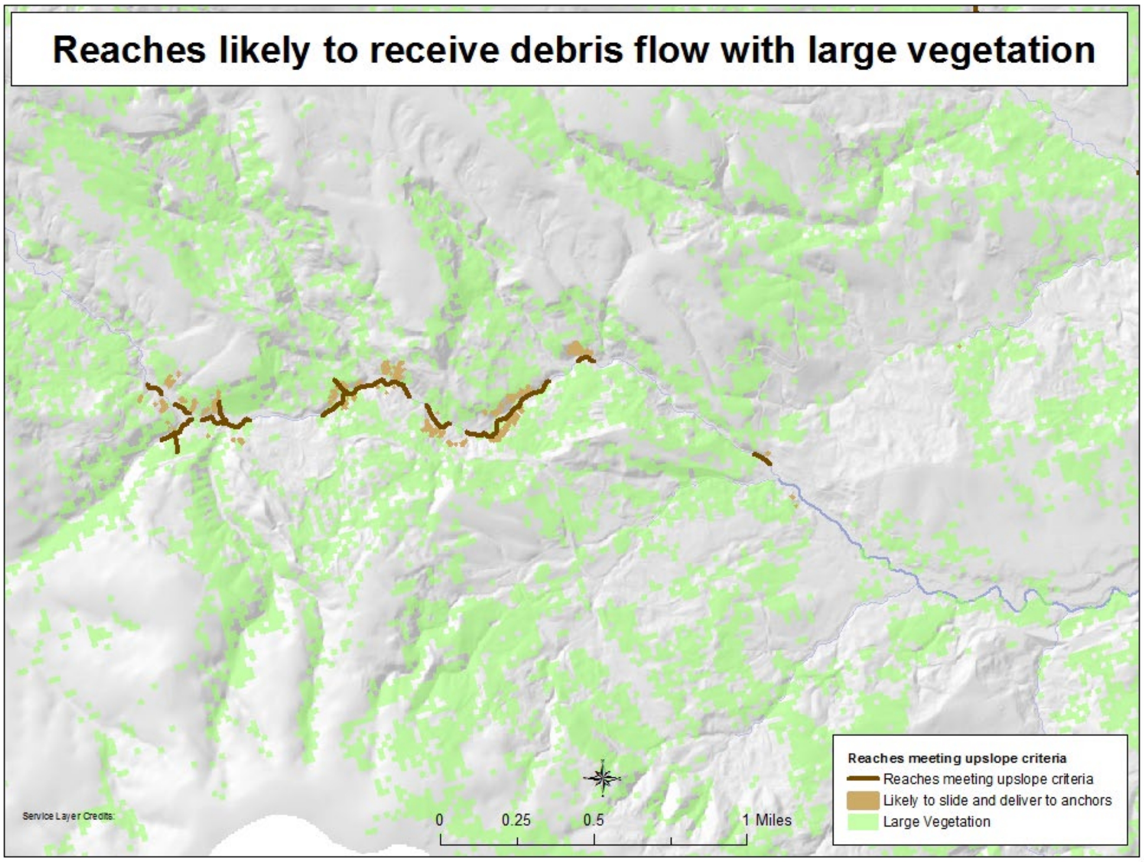


Figure 4: Reaches both in areas of large, tall vegetation, and likely to receive debris flows

Review and edit manually

Reaches that met all of these criteria (214), were then manually reviewed against aerial photography to ensure that trees hadn't been harvested since the LEMMA vegetation data set was generated. Edits were made accordingly. If reaches no longer had significant old growth vegetation upstream, reaches were removed from final results.

Results

Figure 5 depicts the remaining high priority reaches and the stands surrounding the high landslide delivery areas. These are the areas that would be reviewed for potential interest in protection.

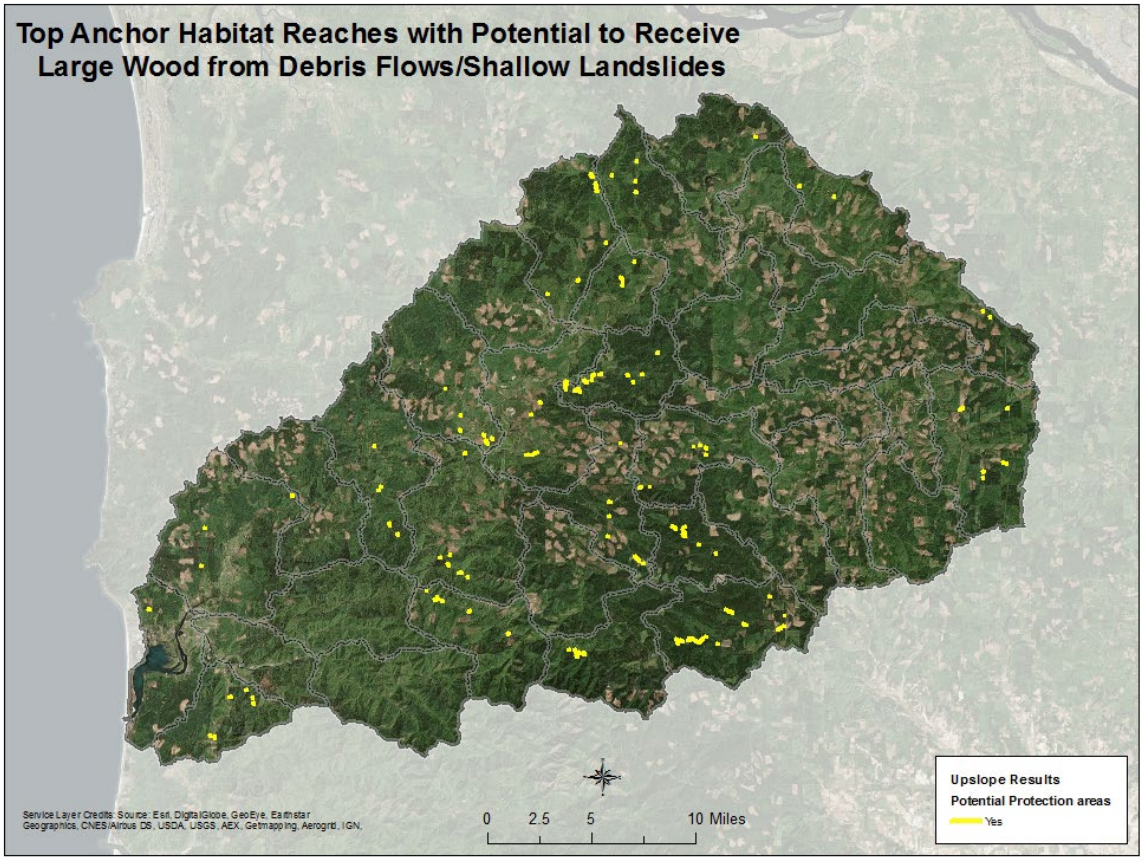


Figure 5: High priority upslope reaches

Limitations and Error

There is inherent error and limitations in modeled data. Whenever possible, results should be ground-truthed. Lemma data was collected in 2012 and changes in vegetation may have occurred since this time. While we made every attempt to verify with aerial photos, field data may still yield more up-to-date results.

Conclusions and next steps

Combining upslope analysis of areas likely to slide and deliver debris to potential anchor habitat along with large late seral vegetation, yields locations where it might make sense when willing landowners are available, to protect land as well as work instream. These locations may be areas well suited to allow natural process to deposit woody debris into streams. Stream restoration actions could work with natural process to promote optimal conditions for Oregon Coastal Coho.

Prepared by: Jill Ory, NOAA Restoration Center

Appendix 8

Methods - Beaver Intrinsic Potential Mapping

Using Netmap data to predict areas where beaver dams are likely to occur

The Nehalem Strategic Action Planning (SAP) team was interested in examining whether Netmap could be used to find sites that have been documented in the field as having beaver dams, and then use the same criteria to model good sites where beaver could be encouraged to build future dams.

Initial analysis was begun by Cain Allen at the Upper Nehalem Watershed Council. Cain created layers of potential beaver habitat based on two different research papers, “Assessing Beaver Habitat on Federal Lands in New Mexico” (Wild Earth Guardians 2013) and “Habitat Classification Models for Beaver in the Streams of the Central Oregon Coast Range (Suzuki and Mccomb 1998) and looked at how these matched up with Rapid Bioassessment field data collected by Steve Trask in the Upper Nehalem from 2009-2011. In Cain’s analysis he found a good correlation with existing beaver dams and medium to high intrinsic potential beaver habitat.

We built off this analysis by examining information in the recently published Beaver Restoration Guidebook (Castro, et. al. 2015) to determine what stream attributes are likely to promote beaver dams, and to see how close a match this is with locations of known beaver dams from existing field-collected data (Hereafter referred to as “modified Beaver Restoration Guidebook method”). As indicated above, the field data was collected in the Upper Nehalem during RBAs from 2009 - 2011. We found that selecting out streams that met the criteria presented in the Beaver Restoration Guidebook, approximately 59 – 76% (depending on the year) of the beaver dams identified in the RBA were on streams selected out following the modified Beaver Restoration Guidebook method.

The beaver preference parameters we selected to use from the Beaver Restoration Guidebook (pg 3) include:

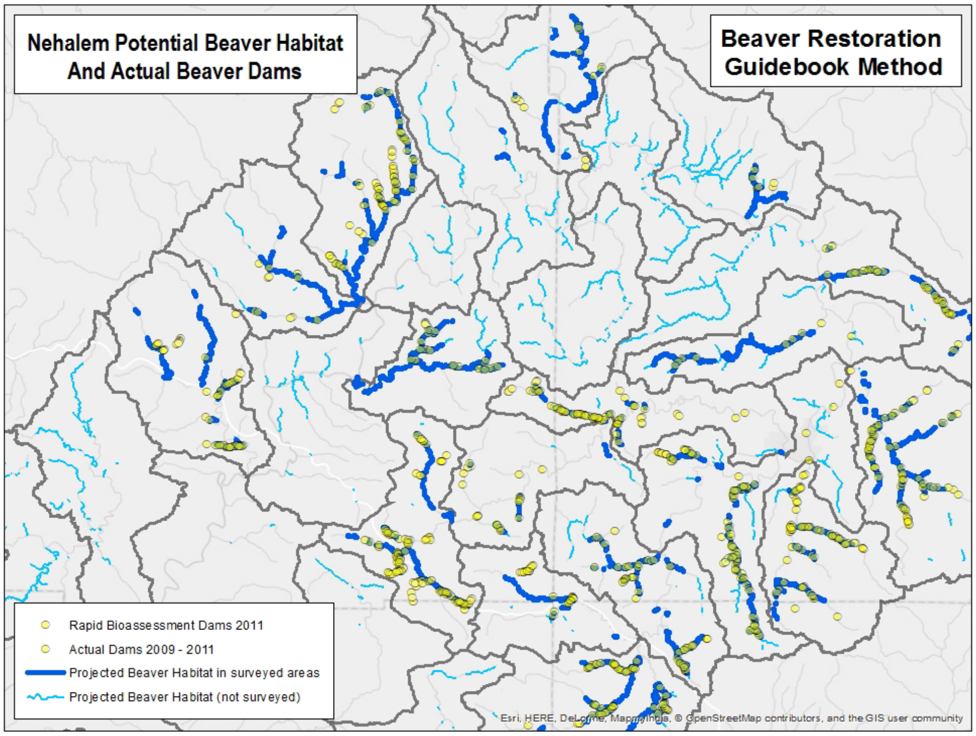
- Small to medium sized streams. We defined this in Netmap at stream order <= 5 (net map uses a scale of 1 to 6) to rule out mainstems.
- Low gradient streams – We defined this as <= 2%.
- Valley’s that are less constrained (Valley Constraint >=2) – in N etmap least constrained are higher numbers

These parameters were selected as those mentioned as preferential, though the guidebook takes care to explain that beaver will use many less preferential sites. In addition, parameters had to be easily adaptable for netmap data and RBA sites. For this reason we did not model beaver preferences for bodies of water such as lakes, wetlands and estuaries, for comparison to actual sites. Though it would be important to consider all standing bodies of water as potential beaver habitat.

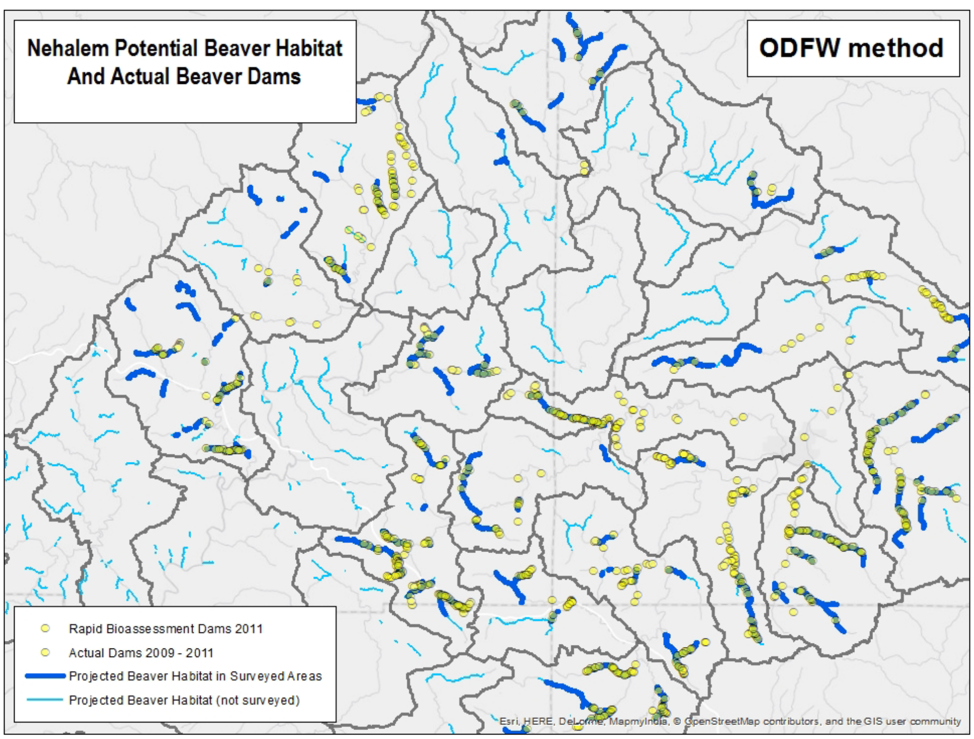
Finally, we compared this against ODFW’s methodology (referred to as modified ODFW method) which looks at the following parameters:

- Small perennial streams with active channel width of 4-8 m
- Valley width greater than 2 times the active channel width
- <=5% gradient
- Density of >= 550 trees/ha of small (15-30 cm DBH) deciduous trees or shrubs within 30 m of the stream (willow, cottonwood, alder – were the ones from odfw’s list found in the Nehalem) * not used in final analysis

The figures below show a comparison of the projected streams using our interpretation of the Beaver Guidebook recommendations and ODFW recommendations.



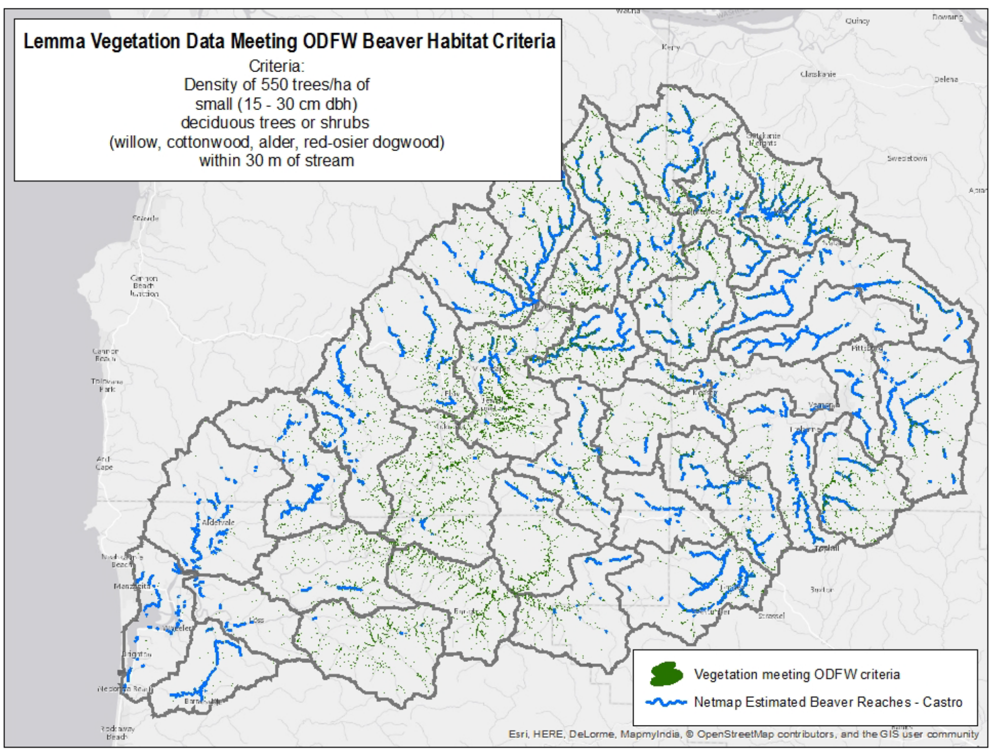
Nehalem Potential Beaver Habitat
And Actual Beaver Dams
Beaver Restoration
Guidebook Method
Rapid Bioassessment Dams 2011
Actual Dams 2009 - 2011
Projected Beaver Habitat in surveyed areas
Projected Beaver Habitat (not surveyed)
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



Nehalem Potential Beaver Habitat
And Actual Beaver Dams
ODFW method
Rapid Bioassessment Dams 2011
Actual Dams 2009 - 2011
Projected Beaver Habitat in Surveyed Areas
Projected Beaver Habitat (not surveyed)
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Because of projection issues with points not always being perfectly snapped to streams, there is not an easy way to quantify percentage of streams that have actual dams on them. Therefore, we present the results qualitatively as a map, rather than attempting to quantify. It appears the modified Beaver Restoration Guidebook method, captures a larger percentage of the actual dams in the projected habitat, while also possibly slightly over-predicting projected habitat locations. Whereas the modified ODFW method does not predict as many of the locations that actually have beaver habitat.

For both methods we attempted to include vegetation (food source) data, generally described as availability of *salix, populous,* and alder species, in certain size classes and densities. The results from this analysis in Netmap did not correlate well with the known beaver dam sites documented in the RBA data. Because the only vegetation data that we have for the whole Nehalem is 30-m resolution LEMMA GRID data, we suspect that this may not be high enough resolution data to capture species of some of the smaller streamside vegetation. While realizing that food source availability may be a critical indicator of beaver suitability, the data we had available to us doesn't seem to show this. It is unclear whether our data shows that geomorphology is a better predictor than vegetation of beaver habitat, or whether vegetation would be an equally good predictor, but we don't have the data resolution needed to assess. Perhaps, LIDAR highest hit data could be examined to further assess this element.



Finally, the Nehalem SAP team is interested in looking at whether we might be able to use LIDAR to find areas with a uniform terrace height (right and left as well as upstream and downstream) along streams as a way to find historic beaver habitat and to look at the parameters that characterized historic habitat. We attempted to do this through slope and nearest neighbor analysis of LIDAR data, but were not able to select these types of areas based on this analysis. More work in this area is recommended to determine if there is a method available with LIDAR and Netmap data.

In conclusion, the modified Beaver Restoration Guidebook method analysis is recommended for use to predict locations of potential beaver habitat. If possible, it would also be valuable to ground truth this data with additional sites in the lower Nehalem.

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Appendix 9

Rock Creek Limiting Factors Analysis

Limiting Factors Analysis and Restoration Plan

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Lower, Middle and Upper 6th Fields

Rock Cr Basin

Tributary to the Nehalem River

May 2011

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Upper Nehalem Watershed Council

Cover Photo: Inman – Paulson Mill Pond Site

Executive Summary

Purpose

This document identifies the dominant processes and habitat characteristics that currently limit the production of Coho salmon smolts in Rock Creek, a primary headwater tributary of the Nehalem River, Oregon.

The plan concept is a limiting factor analysis that identifies habitat conditions restricting the success of one or more Coho life history stages. The plan is based on these guidelines:

- Protect remnant (core) populations against extinction.
- Protect the refuge areas which support core populations.
- Protect life history and genetic diversity.
- Emphasize protection of intact habitats over restoration of degraded habitats.
- Emphasize restoration of ecosystem functionality over site-specific habitat enhancement.
- Emphasize restoration of low-elevation floodplains and wetlands where resources and land ownership allow.
- Ensure that the habitat needs of all life history phases are supported.
- Ensure connectivity (accessibility) among the habitats needed by all life history stages.
- Ensure that habitat enhancement actions support the natural recovery of the system.

The scale of effort is confined to a single target species (Coho) within a restricted geographic zone, in this case three conjoined HUC 6th field basins. The primary attributes evaluated are fish distribution, the abundance and distribution of aquatic habitats, spatial differences in thermal water quality, and historical upslope management activities.

The assessment process relies on responses to structured sets of questions that progressively reveal the status and needs of stream channels in relation to Coho habitat use. The end product of the analysis is a list of specific needs and actions (prescriptions) prioritized according to effectiveness, urgency, cost, and practicality.

The prescriptions include a mix of strategies involving the recovery of riparian canopies, culvert removal or improvement, securing headwater wood and substrate recruitment corridors, instream wood placement, road assessment/removal, easement acquisition and cooperative planning strategies.

System overview

The Rock Creek sub-basin size is 39,947 acres and contains 51.7 miles of stream corridor in the mainstem and 21 tributaries corridor that are utilized by Coho salmon. Current stream habitat function is greatly reduced below that of historical levels due to interactions between natural forces and man-produced changes. These changes have created a trajectory of channel simplification that will continue into the future.

Management practices and flood events

- Timber harvest began as early as 1917 when the Oregon American Company purchased the DuBois Tract.
- Over the succeeding years, there has been extensive conversion of native forests into a managed rotational crop.
- Aggressive fire suppression has also occurred, as is typical of managed forests. This has eliminated the production of fire-toppled trees along with their contribution of large wood to the stream corridor.
- Each winter since the wildfires of 1933 – 1945, flood events have pushed wood downstream and out of the system, reducing aquatic and riparian supplies of legacy fire-contributed wood. The effects of recent such events (1964 and 2007) are easily observable.
- In 1960's and 1970's state, federal agencies in charge of managing fishery resources determined that massive wood jams recruited to the Oregon Coast Range stream channels were having a deleterious effect on anadromous fish populations by denying adults access to the historical range used for spawning and rearing. The agencies began removing large wood from streams. These efforts have contributed to the problems of wood loss created by timber harvest, crop rotation, and fire suppression.
- The sum effect of all these practices has been to remove riparian and upslope large wood resources from the landscape. The present condition is that almost all significant wood complexity has been removed from the mainstem, and is not being replaced because riparian and upslope large wood resources no longer exist.

Beaver colonies

Historically, the upper mainstem of Rock Cr and its low gradient tributaries were extensively populated by beaver colonies, as evidenced by the legacy of deposition plains exhibiting a complex side channel matrix. This indicates that both the valley form and channel morphology exist to support stable and persistent beaver colonies.

At present, although robust beaver colonies exist at a few sites, overall utilization of legacy habitats is very low. Thus development of rearing ponds, wood storage, and gravel depositions created by beaver colonies are at equally low levels.

Status of Coho

Adult spawning escapement was estimated by ODFW's SRS method at 21,753 coho for the entire Nehalem Basin during the winter of 2009. This represented a basin-wide increase of 26% in adult escapement from the previous winter. Adult escapement estimates for the Nehalem Basin have exhibited a continuous and increasing trend in abundance since the 2005 parent brood. The adult coho estimate for the 2009 winter brood (21,753) is the largest for the Nehalem since the winter of 2003, which was from a related cohort. A similar trend was observed in adult coho escapement for the Oregon Coastal ESU (which exhibited an increase of 36% between 2008 and 2009). The estimated coast-wide escapement of 295,208 adult coho in 2009 was the highest estimate since 1979.

Contrary to these observed increases in adult coho escapement, juvenile Coho abundance exhibited a decline of 43% during the summer of 2010 when compared to surveys conducted in the summer of 2009. This important observation is based on a normalized comparison of identical streams surveyed in both years. Declining juvenile coho parr abundance was observed in almost every stream. It appears that significant differences existed between these years in the seasonal survival rates that likely influenced spawner success, egg to fry or fry to parr survival rates. The actual environmental factors driving this decline in juvenile abundance within a year of increased spawner escapement are unknown. There is no doubt that differences in winter and spring flow regimes are important variables to consider.

Concepts and approach

The concepts of Core Area and Anchor Site are used to specify project goals and focus effort. Definitions of these terms direct the investigation in identifying the specific sites and conditions of the aquatic system that support the remnant population by determining how these sites function together to allow completion of the Coho freshwater life history.

Core Area: A contiguous section of stream channel or channel system where juveniles rear on a consistent (year to year) basis.

Anchor Site: A portion of the Core Area which provides all essential habitat features necessary to support the complete Coho freshwater life history. An Anchor Site is a stream reach that supports all of the seasonal habitat needs of Coho salmon from egg to smolt outmigration: optimal gradient, potential for floodplain interaction, and accumulation of spawning gravels. It provides the greatest opportunity for boosting or restoring channel function.

The prioritization process thus relies on identifying the Core Area where the remnant population is sustained, and then identifying the enclosed habitats that function as Anchor Sites. The overarching goal is to conserve and expand the population within the Core Area, and to do this in ways that contribute to normalized landscape and stream function.

Data sources used:

- Reports of summer physical habitat surveys, usually conducted by the ODFW AQI research team.
- Rapid Bio Assay snorkel surveys of juvenile Coho conducted by Bio-Surveys, LLC. These surveys also collect pool dimension data.
- Field studies conducted by Bio-Surveys during the course of the current investigation. This work provided habitat data for stream sections not included in the surveys listed above.
- Topographic maps, which were used to identify and characterize valley morphologies that generate stream habitats suitable for Coho rearing.
- Temperature data collected by the Upper Nehalem Watershed Council

In addition to distributional analyses, we employed the concept of "seasonal habitat bottleneck" developed by Tom Nickleson of ODFW. The model uses habitat areas and Coho seasonal survival rates to determine which seasonal habitat mostly likely creates the greatest restriction to smolt production. We used two sets of survival rates, one provided by ODFW and the other by Jim Hall of Oregon State University (Alsea Watershed Study). The different model outputs each provide useful insights into Coho production dynamics.

Results

Core Area

Field and topographic work identified the Core Area as extending from Rock Creeks confluence with the mainstem Nehalem to the end point of their distribution in the mainstem at RM 28.1. In addition, the core includes 23.6 miles of tributary habitat This describes the full extent of the summer distribution of juvenile coho (Appendix *7)*.

Anchor Sites

Twenty four Anchor Sites were identified within the Core Area, nine of which are in the mainstem. The remaining 15 Anchor Sites are located in NF Rock Creek, SF Rock Creek, Military Creek, Weed Creek, Selder Creek and Tributary D of the mainstem. Appendix 10 shows the locations of the Anchor Sites.

Basin-wide limiting factors

The Nickelson Model identified spawning/incubation gravel as the seasonal habitat resource that currently most limits smolt production. This conclusion was reached with both sets of survival rates, and is considered robust.

Previous habitat inventories and current field work identify two primary causes for gravel insufficiency: The aquatic corridor as a whole is extremely deficient in large woody debris (LWD); and beaver dam habitat is at very low levels. LWD and beaver dams are the primary mechanisms for trapping, storing, sorting and pulsing spawning gravel resources through a stream network. The foundation of this lack of instream wood is the long legacy of extensive upslope harvest that included the riparian corridors of many important salmonid producing tributaries before the changes in Oregon Forest Practices provided protection for riparian buffers. In addition, the shift to a shorter rotation forest management model will result in less large wood available for recruitment through natural processes (debris torrent and mass wasting).

The mainstem has vast amounts of under-used (inadequately seeded) summer and winter rearing habitats. This condition can only be addressed by creating conditions at appropriate sites in tributaries that will increase storage and sorting of gravels suitable for Coho spawning.

Smolt production is also heavily restricted by high summer temperatures in the mainstem, which compromises the summer rearing potential of mainstem habitats below (RM 12). These conditions have been created by cumulative basin-scale impacts to functional riparian canopies.

Gravel and mainstem thermal limitations are the dominant issues affecting smolt production in the sub basin.

Addressing the constraints

Within this large-scale perspective, the report works step by step through conditions and constraints that control channel functionality at each Anchor Site, and establishes what actions to take that will relieve these restraints in ways that contribute to the expansion of the Core Area and to improvements in whole-system health and functionality. The prescription actions are collated into a table of prioritized prescriptions presented in Appendix 11. Locations of the proposed actions are shown in Appendix 10. Please note that the Appendix 11 table can be copied to MS Excel, where sort and filter operations can be used to create organized short-lists of prescriptions. As more specific information is needed about a prescription, refer to the text that describes the Anchor Site, its problems, and how they may be addressed.

Appropriate use of document

Complexity and localization of issues

This report examines the physical and biological interactions that form a large and highly complex stream system. The approach taken assumes that a high level of inter-dependence exists among habitats that extend from the low gradient mainstem to the high gradient headwater reaches. Emphasis is placed on how current and historical conditions have broadly reduced Coho habitat throughout the system.

It should also be understood that limitations defined for the whole sub-basin are not always those operating at the individual tributary or reach level. Both scales of concern have been considered in defining the prescriptions and their order of implementation. It is the conditions working at local levels that occupied most of the field and analytic work, and which the report documents. The reader should refer to the body of the report to access information about specific sites and prescriptions.

Order of restoration actions

A limiting factor analysis establishes an ordered progression of actions, not a single-effort solution. Once significant progress has been made toward resolving the seasonal limitations addressed by Priority 1 prescriptions, attention to Priority 2 prescriptions should then logically begin. However, it is understood that an orderly process like this suggests may not occur.

For one thing, the realities of owner cooperation, funds acquisition, and physical restraints may prevent an entirely orderly process. It is also true that the effects of implementing the Priority 1 actions may create responses from the system that lead to a re-prioritizing or modification of the remaining prescriptions. Priority levels should be thought of as providing a strong set of guidelines, and not as a rigid set of rules.

Contents

Introduction

This document contains an evaluation of the physical and biological attributes of the Rock Cr subbasin which when combined describe the relationships that drive system function in the basin. The goal of this document is to identify the dominant processes and habitat characteristics that currently limit the production of coho salmon smolts in the subbasins, and to develop a prioritized list of actions ("prescriptions") for removing the limitations in ways that normalize landscape and stream channel function.

The restoration and assessment protocols used in developing the plan are described in "Midcoast Limiting Factors Analysis, A Method for Assessing 6th field subbasins for Restoration", available at www.midcoastwatershedscouncil.org/GIS. It is highly recommended that a review of this document accompany the utilization of the Limiting Factor Analysis (LFA) for the provision of background discussions of the fundamental processes and relationships that are significant for supporting the development of the conclusions constructed within this analysis. Many of these relationships are similar for the myriad of habitat subdivisions that are parsed out within this analysis. Please refer to this document for detailed information on assessment, nomenclature, prioritization rationale and methodology.

The Rock Cr sub basin functions in response to a long legacy of historical impacts that have shaped its current condition and consequently its future trajectory. A historical perspective is required to piece together the time line of formative events that have been critical in the development of its current condition.

The magnitude of the flooding that occurred in 2007 is represented in the active channel and adjacent floodplains of Rock Cr and its tributaries in a multitude of ways that has been both positive and negative for the restoration of system function. Almost all significant wood complexity was removed from the mainstem and not replaced. There are only two significant exceptions. The first is located at RM 10 where a large quantity of wood is currently stored in a full spanning jam that has accumulated transient material for several hundred lineal feet. This jam lies within the confines of what has been classified both in the text and the final prescription map as Mainstem Anchor Site #4. The second is at RM 24.2 (1.2 miles downstream of the confluence of Military Cr) where a large full spanning jam anchored by a collapsed log stringer bridge (Photo 32) still knits together the exceptional function observed in mainstem Anchor Site #8.

This lack of mainstem wood complexity is indicative of the long term trajectory in Rock Cr that has resulted in extreme channel simplification. It's important to note that this process of simplification was already well along in a continuum of events that began with the logging practices of the Oregon American Company that purchased the DuBois Tract in 1917 which included large portions of mainstem Rock Cr, NF Rock Cr , Weed Cr and Ginger Cr. According to R2 Resource Consultants and Benda Associates (2005), almost all of the OAC timber resources in the Rock Cr basin were exhausted by 1957.

Within the 40 year span that OAC was operating in the basin, the wildfires of 1933 - 1945 consumed additional large acreages of riparian old growth forest in Rock Cr and some of its primary tributaries such as Selder Cr. where this burned riparian timber was not salvage logged (Selder Cr), you can still view the incredible difference in channel morphology that has been maintained by the slow contribution of this burned timber to the active channel (Photo 20).

According to a Forest Fire Simulation Model developed for the central Oregon Coast Range (Benda and Dunne, 1997a, b), approximately 50% of the total wood recruitment over thousands of years would have been delivered from the post fire toppling of fire killed trees from the riparian. This very critical vector for wood delivery to the active stream channel has almost entirely been exhausted by a significant chain of events (referenced below) that form the story line for the Rock Cr basin. Because of the extensive conversion of native forests to a managed rotational crop and the aggressive fire suppression that is a given in managed forests, this aquatic wood source (fire toppled trees) will never exist again on coast range stream corridors.

Each massive winter flood event since the wildfires of 1933 – 1945 has continued to reduce the aquatic and riparian supply of this fire legacy downed wood. The 1964 flood event caused flooding and massive slope failures whose legacy can still be observed on steep hillslopes by the torrent tracks recolonized by mature alder. This event recruited to the stream channel, massive quantities of old growth coniferous wood from upslope locations that had burned or been left as a byproduct of the rail logging that occurred in Rock Cr. This harvest byproduct was either an unmarketable species or diameter and they persisted on the forest floor until they were recruited to the stream through slope failure or debris flow. This material was a major bonus for the Rock Cr aquatic corridor. The presence of this woody debris in the stream channel that was recruited from a single storm event 47 years ago could have held Rock Cr together without fail for 5 decades to the present. However, in the late 1960's and well into the 1970's state and federal agencies in charge of managing fishery resources determined that the massive wood jams recruited to the Oregon Coast Range stream channels were having a deleterious effect on anadromous fish populations by denying them access to their historical range for spawning and rearing.

The practice was initiated of removing log jams in coastal streams to enhance access for salmonids that lasted nearly a decade and succeeded in initiating a process that resulted in the unraveling of the system functions required for Coast Range streams to produce large volumes of salmonid smolts of all species. The flood of December 7, 2007 that inundated the town of Vernonia succeeded in pulsing even more of this legacy wood out of the system to accelerate the decline in channel complexity and thus the retention of mobile substrates (gravels). These are the issues in play that have accelerated Rock Cr on its path toward simplification. The places that continue to maintain this old growth wood complexity in the channel are becoming increasingly rare (SF Rock, NF Rock and Selder Cr). The imbalance between the wood resources being recruited to the active channel and those that have been lost has reached an all-time high and Rock Cr may be nearing its simplest form, the result of a trajectory created by a chain of events that began over 100 years ago.

In summary, most potential riparian and upslope large wood resources have been completely removed from the landscape in the Rock Cr basin and limited future potential for replacement exists because of a reduction in the age of industrial forest harvest rotations. This leaves a few remnant accumulations of legacy wood in a very few tributaries that have not been scoured by debris flow and nearly zero wood resources of consequence in the mainstem of Rock Cr. This history leads us to the current condition revealed in numerical terms by the habitat based Nickelson Model that is utilized to determine the seasonal habitat shortage that is limiting the production potential of the habitat as it exists for coho.

Using this report

All of the data summaries, charts, maps, and photographs are presented as appendices. Please refer to the following appendices as they are referenced in the text of the report:

- Appendix 1. Significant drainages of the Rock Creek (Nehalem) 6th field
- Appendix 2. Features and habitat survey status of streams within the Rock Creek (Nehalem) 6th field which contribute significantly to coho rearing potential
- Appendix 3. Habitat data used to calculate juvenile coho carrying capacity and smolt potential in upland stream channels of the Rock Creek (Nehalem) 6th field
- Appendix 4. Habitat data used to calculate juvenile coho carrying capacity and smolt potential in lowland lakes, ponds, and wetlands of the Rock Creek (Nehalem) 6th field
- Appendix 5. Coho salmon spawning gravel in the Rock Creek (Nehalem) 6th field
- Appendix 6. Rock Cr (Nehalem) 6th field, limiting habitat analysis based on the Nickelson model
- Appendix 7. Rock Cr (Nehalem) 6th field, summer coho distribution chart
- Appendix 8. Rock Cr (Nehalem) 6th field, summer cutthroat distribution chart
- Appendix 9. Rock Cr (Nehalem) 6th field, summer steelhead distribution chart
- Appendix 10. Rock Cr (Nehalem) 6th field, prescription chart
- Appendix 11. Rock Cr (Nehalem) 6th field, prioritized list of prescriptions
- Appendix 12. Photos

The following acronyms are used:

- AQI – Aquatic Habitat Inventory (Oregon Department of Fish and Wildlife)
- AWS – Alsea Watershed Studies (survival rates)
- DBH – Diameter Breast Height
- ESU – Evolutionarily Significant Unit
- HUC – Hydrologic Unit Code
- LFA – Limiting Factor Analysis
- LWD – Large Woody Debris

- nd – no data
- OAC – Oregon American Company
- OCN – Oregon Coast Natural
- ODEQ – Oregon Department of Environmental Quality
- ODF – Oregon Department of Forestry
- ODFW – Oregon Department of Fish and Wildlife
- OFP – Oregon Forest Practices
- RBA – Rapid Bio-Assessment Inventory
- RM – River Mile
- RMA – Riparian Management Area
- SRS – Stratified Random Sample
- UNHASR – Upper Nehalem Habitat Assessment Stream Report
- UNWC – Upper Nehalem Watershed Council
- USFS – United States Forest Service

Watershed overview

This analysis combines three separate 6th field HUC subdivisions (Lower, Middle and Upper Rock Cr) into a single natural geographic subdivision. The analysis area includes all of mainstem Rock Cr and its tributaries above its confluence with the mainstem Nehalem at RM 91 in the town of Vernonia. In this case, the larger geographical area represented by the three 6th fields represents the type of watershed subunit that the LFA methodology is designed to effectively interpret. These three 6th fields exhibit a complex interactive relationship that corporately supports what is probably a single deme of OCN coho.

The Rock Creek sub-basin drains an area of 39,947 acres (Langmaid, 2005). The sub basin contains 51.7 miles of stream corridor that was utilized by coho salmon during the 2009 RBA snorkel inventory conducted by Bio-Surveys. It also contains fall chinook, winter steelhead, cutthroat trout and pacific lamprey. This analysis is designed to be coho centric and the assumption is made that most restoration prescriptions outlined in this review would also have positive and not negative effects on these other species of salmonids.

The geology according to Langmaid (2005) is evenly mixed between tuffaceous volcanic (39%), marine sedimentary (33%), and sandy shale (25%). Soils are extremely varied with no more than 13% of the area in any one type. There are stony complexes and silt loams, but no overabundance of any single type. Over 25,000 acres (62%) are managed forestland owned by a variety of corporations and 30% of the basin is owned by the state of Oregon and managed by the Oregon Department of Forestry. Rural residential properties and small woodlots account for the remaining 2,900 acres.

Within the combined study area there are 21 mainstem Rock Cr tributaries that provide habitat for coho salmon. These tributaries vary significantly in their capacity to provide spawning and rearing habitats for coho salmon and therefore should be viewed as dissimilar and unique components of the whole Rock Cr sub basin. This issue becomes important in the following discussions of system function and how to prioritize actions designed to address the identified limitations.

There are many additional 1st , 2nd, 3rd and even 4th order tributaries that provide potential sources of cold water to the mainstem of Rock Cr, but do not provide significant habitat for salmonids, due to their limited habitat capacity, high gradient and/or natural migration barriers. The majority of the tributary stream miles are managed for timber production. Management styles vary considerably throughout the various ownerships, with robust, true buffers present on some state and privately owned stream reaches. Some of these tributaries also contain significant sub-populations of resident cutthroat trout and are important source locations for maintaining genetic variability (isolated from anadromous or fluvial cutthroat stocks, Ginger Cr and Martin Cr).

Coho distribution in the mainstem of Rock Cr extends for 28.1 miles and exhibits low to moderate gradients throughout (the first 10 miles averages 0.2% and the last 1.9 miles above the confluence of the SF Rock averages 2%). There is a significant change in land use near RM 12.3 (just above the confluence of Selder Cr) from rural residential agricultural operations to exclusive commercial forest use. The mainstem of Rock Cr is 303(d) listed as temperature impaired by the DEQ from the mouth to RM 11. Mainstem temperature gradients reviewed by Langmaid (2005) in the State of the Nehalem Final Report document suggest that this limitation is the result of cumulative headwater impacts and not solely the effect of the solar exposure impacting the mainstem reaches associated with rural residential agriculture. The results of the LFA analysis agree with this conclusion and a prioritized strategy for addressing dysfunctional riparian corridors in headwater reaches are included.

A very pronounced legacy of historical beaver colonization in the upper mainstem of Rock Cr and its other low gradient tributaries suggests that the morphological and vegetative conditions existed for stable and persistent beaver colonies to prosper. Current utilization of these legacy habitats is limited. There are however several strongholds where beaver colonization is currently robust, these are Selder Cr, Trib D of mainstem Rock and Bear Cr, a tributary of SF Rock. These three locations contained 70% of all beaver dams (98) documented in the Rock Cr basin in 2009 by the RBA snorkel inventory. All three of these streams also exhibited the highest levels of large wood loading.

Current status of coho

Basin wide

The status of Oregon Coast Natural (OCN) coho in the Nehalem basin has been well documented for adult
spawners by ODFW's Stratified Random Sampling Program, and for the summer standing crop of juveniles
by the Upper Nehalem Watershed Councils Rapid Bio-Assessment Inventory (RBA). The adult data provide a sense of basin-wide trends in abundance, while the juvenile data indicate trends within specific 5th and 6th fields.

The juvenile abundances recorded during the summer of 2010 were the result of an adult escapement estimated by ODFW's SRS method to be 21,753 adult Coho for the entire Nehalem Basin during the winter of 2009. This represented a basin-wide increase of 26% in adult escapement from the previous winter. Adult escapement estimates for the Nehalem Basin have exhibited a continuous and increasing trend in abundance since the 2005 parent brood. The adult coho estimate documented for the 2009 winter brood (21,753) is the largest for the Nehalem since the winter of 2003, which was from a related cohort. A similar trend was observed in adult coho escapement for the combined Oregon Coastal ESU (which exhibited an increase of 36% between 2008 and 2009). The estimated coast-wide escapement of 295,208 adult coho was the highest estimate since 1979.

It is unusual to note, therefore, that contrary to these observed increases in adult coho escapement that juvenile Coho abundance within the scope of the Upper Nehalem RBA Inventory actually exhibited a decline of 43% during the summer of 2010 when compared to surveys conducted in the summer of 2009. This important observation is based on a normalized comparison of identical streams surveyed in both years. Declining juvenile coho parr abundance was observed in almost every stream. It appears that significant differences existed between these years in the seasonal survival rates that likely influenced spawner success, egg to fry or fry to parr survival rates. The actual environmental factors driving this decline in juvenile abundance within a year of increased spawner escapement are unknown. There is no doubt that differences in winter and spring flow regimes are important variables to consider.

Exceptional average rearing densities for summer rearing coho parr were one of the most notable observations from the 2009 Upper Nehalem RBA data set. Average pool rearing densities between 3.5-6.5 Coho/sq m were observed (from highest to lowest) in Trib A/East Fork Nehalem, Green Timber/Clear, West Fork Pebble, South Fork Rock, and South Prong/Clear. These levels currently stand as the highest average densities observed within the Oregon Coastal ESU during 13 consecutive years of summer snorkel inventories that included more than 8,000 miles of broadly distributed (geographically) coho rearing habitat. This includes RBA inventories conducted in the Nestucca basin

(194 miles) during the summer of 2003 that followed the second largest coast wide escapement of Coho (287,607) since 1979. During the 2003 Nestucca inventories, only 2 tributaries exceeded an average pool density greater than 1.5 Coho/sq m (Elk Cr at 2.8 Coho/sq m and Baxter Cr at 2.0 Coho/sq m). Unusually high densities (up to an average of 7.0 Coho/sq m) were also observed in Oglesby Cr in the Yaquina Basin during the summer of 2009. This historical data is presented here to suggest that conditions can exist in the Nehalem basin that appear exceptional within the ESU for the production of OCN coho.

Average summer rearing densities observed for coho parr were considerably lower during the 2010 Upper Nehalem RBA as a result of the 43% decline in juvenile abundance (3.2 Coho/sq m in Green Timber/Clear was the highest). The observed average rearing density for a stream segment is utilized as a metric for evaluating inter-annual variation and identifying trends. The average has been calculated by dividing the sum of the raw pool averages by the total number of sample pools. This is not a weighted average that would divide the total metric surface area of the sampled pools by the total number of fish observed. The average rearing density for a surveyed reach (fish/sq m of pool surface area) is an excellent measure of trend that can be monitored from year to year. However, it tends to portray only a general description of the current status within a reach.

Understanding how each reach is functioning is more accurately interpreted in a review of how the rearing density changes within the reach. This type of analysis allows us to get a sense of what the true rearing potential is for a subset of the highest quality individual pool habitats (anchor sites). This analysis utilizes the distribution pattern within stream segments (tributaries) to assist in identifying the key anchor habitats that exhibit exceptional function. Identifying these key zones of high production potential aids in understanding the unique biological and morphological characteristics that create and maintain exceptional ecosystem function. Anchor habitats may be capable of rearing salmonid juveniles at disproportionately higher rates than historically observed. In many cases, these unique habitats require special conservation measures to be applied to their management in order to maintain and enhance their potential for salmonid production.

The Combined 6th fields of Rock Cr

Bio-Surveys LLC conducted a summer juvenile abundance survey for the entire Rock Cr subbasin in both 2009 and 2010. This included all of the habitat occupied by juvenile coho within all 3 of the Rock Cr 6^{th} fields (Lower, Middle and Upper). The survey was designed to quantify the summer abundance of coho parr from the 2008 and 2009 spawning class of OCN adult coho (not available separately for Rock Cr in the basin scale review above). The RBA inventory of Rock Cr refines the basin scale review by summarizing juvenile coho parr abundance in just one of the upper Nehalem's most productive tributaries.

In 2009 there were an estimated 235,278 coho parr rearing in the Rock Cr sub basin. In 2010 the number decreased to 160,752 coho parr. This represents a 32% decline in abundance (compared to the 43% decline noted for the broader basin wide inventory discussed above). The 6th field level assessment of a declining trend in abundance although not as severe as the broader basin scale review, still concludes that increases in adult escapement did not result in comparable increases in juvenile abundance.

Core Area

The core describes the full extent of the summer distribution of juvenile coho. The core area for the 6th fields discussed in this report extends from Rock Creeks confluence with the mainstem Nehalem to the end point of their distribution in the mainstem at RM 28.1. In addition, the core includes 23.6 miles of tributary habitat (appendix 1). Each of the listed tributaries remain a part of the Core Area to the end of anadromous potential. Within the extent of this Core area however, the mainstem of Rock Cr from its confluence with the Nehalem upstream to RM 12 can currently be classified as summer limited for juvenile salmonids because of elevated summer temperatures that initiate upstream temperature dependent migrations. The Rapid Bio-Assessment surveys conducted in 2009 and 2010 observed very low summer rearing densities in the lower Core area.

The dysfunction observed in the lower Core area is the result of the cumulative impacts to water quality that begin high in the basin as a result of low gradient stream channels and un-buffered non fish-bearing (Type N) streams. These impacts are magnified in the lower mainstem by inadequate riparian buffers for protecting the broad lower mainstem from solar exposure.

Limiting seasonal habitat analysis

Data sources

The limiting habitat model uses the amount of spawning gravel and the amounts of spring, summer, and winter rearing habitats to estimate potential smolt production. Stream valleys as well as upper basin and estuarine lowland habitats are included in the estimation process. Data were obtained from the following sources:

- Summer habitat surveys, usually conducted by the ODFW AQI research team.
- RBA juvenile coho surveys, which collect pool dimension data. These surveys were conducted by Bio-Surveys, LLC.
- LFA field studies conducted by Bio-Surveys during the course of the current investigation. This work provided habitat data for stream sections not included in the surveys listed above.
- Topographic maps, which were used to identify and characterize valley morphologies that generate stream habitats suitable for coho rearing.

Model limitations

The Nickelson model (Nickelson, 1998) was employed to determine whether spawning gravel or one of the seasonal rearing habitats constitutes the resource that most limits coho smolt production. Information for this analysis came from two principle sources: 1) The Field Assessment phase of the project, which provided estimates of the quantity and quality of spawning gravel; and 2) ODFW habitat inventories, which provided most but not all of the necessary habitat data.

Habitat conditions and distribution are then compared to an overlay of summer juvenile salmonid distribution. These two data layers provide a real world display of interaction between populations and physical habitat variables. These distribution and abundance layers (fish and habitat) are then compared to the Nickelson modeling exercise that looks at hypothetical subbasin relationships utilizing only total seasonal habitat surface areas and their associated seasonal survival rates (the data available for the basin does not allow us to actually estimate the abundance of spring habitat and winter habitats are estimated utilizing a regression equation developed from existing summer habitat inventories to identify a habitat bottleneck (limiting factor).

It is important to clarify that the modeling exercise is not capable of evaluating all existing density dependent factors and their impacts on seasonal survival rates. Habitat quality, levels of sedimentation, temperature thresholds, intra and inter-specific competition and similar potentially important factors are not included in the Nickelson model. Because of this important weakness, we also apply seasonal survival rates summarized from the Alsea Watershed Study that better reflect the impacts of these other factors.

At this point we incorporate professional judgment into the process of identifying limiting factor issues. We utilize all of the information consolidated in the following assessment to specify both the short-term and long-term issues of concern in the subbasin that when addressed are expected to restore functional processes and boost subbasin smolt production

South Fork Rock Creek assessment

Migration barriers

The only passage barrier on mainstem South Fork Rock Creek is a boulder pinch at RM 2.5. Based on RBA juvenile distribution data , adult coho passage ended at this site in both 2009 and 2010 . The barrier is created by a 6 ft vertical drop that is complicated by large woody debris. The barrier could become passable if a wood redistribution event occurs clears an effective jumping lane. (Photo 1)

Trib A has an ephemeral log jam at its mouth that forms an adult and juvenile passage barrier. Based on RBA data, this jam terminated adult coho passage in 2009 but not in 2010.

Temperature Issues

The headwater location of the SF Rock assists in the provision of cool summer stream temperatures for optimizing juvenile salmonid production (not too cold not to warm). RBA inventories in 2009 and 2010 did not find mainstem SF Rock temperatures above 64 deg. There are however, solar impacts to the aquatic corridor that in the lower system (below the Sunset Hwy Park) that initiate the cumulative impacts that will become habitat limitations in the lower 12 miles of the mainstem of Rock Cr.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

A total of 4,666 sq ft of spawning gravel was identified during the Bio-Surveys 2010 field inventory of SF Rock Creek. Of this, 100 sq ft (2%) were classified as fair quality and 4,566 sq ft (98%) as good quality. None was classified as poor quality.

Almost all spawning gravels are located within South Fork Rock Creek's three anchor sites. A large portion, 1,885 sq ft (40%), is within Anchor Site 1 (mouth to RM 0.36). Another 902 sq ft (19%) is in Anchor Site 2 (extends approximately 0.5 mile downstream from the Hwy 26 culvert crossing). An additional 1,418 sq ft (30%) is in Anchor Site 3 (from the confluence of Trib A upstream 0.9 RM).

Additional minor gravel accumulations are scattered within several transport reaches.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

The distribution of coho juveniles is based on RBA summer surveys conducted in 2009 and 2010. Both 2009 and 2010 surveys documented strong juvenile coho densities from the mouth to the end of distribution at the RM 2.5 barrier falls. Average density was 3.02 coho/sq m in 2009 and 2.03 coho/sq m in 2010. Densities increased as pool size diminished toward the end of distribution. Individual pool counts were strong throughout the entire survey.

Highest pool counts occurred between the mouth and the confluence of Bear Cr. This zone exhibits a combination of physical attributes (low gradient, wide valley floor and interactive floodplain terraces) that have coalesced to produce extremely high quality rearing conditions. Although pools are not complex, they were formed by legacy wood and are well established, providing high quality summer rearing habitat. Water quality and temperature conditions are also high quality.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The 1993 AQI aquatic habitat inventory found modest amounts of large woody debris in the system that contributed little to habitat complexity. The average complexity score was 2 on a scale of 1-5. The 2009 RBA survey also found that pools, although well established with good depth and water quality, lacked good cover complexity. The average pool complexity rating was 2.1 (scale of 1-5).

During the 2010 LFA field inventory, we observed that large quantities of legacy large wood on the flood plain continue to contribute greatly to the form and function of the summer pool habitat, but are not currently contributing substantially to pool complexity and in-water woody debris. This legacy wood has retained a deep bedload of mobile gravels, which has maintained floodplain connectivity while providing an erodible substrate susceptible to deep pool scour. (Photo 2)

The 1993 AQI survey determined that riffle and glide habitats were the dominant habitats throughout SF Rock Cr. Pool percentage decreased and gradient increased decreased progressively upstream. A well-defined transition occurred at the Sunset Hwy Wayside Park, where pool surfaces gave way to primarily riffle /rapid /glide habitats upstream of the park.

Cobble and gravel made up the majority of the observed substrate.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Habitat structure is currently limited in mainstem SF Rock Cr, and the channel is trending toward simplification as the powerful effects of legacy old growth conifer buried in the active channel diminish over time.

Some (un-quantified) high quality winter habitat in the form of back waters and low terrace floodplain associated with the remaining key wood pieces. located downstream of Hwy 26. There is a visible legacy of very complex floodplain interaction that has created channel braids and back waters, but much of this habitat is no longer connected during winter flow regimes because of the diminishing abundance of large wood in the active channel. Currently the majority of quantifiable wood complexity in stream is composed of alder contributed during the 2008 / 2009 ice and wind event. This material is providing short-term complexity but will not be able to prevent vertical incision and simplification of the channel.

In-stream habitat structures were observed at the upper end of Anchor Site 3 during the 2009 LFA survey. The structures start at the confluence of Bear Cr and continue upstream to the next logging road bridge. The area exhibits a very high level of function because of these structure placements, and offer the best winter habitat observed in the upper reaches of SF Rock.

In other regards, juvenile winter habitat is absent above highway 26, and naturally recruited wood occurs in limited amounts.

A 0.3 mile reach of the active channel above the Hwy 26 crossing has long stretches of exposed bedrock and is not currently retaining woody debris or gravel.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction.

From the confluence with Rock and extending upstream to Sunset Park, there is an exceptional legacy of broad channel meander.(Photo 3) This reach has a low interactive terrace (2-3ft) with a 140-300 ft band width (including both sides of the active channel). A legacy of large conifer stored in the active channel has contributed to this high level of function. Currently this reach is trending toward simplification because of the lack of beaver and diminishing supplies of large wood being recruited to the channel. Immediate recruitment potential is low because large conifers are scarce in this recently logged riparian corridor.

Starting at Sunset Park and continuing up stream to the confluence of Trib A the channel becomes hillslope confined on both sides. The portion of Hwy 26 that exists on the valley floor also contributes to this confinement. SF Rock is then confined by alternating hillslopes for an additional 0.9 mile above the confluence of Trib A (average floodplain width of 60 ft). This section should be seen as a transport reach with higher gradients, abundant exposed bedrock and very limited floodplain interaction. Wood retention is limited.

Instream habitat structures were visible in the upper 0.3 mile of the reach during the 2009 LFA survey. The treated area currently exhibits a high level of floodplain interaction. Upstream of these log structures, channel width decreases quickly as gradient increases.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The potential for improving channel complexity in the segment of SF Rock downstream of Hwy 26 is very high. The legacy of large wood in this reach still supports remnants of complex, channel characteristics, frequent low terraces, legacy back waters, and side channels (habitats that exhibit a history of being linked to the active winter channel). These conditions maintain the potential for re-establishing future linkage. Large wood placement in this zone would be extremely beneficial for restoring and then maintaining exceptionally high winter function.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) A scarcity of long lasting coniferous woody debris both in the active channel and within the riparian corridor. The majority of wood complexity in SF Rock is deciduous and short lived. The potential for future recruitment is limited because the riparian corridor lacks large conifers.

2) Limited beaver activity in the reach below Hwy 26. Very little evidence of beaver activity was observed in SF Rock during the LFA field review (May / June 2010). Beaver activity would create off-channel habitat for rearing salmonid juveniles.
3) The concrete divider at the inlet of the highway 26 culvert is restricting woody debris transport to the downstream reach of SF Rock where it would provide its greatest benefit.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

Addition of full spanning structures would provide a short-term solution to the problems of compromised channel complexity in SF Rock Creek. Possible long-term solutions include:

1) Protection of upslope wood source areas, riparian buffers and buffers on 1st order streams subject to failure. Riparian planting would also be beneficial in the reach downstream of Hwy 26.
2) The re-establishment of a robust beaver population (natural recruitment with a no-take policy, or re-introduction) through long range planning that provide forage species such as willow in the reach downstream of Hwy 26.
3) Removal of a concrete channel divider (not a structural component of the installation - Photo 6).

Anchor Site 1

Location and length

Anchor Site 1 starts at the mouth of SF Rock and continues upstream 0. 4 mile to just before the first bridge crossing.

Channel structure

The creek is moderately sinuous in this area, and spawning gravels are abundant. Gravel retention is aided by low terraces that dissipate hydraulic potential during high winter flow regimes and prevent vertical scour and entrenchment.

Floodplain structure

Terraces in this anchor site are approximately 2 ft high for the first 1,200 ft and extend out 150 ft on both sides of the stream. The upper 600 ft has 36 inch high terraces, with reduced terrace. Floodplain interaction is high throughout the anchor site. The primary vegetation is alder and shrubs with an increasing infestation of Reed Canary Grass.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

This 1,900 ft segment of SF Rock Creek contains all of the attributes necessary to complete the coho life cycle from spawning through winter rearing. The quality and current level of function of these habitats is currently high. However, this function is at risk due to low wood abundance and low recruitment potential (no late successional conifers in the riparian corridor).

RBA inventory data indicate that Anchor Site 1 reared 3,890 summer coho parr in 2009, representing nearly 16% of the SF Rock mainstem total. Average coho densities exceeded 2.5 coho/sq m. Estimates for 2010 were 2,200 summer coho parr and at an average pool density of 2.1 coho/sq m.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

Low levels of large wood and loss of beaver impoundment have led to channel simplification within Anchor Site 1. This reduces rearing capacity during both summer and winter flow regimes. Areas of extensive solar exposure are also present within the anchor site, contributing to temperature problems that have been identified in mainstem Rock creek.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Enhance floodplain interaction by injecting large wood in full spanning structure complexes. The structures will boost the abundance of off channel habitat surface areas, increase channel braiding and contribute to the linkage of the existing legacy of side channels and backwaters.
2) Provide for the re-colonization of beaver within the subbasin by planting forage species that will attract and sustain active breeding colonies of beaver. (willow, vine maple, cottonwood, ash)
3) Riparian Planting to develop the long term riparian conifer potential for recruitment.
4) Elevate the level of riparian protection for the existing conifer within 1 site potential of the active channel.

Anchor Site 2

Location and length

Anchor Site 2 starts 550 ft upstream of the first concrete bridge and extends 2,500 ft upstream to Sunset Park.

Channel structure

The creek is moderately sinuous in this area and spawning gravels are abundant. Gravel retention is aided by alternating low terraces that dissipate hydraulic potential during high winter flow regimes. Gravel retention is also aided by several legacy wood jams.

Floodplain structure

Anchor Site 2 has alternating low terraces that are approximately 24 to 36 inches in height, extending out 100 ft from the channel. Floodplain interaction is limited. The over-story is a mix of deciduous and coniferous species with a complex under-story of native shrubs.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

This 2,500 ft segment of SF Rock Creek contains all of the attributes necessary for the complete coho life cycle. Spawning gravel is plentiful and good quality. Pools are well developed and summer temperatures do not limit the rearing capacity of the habitat. Pools are not highly complex and cover for juvenile rearing is limited. However, the current level of function is poor for the provision of winter habitat because off-channel low velocity refugia from high water events is limited.

Based on the 2009 RBA data, Anchor Site 2 reared an estimated 4,398 summer coho parr. This represents almost 18% of the SF Rock mainstem production. The high quality habitat is seen in high pool densities, exceeding 2.4 coho/sq m.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

Low levels of large wood interacting directly with the active channel and a loss of historical beaver impoundments have led to channel degradation (incision) within this anchor site. These changes have reduced both summer and winter rearing capacities.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Enhance floodplain interaction by injecting large wood as full spanning structure complexes. These structures will stimulate development off-channel habitat, increase braiding, and increase the frequency of inundation for existing side channels and backwaters.
2) Plant riparian forage species that support beaver colonization within this anchor site, as part of the overall goal of establishing a strong population though out the subbasin.

Anchor Site 3

Location and length

Anchor Site 3 begins at the confluence of SF Rock and Tributary A and continues upstream 4,700 ft to the first bridge crossing upstream from Bear Creek. It also includes the lower 1,200 ft of Tributary A.

Channel structure

From the confluence of Tributary A to the confluence of Bear Creek, the stream channel has low sinuosity, and spawning gravels become less abundant than observed downstream..

Above the confluence of Bear, treatment with full spanning log structures has increased sinuosity, gravel retention, and floodplain interaction (Photo 7).

Near Tributary A, sinuosity is high, and is accompanied by low interactive terraces. These conditions are primarily the effects of a legacy debris jam located at the tributary mouth.

Floodplain structure

Terraces are approximately 24-36 inches high for the majority of the anchor site. Floodplain width is approximately 60 ft. The riparian canopy is a mix of deciduous and coniferous species.

In the treated area above Bear Cr, appropriately placed wood structures have interacted well with low terraces to create a high level of floodplain interaction. These improvements could be duplicated below Bear Cr with similar work.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Above Bear Cr, Anchor Site 3 contains all of the habitat conditions needed to complete the coho life cycle, from spawning through winter rearing. Below the confluence of Bear Cr, the anchor site very clearly lacks wood complexity, as well as high quality floodplain interaction during winter flows. The two sections differ strongly because the upper section has been treated with wood structures.

Based on the 2009 RBA survey, this anchor site reared 54% of the 13,045 summer parr supported by mainstem SF Rock . The average summer rearing density for coho was 3.35 fish /sq m, which includes both the high and low functioning segments. These density levels are uncommon in coho bearing streams of the Oregon Coast. High quality individual pools within the treated segment above the confluence of Bear Cr exhibited summer pool densities as high as 5.7 fish /sq m.

The 2010 RBA survey observed 38% (5,340 coho) of the total summer parr in the mainstem rearing within the anchor. The average rearing density was lower than observed in 2009 at 1.8 fish /sq m. However, maximum densities were still very high, greater than 4 fish/sq m.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

Low levels of large wood and the loss of beaver impoundment are the primary limitations on production potential. These conditions will lead to channel degradation, reducing rearing capacity in both summer and winter flow regimes.

Below Bear Cr, both summer and winter rearing potentials are definitively lower than those in the treated section above Bear Cr because of the absence of large wood and/or beaver impoundment.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Enhance floodplain interaction and protect upstream structure investment by injecting large wood in full spanning structure complexes below the confluence of Bear Cr. The structures will boost the abundance of off-channel habitat sites, increase braiding and contribute to the use of existing side channels and

backwaters. In addition, these structures would capture additional spawning gravels to address the primary basin scale limitation.
2) Provide for the re-colonization of beaver within the subbasin by enhancing the development of forage species in the riparian (cottonwood, willow, vine maple, ash).

Anchor site rankings

Function

Rank the identified anchor sites in terms of current function (1= best).

1) Anchor Site 1
2) Anchor Site 2
3) Anchor Site 3

Restoration potential

Rank the identified anchor sites in terms of restoration potential.

1) Anchor Site 1
2) Anchor Site 2
3) Anchor Site 3

Secondary Branch 1 Trib A

Location and length

Trib A enters SF Rock Creek from the south west 1,100 ft upstream of the Highway 26 road crossing. A 1995 AQI survey inventoried the lower 7,735 ft of this tributary. However, a 2010 RBA survey found coho only up to RM 1.0.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

The LFA field review documented 13.8 sq m of spawning gravel near the mouth of Trib A. Very limited spawning gravel resources exist above the broad interactive terrace located in the first ¼ mile of stream corridor.

Beaver activity in Trib A was rated as high in both the 1995 AQI and the 2010 LFA surveys.

Secondary Branch 1 Trib A is an important part of the Rock Creek rearing system when woody debris near the mouth allows upstream adult passage. It has sufficient spawning gravel near the mouth (13. 8 sq m found by the LFA field survey), and some gravel upstream to seed the lower 1.0 mile of the tributary. Access to these habitats has varied. In 2009, an RBA survey found no juveniles above the jam indicating that no adults had passed through it. However, the 2010 RBA survey found large numbers of juveniles rearing up to RM 1.0. The RBA estimate for 2010 was 5,245 summer parr.

The primary source of this high rearing potential is a legacy of beaver impoundments located near the confluence of Trib a of Trib A, augmented by the woody debris. The impoundments have created large amounts of off-channel habitat that provide low velocity winter refugia.

In sum, Trib A provides a rare package of all the right habitat components for completing the entire year long life cycle of coho salmon. Because of these features a significant anchor habitat area has been designated within Trib A (see map).

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

Currently this tributary is functioning very well. A high abundance of woody debris and an active beaver population have created complex and highly functional habitats. The primary limitation for coho production in Tributary A is the inverse distribution of spawning gravel from the mouth: Most of the high quality gravel exists near the mouth. Upstream valley morphology does not encourage the development of channel structures that retain suitable gravels. Large wood and beaver structures are also absent. Efforts to develop the storage of gravels above the mapped anchor habitat would be highly beneficial for expanding the production capacity of the tributary for salmonids.

Addressing the limitations

Protect existing conditions to ensure long-term success. To accomplish this, maintain a broad and intact Riparian Management Area, and plant beaver forage (cottonwood, vine maple, willow and ash).

Install log placements upstream of the anchor site in the confined portion of the active stream channel. This will improve gravel retention in Tributary A, as well as increase pool surface area and summer /winter rearing habitat.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

In the 1993 ODFW AQI report, the riparian vegetation from the mouth to Sunset Springs Rest Area consisted of a conifer/hardwood mix dominated by 86% hardwoods. The canopy closure was 87%. In 2010 Bio-surveys noted that a sparse logging buffer in the lower 1,500ft had resulted in accelerating blow down which left the stream in this reach exposed to solar impacts. While these conditions do not pose a temperature threat to the SF Rock, limiting this type of exposure is favorable for reducing the cumulative impact to lower mainstem reaches with known temperature limitations.

The highest percentage of conifer in the riparian corridor during the 1993 inventory was 67% in AQI reach 2, which extended from RM 0.15 to RM 0.7. The remaining surveyed reaches were a hardwood/conifer mixture ranging from 45% to 63% conifers. During the 2010 LFA survey there was no canopy exposure greater than 70% from the first concrete bridge to the end of coho distribution.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

The recruitment potential in the first 2,000ft of SF Rock is limited. The accelerated recruitment of existing alder caused by blow down adjacent to a recent harvest unit is a short lived benefit to active stream channel. The few existing conifers are young suggesting only long term recruitment potential. The trajectory toward channel simplicity will continue with limited assistance from the riparian in the short term. Above this lower 2,000 ft, recruitment potential is higher because of higher conifer densities but the riparian still exhibits limited short term potential (50 years).

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

Currently the only potential thermal issue is located from the mouth to the first concrete bridge crossing. The exposure on the aquatic corridor in this lower stream segment has been created by an inadequate harvest unit buffer for maintaining the integrity of a functional riparian corridor. Many of the alder remaining in the harvest buffer have blown down and sun scalded (Photo 5). Stream temperatures here remain adequate for juvenile salmonids but when protection of these headwater cool water resources begins to be compromised in multiple locations simultaneously on the watershed scale, it results in temperature impacts to the mainstem of Rock Cr. The end result of these cumulative effects is the declining lineal distribution of summer salmonid parr in the mainstem of Rock Cr.

Bear Creek (South Fork Rock Cr) assessment

Bear Cr. is the largest tributary of SF Rock Cr. It joins the SF 2.3 RM upstream from the mouth.

Migration barriers

There were no migration barriers noted during the LFA field survey in 2010.

Temperature issues

Summer temperatures are cool as a result of broad floodplain storage in the identified anchor site and because of an intact riparian canopy.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

Forty seven sq m of good quality gravel was present during the 2010 LFA inventory. Bear Creek had much higher sediment levels than the rest of SF Rock, but areas of increased gradient were present throughout the lower one mile of stream that assisted in sorting and cleaning the existing gravels.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

In 2009, Bio-Surveys recorded juvenile coho distributed 1.5 miles from the mouth of Bear Cr. ending in a large beaver swamp. The peak rearing density of 3.2 coho/sq m was reached at RM 0.7, shortly after the peak, densities declined rapidly. The average rearing density for Bear Cr was 1.1 coho/sq m Even though the average rearing densities were not high, Bear Cr. was rearing a large number of coho (5,110). The 2010 RBA inventory of Bear Cr observed a slightly shorter distribution at 1.1 miles with an average rearing density of 1.5 coho/sq m and a total coho production estimate of 5,202 summer parr. The many beaver pond habitats here are creating ideal rearing conditions for juvenile coho during both summer and winter.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The average complexity score given by the 1997 ODFW Aquatic Inventory was 1.4. During the same inventory there were six beaver dams counted. This was just one year after the major flood event of 1996. Since 1997 the stream appears to have gained complexity in part from beaver re-colonization. During the 2009 RBA survey conducted by Bio-surveys there where a total of 33 beaver dams counted and the average pool complexity score was 2.7 on a scale of 1-5. This scale is based on the total percentage of pool surface area that is associated with some form of structural complexity that is capable of providing cover (Over hanging vegetation, large substrate, wood, undercut bank, etc.) 2 is 1-25% of pool surface area, 3 is 26-50% of pool surface area associated with cover.

As a result of the extensive beaver activity in the lower 0.7 RM, there is a very large amount of pool surface area (un-quantified since the 1997 AQI which does not include the rearing capacity of the current 33 beaver dams) in relation to the size and flow of the stream. This increase in habitat due to beaver activity allowed for much higher summer rearing juvenile numbers than would have been physically possible with the normal active channel pool dimensions. During the 2009 RBA survey conducted by bio-surveys 85% of the summer rearing coho where located in the first 0.7 RM. In the 2010 survey 91% were rearing in the first 0.7 miles.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The lower 0.7 RM of Bear Creek offers ideal winter cover during high winter flow regimes. A wide floodplain, good wood complexity, low interactive terraces, and extensive beaver impoundment provide the high quality cover and low velocity habitat that defines winter refugia (Photo 8) Much of the stream above RM 0.7 is hill slope confined and offers only minimal winter refugia.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction.

For the first 3,000 ft the flood plain in Bear Creek is 100 to 150 feet wide. Above the first bridge, terraces become low (<1 ft) with a high level of winter and summer interaction enhanced by the presence of beaver. According to the 1997 Habitat Inventory conducted by ODFW, the stream gradient is 1.9% on average in this area. Continuing upstream the floodplain becomes more hill slope confined but gradient does not increase dramatically.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The greatest possible potential for channel complexity is currently being realized in the 1,400ft reach of stream directly above the first road crossing. This is a stream segment that is easily accessed and is a classic reference location for viewing a stream segment that has climaxed into nearly peak performance condition for the production of both coho and cutthroat. The reach of stream from the mouth to the first road crossing does not display this same level of functionality and would benefit from log placement or beaver impoundment..

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Channel complexity below the first road crossing in Bear Creek is limited by higher terraces and a lack of impoundment.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Channel complexity could be increased in the lower portion of Bear Creek by encouraging beaver colonization by planting key forage species (Vine Maple, Willow, Ash, Cottonwood) . In addition, wood complexity could provide the aggradation necessary to engage higher terraces while providing a platform for beaver to anchor winter persistent dams.

Anchor Site 1

Location and length

Anchor Site 1 begins at the first road crossing and extends 1,400ft up stream ending in hill slope confinement on both sides.

Channel structure

The anchor site is currently exhibits exceptional sinuosity that utilizes the full extent of the meander belt within the floodplain. Additional enhancements are unnecessary.

Floodplain structure

Terraces are low (<1 ft) and exhibit indicators of frequent interaction as a result of large wood and beaver impoundment. They have been formed by the deposition of fines and sediments and exhibit an even age class of older alder and understory shrubs.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

This Anchor does not contain a large quantity of spawning gravel (13.5 sq m), but it does exhibit large surface areas (un-quantified) of impounded beaver dam habitat that is providing both high quality summer rearing habitat and extremely high quality winter refugia. The current status of this site would be classified as highly functional.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The shortage of spawning gravel in Bear Cr within and above this anchor site limit it production potential significantly. The modest average rearing densities (1.1 and 1.5

coho/sq m) observed in two consecutive years, suggests that even on years of high spawner escapement (2008), all gravel resources are being used to capacity.

In addition, the lack of conifers in the riparian corridor suggests there is no long term stability in the wood complexity that currently assists the beaver in holding this site together during high winter flow regimes. The lack of beaver forage will also eventually force beaver to disperse from the site and abandon the dams that currently are providing the bulk of the functionality for salmonids.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Riparian planting of beaver forage would help ensure continued function. This could be accomplished by strategic girdling to encourage sunlight and then cluster planting and caging forage species such as willow.

2) Riparian planting and caging of conifers clustered on high ground. Some alder girdling may be required to accelerate growth and enhance survival.

Secondary branches

No secondary branches were identified.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

In the 1993 AQI conducted by ODFW, the riparian canopy was described as consisting of a mixture of 75% hardwoods and 25% confers. Canopy closure remained above 79%. Canopy closure remained excellent throughout Bear Creek during the 2010 LFA field inventory. The area of the highest conifer concentration was in reach 3 above Highway 26 with 75% conifer dominant. In 2010 it was noted that the lower 2,500ft of Bear was dominated by older age class alder with conifers increasing upstream of the identified anchor habitat.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

The short term recruitment potential of wood resources from the riparian corridor on Bear Creek is almost exclusively alder. There is contemporary conifer recruitment potential within the riparian but its limited by low conifer density and young seral condition (<50 yrs old).

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

At present there are no indicators that thermal problems exist in Bear Creek. However, the known temperature limitations in the lower mainstem Rock, suggest that maintaining the delivery of high quality cold flow from Bear Creek is an important factor for addressing basin scale limitations for summer rearing salmonids. This becomes critically important when harvest activities threaten the integrity of the standing riparian. The alder here is susceptible to blow down (saturated soils from exceptional floodplain water storage) and sunscald. Additional buffer widths (beyond the standard 100 ft) should be negotiated for the next harvest rotation within the identified anchor site (see map).

NF Rock Creek assessment

NF Rock Creek enters mainstem Rock Creek 2.5 RM downstream from SF Rock and 3 RM downstream from the Highway 26 crossing.

Migration barriers

According to Bio-Surveys 2009 RBA survey of the NF, coho distribution terminates at a six foot falls 4.1 RM from the mouth. It was also noted that there were two natural bedrock falls within the first one RM that were definitive juvenile barriers (Photo 9). Several more similar bedrock steps were encountered further upstream.

One of the largest tributaries of the NF Rock (classified by flow) enters on the left 1.0 RM from the mouth. This tributary is inaccessible to anadromous species because of a boulder falls / cascade at the mouth.

Temperature issues

There are no indications of temperature issues in NF Rock Creek that immediately impact the summer rearing of juvenile salmonids. However, recent un-buffered harvest units on headwater tributaries with significant summer flows have likely contributed to elevated pinch period temperatures in the mainstem of Rock Cr (unverified). The issue of cumulative impacts that affect the mainstem of Rock Cr applies within the NF sub basin as a part of a subset of impacts occurring simultaneously throughout the watershed. The intent of the LFA field inventory was not to gather single point temperature data but to assess the status of these critical issues (temperature) on a landscape scale. There may be creative ways to reduce the upslope impacts of solar exposure on non fish-bearing streams until early seral vegetation can be recovered to protect the aquatic corridor from solar exposure (retention of logging slash, etc.).

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

High quality spawning gravel is plentiful in NF Rock. There are 358 sq m of good quality spawning gravels in the mainstem of NF Rock Creek. Seven sq m of good quality gravel in Trib A and another 24 sq m of good quality gravels in Trib B. The most exceptional abundance of spawning gravel exists in Anchor Site #4 as a result of a large wood jam from a debris flow event during the 1964 flood. This jam has trapped acres of spawning gravel near the junction of Trib B and is responsible for the continued high function that can be observed here (Photo 10). The obvious shortage of complex woody debris however, indicates that the NF Rock has great potential for trapping and storing additional spawning gravels with the addition LWD. This is one of 4 primary spawning destinations for adult coho.

The existing abundance of gravel appeared to be utilized to capacity for the 2008 brood. Enhancing gravel storage in the NF Rock is very high priority on the basin scale because of its capacity to deliver nomadic fry to vast rearing areas existing in the lower mainstem once temperature limitations can be addressed there.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

NF Rock was a major contributor to the Rock Cr sub-basin during the 2009 RBA survey, carrying 17% of all of the coho Parr enumerated for the entire basin (40,645), while only containing 11% of the total lineal distance in the Rock Cr. system. The average rearing density was 2.2 coho/sq m reaching a strong and even peak of 3.5 coho/sq m at RM 1.6. The 2009 adult escapement of coho into the NF Rock was large and may have succeeded in fully utilizing the available spawning gravels. From the total spawning gravels documented in the 2009 LFA field inventory (399 sq m). The Alsea Watershed Study seasonal survival rates (appendix 4, table D1) predict a summer parr abundance of 30,398 (this is utilizing 1.7 coho/sq m as full seeding). Rock Cr surpassed this summer abundance in 2009 with 40, 645 coho estimated rearing in the mainstem. The higher rearing density of 2.2 coho/sq m certainly was responsible for some of this additional production.

It is likely that unless higher average pool densities can be sustained by the quality of the habitat in the NF Rock (> 2.2 coho/sq m) then the production observed during the summer of 2009 (results of the 2008 brood year) is near capacity. From RM .4 to RM 2.8 (Pool #6 to Pool #38) held almost all of the 1+ Steelhead present in NF Rock. These numbers describe an important and productive stretch of habitat that was functioning well at the time of survey. For comparison, the 2010 RBA inventory observed only 13,640 coho parr rearing in the mainstem of NF Rock Cr. This was just 7% of the Rock Cr watershed total (194,658).

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Summer cover for juvenile salmonids is often expressed in quantitative inventories as the abundance of wood. NF Rock Creek has a fair supply of transient small woody debris. It was noted during the 2010 LFA field inventory that several legacy wood jams had created complex habitats starting around RM 2.8. There are also areas that have been treated with large wood that are currently functioning at a very high level. These wood placement sites begin at RM 0.6.

In 2009 the Bio-Surveys rapid bio-assessment rated pool complexity at 2.1 on a scale of 1-5. This scale is based on the total percentage of pool surface area that is associated with some form of structural complexity that is capable of providing cover (Over hanging vegetation, large substrate, wood, undercut bank, etc.) 2 is 1-25% of pool surface area, 3 is 26-50% of pool surface area associated with cover.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Areas of exceptional winter cover where noted during the 2010 LFA ground work. Extending 800ft upstream from the first bridge crossing a wide floodplain, braided channel, and exceptionally low terraces offer the potential for high quality winter habitat low in the system where it has the potential to benefit all non-volitional migrants displaced from upstream habitats by winter flows.

Starting at RM 0.6 and extending upstream 3,000ft the creek has been treated with large wood structures that are beginning to create channel braiding, backwaters, and floodplain interaction. The highest quality winter habitat in NF Rock is located from the confluence of Trib A extending upstream one mile past the confluence of Trib B. Much of this stream reach is characterized by interactive floodplains, good sinuosity, high quality gravels, and good wood complexity. There were five full spanning wood jams noted in this reach during the 2010 LFA ground work

In 2002, the ODFW aquatic habitat inventory documented wood densities ranged from 8.2 to 97.3. pieces / 100m, increasing as the survey progressed up stream. The ODFW benchmark for desirable quantities of wood is >20 pieces/100 m. Because of the December, 2007 flood event, this 2002 AQI data does not represent the current instream wood densities which are reduced (un-quantified).

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction.

Much of NF Rock that was not hill slope confined was exhibiting varying levels of floodplain interaction with the potential to greatly increase complexity in some areas with the placement of full spanning wood complexes. From the mouth extending 1.4 miles the average stream gradient did not exceed 2% according to the 2002 ODFW Aquatic Habitat Inventory. During the 2009 RBA Bio-Surveys, a 1,700ft reach starting 800ft from the first bridge was almost completely scoured to bedrock. Sinuosity was varied but reached very high levels near the confluence of Trib B. At this juncture, complex channel braiding, mid channel islands and terraces <1ft exhibited reference characteristics for high floodplain connectivity.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The potential for development of complex channel features is currently being realized in several locations on NF Rock Creek. Anchor Site 4 near the confluence of Trib B, exhibits extensive channel complexity and floodplain interaction as a result of a legacy wood jam. Also the large wood treatment that begins at RM 0.6 has initiated a trajectory toward complexity that has created meander, braiding, and side channel development. These locations illustrate the effectiveness of large wood in creating complex and interactive channels.

The potential for further channel development is extensive, and the results would mirror the current complexity that can be observed in these two locations. Evidence of historical beaver impoundment was observed near the top end of Anchor Site 4 and extended into the headwaters (Photo 13). A limited beaver legacy was observed below the confines of Anchor Site 4. This was the same summary of beaver use documented in the 2002 ODFW Aquatic Habitat Inventory .

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) No active beaver impoundment in the lower 3.5 RM (including likely side channel sites)
2) Limited riparian potential for the recruitment of large conifer to the aquatic corridor for providing long term persistent structure.
3) Low wood densities and decaying legacy wood from the 1964 flood in obvious transport out of the system.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Encourage beaver colonization by planting forage sources.
2) Leave current high quality buffers in place long term, riparian planting in areas with scarce conifer presence (may include alder girdling and cluster planting).
3) Place full spanning wood structures throughout the mainstem except in Anchor Site 4 where complexity is peaking and providing for the majority of the current productive spawning gravel.

Anchor Site 1

Location and length

Anchor Site 1 begins at the first bridge crossing over NF Rock Creek and extends upstream 800 ft ending at a bedrock step that exhibits a three ft falls.

Channel structure

There is potential for increasing the current low level of sinuosity observed within this anchor. Currently sinuosity is low because of the lack of large wood to encourage deflection (Photo 12).

Floodplain structure

Terraces are approximately 1 ft in height with off-channel braiding and signs of frequent interaction during high water regimes. An even aged and mature class of riparian alder exists on the low interactive terrace for providing future channel complexity. Younger age class conifers make up the majority of the upslope vegetation.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

There are 9 sq m of good quality spawning gravel in the anchor site. In 2009 the Bio-Surveys rapid bio-assessment observed strong coho numbers in this location. Winter rearing potential is excellent with frequent inundation of adjacent low floodplain terraces. Habitat conditions here would improve dramatically with the injection of large wood structures.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

Currently the anchor site is trending toward simplification and lacks the large conifers within the riparian corridor to recruit key wood components to the channel that are capable of retaining spawning gravels.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Large wood structure placement would protect the current level of observed function and enhance the anchors carrying capacity during both summer and winter flow regimes..
2) Protection of existing conifers that will contribute to the long term future of this sight. This might involve a special designation during the next harvest rotation that is site specific for the 800 ft long anchor site.

Anchor Site 2

Location and length

Anchor Site 2 is located 2,850ft upstream from the mouth of NF Rock Creek and extends 4,000 ft upstream to end at an extended reach of hill slope confinement that suggests a transition to a transport reach where wood placement would not only be inappropriate but would result in limited benefit to aquatic complexity..

Channel structure

Sinuosity is limited in the majority of Anchor Site 2. There is however a 700 ft segment of this anchor that starts immediately where sinuosity has been increased as a result of well-established and well-constructed large wood structures (Photo 11).

Floodplain structure

The active floodplain is not extensive with a variable width of 75ft-150ft, but three foot terraces are present and potentially accessible, during winter flow regimes with enhancement. The active channel would respond rapidly with horizontal migration with an addition of wood complexity. This is illustrated by the high level of function achieved lower in the anchor site from the addition of large wood complexity (ODFW). The first 3,000ft of the anchor site has been treated with large wood structures that have persisted and are performing effectively to create a very dynamic mix of aquatic habitat complexity.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

There are 157 sq m of good quality spawning gravel in the anchor site. In 2009 the Bio-Surveys rapid bio-assessment observed strong coho parr numbers with average pool densities exceeding 1.7 coho/sq m The expanded total of summer rearing coho within this Anchor was 8,785 during the 2009 RBA. That represents 24% of NF Rock total. Pools where well developed within the treated segment of the anchor site and provided good summer cover. The abundance of winter rearing habitat was weak but additional wood injections will complement the existing structures by dissipating hydraulic potential and boosting complexity. There are recent log placements located within this anchor that should soon recruit smaller transient wood and begin to address this problem. Water quality and temperature are both good.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) The high flow winter refugia created by impoundment from large wood placement or beaver colonization are missing and likely limit the local conditions within this habitat segment.
2) It is also important to state that the abundant gravels in the NF Rock are beyond adequate for seeding the available summer rearing habitat. When the scale of the review is expanded to include the entire Rock Cr sub basin and we consider how the NF Rock factors into the provision of different seasonal habitats, it's clear that additional capacity for the Rock Cr basin for fry production can only come from a few key places. One of these key locations is the NF Rock. With this frame of reference, the abundance of spawning gravels in several headwater tributaries (NF Rock included become a primary limitation for coho on the entire Rock Cr sub basin scale.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) There is a 1,000ft section at the top of this anchor that has not yet been treated with large wood. This reach would greatly benefit from log placement to increase floodplain interaction and sinuosity. This would likely be a helicopter project. Additional wood treatment increases the potential for floodplain connectivity during winter flows and traps mobile gravels that provide additional capacity for incubating nomadic fry to supplement the mainstem of Rock Cr.
2) Protect and expand the current buffer to insure the future recruitment of large wood to the active channel.

Anchor Site 3

Location and length

Anchor Site 3 starts 1,400 ft above Anchor Site 2 or 500 ft above Quarry Cr (Trib left looking upstream). The anchor extends upstream to end 500 ft below the confluence of Trib B at the site of a large 1964 flood event debris flow jam. Anchor habitat characteristics extend far above this jam but the physical metrics of the anchor site above this jam are so distinctly unique that it has been classified as a separate site. The first 300ft of Trib A is also included in this anchor. The total distance of the anchor site is 9,100ft and includes several small transport reaches within the anchor.

Channel structure

Sinuosity varies throughout this long anchor. Some areas are highly sinuous with side channel habitats that exhibit historical channel meander created by the presence of woody debris that is long gone. Other stream segments exhibit low sinuosity and a trend toward channel simplification.

Floodplain structure

The active floodplain varies from 100ft-150ft with terraces of 18”-36”. Terraces exhibit indicators of interaction during winter flow regimes. The channel has the potential to migrate with the addition of large wood complexity. The riparian corridor is varied with good recruitment potential for coniferous large wood.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

There are 73 sq good quality spawning gravel in the anchor site. In 2009 the Bio-Surveys rapid bio-assessment observed strong coho numbers in this reach. Average rearing densities continued to exceed 1.7 coho/sq m. Approximately 15,000 summer rearing coho Parr where rearing within this anchor during the summer of 2009. This represents 37% of the total production for the entire NF Rock Creek in 42% of the lineal distance.

Rearing limitations

Which functions limit the site’s production potential, and what causes these limitations?

1) This anchor is currently trending toward simplification and a lower level of function driven by the natural decay and then transport of legacy LWD from within the floodplain and active channel. The process of simplification is reducing habitat complexity, the capacity for gravel storage and sorting and the frequency of floodplain interaction. There are several old large wood structures (ODFW) and legacy wood jams (containing old fire scars) that are unraveling as a result of recent flood flows (2007).

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Augmentation with large wood in key areas throughout this anchor would greatly increase the level of function which would result in higher production capacities for coho during all seasons of the year.
2) Planting prescriptions to add a conifer component to the alder dominated riparian corridor for the provision of long term structure.

Anchor Site 4

Location and length

Anchor Site 4 begins 500ft downstream of Trib B at the 1964 era debris flow jam and continues upstream 5,500ft to end at a significant gradient transition in the headwaters of NF Rock. The lower 800ft of Trib B is also included in this anchor.

Channel structure

The anchor site exhibits a very high level of sinuosity. By comparison, this may be the highest sinuosity observed throughout the entire Rock Cr LFA .The sinuosity is represented by a complex network of channel braids and mid channel bars and islands. The high sinuosity (fostered by the debris flow jam below) has been responsible for the reduction of the hydraulic potential resulting in deep accumulations of well sorted spawning gravels.

Floodplain structure

Terraces are broad and interactive averaging 300ft in width and 12”-24” in height. There is extensive channel braiding, side channels, and backwater features. Older age class (45 yr) alder dominate the riparian vegetation for much of the anchor. A substantial legacy debris flow jam formed at a hill slope pinch during the 1964 flood event 500 ft downstream from Trib B. This jam has resulted in a massive accumulation of bedload that has formed the broad flat terraces in the lower portion of Anchor Site 4. This site exhibits extensive potential for the encouragement of beaver to ramp up year round flood plain water storage.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

There are 102 sq m of good quality spawning gravel in the anchor site. In 2002 the Bio-Surveys rapid bio-assessment observed average rearing densities well above 1.7 coho/sq m in the lower portion of the anchor. The densities here were lower than observed in Anchors 2 and 3. Coho rearing densities began to decline in the upper ½ of the anchor site as a result of diminishing gravel resources. A total of 7,705 summer rearing coho Parr where using this anchor during 2009. This was 19% of the NF Rock total rearing in 26% of the lineal distance. The abundance of winter habitat is average and falls below the classification of exceptional because of the lack of highly complex cover in the form of woody debris. There is however great potential for achieving an expansion of winter habitat surface area with the successful re-colonization of beaver here.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) This anchor site is currently a model of a properly functioning stream segment. The primary long term limitation is the lack of large riparian conifers to maintain floodplain interaction.
2) The current scarcity of beaver forage also predisposes the anchor site to winter rearing limitations from the decline in active beaver colonies (and their dams) that were obviously abundant within the anchor site historically (visual on abandoned beaver flats).

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Riparian planting of conifers would ensure long term function. May require girdling and caging.

2) The planting of beaver forage would also encourage the development of additional winter habitat surface areas (beaver impoundments).

Anchor site rankings

Function

Rank the identified anchor sites in terms of current function (1= best).

1) Anchor site 4
2) Anchor site 2
3) Anchor site 3
4) Anchor site 1

Restoration potential

Rank the identified anchor sites in terms of restoration potential.

1) Anchor site 3
2) Anchor site 1
3) Anchor site 2
4) Anchor site 4

Secondary Branch 1

Location and length

Trib A enters NF Rock Creek from the west 2.6 RM from its mouth. There is approximately 1,500ft of stream utilized by summer rearing coho.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

The lower 300ft of Trib A is included in the mainstem Anchor Site 3 and exhibits the potential for quality off channel rearing during winter flow regimes. This tributary is also an important cold water contributor for the maintenance of cool mainstem temperature profiles. The RBA data from 2009 indicated a summer rearing estimate of 795 coho Parr.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

This is a small tributary with small summer pool surface areas. These small pool surface areas limit the tributaries capacity for coho production. However it was noted during the 2009 RBA that a recent clear cut with a sparse riparian buffer was compromising the cold water contribution with direct solar exposure.

Addressing the limitations

1) Including this tributary into a mainstem treatment of large wood would increase pool surface areas and increase both winter and summer rearing contribution.
2) Protection of the riparian corridor in even these small tributaries is important for reducing the cumulative temperature impact to the lower mainstem of Rock Cr during pinch period summer flows.

Secondary Branch 2

Location and length

Trib B enters NF Rock Creek from the east 3 RM from its mouth. There is approximately 4,000ft of stream utilized by summer rearing coho.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

The lower 1,000ft of Trib B is included in the mainstem Anchor Site 4 and exhibits the potential for quality off channel rearing during summer and winter flow regimes. Floodplain terraces were wide (up to 200ft total width) but were beginning to show signs of entrenchment. A strong legacy of beaver dam impoundment was observed here that was historically responsible for providing large quantities of pool surface areas for both summer and winter rearing. Beaver are not currently active in this reach and all high quality forage species are missing.. This tributary is also an important cold water contributor. The RBA data from 2009 estimated a summer rearing population of 1,085 coho Parr.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

Currently, Trib B is limited by the abundance of spawning gravel (appendix 4, table E1). There are significant amounts of nutrient rich sediments stored in the legacy beaver terraces in the first 1,000 ft of stream corridor. The majority of the identified spawning gravels are also stored here. Recent harvest activity in the headwaters of Trib B. have recently elevated sediment contributions (visual observations of turbidity during active harvest, May 2010).

Addressing the limitations

1) Provision of beaver forage in the lower ½ of the current coho distribution (2,000 ft) would help to encourage re-colonization. Planting conifers would also provide the riparian wood source for the long term recruitment of structure.

Secondary Branch 3

Location and length

Trib C enters NF Rock Creek from the right 2,100ft above the confluence of Trib B. There is approximately 1,000ft of stream utilized by summer rearing coho.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Trib C is small (wetted summer channel width is 4 ft) with very little opportunity for spawning and rearing. An expanded estimate of 135 summer rearing coho were observed during the 2010 RBA. The primary contribution of this stream is cold water and gravel resources to the mainstem of NF Rock.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

This is a small tributary with small summer pool surface areas. This is the primary seasonal limitation to production.

Addressing the limitations

1) Effective re-colonization of beaver would be the most effective and practical way to increase surface area in this tributary.

Secondary branch site rankings

Function

Rank the identified branch sites in terms of current function (1= best).

1) Trib B
2) Trib A
3) Trib C

Restoration potential

Rank the identified branch sites in terms of restoration potential.

1) Trib B
2) Trib A
3) Trib C

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The 1993 ODFW AQI describes the riparian area as 64% hardwood 36% conifer. This percentage holds fairly steady for length of the survey. Canopy closure at regular transects ranged from 75% to the 90% range. The last reach, near the end of coho distribution was conifer dominated.

In 2010, the Bio-Surveys LLC survey noted recent upslope harvest activity on both sides of the river from RM 0.5 to RM 1.5. A healthy buffer was present with substantial conifer contribution potential. It was also noted that Anchor Site 4 near the mouth of Trib B was dominated by older age class alder with limited conifer present. An abandoned beaver flat 1 mile above the confluence with Trib B is exhibiting 500 lineal feet of solar exposure (Photo 13).

Canopy conditions in the sub basin are high quality and providing extensive protection from solar exposure. The value of maintaining this condition for the temperature limited portions of mainstem Rock Cr cannot be overstated.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Hardwood recruitment potential on NF Rock is currently good throughout the anadromous use area. There are also significant reaches that currently display good potential for riparian conifer recruitment. There are concerns that alternate OFP prescriptions of basal area calculation or alder conversion could threaten the integrity of the existing canopy that is critical for temperature maintenance. This possibility is mentioned because these alternate OFP prescriptions can be observed in other tributaries of the Rock Cr basin.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The current riparian condition on the NF Rock Creek mainstem protects mainstem habitats downstream from reaching thermal thresholds during low summer flows. Proactive protection of the existing riparian area will continue to mitigate for the cumulative downstream impacts occurring in other tributaries of the basin.

There have been recent negative impacts on east side 3rd and 2nd order tributaries from un-buffered harvest activities on Type N streams that have elevated the contributing temperatures of these tributaries. The impact to the mainstem of NF Rock is undocumented. However, these are the cumulative issues that when combined on the basin scale will eventually exacerbate the elevated mainstem temperatures of Rock Cr.

Weed Creek assessment

Weed Creek enters Rock Creek from the north 1.5 miles downstream from the confluence of NF Rock Creek.

Migration barriers

There are no major fish passage barriers on Weed Creek. At RM 2.2 there was an ephemeral wood jam that terminated adult coho migration in 2009. In 2010, adult coho extended their distribution to RM 2.8.

Temperature issues

There are currently no temperature limitations in Weed Creek. In the 1993 Aquatic Habitat Inventory Conducted in mid-August temperatures did not exceed 54 degrees F.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

A total of 129 sq m of good quality spawning gravel was documented in Weed Creek. The spawning gravels were widely distributed with higher concentrations in the two identified Anchor sites. Large wood complexity was essential for gravel storage in this system because of the average gradient (3.4%) and the hillslope confinement. Many legacy wood jams were decayed and unraveling and there is a concern that the high productivity for salmonids currently observed in Weed Cr will be declining in the next decade with this loss of old structure.

The absence of the morphological potential for high quality winter habitat suggests that we should view Weed Cr as an extremely high production site for spawning and incubation. Elevated gradients provide the necessary hydraulics to keep gravels well sorted and cleansed of sediment. Weed is a very important piece of the basin scale puzzle because it is capable of producing large quantities of nomadic coho fry that because of density dependent pressure, drop out of the tributary to summer and winter rear in mainstem Rock Cr habitats.

Based on the abundance of spawning gravels documented in the 2010 LFA field inventory by Bio-Surveys, there is currently 2.5 times more smolt capacity in spawning gravel than the carrying capacity of the summer habitat (Appendix 4, Table E1).

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

The 2009 Bio-Surveys rapid bio-assessment observed juvenile coho to an ephemeral log jam 2.2 RM from the confluence with Rock Creek. For most of the 2.2 miles, Weed was one of the most productive tributaries for coho in the Rock Cr basin. The average rearing density was 2.7 coho/sq m with an extended spawning peak of 4.1 coho/sq m at RM 0.5. From the mouth to RM 1.7 only four pools contained summer rearing densities below 1.7 coho/sq m. Ninety per cent of all coho Parr in Weed Cr were rearing in this same 1.7 mile stretch. The total coho parr production estimate for Weed Cr in 2009 was 14,400. In 2010, total abundance declined to 6,192 coho parr and average rearing densities declined to 1.4 coho / sq m. The regions of high spawner activity remained similar near RM 0.5.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Although Weed Cr. flows in a tight canyon, the gradient is not overly steep (3.4%) and there are areas of good gravel retention and wood complexity due to the legacy of large wood. This legacy wood includes fire toppled wood from the 1930's burn and large quantities of woody debris recruited from hillslope failure.

Most of the premium aquatic habitats are located in the first 1.5 miles. It was noted that Weed Cr was a well shaded stream with the primary riparian components alder and Douglas Fir. In the 1993 Aquatic Inventory conducted by ODFW the average wood complexity score was 2.2 on a scale of 1-5.

Pool complexity scores calculated by Bio-Surveys LLC in 2009 averaged 2.2 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity that is capable of providing cover (over hanging vegetation, large substrate, wood, undercut bank, etc.). A ranking of 2 represents 1-25% of pool surface area associated with cover and 3 represents 26-50%.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

This stream seems to be trending toward simplification at a faster rate than other streams in the Rock Creek system with the same age class of stored legacy wood. This could be the result of its narrow canyon creating higher velocities. Terraces exhibit recent interaction but as wood complexes unravel and are lost to the system, new wood complexity will be required to arrest the process of simplification. There are several sites throughout the extent of coho distribution that exhibit have large wood still functioning at a high level. These are the only significant locations for refugia during winter flow regimes.

The 1993 Aquatic Habitat Inventory did not record any beaver dams in Weed Creek. In 2009 the Bio-Surveys RBA snorkel inventory documented eight beaver dams present in the system; most were insignificant summer dams, providing limited potential for winter habitat. One dam complex was anchored with large wood and provided excellent winter cover that would be stable during winter flows. The location of this large dam pool however was not high in the system and consequently it was unavailable to most non volitional migrants displaced by increasing winter flows..

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction.

Weed Creek traverses a narrow pinnate canyon with steep hill slopes. The Valley Width Index score provided by ODFW in their 1993 AQI was 2.5. This score was considered “very narrow”. Most of the stream is hill slope confined, leaving little valley floor to create meander and functional floodplain terraces. Large wood complexity is very important in this system for providing the foundation that creates impoundment. In locations of impoundment the stream was able to store gravel and create interactive terraces with complex features capable of supporting juvenile salmonids during winter flow regimes.

There are many indicators throughout the stream course to suggest that historical floodplain interaction was much higher. Floodplain connectivity is in decline as the active channel trends toward simplification from the decay and transport out of the system of old wood.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The potential for creating complex channel forms is limited because of the narrow valley form. However, because of Weed Creeks importance as a spawning destination that supports the mainstem of Rock Cr, sufficient amounts of large wood should be supplemented to increase bedload storage and maintain the current levels of high function observed. This is a stream at risk because of the disparity between the wood in and the wood out of the system. Currently more wood is being lost than there is being recruited.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Narrow valley
2) Accelerating loss of legacy wood
3) Limited beaver population
4) Limited conifer recruitment potential for providing persistent structure naturally

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Large wood placement in first 1.7 miles to aggrade bed materials, create diverse off channel habitat types, and give a foundation for beaver impoundment.
2) Retain riparian buffers on the mainstem and on 1st and 2nd order tributaries capable of delivering large wood.
3) Enhance beaver forage (Willow, Vine Maple, Cottonwood, Ash) in Anchor Site 2 and headwater flat that begins at RM 2.5

Anchor Site 1

Location and length

Anchor site 1 is located 1 mile above the confluence with Rock Creek and stretches upstream 1,200’.

Channel structure

Sinuosity is low because of the limited valley width of this anchor site. There is limited potential for increasing meander.

Floodplain structure

Terraces are not extensive but they are low and interactive. They are primarily the result of a debris flow from an adjacent small tributary that deposited large wood and fines in the mainstem of Weed Cr. Vegetation is mostly young alder recolonized on the disturbed debris flow soils.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

There was 28 sq m of spawning gravel classified as good within the anchor. The impoundment caused by debris flow as a result of slope failure has created conditions capable of supporting all of the seasonal habitat needs of coho salmon.

In both 2009 and 2010, the rapid bio-assessment snorkel inventory conducted by Bio-Surveys observed densities of juvenile coho salmon in excess of 3.0 coho/sq m within the anchor site.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The site exhibits the morphological constraints of a narrow valley floor. In addition, the future recruitment of persistent woody debris will limit the streams ability to continue to function as a key spawning destination.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Protect riparian buffers on the mainstem and steep slide prone contributing tributaries.
2) Enhance wood complexity with full spanning structure to arrest the progression toward simplification.

Anchor Site 2

Location and length

Anchor site #2 is located 1.6 RM from the confluence with mainstem Rock Creek and has a total length of 1,200ft.

Channel structure

Relative to other Anchor sites in the basin, sinuosity would have to be classified as moderate, the result of hill slope constraint. Within Weed Cr, the highest level of sinuosity was observed within this anchor site.

Floodplain structure

Terraces are 2ft-3ft and interactive with an active floodplain width of 75ft. The terraces are a result of the deposition of fines caused by impoundment from a legacy wood jam.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Spawning gravels in this anchor are plentiful and very high quality. Bio-surveys 2009 RBA data indicated that summer rearing here was exceptional with pool densities exceeding 3.0 fish / sq m. Coho rearing densities dropped sharply after this anchor. There were not extensive backwater and side channel complexes but floodplain interaction as a result of impoundment was occurring during winter flow regimes.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

A deficiency of full spanning large wood structures limits floodplain complexity in this anchor site.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Inject additional large wood in full spanning jam complexes

Anchor site rankings

Function

Rank the identified anchor sites in terms of current function (1= best).

1) Anchor Site 1
2) Anchor Site 2

Restoration potential

Rank the identified anchor sites in terms of restoration potential.

1) Anchor Site 2

2) Anchor Site 1

Secondary Branch 1

Location and length

There were no coho bearing Tributaries in Weed Creek. However their cumulative contribution was important to the overall function of the combined Rock Cr 6th fields.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Weed Creek tributaries were small and steep, offering very little in the way of rearing or spawning for salmonids except where they briefly traversed Weed Creeks narrow floodplain. The majority of these tributaries however were exceptionally prone to slope failure. Their value as sources of large wood and gravel for the mainstem of both Weed and Rock Cr has been historically significant. It was noted during the 2010 LFA that several of these tributaries had experienced recent slope failures. These failures were directly responsible for creating the most functional locations in the system through their contribution of stable large wood, terrace forming sediments, and spawning gravels. They also deliver cold summer flows to the mainstem which directly mitigates for elevated temperatures in the lower mainstem.

The steep narrow canyon of Weed Creek predisposes the system to simplification. Without the resource contributions from the tributaries, Weed Creek could not function at its current high level. The protection of riparian buffers on Weed Creek Type N tributaries is a high priority for the future success of the entire Rock Cr system.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

In 1993, the AQI described the species composition of Weed Creek riparian as dominated by 81% hardwoods. In May of 2010, the Bio-Surveys LLC stream inventory noted a similar mix of species. However, there was scattered conifer recruitment potential in some reaches. Weed Creek was well shaded in both the 1993 and 2010 inventories.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Recruitment potential for LWD is limited in the short term by the absence of large conifers in some reaches, but there is significant recruitment potential of large conifers on a limited basis. Some older alder will add ephemeral structure in the short term. Heavy upslope harvest activity has diminished the availability of resources recruited through slope failure and debris flow.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

A contiguous and intact riparian corridor in conjunction with a narrow canyon and a north south aspect have resulted in cool flow emanating from Weed Cr during summer low flow regimes (no temperature data available)..

Tributary D assessment

Migration barriers

There were no migration barriers on Trib D.

Temperature issues

ODEQ temperature monitoring data in the mainstem at the confluence of Rock Creek and Trib D show temperatures close to 64 degrees F for the seven day average of daily maximums. It is possible that large exposed beaver ponds in Trib D are contributing to these elevated temperatures. The impounded terrace is broad (200ft) and beaver dams are modest in height because great surface areas can be inundated with limited dam height. Therefore, deep ponded habitat is not occurring here that would normally stratify and provide cool subsurface leaching. Planting prescriptions here would be classified as high priority.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

There was 3.4 sq m fair quality spawning gravel and 36.1 sq m of good quality spawning gravel observed in Trib D during 2010. The majority of that gravel was observed above RM 0.5. The location of these gravels is perfect for seeding the vast surface areas of impounded habitat in the lower end of Trib D.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

The 2009 RBA conducted by Bio--Surveys observed 7,400 ft of juvenile coho distribution from the confluence with Rock Creek. The average rearing density was 1.3 coho/sq/m.

in 2009 and 1.6 coho / sq m in 2010. The expanded production estimate for the stream was 8,675 summer rearing coho Parr in 2009 and 5,244 in 2010. Most of the summer rearing was occurring in the well-developed beaver ponds throughout the system. Confidence in the overall estimate of summer parr is weak in Trib D because of the massive quantities of off channel habitat that was not incorporated into the snorkel inventory as a matter of protocol. Consider the values above as underestimates of the true production.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Summer cover for juvenile salmonids is often expressed in quantitative inventories as the abundance of wood. The 1-5 rating scale is based on the total percent of pool surface area that is associated with some form of structural complexity that is capable of providing cover (Over hanging vegetation, large substrate, wood, undercut bank, etc.) 2 is 1-25% of pool surface area, 3 is 26-50% of pool surface area associated with cover.

The average complexity rating given by Bio-Surveys during the 2009 RBA survey was 2.36, but complexity was considerably higher in areas influenced by beaver activity. Much of the summer rearing appeared to be taking place in the well-developed beaver ponds throughout the system. Solar exposure was heavy in the ponded areas.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The highly complex beaver impoundments exhibit the highest quality winter habitat in all of the Rock Cr subbasin. These large beaver ponds were capable of harboring huge numbers of juvenile salmonids during high winter flows (Photo14). The largest of the beaver influenced reaches encompassed the majority of the lower 0.5 RM. This location low in the tributary system offers refuge for juveniles purged from higher spawning reaches during winter flow regimes.

There are several recent log structures placed above the first road crossing that have not yet developed significant complexity. It is likely that the Trib D at this juncture does not frequently have the hydraulic potential for transporting transient bedload or canopy litter.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction..

The lower portion of Trib D, below the first road crossing, has a wide valley floor with an extensive and highly interactive floodplain. There is a very significant legacy of fire toppled wood in the lower 600 ft that is responsible for everything else that has subsequently occurred in this tributary. With this large volume of large conifer buried in the floodplain, beaver have been able to take advantage of these purchases for dam construction that is winter stable and the site exhibits a legacy of long term colonization. Beaver dams have created a 300 ft wide highly interactive floodplain terrace in the lower 0.5 miles of stream corridor.

Above the road crossing the stream becomes much more constrained by hill slopes and there is no longer any potential for the broad interactive floodplain observed below the crossing. Around RM 1 another well-established but smaller beaver complex creates interactive terraces but hill slope confinement still defines the extent of this 500ft long interactive site.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The reach below the first road crossing may be functioning at full capacity for the provision of meander, braiding and off channel habitat complexity. This is a site that would be classified as reference location in its prime for providing all of the habitat components required to optimize coho production. Above the road crossing, there is limited opportunity for the development of these complex channel forms because of hill slope confinement. Beaver have created a condition of complex habitats above RM 1 even within this narrow valley morphology. The recent structure placements above the road crossing may eventually encourage beaver impoundment.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Currently beaver forage is scarce. This will eventually lead to abandonment of the site which will result in simplification of the complex channel form that can be observed here now..
2) The long term recruitment potential of persistent conifer is limited below first road crossing to maintain the foundation that beaver have succeeded on.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) The planting of willow and other beaver forage would provide an extended food source and also mitigate for the solar exposure associated with ponds.
2) Plant wetland species of conifer on hummocks and dry sites for future recruitment.

Anchor Site 1

Location and length

Anchor site # 1 is located 500ft from the confluence with mainstem Rock Creek and has a total length of 2,000ft.

Channel structure

Sinuosity is exceptional as a result of the wide floodplain, extensive beaver activity, and the presence of legacy wood that creates diversion.

Floodplain structure

Terraces are low and highly interactive with many complex channel features. The terrace structure is a result of the deposition of fines recruited from headwater reaches of Trib D and trapped and stored by the impoundments formed by legacy wood and a long history of beaver activity. Vegetation is dominated by reeds, grasses, skunk cabbage and low shrubs. No Reed Canary Grass was present in 2010. The absence of Reed Canary Grass above the Hwy 26 crossing is especially interesting since it exists just below the Hwy 26 crossing abundantly.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Spawning gravels in this anchor are limited because the low gradient does not provide for scour and sorting, There is however 8 sq m of spawning gravel near the top end of the anchor site that is critical for seeding the available rearing habitats downstream. Rearing densities encountered by Bio-Surveys during their 2009 RBA snorkel inventory hovered around 1.0 coho/sq m within the anchor. 35% of the estimated total coho Parr were documented within the anchor. The 38 sq m of good spawning gravel quantified in the LFA field inventory was not enough to seed the summer or winter rearing habitat available within Trib D. Increases in production within the tributary are solely dependent on increasing the availability of the primary limiting factor (spawning gravel). These gravel limited tributaries are not capable of contributing excess nomadic fry to the lower mainstem of Rock Cr.

With the location of the anchor site low in the system, its exceptional level of function, and its large surface area (capacity) of low velocity impounded habitat, the anchor site provides very high quality and important winter rearing habitat.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

This site is currently a model of a properly functioning stream segment. Excessive solar exposure that contributes to lower mainstem temperature limitations and the lack of beaver forage are the primary issues that challenge the site.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

Planting of beaver forage such as Willow, Cottonwood, Vine Maple and Ash coupled with the judicious location of water tolerant conifers would provide mitigation for both issues.

Secondary branches

No secondary branches were noted on Trib D that contained coho distribution beyond the tributary within the heart of the 0.5 mile anchor site that is completely inundated with beaver impoundment. This tributary and its associated channel morphology are a portion of what has allowed the broad floodplain development to occur in Anchor Site 1.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The lower 2,500ft of Tributary D below the first road crossing is solar exposed with very little canopy cover (Photo 15). Above the road crossing the canopy closes dramatically. The riparian corridor is primarily alder with some conifers mixed in.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

There is some potential for the contemporary recruitment of conifer. Several stands of re-prod will eventually offer recruitment potential in the lower 600 ft of Trib D. This is a critical location for maintaining the long term recruitment of large wood that will hold the anchor site habitat together and prevent channel incision. Alder is currently the primary source of upslope wood complexity above the road crossing.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The solar exposure within the anchor site is likely causing elevated temperatures. These temperatures are likely not an issue at the site, but they do contribute to elevated temperatures in the lower mainstems of both Rock Creek and consequently the Nehalem River. Because of the massive floodplain water storage that is occurring in Trib D, vegetative succession has been retarded by a year around high water table. The quickest remedial step for addressing both the lack of beaver forage and the lack of solar protection is a willow planting blitz. Willow stakes would need to be protected with cages until their roots have stabilized and the plants can be exposed to beaver use.

Ivy Creek assessment

Ivy Creek enters Rock Creek 10.2 RM from the Nehalem confluence.

Migration barriers

There were several natural ephemeral passage barriers throughout Ivy Creek. A log jam beaver dam combination at 3,440 ft stopped adult coho in both 2009 and 2010.

Temperature issues

Limited temperature data is available for Ivy Creek but random summer data points collected August 19, 2009 (59 deg) and July 21, 2010 (57 deg) during the Bio-Surveys snorkel inventory indicate moderate summer temperature profiles. As was observed in other tributaries of the lower Rock Cr mainstem (Fall, Trib C), Ivy exhibits a temperature dependent upstream migration of coho juveniles that extends a short distance above the mouth (500 ft). This behavior was observed in both 2009 and 2010.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

There were 11.1 sq m of fair quality spawning gravel and 9.8 sq m of good quality spawning gravel in Ivy Creek. Gravel was located sporadically throughout Ivy and usually associated with wood complexity. Exposed bedrock was frequent.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

Modest coho numbers were observed in Ivy Creek during both the 2009 and 2010 RBA conducted by Bio-Surveys. In 2009 distribution extended ,3,880 ft from the mouth and an expanded estimate of 1,860 coho parr was observed.. In 2010, a year with markedly lower adult escapement across the basin, the extent of distribution was similar at 3,440 ft but the summer standing crop was estimated at only 900 coho.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Summer flows in Ivy Cr were very low (un-quantified) with some reaches exhibiting almost no surface flow between pools. The average complexity score given during the Bio-Surveys RBA surveys was 2.16. The 1-5 rating scale is based on the total percent of pool surface area that is associated with some form of structural complexity that is capable of providing cover (Over hanging vegetation, large substrate, wood, undercut bank, etc.) 2 is 1-25% of pool surface area, 3 is 26-50% of pool surface area associated with cover.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The majority of quality winter cover was associated with beaver activity and low gradients in the lower portion of Ivy creek. Some wood complexes show signs of creating floodplain interaction and impounded low velocity refugia during winter flow regimes. Above 2,000ft the canyon becomes tightly hillslope confined and the development of winter cover and complexity is nonexistent. It is likely that many summer coho parr are frequently recruited to the mainstem of Rock Cr and depend on finding winter refugia there after the first fall freshets.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction.

Flood plain interaction is limited in Ivy Creek above 2,000ft from the mouth because of narrow canyon morphology. The lower reach of Ivy exhibits signs of floodplain interaction during winter flow regimes. Wood complexity and beaver impoundment are corporately working to provide the limited floodplain interaction observed. Maintaining this mix of Beaver and large wood would be a an important goal for securing the productive capacity of Ivy in the future.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The lower reach has the characteristics necessary for the establishment of complex channel forms in addition to the current level of floodplain interaction. Increases in channel roughness would exhibit immediate benefit to the development of channel complexity.

In the upper reaches of hill slope confinement there is not extensive potential for a high level of channel complexity. This reach is still important for the storage of spawning gravels and summer rearing. In this small low flow stream there in no anchor site capable of supporting all of the coho's seasonal habitat requirement and therefore linkages with other rearing habitats in the Rock Cr basin are important.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) The primary limitation of Ivy Creek is its small summer pool surface areas and its hillslope confined channel morphology.
2) In the lower gradient reach, the lack of beaver activity is the primary limitation.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Protect existing riparian to ensure future large wood recruitment and encourage long term beaver colonization.

Anchor sites

No anchor sites identified.

Secondary branches

No secondary branches were identified.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The majority of this streams lineal distance currently utilized by coho for spawning and rearing has a healthy riparian canopy of mixed hardwood/conifer with an average canopy closure greater than 70%. In the headwaters of Ivy near the end of anadromous use the primary canopy shifts to a young conifer plantation (approximately 15-20 years old). The harvest did not leave a strong riparian buffer and only a sparse alder riparian remained intact.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

There is very limited contemporary recruitment potential in the headwaters of Ivy Cr because of the age class of the managed conifer plantation. Future recruitment potential in the head water reach will be strong as long as there is a commitment to retain a functional RMA. For the majority of Ivy the potential for full spanning LWD recruitment is good for both the short and long term.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The 2010 LFA inventory conducted by Bio-Surveys did not detect the upslope conditions, the aspect or the riparian solar exposure that would suggest that summer temperature limitations would be an issue for Ivy Cr.

Ginger Creek assessment

Ginger Creek enters Rock Creek 15.5 RM from the Nehalem confluence.

Migration barriers

Ginger Creek has an impassable 10+ft falls 150ft from its mouth.

Temperature issues

Ginger Creek has substantial summer flow (un-quantified) and is very important for cold water contributions to the mainstem of Rock Cr during summer flow regimes. Temperatures in the mainstem of Rock Cr become a limitation for summer rearing salmonids approximately 4.5 miles downstream of the Ginger Cr confluence. No site specific temperature data was available for Ginger Cr.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

Spawning gravel inventories were not conducted for Ginger Cr because the habitat is permanently inaccessible to anadromous salmonids as a result of the falls near its mouth. There are likely viable quantities of spawning gravel of the appropriate size for resident cutthroat. These gravels were not quantified.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

In both 2009/2010 RBA snorkel surveys conducted by Bio-Surveys, coho were observed in only the 150 ft segment from the confluence of Rock Cr to the impassable falls.

Juveniles were likely upstream migrants from the mainstem of Rock Cr. This habitat segment is insignificant for coho production.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Because the habitat is inaccessible to anadromous salmonids at all seasons of the year, there is no viable summer habitat for coho.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Because the habitat is inaccessible to anadromous salmonids at all seasons of the year, there is no viable winter habitat for coho.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction..

Channel characterizations for Ginger Cr are not possible from the results of the 2010 field inventory conducted by Bio-Surveys. Because the habitat is inaccessible to anadromous salmonids, habitat conditions were not quantified above the falls.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

Channel characterizations for Ginger Cr are not possible from the results of the 2010 field inventory conducted by Bio-Surveys. Because the habitat is inaccessible to anadromous salmonids, habitat conditions were not quantified above the falls.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

No limitations observed because habitat was not inventoried.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

Not applicable

Anchor sites

No anchor sites were identified.

Secondary branches

No secondary branches were identified.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The majority of the riparian corridor of Ginger Cr is dominated by early seral plantation conifer. Approximately 25% of the streams lineal distance is associated with recent harvest but riparian buffers are present and intact. The primary open canopy exists at a large beaver dam complex at RM 0.75.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Because riparian buffers have been maintained in recent upslope harvest actions, there is the potential for future wood recruitment to the aquatic corridor. Because this RMA management strategy is contemporary, the time frame to significant recruitment is long (approx. 50 - 70 years).

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The importance of protecting the riparian corridor long term within the Ginger Creek sub-basin cannot be overstated because of its cumulative importance to the mainstem of Rock Cr and its proximity to the beginning of temperature limitations in the mainstem of Rock Cr. Currently all of the Ginger Cr basin is located within the boundaries of industrial timber land. As was observed in much of the Rock Cr basin, upslope harvest has been significant in Ginger and nearly all of the lineal distance is in some form of early seral conifer regeneration. Currently the majority of Ginger is not suffering from solar exposure. Approximately 25% of the lineal distance is associated with recent harvest but riparian buffers are intact. There is an exposed 0.8 acre pond 0.75 RM from the mouth that could be contributing warm water to the system.

Fall Creek assessment

Fall Creek enters Rock Creek 13.3 RM from the Nehalem confluence.

Migration barriers

There is a 12ft falls at RM 0.5 that terminates anadromous use. At RM .25 a culvert has rusted through and is now dry at low summer flow and passing all water subsurface. This blockage has truncated the upstream migration of all fish at summer flow, most notably Cutthroat and coho salmon seeking cold water refugia from the mainstem of Rock Cr. This is not and adult migration barrier.

Temperature issues

Fall Cr was documented as containing cool summer flows during the RBA snorkel inventories conducted in 2009 and 2010. The confluence of Fall Cr is located very close to the region of mainstem Rock Cr that begins to exhibit elevated summer temperatures for extended periods that exceed the DEQ standards for water quality. In both 2009 and 2010 the highest coho densities were observed in the first 1,000 ft of Fall Cr, a result of the upstream temperature dependent migration of juveniles from the warming mainstem of Rock Cr. It would not be uncommon for large quantities of summer rearing juvenile salmonids to be pushing up from the lower mainstem reaches to reach a location in the mainstem or one of its tributaries that is below their summer temperature threshold. Understanding this behavior helps us identify and prioritize restoration actions to address a specific habitat need.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

Spawning gravel was limited in Fall Creek and heavy depositions of silt burden all observed spawning gravels rendering them dysfunctional for the incubation of salmonids. Only 1 sq m of good quality, 4.4 sq m of fair, and 2.2 sq m of poor quality spawning gravels were present during the Bio-surveys 2010 LFA inventory. Nearly 60% of this gravel was located in the lower 1,000ft of the stream. Silts appear to be originating from significant slope failures upstream of the falls.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

In both 2009/2010 RBA snorkel surveys conducted by Bio-Surveys, Coho were observed from the mouth to the falls at RM 0.5. summer rearing Coho numbers were substantially higher in 2009 with an expanded estimate of 4,002, and an average rearing density of 2.96. In 2010 this estimate dropped to just 1,296 with an average rearing density of 1.52. It is possible that the high numbers documented in 2009 were partially a result of a temperature dependent migration that did not occur in 2010 because of higher sustained summer flows and lower mainstem Rock Cr water temperatures. Actual origins (mainstem Rock or spawned in Fall Cr) of the summer parr are not possible within the scope of this analysis but there are two potential origins that stand out within Fall Cr that warrant further investigation.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The stream has adequate wood abundance associated with the active channel to provide complex summer cover. This feature combined with a consistent closed canopy reduces the impact from avian predation. The cold water refugia presented by Fall Cr to the mainstem of Rock Cr is being utilized during summer pinch period flows by temperature dependent upstream migrants. Consider expanding the surface area available to these migrants in the lower 1,000 ft of stream corridor to boost the summer capacity of this temperature refugia.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

A full spanning wood treatment was implemented above the county road crossing. This reach is hill slope confined and does not offer much opportunity for the development of flood plain interaction. The primary effect of this treatment will be realized in the added pool complexity and the potential for trapping additional spawning resources (limiting). A much more appropriate site for large wood placement exists in the 1,000 ft of sinuous stream corridor between the County road and Rock Cr. The stream traverses the floodplain terrace of mainstem Rock Cr and there is potential for expanding both summer and winter habitat surface areas here.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction..

Below the county road Fall Creek is in the mainstem floodplain. The channel is interactive during winter flow regimes but complexity and interaction could be increased significantly. Directly above this area large wood has been added and floodplain reconnection is in progress but will never be extensive because of morphological limitations (hillslope confinement).

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The presence of a broad active floodplain suggests that the lower 1,000ft of Fall Cr exhibits extensive potential for the development of complex channel features. Given the proximity to the upper limits of the temperature limitation that exists in the mainstem, this location is important for expanding the capacity of functional summer rearing habitat until elevated temperatures in the mainstem can be reduced. The opportunity for the development of off channel backwater and alcove habitat is high in this reach.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Low beaver abundance
2) Lack of LWD in reach below the county road crossing.
3) Morphological constraints above the county road.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Allow and encourage beaver colonization in Fall Creek.
2) Add LWD in low terrace area below county road.
3) Develop off channel ponds/back waters below county road.
4) Replace degraded county road culvert that is currently creating a barrier to the upstream temperature dependent migration of juvenile salmonids.

Anchor sites

There were no anchor sites independently classified within Fall Cr. This was primarily a function of the limited scope of the high quality habitat (exhibiting anchor characteristics). However, the 1,000 ft of stream channel between the mainstem of Rock and the county road crossing have been functionally incorporated into mainstem Rock Creeks Anchor Site 5. This is unique habitat because it joins the mainstem of Rock at a point where the mainstem becomes temperature limited and upstream temperature dependent juvenile migrants utilize this habitat for cold water summer refugia.

Secondary branches

No secondary branches were identified.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Alder was the primary riparian species in Fall Creek. Some mature conifers where present throughout the corridor. Canopy closure was generally very good (>80%). Much of the stream above anadromous distribution (barrier falls at RM 0.5) is contained in industrial forest ownership.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

There is mature conifer present along lower portions of Fall Creek sufficient in size to create functioning LWD jams upon recruitment. The retention of the standing conifers in these well stocked buffers is critical to maintaining long term channel and floodplain function. Varying age class conifers are present and maintaining a healthy buffer. This condition will ensure healthy future recruitment unless modified by harvest. Above the county road, alder is the primary recruitment source.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

Currently the 0.5 mile reach accessible to anadromous salmonids in Fall Creek is well shaded. Because the falls truncates anadromous fish use, there is concern that the headwater riparian corridor could be viewed as less significant for fish habitat. Given the special significance of the cold water contribution of Fall Cr to the mainstem of Rock, it is important to maintain a robust riparian buffer above anadromous use to ensure continued function. Currently the Fall Cr basin is in a state of harvest recovery with a largely intact riparian corridor dominated by alder supported by young conifer stands upslope.

Martin Creek assessment

Martin Creek enters Rock Creek at RM 18.5 above the confluence with the Nehalem River.

Migration barriers

At 200ft a 3ft falls terminated coho distribution in 2010. Adult coho passed this falls however in 2009. This falls is a definitive juvenile barrier but does not appear to be a significant adult barrier during years of higher adult abundance. Gradient increases above this falls.

At 850ft a boulder and wood jam in a bedrock pinch coupled with a steep bedrock slide stopped adult coho migrations in 2009. In is likely that both of these features are capable of stopping anadromous migration. It is unlikely that this stream will ever provide significant anadromous production because of these morphological issues that compromise access.

Temperature issues

Currently temperature is not a limitation in this stream, but as observed in many other tributaries of Rock Creek, it functions to provide cool water to the mainstem of Rock during pinch period summer flows and therefore the importance of maintaining a well shaded RMA cannot be overstated.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

There was no spawning gravel documented within the anadromous use area of Martin Creek. Gradient in this reach does not allow for significant gravel sorting (13.8 %% avg for the 1st ½ mile).

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

In 2010 only 6 coho where observed, all in the first sample pool. These fish were the result of a small upstream migration. In 2009 an expanded total of 56 summer rearing coho where present 850ft from the mouth. Given the fact that juvenile coho where present above the 3ft falls at 200ft it is highly likely that a pair of adults were able to partially spawn in lower Martin Cr. This is not likely a frequent event given the poor conditions.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Summer cover is very limited and the habitat would be more suitable for steelhead use if spawning gravels were available for seeding the limited amount of available habitat.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Winter cover is almost nonexistent in Martin Creek given the steep gradient and poor pool complexity.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction.

The confined active channel combined with steep average gradients (13.8%) suggest insignificant floodplain interaction exists. Hillslope confinement was common, further indicating a lack of floodplain interaction.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

There is very limited potential for the development of the complex channel forms provided by sinuosity and channel braiding. In addition, no backwater or off channel habitat types were observed.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Hillslope confinement
2) Steep stream gradients

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

No.

Anchor sites

No anchor sites identified.

Secondary branches

No secondary branches were identified.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Martin Creek is within industrial forest ownership. Protecting riparian buffers is important for the overall health of the watershed. Nearly 70% of the Martin Cr basin has been recently clear-cut. The riparian buffer is sparse and primarily alder.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Recruitment potential is limited because of shortened upslope harvest rotations. A narrow band of riparian alder and early seral Douglas Fir are the only available sources of future wood recruitment.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The poor riparian condition does not immediately impact Martin Cr aquatic habitats but the potential to contribute to the cumulative temperature impacts in the Rock Cr mainstem clearly exist.

Olson Creek assessment

Olson Creek enters Rock Creek from the South East between Weed Creek and NF Rock Creek at RM 22.9.

Migration barriers

At 1,000ft a 6ft log jam presents an ephemeral barrier that may affect adult migration (Photo 16). However, snorkel inventories in 2009 suggested that the barrier was passed by adult coho. In 2010, there were no coho observed in Olson Cr and it may have played a significant role in denying access to upstream spawning habitats and turning adults completely out of the tributary. This is the only substantial migration barrier on Olson and it currently is responsible for maintaining incredible system function in the form of floodplain connectivity upstream of the jam (Photo 16).

Temperature issues

Temperatures are cool in Olson Cr even though vast surface areas are contained in impounded beaver dam habitats and their associated wetlands near the headwaters. Large volumes of water are currently being ground water stored and cooled in the headwaters of Olson Cr.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

There was a total of 107 sq m. of spawning gravel in Olson Creek. All but one sq m. of this gravel was classified as high quality and 93% of these high quality gravels were observed in mainstem Olson above the barrier log jam at 1,000ft (Photo 17). Bedrock exposure was the primary substrate feature below the jam. These abundant gravels overwhelm both the summer and winter rearing capacity of Olson Cr aquatic habitats (appendix 4, table E1) and therefore provide an important source of nomadic fry for seeding downstream habitats in the mainstem of Rock Cr.

This is the type of seasonal habitat balance that is necessary to utilize the vast rearing surface areas available in the lower mainstem of Rock. This is how the Rock Cr system as a whole used to work until the loss of integrated large wood in headwater tributaries drove the system toward the channel simplification that resulted in the loss of stored spawning substrates.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

Coho juveniles were observed at moderate densities (1.36 coho/sq. m.) throughout the majority of Olson Creek to RM 1.1 in 2009, during the Bio-Surveys LLC RBA inventory. Densities where much higher below the log jam averaging 3.01 coho/sq m. The average densities above the jam when isolated from the habitats below the jam where only 0.87 coho/sq m. This suggests that the log jam although not a definitive barrier, is functioning to delay and frustrate access to high quality head water spawning gravels. Much higher utilization of these gravels would be obtained if a series of large wood placements below the existing jam were designed to help step the incised channel up for adult passage. The current log jam is a very valuable asset that forms the foundation for all of the gravels stored above and should be maintained at all cost.

The density spike observed at the mouth of Olson Cr for coho juveniles during the snorkel inventory would normally be associated with a high temperatures in the main stem, but at RM 22.9 temperature data suggests that this is not the case in the mainstem of Rock Cr at this juncture. This leads us to conclude that the partial barrier is crowding adult spawners into a short 1,000 ft stream segment and they are seeding to capacity the limited gravel resources that exist there.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

During the 2009 RBA survey conducted by Bio-Surveys the average complexity score was a 2.2 on a scale of 1-5 (2 is 1-25% of pool surface area, 3 is 26-50% of pool surface area associated with cover). This represents a moderate level of cover.

It was noted during Bio-Surveys’ 2010 LFA field inventory that there was significant in stream wood complexity and gravel retention above the jam at 1,000ft, and below the jam wood and gravel where scarce. This reach was dominated by exposed bedrock and pools where not well developed. The lower 1,000 ft has definitively been the recipient of a dam break flood event that completely flushed all stored resources (wood / gravel) from this segment of stream channel.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

In the lower 1,000ft of Olson winter habitat is poor, providing no off channel winter habitat in the form of back waters or interactive floodplain terraces. Above this reach winter cover is high quality with low interactive terraces supplemented by beaver impoundment. Currently beaver activity is not as high as the residual evidence suggests it used to be but dam complexes are being maintained in the upper reaches.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction.

Directly above the jam there are interactive terraces resulting from the LWD impoundment. The majority of the 0.9 RM has alternating hill slope terrace morphology. In this reach floodplain interaction is frequent in areas with large wood. Above RM 0.9 the gradient begins decreasing and the floodplain becomes highly interactive. This upper reach has the majority of the active beaver colonies documented in Olson Cr. Much of this area is not being utilized by juvenile coho because it is above spawning gravel resources.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

Above the jam, channel complexity increases dramatically with very low terraces (<1ft) and an increased level of sinuosity. This section of the stream is functioning at a high level for the provision of habitats for salmonids at all seasons of the year. Below the jam there is potential to greatly increase the complexity and improve system function with wood placement but this lower reach is more hill slope confined and will never exhibit the level of meander and off channel habitats observed in the upper stream segment.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

The primary limitation in this stream is the inaccessibility of the upper reaches of the system for spawning and incubation. The main cause of this is not necessarily the jam itself but rather the degradation of the habitat below the jam (incised and scoured to bedrock).

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Adding full spanning wood complexity to the lower 1,000ft of Olson would create an approach to the barrier making passage much more likely.
2) Adding full spanning wood to the 3,500 ft upstream of the log jam would be recommended as a secondary priority.
3) Enhance beaver stability in a location of known beaver abundance by planting and protecting beaver forage species (Willow, Ash, Vine Maple, Cottonwood) above the tributary confluence at 4,500 ft.

Anchor sites

No anchor sites identified.

Secondary branches

No secondary branches were identified.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy

The lower 1,000ft of Olson has large mature conifers within the riparian corridor. Above this reach the stream becomes alder dominated with varying age classes of conifer plantation upslope. Above RM 1.0 there are areas of solar exposure due to a long term legacy of consistent beaver activity.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

The contemporary recruitment potential of large conifers in the lower reach of Olson is excellent. Above this, the recruitment of conifers depends on the preservation of riparian buffers.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The majority of the riparian corridor within the Olson Cr basin is intact. Above the mature conifer in lower Olson a strong alder buffer dominates the riparian corridor. The upslope is industrial forest that is all in an advanced state of recovery. The only solar exposure observed within Olson was associated with well-established beaver complexes that work to increase summer flow and are not currently contributing warm water because of stratification and subsurface release.

Military Creek assessment

Military Creek enters Rock Creek from the North West 0.25 miles downstream from the confluence of SF Rock Creek. This is approximately RM 26 on the mainstem of Rock Cr.

Migration barriers

No migration barriers where present during the 2010 LFA survey conducted by Bio-Surveys.

Temperature issues

According to the ODFW AQI conducted on July 28, 1993 the highest water temperature recorded in Military Creek that day was 58.5 degrees F. Since that time there has been extensive logging in the head waters of Military Cr. The impact of headwater harvest activity on current stream temperatures is undocumented relative to this historical temperature data.

There is significant opportunity for solar exposure (Photo 18) related to the abandoned beaver terraces that have not recovered vegetatively, exacerbated by a NW / SE aspect that likely prolongs the duration of daily solar exposure. The active channel has begun to incise within this historical beaver terrace and some solar protection is provided by the shadow of vertical banks.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

There were 28.2 sq m of fair quality spawning gravel observed in Military Creek during the 2010 LFA inventory. 71% of the these gravels were located below the confluence of Trib A (in the first 0.5 RM). The entire tributary is heavily burdened with deep sediments that reduce the incubation capacity of the gravels. There were no spawning gravels observed in Trib A.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

Coho use ended at RM 1.2 in a large heavily silted headwater swamp in both 2009 and 2010. 2009 was the most productive year, with an expanded total of 3,102 summer rearing coho parr and an average rearing density of 1.99 coho/sq m. The first 3,000ft of

Military Creek were the most productive in terms of densities and individual pool counts both years, likely due to the lack of quality spawning gravels in the upper reaches.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Good wood densities (60.2 pieces/100 m of stream length; ODFW benchmark > 20 pcs/100 m) were recorded during the 1993 AQI study conducted by the ODFW and an average complexity score of 2.9 was given (on a 1-5 scale). The 2010 LFA survey resulted in a similar conclusion. The first 0.5 RM has the highest wood densities and the best canopy closure. The 0.7 remaining miles of coho distribution exist within the confines of a series of abandoned beaver terraces with limited contribution to cover and complexity from the riparian because of the historical inundation that reset vegetation to early seral grasses and forbes.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The abundance of wood complexity associated with the active channel below Trib A provides substantial floodplain interaction and off channel refugia from high winter flows despite the morphological constraints of a hillslope confined canyon. Above RM 0.5 and including Trib A, the gradient decreases and the valley floor broadens to 100 ft. There are indicators of an extensive beaver legacy in this reach with the potential to provide ideal winter cover (Photo18). The 1993 AQI report lists 4 beaver complexes. The 2010 RBA inventory identified 6 active beaver dams.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction..

Below Trib A the stream is hill slope confined in a steep V shaped valley. Flood plain interaction in this reach is limited to small alternating terraces created and maintained by excellent accumulations of woody debris. Directly below the mouth of Trib A a legacy wood jam (likely from the 64 flood event) has created a wide interactive flat. Above this primary depositional plain, channel gradients decrease and the valley floor widens. The combination of broad floodplain and the presence of beaver has succeeded in maintaining a highly functional interactive floodplain.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The current level of channel complexity in this stream is high. However, there is the opportunity for increased complexity in and above Trib A. This upper 0.7 miles of low gradient channel morphology lends itself to the natural storage of winter run off. Enhancing both the water storage and salmonid production capacity of this upper basin site could be achieved through the development of off channel backwater habitat and the re-colonization of beaver.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Natural hillslope confinement currently limits the development of complex off channel habitat below Trib A.
2) Food sources for beaver are currently extremely scarce and limiting the persistence and potential expansion of beaver colonies.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

Yes. The planting of beaver forage would be required for removing the current limitation to what appears to be the historical productive capacity of the sub basin., This single restoration prescription would improve complexity, production and water storage capacity.

Anchor Site 1

Location and length

Anchor Site 1 begins at RM 0.5 just below the confluence of Trib A and continues up the mainstem 3,500ft to nearly the end of coho distribution. Anchor Site 1 also includes the first 1,500ft of Trib A.

Channel structure

Sinuosity within the anchor site is currently moderate but could be increased in the long term with increased impoundment which accelerates the development of complex channel forms.

Floodplain structure

Terraces within the anchor site are wide (100 ft) and uniform in elevation. They are a result of sediment deposition resulting from a legacy of impoundment, both beaver and LWD. In areas of beaver activity terraces are highly interactive, but reaches that have transitioned out of an impounded state are beginning to incise causing isolation from the floodplain in all but the highest winter flow regimes. The majority of these terraces are dominated by early seral grasses. There is a significant infestation of Scotch Broom beginning to colonize stream adjacent terraces in Trib A.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

The majority of the anadromous spawning that occurs in Military Creek occurs in the 0.5 mile stream segment below the anchor site. This leaves much of the identified anchor habitat under seeded. 2008 / 2009 was a significant return year for adult coho and densities within the anchor site only averaged 1.1 coho/sq m (compared to 2.6 coho/sq m below). 46% of all coho observed in Military Cr were rearing within the anchor site in 2009.The anchor site provides exceptional summer and winter rearing habitat.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

Within the anchor site spawning gravel is the main limitation to salmonid production. Only 29% of the total spawning gravel observed in Military Cr was located within the anchor site and no spawning gravel was present in Trib A. the primary reason for the spawning gravel limitation is the heavy silt load. With lower gradients in this reach the stream is unable to sort and clean the existing depositions of gravel.

Recent upslope harvest activity in the headwaters of Military Cr in conjunction with the heavy flooding experienced in 2007 have likely contributed to increased silt loading and the low gradient reach (Anchor Site 1) predisposes this stream segment to higher silt retention rates than observed in other stream segments.(with or without the harvest impacts).

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Riparian planting of forage species to encourage beaver recovery (the identified anchor exhibits a strong and recent legacy of beaver impoundment)
2) Place full spanning log structures to trap and sort mobile gravels. This treatment would likely provide a viable platform for stable beaver dam construction.

Secondary Branch 1

Location and length

Trib A enters Military Creek 3,000ft from its mouth and forks just upstream from its start. Including both forks there is roughly 2,500 ft of stream accessible for anadromous use.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

There was no spawning gravel documented in Trib A during the 2010 field inventory conducted by Bio-Surveys. In 2009 coho juveniles were present in very low numbers (126 expanded) and only observed in the first pool during the 2010 RBA inventory.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The complete lack of viable spawning gravels is the primary limitation here.

Addressing the limitations

There is no viable prescription for addressing these limitations.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian area below Trib A consists primarily of mature conifer with a narrow alder corridor tight to the stream. The canopy exhibits 95% closure. Above and including Trib A there is a mix of Alder and conifer with an open inner riparian dominated by early seral grasses and forbes. The only protection from solar exposure is the perimeter canopy that exists beyond 50 ft on each side of the active channel.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Large wood is readily available and abundant for future recruitment to the active channel below the confluence of Trib A. Above Trib A and including the Trib A corridor, recruitment potential is limited to sparse buffers beyond 50 ft. This predisposes this segment of stream channel to small wood contributions from naturally recruited tree tops well into the future. The recruitment of mobile wood to this section of stream channel is also limited due to the low gradient profile and it's headwater location where flows are diminished from arterial branching (Trib A).

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The wide terraces with grass dominated vegetation and sparse buffers leave much of upper Military Creek exposed to solar radiation. Currently, temperatures do not exceed the threshold for juvenile coho survival, but there may be negative cumulative negative effects to mainstem Rock Cr temperatures when combined with similar impacts in other headwater locations.

Selder Creek assessment

Selder Creek enters Rock Creek from the North West at approximately RM 12.

Migration barriers

Trib A, enters from the North 660ft above the mouth of Selder. A barrier falls terminates anadromous passage 560 ft above the Trib A / Selder Cr confluence. In addition, there is a culvert exhibiting a 4ft perch upstream of the falls (Photo 19). This combination of factors definitively terminates access for migratory fish species. Cutthroat are present and abundant above the falls. The perched culvert is undersized and not allowing natural resource migration (wood and substrates).

Temperature issues

A temperature gage at the mouth of Selder Creek, (UNWC) recorded temperatures that slightly exceeded the DEQ standard for 303 d listing of 64 degrees F from 07/12/03 to 08/01/03. It should be noted that mainstem Rock Creek becomes temperature limited near the mouth of Selder consistently from year to year.

Identifying the temperature impacts to the aquatic corridor in Selder Cr is critical for restoring the summer function of the habitats of mainstem Rock Cr below the Selder Cr confluence. This is a key tributary for addressing cumulative downstream impacts. There is no doubt that the long term protection of riparian corridors in the headwater tributaries (including some type N streams) of Selder will be required to correct the current observed conditions.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

In 2010, 17.6 sq m of fair and 84 sq m of good spawning gravels were quantified in Selder Cr. There were large gravel deposits throughout Selder but heavy silt loading has compromised the capacity of these gravels to provide high egg/fry survival rates (professional opinion, un-quantified). Selder Cr was visually classified as maintaining higher silt loads than any other Rock Creek tributary. The majority of the quality gravels were located above RM 1.0 where the increase in gradient begins to mitigate for silt loading with increased potential for hydraulic scour.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

Coho use terminated 3.5 RM from the mouth of Selder Creek in 2009. The following year distribution extended to RM 4.2. In 2009 the highest juvenile Coho counts and densities were located in the first 1mile of distribution and a peak rearing density of 2.6 Coho/sq m was observed at RM 0.5. 35% of the Coho Parr, including Selder Cr tributaries, were located in the first 0.6 RM of habitat and 19% were rearing in the first .1 RM.

Given the location of Selder Cr near the start of the temperature limited lower mainstem of Rock Cr,. it is likely that a percentage of the summer rearing Coho Parr observed in lower Selder Cr were upstream temperature dependent migrants from the mainstem of Rock Cr. These concentrations of summer rearing parr in lower Selder were not observed in 2010. It is likely that the cooler stream temperatures observed in 2010 in the mainstem of Rock Cr did not trigger the need for upstream migration to cool tributary refugia. In 2010 coho densities were higher above RM 1.0 where gravel quality is higher.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Good large wood densities where present during the 2010 LFA field work (Photo 20). The 1996 ODFW AQI recorded moderate wood levels of (35 pieces/100 m of stream length; ODFW benchmark > 20 pcs/100 m) but their inventory only included the first 2,900ft of Selder. The highest wood densities where located further upstream. Selder Cr contained legacy large wood recruited from the riparian as a result of a historical wildfire. This wood was creating diverse, complex and interactive summer habitats.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The high densities of large wood from historical wildfire were also creating complex winter habitats from enhanced floodplain interaction that has resulted in the development of off channel habitats. These off channel habitat features hold large numbers of winter rearing coho juveniles during even moderate winter flows. This level of naturally occurring large wood complexity is not common in Western Oregon Coast Range streams. The general trend for habitat complexity in Selder Cr will be negative as a result of the continual decay of these key pieces of legacy wood that cannot be replaced by the current riparian corridor.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction..

The lower 0.5 RM of Selder has a wide valley and is terrace constrained. This reach is currently entrenched four to five feet and is interacting with its floodplain at a very low frequency. This lower reach was scoured to bedrock in the 1996 flood from what appears to be a dam break flood event. Above the second culvert crossing the valley transitions to a moderate V valley form but increased large wood densities have retained migratory substrates that have in turn maintained a much higher level of floodplain interaction than observed in the lower 0.5 miles.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The potential for the development of complexity in lower Selder is high.. An increase in the abundance of full spanning large wood would aggrade the scoured stream channel and reconnect the active channel with its floodplain at a much higher frequency than currently occurs. There is also good potential for increasing channel complexity around RM 2.3 with the addition of large wood complexes. The reach of stream from RM 0.5 to RM 2.3 is currently functioning at a high level but additional wood recruitment from the riparian corridor is 75 years out.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) The lack of large wood in lower 0.5 RM
2) Long term riparian recruitment potential from RM 0.5 to RM 2.
3) Undersized culvert on Trib A limits resource transport to lower Selder and mainstem Rock Cr

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Full spanning LWD RM 0 – 0.5
2) Establish a permanent RMA to protect riparian corridor from being harvested to the active stream channel again.
3) Remove and replace culvert. In addition place a series of full spanning structures below the falls on Trib A to attempt to back water and provide passage for adult migrants to spawning gravels above the road crossing.

Anchor Site 1

Location and length

Anchor Site 1 starts 0.8 RM from the mouth of Selder and extends 2,500ft upstream.

Channel structure

The anchor site exhibits a high level of sinuosity. This is provided by the high density of large wood that resulted from fire toppled riparian conifers recruiting continually to the active channel. This natural process can only rarely be observed in coast range forests and has been a pivotal component of the high function observed in Selder Cr.

Floodplain structure

Most floodplain terraces are less than 2 ft vertical with a width of 75-100ft.. They exhibit indicators of frequent interaction as a result of large wood impoundment. They have been formed by the deposition of sediment and fines behind full spanning legacy wood jams. The primary vegetation that dominates the current floodplain terraces is early seral grasses and shrubs (salmonberry). Alder are scattered and less abundant than early seral vegetation classes..

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Summer and winter rearing capacity within this anchor are excellent because of the complex channel characteristics provided by high wood complexity that result in off channel back waters. These backwater and dam pool habitats provide increases in both summer and winter rearing habitat surface area. Spawning gravels were plentiful in and above the anchor site with 77% of the spawning gravel observed in Selder, in or above Anchor Site 1.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The primary limitation within Anchor Site 1 is the lack of any long term wood recruitment from the riparian corridor. The recruitment of substantial conifer is 75 years out. No riparian buffer was retained adjacent to the stream corridor within the anchor site during the last harvest rotation and solar exposure is currently present that impacts the mainstem of Rock Cr below the confluence of Selder Cr. Summer temperature profiles within Selder Cr , although currently not a primary limitation for salmonids, are likely to be rapidly degraded above DEQ thresholds with any future harvest impacts that increase aquatic solar exposure.(this includes some Type N streams).

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Riparian planting of beaver forage (willow, ash, vine maple) would mitigate for current solar exposure and encourage additional impoundment.
2) Protection of riparian buffers to ensure long term large wood recruitment and continued long term protection from solar impacts.

Anchor Site 2

Location and length

Anchor Site 2 starts RM 2.2 from the mouth of Selder and includes 3,500 lineal feet of stream.

Channel structure

Sinuosity is very low in Anchor Site 2. The wood complexity required to create the impoundment and aggradation necessary for stimulating floodplain interaction and complex channel forms is absent.

Floodplain structure

Terraces range from 2-3 ft. Floodplain widths are broad and extend to 250ft wide There is little evidence of significant floodplain interaction on the terraces however, suggesting that channel incision is on an increasing trajectory.. Old meander channels have been abandoned by the stream that used to be highly interactive during winter flow regimes. The primary riparian vegetation is 50+ year old Douglas fir with a mixed deciduous understory of shrubs. This is the location of multiple tributary junctions which is the primary morphological feature that facilitates the wide floodplain character that sets this habitat segment apart as an anchor site from other downstream locations.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Spawning gravels suitable for coho were scarce in this zone but summer rearing coho numbers began to increase in both 2009 and 2010 within the anchor.. Complex channel forms are not present here as a result of low wood density. The ability of this anchor site to provide significant low velocity winter refugia is low.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Summer and winter rearing is limited in this anchor because of the lack of complex channel forms. This lack of channel complexity is driven by the current low densities of instream wood.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) The addition of onsite large wood would increase floodplain interaction and boost channel and floodplain complexity.
2) The planting of beaver forage would also provide a platform for beaver colonization which would result in increased gravel retention for boosting headwater spawning.

Anchor site rankings

Function

Rank the identified anchor sites in terms of current function (1= best).

1) Anchor site 1
1) Anchor site 2

Restoration potential

Rank the identified anchor sites in terms of restoration potential.

1) Anchor site 2
1) Anchor site 1

Secondary Branch 1

Location and length

Trib A enters Selder Creek 850ft from its mouth and coho distribution only continues a short distance because of an 8ft bedrock barrier falls 435 ft upstream from the mouth. In addition, there is an impassable culvert above the falls with a 4 ft perch

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Because of the location of the barrier falls low in the system, Trib A does not play a significant role in the provision of spawning or rearing habitat for migratory salmonids. This tributary however, is an important contributor of cold water to the lower mainstem of Rock Creek that is temperature limited during low summer flows. There also appears to be considerable potential for gravel contribution from Trib A that is currently being restricted by the undersized and perched culvert above the falls.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The primary rearing limitation is the natural barrier falls located just upstream from the mouth of Trib A.

Addressing the limitations

There is a possibility that the introduction of full spanning LWD complexes in both the mainstem of Selder Cr and in lower Trib A could result in aggradation within Trib A that lifts the high flow channel elevation enough to provide passage at the barrier falls. The removal of the undersized culvert would be a more appropriate investment of restoration resources if this could be accomplished.

Secondary Branch 2

Location and length

Trib B enters Selder Creek from the west at RM 2.2. In 2009, coho distribution extended 0.7 miles and included utilization of the first few pools of Tributary B1.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

In 2009, the summer rearing coho population was 1,625 (expanded). The stream forks at RM 0.5 and 90% of the summer rearing coho found in Trib B were located below the forks. The average rearing density in this same reach was 1 coho/sq m In 2010 a summer rearing population of 36 (expanded) was observed. Winter rearing in this reach is good. Beaver activity and wood densities are high. It appears that substantial spawning and rearing is occurring here during years of strong adult escapement.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The current condition and complexity of the aquatic habitat in Trib B is excellent with the primary limitation being adult escapement.

Addressing the limitations

There are no addressable limitations.

Secondary branch site rankings

Function

Rank the identified branch sites in terms of current function (1= best).

1) Trib B
2) Trib A

Restoration potential

Rank the identified branch sites in terms of restoration potential.

1) Trib A
2) Trib B

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor varies widely throughout the Selder Creek system. The lower 700ft of the stream flows through pasture and exhibits significant solar exposure. Above the pasture reach, to the second road crossing at RM 0.5, large wood recruitment potential from riparian conifer is good with 100% canopy closure. Above the road crossing land use switches to industrial forest management and the primary riparian canopy is young stands of conifer reprod. This reach exhibits zones of solar exposure. In addition, this stream segment was harvested to the active stream channel with no riparian buffer retained. Current elevated temperature profiles are likely a result of the slow recovery of this un-buffered harvest.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Beginning at the top of the agricultural segment near the mouth to the second road crossing (RM 0.5) there is good future recruitment potential. Above the second road crossing and extending to RM 2.0, any significant potential for recruitment is 75 years out. Above RM 2 the riparian contains both a deciduous and conifer component that will be capable of providing wood to the active stream channel.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The reach of pre-commercial thinning that begins at RM 0.5 and extends to approximately RM 2 exhibits consistent solar impacts from a legacy of complete riparian harvest. It is likely that these impacts will decrease as tree height increases with age. There are also beaver flats throughout upper Selder and its tributaries that exacerbate these harvest impacts. These areas would benefit from riparian planting prescriptions designed to provide forage for beaver.(willow, vine maple, ash, cottonwood).

Maynard Creek assessment

Maynard Creek enters Rock Creek at RM 11.3.

Migration barriers

There was an ephemeral log jam that formed a passage barrier at 4,200ft. this jam terminated adult coho migration in 2009 but not in 2010.

Temperature issues

No temperature data was available for Maynard Creek.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

A total of 10.4 sq m of good quality spawning gravel and 7.9 sq m of fair spawning gravel was documented during the LFA inventory. The majority of this gravel was located between 500ft and 2,500ft from the mouth.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

In 2009 the expanded summer rearing abundance of coho parr was 2,184 and the average rearing density was 2.2 coho/sq m In 2010, the expanded summer rearing estimate for coho was 2,550 and the average rearing density was 1.2 coho/sq m. There were two beaver dam pools included in the sample in 2010 and an overall increase in the abundance of beaver dams (up 40%). Beaver dam habitat was responsible for 57% of the summer rearing population of coho in 2010. This illustrates the importance of beaver dam habitat for immediate expansions of potential rearing habitat. Both years the zone exhibiting the greatest production occurred between 500 and 2,500ft.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The reach providing the highest quality and most productive summer cover was also the reach with the best spawning gravel from 500ft to 2,500ft. This reach had active beaver dams that provided ideal summer rearing surface area.. Above this reach the small size of the stream limited both spawning and rearing potential. The majority of the stream corridor displayed excellent canopy cover and channel roughness.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The majority of winter cover in Maynard is currently provided by beaver impoundment. Additional wood complexity provided supplemental cover in both impounded and un-impounded stream segments. Without the presence of these high quality beaver dam habitats Maynard Cr would exhibit weak winter linkages. The reach of best winter rearing was from the mouth to 2,500ft.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction.

Flood plain interaction is limited in Maynard Creek above 2,500ft because of the hillslope confinement that results in a narrow canyon morphology. The lower reach of Maynard Cr exhibits highly interactive floodplains during winter flow regimes as a result of beaver impoundment.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The lower reach (0 – 2,500 ft) has the characteristics necessary for the establishment of complex channel forms in addition to the current level of floodplain interaction provided by beaver impoundment. Increases in channel roughness would exhibit immediate benefit to the development of channel complexity. In addition, there appears to be an increasing trend in the abundance of beaver dams with 5 observed in 2009 , 7 observed in 2010. In the upper reaches of hill slope confinement there is no potential for the development of additional channel complexity. This reach is still important for the storage of spawning gravels and summer rearing.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) The primary limitation for coho in Maynard Cr is stream size and channel morphology above RM 0.5. Current conditions within Maynard Cr represent a very high state of function for coho production.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Protecting the riparian area to ensure future large wood recruitment.

2) Providing for continued beaver utilization by ensuring an adequate food source remains viable in the inner riparian corridor.

Anchor sites

There were no anchor sites identified in Maynard.

Secondary branches

No secondary branches were identified. .

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The first 2,000 lineal feet of Maynard Creek has good canopy cover (75%). However at 2,500 ft there is a 1,000ft reach with little to no harvest buffer which has resulted in extensive solar exposure. Again at 4,200ft a narrow harvest buffer exhibits heavy blow down loss which has also resulted in significant solar exposure. Each of these upslope impacts contribute to the temperature degradation observed in the mainstem of Rock Cr that have been described in this document as the sum total of the cumulative impacts occurring in tributaries just exactly like Maynard.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Riparian recruitment potential for Maynard Cr is good. Because the active channel width is only 6 ft , both deciduous and coniferous contributions from the riparian will be well retained and form functional instream wood complexity even at winter flows.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No temperature data was available for Maynard, but the solar exposure associated with the lack of riparian buffer associated with upslope harvest activity has been identified as a primary limitation for salmonids on the Rock Cr basin scale.

Bear Creek (Rock Cr) assessment

Bear Creek enters Rock Creek 670 ft upstream from Rock Creeks confluence with the mainstem Nehalem River. The confluence is in Anderson Park in downtown Vernonia.

Migration barriers

There were no adult migration barriers observed within the inventory.

Temperature issues

Temperature data collected by the Upper Nehalem Watershed Council and its partners was inconclusive because the thermistors deployed were exposed to air during the inventoried year. Bear Cr has been dry (no contiguous surface flow during both 2009 and 2010 summer snorkel inventories). Because the stream regularly dries up during midsummer flows, it is likely that temperature becomes a serious summer limitation for rearing salmonids.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

During the 2010 LFA field inventory there were 3.5 sq m of good spawning gravel documented in Bear Creek above the urban use area (0.5 miles). Within the urban use area, there is no spawning gravel suitable for adult coho.

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

During the 2009 and 2010 RBA snorkel inventories the stream was reported to have no flow and no coho were observed in the first 500ft of the stream. The survey was terminated because of the absence of coho. Coho were however, documented above the urban use area (RM 0.5) during the spring of 2005. This information was extracted from the Upper Nehalem Habitat Assessment Report It is possible that surface flows are retained above the urban use area during pinch period summer flows but this was not verified during the extent of this analysis.

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Because the lower reach of Bear Creek frequently stops flowing during summer months it cannot be considered viable summer rearing habitat. It is possible that the upper reaches of Bear Cr maintain flow and do provide some summer rearing habitat. This was not verified by Bio-Surveys.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Within the urban use area of Bear Creek there is no winter rearing habitat. This condition is the result of low channel complexity, deep channel incision and the historical treatment of the stream corridor as primarily a drainage corridor.. Current channel form is the result of urban manipulation and wood complexity is non-existent. Above the urban use area there is more wood complexity and better pool development. The stream still does not exhibit a high degree of floodplain interaction and off channel winter rearing habitat is poorly represented. The best winter rearing location is a large dammed pool just upstream from the urban use area.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction.

Floodplain interaction is severely limited in the urban use reach because the stream flows through town and has been manipulated to stay well entrenched within its active channel. Floodplain interaction is also limited in the upper reaches because of the lack of large wood and consistently increasing valley constraints.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

The potential for increasing floodplain interaction within the urban use area is extremely low because of the implications for flooding residential terraces. Above the urban use area there is some potential to enhance the storage of winter flows. The addition of LWD complexes or the encouragement of beaver utilization would increase channel complexity.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Human manipulation within the residential landscape constrains natural process.
2) The lack of beaver impoundment.
3) Lack of LWD complexity

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above

1) No restoration prescription is available for addressing the limitations existing within the residential corridor.
2) The lack of beaver impoundment could be addressed by the provision of beaver forage in the upper 0.5 stream miles above the residential corridor.

3) Wood complexity would likely have the least return on the investment because of the low hydraulic potential in Bear Cr that would be required for transporting and aggrading gravel resources for spawning.

Anchor sites

No anchor sites were identified.

Secondary branches

No secondary branches were identified.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The 2005 Upper Nehalem Habitat Assessment Stream Report for Bear Creek indicated that the urban use reach was solar exposed, with only 48% canopy cover. The 2010 LFA also observed significant solar impacts within the urban residential area. Riparian planting has taken place throughout this reach over the last several years. This will provide future riparian closure and assist in mitigating for the cumulative impacts to the mainstem of Rock Cr.. Above the urban use area canopy cover was quantified at 81% in the UNHASR.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

The only reach with riparian recruitment potential was above the urban use area on industrial forest ownership. The upper basin reach exhibits canopy components currently available for recruitment to the active channel.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The solar exposure observed in the lower 0.5 miles of Bear Cr likely contributes to mainstem Rock Cr elevated temperature profiles until surface flow is terminated. The period of elevated temperature contributions is likely very narrow (period un-quantified).

Rock Creek assessment

Rock Creek enters the Nehalem River at RM 91 in the town of Vernonia. This survey started from its mouth and continued up to the end of coho distribution at RM 27.5.

Migration barriers

A trash rack at the inlet end of the undersized HWY 26 culvert on mainstem Rock Creek accumulates large quantities of transient detritus and woody debris (Photo 23). This infra-structure designed to protect an under sized culvert does not appear to be included in a regular highway maintenance schedule. The current accumulation of debris has formed a vertical falls that is a definitive juvenile barrier and likely functions to delay adult salmonid migrants at the very least. This is a high risk impediment to migration because it exhibits the potential for isolating some of the highest quality coho and steelhead spawning and rearing habitat in the basin.

Frequent natural juvenile barriers in the form of bedrock steps where noted starting above RM 12. These steps suggest that tributary habitats are critical for providing thermal refugia during elevated summer temperature profiles in the mainstem of Rock Cr.

An undersized culvert on Trib C of mainstem Rock Cr is a juvenile barrier and isolating important thermal refugia for salmonids seeking escape from elevated summer temperatures in the mainstem .

Temperature issues

The Rock Creek mainstem exceeds DEQ water quality standards for temperature everywhere below the confluence with Selder Creek (at RM 12). This limitation occurs during summer low flows and has been documented multiple years between 1993 and 2005 by the Upper Nehalem Watershed Council and its partners. The thermistors that regularly registered temperatures meeting or exceeding (17.8 C) were located at RM 14, RM 10, RM 3, RM 0.9, and RM 0.1. According to the temperature profiles displayed from these sampling sites, temperature limitations became more acute in the lower three miles of the mainstem of Rock Cr (Photo 24).

Superimposing the 2009 coho distribution layer on top of the mainstem Rock Cr temperature profile suggests that the lower five miles of mainstem Rock Creek maintains summer temperatures that severely limited the aquatic habitats capacity to summer rear salmonids. In 2009 individual pool counts of coho began to increase above RM 5 and the highest individual pool count observed in the mainstem were documented at RM 9.5. This aggregation of coho parr at RM 9.5 supports the existence of an upstream temperature dependent migration in the mainstem for coho fleeing the environmental stress of elevated temperature that has been observed to have significant physiological (survival, prey avoidance, condition factor) ramifications for juvenile salmonids.

In 2010, summer rearing temperature limitations were not as severe with a higher abundance of juvenile coho rearing in the lower mainstem of Rock Cr. Because this extended mainstem distribution was observed on a lower adult escapement year than

2009 the most likely explanation is that nomadic fry from upper basin spawning reaches were able to reside throughout the summer in the mainstem because of cooler temperature profiles (documented).

An extensive legacy of logging, agricultural use and residential development on Rock Creek, dating back to the early 20th century and continuing to the present, has left much of the aquatic corridor over exposed to solar radiation. This is a cumulative impacts issue that begins to develop in headwater reaches long before the lower mainstem of Rock Cr displays its acute symptoms. From the headwaters to the mouth there are many areas that have been identified in this analysis for treatment. These sites include the maintenance of functional harvest buffers and lower basin riparian setbacks that protect the active channel from compounding solar exposure.

Aquatic habitats overview

Spawning gravel

Describe the quantity, quality and location of spawning gravel.

There was a total of 594.8 sq m of spawning gravel observed in the 2010 LFA inventory within the mainstem of Rock Creek from its mouth to the end of coho distribution at RM 27.5. 95% was classified as good quality. From the mouth to the end of Keasy Rd (RM 14) there was a total of 162 sq m of spawning gravel (27% of the mainstem total). The reach from RM 14 to the confluence of Olson Creek near RM 21.5 contained 138 sq m of spawning gravel (23% of the mainstem total). The reach from Olson Cr to the end of distribution at RM 28.1 contained the remaining 50% of spawning gravels observed in the mainstem. This upper segment of mainstem of Rock Cr is approximately 22% of the total lineal distance.

For perspective, it's important to recall the quantities of spawning gravel documented for Rock Creeks primary headwater tributaries, NF Rock (total spawning gravel = 358 sq m) and SF Rock (total spawning gravel = 434 sq m). All 28.1 miles of mainstem Rock Cr contains only 37% more spawning gravel than just one of these headwater tributaries (SF Rock). This conclusion of low spawning gravel abundance will be important when this analysis reviews the results of the habitat based modeling exercise in the Restoration Analysis section of this document

Summer juvenile distribution

Describe the summer distribution of coho juveniles. Include a description of the resources used.

The 2009-10 RBA snorkel inventory documented an expanded estimate of coho parr of 106,926 in 2009 and 83,466 in 2010 for the mainstem segment of the basin.

Limited summer coho use was documented in the mainstem of Rock below RM 5 in 2009 during a temperature limited summer and increases in utilization were noted for this same reach in 2010 when summer stream temperatures were lower. In 2009, a year with elevated mainstem temperatures, there were only 2,724 (expanded) summer rearing coho parr observed. In 2010, mainstem Rock stream temperature were less of a limitation and 5,898 coho parr were observed in the lower 5 miles of the mainstem. This amounts to 2.5% of the mainstem total coho abundance in 2009 and 7% 2010. The increased utilization during cooler stream profiles occurred even though overall coho abundance was lower in 2010.

Individual pool counts of Coho started to noticeably increase after the first five miles, but densities remained low because of large pool size. Individual pool counts of coho fluctuated greatly from the mouth to RM 21. The abundance of coho in a pool seemed to relate to the amount of large wood complexity associated with it.

Rearing densities increased steadily above Olson Creek reaching pronounced and strong spawning peaks near SF Rock in 2009 and further up near the end of distribution (RM 26.5) during 2010. The mainstem of Rock above the confluence of the SF Rock contains the best spawning gravels in the mainstem In 2010, the average rearing density for this reach was 1.71 coho/sq m and in 2009 it was 2.75 coho/sq m.

Mussels are present in the lower mainstem but not abundant (un-quantified).

Summer cover

Describe the character and distribution of summer cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

The lower mainstem from the mouth to the end of Keasy road at RM 14 in general, offers significant future potential for the provision of high quality summer cover. There are intermittent accumulations of complex wood and side channel habitats that exhibit the structural cover components of high quality summer habitat that are currently underutilized because of summer temperature limitations.

The stream is large in this reach with a 60-70ft active channel width and does not currently display frequent wood interaction from its riparian corridor. Wood exists only in the form of jams that are broadly distributed and rely on the transport hydraulics provided by winter flow regimes. The dominant inner riparian vegetation is Reed Canary Grass which terminates seral progression because of its ability to out compete woody species. This locks the inner riparian into an early seral plant community and compromises the development of the woody band of stream side vegetation that would have historically provided cover to juvenile salmonids from overhang.

There are isolated segments of extremely high cover complexity in the form of large wood that is creating channel braiding, back waters and complex cover from predation.

The highest fish numbers in this reach during both the 2009-2010 snorkel inventory were tightly associated with these brief zones of concentrated cover and complexity. Even though stream gradients are not high (0.2%) in this reach , there are still good pool riffle complexes and the flow is not stagnant even during low summer flow regimes

The mainstem above RM 14 transitions into a very constricted zone of hillslope confinement displaying distinctly higher stream gradients (2%) and the riffle / rapid habitat structure that is more heavily utilized by steelhead than coho. This uniquely different stream segment extends approximately 3.5 miles to RM 17.5.

From RM 17.5 to Olson Creek there is very little large wood complexity and bedrock exposure was a more dominant feature than observed below or above. In 1992 the ODFW gave this reach an average complexity score of 1.4 on a scale of 1-5 and classified it as having little to no large wood. Pools consistently lacked any form of summer cover and any coho juveniles were very tightly associated with small clusters of overhanging wood complexity.

Above Olson Creek, gradients decrease to an average of 1% and large wood densities increase. Pools are smaller with more variation and good depth (indications of scour associated with the presence of wood).

Above the confluence of the South Fork stream order decreases resulting in a smaller wetted summer channel width (10ft) and Beaver activity becomes frequent. This stream segment provides the highest quality summer rearing habitat available in the entire Rock Cr basin (on parr with the high quality segments observed in both the SF and NF Rock). In 2002, ODFW noted wood densities from 8-54 M3/100m.

Winter cover

Describe the character and distribution of winter cover. Note that this evaluation generally lacks quantitative measurement, and relies on professional judgment.

Winter cover is present throughout the lower mainstem below RM 14. This winter habitat exists in the same locations that were observed as providing high quality summer rearing habitat. These sites are broadly dispersed but exhibit extensive back waters, side channels, and low terraces. These sites exhibit highly interactive floodplain habitats during elevated flows that are providing high quality off channel refugia during winter flow regimes. Large wood jams in association with low terraces are the key in creating and maintaining the function observed. These sites have been identified on the final map contained within this document and identified as “Anchor Sites”.

From RM 14 to the confluence with Olson Cr (8.3 mile segment) there is virtually no winter refugia. Hill slope constraints steeper gradients and low wood densities combine to reduce the winter capacity of this segment to provide low velocity refugia during high flows.

One mile above the NF confluence, a large full spanning log jam exists at the historical road crossing to the old Inman-Paulsen mill pond. The jam was formed by collapsed bridge stringers that still form the key log foundation for the jam. From this point up to the headwaters of Rock Creek the flood plain widens and there are many locations that exhibit good potential for the provision of winter rearing habitat. Beaver impoundment, interactive terraces, and back water complexes all offer complex off channel winter flow refugia in the upper basin. The abundance of beaver dam habitats has declined substantially since 2002 when ODFW documented 24 dams in Rock Creek above the SF Rock confluence. In 2010 there were only six observed during the summer RBA snorkel inventory.

Channel form and floodplain interaction

Describe the channel form and degree of floodplain interaction.

From the mouth of Rock Cr to RM 14, the valley floor is wide (>300ft) and the stream is terrace constrained with oscillating hill slope confinement becoming more frequent above the confluence of Selder Cr. Land use is largely rural residential and alternates between pasture and managed stands of conifer (<50yr old). Floodplain interaction is not common or extensive overall but there are sites (identified as anchors) with exceptional floodplain interaction that are extremely important for the retention and restoration of habitat diversity for maintaining salmonid populations in the lower mainstem.

There is a radical transition in stream channel morphology above RM 14. Gradients increase and the stream becomes primarily hill slope constrained. Substrates transition immediately to large cobble and small boulder with extensive stretches of exposed bedrock. This begins an area of very limited floodplain connectivity, extending upstream to RM 20. Above RM 20, the floodplain broadens to > 300 ft and the potential for floodplain interaction becomes more frequent. Bedrock exposures are still common with low wood densities resulting in poor substrate retention. This reach continues to the major log jam above the NF Rock confluence.

Floodplain interaction increases substantially above the full spanning jam at approximately RM 24.3. The valley floor is wide with low interactive terraces. Limited wood complexity creates high quality winter cover where it is present and gravels become the dominate substrate. Much of this complex habitat that is currently functioning well is trending toward simplification because of the lack of full spanning LWD complexes.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.

There is extensive potential within the Rock Creek mainstem to increase floodplain interaction and complexity. The only reach that does not show potential is the stream segment from RM 14 to RM 18. This reach is morphologically constrained and does not exhibit the potential to develop complex channel characteristics. The high priority reaches for developing channel complexity are contained within “anchor sites” these sites will be discussed specifically in the anchor site section of this document.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Morphological constraints from RM 14 to RM 18.
2) The lack of full spanning wood jams limits the streams ability to trap and store transient substrates (gravels and cobbles) that cause channel aggradation and consequently interactive floodplains.
3) Diminishing beaver populations in upper Rock Creek mainstem above the Hwy 26 crossing
4) The natural attrition of existing legacy wood jams that are not being replaced from riparian or hillslope failure sources.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) The introduction of full spanning LWD complexes would aggrade transient bedload materials reconnecting the flood plain on a higher frequency.
2) Protecting, enhancing and encouraging beaver population recovery throughout upper Rock Creek.
3) Protect riparian buffers and implement riparian plantings to ensure future wood recruitment to maintain natural function.

Anchor Site 1

Location and length

Anchor Site 1 is located at RM 2.5 and includes 1,600 lineal feet of mainstem Rock Creek.

Channel structure

Sinuosity is very high throughout this anchor, with extensive back water habitat resulting from old channel meander. A full spanning wood jam has redirected the channel leaving the old channel acting as a large back water that exhibits high function during all winter flow regimes.

Floodplain structure

Terraces are low and interactive (3 – 4 ft) during most winter stream elevations. The riparian is dominated by Reed Canary Grass which results in extensive solar exposure at this site during summer low flow (Photo 24). There are alder present on the outer riparian but no conifer exists to provide the key log components that this site will need for long term persistence. Because of the current high level of sinuosity, the site may be capable of retaining mobile wood components delivered from the headwaters.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

This anchor site contains gravel resources but it is unlikely that coho spawn here because of its proximity low in the basin. The general nature of adult coho is to push as high as flows will allow them to access in headwater reaches of the basin. Chinook would be more likely the salmonid observed utilizing the gravels present within the anchor. Elevated summer temperatures are also limiting summer juvenile use in this reach.

The abundance of coho parr is very low and will not improve until water quality improves during pinch period summer flows. Because this reach has the characteristics of complex channel form and ample back water habitats it probable that this anchor is primarily functioning as winter refugia for juvenile salmonids flushed out of simplified headwater reaches (low wood complexity).

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) The primary rearing limitation in Anchor Site 1 is the temperature limitation that occurs during pinch period summer flows for the provision of viable water quality for salmonids.

2) Lack of a mature large conifer resource in the riparian that can be effective at providing channel roughness, encourage floodplain interaction and provide the height required to shade a broad active mainstem stream channel.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) The addition of multiple edge oriented large wood structures within the anchor site and below the identified anchor would enhance and maintain the winter linkage of the off channel oxbow habitat.

2) Riparian planting within the anchor site to increase long term recruitment potential very specifically where it will be most effective when recruited to the active channel in future decades. Additional planting throughout zones of solar exposure to mitigate for cumulative temperature impact (this is lower priority because of its lower basin location even though summer temperature is the primary limitation for salmonids).

Anchor Site 2

Location and length

This anchor site is located in lower Rock Creek at RM 5 and includes 3.500 lineal feet of mainstem Rock Cr.

Channel structure

The channel is highly sinuous in this area, with back water habitat and braiding created by large wood complexity and broad channel meander.

Floodplain structure

Terraces are low and wide exhibiting signs of frequent winter interaction. Large wood complexes are present that extend well up onto the adjacent terraces suggesting the site is stable, well anchored and a prime location for structure enhancement that can be effectively secured. Reed Canary Grass is the dominant riparian species and the interactive floodplain terraces exhibit very low densities of any woody species which leaves the site solar exposed and unprotected from scouring winter flows.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Spawning gravel suitable for coho was scarce in this zone and elevated summer temperature remains the primary seasonal limitation to salmonid production. It is within this anchor site that the abundance of summer rearing coho began to increase in both the 2009 and 2010 snorkel inventory. The increased complexity of the habitats within the anchor site described as high sinuosity and low interactive terraces provide an excellent foundation for the provision of winter habitat. Other seasonal habitats appear to limit the production potential of Rock Cr however, long before the competition for viable winter habitat becomes a survival issue.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1 Even though juvenile salmonids were utilizing this zone during both the 2009 and 2010 RBA inventory, their low abundance suggests that elevated summer temperatures still inflict a seasonal limitation on their ability to fully utilize the rearing potential of the habitat.

2 Sparse riparian canopy limits the long term potential of wood recruitment to the active channel. This results in limited cover and complexity and additional solar exposure that exacerbates the cumulative impacts of elevated stream temperature already existing in the mainstem as it arrives to the anchor site.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Riparian plantings within the anchor site in zones of solar exposure would assist in addressing the identified cumulative impact on stream temperature. Planting within the anchor site would also help future recruitment for the provision of habitat complexity and structure.
2) This anchor is currently functioning at a high level but the introduction of edge oriented full spanning LWD complexes would increase terrace interaction and ensure prolonged function of the site.

Anchor Site 3

Location and length

This anchor site is located in lower mainstem of Rock Creek. The center of the 3,500 ft lineal anchor is at RM 8, 1.3 miles downstream from the first crossing of Rock Cr by Keasy Rd.

Channel structure

The channel is highly sinuous in this area, with a large secondary channel habitat created by the recent formation of a new primary channel (Photo 25) that is in the process of abandoning a large mainstem oxbow. The stream has recently carved a short pathway through a 15 ft high peninsula where the primary winter flows are currently directed. This new channel has resulted in a reduction in winter hydraulics in the old channel that will make it premier low velocity winter habitat for rearing salmonids.

Floodplain structure

Terraces are exceptionally low in this anchor with frequent interaction taking place. The primary vegetation is alder and deciduous shrub with scattered conifer present. There is extensive potential for increasing floodplain water storage and off channel rearing habitat within this anchor site. This potential relies on the reconnection of oxbow habitats that remain truncated by the fill from a 220 meter segment of a historical Rail Road that bisects the historical stream channel.

There are both upstream and downstream habitat linkages on the floodplain within this oxbow that have been seriously compromised by the Rail bed and the restoration of this site addresses the issue of accelerated hydraulic power within the mainstem of Rock Cr that have exacerbated historical flooding. There is no better example of unrealized restoration potential within the mainstem of Rock Cr than can be observed within the floodplain of this anchor.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

As with the majority of the lower mainstem of Rock Creek, spawning gravels are more suitable for Chinook within the anchor. The summer temperature limitations documented by the UNWC , although still present, become less severe in amplitude and duration within this anchor. In both 2009 and 2010 RBA inventories, there were significant numbers of summer rearing coho present in this reach. Coho abundance however, was still far below the habitats measured carrying capacity (ODFW AQI data). Given the high level of function and complexity, the site ranks extremely high for the provision of large surface areas of low velocity winter refugia.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Floodplain habitats truncated by the historic Rail line that crosses the meander belt of mainstem Rock Cr within this anchor has impacted stream hydraulics and eliminated approximately 500 lineal meters of spawning and rearing habitat.
2) Elevated summer temperatures as a result of cumulative headwater impacts continues to limit summer salmonid carrying capacity.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Breach the Rail road bed on both the upstream and downstream end of the historical oxbow to reconnect approximately 500 meters of historic mainstem Rock Cr stream channel.
2) Riparian planting in zones of solar exposure to assist in addressing cumulative upstream temperature impacts.
3) Acquisition of riparian setback throughout this anchor to ensure future wood recruitment and continuation of a high functional state.
4) Improvement of existing off channel backwater complexes. Could be incorporated with existing small cold water tributary on the North East side of the anchor site and would increase the availability of off channel rearing habitat

for both summer and winter. This would also increase winter water storage potential

5) The addition of full spanning LWD complexes throughout the anchor site to ensure continued function (floodplain linkage) and increase habitat complexity. This would also slow winter hydraulics and provide additional winter capacity to service the winter habitat needs of non volitional presmolt migrants from many dysfunctional headwater reaches.

Anchor Site 4

Location and length

Anchor Site 4 begins at RM 10 and extends 3,200 lineal feet upstream on the mainstem of Rock Creek.

Channel structure

Sinuosity is very high throughout this anchor. A large full spanning wood jam (very rare in the mainstem) has created channel meander, braiding and backwater complexes. The jam is ephemeral and largely composed of LWD components that do not necessarily display key log characteristics. Large amounts of gravel are currently being stored by this jam. The active channel is unusually wide within this anchor (100ft). This creates unique channel and flow characteristics that in turn provides beneficial habitat diversity for both summer and winter rearing salmonids..

Floodplain structure

Terrace elevations are highly variable within the anchor site and range between 2 and 8 ft. The lower terraces display indicators of frequent interaction directly related to the presence of the full spanning wood jam. The jam is reducing winter velocities and facilitating the deposition of migratory fines and sediments below the jam that have vegetated and have stabilized into permanent structural features on the floodplain. Again, these low terraces are highly dependent on the stability of the giant wood jam observed here.

An extensive low terrace on the north side of the anchor site has two small tributaries that traverse its 150 ft wide platform. The zone accessed by these tributaries provides extensive potential for the provision of winter refugia. Reed Canary Grass has become the dominant vegetative feature and is beginning to severely limiting the ability of the floodplain terraces to advance from an early seral condition to larger woody species that are important for providing the long term stability within the anchor site not currently provided by the ephemeral wood jam (Photo 27).

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

Even though the anchor site exists within a reach still listed as water quality limited by elevated summer temperature by the DEQ, there is still significant summer rearing of coho occurring . During the 2009 RBA snorkel inventory a pool associated with the large wood jam in this anchor held 1,050 summer coho parr. This was one of the highest pool counts observed in all of mainstem Rock Cr that year. Because the anchor site exists near the zone where temperature limitations begin to weaken in amplitude and duration (classified as temperature limited to RM12), we would expect this to be the zone that was also receiving upstream temperature dependent migrants from the lower 10 miles of mainstem Rock. This transition zone then becomes even more significant when viewed within the context of its basin scale importance. Critical cover (massive full spanning jam) and cold water (north tributaries) provide unique summer refugia here for reducing the physiological stressors of elevated temperature and constant pressure from avian and piscivorous predators in the lower mainstem with low wood density.

Within the anchor, there was 59 sq m of spawning gravel quantified during the 2010 LFA. It should also be noted that an additional 81 sq m of spawning gravel was located in the 3 mile section just above this anchor site. This represents 24% of the total mainstem spawning gravel observed. With the combination of good full spanning wood complexity, interactive floodplain, good gravels, and the cold water contribution of two small tributaries it is likely that this is a unique location capable of rearing disproportionately large numbers of salmonids during both winter and summer flow regimes.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Even though juvenile salmonids were observed utilizing this anchor site, warm stream temperatures emanating from the Selder Cr sub basin just above this anchor site still predispose the anchor site to the potential of a summer temperature limitation..
2) The active channel is solar exposed because of the Reed Canary dominated riparian that suppresses seral development.
3) Full spanning LWD complexes are not present in the lower anchor. In addition, key log features are also not present to provide long term stability for the ephemeral jam at the top end of the anchor site.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Riparian planting within the anchor site to increase recruitment potential, provide cover, shade and vegetative diversity. Additional planting throughout zones of solar exposure to address cumulative temperature impact.

2) Create backwater/alcove that incorporates adjacent cold water tributary (north side) to increase both summer and winter off channel rearing potential. This would also increase the water storage capacity of this broad floodplain terrace.
3) The addition of edge oriented LWD in the lower portion of the anchor site would store additional gravels and increase the frequency of terrace interaction. These placements would also assist in maintaining higher summer water tables on the broad floodplain terrace.

Anchor Site 5

Location and length

This anchor site starts upstream from the mouth of Selder at RM 12.5, and includes 1.8 miles of mainstem Rock Creek and the lower 1,000ft of Fall Creek. The portion of Fall Cr included in the anchor site traverses the Rock Cr floodplain and terminates at the county road culvert crossing. This habitat segment is integrally associated with mainstem Rock Cr habitats.

Channel structure

Sinuosity in this anchor was high but the channel lacks the complexity and roughness normally associated with wood. There is considerable potential to increase complexity, aquatic cover, pool scour and roughness with the addition of LWD.

Floodplain structure

Terrace height fluctuates from three to five feet. Terraces are not lineally contiguous throughout the anchor site but can be described more accurately as consistently associated with each meander bend. Between these short interactive terraces are zones of hillslope confinement exhibiting no significant floodplain potential. Floodplain interaction is taking place throughout the anchor, but it is not generally extensive. Vegetation is a mix of alder, maple and conifer with a healthy and diverse mix of deciduous understory. Good canopy closure is present throughout the anchor site and there are no impacts from the solar exposure commonly observed below this juncture..

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

The mainstem pools in this reach are still very large so the documented rearing densities remained low. The anchor site exhibited good individual pool counts of coho during both 2009 and 2010 RBA surveys. Coho numbers declined precipitously during both years after proceeding upstream above this anchor site. During the 2010 LFA inventory there were 97.8 sq m of spawning gravel documented within the anchor. This represents 16.4% of the mainstem total.

Temperature is still a concern in this zone but likely only during the hottest years. Winter rearing is likely taking place here but because of the smaller terrace surface areas and the higher terrace heights, it is more likely that juvenile salmonids wintering within the anchor site are short term residents as they pulse on and off of these stream adjacent terraces with the cycle of winter freshets. There appears to be extensive untapped potential for increasing floodplain interaction and complexity through restoration.. This would greatly improve both the summer and winter rearing capacity of Anchor Site 5.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Channel degradation from the lack of full spanning large wood complexity results in a simplified channel that limits the anchors potential to form complex off channel habitat types. In addition, the lack of roughness in the form of wood, reduces the streams scour potential within the anchor, which results in poorly sorted gravels for spawning.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) The addition of edge oriented LWD jams would benefit this area by aggrading and sorting bedload material (spawning gravel), increasing floodplain interaction, water retention on the floodplain and the development of interactive backwater habitats. This action will increase the complexity and function of winter rearing habitat. Large wood should also be added to the lower 1,000ft of Fall Cr as part of this prescription.

Anchor Site 6

Location and length

Anchor Site 6 begins at RM 22.8. this is approximately 0.5 miles above the mouth Olson Creek and extends 2,000 lineal feet upstream.

Channel structure

Sinuosity is low in this short anchor. The stream is constrained by a logging road that runs down the center of the floodplain isolating the active channel from its historical meander belt.

Floodplain structure

Terraces are low, broad and capable of being interactive. Currently interaction is limited because the stream lacks the impoundment that would have historically been driven by the accumulation of naturally recruited wood from the riparian. Currently this higher gradient anchor exhibits low function. Bedrock intrusions that intersect the active channel have prevented down cutting and terrace isolation. Vegetation on the south side of the stream is primarily alder with a diverse deciduous understory. The north side of the stream is young re-prod (20years).

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

This anchor was summer rearing significant numbers of coho juveniles but rearing densities consistently fell far below the observed potential of the site. Pool complexity was poor, channel roughness was poor and consequently there was limited cover for protecting summer parr form predation. Spawning gravel was scarce in this anchor an obvious response to extremely low wood densities. Exposed bedrock was present throughout much of this zone. Pools were shallow and not well developed.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) The absence of large wood complexity has resulted is the lack of high functioning winter and summer rearing habitats.
2) Spawning gravels are not being stored because of this systemic lack of large wood complexity.
3) The valley floor road is isolating the stream from a large tributary (Trib C) fed wetland area that was once part of the mainstem floodplain. Currently the stream is flowing through an undersized pipe and is a juvenile barrier.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) The addition of full spanning LWD complexes would aggrade bedload, retain spawning gravels, increase pool complexity, and aggrade the active channel to increase floodplain interaction. This would dramatically improve the primary limitation for the production of salmonids within the anchor site.
2) Remove and replace the undersized culvert on Trib C (within the anchor site) to increase juvenile access to the high quality summer refugia in Trib C.

Anchor Site 7

Location and length

Anchor Site 7 begins at RM 23.6 (0.5 miles) above the mouth of NF Rock Creek and extends 1,500 lineal feet upstream.

Channel structure

Sinuosity is low in this short anchor because it is completely lacking any large wood complexity. The gradient is approximately 1% and no form of channel complexity is present. The simple nature of the channel here suggests a state of poor function.

Floodplain structure

Terraces are low (2.5ft), broad (200ft) and capable of high levels of interaction. Currently interaction is limited because the stream lacks the large wood complexity required to create the deflection and impoundment necessary for initiating floodplain interaction. Bedrock intrusions continue to provide the hydraulic controls that were preventing down cutting and terrace isolation (Photo 28). Vegetation in the riparian corridor is primarily alder with a diverse deciduous understory. Some mature second growth conifers are present in the riparian for the provision of future wood recruitment to the active channel..

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

This anchor is currently summer rearing significant numbers of coho juveniles but still falling far short of its production capacity. Rearing densities were low and pool complexity was extremely poor. Spawning gravel was scarce within the anchor.. Exposed bedrock and large cobble were the dominant substrate components. Pools were shallow, exhibited limited scour and were poorly developed.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) The absence of large wood complexity has resulted is the lack of high functioning winter and summer rearing habitats and the inability to capture, sort and store spawning gravels.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) The addition of full spanning LWD complexes would aggrade bedload, retain gravels, increase pool complexity and increase floodplain interaction. This would dramatically improve the system's ability to function for the production of salmonids.

Anchor Site 8

Location and length

This anchor site begins 1.0 mile upstream from the confluence with NF Rock, and includes 1 mile of
the mainstem of Rock Creek. In addition, two significant cold water tributaries enter the anchor site that exhibit the potential of providing vast quantities of interactive off channel habitat.

Channel structure

Sinuosity in this anchor was good throughout the upper third of the anchor. Large wood complexes are present, channel braiding is occurring and the stream is interacting frequently with its floodplain (Photo 31). The lower portion of the anchor site has limited sinuosity because the channel is lacking complexity. There is considerable potential to increase sinuosity within the anchor site through the addition of LWD complexity and the development of off channel backwater/alcove habitats..

Floodplain structure

The flood plain in this anchor varies from 200ft to 750ft. at its widest point. The broad segment of the floodplain is the location of the old Inman-Paulson mill pond. Currently, the site is a Reed Canary Grass dominated terrace that is elevated approximately 4ft above the elevation of the summer stream channel (Photo 29). The stream is subjected to extensive solar exposure in roughly the lower two thirds of the anchor. This reach is lacking large wood complexity and is on a rapid trajectory toward simplification and isolation from its floodplain. The broad floodplain characteristics and relatively low terraces are a legacy of a full spanning wood jam at the bottom of the anchor site caused by a collapsed log stringer bridge (Photo 32). The jam is still in place but breaking down rapidly. This jam has created a long legacy of high function within the anchor site for the provision of both summer and winter habitat. The loss of this jam will initiate the process of channel incision and large quantities of stored bedload will be swiftly transported out of the Rock Cr subbasin.

The upper third of the anchor site has broad 3ft terraces that appear to be formed of highly erodible sediments. In this reach the channel is much more complex with wood structure and braiding. Terraces are vegetated by a mixture of alder, conifer and willow. There is evidence of beaver activity on several small tributaries that enter the mainstem in this location.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

In both the 2009 and 2010 snorkel inventories, the average pool densities for coho increased radically over the average densities observed below this anchor. Coho densities remained very strong from this anchor to the end of their distribution in both inventoried years. The 2009 expanded estimate of summer rearing coho within this anchor was 11,934 (11.2% of the mainstem total) and the average rearing density was 1.65 coho/sq m. In 2010, the estimate was 7,716 coho rearing at an average density of 1.49 coho/sq m representing 9.2% of the mainstem total.

Spawning gravels in this anchor are of high quality and plentiful. 164.5 sq m of spawning gravel were inventoried in or adjacent to Anchor Site 8 during the 2010 LFA. This represents nearly 28% of the mainstem total.

Given the heavy summer rearing use observed and the existence of complex channel forms that extend onto very low interactive floodplain terraces, The potential for the provision of winter habitat exists within the anchor. The most significant observation is that there is tremendous unrealized winter potential on the old mill pond site. This would require the development of a new channel matrix that could contain high wood densities, and extensive off channel low velocity aquatic surface area.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) The lack of full spanning large wood currently limits the sites potential to maximize the abundance of both summer and winter habitat surface area.
2) Lack of canopy cover and vegetative diversity caused by the infestation of Reed Canary also limits the anchors riparian corridor from maturing and developing future wood recruitment potential. This lack of seral development also leaves the site solar exposed with no potential for improvement.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Full spanning LWD complexes will maintain and improve the complex function by aggrading bedload material, raise frequency and duration of floodplain interaction, improve sinuosity, and increase the storage of winter flood flows on the floodplain.. The addition of LWD would likely encourage beaver activity in the mainstem.
2) Design supplemental side channel construction for the Inman – Paulson mill pond site. This would include side channel construction and diversion, off channel and back water habitat development and alcove excavation within two tributary confluences. This type of off channel development would be implemented and planted well before the diversion of active channel flows to allow the site to stabilize and vegetatively mature. Final treatment would be the

breaching of channel plugs and the placement of full spanning wood in the mainstem to encourage channel bifurcation.

3) Riparian planting on the Inman –Paulson mill pond site in association with the proposed side channel development to reduce solar exposure, ensure future wood recruitment, increase cover, and vegetative diversity.

Anchor Site 9

Location and length

Anchor Site 9 begins at RM 25.6 (confluence with of SF Rock) and continues upstream 1.9 miles to the end of coho distribution.

Channel structure

Sinuosity in this anchor is high because of the broad valley floor with a 100 -300 ft. Meander belt. Channel incision is uncommon and the presence of beaver dam complexes plays a significant role in forming the current channel metrics (Photo 34). There are several areas throughout the anchor site that are currently exhibiting entrenchment that effectively isolates the active channel from its historic floodplain. These reaches are characterized by steep erodible banks and a narrow channel with no impoundment. The most distinct example of this channel form exist just below the Hwy 26 culvert crossing and extends downstream approximately 1,400 ft.

Floodplain structure

The floodplain within the majority of this anchor is wide and unrestricted (100 -300 ft). Terraces fluctuate in height from 1-3 ft. There is evidence of frequent floodplain inundation in multiple locations and a strong legacy of beaver impoundment and homestead use is visible. Beaver utilization is currently far below the historical levels as observed by the abundance of abandoned beaver terraces. The reduced watershed area for this headwater anchor site (a result of its location above the confluence of the SF Rock) creates an ideal scenario for successful (winter stable) beaver dam construction. There were 2 beaver dams observed in 2009 and 4 observed in 2010 in this 1.9 mile long anchor site. These sites are providing ideal habitats for summer and winter salmonid rearing.

Riparian vegetation on the floodplain terraces varies greatly throughout the anchor. Alder and Fir are the primary canopy cover where there is an intact canopy. Much of the stream flows through historic homestead meadows and still maintains high levels of solar exposure. This zone has remained in early seral vegetation because of extensive year around pressure from large numbers of elk. Currently, Reed Canary Grass is not present and its absence suggests that its upstream migration from known populations just downstream of the Hwy 26 culvert crossing may have been retarded by the deep road fill and undersized culvert that exists under the Highway.. Scotch broom is currently present and abundant above the Hwy 26 crossing . A legacy of old growth Cedar exists in this anchor, 6-8ft DBH stumps were observed.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

In both the 2009 and 2010 RBA survey, average coho rearing densities were excellent in this anchor exceeding the commonly referred to standard for full seeding of 1.5 coho/sq m. The 2009 expanded estimate of summer rearing coho within this anchor was 13,080 (12.2% of the mainstem total) and the average rearing density was 2.95 coho/sq m. In 2010 these numbers declined to 10,608 and 2.24 coho/sq m but the reach continued to produce 12.7% of the mainstem total. This describes a very important location within the Rock Creek system.

Spawning gravels in this anchor are of high quality and plentiful. 87 sq m of spawning gravel were documented in Anchor Site 9 in 2010. This represents 14.6% of the mainstem total. Winter rearing is likely occurring within the anchor, but there is limited high quality winter habitat.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) The lack of full spanning large wood and the reduction in beaver impoundment from historic levels will eventually result in channel simplification and entrenchment that will slowly isolate the active channel from its winter floodplain.
2) Lack of an intact riparian canopy exacerbates downstream cumulative temperature impacts that effect the lower mainstem of Rock Cr and reduces the potential for the recruitment of future large wood.
3) The unmaintained trash rack at the Hwy 26 crossing has the potential of reducing adult spawner escapement to the majority of the anchor site in years of low winter flows.

Addressing the limitations

List and rank the restoration work at the site that would most effectively increase survival within the site and stabilize the core population at a higher base level.

1) Full spanning LWD complexes will maintain and improve floodplain function by aggrading bedload material that elevates the active channel and increases the frequency of floodplain interaction.
2) Encourage beaver populations by providing abundant forage species that would result in increased pool surface area, rearing potential and floodplain interaction.
3) Riparian planting to provide a reduction in solar exposure, ensure future recruitment, increase cover, and boost complexity.

4) Remove, redesign or commit to the annual maintenance of the Hwy 26 trash rack to improve access to key spawning and rearing habitat

Anchor site rankings

Function

Rank the identified anchor sites in terms of current function (1= best).

1) 9
2) 3
3) 8
4) 4
5) 5
6) 6
7) 7
8) 2
9) 1

Restoration potential

Rank the identified anchor sites in terms of restoration potential.

1) 8
2) 9
3) 3
4) 4
5) 5
6) 6
7) 7
8) 2
9) 1

Secondary Branch 1

Location and length

Trib A enters Rock Creek at RM 18 directly downstream from Martin Creek. Coho distribution ended 1,000ft from the mouth.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

In 2009 the expanded total of summer rearing coho was 258 with an average rearing density of 1.3 coho/sq m. Distribution extended 1,000ft from the mouth and terminated at an ephemeral log jam classified as small. It was noted during the 2009 RBA inventory that the stream channel was primarily dry between pools above the end of Coho distribution. In 2010 the expanded summer rearing coho estimate was 120 and the average rearing density declined to 0.6 coho/sq m Distribution extended to 1,600ft from the mouth. It is likely that both years experienced an adult spawning event. This tributary does not likely experience a juvenile upstream migration from the mainstem because of a steep approach at the confluence with mainstem Rock Cr.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The primary limitation in Trib A is the small size and low summer flows that limit both summer and winter rearing habitat. Upslope harvest activity near the end of anadromous distribution has also resulted in increasing solar exposure to the active channel.

Addressing the limitations

Establishing and maintaining long term guidelines for protection of the riparian corridor within and above current fish distribution is the primary need for the Trib A corridor..

Secondary Branch 2

Location and length

Trib B enters the mainstem of Rock Creek at RM 19.5 near a logging road bridge. Coho distribution extended 0.9 miles from the mouth in 2010..

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

In 2009 the expanded total of summer rearing coho was 300 with an average rearing density of 1.7 coho/sq m. Distribution extended only 300ft from the mouth. Coho were only observed in the first two sample pools. In 2010 the expanded summer rearing coho total was 2,220 but the average rearing density decreased to 0.7 coho/sq m. Distribution extended to 0.9 RM from the mouth. The distribution of juvenile coho suggests that adult spawning occurred in both years within the tributary.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The primary limitation for coho within Trib B is related to the observed decline in its resident beaver population. Evidence of an extensive legacy of beaver use was observed during the 2010 RBA survey. There was however, no recent activity and the high quality attributes associated with beaver impoundment were disappearing. A decline in Trib B production potential for salmonids is expected without the re-colonization of beaver.

Addressing the limitations

The re-colonization of legacy beaver flats would increase both summer and winter rearing habitats within the tributary. Planting forage species for beaver would accelerate re-colonization.

Secondary Branch 3

Location and length

Trib C enters mainstem Rock Creek between the confluence of Weed Creek and Olson Creek. The greatest extent of coho distribution observed between 2009 and 2010 was 600ft.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

In 2009 the expanded total of summer rearing coho was 654 with a low average rearing density of 0.4 coho/sq m in 2009 75% were rearing in the first sample pool. This was a beaver pond and densities were low. Distribution extended 600ft from the mouth. It was noted, during the 2009 RBA inventory that an undersized culvert at 650ft was a juvenile barrier and possibly an adult barrier as well. No coho were observed above the culvert. No coho were observed in Trib C during 2010. This Tributary has the potential of providing low velocity winter refugia from the mainstem of Rock Cr..

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

Currently the primary limitation appears to be the truncated access imposed by the perched culvert at 650ft. It is also likely spawning gravel is limited above the culvert because of the low gradient swampy conditions (not verified).

Addressing the limitations

Removal and replacement of the undersized culvert.

Secondary Branch 4

Location and length

Trib E enters Rock Creek 1,100 ft upstream from the HWY 26 culvert crossing. In 2010, Trib E exhibited the greatest lineal distribution of coho at 1,800ft from the mouth that terminated at an ephemeral log jam.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

In 2009 coho were observed only in the first sample pool. During the 2010 sample year extended 1,800ft from the mouth and an expanded estimate of 552summer coho parr was observed. The average rearing density was 0.9 coho/sq m. It appears that spawning is occurring in this tributary. Beaver activity in this tributary provides high quality summer and winter rearing habitat.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The primary limitation of Trib E is its small watershed area. and its lack of high quality beaver forage.

Addressing the limitation

Encouraging beaver with the planting of forage species would assist in maintaining beaver residency.

Secondary Branch 5

Location and length

Trib I enters mainstem Rock Creek at RM 9.7. Coho distribution extended 3,900ft from the mouth.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

During the 2009 RBA inventory there were no summer rearing coho documented in Trib I. In 2010 the expanded summer rearing estimate for coho parr was 990. The average pool rearing density was 1.2 coho/sq m. Distribution extended 3,900ft from the mouth and was terminated by a 3ft perched culvert.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The primary limitation of this tributary is its small watershed area. The culvert that terminates coho distribution is above a primary fork in the stream and continued salmonid rearing potential above the perched culvert is very limited. It was noted that reaches of solar exposure had been planted within the riparian corridor of Trib I.

Addressing the limitations

Planting of beaver forage would encourage colonization and the resultant beaver dams would add rearing capacity to the tributary.

Secondary Branch 6

Location and length

Trib H enters Rock Creek 1.1 RM downstream from the SF Rock confluence. Coho distribution extended 1,100ft from the mouth and was terminated by an ephemeral log jam.

Rearing contribution

Describe how the site contributes to spawning, incubation, summer rearing, and winter rearing.

In 2009, no coho were documented in Trib H. during the 2010 RBA survey conducted by Bio-Surveys an expanded summer rearing estimate of 1,836 coho was observed. The average rearing density was 2.8 coho/sq m. Distribution extended 1,100ft from the mouth and the combination of good gravel and beaver impoundment created the habitat to support a robust summer population.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

The primary limitation of this tributary was the truncated distribution as a result of natural log jam barriers.

Addressing the limitations

No recommendations are presented for addressing these natural limitations..

Secondary branch site rankings

Function

Rank the identified branch sites in terms of current function (1= best).

1) Trib H.
2) Trib B.
3) Trib E.
4) Trib I.
5) Trib A.
6) Trib C.

Restoration potential

Rank the identified branch sites in terms of restoration potential.

1) Trib C.
2) Trib I.
3) Trib H.
4) Trib B.
5) Trib E.
6) Trib A.

Riparian corridor

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.
The riparian area in the 12 miles from the confluence with the Nehalem to the mouth of Selder Cr is mixed industrial timber and pasture land with the later becoming more dominate in the lower 5 miles. This reach is residentially influenced. 30% of the lineal distance is open canopy, 25% is closed canopy, and the remaining 45% is partially shaded ranging from 25% to 75% closed canopy. The majority of this reach does not have adequate solar protection with exposure being most severe in the lower 5 miles. Banks are dominated by Reed Canary retarding the natural seral progression toward woody vegetation.

From the mouth of Selder Cr extending upstream to the confluence with NF Rock solar exposure is not directly an issue. The overwhelming majority of this reach has a closed canopy with no areas of extensive exposure. The riparian in this reach is primarily alder with scattered conifer. This is typically backed by young re-prod or clear-cut upslope.

One mile upstream from the confluence of NF Rock there is a 1,500ft reach of open canopy located within anchor site 8. This reach is dominated by Reed Canary hindering natural seral progression toward woody vegetation..

Above HWY 26 there is 2.500ft of open canopy through old pasture land located within Anchor Site 9. There is no Reed Canary above the HWY crossing but heavy Elk use has kept old pasture habitat in early seral classes of grasses and forbes.. Above the meadows the canopy is closed with 50+ year old conifer extending upslope.

Recruitment potential

What is the recruitment potential and time frame for delivery to the channel?
From the mouth of Rock Cr to RM 12 there are few large conifers capable of creating full spanning structures at this time. Most of conifer in this reach is decades from reaching its full potential for recruitment if it is not harvested. The majority of this reach is

residentially influenced and most woody debris that is contributed to the stream is removed by land owners.

At RM 13 near the mouth of Fall Cr there is a mature stand of Fir with contemporary recruitment potential.
From Fall Cr to the confluence of SF Rock Cr there are scattered large conifers that are currently adequate for creating full spanning structures. However, this stretch of Rock Cr is dominated by alder.

Above the SF the stream size is reduced and the size of timber capable of making an impact is reduced. In the Rock Cr headwaters above HWY 26 there are 50+ year old timber stands (ODF) with contemporary recruitment potential if left un harvested.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The Upper Nehalem Watershed Council and its partners have collected temperature data at set locations throughout the mainstem of Rock Cr in 1993 – 1997, 1999 – 2003, and 2005. The temperature data collected indicates that there is a significant temperature limitation in lower Rock Cr starting near RM 14 and increasing in a downstream progression. This reach is predisposed to having temperature issues because of the wide valley floor, the wide active stream channel and lower stream gradients.

Temperatures at or near RM 14 regularly exceeded water quality standards for salmonids but typically not by more than one degree C and not for long periods of time. However in 2002 temperatures were recorded as high as 20c and exceeded water quality standards for a week in late July, 2002. In the lower 5 miles of Rock Cr summer water temperatures regularly reach 24C and exceed water quality standards for salmonids for weeks at a time. RBA survey data indicated juvenile Coho abundance greatly decreased below RM 5.

Temperatures exceeding 18c from July, 16 to August, 6 were recorded as high in the system as RM 20 in 1995 but this appeared to be somewhat of an anomaly. The fact that the area of high solar exposure is from the mouth to RM 12 and elevated summer temperatures were routinely recorded at and above RM 14 suggests that there are cumulative temperature issues in the tributaries and headwater reaches that influence the lower mainstem most severely. These cumulative impacts are largely a legacy of extensive upslope harvest activities throughout the basin. The clear-cut harvest of Type N stream corridors impacts ambient air temperatures surrounding tributary corridors that in turn elevates water temperatures. The protection of riparian buffers throughout the entire basin including small non fish producing tributaries is very important to addressing Rock Cr temperature limitations in the lower mainstem.

In the reaches that are solar exposed and riparian planting is an option, planting in the upper reaches and tributaries utilizing a top down strategy would likely be the most effective way to address the actual point sources of impact. Selder Cr exhibited stream temperatures exceeding 18c at its confluence with the mainstem of Rock. This confluence is near the upper end of mainstem Rocks temperature limited reach. Protecting buffers and conducting planting projects on Selder could have a very large impact not only for temperature dependent juvenile migration but also by cooling mainstem temperatures. This could effectively shrink the lineal distance of temperature limitations in the mainstem.

Lowland habitats

Describe lowland habitats and locations outside the 6th field.

The Rock Cr sub basin enters the mainstem Nehalem at approximately RM 90. The extreme distance from the Rock Cr subbasin to lowland habitats suggest that the primary potential lowland linkage would be for the provision of winter habitats for fish displaced from Rock Cr during high winter flow regimes. It is likely that some of this type of seasonal migration occurs but there is no historical information available for quantifying its relative importance for juvenile coho originating this high in the Nehalem basin.

Because the Nickelson modeling exercise suggests that the Rock Cr basin is gravel limited and the lower 12 miles of the Rock Cr mainstem is currently functioning far below its capacity for the production of salmonids during summer temperature regimes, it is more likely that non-volitional migrants from headwater reaches would be seeking and finding functional winter habitat within lower Rock Cr for the provision of winter habitat.

Restoration analysis

Defining the connectivity of habitats

The structure of this document by necessity has made distinctions between habitat segments that have assisted us in breaking down the analysis into manageable stream reaches. These reach subdivisions include primary tributaries (4th order) of the Rock Cr mainstem, secondary Branch tributaries that are generally 3rd order contributors and critical contributing areas that are more likely 2nd order aquatic contributions to the stream network.

It is common for habitat types to overlap near the confluences of these larger and smaller order subdivisions. For example, a 3rd order secondary branch often traverses the broad floodplain of its larger 4th order mainstem. The aquatic habitats of this 3rd order tributary are impacted more significantly by the 4th order streams floodplain characteristics (gradient, substrate composition, etc.) than the 3rd order stream that crosses it. These transitional areas between habitat subdivisions provide extremely important seasonal habitats (summer cold water refugia and winter low velocity habitat) for juvenile salmonids.

Understanding that the linkages between these habitats is a critical component of system function is integrally important to achieving success in the development of a restoration strategy designed to restore function. With this concept in mind, we have included some 3rd order streams traversing 4th order floodplains within the designated anchor site of its 4th order partner (see final prescription map).

Nickelson Model results

We believe the fundamental purpose of the entire Limiting Factor Analysis is to step back and take a basin scale view of the biological, morphological and physical interactions that combine to influence survival and consequently smolt production. This larger view identifies two very significant issues that must be factored into the seasonal survival analysis. 1) The current lack of beaver dam habitats in the assessment area. 2) The extensive impact of elevated summer temperatures in the mainstem of Rock Cr. Both of these issues are strong, reliable indicators of dysfunction. Re-colonization of beaver on the landscape would have an immediate impact on the current seasonal limitation (spawning gravel). Until the abundance of spawning gravel increases, the majority of the mainstem of Rock Cr and the vast quantities of summer habitat that it provides will remain under seeded.

The Nickelson Model provides important insights into the function and deficiencies of the Rock Creek rearing system that support the conclusions described above. As these ideas are developed below, please refer to Appendix 4, which characterizes the results of a modeling exercise designed to identify the seasonal habitat limitation for producing coho smolts in the combined Lower, Middle and Upper Rock Cr 6th fields. As previously explained, the model uses AQI inventories to quantify the abundance of summer habitats within each tributary and the mainstem. It should be noted that much of the inventory data was collected prior to the major storm events of 1996 and 2007 and thus may fail to fully represent current habitat conditions.

If you review table E1 of Appendix 4 you will note that the total column for the combined stream segments suggests that the primary seasonal habitat limitation for coho in the 3 combined 6th fields of Rock Cr is the abundance of ***spawning gravel***. This table utilizes season-to-season survival rates applied to the measured abundance of each seasonal habitat type (spawning, summer and winter) to predict that season's habitat capacity for smolt production. The goal is to identify the seasonal bottleneck to production. There are in fact only a few tributary segments that currently have an abundance of gravel large enough to seed the habitat available within that tributary segment in either summer or winter. What this suggests is that few precious places within the basin still exhibit the level of functionality required to sustain the core population (all of Rock Cr) for the long term. These places are limited to the SF Rock, NF Rock, Rock Cr above the confluence of the SF, Weed Cr and Olson Cr.

These stream segments, (SF Rock, NF Rock, Rock Cr above the confluence of the SF, Weed Cr and Olson Cr.) when viewed independently, exhibit a seasonal habitat limitation other than the abundance of spawning gravel. Because spawning gravel is abundant, they are limited by either the abundance of summer or winter habitat. However, these other limitations are irrelevant because these stream segments are located high in the Rock Cr basin.

This condition suggests that any surplus fry emerging from the abundant gravels in these few tributaries that are unable to find a rearing location because of density dependent pressures in the stream of origin need only to drift downstream into the mainstem habitats of Rock Cr where the severe lack of spawning gravel has resulted in large unutilized pool surface areas for summer rearing. This is why the entire Rock Cr basin should be viewed and managed as a unique population segment (a deme). The majority of the habitats in the mainstem of Rock Cr are highly dependent on the incubation capacity of gravels in its headwater tributaries for the provision of nomadic fry to seed its summer pool habitats.

The interaction between headwater and lower mainstem habitats should be viewed cumulatively to determine the seasonal habitat limitation for the functional deme. This broad scale view of the analysis area is why all 3 6th field HUC's of Rock Cr have been combined to describe and understand system function.

The significance of the historical story line developed within the introduction of this document is that the few places that still exhibit a legacy of large wood from the wildfires of the 1930 are still in the process of unraveling as that wood (stored in deep accumulations of migratory bedload) is continually transported out of the system. When the wood is gone, the gravel goes with it. If the abundance of spawning gravel is currently limiting, then restoration actions designed to store gravel and retain migratory wood (that critical element that knits each stream segment together) are high priority actions for the system.

Another issue that arises in this analysis is the fundamental disagreement between the results of Table D1 and E1. Table D1 represents an assessment of seasonal survival rates that are density independent from the ODFW Nickelson Model. This suggests that inter- and intra-specific interactions between rearing salmonids are not accounted for in the smolt production estimates. This method suggests that the availability of ***winter habitat*** is the primary seasonal limitation.

This is why the results of Table E1 have also been incorporated into this analysis. Table E1 utilizes the seasonal survival rates produced by the Alsea Watershed Study that attempted to factor in density dependent interactions. This method suggests that the abundance of functional ***spawning gravel*** is currently the seasonal limitation. The Alsea Watershed Studies seasonal survival rates have proven to more accurately represent real world interactions (density dependent survival and predator prey relationships) and therefore, although this analysis presents the results of both modeling efforts, we have chosen to consider the AWS more appropriate for the situation.

Defining the production bottleneck

Does the seasonal bottleneck identified by the Nickelson Model remain the primary limiting habitat when each of the other issues identified in the assessment process are factored in? Explain.

We are attempting to establish that the basin as a whole is limited by the abundance of spawning and incubation habitat in the suite of 3 Rock Cr 6th fields when combined. In this analysis we have the ability to overlay fish distribution data on top of the summer temperature profile to look for corroboration. In summary, coho densities in 2009 began to increase dramatically at RM 19.3 near the confluence of Martin Cr. Below the junction of Martin Cr to the confluence with the mainstem Nehalem, there was very limited summer coho production. Summer rearing in the lower 19.3 mile segment of the mainstem was comparatively small when viewed on the basin scale. An expanded total of 38,440 summer coho parr (16% of the Rock Cr sub basin total) were rearing in the lower 19.3 miles of Rock Cr. To put this low level of production into perspective, there was an expanded summer parr estimate of 120,220 coho rearing in the 7.7 miles of just mainstem Rock above the confluence of Martin Cr. This does not include the additional 76,972 coho summer rearing in the tributaries of Rock Cr.

When alternate reasonable functional relationships were considered, the conclusion remained that gravel resources above the 12 mile temperature limited segment of the mainstem cannot generate sufficient summer parr to fully utilize the mainstem rearing area. The approaches taken are reviewed below.

To further test the hypothesis that the abundance of spawning gravel currently limits Rock Creeks coho production potential, we developed an alternative scenario for the Nickelson model that removed all of the temperature limited summer rearing surface area in the first 12 miles of the mainstem as viable summer habitat for coho and added 80 sq m of spawning gravel for the 8 small tributaries where no gravel data was available, Trib I, H, C, etc.). This dramatically reduced the habitat capacity of the system for summer rearing to represent actual current conditions within the subbasin and bumped up the total available gravel by 4%. Note from table E1 that even after suggesting to the model that the lower 12 miles of mainstem Rock Cr was completely unusable for the provision of summer habitat and that significant quantities of spawning gravel might be available in the 8 un-surveyed tributaries, that spawning gravel remains the primary seasonal limitation with no close numerical second utilizing the density dependent survival rates generated by the Alsea Watershed Study.

The second approach taken to this question was to review the network of primary headwater contributions (SF Rock, NF Rock, Weed Cr and Military Cr). These 4 highly productive tributaries enter the mainstem of Rock Cr above the 19.3 mile segment of the Rock Cr mainstem below Martin Cr. Each of these major coho producers delivers high quantities of nomadic coho fry in the spring to this mainstem reach. This is nearly a certainty with the production potential of the gravels in these tributaries exceeding the rearing capacity of the summer pool habitats (even with the extremely high average rearing densities observed, 2.2 coho/sq m for NF Rock and 3.0 coho/sq m for SF Rock). The pool rearing surface areas in the 19.3 miles of lower mainstem Rock Cr are massive yet the standing summer crop of coho parr remains very small.

We also considered the possibility that beaver ponds could contribute to summer rearing and tip the balance away from gravel limitation. All of the tributaries of mainstem Rock Cr and the mainstem of Rock above the confluence of the SF Rock exhibited a major historical legacy of beaver presence in both the historic AQI data reviewed for this analysis and in the field surveys conducted. Beaver are still present on the landscape. However, their dams are disappearing as a major component of system function. It is true that there are glamorous exceptions to this trend in Rock Cr, as in the case of Trib D where beaver dams in small tributary produce as many coho parr (8,675) as Military Cr, Maynard Cr, Olson Cr and Ivy Cr combined. But such examples are not the rule. The system as a whole is steadily losing its beaver-generated rearing habitat.

Potential for lowlands contribution

If the abundance of winter habitat has been determined as the primary factor limiting coho production, discuss how lowland habitats existing outside the boundaries of the 6th field might function to provide winter habitat for smolts produced in the 6th field.

The abundance of winter habitat has not been determined to be the primary limiting factor for coho production. Therefore, the contribution of both fresh water and estuarine lowland habitats for the provision of seasonal habitat is likely not the missing seasonal link for restoring system function.

Ownership issues

To what degree would land use and ownership allow restoration work?

In Rock Cr and its primary headwater tributaries, the majority of the landscape is contained in a matrix of private industrial forest ownership. There is a much smaller percentage of State lands managed by ODF. This disparity in ownership suggests that the management of State lands may require a more critical review for the provision of exceptional forest stewardship that may be more difficult to achieve on private industrial forest lands. This assessment has resulted in defining the importance of developing a new vision for the treatment of the riparian corridors on Type N stream corridors. The significance to the Rock Cr basin as a whole of the contribution of mature wood resources from natural headwater slope failure and the addition of headwater shading in Type N riparian corridors cannot be over-stated for the recovery of proper system function.

The remainder of the basin below the confluence of Selder Cr contains many small non industrial private landowners with highly variable riparian management styles. Indications are that it will be difficult to improve the existing temperature limitations in the mainstem by focusing solely on these lower basin landowners. However, a cooperative strategy that brings all Rock Cr landowners to the table simultaneously would likely be very effective in turning the trajectory around for mainstem temperature limitations currently impacting the lower mainstem aquatic habitats.

Channel complexity summary

What is the potential to increase channel complexity in the long term through natural recruitment processes, with and without restoration?

The long term potential for increasing channel complexity by relying on natural wood recruitment is poor based on current riparian and upslope management practices. The lack of standing wood retention in slide prone Type N stream corridors is a significant factor controlling the abundance of natural wood delivery to the stream network. Even well recovered fish bearing riparian corridors are dominated by deciduous species that fail to provide the long term recruitment potential of the key conifer species necessary for long term hydraulic stability.

There are of course exceptions to this condition that can be observed in the headwater reaches of mainstem Rock where it traverses State forest lands and exhibits a mature conifer component. This riparian potential can also be observed in short reaches of the lower mainstem of Rock Cr where small private tracks of riparian ownership have intentionally retained a mature conifer component. The limited lineal distribution of these examples however suggests that additional measures will be required in the future to create a trajectory aimed at boosting the frequency of riparian conifer. This is the long term goal that will bear the greatest long term benefit for restoring natural process that could eventually be self-sustaining.

Restoration prescriptions and potential restoration sites

The following site-specific prescriptions are listed by stream and are not prioritized.

Stream

South Fork Rock Creek

1) Riparian planting in Anchor Site 1 to increase future recruitment potential for structure and increase canopy cover to reduce temperature limitations in the mainstem. Caging necessary.

2) Develop conservation easement strategy for one site potential (200ft each side of stream) for Anchor Site 1.

3) Full spanning wood structures in Anchor Sites 1 and 2 to preserve existing high function and maintain existing gravel resources. Machine placement possible.

4) Full spanning wood structures in Anchor Site 3 below the confluence of Bear Cr. These structures would greatly increase the floodplain function of the anchor site as well as supplement the investment of the structures placed above the confluence of Bear Cr. Machine placement possible.

5) Full spanning wood complexes in Trib A to trap and store spawning gravels in the stream segment above the high quality rearing habitat identified in downstream Anchor Site 1.

6) Develop (excavate) off channel back waters / alcove at the confluence of Trib A and Trib A1 and on the low interactive terraces of Anchor Site 1. Both locations would provide high quality rearing habitat in all seasons plus supplemental water storage for moderating both summer and winter flows.

7) Plant beaver forage (willow, vine maple, ash, cottonwood) in Anchor Site 1 and Trib A to encourage colonization.

8) Remove concrete divider at Hwy 26 culvert.

9) Extend RMA around identified anchor in Trib A to 200ft.

Bear Creek

10) Plant beaver forage (willow, nine maple, ash, cottonwood) in and around Anchor Site 1. May require selective girdling.

11) Conifer planting in and around Anchor Site 1 to ensure future recruitment for structure. Cedar would likely be the best species. Caging necessary.

North Fork Rock Creek

12) Full spanning wood complexity in Anchor Site 1. Helicopter placement preferable. Machine placement possible.

13) Full spanning wood complexity in the upper 1,000ft of Anchor Site 2. Helicopter placement.

14) Full spanning wood complexity in Anchor Site 3. This would protect and enhance the existing structures that are beginning to fail. Helicopter placement

15) Plant beaver forage (willow, vine maple, ash, cottonwood) in Anchor Site 4. Selective girdling may be necessary.

16) Conifer planting throughout Anchor Site 4. Caging necessary.

17) Full spanning wood treatment in Anchor Site 4 in the future (15-20 years).

18) Extend RMA around Anchor Site 4 to 200ft.

19) Develop strategies for second order non fish bearing streams to limit solar exposure (slash accumulation).

Weed Creek

20) Full spanning wood complexity starting at the mouth and working upstream to Anchor Site 1. Machine placement

21) Protect riparian buffers on first and second order tributaries in the first 1.7 miles. (leaving buffer strips, slash retention). These are sites with high slide potential for recruiting resources (wood, gravel).

22) Facilitate beaver colonization with beaver management plan that recognizes the value of the ecosystem services provided by beaver. Could include trapping moratorium.

Tributary D of Rock Creek

23) Plant conifer throughout Anchor Site 1 for future recruitment for structure and canopy cover to mitigate for extensive solar exposure. Would require caging and moisture tolerant species (cedar).

24) Plant beaver forage (willow, vine maple, ash, and cottonwood) throughout lower 1 mile.

Ivy Creek

25) Protect existing riparian throughout to ensure future recruitment and limit solar exposure.

26) Facilitate beaver colonization with beaver management plan that recognizes the value of the ecosystem services provided by beaver. Could include trapping moratorium. .

Fall Creek

27) Replace culvert crossing on county road.

28) Full spanning large wood placement below county road.

29) Construct off channel rearing locations through the excavation of backwater/alcove complexes.

30) Conservation easement below county road. Very significant site providing cold water refugia to upstream migratory juveniles escaping the temperature limited mainstem.

Olson Creek

31) Large wood placement below the jam at 1,000ft to aggrade bedload material and create a passable approach to the jam. This would be considered high priority. Placing additional large wood over the next 3,500ft is also recommended as a secondary priority. Machine placement.

32) Plant beaver forage (willow, vine maple, ash, and cottonwood) in upper beaver flats starting 4,500ft from mouth.

Military Creek

33) Plant beaver forage (willow, vine maple, ash, and cottonwood) to alleviate solar exposure and encourage beaver impoundment. This would increase water storage potential for moderating both summer and winter flows.

34) Large wood placement throughout Anchor Site 1. Using material thinned from adjacent stands outside the riparian would be preferable in this location. Machine placement.

35) Remove invasive scotch broom in Trib A portion of Anchor Site 1 while it is still manageable.

Selder Creek

36) Full spanning large wood placement in lower 0.5 RM to aggrade bedload and restore floodplain connectivity.

37) Replace undersized culvert on Trib A to facilitate resource transport.

38) Establish permanent RMA to prevent harvest to the active stream channel again.

39) Large wood placement in Anchor Site 2 to increase floodplain connectivity and rearing potential. Using on site trees would be possible. Machine placement.

Rock Creek Main

40) The addition of multiple edge oriented large wood structures in Anchor Site 1 to encourage back water development, encourage water storage and provide winter rearing habitat.

41) Riparian planting within Anchor Site 1 to reduce solar exposure, mitigate for temperature limitations and provide a future source of LWD. Because of the potential for storage that currently exists within this anchor site, planting prescriptions should focus on the establishment of conifer. The site exhibits long term significance for maintaining persistent function that traps and retains both large wood and spawning gravel.

42) Riparian planting within Anchor Site 2 to reduce solar exposure, mitigate for temperature limitations and provide a future source of LWD. Because of the potential for storage that currently exists within this anchor site, planting prescriptions should focus on the establishment of conifer. The site exhibits long term significance for maintaining persistent function that traps and retains both large wood and spawning gravel.

43) Place multiple edge oriented large wood structures in Anchor Site 2 to encourage off channel habitat development, water storage and winter rearing habitat.

44) Riparian planting within Anchor Site 3 and throughout zones of solar exposure to address cumulative temperature impact. Planting within the anchor site would also provide large wood recruitment for structure and cover.

45) Conservation easement to obtain a riparian setback and develop the easement platform required for addressing the removal of the Rail Road bed that bisects the historical river channel. All parts of Anchor Site 3 could be included in this strategy starting at RM 7.5 to ensure future recruitment of LWD and floodplain interaction.

46) Improve existing off channel backwater complexes (excavation) in Anchor Site 3. Could be incorporated with existing small cold water tributary on the North East side of the anchor site and would increase the availability of off channel rearing habitat for both summer and winter. This would also increase both summer and winter water storage capacity.

47) The addition of full spanning LWD complexes throughout Anchor Site 3 to ensure continued function and increase complexity and floodplain interaction. This would also increase water storage during both summer and winter flows. Helicopter placement.

48) Riparian planting within Anchor Site 4 to increase recruitment potential, provide cover and riparian diversity. Additional plantings outside the anchor site would also assist in mitigating for solar exposure to address cumulative temperature impacts.

49) Create backwater/alcove in Anchor Site 4 that incorporates cold water tributaries to increase both summer and winter off channel rearing potential. This would also increase the water storage capabilities of the site during both summer and winter flows.

50) Place edge oriented LWD complexes in Anchor Site 4.

51) Place edge oriented large wood complexes throughout Anchor Site 5.

52) The addition of full spanning LWD complexes in Anchor Site 6 would aggrade bedload, retaining gravels, increase pool complexity, and increase floodplain interaction. This would dramatically improve the main limitations at this location. Helicopter/machine placement.

53) Remove and replace the undersized culvert on Trib C in Anchor Site 6. This would increase juvenile accessibility to important off channel rearing habitats.

54) The addition of full spanning LWD complexes in Anchor Site 7 would aggrade bedload, retain spawning gravels, increase pool complexity, and increase floodplain interaction. This would address the primary limitations at this location and on the basin scale. Helicopter/machine placement.

55) Full spanning LWD complexes within Anchor Site 8 to aggrade bedload material, raise frequency and scope of floodplain interaction, improve sinuosity, and increase water storage. Full spanning LWD complexes would likely encourage beaver activity in this portion of the mainstem. Machine placement.

56) Design side channel construction for the Inman-Paulson mill pond site. This would include stream diversion and off channel backwater and alcove development associated with tributaries located within the site.

57) Riparian planting to reduce solar exposure in new side channel at Inman – Paulson Mill Pond site to ensure future recruitment, increase cover, and vegetative diversity.

58) Full spanning LWD complexes in new side channel to encourage complexity, aggrade bedload material, raise frequency and scope of floodplain interaction,

improve sinuosity, and increase water storage. There is the opportunity to use wood from onsite sources.

59) Plant beaver forage (Willow, Ash, Cottonwood, Vine Maple) throughout side channel development at Inman – Paulson Mill Pond Site to encourage colonization of the created off channel habitats.. This results in increased pool surface areas and rearing capacity.

60) Riparian planting to reduce solar exposure, ensure future recruitment, increase cover, and vegetative diversity. This is a general prescription that applies to all mainstem locations exhibiting degraded riparian canopies. Prioritize upper basin prescriptions but consider all potential sites.

61) Remove and replace the undersized culvert under the Hwy 26 crossing. This site severely restricts the natural recruitment of natural resources (wood and gravel) to lower mainstem reaches.

62) Permanently remove the trash rack directly above the Hwy 26 crossing because it terminates resource migration (wood and gravel) to lower mainstem reaches and delays and potentially blocks anadromous access to headwater spawning reaches.

63) Eradicate invasive scotch broom infestation from meadows in the upper mainstem of Rock above the Hwy 26 crossing.

64) Full spanning LWD complexes within Anchor Site 9 will provide complexity, aggrade bedload (spawning gravel), increase the frequency and scope of floodplain interaction, improve sinuosity, and increase water storage. Full spanning LWD would also encourage beaver activity in the mainstem. Machine placement.

65) Riparian planting to reduce solar exposure in Anchor Site 9, ensure future recruitment for structure, increase cover, and provide vegetative diversity.

66) Plant beaver forage (willow, vine maple, ash, and cottonwood) to alleviate solar exposure and encourage beaver impoundment. This would increase water storage potential for moderating both summer and winter flows.

67) Conduct temperature monitoring on tributaries of mainstem Rock Cr like Selder, Fall, Olson, Military and others to identify cold/warm water sources to address cumulative temperature impacts.

Issues

All of the prescriptions listed above are included in the following condensed discussion of general issues, goals, methods, complications and results.

1) Mainstem Rock Cr temperature limitations from its confluence with the mainstem Nehalem to RM 12 on Rock Cr impair anadromous distribution and abundance. This is a cumulative problem that begins in many head water tributaries of Rock Cr and in the upper mainstem from the impacts of upslope harvest activities. Many riparian corridors (including non fish bearing and fish bearing stream corridors) were recently logged with no riparian protection retained to protect the aquatic corridor from solar exposure.
2) Because temperature limitations in the mainstem limit its summer carrying capacity, it is also important to protect, maintain and enhance the riparian buffers that currently exist on small private and industrial timber ownership.
3) Because temperature limitations in the mainstem limit its summer carrying capacity, it is important to provide unimpeded escape routes to upstream cold water refugia. Therefore the restoration of passage for juveniles through culvert replacement is critical.
4) The legacy of industrial timber extraction upslope and throughout type N streams has led to a precipitous decline in the system's capacity to provide LWD to the aquatic corridor. This lack of wood complexity is the root cause of the channel degradation that can be observed today in simplified channel habitats scoured to bedrock. The ability of full spanning log structures to raise the stream adjacent water table and to provide vast summer water storage capacity to mitigate for elevated summer flows is well established.
5) The legacy of industrial timber extraction has reduced the riparian corridors capacity for the provision of the coniferous LWD that would historically have been the foundation for the retention and sorting of high quality spawning gravels for Coho.
6) The declining abundance of beaver dam habitat in conjunction with low wood densities has accelerated the migration rates of substrates (including spawning gravels) out of the Rock Cr headwaters where they historically were trapped and retained in the headwater locations utilized by spawning salmonids.
7) Low instream wood densities are resulting in the loss of spawning gravel storage capacity which is currently the primary limitation for the production of coho and cutthroat trout in the Rock Cr basin.

Goals

1) Initiate a change in the trajectory of the mainstem Rock temperature limitation utilizing a broad range of prescriptions that simultaneously addresses the multiple issues that combine to create the downstream cumulative impacts limiting salmonid production.

2) Develop enhancement and conservation strategies for upslope harvest units that take into consideration the importance of protecting existing riparian buffers that currently provide positive benefit to both fish bearing and non fish bearing aquatic corridors.
3) Replace, remove or retrofit culverts and historic rail road fills identified in the LFA as passage issues for juvenile salmonids to provide access to summer cold water refugia.
4) Develop watershed scale management teams to assist in identifying critical slide prone areas for consideration as resource leave areas as a source of future wood recruitment to salmon bearing segments within the Rock Cr network of streams.
5) Restore a conifer component in riparian corridors dominated by deciduous species within one site potential of salmon bearing stream corridors.
6) Restore a forage base appropriate for providing a foundation for the natural re-colonization of beaver.
7) Provide a short term fix for depleted LWD densities within the aquatic corridor until riparian recovery and protection actions can sustain the delivery of large wood through natural recruitment.

Method

1) Riparian management areas must be established and expanded on both public and private industrial forest lands throughout the basin. This would ideally include type N headwater streams with live summer flow. The prescription for these areas would include a variable width no cut buffer (width dependent on stream order). Basal area prescriptions, variable density thinning and alder conversions for the riparian would not be allowed in these areas. This is unlikely to be accomplished within the guidelines of the current regulatory processes so creative strategies for landowner compensation would be an immediate alternative solution for achieving recovery (conservation easements, etc.) Lower on the mainstem, riparian livestock exclusion and the planting of riparian buffers on historical pasture lands would also assist in the long term recovery of mainstem temperature profiles (lower priority).
2) Same as above
3) Culvert replacements and the removal of rail road fill would address compromised passage. Tackle each site in a prioritized fashion that achieves access to the largest tributaries first (higher rearing capacity) and the smaller systems last.
4) Develop an attractive easement program to encourage landowners to limit the future conversion of these highly significant riparian canopies to younger seral stages.
5) Understory plant existing deciduous riparian corridors with conifer to provide a long term source of key wood for recruitment to the active stream channel. This could include girdling, topping or the creation of small openings by felling.

6) Plant the preferred forage species for beaver (willow, vine maple, ash, cottonwood) to encourage natural re-colonization in zones exhibiting legacy beaver characteristics with willow planting.
7) Place large wood structures as a short term solution to the lack of naturally recruited conifer. Select sites with the morphological characteristics for boosting floodplain interaction.

Potential complications

1) *Conservation Easements*: On private industrial forest land, this has not been a well tested restoration tactic. This would require significant commitment and long term planning. In addition, methodologies would have to be developed to create the infrastructure necessary to hold and maintain these conservation easements.
2) *Culverts replacements:* These are generally considered low hanging fruit for restoration with ample willingness from a multitude of partners. No complications anticipated.
3) *Restoring beaver populations as an integral part of a restoration strategy:* This would be a formidable change in how we view the places where we live. With their history as a nuisance species, the education of landowners and agencies on the importance of beaver in system function would have to be accomplished with extensive outreach. This would require a form of support that funding agencies with a desire to show progress on the ground would struggle with.
4) *Large Wood Placement:* Rock Cr exhibits a large watershed area that is capable of developing formidable winter hydraulics in the mainstem. Considerable expertise would be required for the development of design solutions that would remain winter stable. LWD placement within the anchor site habitats identified in this document would be highest priority.

Expected results

1) *Conservation Easements:* This is a long range restoration objective that attempts to deal with the root source of system dysfunction. There would be no quick recovery in mainstem temperature profiles but there may be immediate impacts on the trajectory of degradation (additional upslope harvest impact that could continue to exacerbate the current condition). Recovery trends could be detectable in 20-30 years when the shade provided by recovering canopies could begin to impact mainstem temperatures.
2) *Culverts replacements:* Each culvert replacement or retrofit for passage unlocks the access for temperature dependent summer migrations of juvenile salmonids to cool water refugia. This has an immediate benefit on survival to smolt and increases production.
3) *The restoration of beaver:* If successful, will have a rapid and profound effect on system function. This single task immediately mitigates for much of the damage

currently observed from upslope industrial forestry impacts on stream temperature profiles.

4) *Large Wood Placement:* Provides a short term solution to the lack of channel roughness and the low instream wood densities that have resulted in the primary seasonal habitat limitation identified in this analysis (abundance of spawning gravel). Wood in the active channel creates the foundation for a chain of events that restores system function.

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Appendices

Appendix 1. Significant drainages of the Rock Creek (Nehalem) 6th field.

LFA ID	Name	RBA ID	ODFW ID	River mile	Enters from	Slope faces	Gradient	Flood plain width	Relative size
	Mainstem tributaries								
1	Bear Crk			0.12	Left	E	Low	Wide	Small
2		Trib I		9.92	Left	N	Very low	Wide	Small
3	Ivy Crk			10.31	Right	SE	Low	Narrow	Small
4	Maynard Crk			11.45	Left	N	Low	Narrow	Medium
5	Selder Crk			11.94	Right	SE	Low	Medium	Large
6	Fall Crk			13.43	Left	NW	Low	Medium	Medium
7	Ginger Crk			15.82	Right	SE	Very low	Medium	Large
8		Trib A		18.63	Right	SE	Moderate	Narrow	Small
9	Martin Crk			18.92	Right	E	Moderate	Narrow	Small
10		Trib B		20.37	Left	N	Very low	Wide	Small
11	Weed Crk			22.15	Right	S	Very low	Narrow	Large
12		Trib C		22.45	Right	E	Very low	Wide	Small
13	Olson Crk			22.56	Left	NW	Very low	Wide	Small
14	NF Rock Crk			23.58	Right	S	Low	Medium	Very large
15		Trib H		24.76	Left	NW	Low	Wide	Very small
16	Military Crk			25.61	Right	SE	Very low	Wide	Medium
17	SF Rock Crk			25.85	Left	NW	Very low	Wide	Very large
18		Trib D		26.38	Left	N	Very low	Very wide	Very small
19		Trib E		26.57	Left	NE	Very low	Very wide	Small
	Secondary tributaries								

14.1	NF Rock/Trib A	Trib A		2.54	Left	E	Low	Wide	Very small
14.2	NF Rock/Trib B	Trib B	Trib A	3.25	Right	W	Low	Wide	Very small
14.3	NF Rock/Trib C	Trib C		3.80	Right	SW	Moderate	Narrow	Very small
17.1	SF Rock/Trib A	Trib A	Trib 1	1.37	Right	NE	Low	Wide	Small
17.2	SF Rock/Bear Crk			2.12	Left	NW	Very low	Wide	Large

1) River Miles were obtained from the Terrain Navigator program, and are typically lower than those calculated from field survey data.
2) SF Rock/Trib B and Selder Creek Tribs A, B, C and D are not considered to provide significant spawning and rearing habitat, although a few juveniles have been seen in the mouths of these tributaries in some RBA surveys. These tributaries are not included in the smolt capacity estimates.

Appendix 2. Features and habitat survey status of streams within the Rock Creek (Nehalem) 6th field which contribute significantly to coho rearing potential.

Current ID		Survey					Valley Morphology			Aquatic Habitats			
LFA ID	Name	Surv Rch ID	Type	River Mile			Grad (%)	Valley Width	Constraint	Pools (%)	Bvr Pnds (#)	Wood (pcs/mi)	
				Len	Beg	End						Total	Key
1993 Surveys													
1	Bear Crk	1	ODFW AQI	0.45	0.00	0.45	0.6	Very broad	Terrace-Hillslope	49	0	632	nd
		2		0.39	0.45	0.83	1.2	Very narrow	Hillslope	40	0	600	nd
		3		0.38	0.83	1.22	0.3	Very broad	Unconstrained	19	0	686	nd
16	Military Crk	1	ODFW AQI	1.20	0.00	1.20	1.1	Broad	Terrace-Hillslope	62	0	969	nd
14	NF Rock Crk	1	ODFW AQI	0.33	0.00	0.33	2.7	Very broad	Terrace-Hillslope	22	0	145	nd
		2		0.23	0.33	0.56	2.8	Broad	Terrace-Hillslope	14	0	166	nd
		3		0.12	0.56	0.68	1.0	Broad	Unconstrained	36	0	351	nd
		4		0.08	0.68	0.76	2.1	Very narrow	Hillslope	28	0	105	nd
		5		0.12	0.76	0.88	2.1	Narrow	Terrace-Hillslope	19	0	272	nd
		6		0.18	0.88	1.06	2.7	Very narrow	Hillslope	19	0	542	nd
		7		0.19	1.06	1.24	1.3	Narrow	Unconstrained	16	0	299	nd
		8		0.77	1.24	2.02	1.9	Narrow	Hillslope	37	0	521	nd
		9		0.86	2.02	2.88	1.1	Narrow	Terrace-Hillslope	50	0	869	nd
		10		0.96	2.88	3.84	1.0	Broad	Unconstrained	60	0	620	nd
		11		0.28	3.84	4.12	4.8	Narrow	Hillslope	26	0	827	nd
Main stem	Rock Crk	1	ODFW AQI	0.60	0.00	0.60	0.8	Broad	Terrace	25	0	114	nd
		2		1.00	0.60	1.60	1.1	Broad	Unconstrained	30	0	77	nd
		3		0.85	1.60	2.44	1.4	Very narrow	Hillslope	39	0	72	nd
		4		0.37	2.44	2.81	1.3	Narrow	Terrace	16	0	55	nd
		5		2.42	2.81	5.23	1.4	Very	Hillslope	27	0	45	nd

								narrow					
		6		0.66	5.23	5.89	0.6	Narrow	Unconstrained	13	0	84	nd
		7		0.36	5.89	6.26	0.6	Narrow	Terrace	10	0	92	nd
		8		1.18	6.26	7.43	0.4	Narrow	Terrace-Hillslope	18	0	61	nd
		9		1.19	7.43	8.63	0.1	Very broad	Unconstrained	16	0	68	nd
		10		0.62	8.63	9.24	0.7	Very narrow	Hillslope	56	0	50	nd
		11		1.05	9.24	10.30	0.3	Very broad	Unconstrained	29	0	58	nd
		12		0.57	10.30	10.87	1.7	Very broad	Terrace-Hillslope	19	0	58	nd
		13		0.42	10.87	11.28	2.9	Very narrow	Hillslope	26	0	183	nd
		14		0.49	11.28	11.78	0.9	Very broad	Unconstrained	39	0	150	nd
		15		0.37	11.78	12.15	2.0	Narrow	Terrace	23	0	214	nd
		16		0.48	12.15	12.63	1.7	Very narrow	Hillslope	5	0	172	nd
17	SF Rock Crk	1	ODFW AQI	2.90	0.00	2.90	2.3	Very broad	Terrace	28	0	327	nd
		2		0.12	2.90	3.02	7.5	Very narrow	Hillslope	21	0	863	nd
		3		0.30	3.02	3.32	3.1	Broad	Terrace	52	0	306	nd
		4		1.71	3.32	5.04	5.1	Narrow	Hillslope	15	0	496	nd
11	Weed Crk	1	ODFW AQI	0.25	0.00	0.25	1.7	Broad	Terrace-Hillslope	15	0	312	nd
		2		2.60	0.25	2.85	1.5	Narrow	Hillslope	18	0	594	nd
1994 Surveys													
17.1	SF Rock Crk/Trib A (ODFW Trib 1)	1	ODFW AQI	0.14	0.00	0.14	2.6	Broad	Unconstrained	92	5	348	nd
		2		0.83	0.14	0.97	2.0	Broad	Terrace-Hillslope	60	15	391	nd
		3		0.51	0.97	1.47	2.7	Narrow	Hillslope	16	1	333	nd
1996 Surveys													
Main stem	Rock Crk	1	ODFW AQI	2.82	0.00	2.82	0.4	Broad	Unconstrained	38	0	304	8.0
		2		0.95	2.82	3.77	0.3	Broad	Unconstrained	46	0	140	1.6
		3		0.49	3.77	4.26	0.2	Broad	Unconstrained	68	0	89	1.6
		4		1.01	4.26	5.27	0.5	Broad	Unconstrained	43	0	431	3.2
		5		1.35	5.27	6.63	0.5	Broad	Unconstrained	56	0	212	3.2
		6		1.27	6.63	7.90	1.2	Very narrow	Hillslope	40	0	117	0.0

5	Selder Crk	1		0.00	0.55	0.55						5,021	3.2
1997 Surveys													
17.2	SF Rock Crk/Bear Crk	1	ODFW AQI	0.53	0.00	0.53	1.9	Narrow	Terrace-Hillslope	47	1	568	12.9
		2		0.61	0.53	1.14	1.9	Very narrow	Hillslope	48	1	613	9.7
		3		0.51	1.14	1.66	2.6	Narrow	Terrace-Hillslope	89	4	494	8.0
17	SF Rock Crk	1	ODFW AQI	1.23	0.00	1.23	1.3	Broad	Unconstrained	35	0	246	0.0
		2		0.90	1.23	2.13	1.8	Very narrow	Hillslope	21	0	304	4.8
		3		0.88	2.13	3.01	2.7	Narrow	Terrace-Hillslope	24	0	613	11.3
		4		1.38	3.01	4.39	3.9	Very narrow	Hillslope	15	0	657	16.1
		5		0.51	4.39	4.90	13.7	Very narrow	Hillslope	5	0	724	3.2
2002 Surveys													
14	NF Rock Crk	1	ODFW AQI	0.54	0.00	0.54	1.6	Narrow	Hillslope	22	0	87	1.6
		2		0.76	0.54	1.29	1.9	Narrow	Terrace	29	0	533	30.6
		3		1.50	1.29	2.79	1.8	Narrow	Terrace-Hillslope	34	0	481	27.4
		4		1.22	2.79	4.01	1.8	Narrow	Terrace-Hillslope	63	3	555	64.4
		5		0.43	4.01	4.45	3.3	Narrow	Terrace-Hillslope	55	3	526	30.6
		6		1.33	4.45	5.78	4.0	Narrow	Terrace-Hillslope	57	1	507	24.1
14.2	NF Rock Crk/Trib B (ODFW Trib A)	1	ODFW AQI	1.03	0.00	1.03	2.8	Narrow	Terrace-Hillslope	74	4	803	30.6
		2		0.66	1.03	1.69	10.4	Narrow	Hillslope	25	1	507	27.4
Main stem	Rock Crk	1	ODFW AQI	0.50	0.00	0.50	0.6	Broad	Terrace-Hillslope	38	0	193	0.0
		2		1.34	0.50	1.84	1.0	Broad	Unconstrained	59	7	121	1.6
		3		0.40	1.84	2.25	1.2	Very narrow	Hillslope	60	2	333	22.5
		4		0.49	2.25	2.74	3.6	Very narrow	Hillslope	85	9	444	30.6
		5		0.66	2.74	3.39	8.1	Very narrow	Hillslope	48	8	406	35.4
No Surveys													
2	Trib I												

3	Ivy Creek	
4	Maynard Creek	
6	Fall Creek	
7	Ginger Creek	
8	Trib A	
9	Martin Creek	
10	Trib B	
12	Trib C	
13	Olson Creek	
15	Trib H	
18	Trib D	
19	Trib E	
14.1	NF Rock/Trib A	
14.3	NF Rock/Trib C	

1) Early surveys, such as the 1993 surveys, appear to have miss-identified scour pools as glides. This resulted in very low Pool % estimates.

Appendix 3. Habitat data used to calculate juvenile coho carrying capacity and smolt potential in upland stream channels of the Rock Creek (Nehalem) 6th field.

The values are best estimates of current conditions based on USFS and/or ODFW habitat surveys, Bio Surveys Rapid Bioassay surveys of fish populations (which provide pool dimension data), and field work conducted during the current project. Note that in some cases the number of beaver ponds reported by older surveys has been substantially reduced based on more current information. (Habitat data unavailable for Bear Cr /Rock Cr.)

Identity			Summer Uplands Habitat (m2)												Winter Uplands Habitat Data				
LFA Stm #	Strm	LFA Rch #	Cscds	Rpls	Grv Rffls	Glds	Trnch pls	Plng Pls	Lat Scr Pls	Mid Chan Scr Pls	Dam Pls	Alcv Pls	Bvr Pnds	Bkwtr Pls	Act chan wid (m)	Grad (%)	# bvr pnds	Prcnt pls (fract)	Rch len (m)
0	Rock Crk	1			24,754	38,472			60,273	2,439	18,151				16.8	0.0	0	0.56	11,252
		2	413	2,622	25,451	21,956	443		19,955	10,285	396	287		315	22.3	0.4	0	0.38	4,532
		3		650	8,879	3,988		4	10,928	476				136	18.7	0.3	0	0.46	1,536
		4		44	3,844	42			7,763	893		48			22.9	0.2	0	0.68	788
		5		1,487	9,274	3,504			10,859	1,956		160		211	21.7	0.5	0	0.43	1,633
		6		236	11,721	2,952			16,914	2,205					21.9	0.5	0	0.56	2,175
		7	3,580	4,179	7,910	2,108	3,125	574	7,026	1,254				105	22.8	1.2	0	0.40	2,042
		8		5,695	26,527	14,780		443	2,890	8,729				5,461	17.0	1.4	0	0.27	3,900
		9	21	489	8,717	5,829			510	1,704				17	16.9	0.6	0	0.13	1,064
		10	42	22	4,749	1,625			404	213				83	17.0	0.6	0	0.10	582
		11		550	10,181	12,468			958	4,071				57	16.5	0.4	0	0.18	1,897
		12		638	6,921	12,057			1,044	2,466				243	15.4	0.1	0	0.16	1,921
		13	982	530	1,792	2,182		170	2,234	4,692				121	16.0	0.7	0	0.56	990
		14	5	1,647	9,968	4,503			4,776	1,679	115			38	14.7	0.3	0	0.29	1,696
		15	597	1,232	3,050	1,663		180	450	848				91	8.2	1.7	0	0.19	920
		16		2,438	232	1,075				384	950				8.5	2.9	0	0.26	669
		17		77	1,049	2,180			857	682	492			47	8.2	0.9	0	0.39	794
		18		441	159	2,135			438	390				39	9.5	2.0	0	0.23	600
		19		1,872	2,725	1,488			264					50	9.5	1.7	0	0.05	779
		20		926	1,642				1,744					7	9.0	0.6	0	0.38	803
		21		545	3,302			173	2,938		1,234		1,417	149	7.4	1.0	7	0.59	2,159
		22	79	939	877			106	461		248			19	8.3	1.2	0	0.30	651
		23	63	12	1,094			105	230				7,197		7.1	3.6	9	0.85	790

1	Bear Crk																		
2	Trib I				1,242				498		47				2.4	4.2	0	0.31	1,310
3	Ivy Crk	1			703			1,564	1,564	51	35				5.5	2.4	0	0.73	1,253
4	Maynard Crk	1			1,420			73	352	327	190		1,401		3.0	3.6	10	0.62	1,798
5	Selder Crk	1			521	308			1,508	54	89		813	6	7.1	0.6	5	0.25	886
		2			7,851				4,159	1,666	1,185		2,264		5.5	3.6	20	0.56	5,837
6	Fall Crk	1			765			78	184	306	297				3.0	1.6	0	0.53	848
8	Trib A	1			326				199	19	41				1.2	9.3	0	0.44	548
9	Martin Crk	1			282			62	129						1.8	1.9	0	0.40	340
10	Trib B				393			75	675	144	2,645				3.0	0.4	0	0.90	1,487
11	Weed Crk	1		432	426			15	284	69					7.2	1.7	0	0.30	408
		2	107	1,067	5,820			214	3,355	613					5.1	1.5	0	0.37	4,179
12	Trib C	1			113				250		73		694		2.4	2.8	10	0.90	389
13	Olson Crk	1			1,582			369	987	412	281				3.4	2.3	2	0.73	1,779
14	NF Rock Crk	1	88	1,789	3,401			216	1,342					35	12.8	1.6	0	0.22	865
		2		2,409	5,079			145	2,862		146	34		31	11.5	1.9	0	0.29	1,218
		3		3,257	7,089			475	5,051					72	10.3	1.8	0	0.34	2,415
		4		227	2,431			82	4,031		60	9	3,169	126	8.8	1.8	3	0.74	1,961
		5	306	587	439			150	639		88	11	794		5.0	3.3	3	0.55	700
		6	167	790	825		13	23	1,108		1,241		106	4	3.9	4.0	1	0.57	2,140
15	Trib H	1			355				73		93		655		1.8	5.7	10	0.70	486
16	Military Crk	1			1,175				2,136	213	4,707		1,003		5.0	1.1	10	0.87	1,927
17	SF Rock Crk	1		95	8,170	384		85	4,886						16.2	1.3	0	0.35	1,972
		2		1,263	6,929				2,255			13			8.6	1.8	0	0.21	1,449
		3	141	151	1,856			95	561			23		7	6.7	2.7	0	0.24	1,423
18	Trib D	1			1,811				945	367	747		7,449		4.6	4.9	40	0.85	2,416
19	Trib E	1			499			30	141		152		348		1.5	5.4	5	0.57	738
14.1	NF Rock/Trib A	1			912			49	380	73			205		3.0	3.0	10	0.44	934
14.2	NF Rock/Trib B	1	30	922	1,285			185	2,065		2,296		2,616	30	5.6	2.8	4	0.74	1,659
14.3	NF Rock/Trib C	1			297				51	24	11				1.2	4.5	0	0.23	355
17.1	SF Rock/Trib A	1		20	206			43	29		91		4,246	12	11.1	2.6	5	0.92	222
		2			1,679	429		228	507	176	227		2,056	115	5.4	2.0	15	0.60	1,333
		3			332	126			168	27	107		39		6.2	2.7	1	0.16	815
17.2	SF Rock/Bear Crk	1			1,437			63	1,006				224	12	5.8	1.9	1	0.47	853
		2		157	1,600				1,417	61			1,497		6.8	1.9	15	0.63	1,550

Appendix 4. Habitat data used to calculate juvenile coho carrying capacity and smolt potential in lowland lakes, ponds, and wetlands of the Rock Creek (Nehalem) 6th field

No lake, pond or wetland coho rearing habitats exist within the Rock Creek (Nehalem) 6th field.

Appendix 5. Coho salmon spawning gravel in the Rock Creek (Nehalem) 6th field.

LFA ID	Stream	Spawning Gravel (m2)		
		Poor	Fair	Good
Mainstem	Rock Creek	0.0	27.3	567.5
1	Bear Creek (mainstem)	0.0	0.0	3.5
3	Ivy Creek	0.0	11.1	9.8
4	Maynard Creek	0.0	7.9	10.4
5	Selder Creek	0.0	17.7	84.1
6	Fall	2.2	4.5	1.1
11	Weed Creek	0.0	0.0	107.8
13	Olson Creek	0.0	1.1	17.0
14	NF Rock Creek	0.0	0.0	358.0
14.1	NF Rock/Trib A	0.0	0.0	6.7
14.2	NF Rock/Trib B	0.0	0.0	24.0
16	Military Creek	0.0	28.1	0.0
17	SF Rock Creek	0.0	9.3	424.2
17.1	SF Rock/Trib A	0.0	0.0	13.8
17.2	SF Rock/Bear Creek	0.0	0.0	46.9
18	Trib D	0.0	3.4	36.2
	Total	**2**	**110**	**1,711.5**

These counts are conservative estimates of the number of spawning sites that are a minimum of one sq m in area and are located in a zone having hydraulics suitable for successful spawning by coho salmon. The counts are qualitatively grouped (Poor, Fair, Good) based on the amount of fines associated with the gravel (state of embeddedness). The counts can also be used to represent the availability of spawning sites appropriate for steelhead trout, but not for chinook salmon or cutthroat trout.

Appendix 6. Rock Cr (Nehalem) 6th field, limiting habitat analysis based on the Nickelson model

Worksheet function

This sheet accumulates the results of the calculations performed on the other sheets to estimate the number of coho that can be supported by the rearing system under analysis.

The specific goals are to: 1) Estimate the number of coho that can be supported during each season of the year, and 2) Rank the seasonal habitats in terms of their ability to generate "potential smolts"; this identifies which seasonal habitat most limits the production of smolts from the system.

Ideally, this evaluation would utilize spawning gravel data along with habitat data describing spring, summer and winter rearing conditions. However, physical habitat surveys are almost always conducted during the summer. In practical terms, winter and spring survey data are not available.

To accommodate these deficiencies, we use a work-around to estimate winter rearing capacity, but currently are unable to estimate the spring rearing capacity.

The work-around method for estimating winter rearing capacity utilizes a polynomial regression equation that relates winter rearing capacity to summer habitat conditions. This equation is provided by ODFW research. No such work-around exists for estimating spring capacity, and it is not estimated.

The current evaluation thus aims at determining whether spawning gravel, summer conditions, or winter conditions are most limiting in the rearing system.

The model used to identify the limiting seasonal habitat is "Version 5.0. Coho Salmon Carrying Capacity Model", provided by Tom Nickelson of ODFW Research Division. This model uses season-to-season survival rates to estimate potential smolt production for each seasonal habitat. We have two sets of survival rates, one provided by ODFW research and the other by Jim Hall's Alsea watershed study. We compare model results using both sets of rates.

Results presented

Five tables are presented.:

Table A lists the summer rearing density for each stream habitat type. The same table is presented in the Summer Uplands sheet, where it is used to calculate rearing capacities. It is included here only to illustrate how strongly reach habitat structure affects rearing capacity.

Table B lists the two sets of survival rates used to evaluate potential smolt production.

Table C lists spawning, summer and winter rearing capacities that have been calculated for each upland stream and lowland habitat.

Table D lists potential smolt production for each upland stream and lowland habitat based on ODFW survival rates.

Table E lists potential smolt production for each upland stream and lowland habitat based on Alsea study survival rates.

Table F lists habitat capacity and potential smolt production for each seasonal habitat. This table comprises the primary product of the analysis.

Table A. Stream summer rearing densities

Table A. Coho rearing density for each summer stream habitat type.

Habitat type	Fish/sq m
Cascades	0.24
Rapids	0.14
Riffles	0.12
Glides	0.77
Trench Pools	1.79
Plunge Pools	1.51
Lateral Scour Pools	1.74
Mid Chan Scour	1.74

Pools	
Dam Pools	1.84
Alcoves	0.92
Beaver Ponds	1.84
Backwaters	1.18

Data of Tom Nickelson based on ODFW research.

Table B. Survival rates to smolt

Table B. Season (life stage) to smolt survival rates.

ODFW Research		Alsea study data	
Life stage	Survival rate	Life stage	Survival rate
Egg to smolt	0.3200	Egg to smolt	0.0270
Spring to smolt	0.4600	June to Smolt	0.0644
Summer to smolt	0.7200	Fall to smolt	0.1110
Winter to smolt	0.9000	Winter to smolt	0.2870

Rates used by Tom Nickelson (ODFW)

Rates provided by Jim Hall (OSU Dept of F & W)

Table C. Rearing capacities

Table C1. Upland rearing capacities.

Stream ID		Rearing capacity (# eggs or fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Bear Crk	2,917		
Stream 2	Trib I	8,333	1,458	859
Stream 3	Ivy Crk	12,852	7,796	2,867
Stream 4	Maynard Crk	11,961	5,794	7,683
Stream 5	Selder Crk	77,419	29,427	80,975
Stream 6	Fall Crk	3,252	2,168	1,044
Stream 7	Ginger Crk			
Stream 8	Trib A	8,333	661	124
Stream 9	Martin Crk	8,333	492	243
Stream 10	Trib B	8,333	8,542	2,837
Stream 11	Weed Crk	89,806	11,905	7,774

Stream 12	Trib C	8,333	2,456	1,508
Stream 13	Olson Crk	83,548	5,108	3,944
Stream 14	NF Rock Crk	298,374	56,665	30,326
Stream 15	Trib H	8,333	2,013	1,242
Stream 16	Military Crk	11,729	19,483	15,199
Stream 17	SF Rock Crk	357,367	21,597	13,127
Stream 18	Trib D	31,626	23,036	50,027
Stream 19	Trib E	8,333	1,671	963
Stream 20	NF Rock/Trib A	5,574	1,807	3,869
Stream 21	NF Rock/Trib B	19,974	17,551	7,602
Stream 22	NF Rock/Trib C	8,333	243	124
Stream 23	SF Rock/Trib A	11,535	20,067	17,927
Stream 24	SF Rock/Bear Crk	39,097	10,658	22,401
Stream 25	Rock Crk	484,335	415,996	228,879
	Totals	1,608,031	666,592	501,544

Table C2. Lowland rearing capacities.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
Stillwater with edge habitat		
Wetland channels		
Flooded wetlands		
Total		

Table D. Potential smolt production based on ODFW survival rates

Table D1. Upland potential smolt production based on ODFW survival rates.

Stream ID	Potential smolt production (# fish)

Number	Name	Spawning	Summer	Winter
Stream 1	Bear Crk	933		
Stream 2	Trib I	2,667	1,050	773
Stream 3	Ivy Crk	4,113	5,613	2,580
Stream 4	Maynard Crk	**3,828**	4,171	6,914
Stream 5	Selder Crk	24,774	21,188	72,878
Stream 6	Fall Crk	1,041	1,561	940
Stream 7	Ginger Crk			
Stream 8	Trib A	2,667	476	111
Stream 9	Martin Crk	2,667	354	219
Stream 10	Trib B	2,667	6,150	2,554
Stream 11	Weed Crk	28,738	8,572	6,997
Stream 12	Trib C	2,667	1,768	1,357
Stream 13	Olson Crk	26,735	3,678	3,549
Stream 14	NF Rock Crk	95,480	40,799	27,293
Stream 15	Trib H	2,667	1,449	1,118
Stream 16	Military Crk	**3,753**	14,028	13,679
Stream 17	SF Rock Crk	114,357	15,550	11,814
Stream 18	Trib D	**10,120**	16,586	45,024
Stream 19	Trib E	2,667	1,203	867
Stream 20	NF Rock/Trib A	1,784	1,301	3,482
Stream 21	NF Rock/Trib B	**6,392**	12,637	6,842
Stream 22	NF Rock/Trib C	2,667	175	112
Stream 23	SF Rock/Trib A	**3,691**	14,448	16,135
Stream 24	SF Rock/Bear Crk	12,511	7,674	20,161
Stream 25	Rock Crk	**154,987**	299,517	205,991
	Total	514,570	479,947	451,390

Table D2. Lowland potential smolt production based on ODFW survival rates.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
Stillwater with edge habitat		
Wetland channels		
Flooded wetlands		
Total		

Table E. Potential smolt production based on Alsea study survival rates

Table E1. Upland potential smolt production based on Alsea study survival rates.

Stream ID		Potential smolt production (# fish)		
Number	Name	Spawning	Summer	Winter
Stream 1	Bear Crk	79		
Stream 2	Trib I	225	162	247
Stream 3	Ivy Crk	347	865	823
Stream 4	Maynard Crk	323	643	2,205
Stream 5	Selder Crk	2,090	3,266	23,240
Stream 6	Fall Crk	88	241	300
Stream 7	Ginger Crk			
Stream 8	Trib A	225	73	35
Stream 9	Martin Crk	225	55	70
Stream 10	Trib B	225	948	814
Stream 11	Weed Crk	2,425	1,321	2,231
Stream 12	Trib C	225	273	433
Stream 13	Olson Crk	2,256	567	1,132
Stream 14	NF Rock Crk	8,056	6,290	8,704
Stream 15	Trib H	225	223	356
Stream 16	Military Crk	317	2,163	4,362
Stream 17	Crk	9,649	2,397	3,767
Stream 18	Trib D	854	2,557	14,358
Stream 19	Trib E	225	185	276
Stream 20	NF Rock/Trib A	151	201	1,110

Stream 21	NF Rock/Trib B	539	1,948	2,182
Stream 22	NF Rock/Trib C	225	27	36
Stream 23	SF Rock/Trib A	311	2,227	5,145
Stream 24	SF Rock/Bear Crk	1,056	1,183	6,429
Stream 25	Rock Crk	13,077	46,176	65,688
	Total	43,417	73,992	143,943

Table E2. Lowland potential smolt production based on Alsea study survival rates.

Habitat type	Rearing capacity (# fish)	
	Summer	Winter
Stillwater with edge habitat		
Wetland channels		
Flooded wetlands		
Total		

Table F. Overall rearing and smolt production capacities.

Table F. Combined upland and lowland rearing capacity and potential smolt production. Smolt production is estimated using both ODFW and Alsea watershed survival rates.

Life stage (season)	Rearing capacity (# fish)	Potential smolt production (# fish)	
		ODFW rates	Alsea rates
Spawning (# eggs)	1,608,031	514,570	43,417
Spring (# fish)	no data	no data	no data
Summer (# fish)	666,592	479,947	73,992
Winter (# fish)	501,544	451,390	143,943

No estimate of spring capacity or potential smolts produced is possible with current data.

Calculation of Spawning (# eggs) is based on the assumptions of 2500 eggs/redd and 3 m2/redd

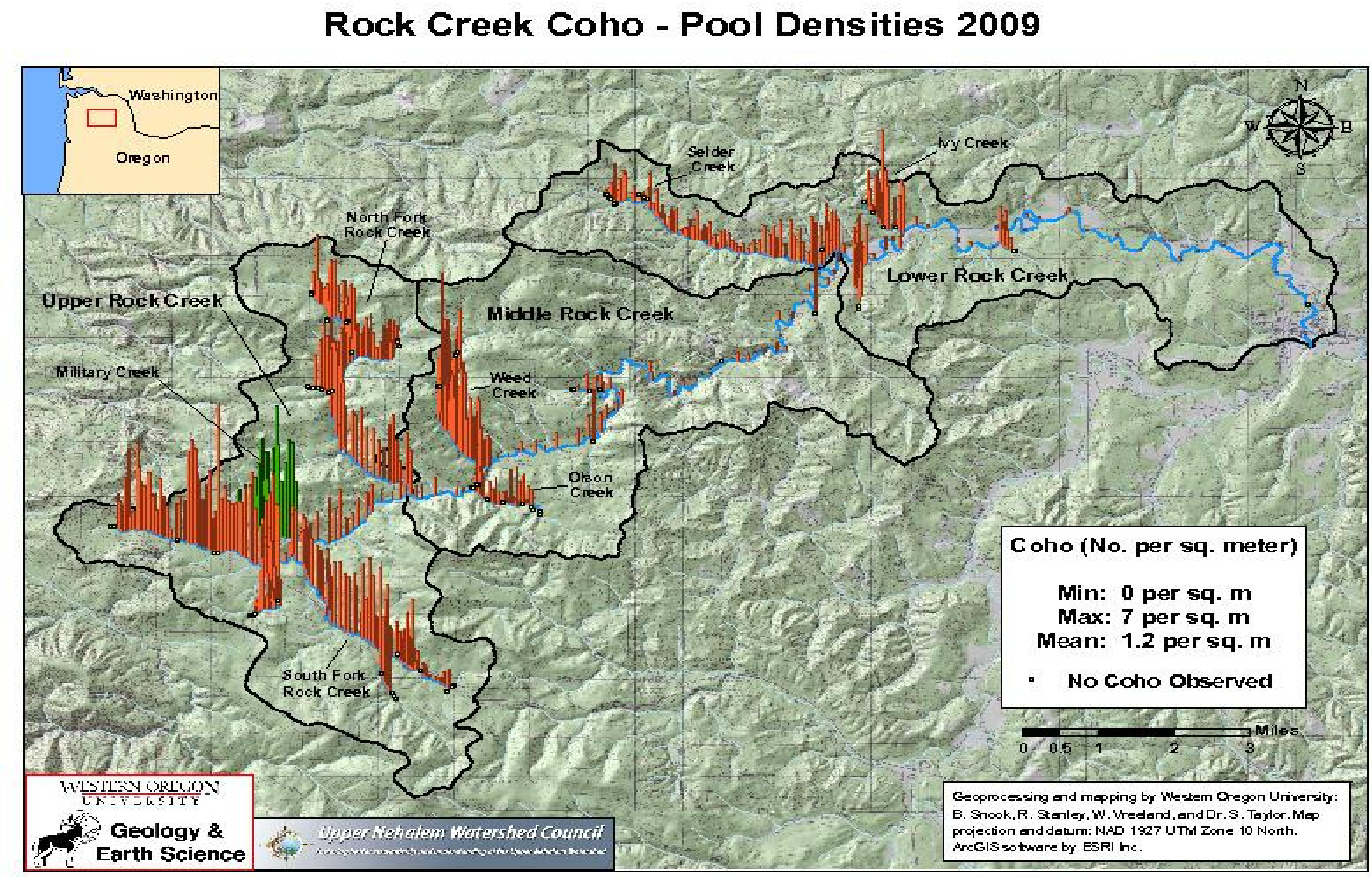
Analyst notes

Notations by analyst describing scenario goals and results
Goals
It appears that spawning gravel is limiting utilizing the Alsea Study survival rates. This helps us think about gravel resources and how they move through the system. The steel trash rack at Hwy 26 terminates downstream gravel transport. This may ramp up the importance of removing this structure and working on the undersized culvert at Hwy 26.

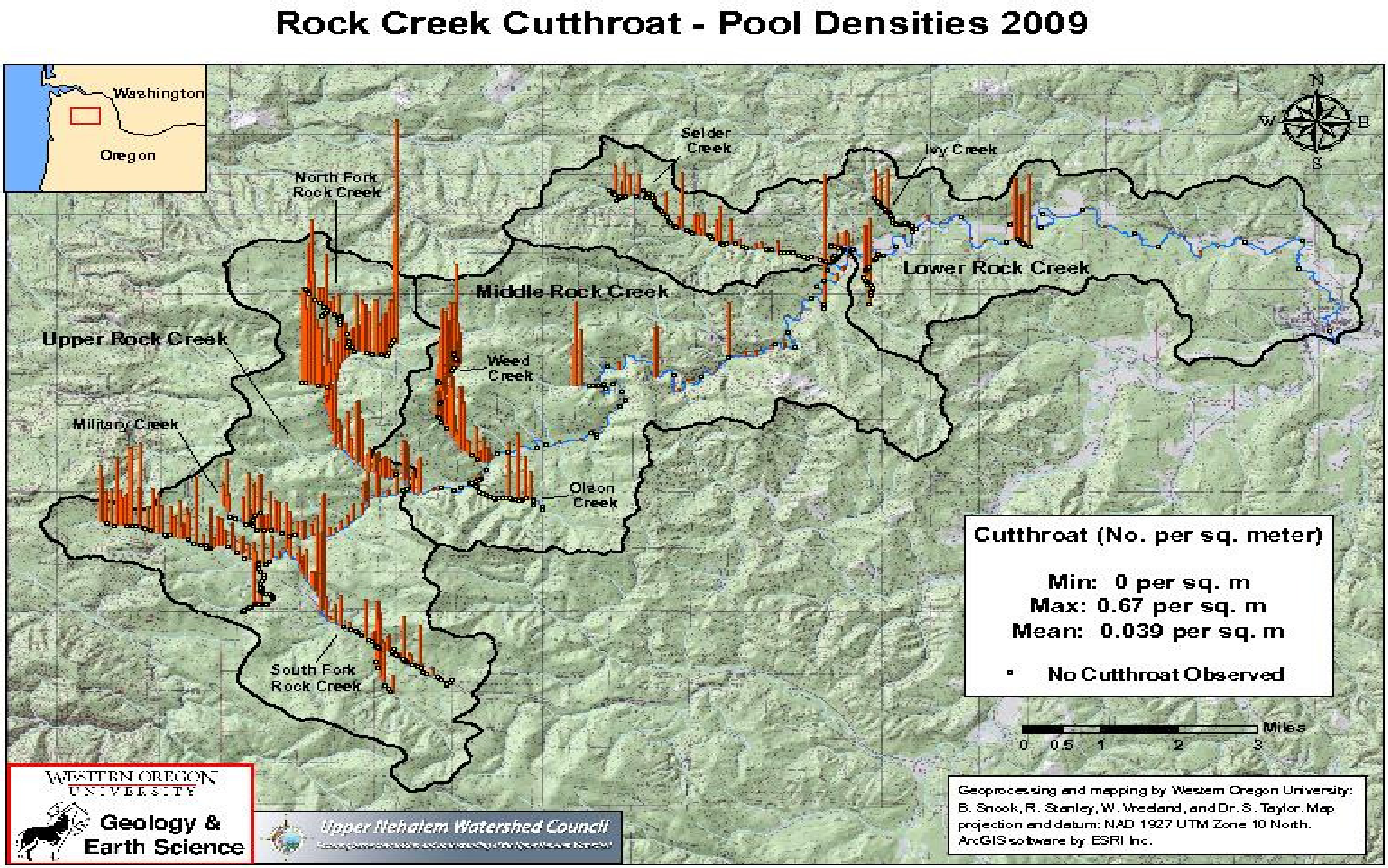
Reaches 1 and 72.3% of Reach 2 of the summer rearing capacity of mainstem Rock have been eliminated from this scenario by making alterations in the summer uplands summary tab. This was done to represent the current temperature limitation that exists in the mainstem of Rock for proper summer utilization of the available habitats by juvenile coho. The temperature limited habitats extend from the mouth of Rock Cr to the confluence of Selder Cr.

Table E1 contains stream reaches with adequate spawning gravel to seed the habitat within the trib to the 2.4 fish/sq m level observed in high quality habitat (Changed in summer uplands tab line 17-24). These streams are highlighted in red in Table E1. These streams are the ones that have the potential of pumping supplemental nomadic spring fry into downstream habitats (mainstem Rock) that don't have significant spawning potential. The big players are SF Rock, NF Rock and mainstem Rock above the SF confluence.

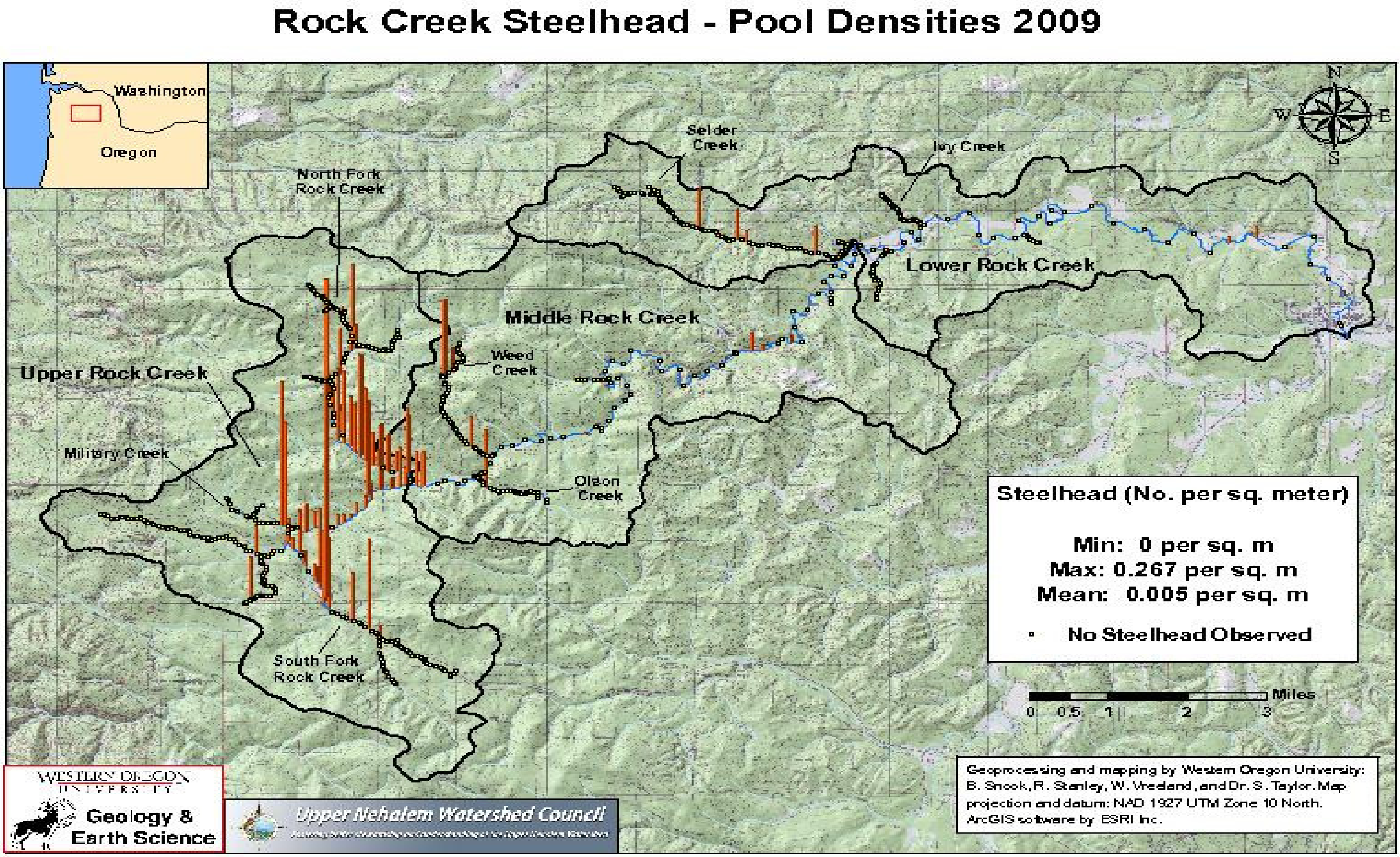
Appendix 7. Rock Cr (Nehalem) 6th field, summer coho distribution chart.



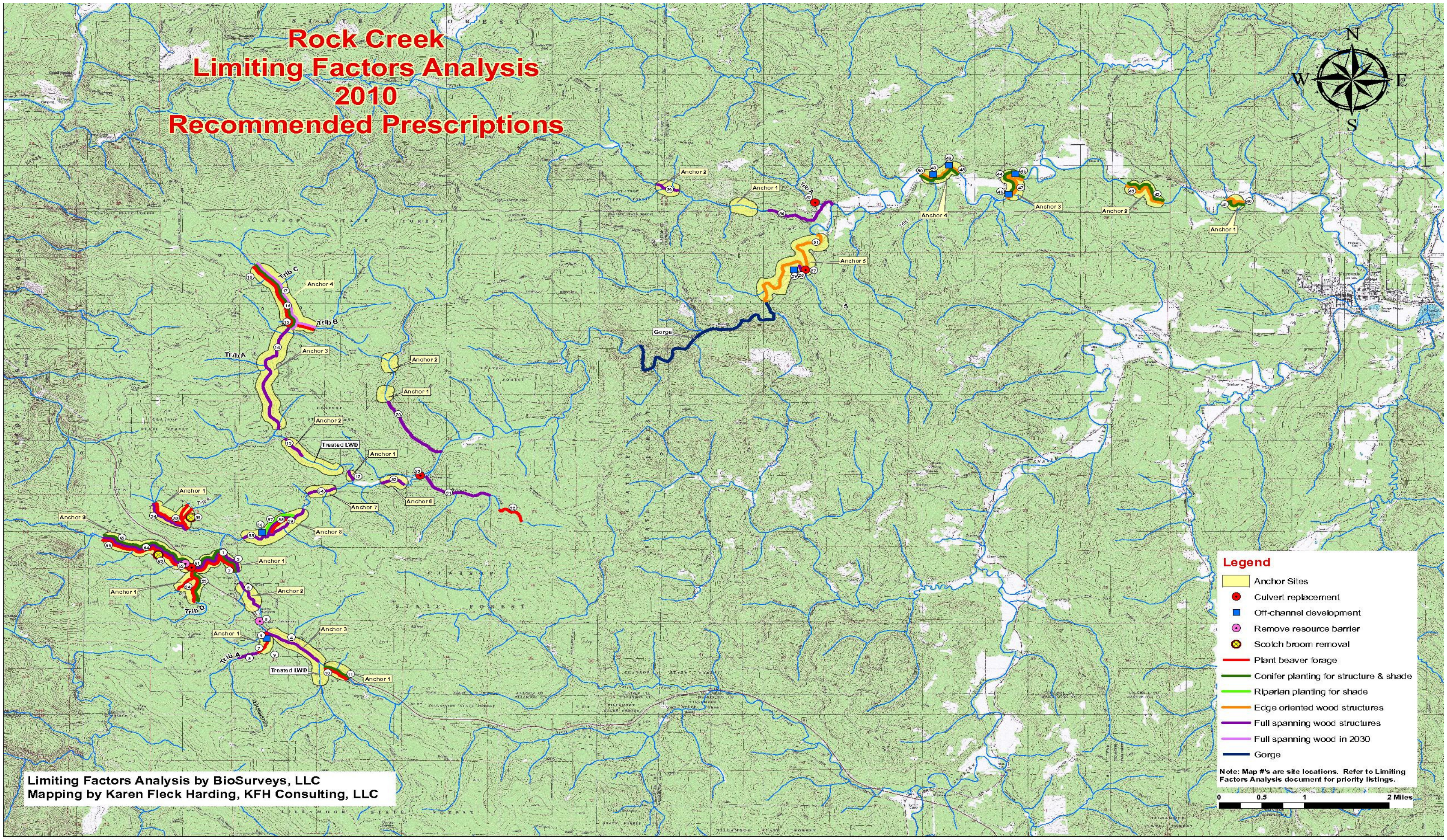
Appendix 8. Rock Cr (Nehalem) 6th field, summer cutthroat distribution chart.



Appendix 9. Rock Cr (Nehalem) 6th field, summer steelhead distribution chart.



Appendix 10. Rock Cr (Nehalem) 6th field, prescription chart.



Appendix 11. Rock Cr (Nehalem) 6th field, prioritized list of prescriptions.

Map #	Priority Level	Stream	Anchor Site	Category	Action	Comment
1	1	South Fork Rock Creek	1	Plant	Riparian planting in Anchor Site 1	To increase future recruitment potential for structure and increase canopy cover to reduce temperature limitations in the mainstem.Caging necessary.
2	5	South Fork Rock Creek	1	Protect	Develop conservation easement strategy for Anchor Site 1.	One site potential (200ft each side of stream)
3	1	South Fork Rock Creek	1, 2	LWD Full	Full spanning wood structures in Anchor Sites 1 and 2	To preserve existing high function and maintain existing gravel resources. Machine placement possible.
4	1	South Fork Rock Creek	3	LWD Full	Full spanning wood structures in Anchor Site 3 below the confluence of Bear Cr.	These structures would greatly increase the floodplain function of the anchor site as well as supplement the investment of the structures placed above the confluence of Bear Cr. Machine placement possible.
5	1	South Fork Rock Creek	1	LWD Full	Full spanning wood complexes in Trib A	To trap and store spawning gravels in the stream segment above the high quality rearing habitat identified in downstream Anchor Site 1.

6	2	South Fork Rock Creek	1	Create off channel	Develop (excavate) off channel back waters / alcove at the confluence of Trib A and Trib A1 and on the low interactive terraces of Anchor Site 1.	Both locations would provide high quality rearing habitat in all seasons plus supplemental water storage for moderating both summer and winter flows.
7	1	South Fork Rock Creek	1	Beaver	Plant beaver forage (willow, vine maple, ash, cottonwood) in Anchor Site 1 & trib A	To encourage colonization.
8	4	South Fork Rock Creek		Remove barrier	Remove concrete divider at hwy 26 culvert.	Blocks resource migration (wood and gravel). Not a fish passage concern
9	5	South Fork Rock Creek	1	Protect	Extend RMA around identified anchor site in Trib A to 200ft.	Exceptionally unique cold water refugia with large production potential because of morphology.
10	1	Bear Creek	1	Beaver	Plant beaver forage (willow, nine maple, ash, cottonwood) in and around Anchor Site 1.	May require selective girdling.
11	2	Bear Creek	1	Plant	Conifer planting in and around Anchor Site 1 to ensure future recruitment for structure.	Cedar would likely be the best species. Caging necessary.
12	1	North Fork Rock Creek	1	LWD Full	Full spanning wood complexity in Anchor Site 1.	Helicopter placement preferable. Machine placement possible.
13	1	North Fork Rock	2	LWD Full	Full spanning wood complexity in the upper 1,000 ft of Anchor Site 2.	Helicopter placement.

		Creek				
14	1	North Fork Rock Creek	3	LWD Full	Full spanning wood complexity in Anchor Site 3.	This would protect and enhance the existing structures that are beginning to fail. Helicopter placement
15	1	North Fork Rock Creek	4	Beaver	Plant beaver forage (willow, vine maple, ash, cottonwood) in Anchor Site 4.	Selective girdling may be necessary.
16	4	North Fork Rock Creek	4	Plant	Conifer planting throughout Anchor Site 4.	Goal is to provide future persistent structure for recruitment.Caging necessary.
17	5	North Fork Rock Creek	4	LWD Full	Full spanning wood treatment in Anchor Site 4 in the future (15-20 years).	Look at this prescription in the year 2030
18	5	North Fork Rock Creek	4	Protect	Extend RMA around Anchor Site 4 to 200ft.	Future harvest to within 100 ft will create the loss of existing alder from windthrow and sun scald, very key site for special concern.
19	2	North Fork Rock Creek		Protect	Develop strategies for second order non fish bearing streams to limit solar exposure.	Slash accumulation, needs creative thinking to solve problem.
20	2	Weed Creek		LWD Full	Full spanning wood complexity starting at the mouth and working upstream to Anchor Site 1.	Machine placement

21	2	Weed Creek		Protect	Protect riparian buffers on first and second order tributaries in the first 1.7 miles.	Leaving buffer strips, slash retention. These are sites with high slide potential for recruiting resources (wood, gravel).
22	5	Weed Creek		Protect	Facilitate beaver colonization with beaver management plan that recognizes the value of the ecosystem services provided by beaver.	Could include trapping moratorium. Cooperative agreement with OFIC and landowner to preserve this keystone species.
23	5	Tributary D of Rock Creek	1	Plant	Plant conifer throughout Anchor Site 1	For future recruitment of structure and canopy cover to mitigate for extensive solar exposure. Would require caging and moisture tolerant species (cedar).
24	1	Tributary D of Rock Creek	1	Beaver	Plant beaver forage (willow, vine maple, ash, cottonwood) throughout lower 1 mile.	This is an important reference site that currently display incredible function but is challenged by diminshing forage.
25	5	Ivy Creek		Protect	Protect existing riparian throughout to ensure future recruitment and limit solar exposure.	Historic harvest has removed all riparian canopy w/ no buffer retained.
26	5	Ivy Creek		Protect	Facilitate beaver colonization with beaver management plan that recognizes the value of the ecosystem services provided by beaver.	Could include trapping moratorium.

27	3	Fall Creek		Remove barrier	Replace culvert crossing on county road.	Current maintenance issue.
28	2	Fall Creek		LWD Full	Full spanning large wood placement below county road.	Site exhibits potential for high function.
29	2	Fall Creek		Create off channel	Construct off channel rearing locations through the excavation of backwater/alcove complexes.	Site exhibits potential for high function.
30	5	Fall Creek		Protect	Conservation easement below county road. Very significant site providing cold water refugia to upstream migratory juveniles escaping the temperature limited mainstem.	Important location near the transition from temperature limitations in the mainstem. Juveniles moving upstream end up here in big numbers.
31	2	Olson Creek		LWD Full	Large wood placement below the jam at 1,000ft to aggrade bedload material and create a passable approach to the jam.	This would be considered high priority. Placing additional large wood over the next 3,500ft is also recommended as a secondary priority. Machine placement.
32	3	Olson Creek		Beaver	Plant beaver forage (willow, vine maple, ash, cottonwood) in upper beaver flats starting 4,500ft from mouth.	

33	2	Military Creek	1	Beaver	Plant beaver forage (willow, vine maple, ash, cottonwood) to alleviate solar exposure and encourage beaver impoundment.	This would increase water storage potential for moderating both summer and winter flows.
34	2	Military Creek	1	LWD Full	Large wood placement throughout Anchor Site 1.	Using material thinned from adjacent stands outside the riparian would be preferable in this location. Machine placement.
35	5	Military Creek	1	Treat Invasive	Remove invasive scotch broom in Trib A portion of Anchor Site 1.	It is still manageable and appears isolated.
36	2	Selder Creek		LWD Full	Full spanning large wood placement in lower 0.5 RM	To aggrade bedload and restore floodplain connectivity.
37	5	Selder Creek		Remove barrier	Replace undersized culvert on Trib A	To facilitate resource transport. Could also be fish passable with a series of structures below that step up to the 5ft waterfall.
38	5	Selder Creek		Protect	Establish permanent RMA	To prevent harvest to the active stream channel again.
39	3	Selder Creek	2	LWD Full	Large wood placement in Anchor Site 2	To increase floodplain connectivity and summer / winter rearing potential. Using on-site trees would be possible. Machine placement.
40	3	Rock Creek Main	1	LWD Edge	The addition of multiple edge oriented large wood structures in Anchor Site 1	To encourage back water development, encourage water storage and provide winter rearing habitat.

41	4	Rock Creek Main	1	Plant	Riparian planting within Anchor Site 1 to reduce solar exposure, mitigate for temperature limitations and provide a future source of LWD.	Because of the potential for storage that currently exists within this anchor site, planting prescriptions should focus on the establishment of conifer. The site exhibits long term significance for maintaining persistent function that traps and retains both large wood and spawning gravel.
42	4	Rock Creek Main	2	Plant	Riparian planting within Anchor Site 2 to reduce solar exposure, mitigate for temperature limitations and provide a future source of LWD.	Because of the potential for storage that currently exists within this anchor site, planting prescriptions should focus on the establishment of conifer. The site exhibits long term significance for maintaining persistent function that traps and retains both large wood and spawning gravel.
43	3	Rock Creek Main	2	LWD Edge	Place multiple edge oriented large wood structures in Anchor Site 2	To encourage off channel habitat development, water storage and winter rearing habitat.
44	4	Rock Creek Main	3	Plant	Riparian planting within Anchor Site 3	To address cumulative temperature impact. Planting within the anchor site would also provide future large wood recruitment for structure and cover.

45	5	Rock Creek Main	3	Protect	Conservation easement to obtain a riparian setback throughout Anchor Site 3 starting at RM 7.5	To ensure future recruitment of LWD.
46	3	Rock Creek Main	3	Create off channel	Improve existing off channel backwater complexes (excavation) in Anchor Site 3.	Could be incorporated with existing small cold water tributary on the North East side of the anchor site and would increase the availability of off channel rearing habitat for both summer and winter. This would also increase both summer and winter water storage capacity.
47	3	Rock Creek Main	3	LWD Edge	The addition of LWD complexes throughout Anchor Site 3	To ensure future recruitment of LWD.This would also increase water storage during both summer and winter flows. Helicopter placement.
48	4	Rock Creek Main	4	Plant	Riparian planting within Anchor Site 4 to increase recruitment potential, provide cover and riparian diversity.	Additional plantings outside the anchor site would also assist in mitigating for solar exposure to address cumulative temperature impacts.
49	3	Rock Creek Main	4	Create off channel	Create backwater/alcove in Anchor Site 4 that incorporates cold water tributaries to increase both summer and winter off channel rearing potential.	This would also increase the water storage capabilities of the site during both summer and winter flows.

50	3	Rock Creek Main	4	LWD Edge	Place edge oriented LWD complexes in Anchor Site 4.	Helicopter placement
51	3	Rock Creek Main	5	LWD Edge	Place edge oriented LWD complexes throughout Anchor Site 5.	Helicopter placement
52	2	Rock Creek Main	6	LWD Full	The addition of full spanning LWD complexes in Anchor Site 6 would aggrade bedload, retaining gravels, increase pool complexity, and increase floodplain interaction.	This would dramatically improve the main limitations at this location. Helicopter/machine placement.
53	4	Rock Creek Main	6	Remove barrier	Remove and replace the undersized culvert on Trib C in Anchor Site 6.	This would increase juvenile accessibility to important off channel rearing habitats.
54	2	Rock Creek Main	7	LWD Full	The addition of full spanning LWD complexes in Anchor Site 7 would aggrade bedload, retain spawning gravels, increase pool complexity, and increase floodplain interaction.	This would address the primary limitations at this location and on the basin scale. Helicopter/machine placement.
55	1	Rock Creek Main	8	LWD Full	Full spanning LWD complexes within Anchor Site 8 to aggrade bedload material, raise frequency and scope of floodplain interaction, improve sinuosity, and increase water storage. .	Full spanning LWD complexes would likely encourage beaver activity in this portion of the mainstem. Machine placement

56	2	Rock Creek Main	8	Create off channel	Design side channel construction for the Inman-Paulson mill pond site.	This would include stream diversion and off channel backwater and alcove development associated with tributaries located within the site.
57	2	Rock Creek Main	8	Plant	Riparian planting to reduce solar exposure in new side channel at Inman – Paulson Mill Pond site	Tto ensure future recruitment, increase cover, and vegetative diversity.
58	2	Rock Creek Main	8	LWD Full	Full spanning LWD complexes in new side channel	To encourage complexity, aggrade bedload material, raise frequency and scope of floodplain interaction, improve sinuosity, and increase water storage. There is the opportunity to use wood from onsite sources.
59	2	Rock Creek Main	8	Beaver	Plant beaver forage (Willow, Ash, Cottonwood, Vine Maple) throughout side channel development at Inman – Paulson Mill Pond Site	To encourage colonization of the created off channel habitats.. This results in increased pool surface areas and rearing capacity.
60	4	Rock Creek Main		Plant	Riparian planting to reduce solar exposure, ensure future recruitment, increase cover, and vegetative diversity.	This is a general prescription that applies to all mainstem locations exhibiting degraded riparian canopies. Prioritize upper basin prescriptions but consider all potential sites.

61	2	Rock Creek Main	9	Remove barrier	Remove and replace the undersized culvert under the Hwy 26 crossing.	This site severely restricts the natural recruitment of natural resources (wood and gravel) to lower mainstem reaches.
62	2	Rock Creek Main	9	Remove barrier	Permanently remove the trash rack directly above the Hwy 26 crossing	Iit terminates resource migration (wood and gravel) to lower mainstem reaches and delays and potentially blocks anadromous access to headwater spawning reaches.Remove in conjunction w/ culvert replacement
63	5	Rock Creek Main	9	Treat Invasive	Eradicate invasive scotch broom infestation from meadows in the upper mainstem of Rock above the Hwy 26 crossing.	Success currently still achievable.
64	1	Rock Creek Main	9	LWD Full	Full spanning LWD complexes within Anchor Site 9	To improve complexity, aggrade bedload (spawning gravel), increase the frequency and scope of floodplain interaction, improve sinuosity, and increase water storage. Full spanning LWD would also encourage beaver activity in the mainstem. Machine placement.
65	1	Rock Creek Main	9	Plant	Riparian planting to reduce solar exposure in Anchor Site 9	To ensure future recruitment for structure, increase cover, and provide vegetative diversity.

66	1	Rock Creek Main	9	Beaver	Plant beaver forage (willow, vine maple, ash, and cottonwood)	To alleviate solar exposure and encourage beaver impoundment. This would increase water storage potential for moderating both summer and winter flows.

1) Map # refers to Appendix 10.
2) Prescriptions are ranked by priority from 1-5. Category 1 prescriptions have the highest likelihood of immediately addressing current limitations.
3) If you are viewing this table in MS Excel, you can use the functions Sort and Filter to organize and group according to Priority, Category, Stream, and other table headings. If you are viewing in MS Word, you can copy and paste the table into Excel for this purpose.

Appendix 12. Photos.

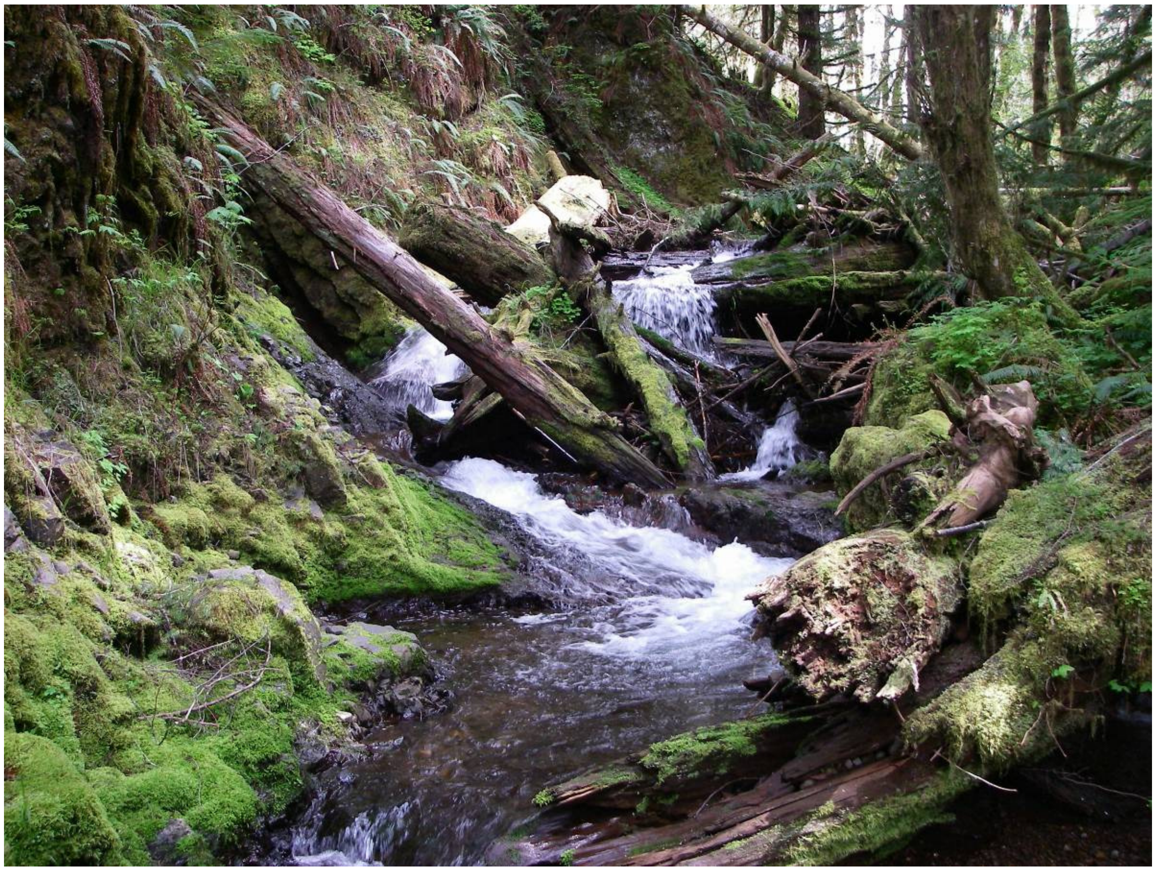


Photo 1. End of anadromous use, SF Rock.

Photo 2. Old growth legacy wood SF Rock, rare.

Photo 3. Backwater and low terrace SF Rock.

Photo 4. Floodplain interaction and potential SF Rock.

Photo 5. Accelerated alder recruitment from inadequate harvest buffer SF Rock Anchor Site 1.

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Photo 7. Area treated with full spanning wood jams, Anchor Site 2 in SF Rock.

Photo 8. High functioning habitat, Anchor Site 1 of Bear Creek on SF Rock.

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Photo 10. Gravel deposition above wood complexity, exhibiting potential for habitat development in NF Rock.

Photo 11. Old and new structure logs creating high quality habitat in Anchor Site 2 NF Rock. Model of effective restoration.

Photo 12. Low terraces but little wood complexity, Anchor Site 1 in NF Rock.


Photo 13. Exposed historic beaver flat at upper end of Anchor Site 4 in NF Rock. Proposed willow planting site.

Photo 14. High quality beaver impoundment and floodplain interaction on Trib D of Rock Cr.

Photo 15. Solar exposure in beaver flat, Trib D of Rock Cr.


Photo 16. Ephemeral wood jam barrier on Olson Creek.

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Photo 18. Beginning of Anchor Site 1 on Military Creek.

Photo 19. Culvert in Trib A of Selder Cr.

Photo 20. Naturally recruited riparian LWD from fire-toppled conifer on Selder Cr. Still exhibiting extreme high function; rare.

Photo 21. Fire legacy wood still available for recruitment in Selder Cr.

Photo 22. Slope failure adjacent to legacy jam. Only small reprod available for recruitment in Selder Cr. Historically logged to stream edge with no buffer retained.

Photo 23. Un-maintained trash rack above HWY 26. Mainstem Rock.

Photo 24. Large backwater and extensive solar exposure. Lower mainstem Rock Cr, Anchor Site 1.

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Photo 31. Legacy channel and backwater habitat in Anchor Site 8 of mainstem Rock Cr. Downstream reconnection site for proposed channel realignment.

Photo 32. Large full-spanning jam formed on collapsed log stringer bridge still holding Rock Cr Anchor Site 8 together.

Photo 33. Under-sized HWY 26 culvert in Rock Cr Anchor Site 9. Compromising resource migration and delivery to lower mainstem Rock Cr.

Photo 34. Beaver impoundment un upper Rock Cr, storing spawning gravels and creating high quality summer and winter habitat within Anchor Site 9.

Appendix 10
Nehalem Rapid Bioassessment Inventory for Salmonids

2018-2019

Nehalem Rapid Bioassessment Inventory for Salmonids

Prepared for: Lower Nehalem Watershed Council

Bio-Surveys, LLC

Authors: Jeremy Lees, Steve Trask, and Nissa Rudh

Date: May 25, 2020

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Executive Summary

A Rapid Bio-Assessment Inventory (RBA) for Salmonids was conducted by Bio-Surveys LLC within the Lower Nehalem watershed during the summers of 2018 and 2019. A total of 202.2 stream miles were snorkeled and the following significant observations were made during the field work and subsequent data analysis phase of this assessment. The highlights below provide context for further review of this report.

- The abundance of anadromous fish fell substantially short of full seeding capacities for both adult and juvenile life stages in most mainstem and tributary habitats.
- 0+ trout of combined cutthroat and steelhead progeny were the most abundant salmonid observed in the mainstem Nehalem tributaries in 2018 and coho were the most abundant salmonid species observed in the North Fork subbasin in 2019.
- A lack of significant habitat complexity and channel roughness in the form of wood complexes was documented throughout the majority of both the mainstem and tributary habitats.
- Mainstem summer temperature limitations and the lack of access to thermal refugia are severely limiting summer rearing potential throughout most of the lower Nehalem mainstem and the lower North Fork Nehalem mainstem. The presence of these durable elevated temperature profiles during pinch period summer flows is driving large scale temperature dependent fish migrations.
- Numerous cold-water contributions were documented providing critical thermal refugia to high abundances of salmonids during the peak summer temperature regime. These refugia lacked adequate refuge in the form of woody debris and other cover, which likely increased rates of predation by larger fish, otters, and birds.
- Lack of availability to high quality spawning gravel was functioning as the primary limiting factor for coho production in several tributaries of both the lower Nehalem and North fork Nehalem, despite low estimated adult escapement for the corresponding brood years.
- 40 Anchor Sites, 11 Thermal Refugia Sites, and 5 barriers to passage were identified as high priorities for future restoration efforts.

Introduction

Purpose

The intent of this project was to quantify distribution and relative abundance of all juvenile salmonid species during pinch period summer low flow regimes that truncate their distribution as a function of elevated stream temperature. The inventory consisted of snorkel surveys that began at a head of tide and/or at the mouth of each tributary. Surveys extended to the end of significant rearing potential for anadromous salmonids, describing the full extent of distribution for steelhead and coho in summer 2018 and 2019. The surveys did not extend to the end of cutthroat distribution. This data establishes base-line distribution and abundance metrics, provides a foundation for long term trend analysis, identifies anchor habitats and guides future restoration and management actions.

The 2018 and 2019 Rapid Bio-Assessment inventory (RBA) of the Lower Nehalem and North Fork Nehalem covered 202.2 miles of river and stream habitat. This effort encompassed all mainstem and tributary habitats exhibiting anadromous potential from the confluence with the Pacific Ocean to the confluence of Humbug Creek (RM 34.7).

Spawning gravel abundance estimates and anchor sites identifications were included in the inventory of 169.6 miles of mainstem and tributary stream habitats (only spawning gravel sites appropriate for coho were quantified). Spawning gravel and Anchor site identification was not included in the mainstem Nehalem thermal refugia inventory.

Inventory of thermal refugia were conducted on 34.7 miles of the lower mainstem Nehalem, starting at the Pacific Ocean and extending to the confluence of Humbug Creek. The intent of this inventory was to identify cold water contributions providing thermal refugia to salmonids during periods of elevated temperature in mainstem habitats of the lower Nehalem.

Historic Context

The Nehalem Watershed encompasses 855 square miles and includes areas of Washington, Columbia, Clatsop, and Tillamook Counties. The basin was historically dominated by old growth coniferous ecosystems with expansive marshlands in the lower gradient areas and estuaries (Kostow 1995). In 1893, Reverend K. Hines described trees in the region averaging 250 feet in height and four to six feet in diameter, with trees frequently 350 feet in height and 10 feet in diameter. Species included Douglas fir, cedar, spruce, oak, maple and alder (Bourhill 1994). Stumps of redwood trees and Port Orford cedar trees in the Nehalem Bay area have been recorded up to 1700 years old (Nehalem Valley Historical Society).

Native peoples lived in the Nehalem Watershed for thousands of years before settlement of Europeans. These people subsisted primarily on salmon and other seafood. These peoples also regularly burned portions of the landscape and the understory of forests to maintain building sites, encourage herbs to grow, and reduce debris. During the late 1700’s, disease carried by Europeans wiped out an estimated 70-90% of the Native Nehalem population.

Pioneering in the Nehalem valley began in the mid 1800's and logging began early and increased substantially as the area became more populated. Settlers used the relatively smooth flowing river as a highway to transport lumber (Cotton 1997). Log drives down the Nehalem River started in 1901 and lasted until 1926, with mills in Wheeler, Pittsburg, and Vernonia. Logs were floated down rivers on high winter flows. This scoured the river bottom and swept large embedded wood structures downstream. Riparian vegetation along stream banks was destroyed as logs were drug into the river.

During these years, splash dams were installed on the North Fork Nehalem. In a splash dam, the river is dammed so that water and logs back up behind it. Then the dam is released along with the cascading water and logs to go to the sawmill downstream, severely damaging the stream and scouring gravel in the process.

It is estimated that a hundred million board feet of timber were floated out of the North Fork of the Nehalem River, mostly with the assistance of splash dams (Farnell 1981). The last old growth timber in the watershed was cut in 1945 (Sword 1999), less than 100 years after the first settlement by Europeans.

Several major fires have occurred within the Nehalem Watershed. In 1800, thousands of acres burned just south of Mist. In August, 1933, the famous "Tillamook Burn" burned 270,000 acres in the region. The Salmonberry River, Cook, Humbug, and Rock Creek drainages were extensively affected as well as the mainstem of the Nehalem River from River Mile 12 to 42 (Weber and Knispel 1972). The Salmonberry River and Cook Creek drainages were burned once again in the "Salmonberry Fire" of 1945.

The Tillamook burn eliminated timber value in the Nehalem, and many of the landowners foreclosed and transferred ownership to the counties. Most of these lands were then transferred to the State Board of Forestry. And so, it is today, over 38% of the Nehalem Watershed is owned by Oregon State. Almost all the rest is owned by large timber companies. Longview Timber owns 35% of the private land in the watershed. Currently an astounding 92% of land use is classified as "Forestry".

Rainstorms and associated landslides in February 1996 and December 2007 caused significant habitat changes in the Salmonberry River Subbasin (a tributary to the mainstem Nehalem). Debris torrents entirely stripped some tributaries of riparian vegetation for several kilometers. The Salmonberry is one of the only North Coast rivers with a healthy population of winter steelhead and has been designated Anchor Habitat by the Oregon Department of Forestry (Fergusson 2011).

The desire for more timber production, in combination with an effort to minimize future fire risk, spurred a reforestation program which began in 1949 and these trees are currently the target of contemporary harvest operations.

Historic and Current Salmon Runs

The Nehalem is home to Chinook salmon, coho salmon, Chum salmon, steelhead, resident and sea-run cutthroat trout, and small populations of resident rainbow trout. Historic runs of salmonids were tremendous compared to current numbers. Meengs and Lackey (2005) estimated Nehalem runs in the late 1800's (post European settlement) of 236,000 coho and 44,000 Chinook based on records from canneries. Salmon runs were likely greater before mass harvest began.

Fishing remained excellent in the Watershed between 1920 and 1940 despite high fish harvest. One angler stated that he and a partner took 23 steelhead in 4 hours at River Mile 8 in 1938. However, salmon runs began noticeably declining in the 1950's (Weber and Knispel 1977).

In recent years (2015-2019) coho runs for the Nehalem have been low — 5,486 in 2017/18 and 4,190 in 2018/19. Abundance in these years was 8% (2017) and 6% (2018) of the Broad Sense Goal. See the figure 1 below for coho runs in the Nehalem since 1994 (ODFW Recovery Tracker).

Recent Chinook runs have also been low, ranging from 5,000 and 20,000 since 1975. Estimated escapement in 2016 was 12,460 and in 2017 was 8,325 (Pacific Salmon Commission 2017). The Pacific Salmon Commission states that "of the three northern coastal Oregon Chinook stocks (Nehalem, Siletz, and Siuslaw), the Nehalem stock has spent more years below escapement objectives than the others. Nehalem River stock of Chinook salmon has experienced a wide array of both exploitation and escapement from 1979 to 2016. See Figure 2 below.

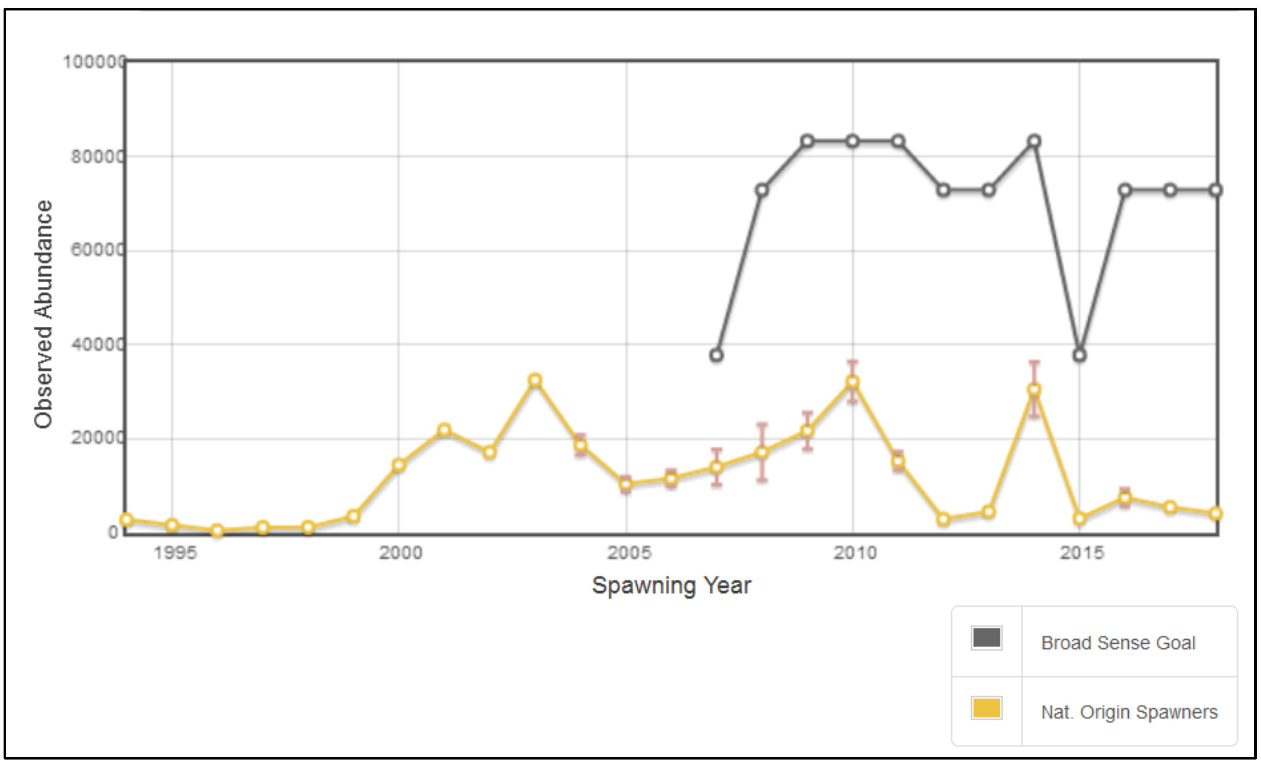

Figure 1 Annual Abundance of naturally produced Coho from 1994 to 2018 for the Nehalem Basin (ODFW Recovery Tracker 2020)

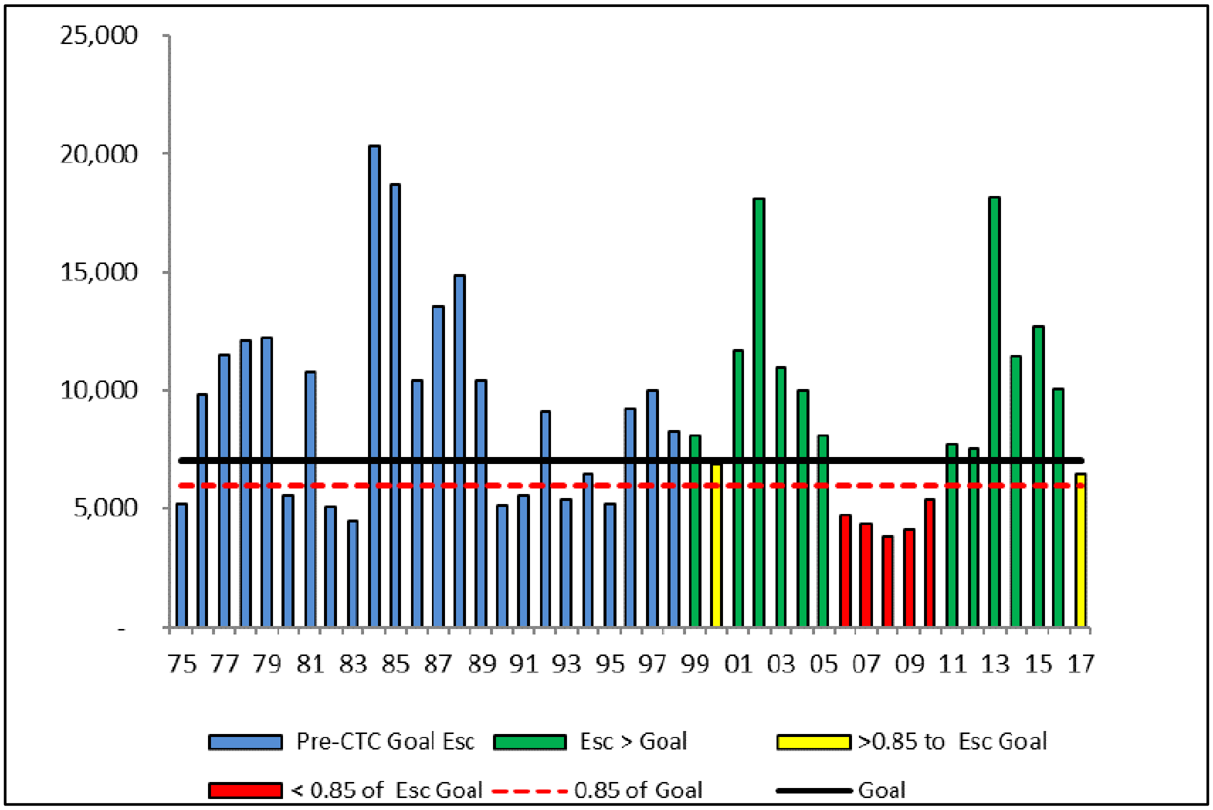

Figure 2 Nehalem River Chinook escapement estimates from 1975-2017 (Pacific Salmon Commission Annual Report for 2017)

Commercial fishing contributed substantially to the general economy of early settlers. Nearly everyone that lived in the valley was connected to commercial fishing in some way. Fishermen worked whenever the fish were running and moved in and out of the area depending on quantities of fish available. Gill nets were used up until 1956 to catch mature fish swimming upstream. Fish canneries were built in Wheeler and canned fish was shipped mainly by rail. During the off-season, fisherman would clear large woody debris from the river which hung up and tore their nets, further eliminating fish habitat. As the fish populations declined, the State of Oregon finally stopped all commercial fishing on the rivers of Oregon except the Columbia River (Nehalem Valley Historical Society).

To sustain fisheries, a hatchery on Foley Creek opened in 1926, rearing cutthroat trout and winter steelhead. The hatchery was closed in 1966 and replaced by the North Fork Nehalem Hatchery. This hatchery currently raises coho, chinook, and winter steelhead. Hatchery runs have had limited success as they are less resistant than wild populations to disease which is exacerbated by high stream temperatures in the lower mainstem (Weber and Knispel 1977).

Current Conditions

Water quality issues within the Nehalem basin may limit anadromous salmonid abundance and adversely affect resident fish and aquatic food web relationships.

Comparatively, the lower Nehalem watershed has been less developed by humans than many watersheds in Oregon. Although it has been heavily logged for generations, much of the land is currently in timber production. USGS Streamstats (Accessed March 2020) provides current information about watershed parameters in the basin. We queried both the North Fork and the Mainstem Nehalem above estuarian influence (due to Streamstats delineation requirements). Upstream of the estuary, about 90% of both the Nehalem and North Fork Nehalem watersheds are forest and shrub lands. Less than 1% is covered with impervious surfaces and only 6% and 5% is considered “developed, open area” (mostly cattle ranches and hay fields) for the North Fork and Mainstem Nehalem subbasins, respectively. Overall forest cover, rather than industrial or residential use, in this watershed means that water quality remains generally higher and supports more fish than other watersheds with further development. Nevertheless, the watershed faces water quality issues as well as habitat degradation that has caused salmonids to decline drastically compared to historic numbers.

The Environmental Protection Agency (EPA) regulates and sets water quality standards for waters of the United States. Section 303(d) of the Clean Water Act authorizes the EPA to assist states, territories and authorized tribes in listing impaired waters and developing Total Maximum Daily Loads (TMDLs) for these waterbodies. A TMDL establishes the maximum amount of a pollutant allowed in a waterbody and serves as the starting point or planning tool for restoring water quality.

The Oregon Department of Environmental Quality (DEQ) assesses water quality in Oregon to meet the federal Clean Water Act Sections 305(b) and 303(d) requirements and reports conditions of Oregon's surface waters. Oregon’s most recent list of Impaired Waters (Submitted 2012) was approved by the EPA December 2016. Waters of the state must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

Water bodies exceeding EPA standards (including water quality issues which impair aquatic life—such as temperature) may be placed on the EPA’s 303(d) “List of Impaired Waters and Total Maximum Daily Loads”. In this section, we review Impaired Waters within the surveyed watershed that are assigned a 303(d) a status of either Category 4 or Category 5. See all status classifications below.

Category 2 – Attaining some criteria/uses

Category 3 – Insufficient data

Category 4 – Water quality is limited (4A TMDL approved)

Category 5 – Water is quality is limited, 303(d) list, TMDL needed.

All anadromous fish within the Nehalem watershed must travel upstream through the Nehalem Bay and estuary, which divides into the North Fork Nehalem and Mainstem Nehalem within tidal influence. Conditions in the following tables are current water quality impairments based on data collected by the DEQ that are known to affect resident fish, aquatic life, anadromous fish passage, salmonid spawning, and juvenile salmonid rearing and migration (Oregon DEQ 2012 Integrated Report). Waters of the state must be sufficient to support aquatic species without detrimental changes in the resident biological communities (Oregon DEQ 2012 Integrated

Report). The EPA's Biological Criteria for water quality states that "waters of the state must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities".

The primary pollutant of mainstem salmonid habitat within the Nehalem watershed are temperatures exceeding salmonid thresholds. Scoured river bottom with a high percentage of bedrock exposure (provides a heat sink and exposes any hyporheic linkage to the impacts of the sun), coupled with low summer water levels drive many salmonids out of large mainstem river environments. Temperature pollution elevates stress levels in rearing salmonids and can be fatal if thermal refugia is not available. Many salmonids take refuge in deep pools, around cold-water seeps, and migrate up colder tributaries to escape lethal temperature limitations during summer low-flows. See the results section for more details on thermal refugia within the Nehalem watershed.

303(d) Listings

Nehalem Bay has **one** Category 4A listing. Fecal Coliform levels exceed EPA standards in the bay, limiting shellfish growth.

Nehalem Mainstem (RM 0-35) has **four** Category 5 and 4A listings affecting River Miles 0-35, which were surveyed for this dataset. Category 4 and 5 listings beginning in reaches upstream of RM 35 were not included in this analysis. Known pollutants are shown in Table 1 below.

Table 1 Nehalem Mainstem (RM 0-35) Category 4 and 5 303(d) Listings in the 2012 Oregon Integrated Water Quality Report

Water Body	River Miles	Pollutant	Season	Beneficial Uses/Criteria	Status
Nehalem River	0-36.2	Dissolved Oxygen	Year Round	Cold-water aquatic life	Cat 5
Nehalem River	0-14.7	Fecal Coliform	Year Round	Shellfish Growth	Cat 4A
Nehalem River	0-92.4	Temperature above 17.8C	Summer	Salmonid fish rearing and anadromous fish passage	Cat 4A
Nehalem River	14.7-92.4	Temperature above 12.8C	Sept 15-May31	Salmonid Spawning	Cat 4A

The North Fork Nehalem has **two** Category 4A 303(d) listings. Knows pollutants are shown in Table 2 below.

Table 2 North Fork Nehalem Category 4 and 5 303(d) Listings in the 2012 Oregon Integrated Water Quality Report

Water Body	River Miles	Pollutant	Season	Beneficial Uses/Criteria	Status
North Fork Nehalem River	0-10.6	Fecal Coliform	Year Round	Shellfish Growth	Cat 4A
North Fork Nehalem River	10.5.-23.6	Temperature above 12.8C	Sept 15-May31	Salmonid Spawning	Cat 4A

Foley Creek, tributary to the Nehalem, has **three** Category 4 or 5 303(d) listings. These are shown in Table 3 below.

Table 3 Foley Creek Category 4 and 5 303(d) Listings in the 2012 Oregon Integrated Water Quality Report

Water Body	River Miles	Pollutant	Season	Beneficial Uses/Criteria	Status
Foley Creek	0-7.1	Biological Criteria*	Year Round	Aquatic life	Cat 5
Foley Creek	0-7.1	E. Coli	Fall, Spring, Winter	Water Contact	Cat 4A
Foley Creek	0-7.1	Temperature above 17.8C	Summer	Salmonid fish rearing and anadromous fish passage	Cat 4A

* Biocriteria – This water body cannot support aquatic species without detrimental changes in the resident biological communities

The Salmonberry River, tributary to the Nehalem has **three** Category 4 or 5 303(d) listings. These are shown in Table 4 below.

Table 4 Salmonberry River Category 4 and 5 303(d) Listings in the 2012 Oregon Integrated Water Quality Report

Water Body	River Miles	Pollutant	Season	Beneficial Uses/Criteria	Status
Salmonberry River	0-18.6	Biological Criteria*	Year Round	Aquatic life	Cat 5

Salmonberry River	0-5	Temperature above 12.8C	Sept 15-May 31	Salmonid Spawning	Cat 4A
Salmonberry River	0-5	Temperature above 17.8	Summer	Salmonid fish rearing and anadromous fish passage	Cat 4A

* Biocriteria – This water body cannot support aquatic species without detrimental changes in the resident biological communities

Wolf Creek, tributary to the Salmonberry River has **two** Category 4 or 5 303(d) listings. These are shown in Table 5 below.

Table 5 Wolf Creek Category 4 and 5 303(d) Listings in the 2012 Oregon Integrated Water Quality Report

Water Body	River Miles	Pollutant	Season	Beneficial Uses/Criteria	Status
Wolf Creek	0-7.8	Biological Criteria*	Year Round	Aquatic life	Cat 5
Wolf Creek	0-7.8	Temperature above 12.8C	Sept 13-May 31	Salmonid Spawning	Cat 4A

* Biocriteria – This water body cannot support aquatic species without detrimental changes in the resident biological communities

Additional creeks with Category 4 or 5 303(d) Status listings included in this RBA sample area include: **Belding**: Biological Criteria, RM 0-2; **Cronin**: Temperature >12.8C (Spawning) RM 0-1.8; **God's Valley**: Temperature >12.8C (Spawning) RM 0-4.8; **Jetty**: Fecal Coliform (Shellfish) RM 0-1.8;

Methods

Basic Survey Protocol

Snorkel survey crews conducted RBA surveys between July 1 2018 and August 30 of 2019. Landowner contacts were made for all the small private, industrial and public ownerships that existed on both sides of every stream reach surveyed.

Stream surveys were initiated by selecting the first pool encountered at the beginning of a mainstem reach or tributary. By not randomly selecting the first sample pool the method was able to identify minor upstream temperature dependent migrations that may not have extended more than a few hundred feet. The identification of this type of migratory pattern in juvenile salmonids is critical for understanding potential limiting factors within the basin (temperature, passage, etc.).

Snorkeler's visually searched 100% of each selected pool, counting all salmonids observed.

The survey continued sampling at a 20% frequency (every fifth pool) until at least four units without steelhead were observed (the survey does not describe the upper limits of native cutthroat distribution). In addition, pools that were perceived by the surveyor as having good rearing potential (beaver ponds, complex pools, and tributary junctions) were selected as supplemental sample units to ensure that the best habitat was not excluded with the random 20 percent sample. This method suggests that the data existing in the database could tend to overestimate average rearing density if these non-random units were not removed prior to a data query (the selected units are flagged as non-random in the database).

Detailed Methods

The snorkeler entered each sample pool from the downstream end and proceeded to the transition from pool to riffle at the head of the pool. In pools with large numbers of juveniles of different species, multiple passes were completed to enumerate by species. (Steelhead first pass, 0+ trout second pass, etc.). This allowed the surveyor to concentrate on a single species and is important to the collection of an accurate value. In addition, older age class steelhead and cutthroat were often easier to enumerate on the second pass because they were concentrating on locating food items stirred up during the surveyor's first pass and appeared to exhibit less of their initial avoidance behavior.

Sample pools had to be at least as long as the average bankfull width. They also had to exhibit a scour element (this factor eliminates most glide habitats) and a hydraulic control at the downstream end. There were no minimum criteria established for depth. Only main channel and select side channel pools in the mainstem were sampled. Back waters and alcoves were not incorporated into the surveyed pool habitats. The primary reasons for not including these off-channel pools is that they compromise the consistency of measuring, summarizing and reporting lineal stream distances (in addition, off channel habitat types are primarily utilized by salmonids as winter refugia).

In sub-basins with low rearing densities, steelhead were not detected for more than four sampled units. These situations were left to the surveyor's discretion, whether to continue or terminate the survey. There is a possibility that very minor, isolated populations of juvenile steelhead could be overlooked in head water reaches of small 2nd order tributaries.

Distances reported in the Access database (See Nehalem_RBA_2019_accdb) are from the beginning of one sampled unit to the beginning of the next sampled unit. The length of the sampled pool is an independent quantity, which was also measured and not estimated. Total distances represented in the database are consistently greater than distances generated utilizing a GIS measuring tool on a GIS stream layer (regardless of projection) because actual sinuosity within the floodplain is greater than that projected in GIS base map layers. If attempting to overlay this database on existing stream layer information, justify linear distances with known tributary junctions (these can be found in the comments column of the Access database). Comparisons of linear distance have not been made between the RBA field data and a LIDAR base layer. We would expect the differences to be less significant between these two platforms.

Pool widths were generally estimated. Because pool widths vary significantly within a single unit, a visual estimate of the average width was considered adequate. Pool widths were typically measured at intervals throughout the survey to calibrate the surveyor's ability to estimate distance.

In large order stream corridors two snorkelers surveyed parallel to each other, splitting the difference to the center from each bank.

Cover Estimate Ratings

A cover/complexity rating was attributed to each pool sampled. This rating was an attempt to qualify the habitat sampled within the reach. The 1 - 5 rating is based on the abundance of multiple cover components within a sampled unit (wood, large substrate, undercut bank, overhanging vegetation). Excessive depth (>3ft) was not considered a significant cover component.

The following criteria were used:

1 0 cover present

2 1-25 % of the pool surface area is associated with cover

3 26-50 % of the pool surface area is associated with cover

4 51-75 % of the pool surface area is associated with cover

5 > 75 % of the pool surface area is associated with cover

The frequency of higher cover/complexity pools increases with a decrease in stream order. This inverse relationship is primarily a function of average channel width and the resultant ability of narrow channels to retain higher densities of migratory wood. Channel morphology begins to play a much more significant role in this relationship during winter flow regimes where increases in floodplain interaction and the abundance of low velocity habitat may become as significant as wood complexity.

Visibility Estimate Ratings

A numerical rating was given to each sampled unit for the surveyor's estimate of visibility. The following criteria were utilized:

1 excellent

2 moderate

3 poor

This variable delivers a measure of confidence to the collected data. Survey segments with a visibility ranking of 1 can assume normal probabilities of detection. Segments with a visibility of

2 suggest that less confidence can be applied to the observed number (uncalibrated) and segments with a visibility rating of 3 suggest that the observation can probably be used to determine presence or absence only.

Beaver dam presence was also recorded during this inventory. Beaver dams were simply counted along the survey and given a sum at the end of each stream. Only intact full spanning dams were counted. This variable may then be sorted in the Access database for presence, absence, and trend within each basin.

Commentary was recorded within surveyed reaches that includes information on temperature, tributary junctions, culvert function, the abundance of other species and adjacent land use. Commentary is included in the raw Access database under the “comments” field.

Distribution Profiles

The distribution of juveniles and their observed rearing densities for each surveyed reach provide a basis for understanding how each reach functions in relation to the remainder of the basin or sub-basin. Distribution profiles can help identify adult spawning locations, identify potential barriers to upstream adult and juvenile migration, identify the end point of anadromous distribution and they may also indicate how juvenile salmonid populations are responding to environmental variables such as increased temperature. You will find a review of these distribution profiles within this document for each of the streams surveyed.

Average Pool Densities and Seeding Levels

The average densities generated in this report represent the average value for a tributary or unique stream reach. They represent a snapshot in time of the current condition that can be compared to known levels of abundance that exist in fully seeded and fully functional habitats. These densities also provide a method for quantifying and comparing changes in rearing densities by reach or sub-basin over time. Average densities utilized as a metric in this analysis are calculated for pool surface areas only. Replicate surveys conducted in these same reaches in subsequent years will function as an indicator of response to future restoration and enhancement strategies, potential changes in land use and changes in adult abundance.

To understand how a particular stream reach functions in relation to its salmonid rearing potential, it is valuable to compare the observed densities of salmonid species to some known standard. The term full seeding is utilized to represent a density of juvenile salmonids that are rearing near the habitat’s capacity. The carrying capacity of habitats varies seasonally in relation to food abundance, adjacent pool / riffle ratios, flow, temperature, and the species tolerance to interspecific competition. The interaction of this multitude of values is complex and unquantifiable at the level of this RBA inventory. Therefore, we can only comment on seeding levels as they relate to standards observed from a combination of many other stream systems in many geographically unique locations. This renders discussions of carrying capacity in this document subjective. Any discussion of carrying capacity in the text is an attempt to highlight the lows and highs within a range of observed values and to use a modicum of professional judgment to help steer comparative analyses in a direction that facilitates the decision making and prioritization necessary to guide restoration.

Extensive bodies of data suggest that, for coho, extremely high-quality habitats can maintain average summer rearing densities in the range of 3.5 fish/m². The Nickelson / Lawson Coho Production Model averaged summer rearing densities across the full geographical range of the coastal coho ESU sets a 1.7 fish/m² meter of pool surface area as a value that represents habitats seeded to their summer carrying capacity (1998).

For cutthroat and steelhead the habitats ability to rear older age class salmonids is heavily influenced by fish size, available pool surface area and food availability. We have observed that in zones of cohabitation by steelhead/rainbow and cutthroat that the combined densities of these similar sized species would not exceed 0.8 - 1.0 fish/m² in the highest quality habitats of the system. Observations in many thousands of miles of both Willamette and coastal streams suggest that densities above 0.7 fish/m² for older age class steelhead or cutthroat without competition from the other are rare.

For 0+trout the highest densities observed in thousands of miles of Willamette basin and coastal stream inventories always hovers around 3 fish/m². The similar habitat characteristics observed in the Nehalem basin to many other watersheds suggests that the 3 fish/m² value would be a fair surrogate for indicating that the reach is somewhere near its capacity for the 0+ age class and that spawning locations existed nearby.

Spawning Locations

The approximate location of steelhead and coho spawning events can often be observed by noting the presence of a distinct spike in rearing density of the 0+ age class that trails off rapidly just upstream. The physical location of a spawning destination has a range of variance plus or minus 4 pools due to the 20 percent sample methodology. Because the quality or quantity of spawning gravel can be a seasonal habitat limitation for salmonids, it is informative to describe not only the range of distribution of the 0+ age class but the peak zones of abundance which are indicating the presence of functional spawning beds. This information assists in guiding restoration prescriptions designed to accumulate spawning gravel to the zone where success is most likely to be achieved.

Spawning Gravel Abundance

Spawning gravel was quantified throughout 169 miles of combined mainstem and tributary habitats. Spawning gravel abundance data was collected to determine if coho in the Nehalem basin could potentially be limited by the abundance of appropriately sized gravels for spawning and incubation and to map the distribution of functional spawning gravel. Many reviews of habitat variables in the contemporary literature refer to the abundance of spawning gravel as seldom the primary habitat limitation for adult salmonids. However, quantitative measurements of this key habitat variable are rarely included in these analyses and an invalid assumption is possible.

The effort targeted only gravels appropriate for coho and did not include the larger diameter gravels used by chinook. This was a 100% sampling effort where every potential gravel accumulation exhibiting the proper hydraulic location and size was estimated. The following criteria were used:

1 Spawning gravels had to be located in a pool tailout, glide or unconsolidated riffle (pocket pool run). All other gravels were excluded from the inventory.

2 A minimum of 1sq meter of gravel had to be present to qualify for a potential spawning location.

3 Only gravels between the diameter range of a marble and a tennis ball were quantified.

The criteria utilized by ODFW's OASIS program documented in their Salmon Spawning Survey Procedures Manual 2012 describes the minimum coho redd as 2 m^2 in area and any redd less that 2 m^2 as atypical. Some of this variation exists because coho are known to spawn in stream orders of various sizes. Because the intent of the spawning gravel inventory in the 2018 and 2019 RBA survey was to both spatially describe the distribution of spawning gravel and test the hypothesis that the abundance of gravel could be a seasonal habitat limitation, we chose to utilize 1sqm of gravel as the minimum area and 3 m^2 as the maximum.

Quantifying spawning gravel is an uncommon metric for collection because of the broad range of variability between surveyors. Spawning gravel estimates are a rough quantitative metric with a broad variance for this reason. Measuring this range of variance in subsequent years is highly recommended as a pre-project attribute for future restoration effectiveness monitoring. The goal was not to necessarily determine exact quantities of spawning gravel but to test the hypothesis that an incubation limitation could exist.

Quantifying the abundance and distribution of spawning gravel is a first cut toward understanding how this basin scale seasonal habitat (spawning gravel for incubation) required for reproduction is functioning. Knowledge of the quantity, quality, and distribution of spawning gravel within a basin is an essential component of designing a prioritized restoration and recovery strategy.

Spawning gravel distribution is not random. Rather, it is dependent on a combination of morphological and hydraulic variables within the stream channel as well as in the watershed that facilitate the deposition of the appropriate sized gravels for spawning.

The fact that spawning gravel distribution is not random but highly dependent on a unique combination of morphological and hydraulic variables that facilitate the deposition of the appropriate sized gravels for spawning is the reason why the expansion of redd counts collected on a specific reach basis (normally a sub sample of total stream miles) to a basin wide estimate will always over estimate adult spawner abundance. This has been commonly done historically in basins to estimate anadromous salmonid run sizes.

Historic Channel Complexity in the Nehalem

Channel roughness, or the presence of channel complexity in the form of large wood or boulders can influence the hydraulic dynamics of the background attributes of gradient and flow that control the deposition and sorting of migratory substrates. Complex wood jams formed by the natural recruitment of riparian old growth conifer would have historically been more prevalent in the tributary network of the Nehalem as well as select mainstem reaches. Presently, almost none of this historical complexity remains and the loss of these wood resources has resulted in an overall increase in gradient resulting in a decline in the system's ability to store and sort spawning gravels. The systems inability to replace this wood (limited wood delivery potential from either upslope debris flows or riparian canopies) currently limits the recovery of system function.

Adult and Juvenile Barriers

Adult migration barriers for anadromous salmonid species are verified by determining that no juvenile production is occurring above a given obstruction (culvert, falls, debris jam, beaver dam, etc.). There are many barriers, both natural and manmade, that impact the migration of salmonids. Some are definitive barriers that are obvious obstructions (such as bedrock falls). Many barriers, however, only impede adult salmonid migrations during low flow regimes. Summer juvenile inventories allow us to definitively quantify whether passage was obtained at any point during the season of adult migration.

Juvenile salmonids migrate upstream for a variety of reasons (temperature, winter hydraulic refuge, food resources). Hydraulic refuge and food resource dependent migrations are typically in fall, winter, and spring. Evidence of these migrations are rarely detectable during summer population inventories. Temperature, however, is probably the most significant driver of upstream juvenile salmonid migrations during summer flow regimes. Potential juvenile barriers were classified subjectively, based on the perception of the observer. The trend in juvenile density can be a method of detecting either partial or full barriers to upstream migration. Each of the surveyed reaches contains a comments section in the Access database to note the presence of culverts, jams and other physical factors that may influence the ability of salmonid populations to make full use of aquatic corridors.

Temperature Dependent Migrations

Potential temperature dependent migrations in the database are denoted by densities that decrease significantly as the lineal distance increases from the mouth of the stream or tributary. This is more likely to be observed in low abundance years where tributary habitats that are seeded to capacity are the exception. During years of high abundance there is more potential for density dependent upstream migrations that would be indistinguishable from the distribution pattern mentioned above. Identifying this migration pattern allows us, during years of low adult escapement, to locate important sources of high water quality within the basin that may be traditionally overlooked (because of some other morphological condition that suggests no significant potential for rearing salmonids, i.e. lack of spawning gravel). These reaches typically exhibit declining densities with increased distance from the mouth and no indication of a spawning peak (a point near the upper distribution of the population with significantly higher rearing densities of the 0+ age class). These tributaries may be functioning as important summer refugia for salmonid juveniles threatened by increasing temperatures in the mainstems. Several significant temperature dependent juvenile migrations were observed in the Nehalem basin in 2018 and 2019. These migrations will be discussed within the document in each stream where the behavior is occurring.

Thermal Refugia

Thermal refugia is key to the survival of salmonids in temperature limited systems. The mainstem Nehalem is severely temperature limited during summer months with a 303d status category 4A listing for temperature extending from RM 0 – 92.4. In addition, the lower 36.2 miles is listed category 5 for dissolved oxygen. Assessing the abundance and availability of these thermal refugia was critical to understanding the mainstem fish population.

We conducted a 100% sample of cool water contributions detectable by snorkeling in the mainstem Nehalem from RM 0 – 34.7. This included tributaries and cool water seeps of all sizes. Additionally, we conducted a 50% sample of mainstem Nehalem pool heads to gain a comparative baseline of mainstem salmonid rearing during this critical time period. We did not inventory the remainder of the pools due to lack of fish rearing in those segments of habitat during periods of high-water temperature and low dissolved oxygen. Lack of adequate visibility also restricted surveyor ability to inventory the deepest points of the mainstem pools. It is likely that in the larger mainstem pools thermoclines had developed in the deeper portions providing potential thermal refugia. It is also likely that these deep water refugia suffered from a deficiency in dissolved oxygen decreasing the value of the habitat for salmonid rearing. Nevertheless, our inventory may have underestimated the abundance of mainstem fish rearing.

Limiting Factors Analysis Lite

The purpose of the LFA Lite inventory was to identify key anchor habitats (stream segments that provide all the seasonal habitat requirements for sustaining salmonids from incubation through winter rearing) existing within a stream segment. Identifying these key zones of high production potential aids in understanding the unique biological and morphological characteristics that create and maintain exceptional ecosystem function. Anchor habitats may be capable of rearing salmonid juveniles at disproportionately higher densities than non-anchor reaches. In many cases, these unique habitats require special conservation measures to be applied to their management and restoration to maintain and enhance their current level of productivity.

The criteria required to be expressed in the anchor were as follows:

- There must be spawning gravel present for incubation
- The anchor must not be temperature limited during low summer flows
- The anchor must exhibit a terrace height of three feet or less
- A minimum 5:1 ratio of total floodplain width to bankfull width

In addition, a numerical rating was given to each identified anchor for the surveyor's estimate of current functionality. Anchors can be highly functioning with high wood densities and high quality off channel linkage or low functioning but with the background morphology to be a candidate for restoration. The following categories were utilized:

1 High Functioning

2 Moderately Functioning

3 Low Functioning

The function rating was estimated by assessing levels of wood complexity, available spawning gravels, channel sinuosity, and floodplain connectivity.

Precautions

Specific location of spawning sites does not infer that the highest quality spawning gravels were targeted by adult salmonids or that there is any relationship between the location of a redd and the quality of the summer rearing habitat that exists adjacent to these locations.

Average densities that can be generated as a product for each stream reach are the result of a 20 percent sample. Consequently, they probably vary significantly around the true average density. There are many sources of potential variation, start point, number of units sampled within the reach, surveyor variability, etc. The range of variability for at least one of these variables (start point), was documented in the final review of the 1998 Rapid Bio-Assessment conducted by Bio-Surveys for the Midcoast Watershed Council. To facilitate the proper utilization of the data included in this inventory, the 1998 results are included in Table 1 below. The true average density of a stream reach was retrieved by querying the database from an ODFW survey on East Fk. Lobster Cr in the Alsea Basin, where every pool was sampled (indicated as 100% sample frequency in table 1). Comparisons could then be made between the true average density and a randomly selected 20 percent sub sample (every 5th pool). Only mainstem pools were utilized within the range of coho distribution to match the protocol for the Rapid Bio-Assessment.

Table 6: ODFW vs Bio-Surveys Salmonid Survey Densities on East Fork Lobster Creek – Alsea Basin (1998)

Sample Frequency	AVG. Coho Density	AVG. Steelhead Density	AVG. Cutthroat Density	AVG. 0+ Trout Density
100% (ODFW)	1.07	0.03	0.04	0.13
50%	1.10	0.04	0.03	0.14
20% Start Pool 1	0.87	0.04	0.03	0.13

20% Start Pool 3	1.01	0.03	0.03	0.13
20% Start Pool 5	1.13	0.05	0.04	0.12

Abundance Estimates

The juvenile census is a 20% sub-sample of pool rearing habitats only (no riffles or rapids were sampled) using a Rapid Assay technique designed to cover large distances and succeed in describing the distribution patterns and the relative abundance of multiple species of salmonids. Beaver dam abundance and road crossing information was also collected. Juvenile salmonid abundance data presented tabularly in this document has been expanded from the 20% sample to represent an estimate of abundance for all pool habitats within a stream segment. Although estimates have been produced for all existing pool habitats this still does not represent a complete population estimate for each stream because steelhead and cutthroat both utilize fast water habitats for summer rearing. Because juvenile distribution within side channel habitats is not evenly distributed, all side channels were sampled at a 100% rate (every pool).

The abundance estimates for steelhead and cutthroat in this document should only be utilized for interannual trend analysis and do not represent an estimate of total abundance. With a life history pattern independent of ocean conditions, cutthroat are powerful indicators of changes in system function and system health. Some cutthroat spend their entire lives within the confines of a watershed. There are also fluvial and sea run cutthroat that migrate long distances to spawn. In general these fish enter and exit tributary habitats to spawn from fall through spring fully emigrating out by early summer. Given the timing of this migration pattern, we would not expect this population to influence summer population estimates in tributary habitats. The fluvial and sea run portion of the population were observed engaged in temperature dependent migrations and seeking thermal refuge at cool water confluence plumes in the lower mainstem Nehalem and mainstem North Fork Nehalem

Average rearing density for a stream segment is utilized in this document as a metric for comparing productivity between streams and stream reaches. The average has been calculated by dividing the sum of the pool densities by the total number of sampled pools with fish present. This is not a weighted average that would divide the total metric surface area of the sampled pools by the total number of fish observed.

Average rearing density for a surveyed reach (fish/m^2. of pool surface area) is also an excellent measure of trend that can be monitored from year to year. However, it tends to portray only a general description of the current status within a reach. Understanding how each reach is functioning is more accurately interpreted in a review of how the rearing density changes within the reach. This more refined analysis of distribution patterns allows us to get a sense of what the true rearing potential is for the highest quality individual pool habitats.

It is important to clarify that two different metrics for location are utilized in this assessment for describing specific fish distributions. This was necessary because the NF mainstem inventory began above the head of tide. For management actions and for all the graphics used in this analysis, we have transposed this measurement into USGS RM locations. The fish distribution graphics that are provided in the Access database and the Excel Pivot table that archive all the recorded data have been described in lineal feet above the survey start point. The use of USGS RM estimates was not required to georefference any of the tributary inventories because all the tributary surveys began at RM 0.0.

Results

During the summers of 2018 and 2019 juvenile coho were the most abundant anadromous fish species rearing in pool habitats throughout the inventoried reaches of the lower Nehalem tributaries in 2018 and North Fork Nehalem subbasin. The total estimated pool abundance of juvenile coho was 128,689. Their distribution was spread across both subbasins and most of the major tributaries. Based on our total coho population estimate and utilizing the season to season survival rates developed for coho by the Nickelson / Lawson Coho model, an estimated 542 adult coho escaped to the lower Nehalem tributaries for the 2017 brood year and 639 adult coho escaped to the North Fork subbasin for the 2018 brood year. These estimates are presented as a minimum metric of adult abundance, they are not meant to be a definitive accounting of escapement.

Steelhead distribution was moderate with a total estimate of 10,159 age class 1+ or older. 26.7% of all steelhead observed were rearing in mainstem habitats of the North Fork Nehalem.

Cutthroat were abundant in most of the inventoried reaches with a total of 11,621 observed. It is important to recognize that unlike coho parr, steelhead and cutthroat are capable of rearing in fast water habitat types such as rapids, riffles and cascades. Because these fast water habitat types were not sampled during this inventory, the observed numbers do not represent any type of population estimate. These pool numbers can be used however as a very effective tool for inter annual variation and trend analysis.

It is important to note that visibility was an issue in most of the lower mainstem reaches where heavy tannins and turbidity limited our range of visibility. In these reaches, slow moving water in deep mainstem pools allows thermoclines to develop providing thermal refugia to fish in the cooler deeper strata. Limited visibility in these habitats has likely led to an underestimation of mainstem rearing cutthroat and coho populations.

Site specific results within this document have been organized based on the significant sub-basins. Following each major sub-basin heading, tributaries are reviewed in alphabetical order. After each review is a summary table that lists the stream's estimated contribution to salmonid production by species.

Production estimates are based on an expansion of the 20% snorkel sample in pools only and therefore do not constitute an entire production estimate for the basin. Estimates greatly under-estimate the standing crop of 0+, steelhead, and cutthroat because a significant component of their summer population is rearing in riffle/rapid and glide habitats that were not inventoried. In addition, there is production for cutthroat that extends upstream beyond the endpoint of most surveys. The information below establishes a baseline for trend monitoring for subsequent survey years on the basin scale and by tributary. It also provides a comparison of relative production potential between tributaries and provides a foundation for prioritizing restoration actions (some streams play a much more significant production role).

Table 7: Lower Nehalem and North Fork Nehalem expanded fish counts for all salmonids

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
Alder	906		160		1		130	1.1		
Anderson			430		75		415	3.6	75	5.5
Bastard	120		115				60			
Batterson	18		170				65		42	3.1
Candyflower	222		95				80			
Cook	7202	5.6	12890	13.8	1205	11.9	758	6.5	172	12.6
Cheviot							20			
Cronin	8430	6.6	1880	2	165	1.6	165	1.4		
Fall	391		505	0.5	11		295	2.5	2	
Foley	12223	9.5	10274	11	1222	12	2397	20.6	510	37.4
George	781		170		15		60			
Helloff	3039	2.4	1035	1.1	162	1.6	516	4.4		
Jetty			115		47		167	1.4		
Lost	8928	6.9	3677	3.9	460	4.53	206	1.8		
McPherson	6		210		10		110	1		
Messhouse			5							
Peterson	110		140		34		184	1.6		
Roy	167		245		160	1.6	165	1.42		
Salmonberry	9866	7.7	38322	41.1	2286	22.7	799	6.7	168	12.3
Snark	206		55				45		5	
Spruce Run	5868	4.6	1645	1.8	510	5	285	2.5	10	
Trib M	6		70				165	1.4		
Trib N	28		11				3			
Trib O	54		30							
Trib P	666		230				100			
Trib Q			1							
Vossburg	403		50				45			
North Fork Nehalem	15090	11.7	10585	11.3	2715	26.7	1005	8.7	360	26.4
Acey	2						1			
Anderson	318		240		15	0.15	95			
Bob's			170				95			
Boykin	3126	2.4	90				130	1.1		
Buchanan	14258	11.1	2970	3.2	285	2.8	550	4.7	10	
Coal	10842	8.4	4286	4.6	380	3.7	821	7.1	10	

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
Cougar							2			
Fall 1			75				5			
Fall 2	930		150		95		65			
God's Valley	5987	4.7	155		10		200	1.7		
Gravel	1042		255				170	1.5		
Henderson	517		165				60			
Little NF	8314	6.5	451		90		515	4.4		
Little Rackheap	840		65		10		86			
Lost	588		360				125	1.1		
Sally	996		15				45			
Sean's	72		180				1			
Sweethome	4908	3.8	395		135	1.3	269	2.3		
Trail			60				10			
Trib B	726		120		40		135	1.2		
Trib D	162		5				10			
Trib E	98						10			
Trib F	24									
Trib G	234		5				1			
Inventory Total	128714		93327		10138		11641		1364	

- Percent contributions are indicated for only those sub-basins that contributed greater than 1% of the total.

- 20% visual bias included for coho expansion

Densities

Coho densities ranged from 0.002 to 16.8 fish/m² with an average density of 0.8 fish/m². The density range from 1.7 to 16.8 fish/m² (densities at or above modeled full seeding) accounted for 10.1% of the 1048 inventoried pools with coho present. The highest densities observed were the result of temperature dependent migration (overcrowding), pool isolation, and surface area reduction due to subsurface summer flows, or high-quality summer rearing habitat.

Cutthroat average density was low at 0.15fish/m² for all inventoried pools. Densities between 0.8 and 4.8 fish/m² were documented as representing the top end of the observed range. The top end range was observed only in 1.7% of pools which were either located below barriers to passage, in isolated pool habitats, or above the end of anadromy in high quality rearing habitats. A more representative upper end of the density range would rest between 0.3 and 0.8 fish/m² which accounted for 15% of inventoried pools with cutthroat presence and 26.4% all cutthroat observed. This range fits within the normal observation of full seeding where interspecific competition for rearing habitat exists (aggregated densities of both steelhead and cutthroat exhibiting full seeding characteristics in the 0.8 -1.0 fish/ m^2 range). In general, cutthroat densities increased above the distribution of steelhead and coho due to the lack of competition for food and rearing surface area.

Steelhead average density was low at 0.1fish/m^2 for all inventoried pools. Densities between 0.6 and 1.15 fish/m^2 were documented as the top end of the observed range but were only observed in 9 sampled pools. The density range from 0.2 - 0.5 fish/m^2 was more representative of the upper end range and represented 31.8% of all steelhead observed and 20.8% of inventoried pools with steelhead presence. Because the habitats ability to rear older age class salmonids is heavily influenced by fish size, available pool surface area and food availability, we assume that in zones of cohabitation by steelhead/rainbow and cutthroat that the combined densities of these similar sized species would not exceed the 0.8 - 1.0 fish /m^2 observed in the highest quality habitats of the system. Observations in many thousands of miles of both Willamette and coastal streams conducted by Bio-Surveys,LLC suggests that densities above 0.7 fish / m^2 for older age class steelhead or cutthroat without competition from the other are rare.

For the 0+ age class, there were 1254 pools within the 2018/19 inventories that contained young of the year fry (combined steelhead / cutthroat) with 59 of these pools exhibiting the highest observed densities between 2 and 5.9 fish/m^2. The highest densities observed in thousands of miles of Willamette basin and coastal stream inventories for the 0+ age class always hovers around 3 fish/m^2. The similar habitat characteristics observed in the Nehalem basin to many other watersheds suggests that the 3 fish/m^2 value would be a fair surrogate for indicating that the reach is somewhere near full seeding capacity for the 0+ age class and that spawning locations existed nearby.

Spawning Gravel Abundance and Distribution

A supplemental sampling effort covering 169.3 miles of mainstem and tributary habitats of the Lower Nehalem and North Fork Nehalem was conducted to quantify the abundance of spawning gravel appropriate for spawning coho. This effort was testing the hypothesis that the abundance of appropriately sized gravels for spawning and incubation could potentially limit coho production. Many reviews of habitat variables in the contemporary literature refer to the abundance of spawning gravel as seldom the primary habitat limitation for adult salmonids. Quantitative measurements of this key habitat variable however are rarely included in these analyses and an invalid assumption is possible.

A decline in channel roughness (historically provided by large wood) and the resultant reduction in the trapping and sorting of spawning gravels impacts the capacity of the system to produce juvenile salmonids. For more information about spawning gravel, channel roughness, and their direct relation to salmonid numbers, see the Methods section above.

The results of the spawning gravel inventory for the Lower Nehalem tributaries and North Fork Nehalem are presented in Table 2 below and will be further discussed in the individual tributary sections.

Table 8: Nehalem Basin Spawning Gravel Counts (in m² for 2018/2019) and Extrapolated Adult Carrying Capacity based on Available Gravel

Stream	Spawning Gravel (m^2)*	Female Coho (high)* ($1m^2$/female)	Adult Carrying Capacity (high)*	Female Coho (low)* ($3m^2$/female)	Adult Carrying Capacity (low)*
Nehalem					
Mainstem Nehalem	No Counts				
Alder & Neahkanie	108	108	216	36	72
Anderson	10	10	20	3	6
Bob's	2	2	4	0.7	2
Bastard	2	2	4	0.7	2
Baterson	2	2	4	0.7	2
Candyflower	16	16	32	5	10
Cook	229	229	458	76	152
Cronin	143	143	286	48	96
Fall	38	38	76	13	26
Foley	719	719	1438	240	480
George	1	1	2	0.3	0.7
Helloff	25	25	50	8	16
Jetty	14	14	28	5	10
Lost	94	94	188	31	62
McPherson	4	4	8	1	2
Peterson	5	5	10	2	4
Roy	12	12	24	4	8
Salmonberry	815	815	1630	272	544
Snark	5	5	10	2	4
Spruce Run	23	23	46	8	16
Trib M	1	1	2	0.3	0.7
Trib N	1	1	2	0.3	0.7
Trib O	7	7	14	2	4
Trib P	14	14	28	5	10
Vosburg	8	8	16	3	6
North Fork Nehalem					

Stream	Spawning Gravel (m^2)*	Female Coho (high)* ($1m^2$/female)	Adult Carrying Capacity (high)*	Female Coho (low)* ($3m^2$/female)	Adult Carrying Capacity (low)*
Mainstem North	204	204	408	68	136
Boykin	34	34	68	11	22
Buchanann	98	98	196	33	66
Coal	147	147	294	49	98
Fall 1	5	5	10	2	4
Fall 2	22	22	44	7	14
God's Valley	149	149	298	50	100
Gravel	36	36	72	12	24
Henderson	54	54	108	18	36
Little NF Nehalem	261	261	522	87	174
Little & Big Rackheap	13	13	26	4	8
Lost	39	39	78	13	26
Sally	41	41	82	14	28
Sean's	12	12	24	4	8
Sweethome	53	53	106	18	36
Trail	1	1	2	0.3	0.7
Trib B	9	9	18	3	6
Trib D	4	4	8	1	2
Trib E	4	4	8	1	2
Trib F	1	1	2	0.3	0.7
Trib G	7	7	14	2	4
Lost	38	38	76	13	26

*Estimated gravel counted in $1m^2$ increments. Gravel counts include both the stream listed and tributaries, High Female coho estimate is based on small coho redd size of 0.8 m^2 in Burner (1951), Low FML coho estimate is based on Gordie Reeves, (1989) 3 m^2/redd. Adult Carrying Capacity is based on multiplication of estimated spawning gravel counts by redd size requirements and assuming a 1:1 M/FML ratio.

The (High) estimated adult capacity presented in Table 2 is a generous estimate that utilizes a minimum redd size of 1 m^2 for all tributaries, well below the norm for coho redd observations (2 m^2 minimum). We elected to drop the minimum to 1 sqm because tributaries contained very few 2 m^2 patches of gravel yet coho were present in significant abundance suggesting utilization. The (Low) estimate was calculated utilizing a maximum redd size of 3 m^2 (Reeves, 1989). In most of the inventoried systems the (high) estimated adult carrying capacity was well above the estimated adult coho escapement value which was based on expanded juvenile abundance documented during the inventory. However, several subasins did present a deficiency in spawning gravel abundance in relation to juvenile rearing capacity - Anderson, Bob's, George, North Fork Cronin, Soapstone, Spruce Run, Tribs C and D (Little North Fork), and West Fork Coal. This seasonal habitat limitation will be further reviewed in individual stream sections.

The hypothesis that the abundance of spawning gravel could potentially limit the Nehalem basin's capacity for producing wild coho smolts appears to be viable. As previously stated the range of variance inherent in estimating the abundance of viable spawning gravel is likely to be significant (no replicate inventories have been conducted to quantify variance). Understanding that a potential limitation may exist for the incubation life history stage informs us in the development of future monitoring and restoration planning.

In addition, the observed spawning gravel limitations were calculated on a very low adult escapement year for wild coho (estimated 5,486 coho in 2017/18 and 4,190 coho in 2018/19) suggesting that additional subbasins could become gravel limited during years of higher adult escapement. Abundance in these years was 42.9% (2017/18) and 32.8% (2018/19) of the ten year average (ODFW, 2019).

Nehalem Mainstem Thermal Refugia

The lower Nehalem mainstem exhibited severe temperature limitations during the summer months of 2018. Maximum daily temperatures were recorded from 20.2C (in lower tidewater reaches) – 25.5C. Temperatures in this range exceed thresholds tolerable to salmonids without detrimental effects on growth, health, and survival. Salmonids rearing in the lower mainstem Nehalem in summer months need access to thermal refugia during these pinch periods to escape the uninhabitable mainstem.

Photo 1 Mainstem Cutthroat Mortality

Mainstem habitats from the estuary upstream to the confluence of Humbug Creek (RM 34.7) were inventoried for cool-water contributions capable of providing thermal refugia to salmonids during pinch periods of elevated mainstem temperatures. This inventory identified a total of 31 sites, 27 of which were observed providing thermal refugia to significant abundances of salmonids (See Table below).

At most of the inventoried sites fish were congregated in high densities in the cool water confluence plumes where tributaries and cold-water seeps entered the mainstem. The mainstem habitats often lacked adequate cover which likely increased the rate of predation by larger fish, otters, and birds. Juvenile fish seeking refugia at these sites are further restricted in their ability to evade predation due to the lack of inhabitability of the surrounding mainstem habitat. Additionally, older age-class salmonids (primarily cutthroat) were often observed seeking thermal refugia at these sites as well. This high-density cohabitation of mixed age classes of fish rearing in habitats lacking adequate complexity in the form of cover likely led to a higher predation rate of the juvenile age-class.

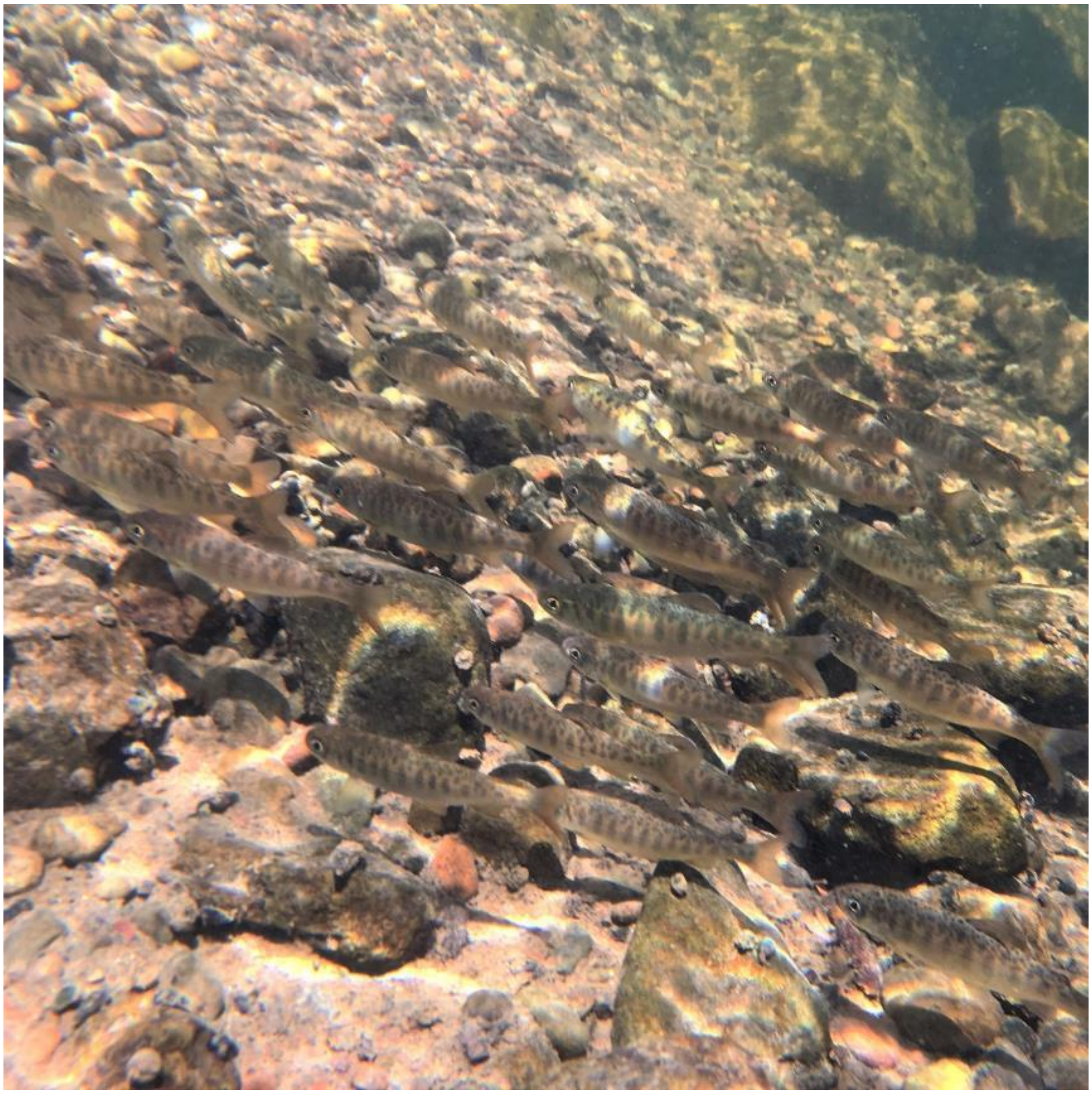

Photo 2 Helloff Thermal Refugia, Juvenile Coho and Chinook

As an example, Cook Creek contributes high volumes of cold water throughout the summer months. At the confluence, Cook Creek enters a deep mainstem Nehalem pool along a steep bedrock intrusion with a broad fan of cobble and gravel extending downstream. The volume and force of winter flows restricts any accumulation of woody debris to serve as cover for juvenile salmonids. The confluence plume of Cook Creek was surveyed multiple times from July 2nd to August 1st, 2018. During the first inventory 55 juvenile chinook and 18 juvenile steelhead were observed in addition to 200 cutthroat of mixed age class. Over the course of the month the abundance of juvenile salmonids diminished and by the last inventory on August 1st the plume was rearing 300 large cutthroat, 2 adult chinook, 1 adult chum, and 1 adult sockeye. No juvenile salmonids remained. This change in abundance profiles with decreased age-class diversity is likely resultant of increased predation pressure on the younger age-class fish. The effort extended for this kind of replicate survey was not possible for other inventoried sites. As the summer progresses, most of the inventoried thermal refugia are likely exhibiting similar reductions in juvenile salmonid abundance.

Photo 3 Surveyor at Cook Creek Confluence

Photo 4 Helloff Thermal Refugia, Older Age-class Cutthroat

Most of the tributaries functioning as thermal refugia at these mainstem sites provided inadequate upstream rearing habitats for temperature dependent migrants due to high gradient; low flow; disconnection from mainstem during low summer flows as a result of deep bedload accumulations at alluvial fans; and channel simplification. As a result of the lack of channel complexity, the lower reaches of these tributaries with habitats capable of rearing salmonids (adequate flows, low gradient, and significant pool habitats) were largely devoid of fish and showed limited evidence of upstream thermal migration. This limitation was observed in the tributaries with the highest volume and rearing potential (Foley, Cook, Lost, Salmonberry, and Spruce Run). One hypothesis is that because of clear water and low channel complexity in the tributaries, predation becomes a significant survival issue and so accumulations of salmonids were occurring only in the much lower visibility mainstem.

Photo 5 Salmonids congregating at tiny tributary confluence (Thermal Refugia #11, RM14)

A few sites were documented rearing coho within tidal and salt-water influence (Vosburg, Coal, and Anderson). The estuarine environment makes these sites unique in that the coho observed were likely seeking refuge from high salinity rather than high-water temperatures. At these sites, fish were not observed rearing in the mainstem, but rather in the lower reaches of the tributaries where tidally connected sloughs extend up from the mainstem to the first hydraulic controls. Sampling of these habitats was challenging due to limitations in visibility resulting from heavy cattle use.

Photo 6 Vosburg Confluence

Table 9: Lower Nehalem Thermal Refugia Sites 2018

TRIB NAME or RIVER MILE (RM)	COHO	0+	STHD	CUT	CHIN	TEMP.	TEMP. MAINSTEM	FLOW
VOSBURG (ESTUARY)	91					12.2C		MED
FOLEY				**15**	**75**	**15.5C**	**20.2C**	**HIGH**
ANDERSON				3		14.9C	20.3C	LOW
RM 11.8, UPSTREAM LEFT BANK TRIB				4	71	13.0C	20.3C	LOW
COOK				**300**		**15.0C**	**22.8C**	**HIGH**
LOST			**3**	**80**		**16.3C**	**21.8C**	**MED**
FALL	**125**		**10**	**325**	**185**	**14.9C**	**24.8C**	**HIGH**
RM 16.2, UPSTREAM RIGHT BANK TRIB	60		1	75	65	13.6C	24.6C	LOW
RM 16.51, UPSTREAM LEFT BANK SEEP	8	3				14.5C	24.6C	LOW
RM 16.65, UPSTREAM LEFT BANK TRIB	15					16.0C	24.3C	LOW
RM 17.73, UPSTREAM LEFT BANK SEEP	45				3	15.5C	23.8C	LOW
HELOFF	**105**		**3**	**215**	**80**	**16.4C**	**23.2C**	**MED**
RM 19.07, UPSTREAM RIGHT BANK TRIB	8	3		20		13.8C	23.4C	LOW
RM 20.58, UPSTREAM RIGHT BANK TRIB	45					17.0C	22.5C	LOW
SALMONBERRY			**3**	**250**	**4**	**18.0C**	**22.1C**	**HIGH**
CRONIN CREEK			2	17	2	13.9C	23.6C	LOW
RM 25.5, UPSTREAM LEFT BANK TRIB	5			30	40	12.9C	23.0C	LOW
CANDYFLOWER	**18**	**3**	**3**	**125**	**35**	**13.3C**	**24.4C**	**MED**
TRIB O				1	2	13.9C	25.5C	LOW
TRIB P	**18**					**15.0C**	**25.0C**	**MED**
RM 29, UPSTREAM RIGHT BANK TRIB	18				4		23.9C	LOW
TRIB N	24			4	6	19.4C/ 15.6C	23.9C	LOW
Spruce Run	**230**		**10**	**70**	**35**	**15.6C**	**23.3C**	**MED**
LOST LAKE				55	12	14.5C	23.5C	MED
RM 32.23, UPSTREAM LEFT BANK TRIB				3	1	13.5C	24.0C	LOW
GEORGE	**39**			**44**	**12**	**15.8C**	**23.0C**	**MED**
HUMBUG	25				58	20.3C	23.3C	HIGH
INVENTORY TOTAL	**879**	**9**	**35**	**1637**	**690**			

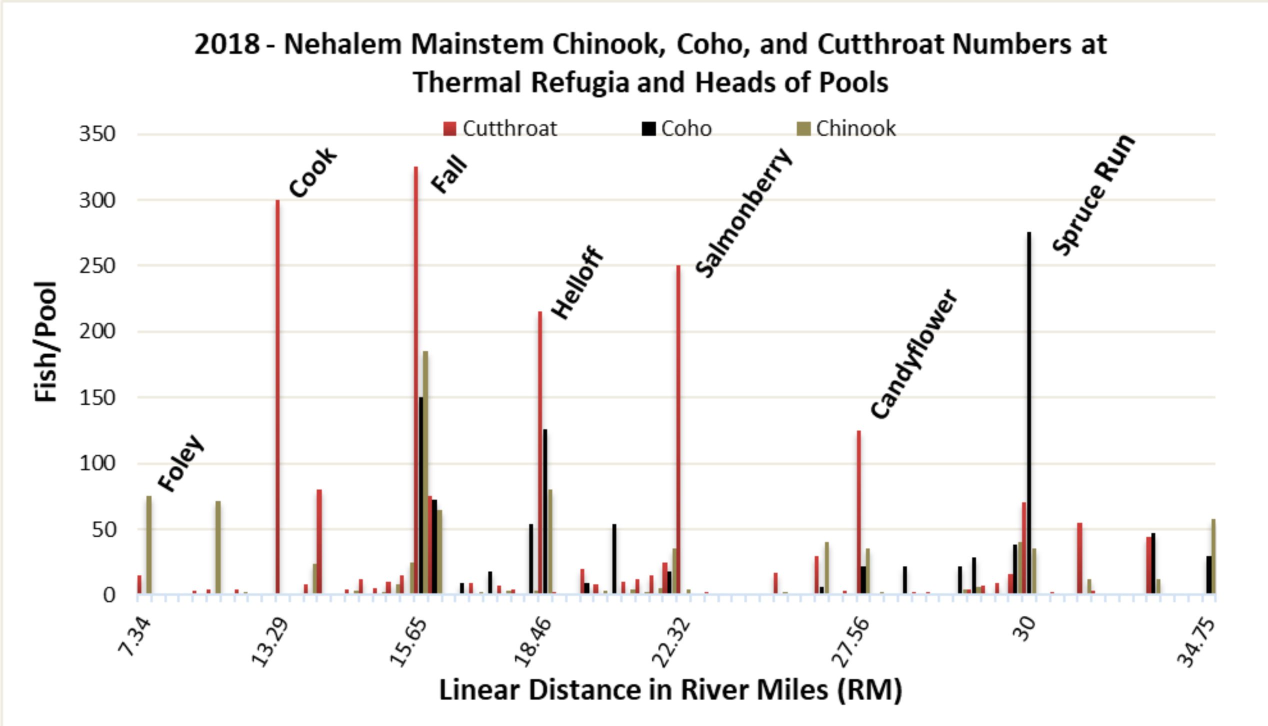

Figure 3: Lower Nehalem Pool Head and Thermal Refugia Salmonid Numbers 2018

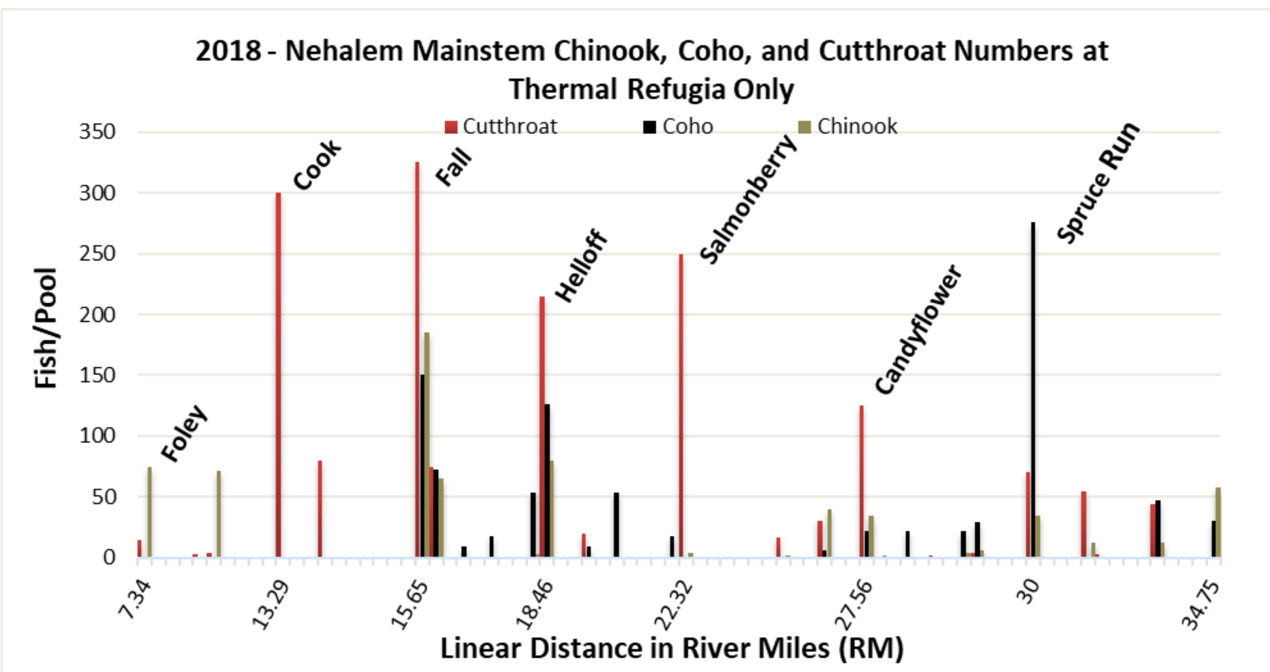

Figure 4: Lower Nehalem Thermal Refugia Salmonid Numbers 2018

Coho

Coho were observed in moderate abundance. No coho were observed below Nehalem Falls, a partial barrier to migration, at RM 15.5 (other than Vosburg). Though a few subbasins with high coho abundance and significant cold-water contributions enter below the falls (Foley, Cook, and Lost), the lack of adequate refuge in the form of cover likely limited the ability of juvenile fish to escape predation (see Cook Creek example above). Throughout the entirety of the inventoried reach coho were observed rearing exclusively in thermal refugia sites with no mainstem rearing documented outside of the influence of cool water contributions.

Coho found rearing in lower mainstem thermal refugia and estuarine habitats represent an important subset of the population. Following emergence from the redd in spring, most coho fry rear in their natal stream for a about a year before migrating to saltwater as smolts. However, large numbers of fry (age 0+, young of the year), typically move downstream following emergence. Chapman (1962) first coined the term “nomads” referring to those coho fry moving downstream between emergence and October.

The component of the coho population expressing this alternative “nomadic” life history trait represents an unknown, but likely underestimated, percentage of the total population. The contribution of nomads to the total watershed production of coho smolts can be substantial and may be important in repopulating both natal and non-natal streams. This general behavior of all salmon and coho, in particular, allows these species to take advantage of more productive habitats downstream resulting in an adaptive capacity to be more ecologically resilient (Koski, K V. 2009).

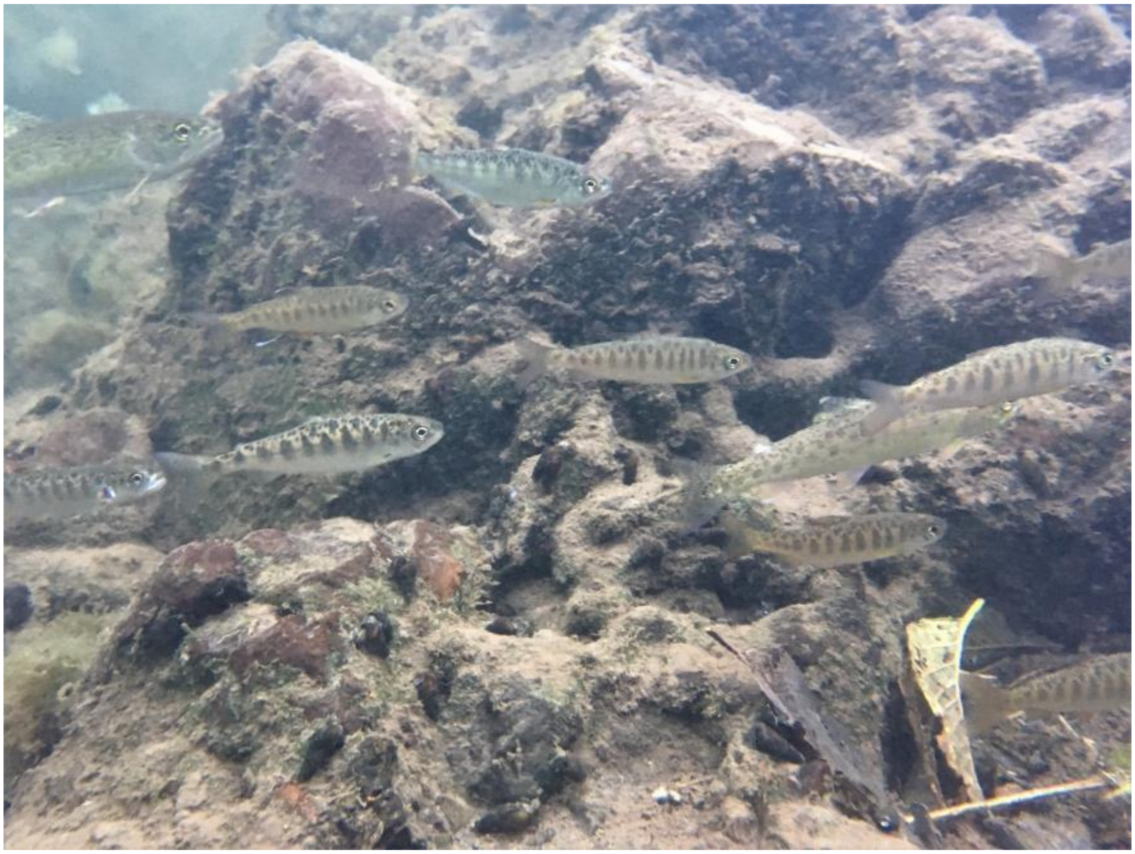

Photo 7 Fall Creek Thermal Refugia

Steelhead

Steelhead were observed in low abundance, likely resultant of steelhead preferences to aquatic habitats with cooler faster moving water.

Cutthroat

Cutthroat trout were the most abundant salmonid observed utilizing the inventoried mainstem thermal refugia. A majority of cutthroat observed were large older age class fish of fluvial and searun origin. Cutthroat abundance declined above the Salmonberry River confluence. This is likely the result of the Salmonberry River being the last significant cool water contribution capable of supporting older age class thermal refugees. In mainstem habitats outside of thermal refugia, cutthroat were the most abundant salmonid observed though in significantly reduced numbers. Mainstem distribution trends showed attraction to thermal refugia with abundance increasing with proximity to refugia sites. This represents a snapshot of largescale upstream thermal migration.

Chinook

Chinook were observed in moderate abundance throughout the inventoried reach rearing in pool heads and thermal refugia.

0+ Trout

Very few (9) 0+ trout were observed rearing in the inventoried thermal refugia. This is likely the result of limited spawning of steelhead and cutthroat in the lower mainstem reaches of the Nehalem due to lack of adequate spawning habitat. Additionally, differences in life history traits from that of other salmonids do not result in outmigration of fry to lower mainstem habitats soon after emergence from spawning sites higher in the basin.

Lower Nehalem Subbasin

The 2018 lower Nehalem inventory was comprised of 124.3 miles of river and stream habitat (not including the North Fork subbasin). This included all mainstem (Thermal Refugia) and tributary habitats exhibiting anadromous potential from the confluence with the Pacific Ocean to the confluence of Humbug Creek (RM 34.7).

The lower Nehalem tributaries included 22 inventoried subbasins totaling 91.6 miles of stream habitat. Anadromous fish distribution was observed in most of the tributaries.

Spawning Gravel and Adult Escapement for tributaries of the lower Nehalem Subbasin in 2018:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, an estimated 542 adult coho or 271 breeding pairs escaped to the lower Nehalem tributaries to spawn. These estimates are presented as a minimum metric of adult abundance, they are not meant to be a definitive accounting of escapement.

Estimated adult carrying capacity based on spawning gravel availability was 1,533 – 4,598 adults indicating that on a basin scale spawning gravel did not appear to function as a limiting factor for coho production for the 2017 brood year.

Table 10: Lower Nehalem Tributaries (not including North Fork Nehalem) – 2018 Expanded Fish Counts for all Salmonid Species

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
Alder			15				5			
Neahkanie	906	1.5	145		1	0.02	125	1.7		
Anderson			430		75	1.2	415	5.8	75	7.6
Bastard	120		115				60			
Batterson	18		170				65		42	4.3
Bob's			170				95	2.1		
Candyflower	222		95				80	1.1		
Chevoit							20			
Cook	5522	9.3	8455	11.7	770	12.1	325	4.5	160	16.3
Side Channel A	202		18				5		8	
Dry	28		15				60		2	
East Fork Cook	396		1405	1.9	320	5	140	1.9		
Forks			100				5			
Granite			305				55			
Hanson			767	1.1	5	0.08	5			
Harliss	78		30				13		2	
Houvet			950	1.3	5	0.08	35			

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
McKenny			140				15			
Platt Canyon	90		195		40	0.63	80	1.1		
South Fork Cook			240		65	1.02				
Strahm	899	1.5	270				20			
Cronin	3342	5.6	505		75	1.17	55			
NF Cronin	4644	7.8	765	1.1	70	1.10	50			
SF Cronin	444		610		20		60			
Fall	391		390		11		165	2.3	2	
Trib A	6		115				130	1.8		
Foley	7554	12.7	6310	8.7	750	11.8	1295	18	500	50.8
Crystal	540		175				120	1.7		
Dry	18		6		1					
Trib A	414		25		5		30			
Trib B	294		35				90	1.3		
Trib B1	18		10				25			
Trib C	50		15				5			
Trib D	24						5			
East Fork Foley	2964	5	3466	4.8	466	7.3	751	10.4	10	1
Side Channel A	70		7				1			
Trib A	277		225				75	1		
George	781	1.3	170		15		60			
Helloff	3039	5.1	1035	1.4	162	2.5	516	7.2		
Jetty			116		47		167	2.3		
Lost	8898	14.9	3647	5	460	7.2	206	2.9		
Trib A	30		30							
McPherson	6		210		10		110	1.5		
Messhouse			5							
Peterson	110		140		34		184	2.6		
Roy	162		225		145	2.3	165	2.3		
Trib A			10							
Trib B	5		10		15	0.23				
Salmonberry	3418	5.7	6545	9	285	4.5	320	4.4	146	14.8
Side Channels	508		147				1		22	2.2
Belding			110				10			

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
Kinney	408		640		35		20			
Pennoyer			155		13		12			
Sappington	12		485		15		10			
Tunnel			200							
Wolf	4980	8.4	4130	5.7	170	2.7	45			
Trib A	90		585		5		20			
NF Salmonberry			22395	30.9	1650	25.9	215	3		
Trib A			160							
Trib B			410		20		80	1.1		
Trib C			310		10		1			
SF Salmonberry	450		2045	2.8	83	1.3	50			
Ripple			5				15			
Snark	206		55				45		5	
Spruce Run	5796	9.7	1500	2.1	510	8	260	3.6	10	1
SF Spruce Run			55				15			
Trib A	54		50				10			
Trib B	18		40							
Trib M	6		70				165	2.3		
Trib N	28		11				3	0.04		
Trib O	54		30							
Trib P	666	1.1	230				100	1.4		
Trib Q			1							
Vossburg	403		50				45			
Inventory	59659		72700		6363		7425		984	

- Percent contributions are indicated for only those sub-basins that contributed greater than 1% of the total.
- 20% visual bias included for coho expansion

Minor Tributaries of the Mainstem Nehalem

Several inventoried tributaries exhibited anadromous potential but either lacked coho distribution or had low coho abundance (less than 200 expanded). A condensed review of these tributaries is provided below. See above Table 10 above for all tributaries surveyed for anadromy.

Chevoit

Chieviot Drains into the south side of Nehalem Bay (45.6836 -123.9240). The inventory extended 0.49 miles. No coho were observed. Gradient was likely passable for coho but shallow pools, and no observed spawning gravel limits potential. A 4” perched culvert under a railroad may limit upstream migration.

McPherson

McPherson enters on the upstream right bank of the Nehalem on the RM 13.45, just upstream of Cook Creek. McPherson entered the Nehalem sub-surface during the survey through a deep gravel bar. The inventory extended 0.58 miles.

A culvert perched 6 feet over a 2-foot-deep pool blocks upstream anadromous migration just upstream of the confluence. One coho and two steelhead were observed in this pool. Water temperatures were low (12.9C) in McPherson compared to the Nehalem Mainstem (21.7C). Above the culvert, habitat was characterized by limited spawning gravel (4 m^2 was observed), hyporheic flow above log jams, and moderate wood complexity. Increased gradient above RM 0.5 limited salmonid potential.

Messhouse

Messhouse Drains into the south side of Nehalem Bay (45.6668 -123.9260). The inventory extended 0.47 miles.

Habitat was dominated by beaver occupation with a total of nine full spanning active dams observed, two of them 6ft in height. No spawning gravel was observed during the inventory.

A failing culvert was documented under the railroad just above the confluence. This culvert is rusted out on the bottom with a 6-foot beaver dam at the upstream end of the culvert, likely blocking anadromous passage.

Trib M

Trib M enters the Nehalem on the upstream left bank at RM 12.6. Trib M was 15.3C at the confluence, with the Nehalem at 22C. The survey extended 0.10 miles upstream where denied access limited further inventory. Low abundances of coho were observed. At RM 0.08, a wood-planked culvert under the railroad is broken and leaking. A 2-foot perch on the downstream side is a juvenile barrier. Coho were not observed in the pool above this culvert.

Trib N

Trib N enters the Nehalem at RM 29.1. The inventory extended 0.03 miles.

The confluence of Trib N is heavily modified and complex. Trib N flow enters the mainstem at three separate points, and upstream of these are two separate culverts under a road. Water flows through these culverts as well as subsurface through the roadbed. A 1ft boulder falls is below the downstream culvert (low flow) and the upstream culvert has an approach of steep bedrock and boulders (no flow). A low flat area connects to a scoured channel leading to the upstream culvert. Above the culverts is a massive beaver complex extending 1000ft upstream. Several beaver dams were observed. The forest around the beaver swamp has been completely clearcut. The swamp is fed hyporehicly from the adjacent toeslope.

Trib O

Trib O enters the Nehalem on the upstream left bank at RM 28. The inventory extended 0.23 miles. Habitat was characterized by low wood complexity, shallow pools, and invasive knotweed riparian. Spawning gravel was observed throughout the inventoried reach ($7m^2$ total). Low salmonid densities occurred with coho occurring in only two sampled pools.

Trib O had low temperatures (12C) compared with mainstem water temps (22.5C) and fish were observed congregating at the plume of cold water at the confluence.

Trib Q

Trib Q enters the Mainstem Nehalem at RM 2.6 on the upstream left bank just downstream of Bob's Creek. The survey began in a wetland upstream of a power corridor at approximately RM 0.25 due to access restrictions. The wetland was wide with a stagnant and muddy channel. Upstream of a 3ft beaver dam, a pond spans the entire valley bottom. Abundant wildlife was noted in this pond. Coho were not observed during the inventory, with a possible barrier to passage on the downstream property. Upstream of the wetland, Trib Q is a narrow 4 ft wide channel with low flow and a forested riparian.

Alder

Alder enters the Nehalem Bay. The RBA inventory began above saltwater influence and extended 1.5 miles upstream where lack of flow and spawning gravel limits further anadromous spawning and rearing potential. Average gradient for the inventoried reach was low at 1.27%. Most of the gradient rise was observed starting about 0.5 miles above Highway 101 in the upper half of the inventory. Very low salmonid abundance was observed throughout. Visibility was reduced throughout most of the inventory due to high tannins and suspended solids, likely resulting in an underestimation of salmonid abundance.

From the start point to about 0.5 miles above Highway 101 stream habitat was characterized by low gradient (ave 0.2%); channel incision; high beaver occupation; silt dominated substrate; high temperature profile; and high solar exposure with thin riparian. Neahkahnie Creek enters just above the Highway 101 culvert.

Photo 8 Alder Creek Above HWY 101 near Neahkahnie Confluence

In upper half of the inventory gradient increases and gravel substrates are first observed. Four low quality gravel sites were documented with field notes indicating embedment with fines. Shallow pools lacking scour; well forested riparian canopy; and low summer temperature profiles were also observed.

Photo 9 Alder Creek

Coho

Coho were not observed rearing in Alder Creek. The inventoried habitat was suitable for coho occupation with the primary limitation being the lack of spawning gravel.

Steelhead

Steelhead were not observed rearing in Alder Creek. The inventoried habitat exhibited low potential for steelhead occupation.

Cutthroat

Cutthroat abundance was low with presence observed in only one pool.

0+ Trout

0+ trout abundance was low with intermittent pool presence.

Chinook

Chinook were not observed in Alder Creek.

Table 11: Alder - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	0	0	15	0	5	0

Neahkahnie

Neahkahnie enters Alder just above the Highway 101 culvert. The RBA inventory extended 3 miles upstream where a 25ft bedrock falls terminates anadromous potential. Anadromous fish distribution extended to RM 2.9.

The lower half of the inventory, extending to Neahkahnie Lake, was characterized by low gradient; channel incision; high beaver occupation; silt dominated substrate; high complexity with overhanging brush; and high solar exposure with a thin riparian corridor. Very few salmonids were observed rearing in this reach. Visibility in this reach was compromised by tannins and suspended solids, likely leading to an underestimation of salmonid abundance.

Above Neahkahnie Lake stream habitat transitions, characterized by increase in gradient (Ave 3.6%); substrate of gravel and cobble with abundant gravel sorting in pool tailouts; shaded channel with coniferous riparian; and a lack of large wood complexity.

Anchor Sites:

One anchor site with moderate functionality due to a lack of large wood complexity extended from RM 2.1 – RM 2.2.

Photo 10 Neahkahnie Creek

Photo 11 Neahkahnie Falls

Coho

Coho abundance was moderate with an average pool density of 0.62 fish/m² expanding to 733 fish/mile. The dominant density peak of 1.7 fish/m² was observed at RM 2.3.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 8 adult (combined male and female) coho escaped to Neahkahnie Creek to spawn. Estimated adult coho capacity based on spawning gravel availability was 70 – 208 coho. In 2018 Neahkahnie Creek was functioning far below its current habitat capacity and limited by inadequate adult escapement.

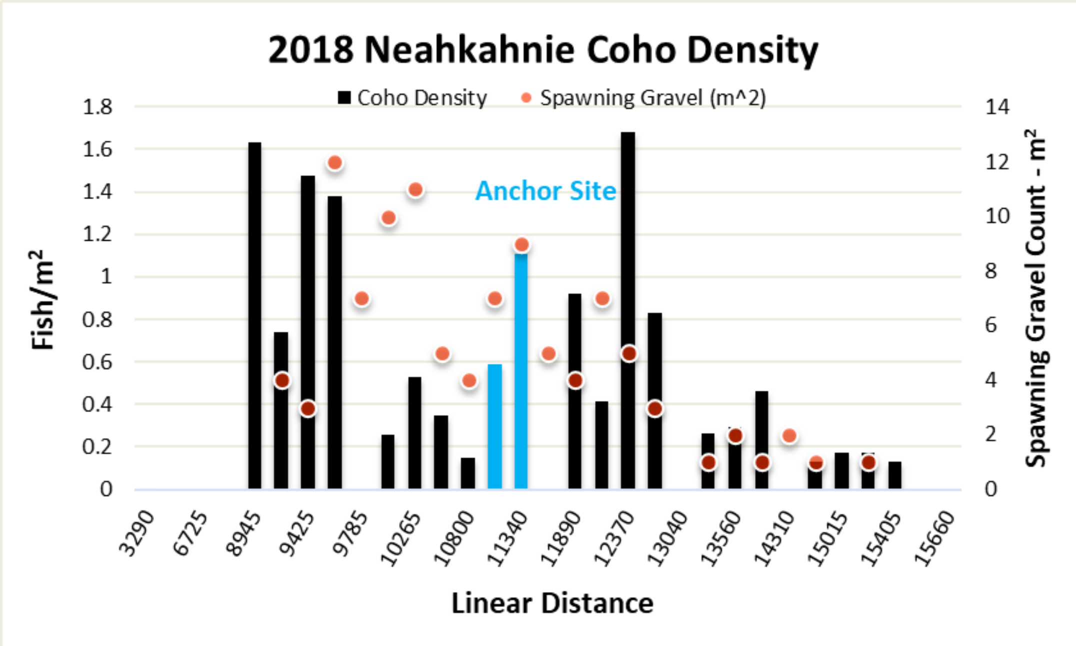

Figure 5: Neahkahnie Coho Densities 2018

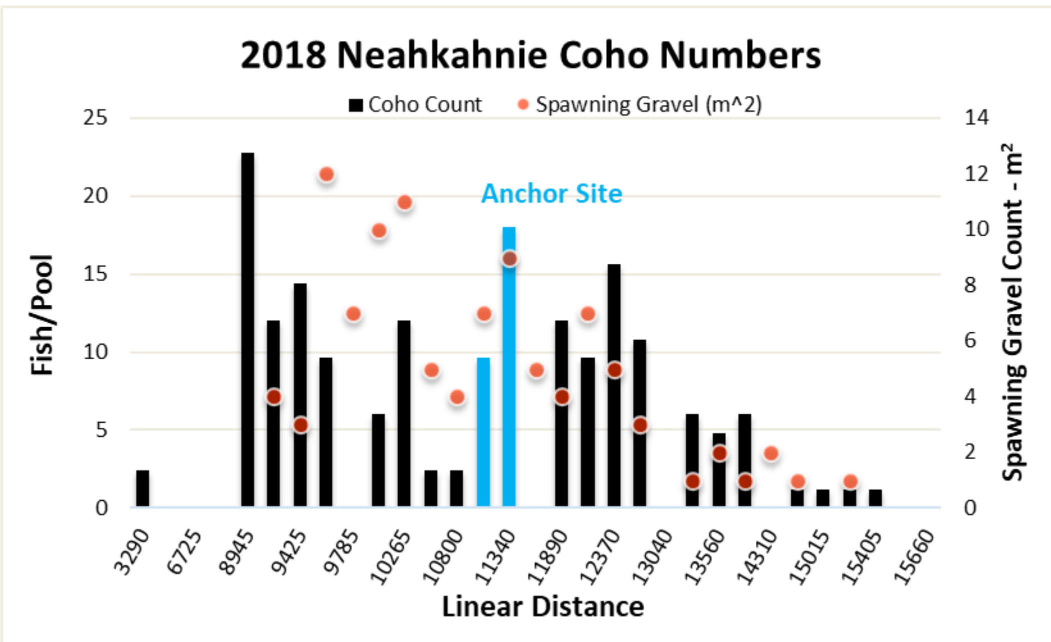

Figure 6: Neahkahnie Coho Numbers 2018

Steelhead

Steelhead were not observed. Stream habitats in the upper half of the inventory were suitable for steelhead occupation

Cutthroat

Cutthroat abundance was low with an average density of 0.16 fish/m^2. Abundance expanded to 35 fish/mile throughout the range of significant distribution.

0+ Trout

0+ trout abundance was low with an average density of 0.17 fish/m^2. Abundance expanded to 87 fish/mile throughout the range of significant distribution.

Chinook

Chinook were not observed. Inventoried habitats were not suitable for chinook occupation.

Table 12: Neahkahnie - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	906	0.62	125	0	145	0

Anderson

Anderson enters the Nehalem at RM 11. The RBA inventory extended 1.8 miles upstream where an increase in gradient over large boulders and lack of spawning gravel limits further anadromous spawning and rearing potential. Anadromous fish distribution extended 0.8 miles.

The confluence was mostly subsurface through broad cobble/gravel fan with limited connectivity to mainstem. No evidence of upstream thermal migration was observed. The confluence plume was inventoried for thermal refugia with three cutthroat observed.

Photo 12 Anderson Confluence with Lower Nehalem

Habitat was characterized by low summer temperature profiles (14.9C); moderate to high gradient (avg. 5.4%); channel meander confined by hillslope; dominant substrate of bedrock, boulder, cobble and coarse gravel with limited sorting in pool tailouts; shaded channel with coniferous riparian; and low wood complexity throughout majority of the inventoried reach, increasing above end of anadromy.

Photo 13 Anderson Habitat

Coho

No coho were observed. Inventoried stream habitats exhibited moderate potential for coho occupation.

Spawning Gravel and Adult Escapement:

Estimated adult (combined male and female) coho carrying capacity based on spawning gravel availability was 7 -20 coho

Steelhead

Steelhead abundance was low at an average pool density of 0.08 fish/m² with intermittent pool presence throughout the range of anadromy. Steelhead were present at 27 fish/mile.

Cutthroat

Cutthroat abundance was moderate with an average pool density of 0.2 fish/m² expanding to 231 fish/mile. The dominant density peak of 0.47 fish/m² was observed above anadromous distribution at RM 1.6.

0+ Trout

0+ trout abundance was low with an average pool density of 0.3 fish/m² expanding to 239 fish/mile. The dominant density peak of 1.4 fish/m² was observed above anadromous distribution at RM 1.7.

Chinook

Chinook abundance was high expanding to 107 fish/mile throughout the range of distribution. Distribution extended 0.7 miles.

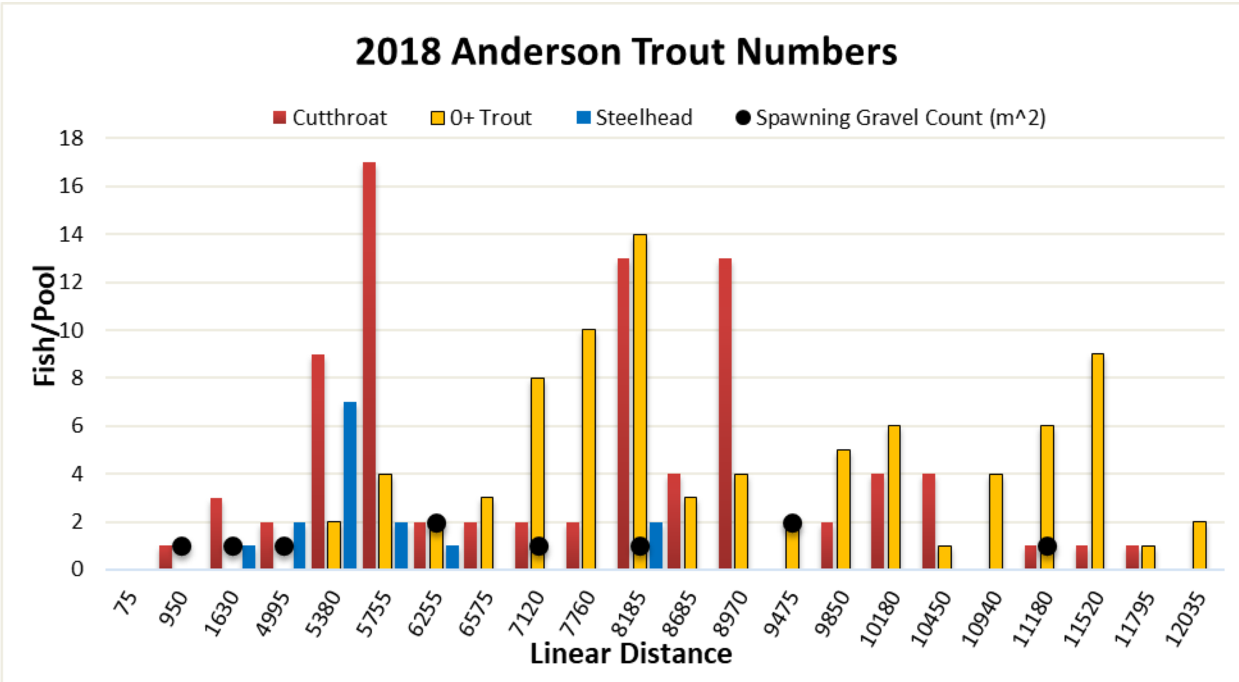

Figure 7: Anderson Trout Numbers 2018

Table 13: Anderson - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	0	0	430	75	415	75

Bastard

Bastard enters the Nehalem at RM 19.7. The RBA inventory extended 0.4 miles upstream where scoured bedrock and lack of spawning substrate limits further anadromous spawning and rearing potential. Coho distribution extended 0.18 miles to a series of bedrock steps.

Bastard was identified as a thermal refugia site. Subsurface flows through deep gravel accumulations at the confluence restricted access for temperature dependent migrations out of mainstem Nehalem. Low flows and lack of channel complexity at the confluence limited the potential of mainstem rearing in the confluence plume. No fish were observed congregating at the confluence.

Habitat was characterized by bedrock dominated channel with lack of sorted gravel; moderate to high gradient (avg. 5.9%); lack of channel complexity; and low summer temperature profiles (15.4C).

Photo 14 Bastard Creek Scoured Bedrock and Boulders

Coho

Coho abundance was low with an average pool density of 0.46 fish/m². The dominant density peak of 0.8 fish/m² was observed in the uppermost pool below a juvenile barrier. Only three pools were observed with coho presence.

Spawning Gravel and Adult Escapement:

Coho abundance was likely the result of one spawning event with low egg to fry survival. Estimated adult (combined male and female) coho carrying capacity based on spawning gravel availability was a maximum of 4 coho.

Steelhead

Steelhead were not observed. The inventoried habitat exhibited limited potential for steelhead occupation with a lack of adequate spawning gravel.

Cutthroat

Cutthroat abundance was low with an average density of 0.1 fish/m² expanding to 150 fish/mile.

0+ Trout

0+ trout abundance was low with an average density of 0.15 fish/m² expanding to 288 fish/mile.

Chinook

Chinook were not observed. The inventoried habitat was not suitable for chinook occupation.

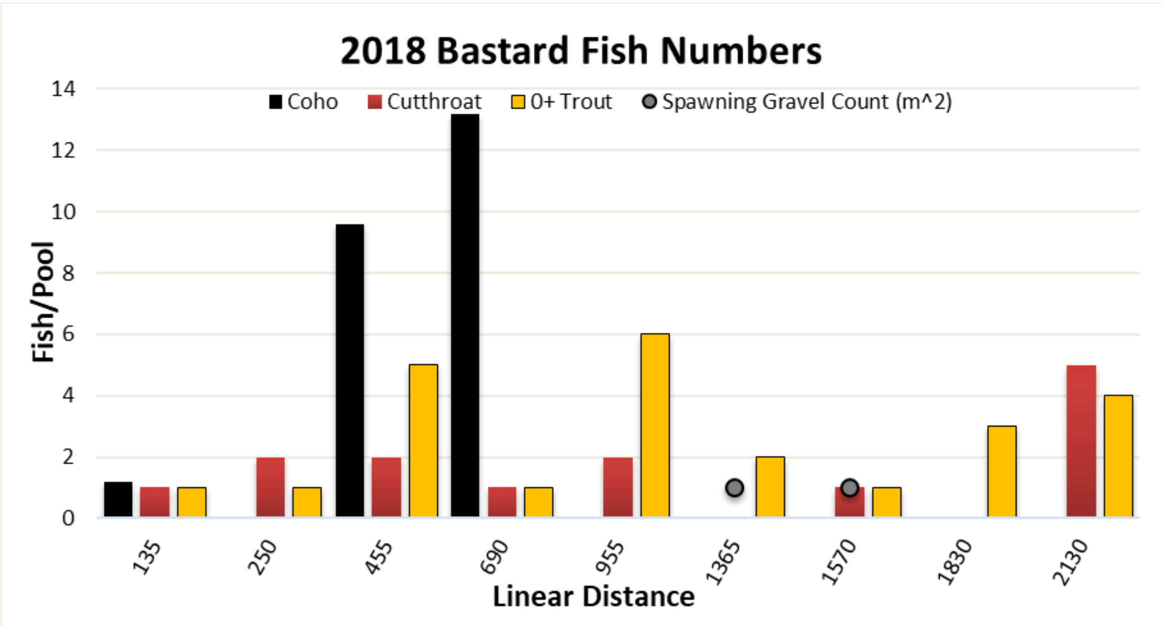

Figure 8: Bastard fish Numbers 2018

Table 14: Bastard - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	120	0.46	115	0	60	0

Batterson

Batterson enters the Nehalem at RM 12.2. The RBA inventory extended 0.3 miles upstream where increased gradient and lack of spawning gravel limits further anadromous spawning and rearing potential. Anadromous fish distribution was observed in only the first sample pool.

The first pool of the inventory was within the mainstem floodplain, maintaining flow connectivity and accessible to upstream juvenile migration. The pool was shallow, but cold (13C) and thick with reed canary grass providing thermal refugia and cover. Mainstem temperatures were 19.7C during the time of the inventory (12:00). Upstream of the first pool flows were subsurface through cobble and gravel as the channel climbed out of the floodplain, terminating upstream migration.

Photo 15 Chinook and Coho Rearing in Shallow Hyporheic Flows at Confluence

Habitat was characterized by moderate gradient (avg. 5.8%); cobble and boulder dominated substrate with lack of gravel sorting; shaded channel with coniferous riparian; and low summer temperature profiles (13C).

Coho

Coho were present in only the first inventoried pool at a density of 2.3 fish/m². Upstream habitat lacked significant spawning and rearing potential for coho.

Spawning Gravel and Adult Escapement:

Coho abundance was the result of temperature dependent migration. Estimated adult (combined male and female) coho carrying capacity based on spawning gravel availability was a maximum of 2 coho or one breeding pair

Steelhead

Steelhead were not observed. Lack of spawning gravel limited potential for steelhead.

Cutthroat

Cutthroat abundance was moderate with an average density of 0.5 fish/m² expanding to 216 fish/mile.

0+ Trout

0+ trout abundance was moderate with an average density of 1 fish/m² expanding to 567 fish/mile.

Chinook

Chinook were present in only the first inventoried pool at a density of 4.5 fish/m². This was the highest chinook density observed in the basin.

Table 15: Batterson - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	18	2.3	170	0	65	42

Bob's

Bob's enters the mainstem Nehalem on the upstream left bank at RM 2.7 within tidal influence, just downstream of the North Fork and Mainstem Nehalem confluence. The RBA began at RM 0.42 due to denied access at the confluence. The inventory extended 1.72 miles upstream to the City of Nehalem property line (access also denied for the inventory on City property). Anadromous fish were not observed in Bob's Creek, indicating a potential barrier on private property downstream of the Stimpson property line where the survey began.

Stream habitat was characterized by moderate gradient (avg. 2.6%); cobble and gravel dominated substrates with limited gravel sorting in pool tailouts; lateral channel migration confined by hillslope outside of anchor sites; low large wood complexity; high temperature profiles (16C – 18.5C); and thin alder riparian with clearcuts and young timber plantations. High beaver occupation was observed in the upper half of the inventory with 11 full spanning active dams.

Photo 16 Full Spanning Beaver Dam

A perched 5ft culvert (6ft in diameter) was observed at RM 1.56. Above the culvert four beaver dams were observed.

Photo 17 Perched Culvert, 5ft

Anchor Sites:

Two short low functioning Anchor Sites were documented on Bob's Creek. Both anchor sites exhibited a lack of large wood complexity and lack of suitable spawning gravel. Seven beaver dams were documented in Anchor Site #2.

Coho

No coho were observed during the inventory.

Spawning Gravel:

Only two square meters of spawning gravel were documented throughout the inventory. Both were within Anchor Site #1. In years with adult coho escapement into Bob's Creek, lack of spawning gravel availability would function as the primary limiting factor for coho production.

Steelhead

No steelhead were observed in Bob's.

Cutthroat

Cutthroat abundance was low with an average density of 0.17 fish/m^2 expanding to 73 fish/mile. The highest density of 0.28 fish/m^2 was observed at RM 0.66.

0+ Trout

0+ trout abundance was low with an average density of 0.18 fish/m^2 expanding to 99 fish/mile. The highest density of 0.34 fish/m^2 was observed at RM 1.16.

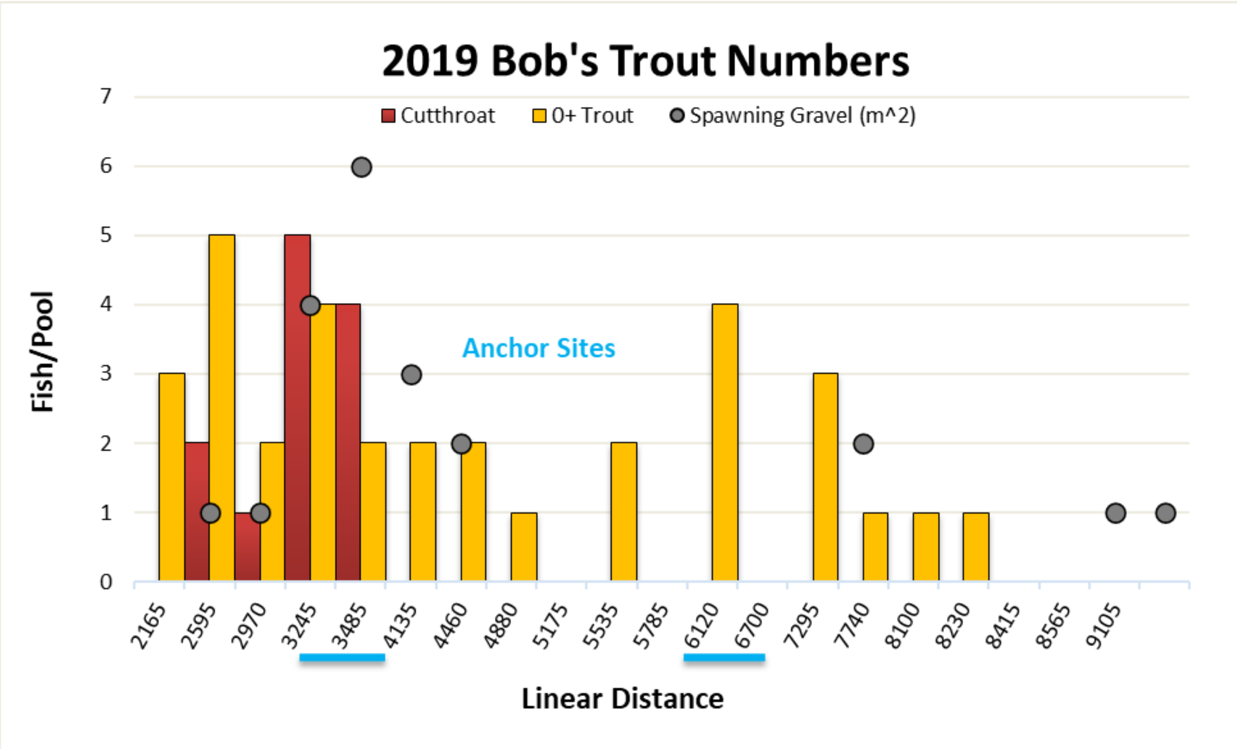

Figure 9: Bob's Trout Numbers 2019

Chinook

No chinook were observed

Table 16: Bob's - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	0	0	170	0	95	0

Candyflower

Candyflower enters the Nehalem at RM 27.7. The RBA inventory extended 0.5 miles upstream where a gradient increase and large wood complexes limit further anadromous spawning and rearing potential. Anadromous fish distribution extended 0.4 miles.

Candyflower was identified as an important thermal refugia, rated as high priority for restoration. High numbers and diversity of salmonids were observed congregating in the mainstem in the confluence plume. Lack of complexity in the form of cover limits the rearing potential of this site. In Candyflower, shallow pool habitat in the lower reach limited rearing potential for temperature dependent migrations with a 2ft sill log serving as a juvenile barrier 285ft above the confluence.

Photo 18 Candyflower Confluence

Habitat was characterized by moderate average gradient of 5.7%; abundant spawning gravel (16 sites); low summer temperature profiles of 13.6C with mainstem at 24.1C; high flow; channel meander confined by hillslope; and high wood complexity of coniferous composition.

Photo 19 Candyflower Wood Complexity

Coho

Coho abundance was low with an average pool density of 0.6 fish/m² expanding to 444 fish/mile. The dominant density peak of 1 fish/m² was observed at RM 0.3.

Spawning Gravel and Adult Escapement:

An estimated 2 adult (combined male and female) coho escaped to Candyflower Creek to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 11 – 32 coho.

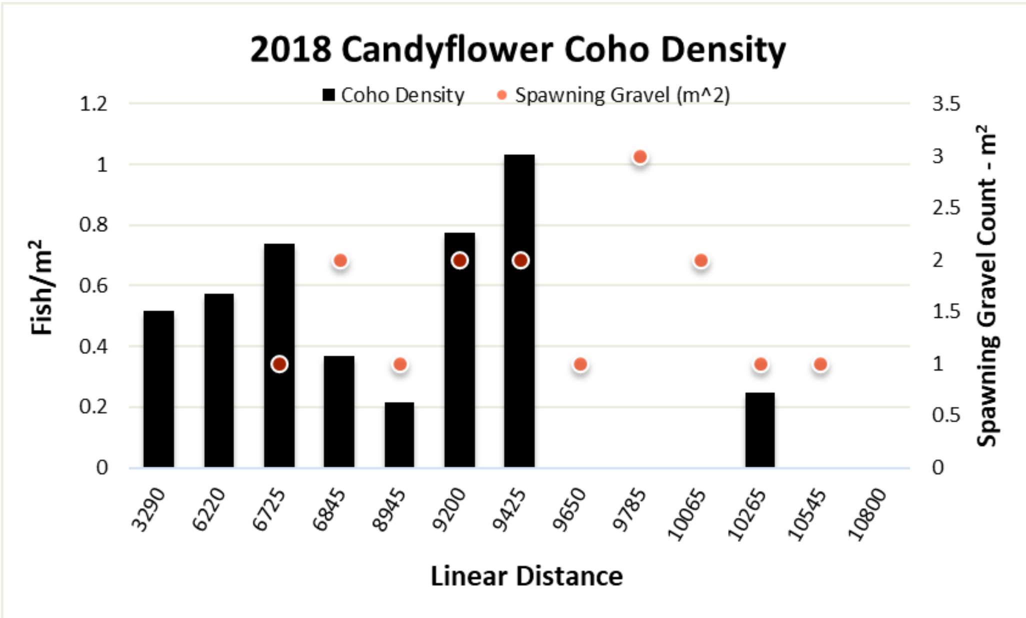

Figure 10: Candyflower Coho Densities 2018

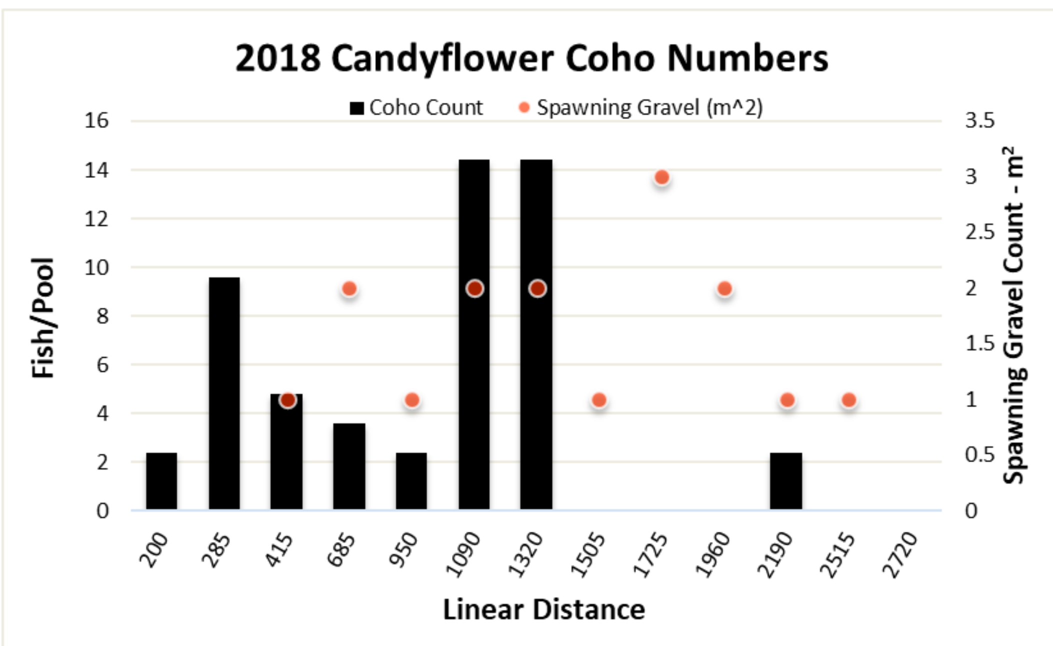

Figure 11: Candyflower Coho Numbers 2018

Steelhead

Steelhead were not observed. Inventoried habitats were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was low with an average density of 0.16 fish/m^2 expanding to 160 fish/mile.

0+ Trout

0+ trout abundance was low with an average density of 0.2 fish/m^2 expanding to 190 fish/mile.

Chinook

Chinook were not observed.

Table 17: Candyflower - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	222	0.6	95	0	80	0

Cook

Cook enters the Nehalem at RM 13.3. The RBA inventory of the Cook Creek subbasin was comprised of 15.8 miles of stream habitat exhibiting anadromous potential. This included 8.4 miles of mainstem with one side channel and 12 tributaries totaling 7.4 miles. The mainstem Cook inventory extended 8.4 miles upstream where gradient increase and lack of spawning gravel limited further anadromous spawning and rearing potential. Steelhead distribution extended 7.85 miles with no barrier to passage observed. Coho distribution extended 7.24 miles to a 3ft bedrock falls.

Coho and chinook production within most of the tributaries was limited, rearing subbasin totals of only 23.3% for Coho and 7% for chinook while contributing 46.8% of the total inventoried stream miles within the subbasin. A similar trend was observed for Steelhead and 0+ trout where, of the subbasin totals, 36.1% of steelhead and 34.27% of 0+trout were rearing in tributaries. For cutthroat, the opposite was true with 57.1% of the subbasin total observed rearing in tributary habitats.

Several of the inventoried tributaries (Dry, Forks, Granite, Harliss, Mckenny, South Fork, and Trib A) exhibited limited spawning and rearing potential due to high gradient, lack of spawning gravel, shallow pools, and/or anadromous barriers. Anadromous fish distribution in these tributaries, when present did not extend far above the first pool. In South Fork Cook no coho were observed, but steelhead distribution extended 0.27 miles to a 9ft waterfall that terminates anadromous potential. Each of the significant tributaries will be reviewed separately below.

Cook Creek was identified as an important thermal refugia, rated as high priority for restoration. Temperatures documented at the time of the inventory recorded a 7.8C differential from the mainstem Nehalem (15C – 22.8C). Cook Creek contributed large volumes of cold water to the mainstem Nehalem throughout the summer months. High numbers and diversity of salmonids were observed congregating in the mainstem in the confluence plume. Lack of complexity in the form of cover providing refuge from predation severely limited the rearing potential for juvenile salmonids at this site.

Photo 20 Cook Creek Confluence

Photo 21 Large Cutthroat in Cook Creek Confluence Plume

Lack of complexity was observed throughout most of the mainstem cook inventory. In particular, the lack of cover in the lower 0.25 miles of Cook Creek limited the rearing potential for temperature dependent migrations out of the mainstem Nehalem. Very few salmonids were observed in this reach despite the abundance of pool habitat and thermal refugia.

Habitat throughout mainstem Cook was characterized by low to moderate gradient (avg. 2.35%); broad active channel with braiding and sinuosity; dominant substrates of boulder, cobble, and gravel with deep bedload accumulations; coniferous riparian with high solar exposure in some reaches due to channel width; long simplified reaches with lack of channel complexity in the form of large woody debris; low summer temperature profiles; and high flow.

Photo 22 Lower Cook Creek Long Boulder Riffle

Photo 23 Cook Creek Stream Habitat

Anchor Sites:

Eleven anchor sites were documented in the Cook Creek subbasin, six of which were in Cook mainstem. Anchor sites varied in functionality with most exhibiting deficiencies in large wood complexity and spawning gravel.

Anchor Site #1 extended 0.2 miles upstream from RM 1.74.

Anchor Site #2 extended 0.26 miles upstream from RM 2.2

Anchor site #3 was the longest extending from RM 3.12 – 3.8. One significant side channel (A) was documented in anchor site #3 (RM 3.5) and included in the inventory. A 100% sample of pool habitats was conducted.

Side Channel A extended 0.2 miles and was comprised of ten pools totaling 363 m^2's of pool habitat. Flows were disconnected from the mainstem at both upstream and downstream ends. 242 Coho were observed rearing at an average density of 0.7 fish/m^2. Juvenile chinook, 0+ trout, and cutthroat were also observed in low abundance. Side Channel habitat was characterized by high wood complexity; low gradient; low flow; sinuous channel; and broad low terrace. Four spawning gravel sites were documented in Side Channel A.

Photo 24 Upstream End of Side Channel A (Anchor Site #3)

Anchor Site #4 extended 0.22 miles upstream from RM 4.8 and includes the confluence of Strahm Creek.

Anchor Site #5 extended 690ft upstream from RM 6.1

Anchor Site #6 extended 0.37 miles upstream From RM 6.8.

Photo 25 Cook Creek Anchor Site #5

Spawning Gravel and Adult Escapement:

An estimated 66 adult (combined male and female) coho escaped to Cook Creek subbasin to spawn. Estimated adult carrying capacity based on spawning gravel availability was 153 - 458 adult coho. Like most of the inventoried subbasins in the lower Nehalem, Cook was limited by inadequate adult coho escapement.

Coho

Coho abundance in Cook Creek was low with an average pool density of 0.45 fish/m² expanding to 791 fish/mile. The dominant density peak of 2.35 fish/m² was observed at RM 6.78 within Anchor Site #6. The second highest density of 1 fish/m² and high pool count of 252 coho were also observed within Anchor Site #3, just above the upstream end of Side Channel A. The secondary peak was more representative of the dominant spawning reach with higher abundances in surrounding pools. The falls at RM 7.24 was not a permanent barrier to adult passage. Lack of spawning gravel abundance above the falls may be limiting additional upstream production.

Photo 26 End of Coho

Spawning Gravel and Adult Escapement:

An estimated 52 adult coho escaped to Cook Creek Mainstem to spawn. Estimated adult carrying capacity based on spawning gravel availability was 76 - 228 adult (combined male and female) coho.

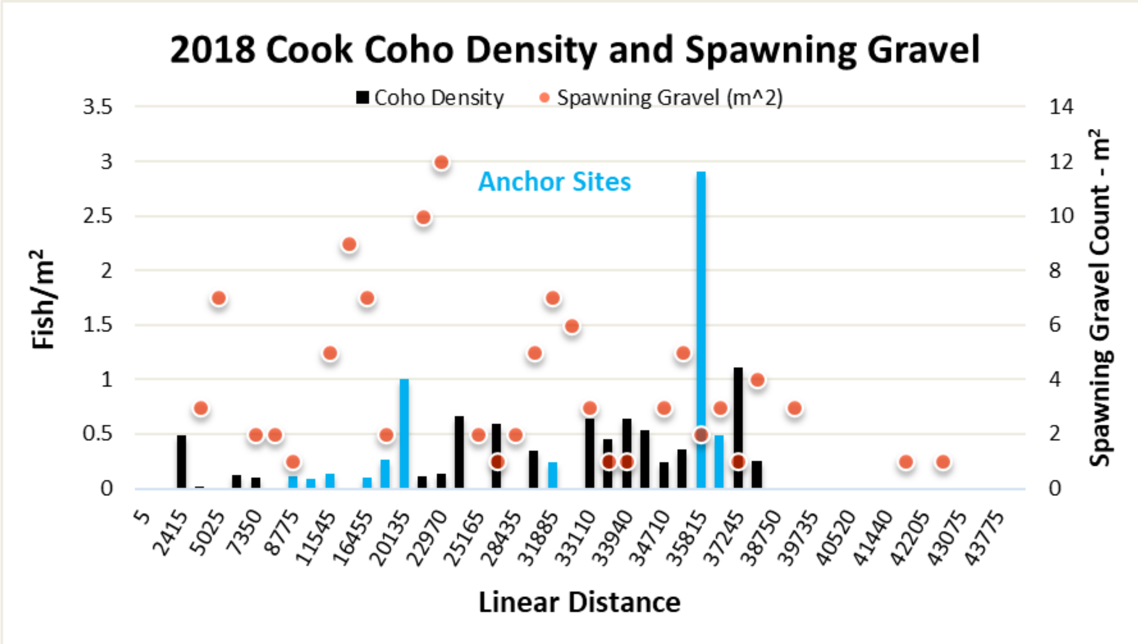

Figure 12: Cook Coho Densities 2018

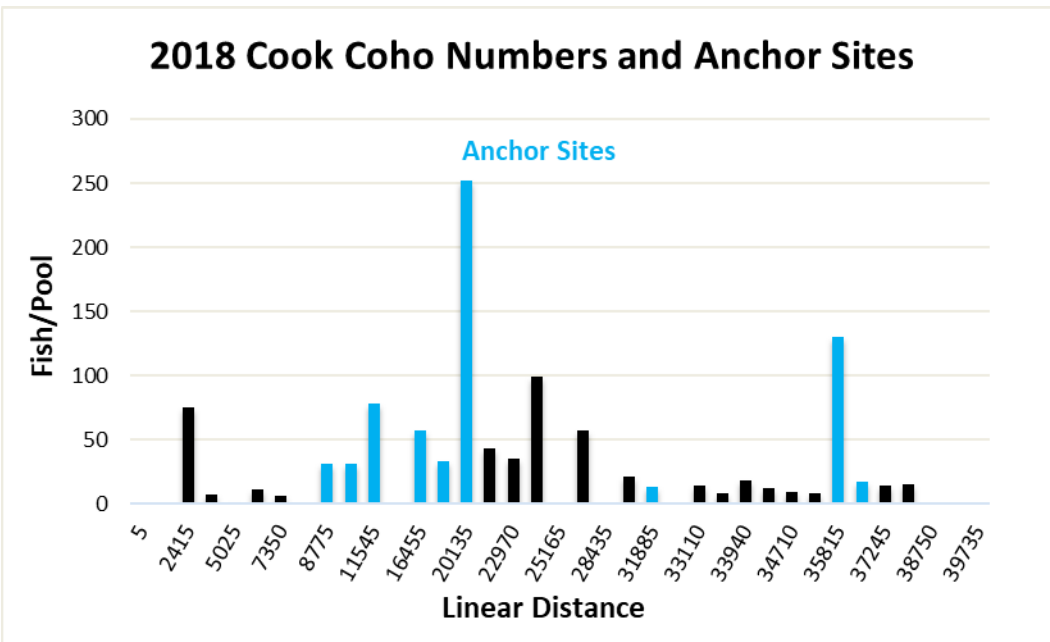

Figure 13: Cook Coho Numbers 2018

Steelhead

Steelhead abundance was low with an average pool density of 0.1 fish/m² expanding to 98 fish/mile. Abundance diminished above the falls at RM 7.24. Lack of spawning gravel above the falls may be a limitation to higher production.

Cutthroat

Cutthroat abundance was low with an average density of 0.05 fish/m² expanding to 39 fish/mile. No increase in abundance was observed above the end of anadromous distribution.

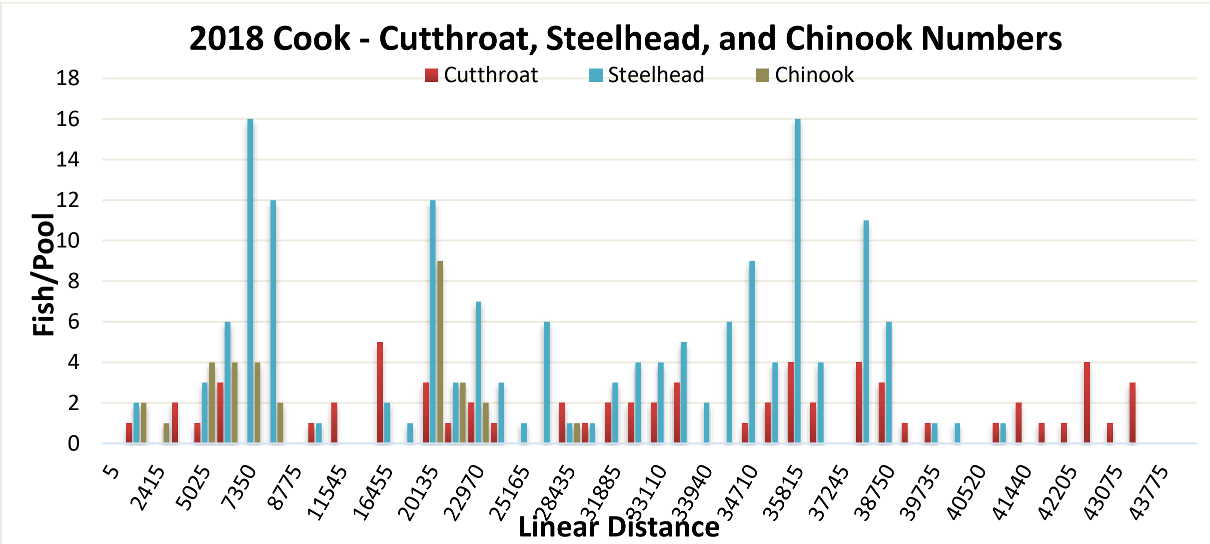

Figure 14: Cook Cutthroat, Steelhead, and Chinook Numbers 2018

0+ Trout

0+ trout abundance was moderate with an average density of 0.48 fish/m² expanding to 1,009 fish/mile. The dominant density peak of 2.08 fish/m² was observed at RM 9.73 just above the end of anchor site #6. The highest pool count (270) was observed in anchor site #1.

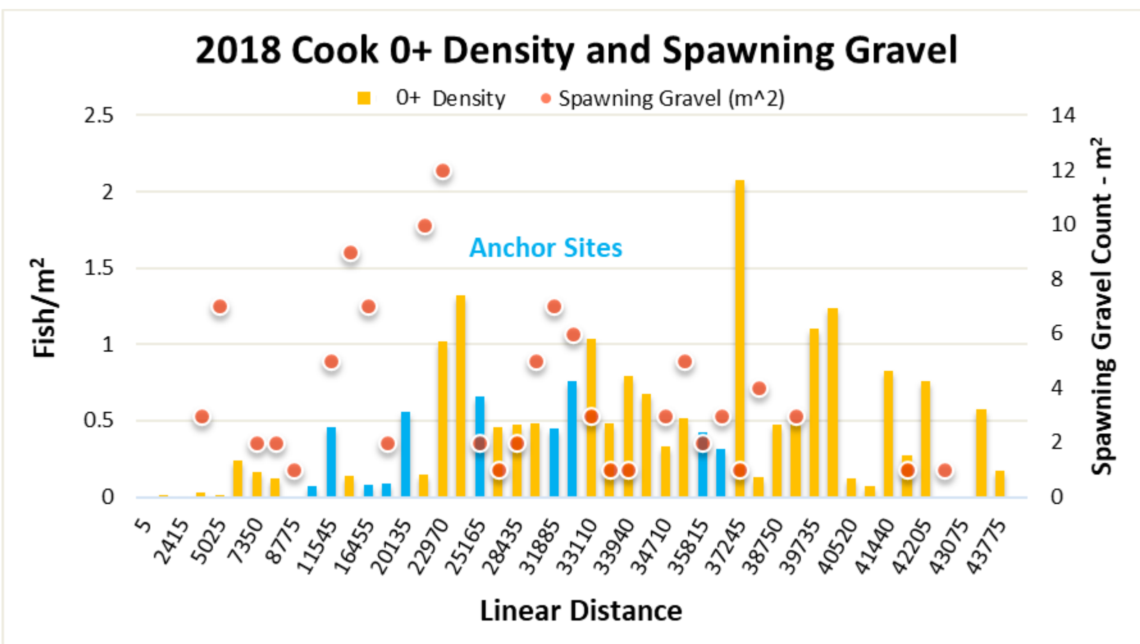

Figure 15: Cook 0+ Trout Densities and Spawning Gravel 2018

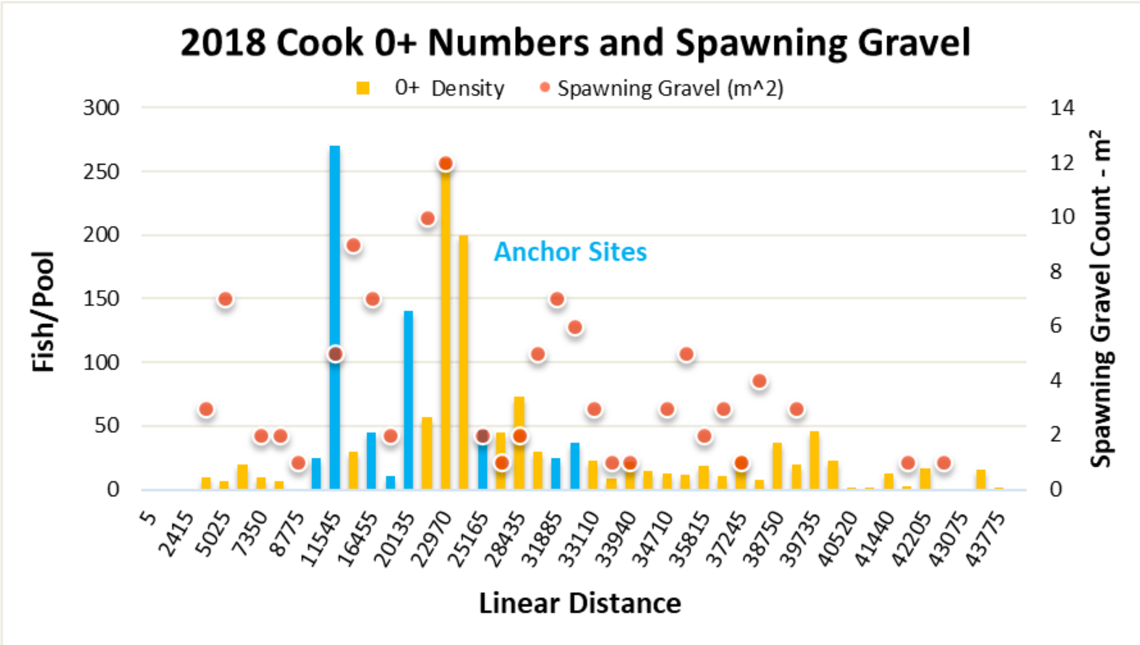

Figure 16: Cook 0+ Trout Numbers and Spawning Gravel 2018

Chinook

Chinook were observed in low abundance throughout the lower 5.4 miles of the inventory.

Table 18: Cook - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	5,724	0.45	8,473	770	330	168

East Fork Cook

East Fork Cook enters Cook at RM 5.1. The RBA inventory extended 2.2 miles upstream where high gradient, confined canyon, and legacy old growth log jams limit further anadromous spawning and rearing potential. Coho distribution extended 0.5 miles to a 10ft bedrock falls. Steelhead distribution extended 1.8 miles.

Habitat was characterized by moderate gradient (avg. 4.6%); dominant substrates of boulder, cobble, and gravel; moderate wood complexity comprised of legacy old growth segments; shaded channel with mixed riparian of deciduous and conifers; channel meander largely confined by hillslope with two reaches of increased floodplain width with side channel habitat (anchor sites); and low summer temperature profiles.

Figure 17 East Fork Cook

Anchor Sites:

Two anchor sites were identified.

Anchor Site #1 began at the confluence and extended 0.3 mile upstream. The confluence was braided across a wide floodplain with a low alder dominated terrace. Coho were observed rearing in isolated pools within side channel habitats. A lack of large wood complexity and sorted gravel reduced the functionality rating to 2 (medium).

Anchor Site #2 began above the falls at RM 0.5 and extended 0.2 miles. This site was rated as high functioning, exhibiting high wood complexity and low gradient with channel braiding across a wide low floodplain.

Figure 18 East Fork Anchor Site #1

Coho

Coho abundance was low with an average pool density of 0.6 fish/m² expanding to 792 fish/mile. The dominant density peak of 1.17 fish/m² was observed in the first dive pool.

The waterfall at the end of coho distribution appeared passable with adequate flows, suggesting it was not a permanent barrier to passage for coho.

Photo 27 East Fork End of Coho

Spawning Gravel and Adult Escapement:

An estimated 4 adult (combined male and female) coho escaped to East Fork Cook to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 4 – 12 coho.

Steelhead

Steelhead abundance was moderate at an average pool density of 0.19 fish/m² expanding to 186 fish/mile. The dominant density peak of 0.5 fish/m² was observed in the pool below the waterfall at RM 0.5. Abundance decreased above the falls indicating potential passage difficulties at the falls over the course of the spawning season.

Cutthroat

Cutthroat abundance was low with an average density of 0.13 fish/m² expanding to 64 fish/mile. The dominant density peak of 0.36 fish/m² was observed in the upper end of the inventory above anadromous distribution.

0+ Trout

0+ trout abundance was moderate with an average density of 0.59 fish/m² expanding to 639 fish/mile. The dominant density peak of 1.35 fish/m² was observed within Anchor Site #1 at RM 0.3. The highest pool count of 57 was observed in Anchor Site #2 just above the falls at RM 0.5.

Chinook

Chinook were not observed.

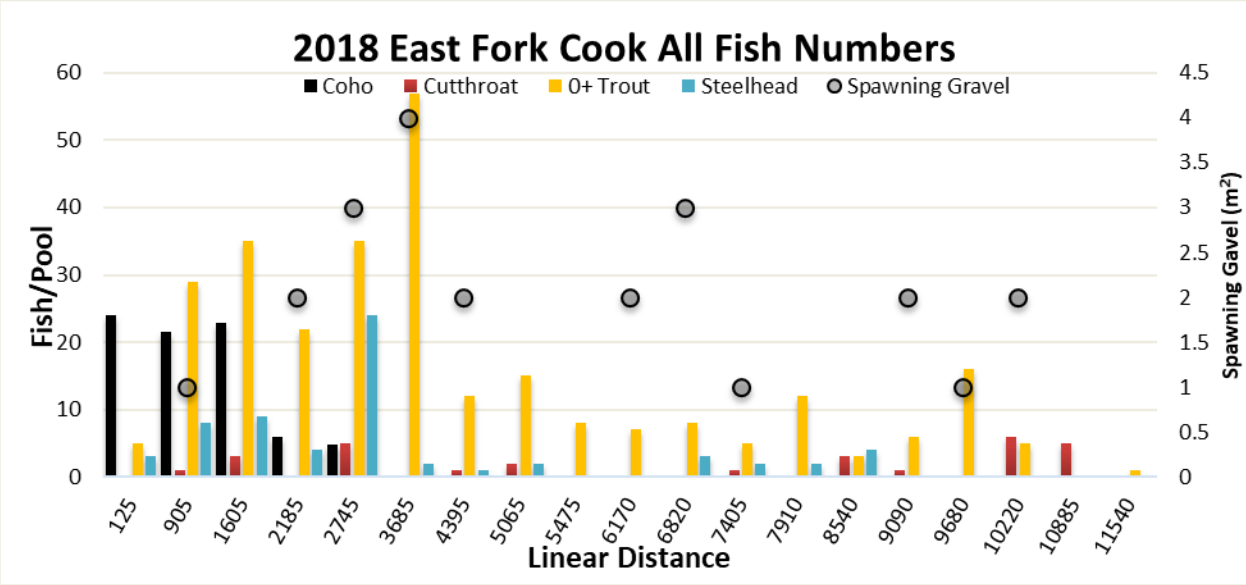

Figure 19: East Fork Cook Fish Numbers 2018

Table 19: East Fork Cook - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	396	0.6	1405	320	140	0

Hanson

Hanson enters Cook at RM 3.1. The RBA inventory extended 0.47 miles upstream where high gradient and consecutive log jams limit further anadromous spawning and rearing potential.

Stream habitat was characterized by high gradient (avg. 7.6%); high wood complexity of deciduous and legacy conifer; dominant substrate of boulder, cobble, and gravel; deciduous riparian; and channel meander confined by hillslope.

Photo 28 Hanson Creek

Photo 29 Hanson Log Jam

Coho

Coho were not observed.

Spawning Gravel and Adult Escapement:

4 m² of spawning gravel was documented within the current range of anadromy. Estimated adult (combined male and female) coho carrying capacity based on spawning gravel availability was 3 – 8 coho.

Steelhead

Steelhead abundance was low with presence observed in only one pool.

Cutthroat

Cutthroat abundance was low with presence observed in only one pool.

0+ Trout

0+ trout abundance was high with an average density of 1.83 fish/m² expanding to 1,534 fish/mile. The dominant density peak of 5.92 fish/m² and high pool count of 154 was observed in the second sample pool270ft above the confluence. This density exceeds the fully seeded capacity level and was the second highest 0+ trout density documented in our 2018 and 2019 inventories.

Chinook

Chinook were not observed.

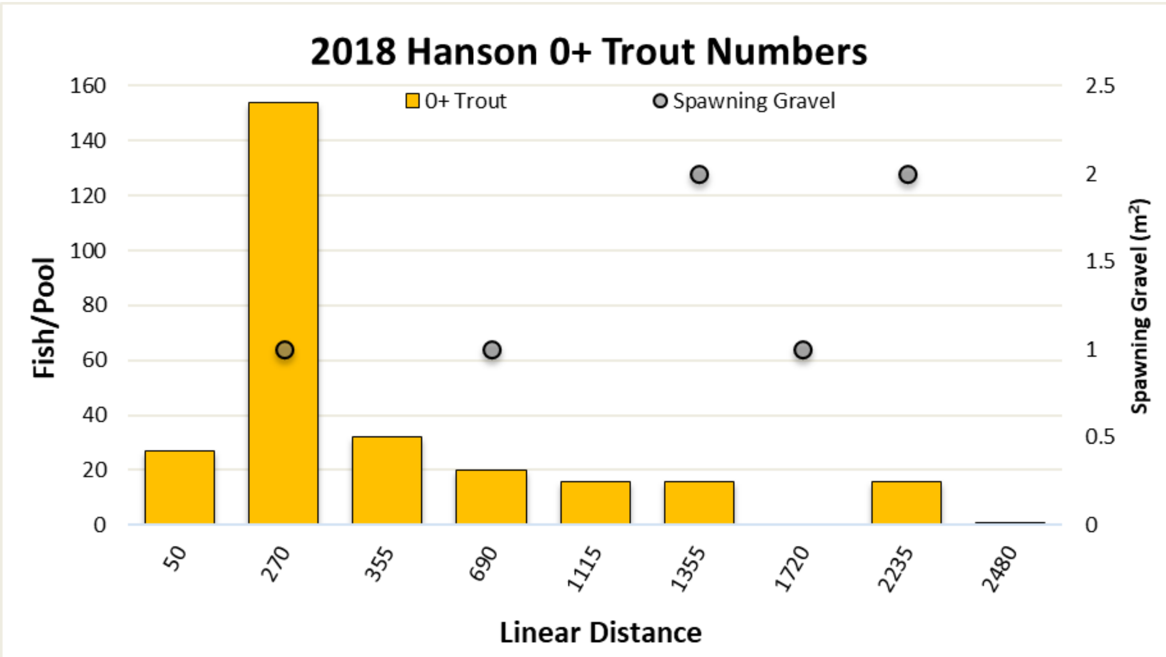

Figure 20: Hanson 0+ Numbers 2018

Table 20: Hanson - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	0	0	767	5	5	0

Harliss

Harliss enters Cook at RM 1.75 within Cook Creek Anchor Site #1. The RBA inventory extended 0.36 miles upstream where increase in gradient and lack of spawning gravel limited further anadromous spawning and rearing potential. Anadromous fish distribution extended 380ft to a ten-foot perched culvert.

Below the culvert, the channel splits with most summer flow diverted out of the main channel into the broad Cook Creek floodplain where it sinks subsurface into the bedload. Flow in the main channel extends a short distance before going subsurface downstream of the first pool.

Photo 30 Upper Harliss Creek

Coho

Coho were observed in only the first pool with a count of 78 coho. The pool density (16.79 fish/m^2) was the highest recorded throughout our 2018 and 2019 inventories. This pool was within the floodplain of mainstem cook and isolated with a juvenile barrier upstream and subsurface flows disconnecting it from the mainstem downstream. The high density observed in this pool was likely the result of fish seeking refuge from high velocity mainstem flows and becoming stranded by receding water levels.

Photo 31 Isolated Pool with High Coho Density

Spawning Gravel and Adult Escapement:

2 m² of spawning gravel was documented above the current range of anadromy.

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was low with intermittent pool presence at an average density of 0.2 fish/m² expanding to 36 fish/mile.

0+ Trout

0+ trout abundance was low with an average density of 0.29 fish/m² expanding to 83 fish/mile.

Chinook

Chinook were observed in only the first pool.

Table 21: Harliss - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	78	N/A	30	0	13	2

Houvet

Houvet enters Cook at RM 7.6. The RBA inventory extended 0.88 miles upstream where gradient increase and channel simplification limits further anadromous spawning and rearing potential. At the confluence with Cook Creek, Houvet contributes approximately 35% of the summer flows.

Habitat was characterized by moderate gradient (avg. 3.3%); lateral channel meander largely confined by hillslope outside of anchor sites; high wood complexity of deciduous material and legacy conifers; dominant substrate of boulder, cobble, and gravel; and low summer temperature profiles (15C).

Photo 32 Confluence of Houvet and Cook

Photo 33 Houvet Creek

Anchor Sites:

Two short moderately functioning anchor sites were identified. Both sites lacked adequate gravel sorting and exhibited floodplain:bankfull ratios on the borderline of qualification (<5:1).

Anchor Site #1 extended from the Cook Creek confluence to RM 0.14. Anchor Site #2 extended fro RM 0.48 – 0.62.

Spawning Gravel and Adult Escapement:

A total of 12 m² of spawning gravel was documented throughout the inventory. Estimated adult (combined male and female) coho carrying capacity based on spawning gravel availability was 8 – 24 coho.

Coho

Coho were not observed. The inventoried habitat exhibited high potential for coho rearing and spawning

Steelhead

Steelhead were observed in only the first pool of the inventory. 0+ trout abundance and densities indicate steelhead spawning likely occurred in the inventoried reach.

Cutthroat

Cutthroat abundance was low with intermittent pool presence at an average density of 0.15 fish/m² expanding to 36 fish/mile.

0+ Trout

0+ trout abundance was moderate with an average density of 1.88 fish/m² expanding to 1080 fish/mile. The dominant density peak of 3.32 fish/m² was observed at RM 0.4. This density peak likely indicates the location of a steelhead spawning event.

Chinook

Chinook were not observed.

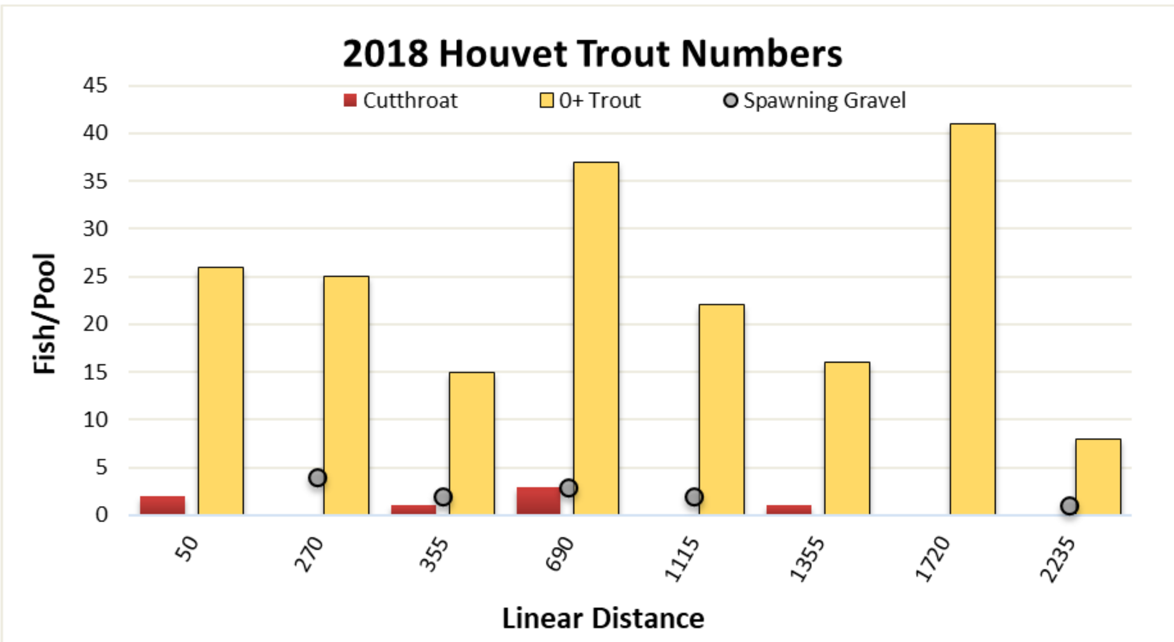

Figure 21: Houvet Trout Numbers 2018

Table 22: Houvet - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	0	N/A	950	5	35	0

Platt Canyon

Platt Canyon enters Cook at RM 3. The RBA inventory extended 0.53 miles upstream where increased gradient and divided flows limit further anadromous spawning and rearing potential. Steelhead distribution extended 0.38 miles to a log jam at a tributary confluence.

Habitat was characterized by moderate gradient; high wood complexity; deep bedload of cobble and gravel; low flows, subsurface for first 280ft.; and low summer temperature profiles.

Photo 34 Platt Canyon Creek

Coho

Coho abundance was low with presence observed in only the first two pools. Distribution profiles suggest that coho spawning did not occur and abundance was likely the result of upstream migration in search of refuge from high velocity mainstem flows.

Spawning Gravel and Adult Escapement:

A total of 12 m² of spawning gravel sites was documented. Estimated adult (combined male and female) coho carrying capacity based on spawning gravel availability was 8 – 24 coho.

Steelhead

Steelhead abundance was low at an average pool density of 0.35 fish/m² with intermittent pool presence throughout the range of anadromy. Steelhead were present at 75 fish/mile. The density peak of 0.6 fish/m² was observed in the first pool.

Cutthroat

Cutthroat abundance was moderate with an average density of 0.6 fish/m² expanding to 151 fish/mile. The dominant density peak of 1 fish/m² was observed in the first pool.

0+ Trout

0+ trout abundance was moderate with an average density of 1.95 fish/m² expanding to 368 fish/mile. The dominant density peak of 4.5 fish/m² was observed above anadromous distribution at RM 0.46.

Chinook

Chinook were not observed.

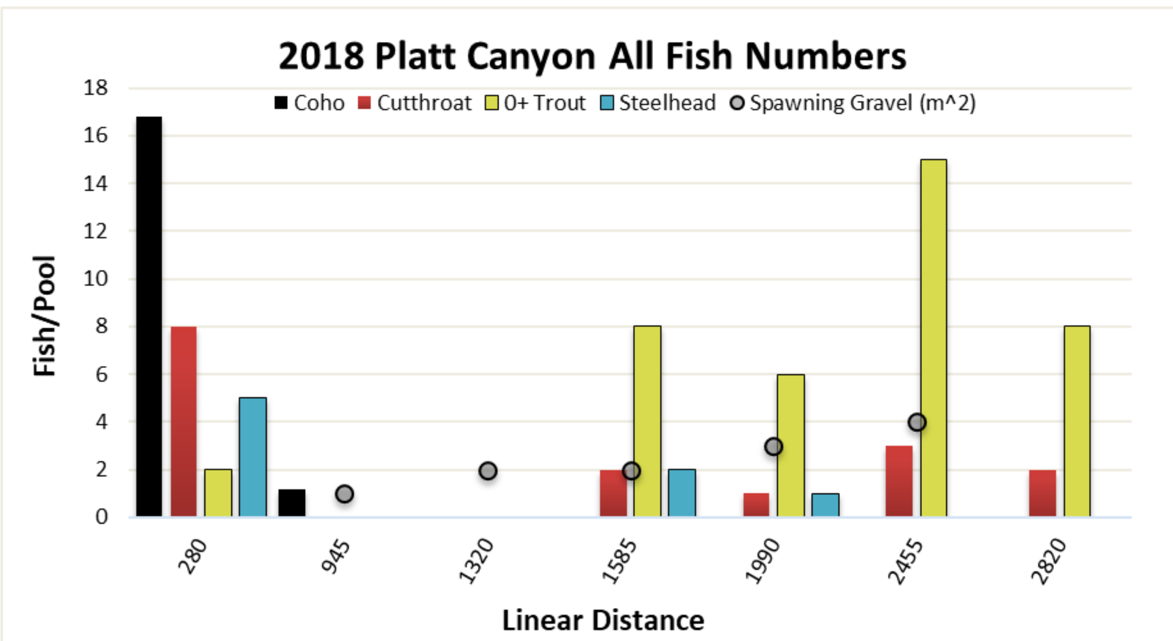

Figure 22: Platt Canyon Fish Numbers 2018

Table 23: Platt Canyon - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	90	N/A	195	40	80	0

Strahm

Strahm enters Cook at RM 4.85. The RBA inventory extended 1.07 miles upstream where increase in gradient, lack of spawning gravel, and low flow limited further anadromous spawning and rearing potential. Coho distribution extended 0.57 miles.

Habitat was characterized by moderate gradient (avg. 6%); deep bedload of gravel; low summer flows, subsurface in sections; low summer temperature profiles; low large wood complexity.

Anchor Sites:

Strahm entered Cook within an anchor site exhibiting a broad alder dominated terrace braided with dry channels that extended 0.17 miles upstream. Abundant gravel was distributed throughout the dry braids with deep bedload accumulation across the terrace. Several isolated pools within the floodplain were documented with high densities of coho. This anchor site was given a low function level rating (3) due to low summer flows and lack of large wood complexity.

Photo 35 Strahm Creek Anchor Site upstream from Confluence of Cook Creek

Coho

Coho abundance was high with an average pool density of 2.36 fish/m² expanding to 1577 fish/mile. The dominant density peak of 6.4fish/m² was observed in an isolated pool 735ft above the confluence, still within the Cook Creek floodplain.

Spawning Gravel and Abundance:

An estimated 8 adult (combined male and female) coho escaped to Strahm Creek to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 25 – 74 coho.

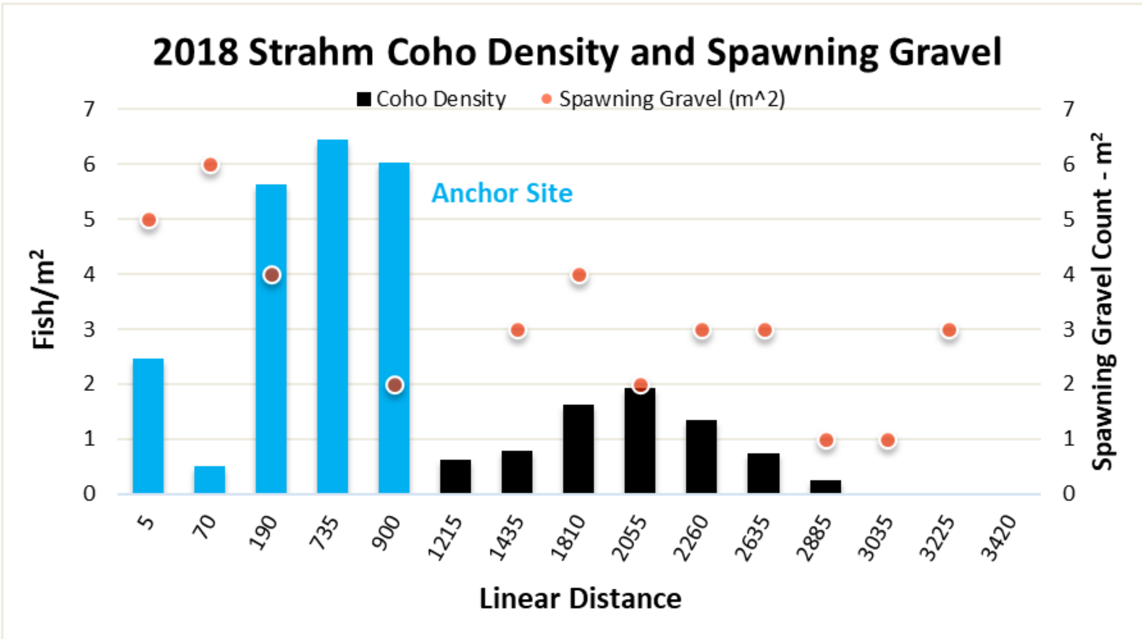

Figure 23: Strahm Creek Coho Densities 2018

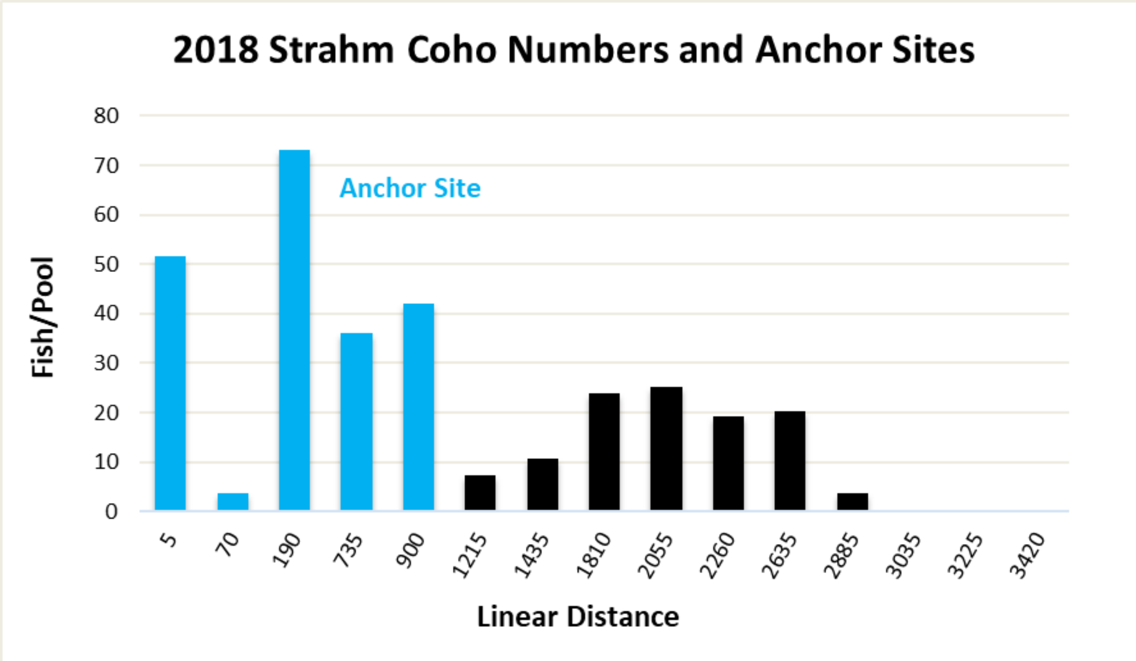

Figure 24: Strahm Creek Coho Numbers 2018

Steelhead

Steelhead were not observed. Inventoried habitats were suitable to spawning and rearing of steelhead.

Cutthroat

Cutthroat abundance was low with intermittent pool presence at an average density of 0.07 fish/m^2 expanding to 20 fish/mile.

0+ Trout

0+ trout abundance was low with an average density of 0.42 fish/m^2 expanding to 252 fish/mile. The dominant density peak of 26.9 fish/m^2 was observed in the uppermost pool of the inventory. This extraordinarily high density was observed in a small isolated pool with subsurface flows both upstream and downstream.

Chinook

Chinook were not observed.

Table 24: Strahm - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	899	1.75	270	0	20	0

Cronin

Cronin enters the Nehalem at RM 24.5. The RBA inventory covered 4.1 miles of stream habitat which included reaches of the North Fork, South Fork, and Middle Fork. Landowner access denial restricted inventory of the lower 0.5 miles from the mouth to the North Fork confluence. The Cronin subbasin was a top producer of coho in the lower Nehalem contributing 13.4% of the estimated population total while accounting for 4.5% of the inventoried linear stream miles in 2018.

Anadromous fish distribution in mainstem Cronin and Middle Fork extended 1.75 miles to a series of landslide debris torrent depositions and associated log jams 625ft above the South Fork confluence. The inventory extended an additional 0.5 miles upstream where further anadromous potential was limited by an ephemeral barrier created by a large log jam with subsurface flows through deep bedload impoundments.

Photo 36 Cronin Creek

Habitat throughout the range of anadromous distribution was characterized by moderate gradient (avg. 2.3%); low wood complexity; Mature coniferous riparian; moderate channel sinuosity with some braiding across the floodplain; Substrates of bedrock, boulder, cobble, and gravel; and low summer temperature profiles (10C – 11.4C). The lower 0.5 miles of stream habitat exhibited anchor site characteristics with high complexity channels braided across an interactive floodplain.

Anchor Sites:

Two anchor sites were documented in Mainstem Cronin. Both anchors were low functioning, lacking sufficient large wood complexity with a floodplain:bankfull ratios on the borderline of qualification (<5:1).

Anchor Site #1 extended from below our startpoint (landowner access denial) to RM 0.91 and Anchor Site #2 extended from RM1.14 – 1.33.

Photo 37 Cronin Creek Anchor Site #2

Coho

Coho abundance was high with an average pool density of 1.13 fish/m² expanding to 2881 fish/mile. The dominant density peak of 4.2 fish/m² was observed in Anchor Site #1 at RM 0.78.

Spawning Gravel and Adult Escapement:

An estimated 30 adult (combined male and female) coho escaped to Cronin Creek to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 30 – 90 coho.

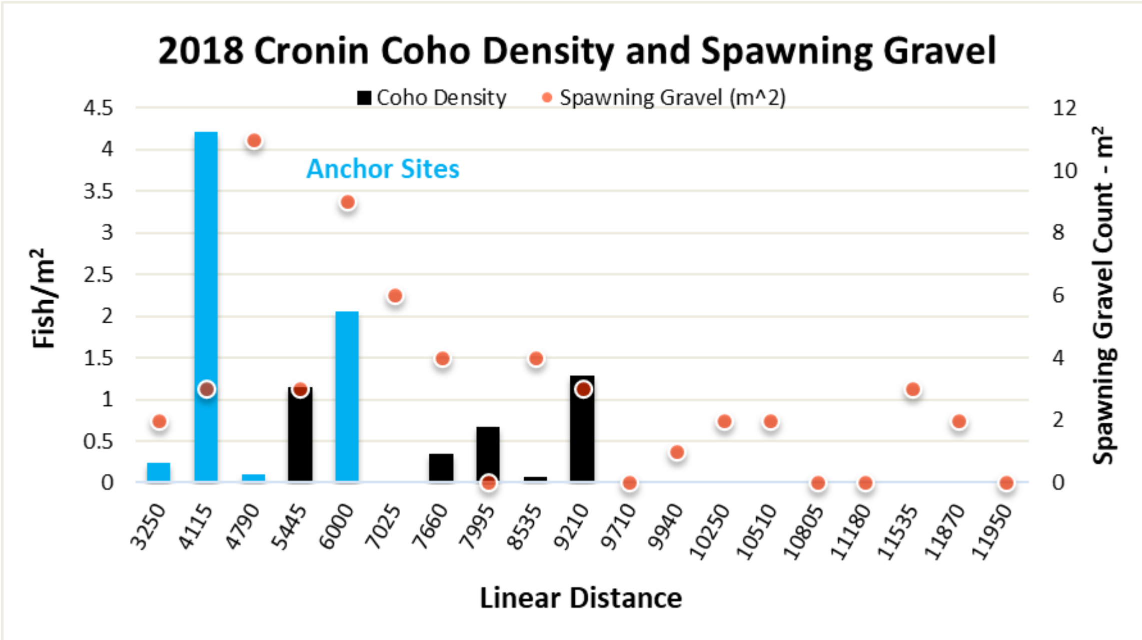

Figure 25: Cronin Creek Coho Densities 2018

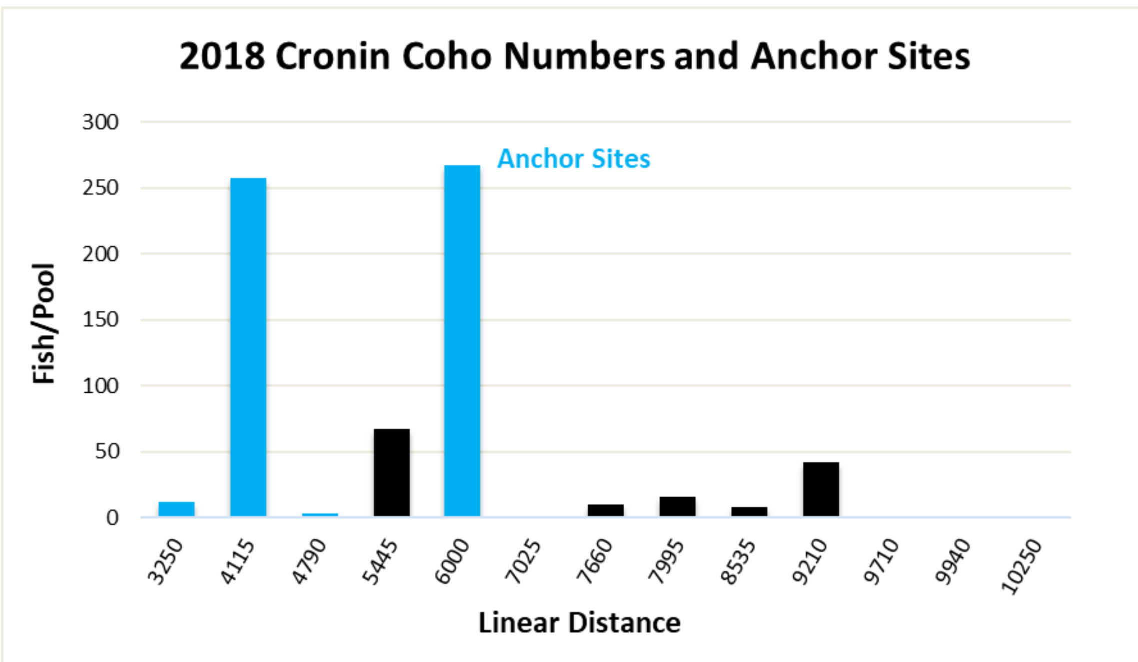

Figure 26: Cronin Creek Coho Numbers 2018

Steelhead

Steelhead abundance was low at an average pool density of 0.09 fish/m² expanding to 65 fish/mile. Intermittent pool presence was observed through the range of distribution.

Cutthroat

Cutthroat abundance was low with an average density of 0.04 fish/m² expanding to 35 fish/mile.

0+ Trout

0+ trout abundance was low with an average density of 0.23 fish/m² expanding to 322 fish/mile. The dominant density peak of 0.9 fish/m² was observed in the last pool within the range of anadromy at RM 1.75. Abundance decreased significantly above the end of anadromy. Abundance expanded to 409 fish/mile within the range of anadromy and 60 fish/mile above anadromous distribution.

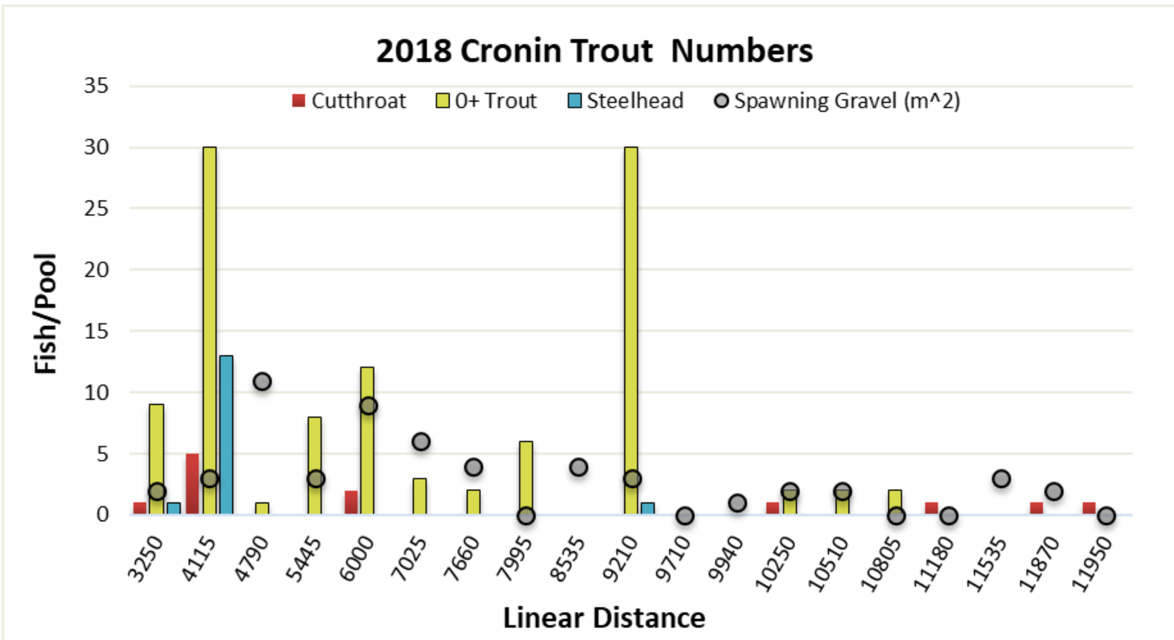

Figure 27: Cronin Trout Numbers 2018

Table 25: Cronin - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	3342	1.13	505	75	55	0

North Fork Cronin

North Fork Cronin enters Cronin at RM 0.47. The RBA inventory extended 1.2 miles. Anadromous salmonid distribution extended 0.6 miles to a large log jam constructed of legacy old growth wood and boulders with subsurface flows through deep bedload accumulations impounded above 10 – 12 ft high. This was functioning as an ephemeral anadromous barrier.

Photo 38 Bedload Impoundment Above Log Jam at End of Anadromy

Habitat was characterized by avg. gradient of 2.45%; braided channel across 2-3 ft terrace with wide floodplain; active channel lacking large wood complexity; low summer temperature profiles; mixed riparian of deciduous and conifer; and dominant substrates of boulder, cobble, and gravel.

Photo 39 North Fork Cronin Creek

Anchor Sites:

One low functioning anchor site was documented extending from RM 0.33 – 0.44. This site lacked large wood complexity and exhibited floodplain:bankfull ratios on borderline of qualification (<5;1) .

Coho

Coho abundance was high with an average pool density of 3.44 fish/m² expanding to 6,070 fish/mile. This was the highest average coho density documented throughout the 2018 Nehalem inventories and an indication that aquatic habitats were seeded to capacity. The dominant density peak of 5.15 fish/m² was observed in the first sampled pool which was not the first pool upstream of the confluence with mainstem Cronin due to landowner access denial restricting inventory of the confluence. Density profiles suggest that this high density may have been the result of upstream juvenile migration, but no significant temperature data was collected to support this conjecture. The inventory was conducted after a significant early season rain on 9/12 which lowered temperature profiles throughout the basin concealing any significant peak temperature differentials.

Spawning Gravel and Adult Escapement:

An estimated 42 adult (combined male and female) coho escaped to North Fork Cronin to spawn. Some of the observed coho abundance may have been the result of upstream juvenile migration, as density profiles suggest, which would reduce the adult escapement estimate by an unknown factor. Estimated adult carrying capacity based on spawning gravel availability was 15 – 46 adult (combined male and female) coho, indicating that adult escapement may have exceeded that estimate. Estimated adult escapement was 91.3% of the upper threshold of estimated adult carrying capacity. This proximity along with fully seeded juvenile rearing densities indicates that spawning gravel and summer rearing habitat (pool surface area) are currently functioning as co-limitations for coho production for the 2017 brood year.

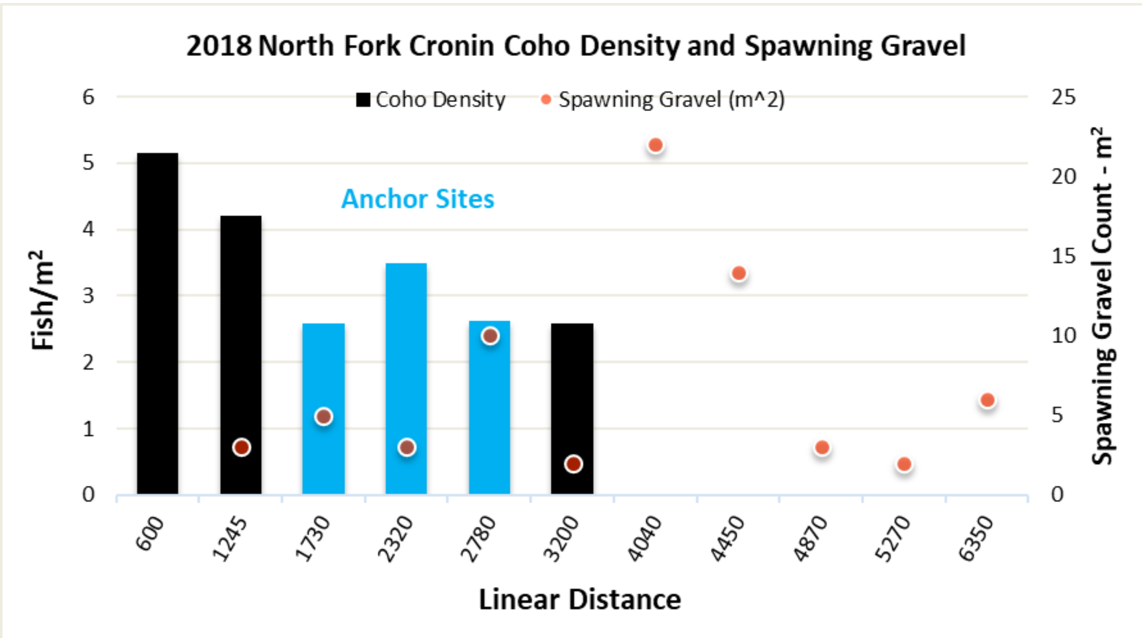

Figure 28: North Fork Cronin Coho Densities 2018

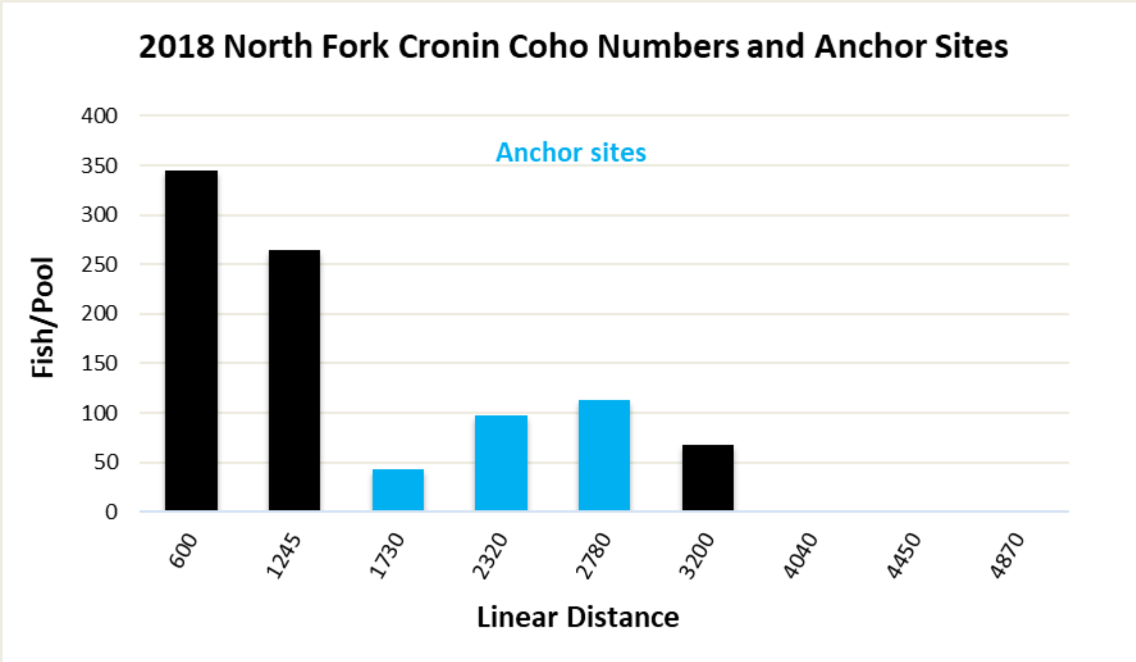

Figure 29: North Fork Cronin Coho Numbers 2018

Steelhead

Steelhead abundance was low with an average pool density of 0.06 fish/m² expanding to Steelhead were present at 117 fish/mile.

Cutthroat

Cutthroat abundance was low with an average density of 0.05 fish/m² expanding to 42 fish/mile. Cutthroat abundance increased above anadromous distribution but remained low.

0+ Trout

0+ trout abundance was moderate with an average density of 0.46 fish/m². The dominant density peak of 1.26 fish/m² was observed within anchor habitat at RM 0.32. Abundance expanded to 1,141 fish/mile within the range of anadromy and 133 fish/mile above anadromous distribution.

Chinook

Chinook were not observed.

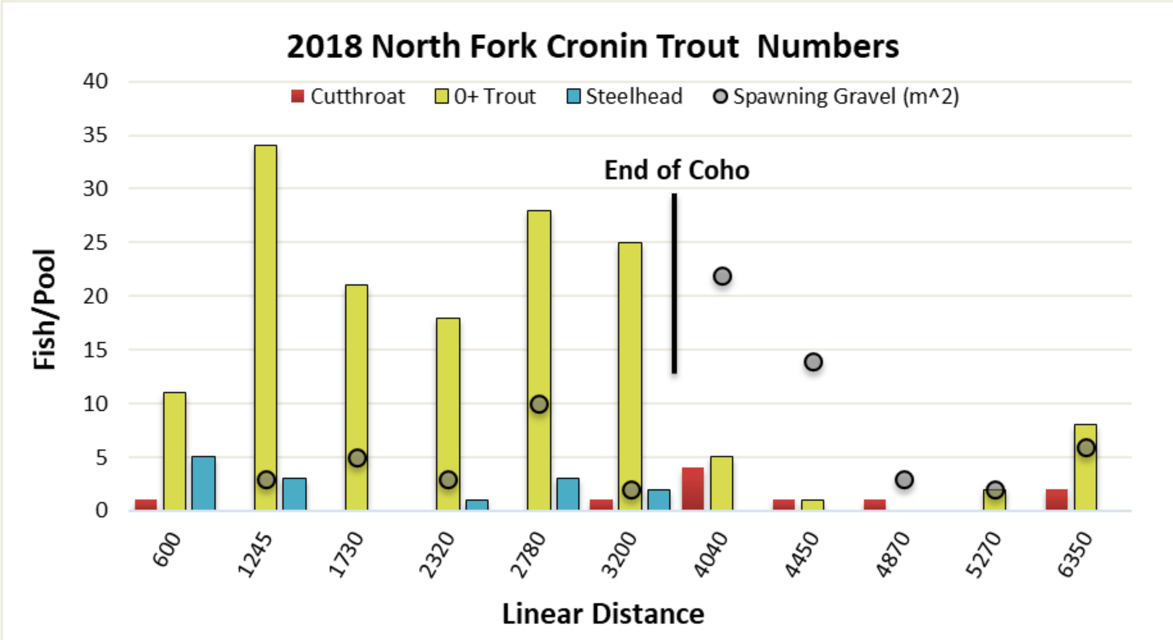

Figure 30: North Fork Cronin Trout Numbers 2018

Table 26: North Fork Cronin - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	4,644	3.44	765	70	50	0

South Fork Cronin

South Fork Cronin enters Cronin at RM 1.6. The RBA inventory extended 0.63 miles upstream where a 25ft bedrock falls terminates anadromous potential. Anadromous fish distribution extended 0.4 miles where gradient increase, confined canyon, and lack of spawning gravel limit further spawning and rearing potential.

Habitat was characterized by high gradient (avg. 7.5%); dominant substrates of bedrock, boulder, and cobble; channel braiding across narrow floodplain; Low summer temperature profiles (9.4C); and moderate large wood complexity.

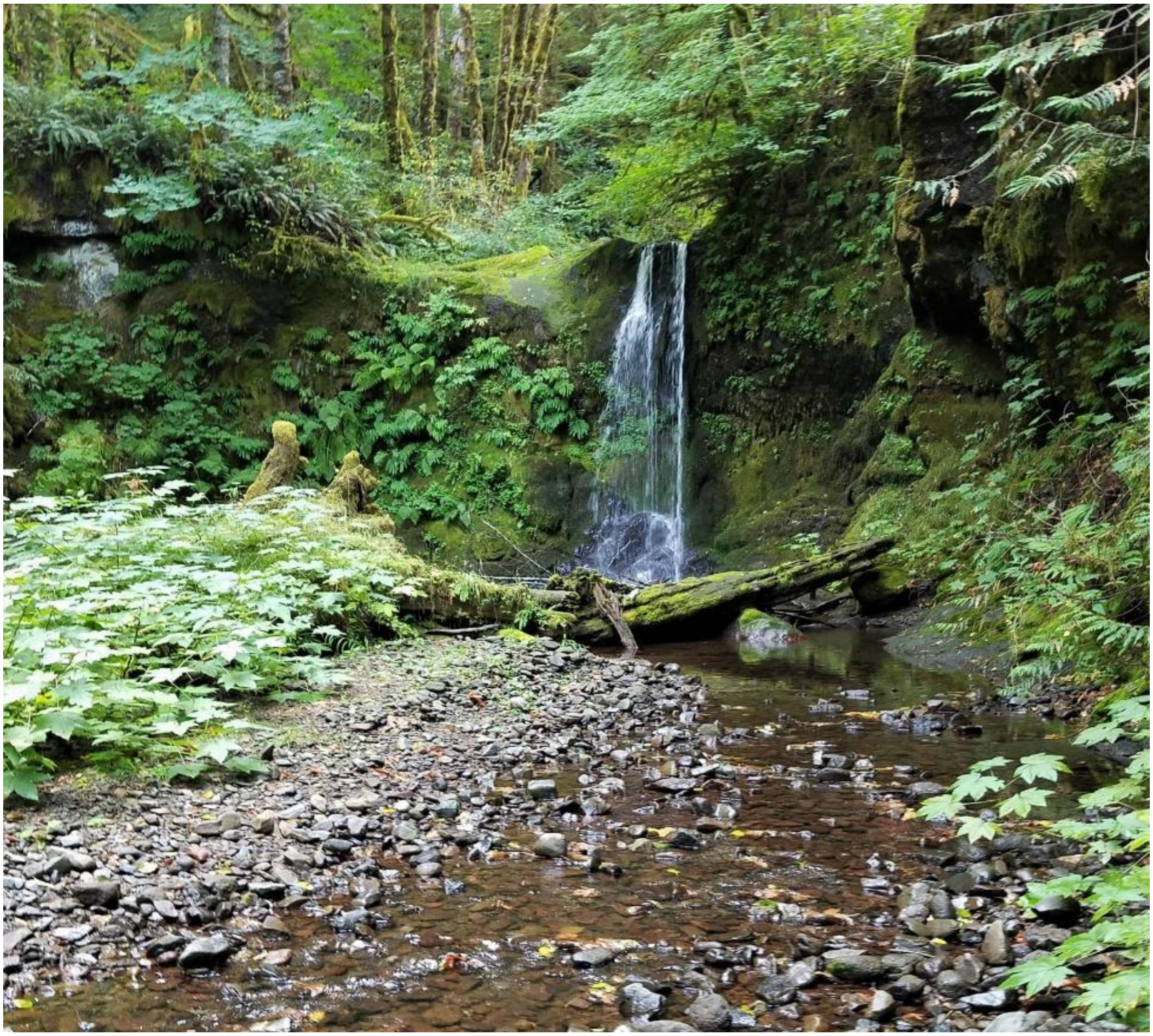

Photo 40 South Fork Cronin Falls

Coho

Coho abundance was moderate with an average pool density of 0.77 fish/m² expanding to 1,138 fish/mile. The dominant density peak of 2.1 fish/m² was observed at RM 0.35 in the uppermost sample pool with coho presence.

Spawning Gravel and Adult Escapement:

An estimated 4 adult (combined male and female) coho escaped into South Fork Cronin to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 12 – 36 coho.

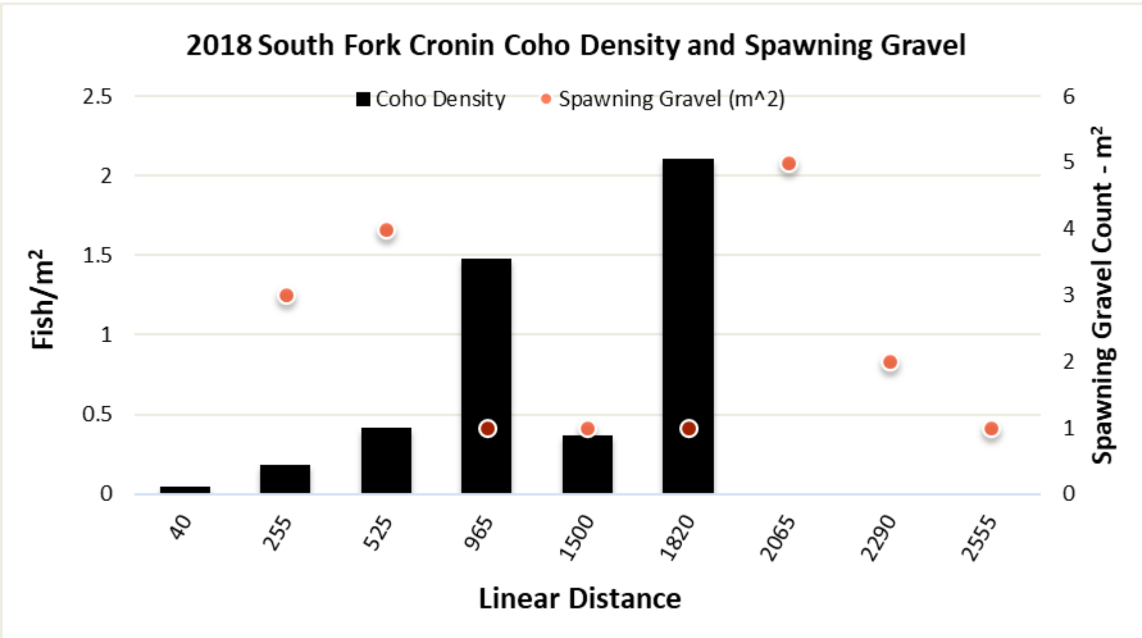

Figure 31: South Fork Cronin Coho Densities 2018

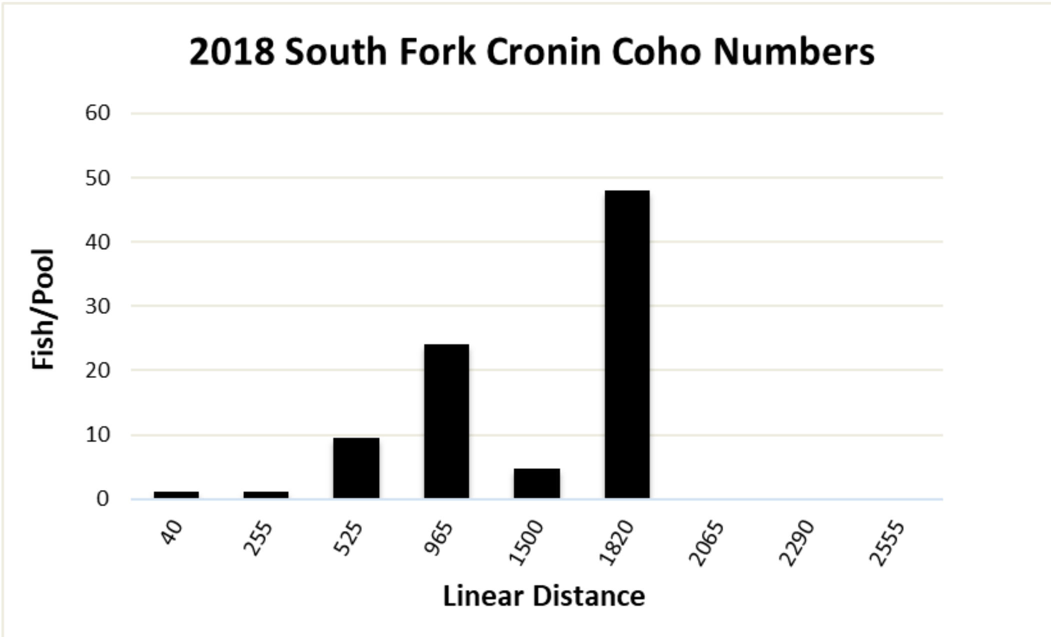

Figure 32: South Fork Cronin Coho Numbers 2018

Steelhead

Steelhead abundance was low with presence observed in only one dive pool.

Cutthroat

Cutthroat abundance was low with an average density of 0.13 fish/m² expanding to 95 fish/mile.

0+ Trout

0+ trout abundance was moderate with an average density of 0.65 fish/m² expanding to 968 fish/mile. The dominant density peak of 1.53 fish/m² was observed at RM 0.48.

0+ Trout

No chinook were observed.

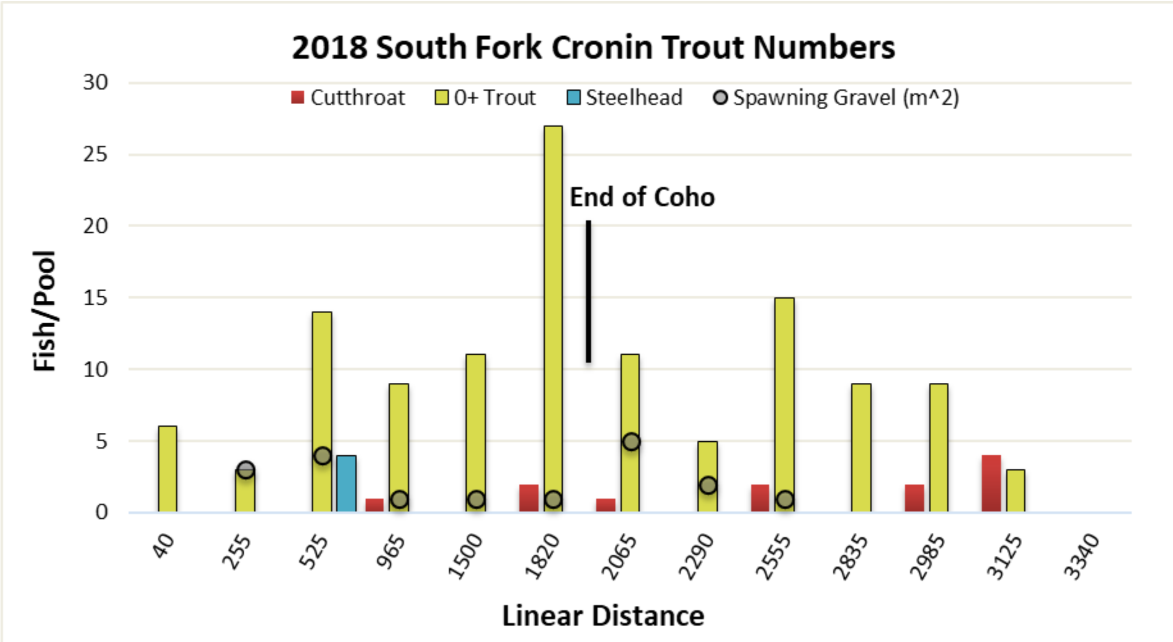

Figure 33: South Fork Cronin Trout Numbers 2018

Table 27: South Fork Cronin - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	444	0.77	610	20	60	0

Fall

Fall enters the Nehalem at RM 15.6. The RBA inventory extended 1.4 miles upstream where gradient increase and divided flows limited further anadromous spawning and rearing potential. Coho distribution extended 0.77 miles to a three-foot sill log functioning as a juvenile barrier. Steelhead distribution extended to RM 1.3. One tributary (Trib A) was included in the inventory.

Fall Creek was identified as an important thermal refugia and rated as a high priority for future restoration efforts. Temperatures documented at the time of the inventory recorded a 9.9C differential from the mainstem Nehalem (14.9C – 24.8C). High numbers of coho, cutthroat and chinook were observed in high densities congregating in the mainstem Nehalem at the confluence plume of Fall Creek. Of all the inventoried thermal refugia, this site was documented with the highest cutthroat and chinook count along with the second highest coho count. High numbers of largescale suckers were also observed. Basalt intrusions around the site provided some cover from predation and most importantly protection from temperature mixing with mainstem flows.

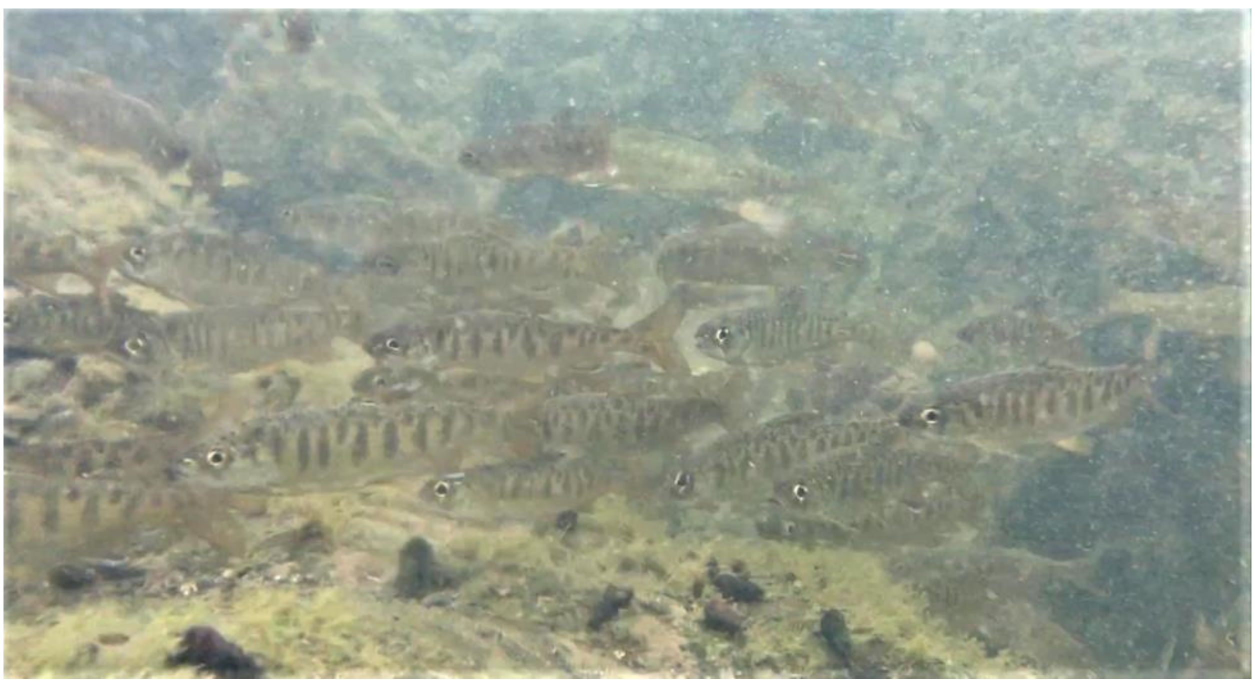

Photo 41 Coho in Fall Creek Confluence Plume

Photo 42 Cutthroat in Fall Creek Confluence Plume

A large log jam packed around a railroad trellis was observed just above the confluence functioning as a juvenile barrier to passage. Additionally, boulder dominated channel characteristics with shallow pool habitats limited the potential for rearing of temperature dependent migrants upstream of the confluence.

Photo 43 Fall Creek Above Log Jam

Habitat was characterized by moderate to high gradient (avg. 4.8%); lateral channel meander constrained by hillslope; low summer temperature profiles (14.9C); and dominant substrates of bedrock, cobble, and abundant sorted gravel (35 m^2).

Anchor Sites:

One short high functioning anchor site was documented in the upper end of the inventory above coho distribution. The highest quality habitat was not utilized by coho in 2018.

Coho

Coho abundance was low overall with a significant spike in abundance in the first pool evidence of upstream thermal migration. Upstream of the first pool coho were rearing at an average pool density of 0.3 fish/m^2 expanding to 265 fish/mile. The dominant density peak of 13.4 fish/m^2 was observed in the first pool. This was the second highest pool density observed throughout the 2018 and 2019 Nehalem basin inventories. This shallow grass covered pool was in a bedrock pocket located within the mainstem Nehalem floodplain with a shallow active channel maintaining connectivity.

Photo 44 Shallow Pool with High Coho Density

Spawning Gravel and Adult Escapement:

Subtracting the abundance observed in the first pool (likely the product of temperature dependent migration and not localized spawning) an estimated two adult (combined male and female) coho escaped into fall Creek to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 23 – 70 coho. As observed in many other Nehalem tributaries, Fall Cr is currently limited by inadequate adult escapement.

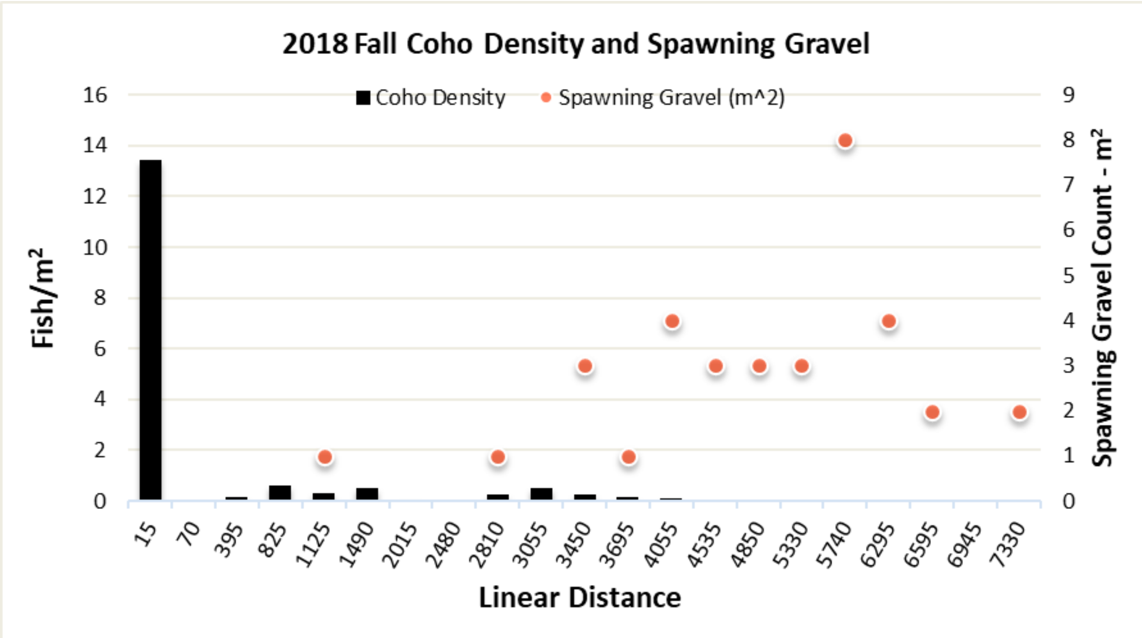

Figure 34: Fall Coho Densities 2018

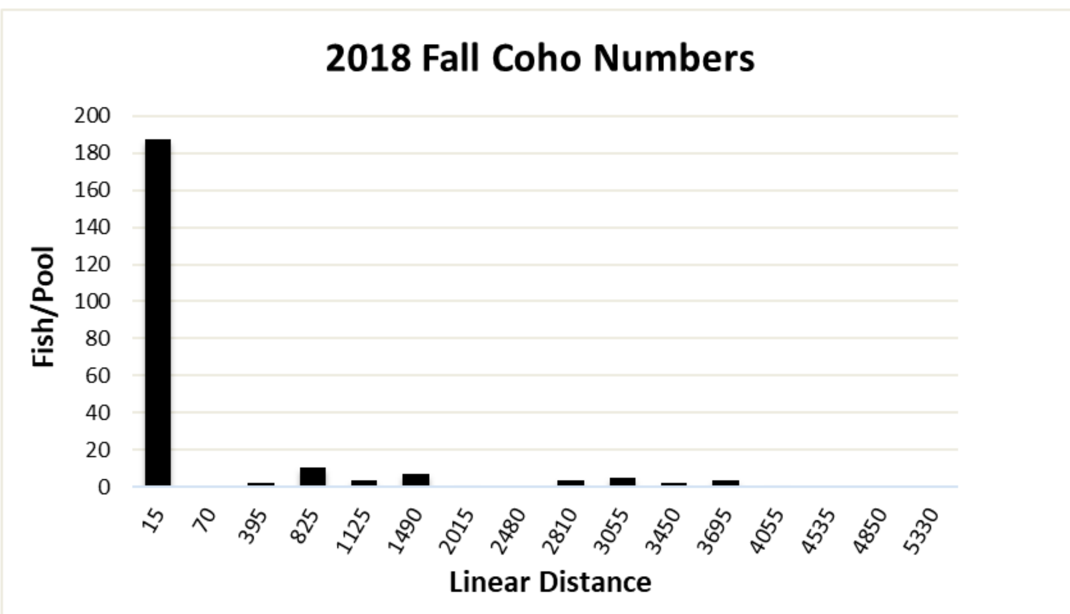

Figure 35: Fall Coho Numbers 2018

Steelhead

Steelhead abundance was low with only two pools observed with presence. Inventoried habitats exhibited high spawning and rearing potential.

Cutthroat

Cutthroat abundance was moderate with an average density of 0.2 fish/m² expanding to 118 fish/mile. The dominant density peak of 0.63 fish/m² was observed at RM 0.2.

0+ Trout

0+ trout abundance was low with an average density of 0.36 fish/m² expanding to 279 fish/mile. The dominant density peak of 1.12 fish/m² was observed at RM 0.58.

Chinook

Chinook were observed in only one pool.

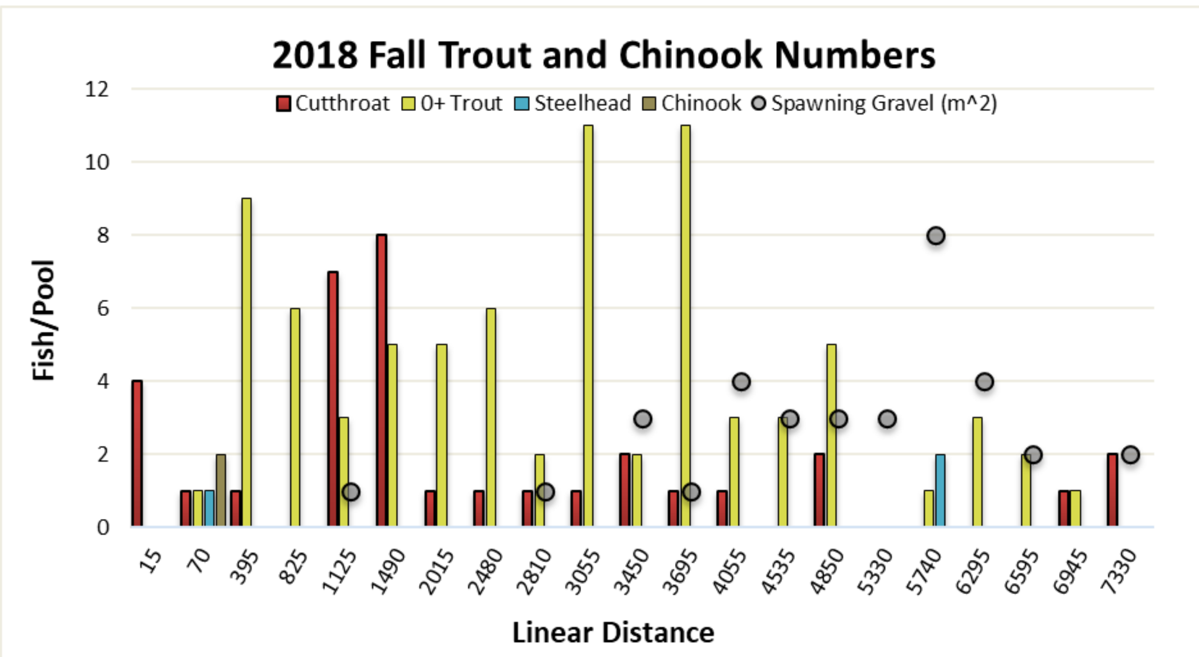

Figure 36: Fall Trout Numbers 2018

Table 28: Fall - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	397	1.48	505	11	295	2

Trib A

Trib A enters Fall Creek at RM 0.38. The inventory extended 0.34 miles. Coho distribution did not extend above the first pool. High gradient, shallow pools, and lack of spawning gravel limited further anadromous salmonid production.

Foley

Foley Creek enters the Nehalem on the upstream right bank within tidal influence at RM 7.5. The RBA inventory of the Foley subbasin contained 11.21 miles of stream habitat exhibiting anadromous potential. This included 7.9 miles of mainstem Foley, 0.96 miles of Crystal, 0.72 miles of Tributary A, 0.78 miles of Tributary B, and a total of 0.85 miles of three smaller tributaries (Dry, Trib C, and Trib D).

Foley Creek was identified as an important thermal refugia and rated as a high priority for future restoration efforts. Temperatures documented at the time of the inventory recorded a 4.7C differential from the mainstem Nehalem (15.5C – 20.2C). High numbers of cutthroat and chinook were observed congregating in the mainstem Nehalem at the confluence plume of Fall Creek. Lack of cover and complexity at the confluence limited the rearing capacity of the thermal refugia.

Photo 45 Foley Creek Confluence at Low Tide

The RBA inventory on mainstem Foley extended 7.9 miles upstream where canyon confinement, increase in gradient, and lack of spawning gravel limited further anadromous spawning and rearing potential. Coho distribution extended 7.53 miles to a tributary confluence dividing flows and a reach of back to back 3ft -5ft beaver dams (ephemeral barriers).

Photo 46 Abundant Spawning Gravel in Lower Foley Creek

Habitat was characterized by sinuous channel meander with wide floodplain and moderate channel incision; lack of large wood complexity; low gradient (avg. 0.87); dominant substrates of cobble, gravel, and sand with abundant gravel sorting in pool tailouts; low summer temperature profiles (13.9 - 16.2C); thin riparian corridor within the lower five mile reach of predominantly agricultural and residential land use; and well forested riparian in upper 2.9 mile reach of forest lands.

Photo 47 Complex Foley Creek Habitat

Photo 48 Upper Foley Creek LWD Treatment

Beaver occupation was high in the Foley Subbasin with 40 full spanning active dams. The highest pool counts for coho (160), 0+ trout (250), cutthroat (52), steelhead (30), and chinook (40) were all observed in an expansive 365ft long beaver pond in mainstem Foley at RM 0.77.

Anchor Sites:

Five Anchor Sites with varying levels of functionality were observed. Most exhibited a lack of large wood complexity and terrace heights on borderline of qualification (>3ft) due to channel incision. Anchor habitat comprised almost 50% of the inventoried reach.

Photo 49 Foley Creek Anchor Site #3

Spawning Gravel and Adult Coho Escapement for Entire Foley Subbasin:

An estimated 111 adult (combined male and female) coho escaped to the Foley subbasin to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 479 – 1,438 coho. The Foley subbasin was functioning well below its production potential for all inventoried species of salmonids.

Coho

Coho abundance was low with an average pool density of 0.24 fish/m² expanding to 985 fish/mile. The highest density of 1.2 fish/m² was observed at RM 7.27. Despite the low documented rearing densities, mainstem Foley was still a top producer contributing 12.7% of the total estimated coho population in the lower Nehalem while accounting for only 7.9% of the 2018 inventoried linear stream miles. The potential for ecosystem uplift is very large in Foley Cr.

Spawning Gravel and Adult Escapement for Foley Mainstem:

An estimated 59 adult (combined male and female) coho escaped to mainstem Foley to spawn. Abundant spawning gravel was observed throughout the inventory with an estimated 569m² documented. Estimated adult coho carrying capacity based on spawning gravel availability was 379 – 1,138 coho. These estimates suggest that a vast amount of spawning gravel was unutilized in the fall 2017/winter 2018 spawning season. Considering the abundance of anchor habitat, low average rearing densities and underutilization of spawning gravel, mainstem Foley was functioning well below production capacity for coho and other inventoried salmonids.

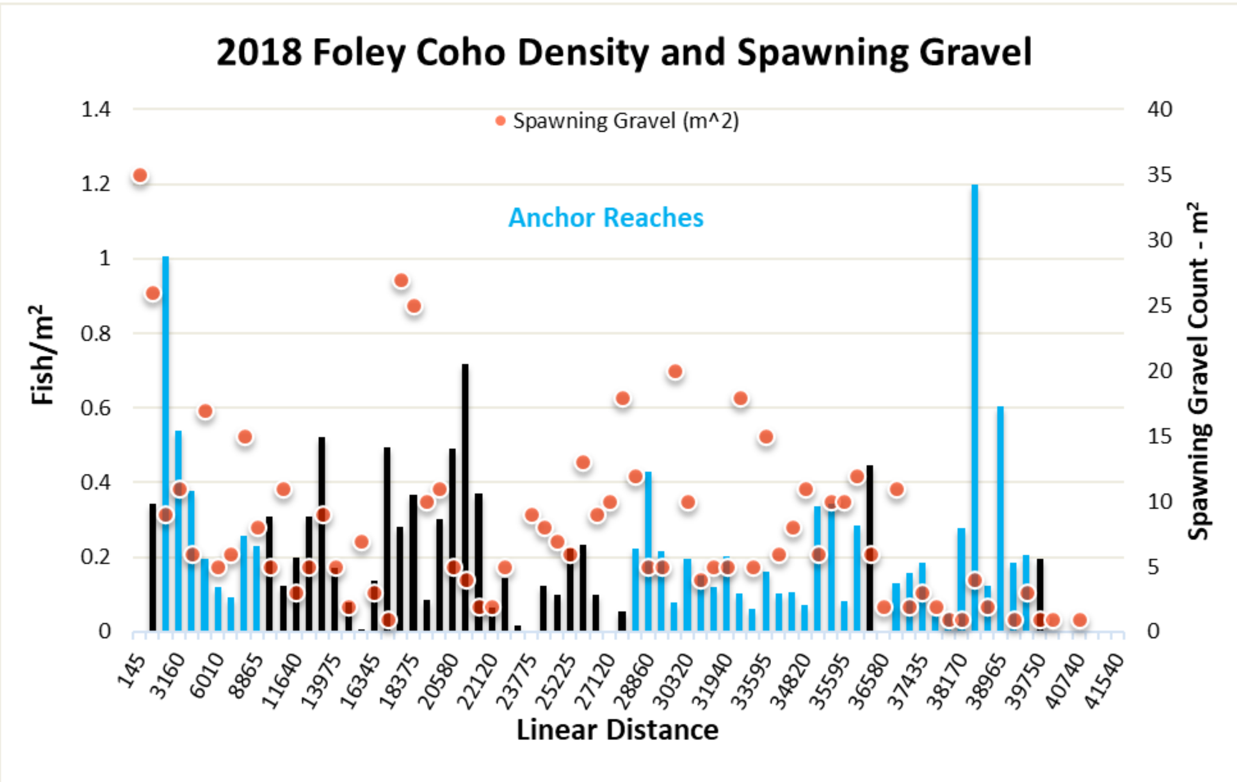

Figure 37: Foley Coho Densities 2018

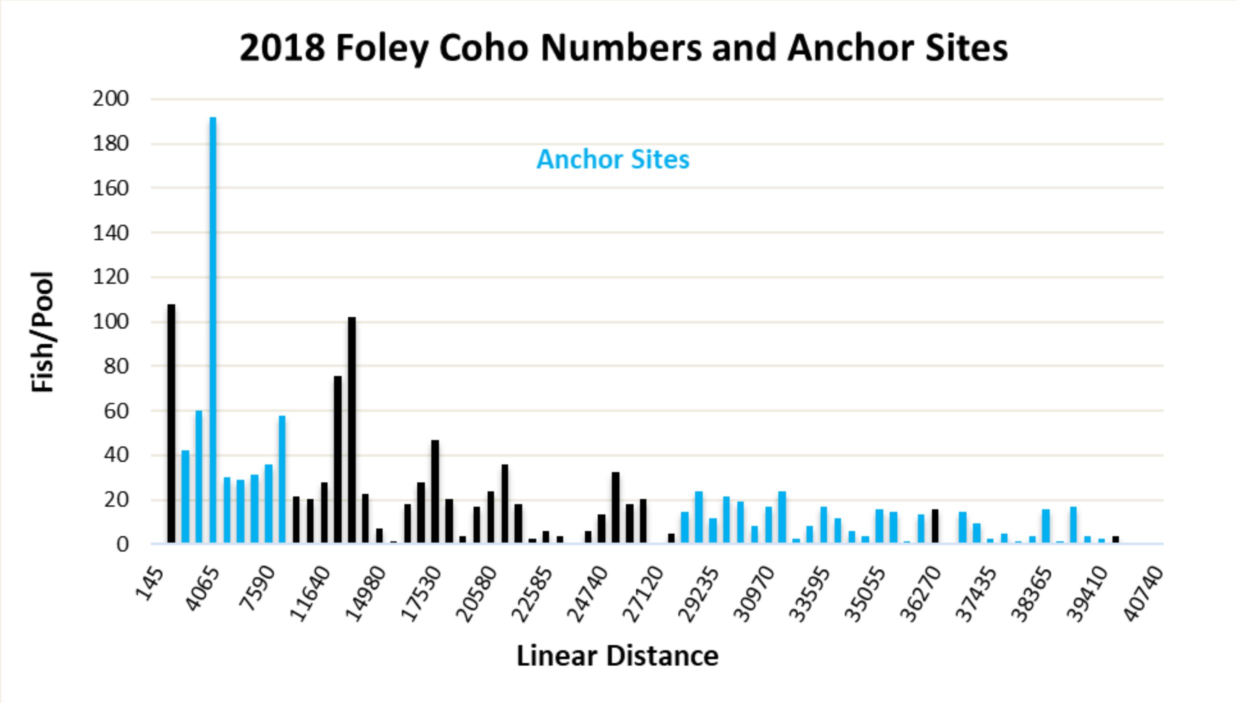

Figure 38: Foley Coho Numbers 2018

Steelhead

Steelhead abundance was low at an average pool density of 0.04 fish/m² with consistent presence up to RM 6.79. Steelhead pool presence expanded to 98 fish/mile. Steelhead abundance was highest in the lower 2.6 miles where pool presence expanded to 198 fish/mile. This reach accounted for 42% of the total abundance and comprised 33.5% of the inventoried linear stream miles.

Cutthroat

Cutthroat abundance was low with an average density of 0.05 fish/m² expanding to 164 fish/mile. Cutthroat abundance was highest in the lower 2.6 miles where pool presence expanded to 325 fish/mile. Densities were still well below full seeding capacities in this reach. Several large searun cutthroat were observed in the second sampled pool. Despite the low rearing densities observed, mainstem Foley contributed 18% of total cutthroat counts throughout the lower Nehalem while accounting for only 7.9% of the 2018 inventoried linear stream miles.

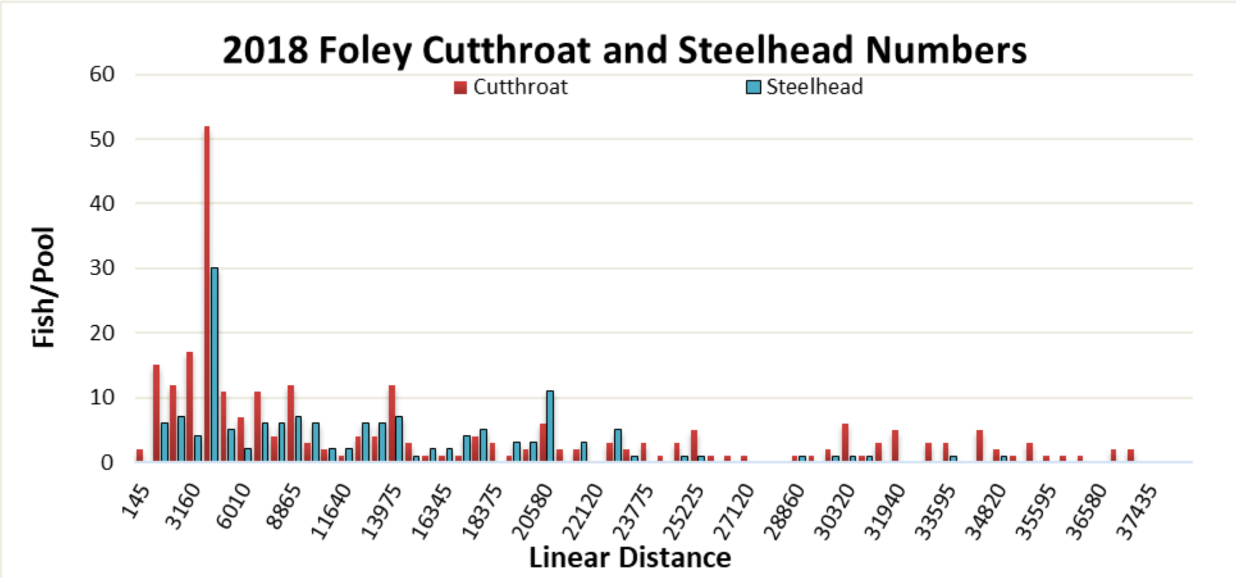

Figure 39: Foley Steelhead and Cutthroat Numbers 2018

0+ Trout

0+ trout abundance was low with an average density of 0.19 fish/m² expanding to 799 fish/mile. The highest density of 0.86 fish/m² was observed at RM 1.86. Abundance was highest in the lower 2.6 miles of the inventory. This reach accounted for 44.6% of the inventory total and comprised of 33.5% of the linear stream miles.

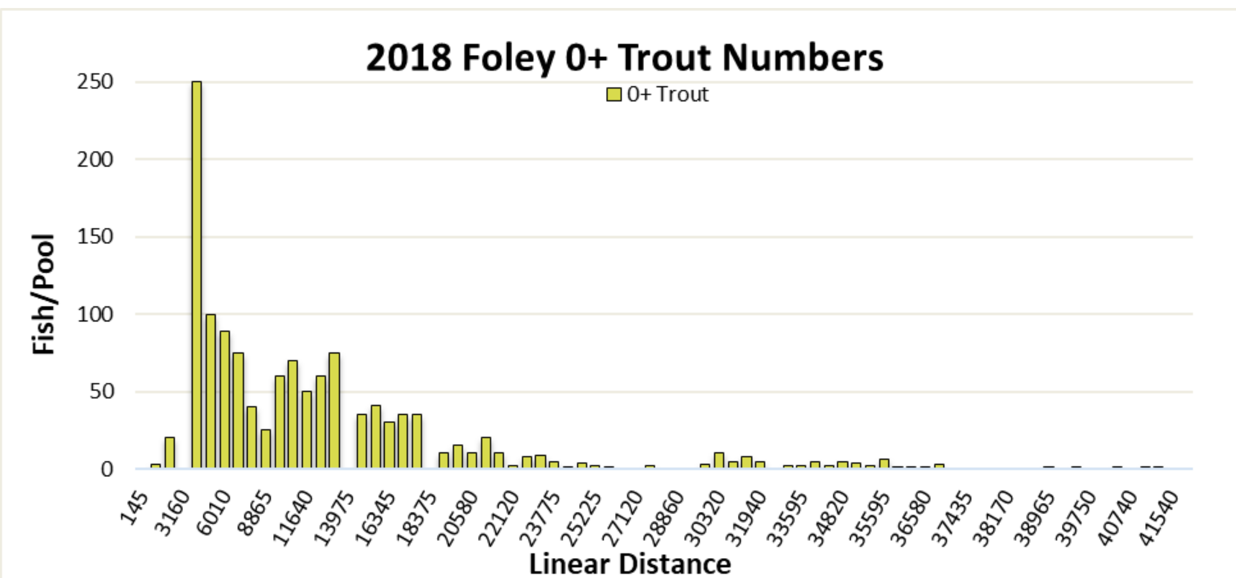

Figure 40: Foley 0+ Trout Numbers 2018

Chinook

Chinook were observed up to RM 2.2. Abundance was high expanding to 202 fish/mile. Mainstem Foley contributed 50.8% of chinook counts in the entire lower Nehalem while accounting for only 7.9% of the 2018 inventoried linear stream miles.

Table 29: Foley Mainstem - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	7,554	0.24	6,310	750	1295	500

Minor Tributaries of Foley Creek (Expanded Coho Counts of < 200)

The following tributaries of Foley Creek exhibited anadromous potential for only a short reach with low counts of juvenile Coho observed. Rather than including large sections for these streams, a condensed review is included below. See the Access database for additional information on these tributaries.

Dry

Enters Foley on upstream left bank at RM 4.1. Inventory extended 0.05 miles. Coho were observed in only the first pool. Lack of flow upstream limited salmonid rearing potential.

Trib C

Enters Foley on upstream left bank at RM 7. Inventory extended 0.44 miles. Trib C exhibited higher potential for coho occupation than was documented in abundance estimates. Low salmonid abundance was observed with coho observed in only two dive pools. Habitat was characterized by low gradient (avg. 1.5%); low flow; high tannins; shallow pools; and dominant substrates of gravel, sand, and silt with gravel sorting in pool tailouts (total of 26 sites).

Trib D

Enters Foley on the upstream left bank at RM 7.5. Inventory extended 0.36 miles. Low abundances of coho were observed in the first few dive pools. Coho distribution was likely the result of upstream juvenile migration from mainstem foley. Cobble dominated substrate with lack of sorted gravel limited coho spawning potential. High beaver occupation with several large (5ft – 8 ft) back to back dams were functioning as ephemeral barriers to passage above RM 0.2.

Crystal (Trib of Foley)

Crystal enters Foley on the upstream right bank in Anchor Site #1 at RM 0.47 The RBA inventory extended 0.97 miles upstream where a 15 ft log jam (ephemeral barrier) limited further anadromous spawning and rearing potential. Anadromous fish distribution extended to the log jam. Temperatures taken at time of inventory recorded Crystal at 16.5C, 1.1C warmer than mainstem Foley at 15.6C.

Habitat was characterized by moderate gradient (avg. 3.16%); sinuous channel meander, but largely confined by hillslope; high terrace heights due to channel incision; mixed deciduous and coniferous riparian; dominant substrates of cobble and gravel; low large wood complexity; and beaver occupation with three active dams.

Photo 50 Lower Crystal Creek

Anchor Sites:

One short Anchor Site was documented extending from RM 0.33 – 0.41. This site lacked adequate large wood complexity and sorted spawning gravel.

Coho

Coho abundance was low with an average pool density of 0.36 fish/m² expanding to 557 fish/mile. The highest density of 0.81 fish/m² was observed at RM 0.11.

Spawning Gravel and Escapement:

An estimated 5 adult (combined male and female) coho escaped to Crystal Creek to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 10 – 30 coho.

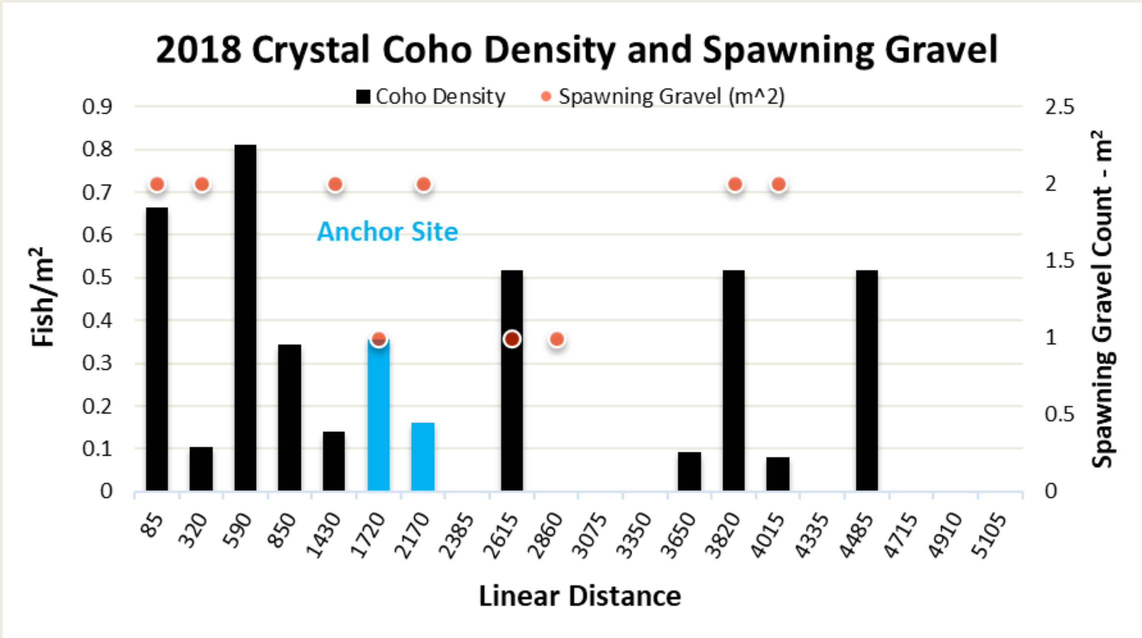

Figure 41: Crystal Coho Densities 2018

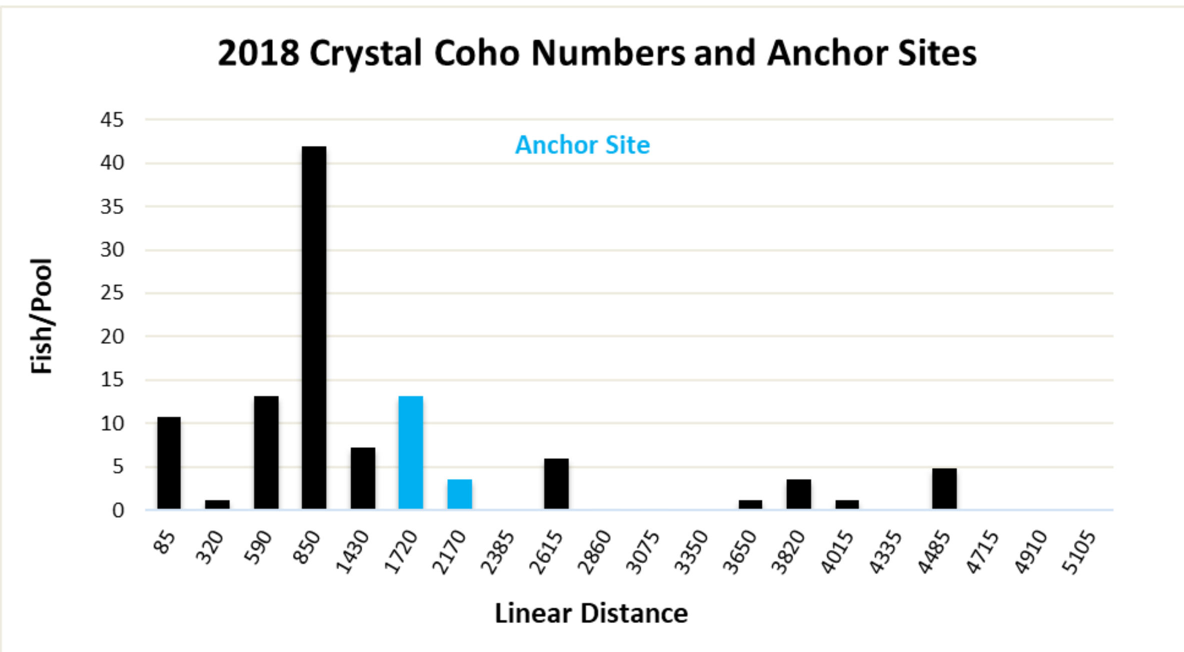

Figure 42: Crystal Coho Numbers 2018

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was low with an average density of 0.12 fish/m² expanding to 124 fish/mile. The highest density of 0.32 fish/m² was observed at RM 0.85.

0+ Trout

0+ trout abundance was low with an average density of 0.18 fish/m² expanding to 180 fish/mile. The highest density of 0.57 fish/m² was observed at RM 0.89.

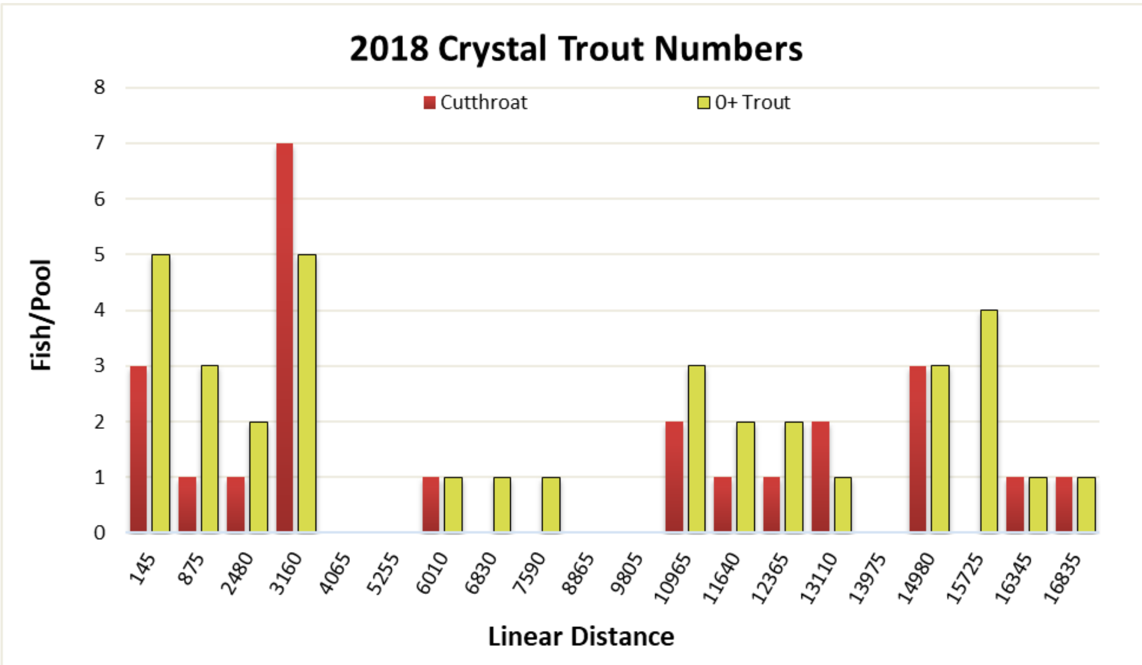

Figure 43: Crystal Creek Trout Numbers 2018

Chinook

Chinook were not observed

Table 30: Crystal Creek - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	540	0.36	175	0	120	0

Foley Tributary A

Trib A enters Foley on the upstream right bank in Anchor Site #3 at RM 5.47. The RBA inventory extended 0.72 miles upstream where low intermittent flows and simplified channel lacking spawning gravel limited further anadromous spawning and rearing potential. Coho distribution extended 0.7 miles with no barrier to passage observed.

Habitat was characterized by moderate gradient (avg. 3.3%); low flows; simplified channel; low large wood complexity; dominant substrates of cobble and gravel; low summer temperature profiles (15.2C); and deciduous riparian with thin buffers along clearcut.

Photo 51 Confluence Trib A with Foley Creek

Anchor Sites:

No Anchor Sites were observed

Coho

Coho abundance was moderate with an average pool density of 0.70 fish/m² expanding to 575 fish/mile. The highest density of 1.66 fish/m² was observed at RM 0.13

Spawning Gravel and Escapement:

An estimated 4 adult (combined male and female) coho escaped to Trib A to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 8 – 24 coho.

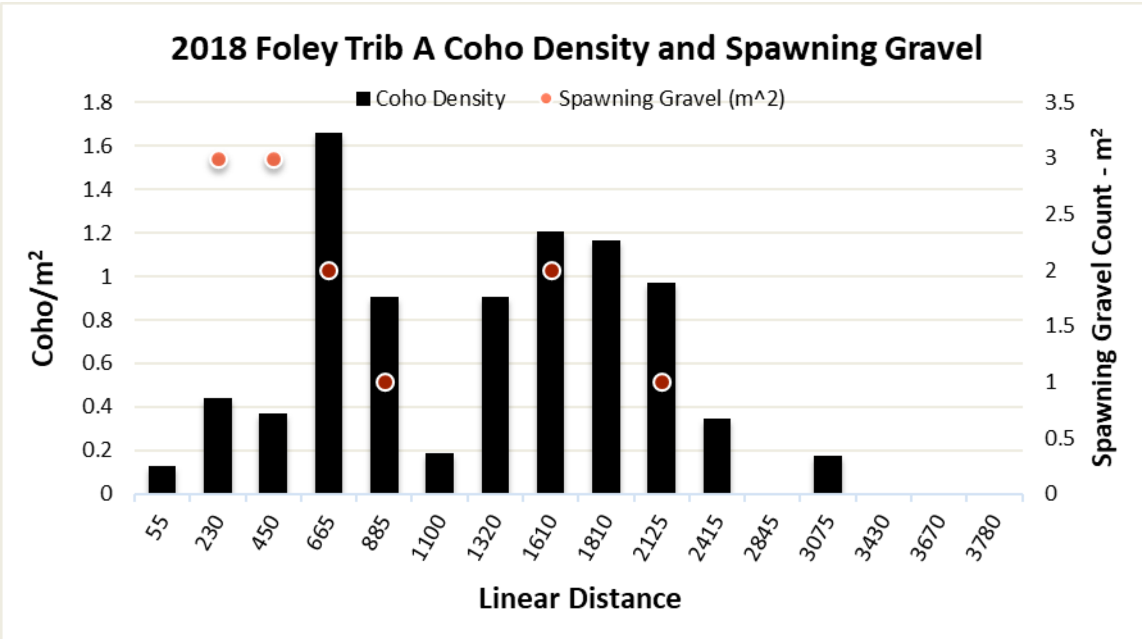

Figure 44: Foley Trib A Coho Densities 2018

Steelhead

Abundance was low with a single steelhead observed.

Cutthroat

Cutthroat abundance was low with an average density of 0.11 fish/m² expanding to 42 fish/mile. The highest density of 0.14 fish/m² was observed at RM 0.58.

0+ Trout

0+ trout abundance was low with an average density of 0.21 fish/m² expanding to 35 fish/mile. The highest density of 0.32 fish/m² was observed at RM 0.01.

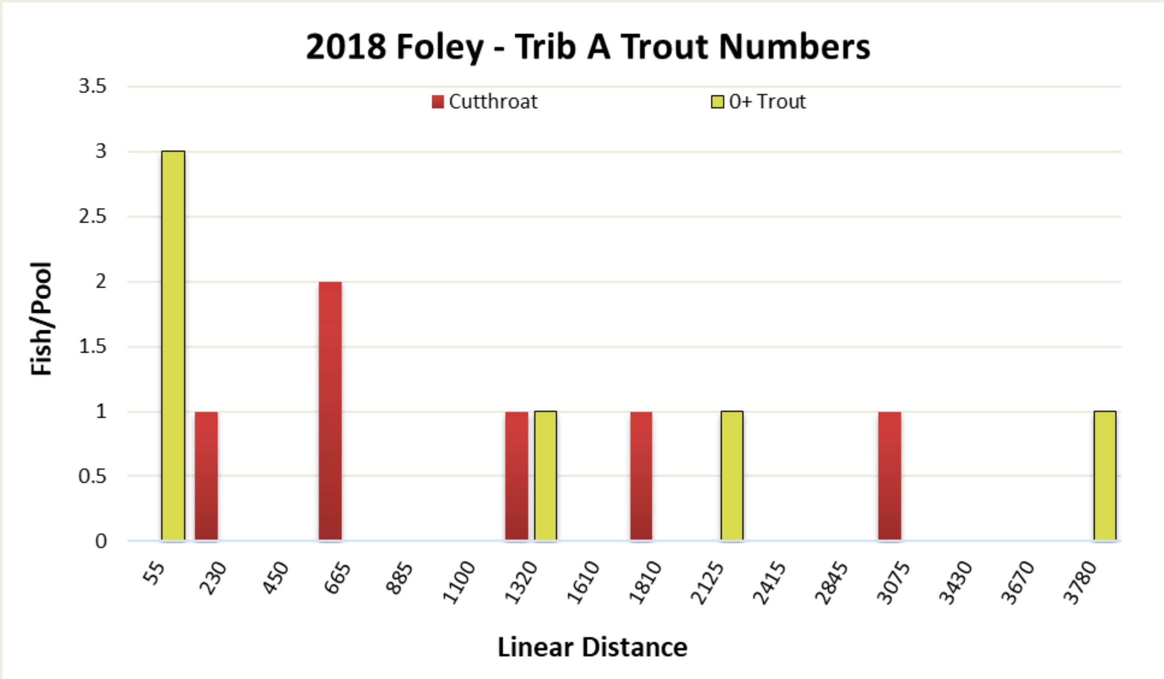

Figure 45: Foley Trib A Trout Numbers 2018

Chinook

Chinook were not observed

Table 31: Foley Trib A - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	414	0.70	25	5	30	0

Foley Tributary B

Foley Tributary B enters on the upstream right bank of Foley at RM 6.51 in Anchor Site #3. The RBA inventory extended 0.78 miles upstream where simplified channel with lack of spawning gravel and shallow pools limited further anadromous spawning and rearing potential. Anadromous fish distribution extended to RM 0.7 with no barrier to passage observed.

Habitat was characterized by moderate gradient (avg. 3.1%); sinuous channel meander; dominant substrates of cobble and gravel; low large wood complexity; and thin riparian buffers along clearcuts.

Anchor Sites:

One anchor site was documented extending 0.33 miles upstream from the confluence with mainstem Foley to just above the confluence of Trib B1. A lack of large wood complexity and sorted gravel was observed.

Coho

Coho abundance was low with an average pool density of 0.35 fish/m² expanding to 420 fish/mile. The highest density of 0.86 fish/m² was observed at RM 0.45.

Spawning Gravel and Escapement:

An estimated 3 adult (combined male and female) coho escaped to Trib B to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 11 – 33 coho.

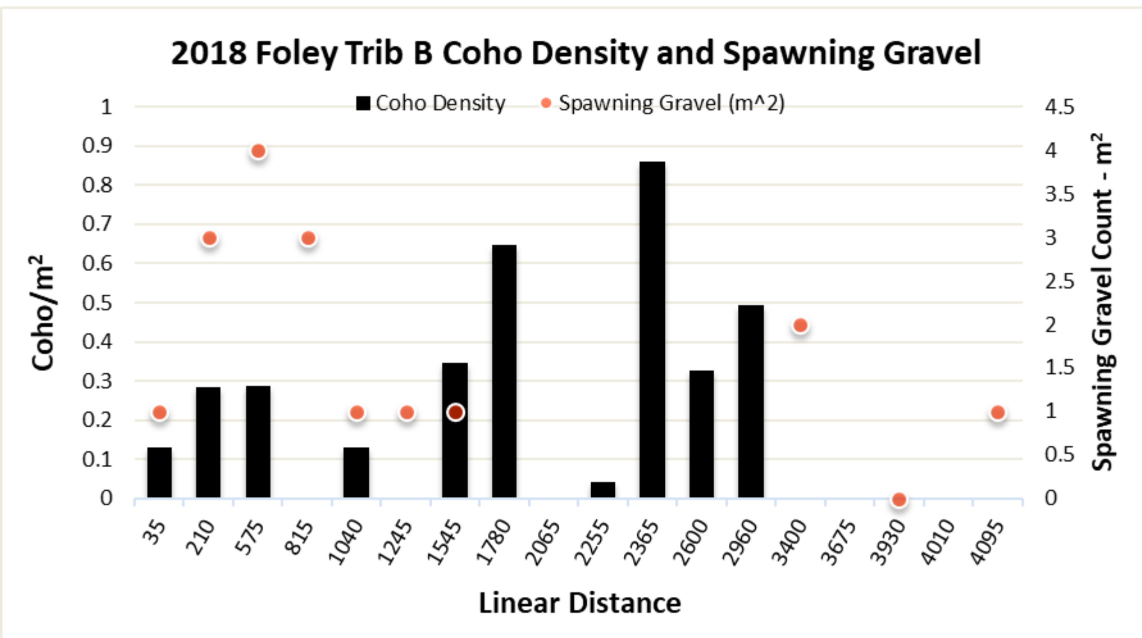

Figure 46: Foley Trib B Densities 2018

Steelhead

No steelhead were observed.

Cutthroat

Cutthroat abundance was low with an average density of 0.13 fish/m² expanding to 115 fish/mile.

0+ Trout

0+ trout abundance was low with an average density of 0.16 fish/m² expanding to 45 fish/mile.

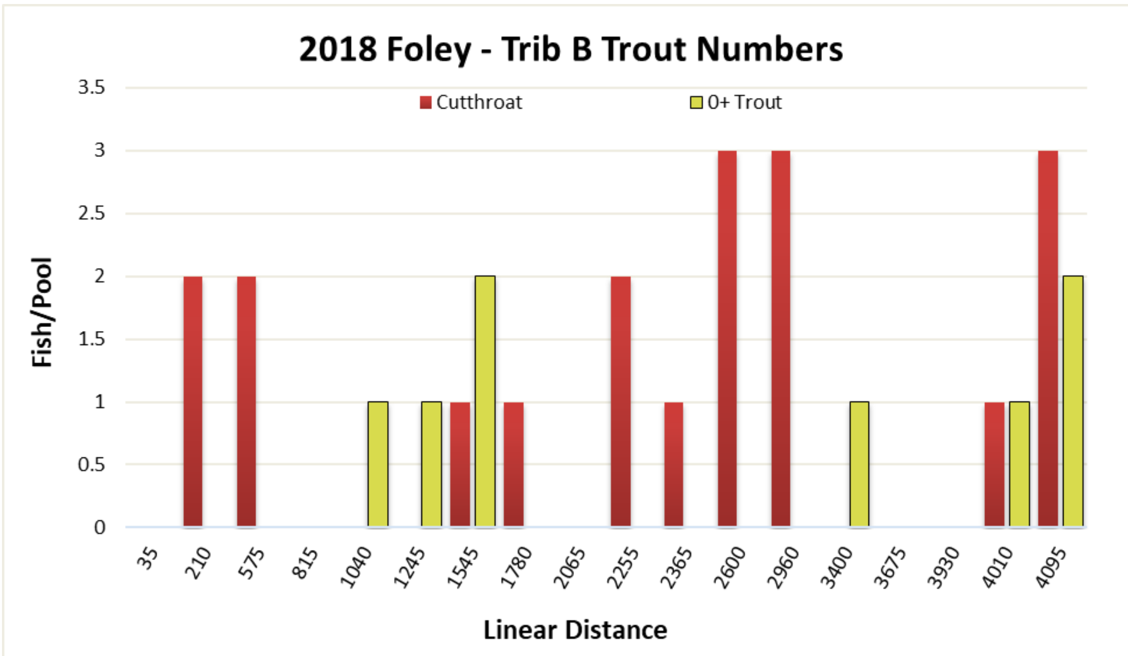

Figure 47: Foley Tributary B Trout Numbers 2018

Chinook

No Chinook were observed

Table 32: Foley Tributary B - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	294	0.35	35	0	90	0

Trib B1

Inventory extended 0.34 miles. Anchor site extends between Trib B and B1 for a few hundred feet. Low abundances of coho observed were likely the result of upstream juvenile migration. Lack of adequate spawning gravel limited coho production.

East Fork Foley

East Fork Foley enters Foley on the upstream left bank at RM 1.29 in Anchor Site #2. The RBA inventory extended 2.83 miles upstream where increased gradient, divided flows above tributary confluence, and simplified channel with lack of spawning gravel limited further anadromous spawning and rearing potential. Anadromous fish distribution extended to a tributary confluence at RM 2.8. No barriers to adult passage were observed.

East Foley was the most productive tributary in the Foley subbasin for all inventoried salmonids. On a basin scale East Foley accounted for 3.6% of the total inventoried linear stream miles in the entire lower Nehalem (2018) while contributing total abundance percentages of: coho 5%, 0+ trout 4.8%, steelhead 7.3%, and cutthroat 10.4%.

Photo 52 East Foley Confluence Trib A

Habitat was characterized by low gradient (avg. 2.37%); sinuous channel meander with braiding across a wide floodplain with low terrace heights throughout the lower 1.5 miles, hillslope confined in upper 1.3 miles; dominant substrates of small boulder, cobble, and gravel; moderate wood complexity of predominantly deciduous origin; well forested riparian of mixed deciduous and conifer; and low summer temperature profiles (13.9C – 14.2C). Beaver occupation with three active full spanning dams was observed in a low gradient flat just above the confluence with mainstem Foley.

Photo 53 East Foley Beaver Dam

Anchor Sites:

One large high functioning anchor site was observed extending from RM 0.59 to RM 1.44. Wood complexity throughout this site was comprised almost exclusively of deciduous material. Side Channel A entered within the anchor site and consisted of four pools lacking connectivity at upstream and downstream ends. A total of 70 coho were observed rearing in the side channel.

Photo 54 East Foley Anchor Site #1

Coho

Coho abundance was moderate with an average pool density of 0.61 fish/m² expanding to 1047 fish/mile. The highest density of 1.16 fish/m² was observed at RM 2.38

Spawning Gravel and Adult Escapement:

An estimated 28 adult (combined male and female) coho escaped into East Foley to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 51 – 154 coho. Considering the extended reach of high functioning anchor habitat, low average rearing densities, and underutilization of available spawning gravel East Foley was functioning well below production capacity for coho and other inventoried salmonids.

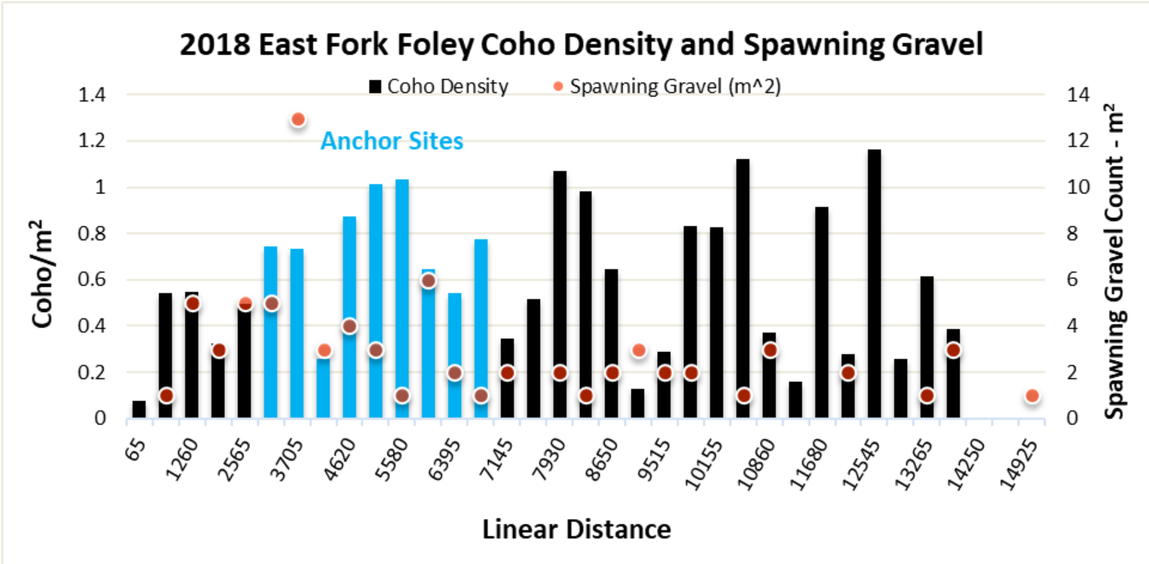

Figure 48: East Fork Foley Creek Coho Densities 2018

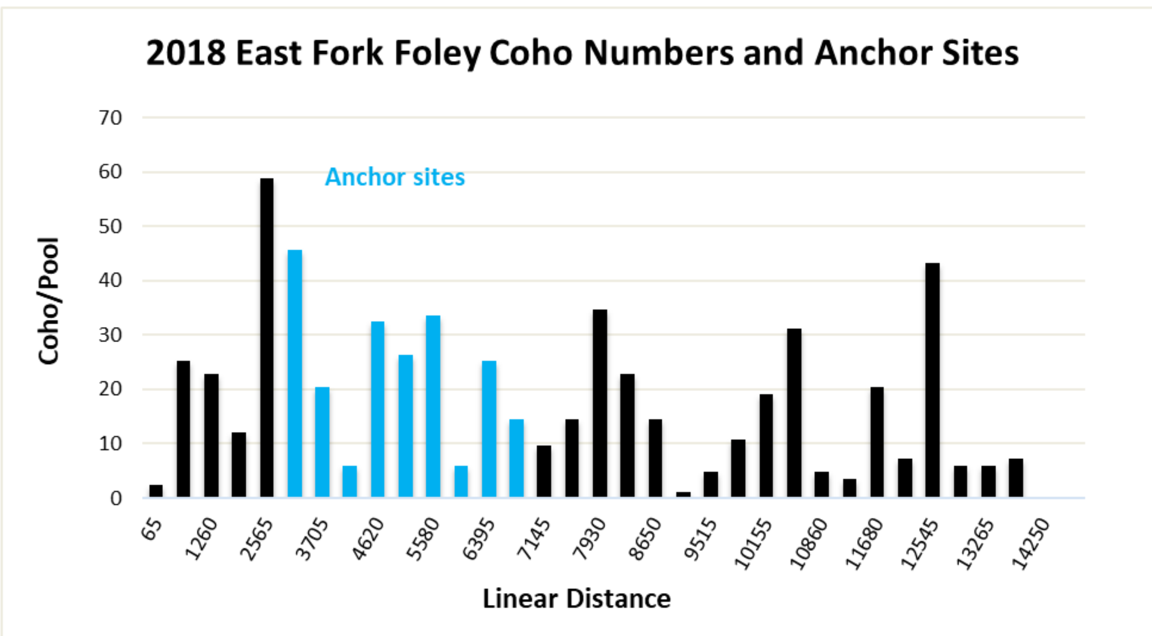

Figure 49: East Fork Foley Creek Coho Numbers 2018

Steelhead

Steelhead abundance was moderate at an average pool density of 0.13 fish/m expanding to 165 fish/mile. The highest density of 0.30 fish/m² was observed at RM 2.38.

Cutthroat

Cutthroat abundance was moderate with an average density of 0.19 fish/m² expanding to 265 fish/mile. The highest density of 0.54 fish/m² was observed at RM 1.29.

0+ Trout

0+ trout abundance was moderate with an average density of 0.68 fish/m² expanding to 1225 fish/mile. The highest density of 1.29 fish/m² was observed at RM 0.79 in Anchor Site #1.

Chinook

Two Chinook were observed in one sampled pool.

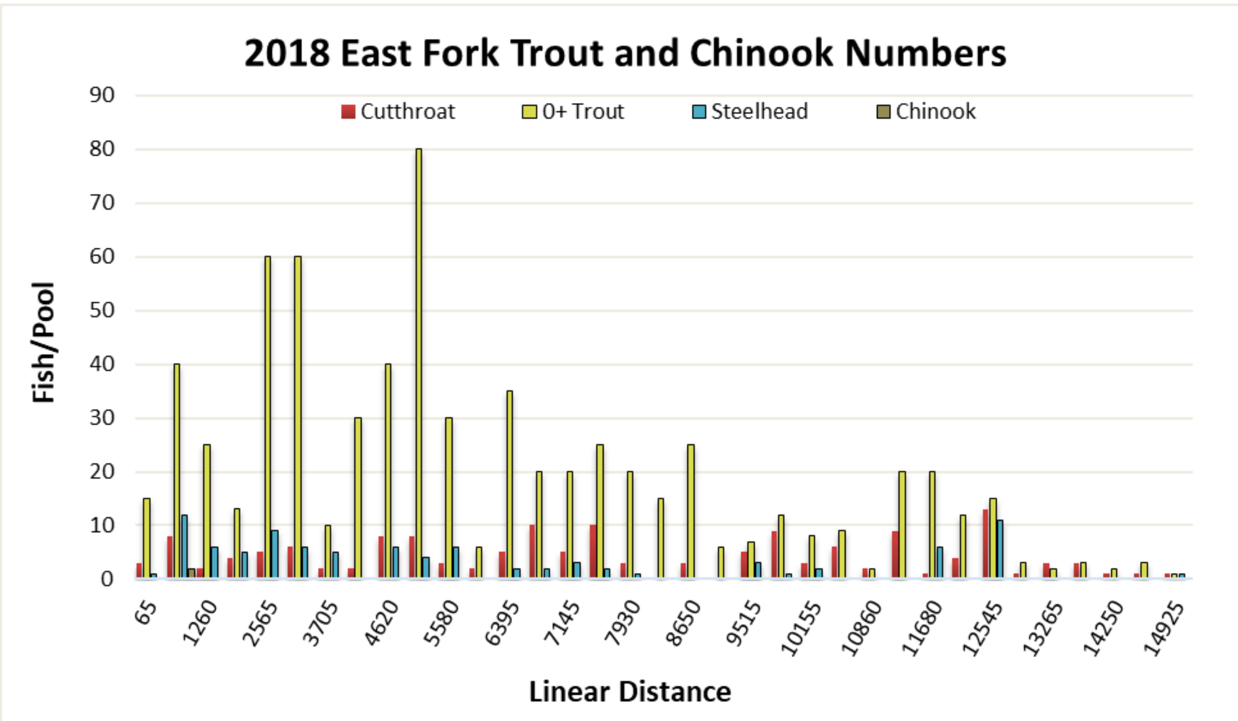

Figure 50: East Fork Foley Creek Trout and Chinook Numbers 2018

Table 33: East Fork Foley Creek - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m²	0+ Trout	Steelhead	Cutthroat	Chinook
2018	2964	0.61	3466	466	751	10

Trib A (East Fork Foley)

Trib A enters East Fork Foley on the upstream right bank at RM 2.29 with a braided confluence across a low terrace. The RBA inventory extended 0.72 miles upstream where increase in gradient, divided flows, and lack of spawning gravel limited further anadromous spawning and rearing potential. Anadromous fish distribution extended to the end of the survey.

Habitat was characterized by lateral channel migration confined by hillslope; high gradient (avg. 8.5%); low flows with isolated pools in reaches of subsurface flow; and lack of spawning gravel with dominant substrates of boulder and cobble. The highest quality habitats were observed in the lower 0.15 miles where braiding across the shared terrace with East Foley could provide off channel refugia from high winter flows.

Photo 55 Upper Trib A (East Foley)

Anchor Sites:

No Anchor Sites were observed

Coho

Coho abundance was low with an average pool density of 1.26 fish/m² expanding to 504 fish/mile. The highest density of 3.44 fish/m² was observed at RM 0.16. Distribution profiles suggest that most of the abundance was the result of upstream juvenile migration from East Foley. Any spawning events that occurred in Trib A likely exhibited low egg to fry survival.

Spawning Gravel and Escapement:

An estimated 3 adult (combined male and female) coho escaped into East Foley Tributary A to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 1 – 4 coho.

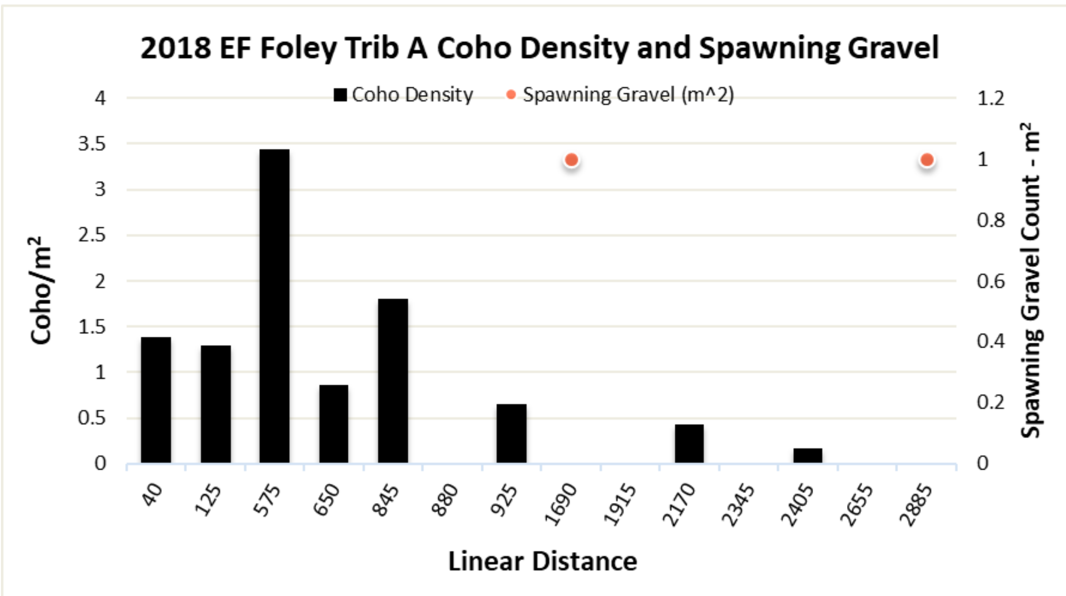

Figure 51: Trib A (East Fork Foley) Coho Densities 2018

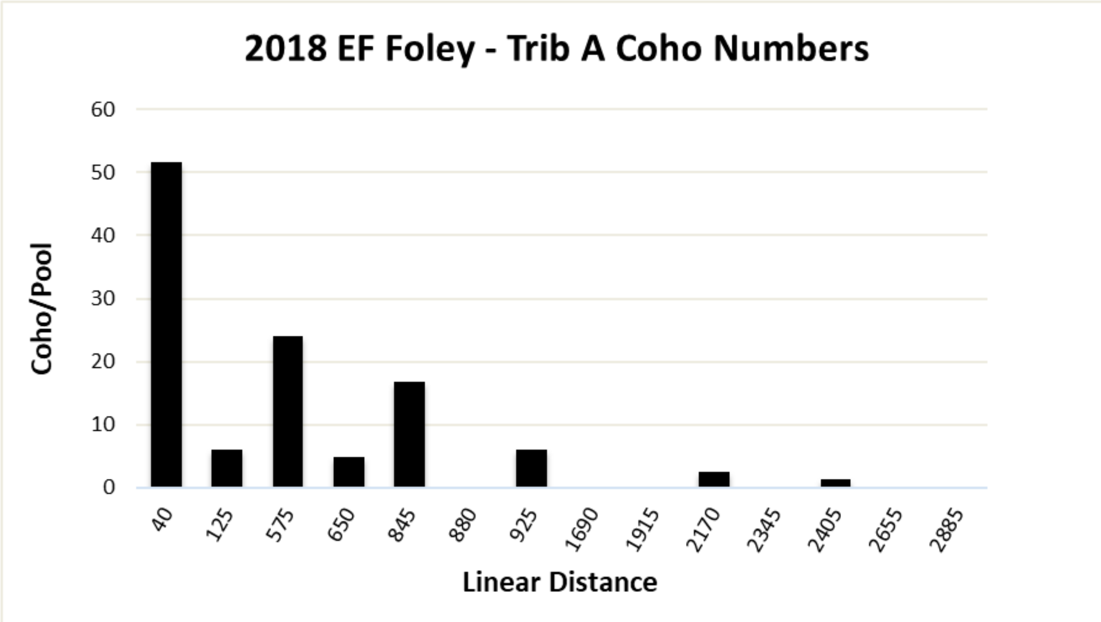

Figure 52: Trib A (East Fork Foley) Coho Numbers 2018

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was high with an average density of 0.42 fish/m² expanding to 136 fish/mile. The highest density of 1.26 fish/m² was observed at RM 0.12. Reduction in riffle and rapid habitats due to subsurface flows likely concentrated abundance in pools.

0+ Trout

0+ trout abundance was moderate with an average density of 0.94 fish/m² expanding to 409 fish/mile. The highest density of 2.15 fish/m² was observed at RM 0.12.

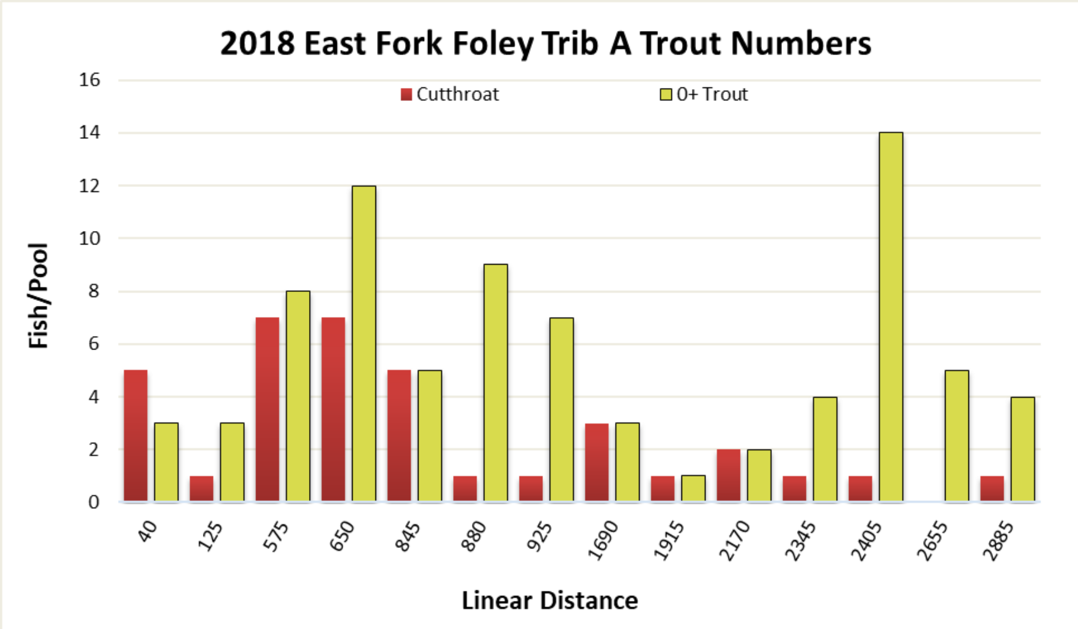

Figure 53: Trib A (East Fork Foley) Trout Numbers 2018

Chinook

Chinook were not observed

Table 34: Trib A (East Fork Foley) - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	277	1.26	225	0	75	0

George

George enters the Nehalem at RM 33.1. The RBA inventory extended 0.47miles upstream where an 8ft bedrock falls limited further anadromous spawning and rearing potential. Coho distribution extended 0.35 miles where successive beaver dams built on bedrock were functioning as a juvenile barrier to passage.

George Creek was identified as an important thermal refugia. Temperatures documented at the time of the inventory recorded a 7.2C differential from the mainstem Nehalem (15.8C - 23C). High numbers of coho, cutthroat and chinook were observed congregating in the mainstem Nehalem at the confluence plume. Simplified stream habitat above the mainstem confluence limited rearing potential for temperature dependent migrants. No evidence of upstream thermal migration was observed.

Photo 56 George Creek Confluence at Lower Left with Nehalem Mainstem

Habitat was characterized by bedrock dominated channel with cobble and unsorted gravel; low summer temperature profiles (13.5C – 15.8C); simplified channel confined by hillslope; moderate large wood complexity concentrated in a few log jams; moderate to high gradient (avg. 5%). Beaver occupation was documented with four active full spanning dams.

Photo 57 George Creek

Anchor Sites:

No Anchor Sites were observed

Coho

Coho abundance was moderate with an average pool density of 1.2 fish/m² expanding to 1,661 fish/mile. The dominant density peak of 3.7 fish/m² was observed at RM 0.3

Spawning Gravel and Adult Escapement:

An estimated seven adult (combined male and female) coho escaped to George Creek to spawn, exceeding the modeled adult carrying capacity estimate. Estimated adult coho carrying capacity based on spawning gravel availability was a maximum of two coho. Lack of high-quality spawning gravel appeared to have functioned as the primary limiting factor for coho production.

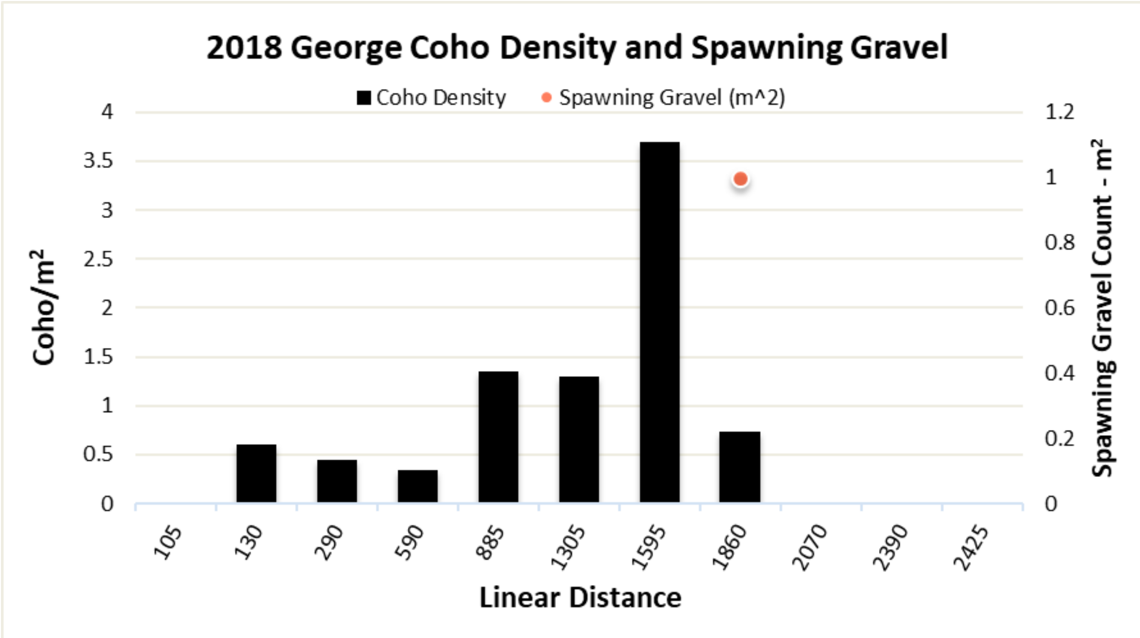

Figure 54: George Coho Densities 2018

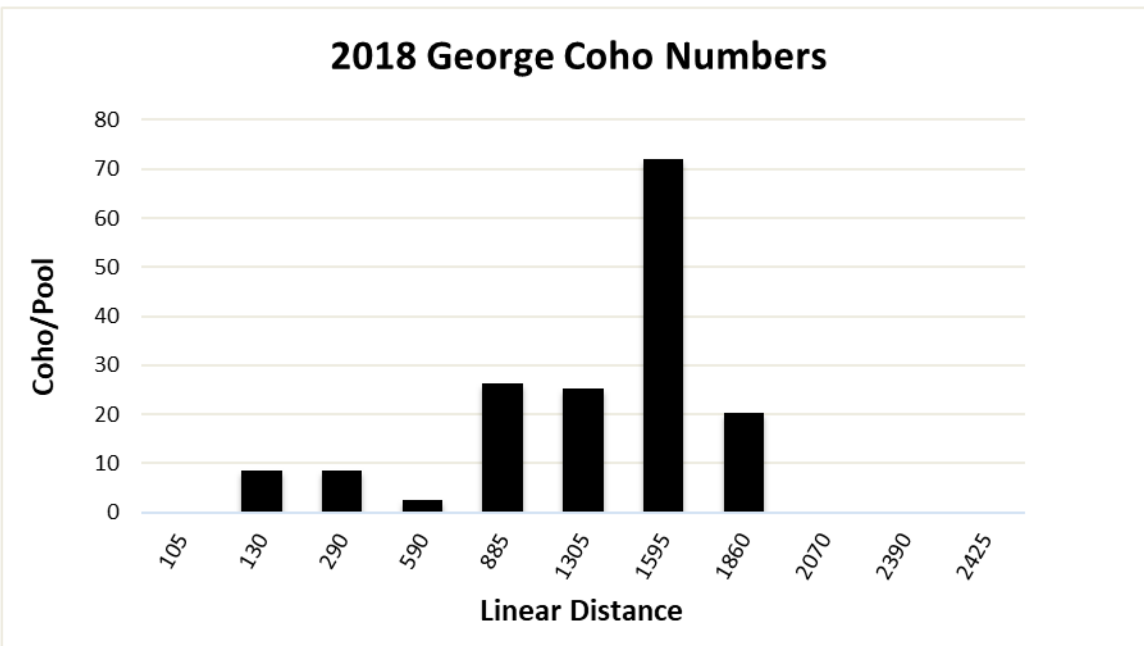

Figure 55: George Coho Numbers 2018

Steelhead

Steelhead were documented in only one pool. Lack of suitable spawning gravel likely limited steelhead production.

Cutthroat

Cutthroat abundance was low with an average density of 0.14 fish/m² expanding to 120 fish/mile. The dominant density peak of 0.29 fish/m² was observed in a beaver dammed pool.

0+ Trout

0+ trout abundance was low with an average density of 0.18 fish/m² expanding to 340 fish/mile.

Chinook

Chinook were not observed.

Table 35: George - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	781	1.2	170	15	60	0

Helloff

Helloff enters the Nehalem at RM 18.4 The RBA inventory extended 1.76 miles upstream where increased gradient and lack of spawning gravel limited further anadromous spawning and rearing potential. Coho distribution extended 1.7 miles.

Helloff Creek was identified as an important thermal refugia and rated as a high priority for future restoration efforts. Temperatures documented at the time of the inventory recorded a 6.8C differential from the mainstem Nehalem (16.4C – 23.2C). High numbers of coho, cutthroat and chinook were observed congregating in high densities in the mainstem Nehalem at the confluence plume. Shallow mostly subsurface flows through deep gravel and cobble depositions at the confluence limited access to temperature dependent migrations. No evidence of upstream thermal migration was observed.

Photo 58 Helloff Creek Confluence with Nehalem

Photo 59 Coho and Chinook in Helloff Confluence Plume

Stream habitat was characterized by moderate gradient (avg. 5.1%); lateral channel migration confined by hillslope; scoured bedrock, boulder, cobble, and gravel accumulations; long straight riffles and shallow pools; overall low wood complexity with a few full spanning log jams; and low summer temperature profiles (14.9C – 16.4C).

Photo 60 Helloff Creek

Anchor Sites:

No Anchor Sites were observed

Coho

Coho abundance was moderate with an average pool density of 1.07 fish/m² expanding to 1,726 fish/mile. The dominant density peak of 4.35 fish/m² was observed at RM 0.6.

Spawning Gravel and Escapement:

An estimated 28 adult (combined male and female) coho escaped to Helloff Creek to spawn. Estimated adult coho capacity based on spawning gravel availability was 17 - 50 coho.

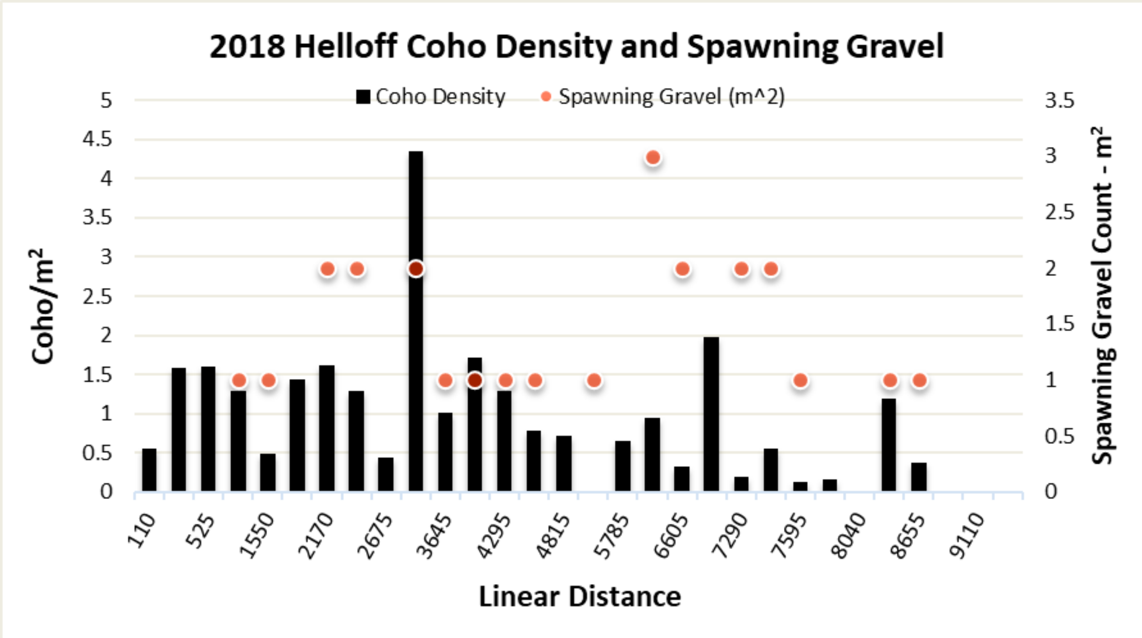

Figure 56: Helloff Coho Densities 2018

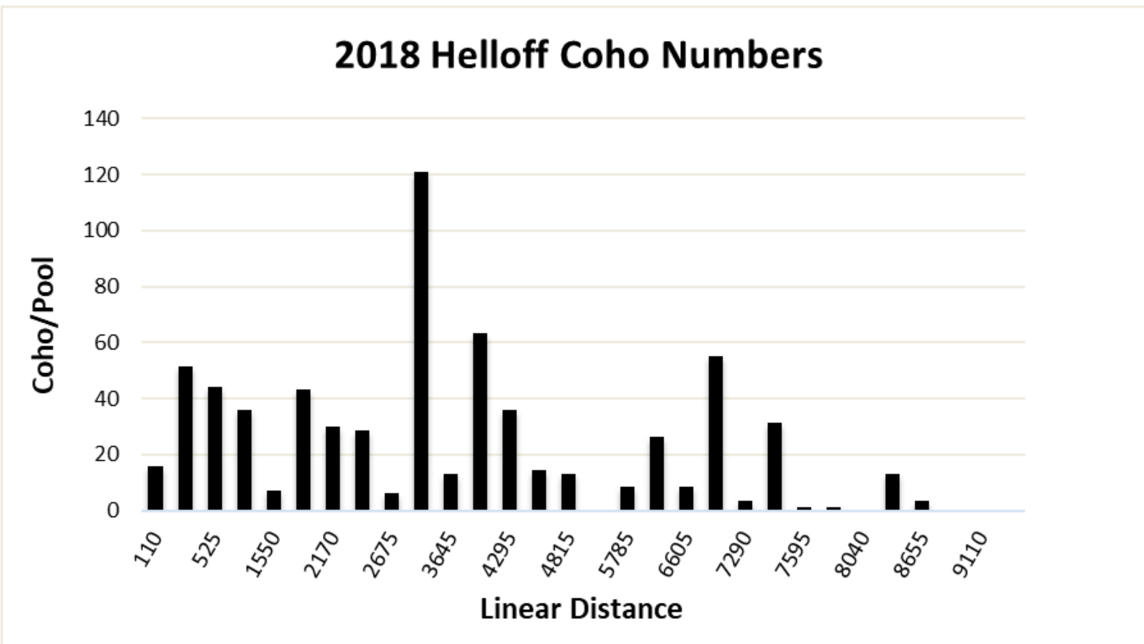

Figure 57: Helloff Coho Numbers 2018

Steelhead

Steelhead abundance was low with an average pool density of 0.09 fish/m² expanding to 113 fish/mile. The dominant density peak of 0.29 fish/m² was observed at RM 0.6.

Cutthroat

Cutthroat abundance was moderate with an average density of 0.25 fish/m² expanding to 293 fish/mile. The dominant density peak of 1.07 fish/m² was observed above the end of anadromous distribution at RM 1.74.

0+ Trout

0+ trout abundance was low with an average density of 0.42 fish/m² expanding to 588 fish/mile. The dominant density peak of 2.11 fish/m² and high count of 55 fish was observed at RM 1.25.

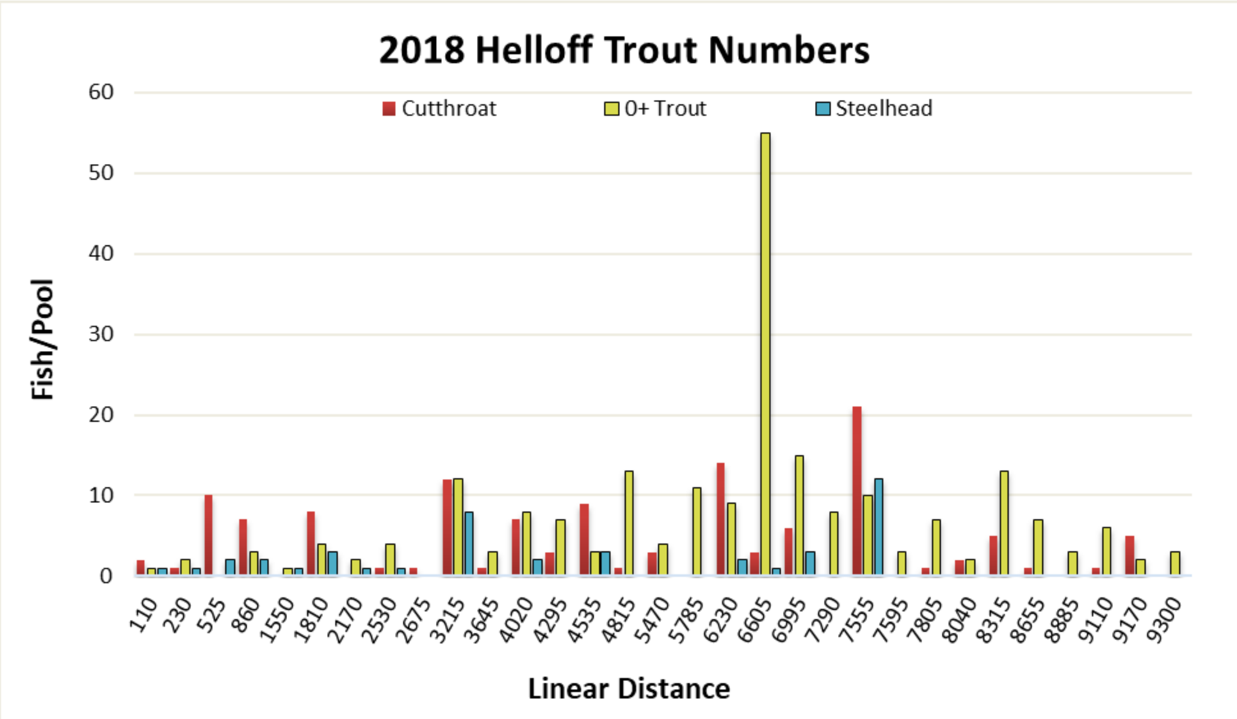

Figure 58: Helloff Trout Numbers 2018

Chinook

Chinook were not observed.

Table 36: Helloff - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	3039	1.07	1035	162	516	0

Jetty

Jetty enters Nehalem bay on the south side just inside the entrance from the Pacific Ocean and behind the South jetty (45.658022, -123.932821). The RBA inventory extended 2.03 miles upstream where increase in gradient and lack of adequate spawning gravel limited further anadromous salmonid spawning and rearing potential. Steelhead distribution extended 1.4 miles with no definitive barrier to passage observed. High turbidity associated with input from a Water Treatment Plant (WTP) adjacent pond reduced visibility in the lower 0.3 miles of the inventory. Very low salmonid abundance (only one cutthroat) was observed below an intake pool for the WTP at RM 0.3, indicating the potential of water treatment methods that are adversely affecting habitability of aquatic habitats in this reach.

Photo 61 Jetty Creek Confluence with Nehalem Bay

Habitat was characterized by moderate gradient (avg. 3.44%); low summer temperature profiles (12.9C); lateral channel meander largely confined by hillslope; dominant substrates of cobble and gravel; simplified channel lacking large wood complexity in lower 0.7 miles, moderate wood complexity for remainder of inventory; and thin riparian buffers from clearcuts above RM 1. Beaver activity was observed with three small full-spanning dams.

Photo 62 Jetty Creek

Anchor Sites:

No Anchor Sites were observed

Coho

Coho were not observed. Inventoried habitats exhibited high potential for coho occupation.

Spawning Gravel and adult Escapement:

Very little spawning gravel was observed in the lower 0.7 miles of the inventory. A total of 14 m^2 of spawning gravel was documented throughout the inventory. Estimated adult (combined male and female) coho carrying capacity based on spawning gravel availability was 9 – 28 coho.

Steelhead

Steelhead abundance was low at an average pool density of 0.23 fish/m^2. Intermittent pool presence was observed throughout the range of distribution. The dominant density peak of 0.79 fish/m^2 and high count of 22 fish was observed in a deep non-random sample pool below the WTP water intake at RM 0.3. No steelhead were observed below this pool, indicating the presence of upstream migration.

Cutthroat

Cutthroat abundance was low with an average density of 0.16 fish/m² expanding to 90 fish/mile.

0+ Trout

0+ trout abundance was low with an average density of 0.12 fish/m² expanding to 58 fish/mile. No 0+ trout were observed below the intake pool at RM 0.3.

Chinook

Chinook were not observed

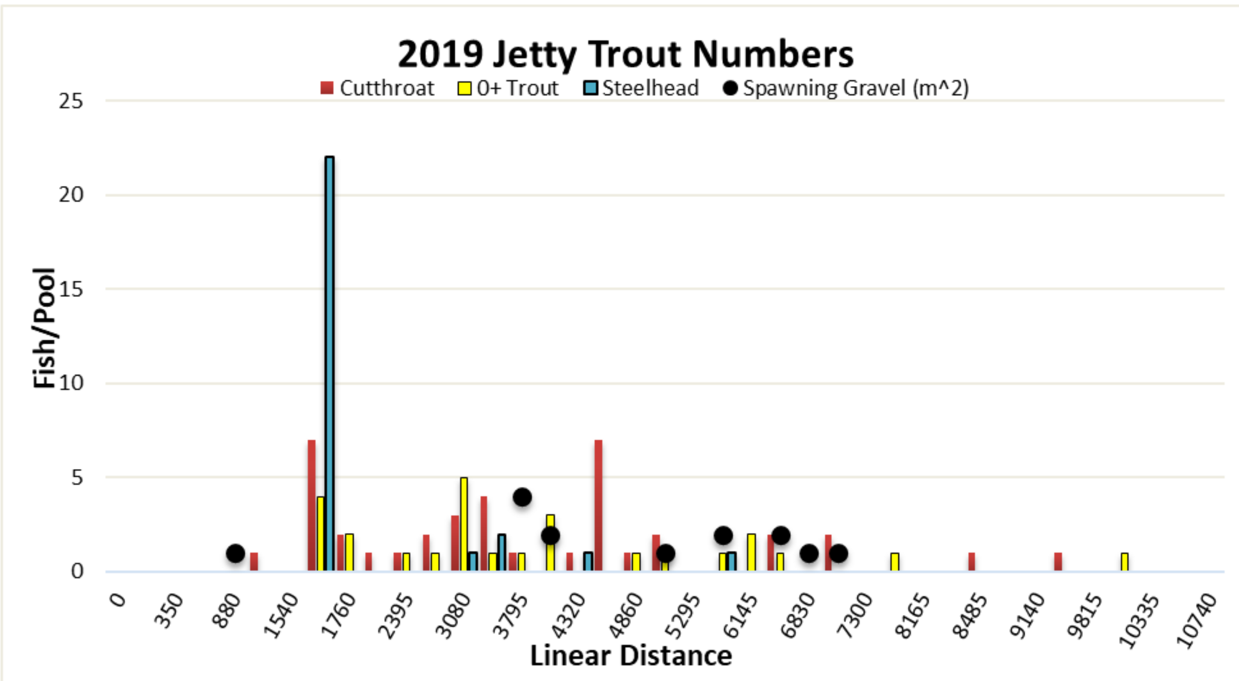

Figure 59: Jetty Trout Numbers 2018

Table 37: Jetty Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	0	N/A	114	47	167	0

Lost

Lost enters the Nehalem at RM 14.3 The RBA inventory extended 3.08 miles upstream where a 12ft vertical boulder/legacy log jam falls terminates anadromous potential. Coho and steelhead distribution extended to an 8ft boulder falls and legacy wood log jam at RM 2.97.

Lost Creek was identified as an important thermal refugia and rated as a high priority for future restoration efforts. Temperatures documented at the time of the inventory recorded a 5.5C differential from the mainstem Nehalem (16.3C – 21.8C). A high number of cutthroat (80) were observed congregating in high density in the mainstem Nehalem at the confluence plume. Shallow mostly subsurface flows through deep gravel and cobble depositions at the confluence complicated access for temperature dependent migrations out of the mainstem into Lost Creek. Additionally, Simplified stream habitat with scoured bedrock and boulders throughout the lower 0.65 miles of Lost Creek limited the salmonid rearing potential upstream of the Nehalem confluence and resulted in very low salmonid abundance in this reach. No evidence of upstream thermal migration was observed however, observations of salmonids in the confluence plume suggest that Lost Creek is a prime target for upstream temperature dependent migration for thermal refugia.

Photo 63 Lost confluence with Nehalem

Stream habitat above RM 0.65 was characterized by low gradient (avg. 2.6%); dominant substrates of boulder, cobble, and gravel with gravel sorting in pool tailouts; low summer temperature profiles (13.9C – 16.3C); moderate wood complexity comprised of deciduous material and legacy oldgrowth segments; and well forested riparian of mixed deciduous and conifer. Channel braiding across wide floodplain terraces was observed throughout anchor sites with lateral channel migration confined by hillslope outside of anchors.

Photo 64 Lower Lost Creek Bank Oriented Structures

Photo 65 Lost Creek Anchor Site #1

Photo 66 Upper Lost Creek

Anchor Sites:

Four Anchor Sites were observed.

Two high functioning lower anchor sites were back to back and extended from RM 0.66 – 1.3. A high complexity swampy side channel pool was observed rearing 300+ coho in Anchor site #2 at RM 1.2.

The upper two sites were low functioning with higher gradient and terrace heights at upper thresholds of qualification (>3 ft).

Photo 67 Lost Creek Anchor Site #2, High Complexity Side Channel Pool Rearing Coho

Coho

Coho abundance was high with an average pool density of 1.43 fish/m² expanding to 3027 fish/mile. The highest density of 4.8 fish/m² and highest pool count of 270 fish was observed at RM 1.3, just above the end of Anchor Site #2. Coho abundance in Lost Creek accounting for 14.9% of the total 2018 population estimate for the lower Nehalem tributaries while comprising only 2.5% of the total inventoried linear stream miles.

Spawning Gravel and Escapement:

An estimated 81 adult (combined male and female) coho escaped to Lost Creek to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 63 – 188 coho.

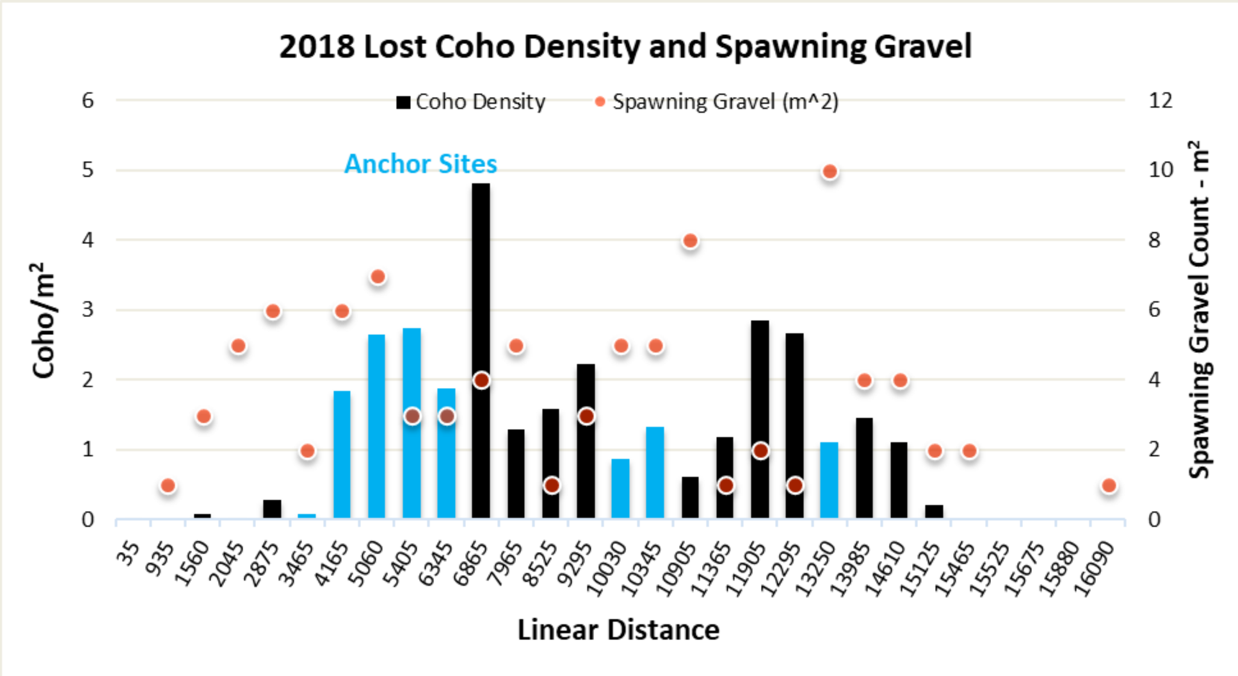

Figure 60: Lost Coho Densities 2018

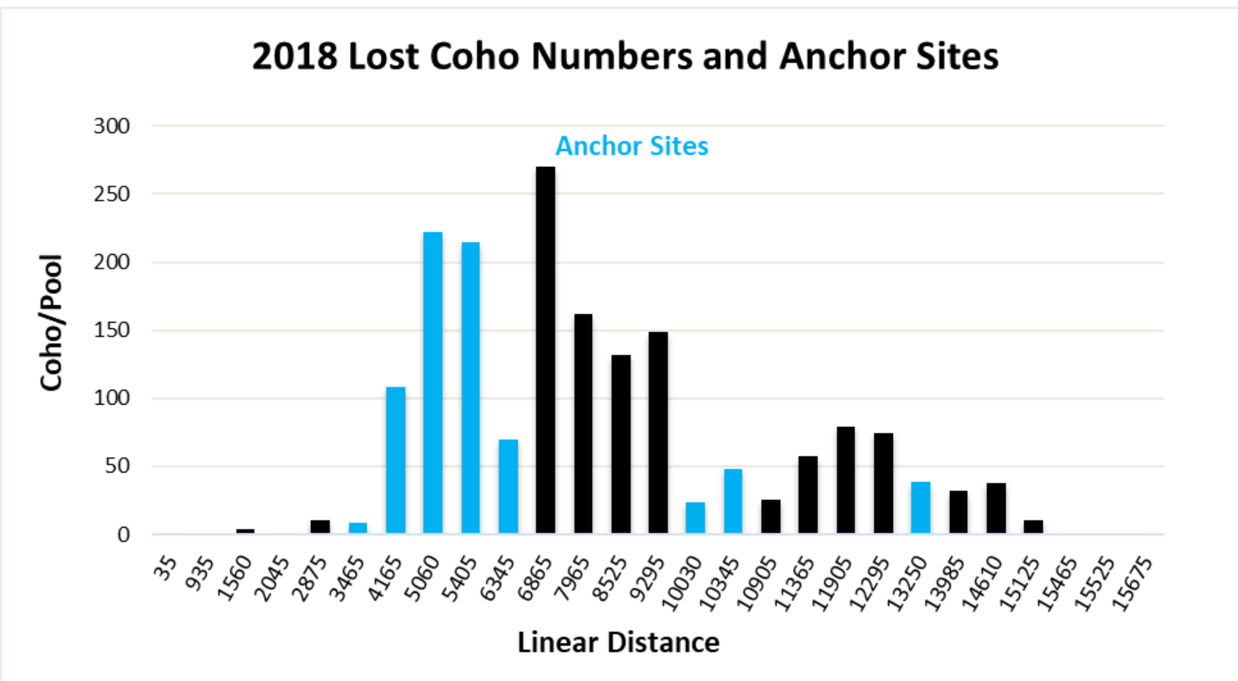

Figure 61: Lost Coho Numbers 2018

Steelhead

Steelhead abundance was low overall with an average pool density of 0.12 fish/m² and intermittent pool presence above RM 1.75. Steelhead counts expanded to 156 fish/mile throughout the range of distribution. The highest density of 0.3 fish/m² was observed at RM 0.8. In the most productive one-mile reach from RM 0.8 to RM 1.8 steelhead were present at 390 fish/mile. This reach extended through Anchor Sites #1 and #2.

Cutthroat

Cutthroat abundance was low with an average density of 0.06 fish/m² expanding to 67 fish/mile. The highest density of 0.14 fish/m² was observed at RM 2.5.

0+ Trout

0+ trout abundance was moderate with an average density of 0.61 fish/m² expanding to 1184 fish/mile. The highest density of 1.54 fish/m² was observed at RM 2.25.

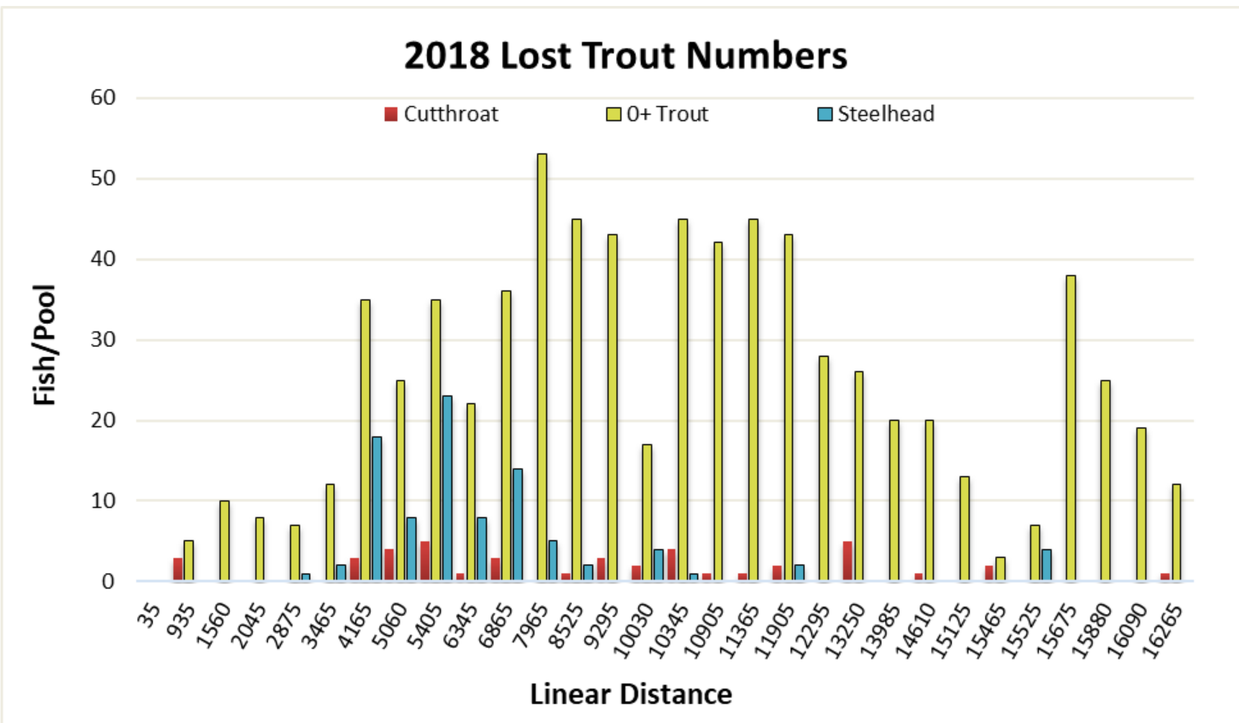

Figure 62: Lost Trout Numbers 2018

Chinook

Chinook were not observed

Table 38: Lost - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	8898	1.43	3647	460	206	0

Peterson

Peterson enters the Nehalem at RM 10.1 on the upstream left bank. The RBA inventory extended 1.0 mile upstream where lack of spawning gravel and a steep gorge limits further anadromous spawning and rearing potential. Anadromous fish distribution extended 0.36 miles to a culvert perched 4ft. Stream habitat above the culvert lacked significant anadromous potential.

Habitat was characterized by low flows, dry at mainstem confluence with isolated pools in lower 0.3 miles; moderate gradient (avg. 4.9%); mixed deciduous and evergreen canopy; low summer temperature profiles (14.4C – 16.7); low wood complexity; and dominant substrates of bedrock, sand, and fine gravel. Riparian habitat in lower ¼ mile was dominated by Japanese knotweed.

Anchor Sites:

No Anchor Sites were observed

Coho

Coho were observed in only three pools. However, within the 0.36 miles of anadromous distribution, abundance was moderate with an average pool density of 1.38 fish/m². The highest density of 2.19 fish/m² was observed in the pool below the culvert pool RM 0.36

Spawning Gravel and Escapement:

The distribution profile and abundance estimate suggest one spawning event with low egg to fry survival occurred in Peterson Creek. Estimated adult (combined male and female) coho carrying capacity based on spawning gravel availability was 3 - 10 coho.

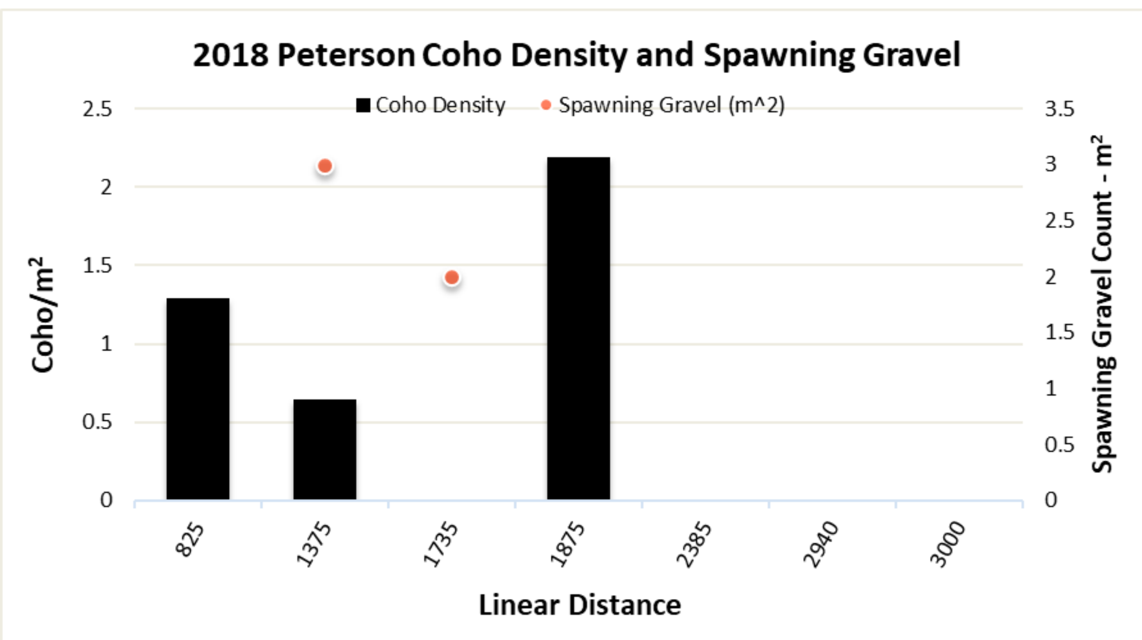

Figure 63: Peterson Coho Densities 2018

Steelhead

Steelhead abundance was low with an average pool density of 0.37 fish/m² expanding to 94 fish/mile. Steelhead were only present in the same three pools as coho were present. The highest density of 0.43 fish/m² was observed below the perched culvert at RM 0.36.

Cutthroat

Cutthroat abundance was moderate with an average density of 0.48 fish/m² expanding to 184 fish/mile. The highest density of 0.81 fish/m² was observed at RM 0.16 in an isolated pool.

0+ Trout

0+ trout abundance was low with an average density of 0.56 fish/m² expanding to 140 fish/mile. The highest density of 1.48 fish/m² was observed at RM 0.16 in an isolated pool.

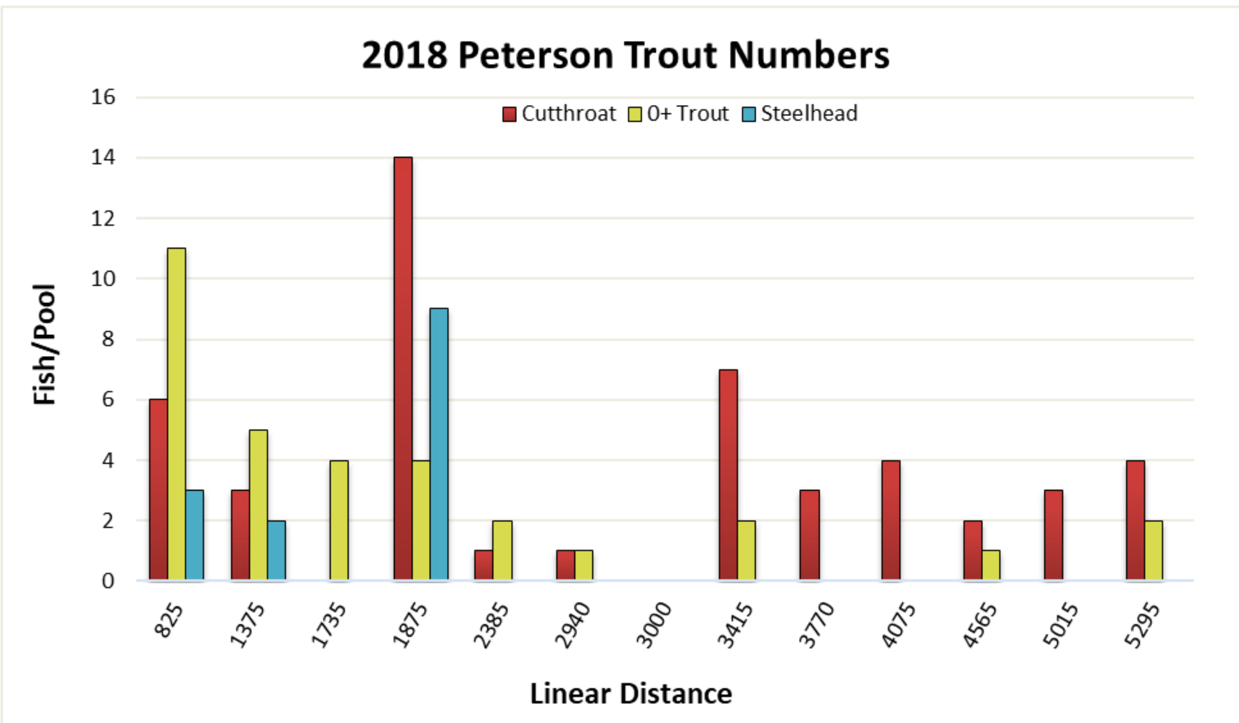

Figure 64: Peterson Trout Numbers 2018

Chinook

Chinook were not observed

Table 39: Peterson - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	110	1.38	140	34	184	0

Roy

Roy enters the Nehalem at RM 8.0 on the upstream left bank. The RBA inventory extended 1.52 miles upstream where high gradient and low channel complexity limit further anadromous spawning and rearing potential. Anadromous fish distribution extended throughout the reach.

Habitat was characterized by simplified channel with lateral channel migration largely confined by hillslope; low subsurface flows at Nehalem confluence with isolated pools in lower 0.1 miles and increased flows upstream; dominant substrates of boulder, cobble, and gravel with limited gravel sorting in pool tailouts; moderate to high gradient (avg. 4.9%); and temperature of 17.2C.

Anchor Sites:

Two short Anchor Sites extended from RM 0.18 – 0.28 and RM 1.21 – 1.38. Anchor sites were low functioning each lacking wood complexity and sorted spawning gravel.

Coho

Coho abundance was low with an average pool density of 0.33 fish/m² expanding to 107 fish/mile. The highest density of 0.45 fish/m² was observed at RM 1.09.

Spawning Gravel and Escapement:

The distribution profile and abundance estimate suggest one spawning event with low egg to fry survival occurred in Roy Creek. Estimated adult (combined male and female) coho carrying capacity based on spawning gravel availability was 8 - 24 coho.

Spawning gravel availability did not appear to limit coho production with an estimated 12 sites documented throughout the inventory.

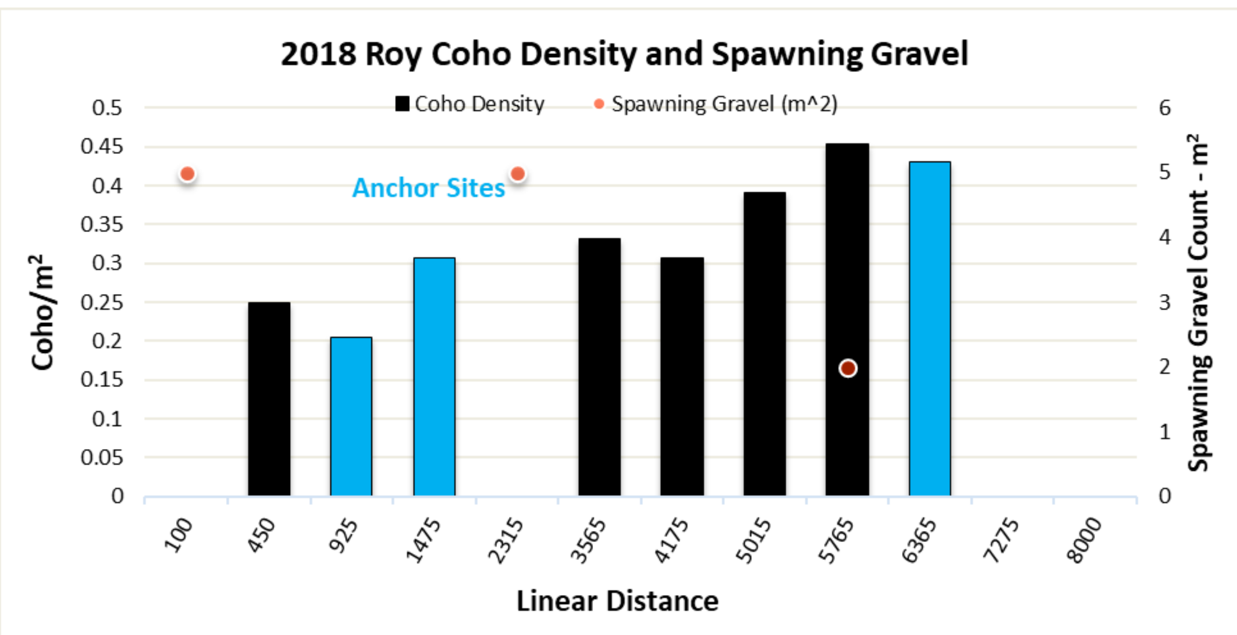

Figure 65: Roy Coho Densities 2018

Steelhead

Steelhead abundance was low with an average pool density of 0.23 fish/m² expanding to 95 fish/mile. The highest density of 0.56 fish/m² and high pool count of 11 fish was observed in Anchor Site #1 at RM 0.28

Cutthroat

Cutthroat abundance was low with an average density of 0.32 fish/m² expanding to 109 fish/mile. The highest density of 0.6 fish/m² was observed in a small pool at RM 1.52.

0+ Trout

0+ trout abundance was low with an average density of 0.40 fish/m² expanding to 148 fish/mile. The highest density of 0.65 fish/m² was observed at RM 0.95.

Chinook

Chinook were not observed

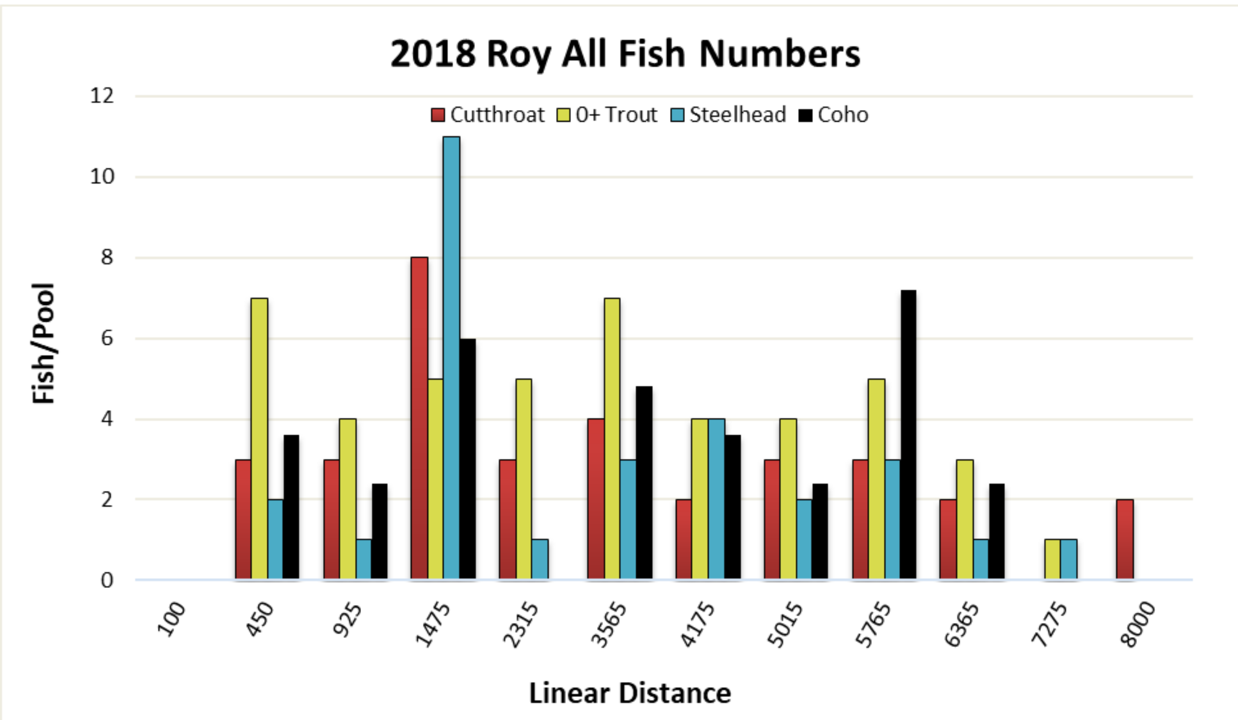

Figure 66: Roy Fish Numbers 2018

Table 40: Roy - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	162	0.33	225	145	165	0

Salmonberry River

The Salmonberry River enters the Nehalem at RM 22.36 on the upstream right bank. The RBA inventory of the Salmonberry subbasin contained 30 miles of stream habitat exhibiting anadromous potential. This included eight tributaries that accounted for 15.35 miles of stream habitat.

The mainstem Salmonberry inventory extended 14.66 miles. Steelhead distribution extended 14.14 miles to a 14 ft bedrock falls functioning as a permanent anadromous barrier. Coho distribution extended to a four-foot bedrock falls at RM 12.9. The falls was likely passable for adult coho with adequate flows.

Photo 68 Salmonberry Falls (End of Anadromy, RM 14.14) Looking Downstream

The Salmonberry River was identified as an important thermal refugia and rated as a high priority for future restoration efforts. Temperatures documented at the time of the inventory recorded a 4.1C differential from the mainstem Nehalem (18C – 22.1C). A high number of large searun and fluvial cutthroat (250) were observed congregating in high density in the mainstem Nehalem pool at the confluence plume. Lack of channel complexity in the form of cover limited the salmonid rearing potential in a majority of mainstem Salmonberry habitats. Evidence of temperature dependent migration was observed but only in one pool at RM 0.18 where 75 large cutthroat and one adult chinook were observed. This suggests the need for the development of pool complexity near the mouth for the provision of holding cover within the high quality thermal refugia.

Habitat was characterized by low gradient (avg.1.8%); high flows; lateral channel migration constrained by hillslope; dominant substrates of bedrock, boulder, and cobble with gravel sorting associated with bedrock intrusions; simplified channel with lack of large wood complexity; wide channel with high solar exposure; and varied temperature profiles (12C – 18C).

Photo 69 Salmonberry RM 3

Anchor Sites:

Two Anchor Sites were observed. Anchor Site #1 extended 0.34 miles from RM 11.26 – 11.64 and was low functioning, lacking channel complexity and sinuosity. Anchor site #2 was high functioning, extending from above the end of anadromy to upstream of our inventory endpoint.

Photo 70 Salmonberry River RM 10

Spawning Gravel and Adult Escapement for the Entire Salmonberry Subbasin:

An estimated 90 adult (combined male and female) coho escaped into the Salmonberry subbasin to spawn. Spawning gravel was abundant with approximately 780 m^2 documented throughout the subbasin within anadromous range. Estimated adult coho carrying capacity based on spawning gravel availability within historical range (not including NF Salmonberry) was 327 – 981 coho.

Photo 71 Salmonberry River RM 11

Side Channels

Three short side channels extending a total of 0.16 miles were included in the mainstem inventory. These habitats consisted of disconnected pools along mainstem channel margins and did not provide significant off channel rearing potential. Nonetheless these habitats were observed rearing high densities of coho and accounted for 15% of the total mainstem Salmonberry population estimate. Four of the top five highest densities observed in the Salmonberry subbasin were documented in these side channel pools. Coho abundance was significantly higher in these short side channels than was observed in adjacent mainstem pool habitats. A total of 610 coho, 147 0+ trout, 1 cutthroat, and 22 chinook were observed rearing in Side Channels A, B, and C.

Photo 72 Salmonberry Side Channel B

Coho

Coho abundance was low with an average pool density of 0.23 fish/m² expanding to 263 fish/mile. The peak density of 7 fish/sqm was observed in Side Channel C at RM 5.5. The highest mainstem pool density of 1.66 fish/m² was observed at RM 11.26. This density peak was observed in Anchor Site #1 and associated with the dominant spawning reach. Distribution profiles suggest that coho were predominantly utilizing spawning gravels in the 1.7-mile reach from RM 9.8 – 11.5. Of the total mainstem Salmonberry estimated coho population 64.5% was observed rearing in this 1.7-mile reach.

Spawning Gravel and Escapement for mainstem Salmonberry:

An estimated 31 adult (combined male and female) coho escaped into the mainstem Salmonberry to spawn. Spawning gravel was abundant with 347 m² documented within anadromous range. Estimated adult coho carrying capacity based on spawning gravel availability was 231 – 694 coho.

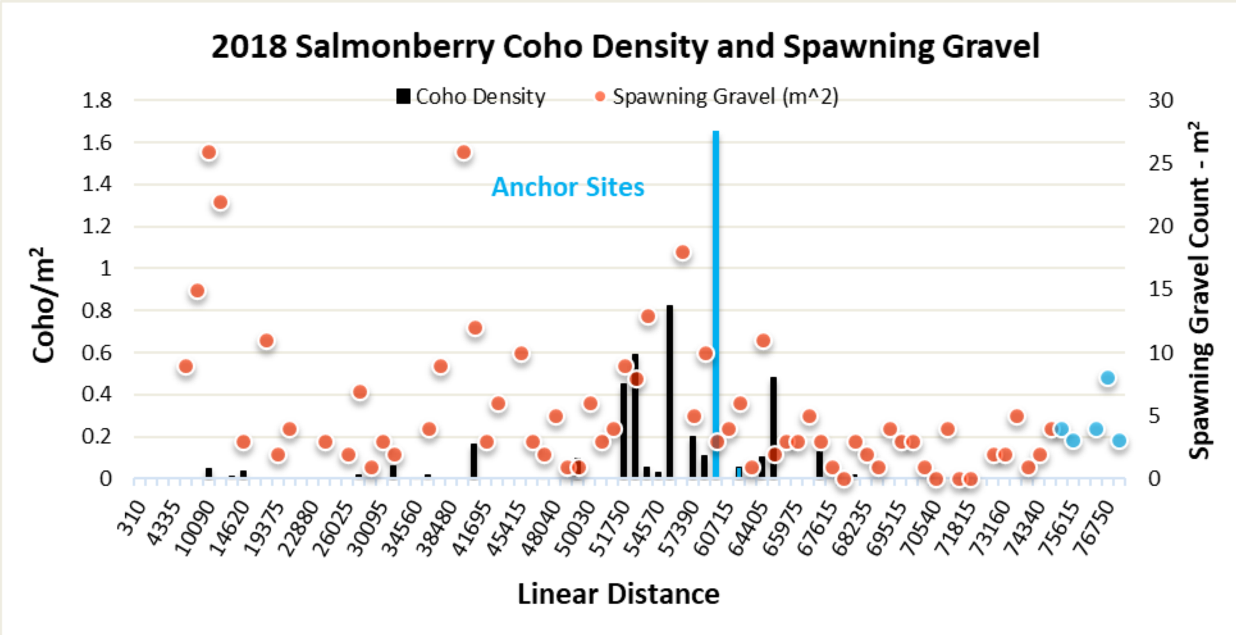

Figure 67: Salmonberry Coho Densities 2018

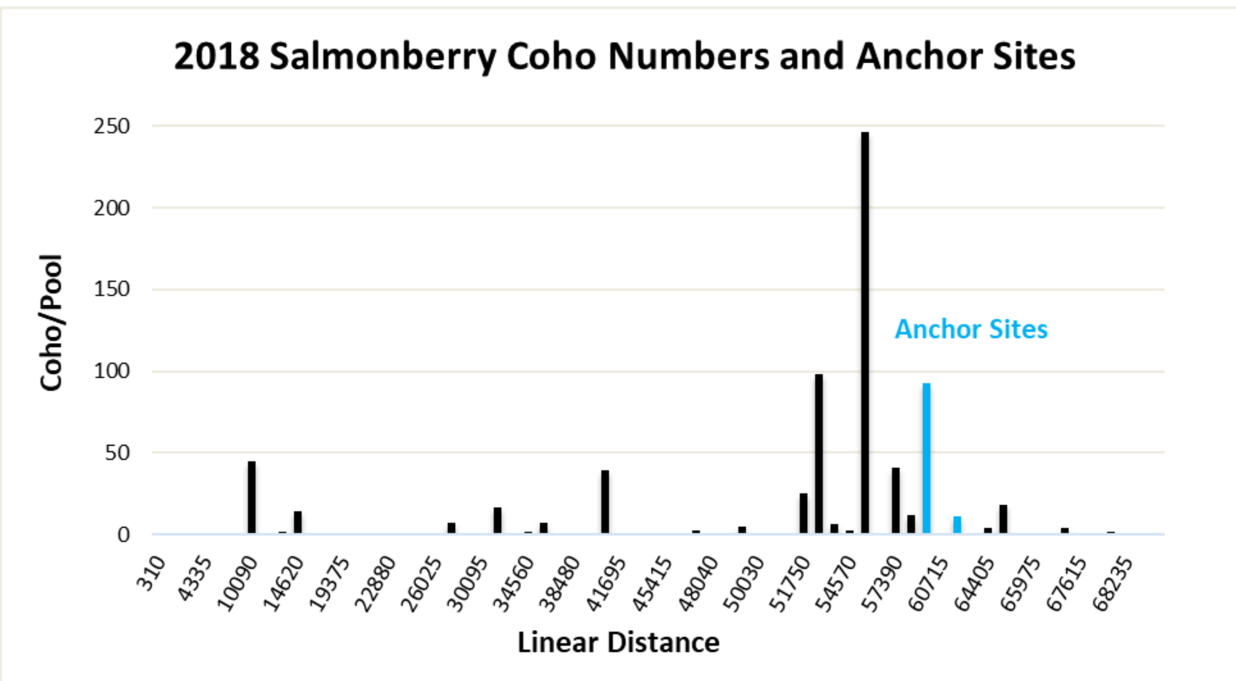

Figure 68: Salmonberry Coho Numbers 2018

Steelhead

Steelhead abundance was low at an average pool density of 0.06 fish/m² with intermittent pool presence throughout the range of anadromy. Steelhead counts expanded to 22 fish/mile. The highest density of 0.6 fish/m² was observed at RM 14.14 in the pool below the falls.

Lack of adequate channel complexity in the form of cover was limiting the rearing capacity of most mainstem pools. Numerous mergansers were observed in multiple locations throughout the inventory. It is likely that the percentage of pool rearing steelhead is significantly lower in the mainstem Salmonberry given this lack of complexity in conjunction with the presence of deep riffle, rapid, and glide habitats providing higher quality refuge from avian predation. This is likely true for cutthroat distribution profiles as well.

Cutthroat

Cutthroat abundance was low with an average density of 0.07 fish/m² expanding to 22 fish/mile. The highest density of 0.44 fish/m² was observed at RM 14.66. The high count (75 fish) was observed just upstream of the mainstem Nehalem confluence.

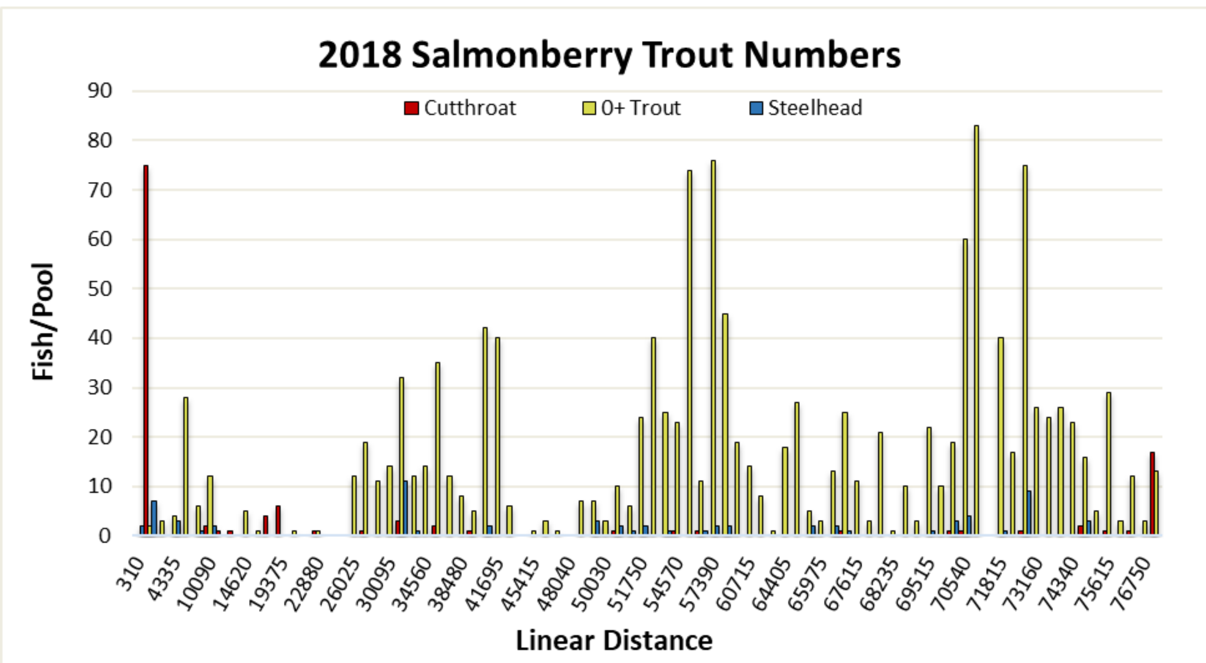

Figure 69: Salmonberry Trout Numbers 2018

0+ Trout

0+ trout abundance was low overall with an average density of 0.47 fish/m² expanding to 446 fish/mile. Abundance was highest from RM 9.8 – 14.14. Abundance in this 4.34-mile reach was high expanding to 1,002 fish/mile. This reach accounted for 67% of the mainstem total while comprising 30.7% of the linear stream miles. The highest density of 3.57 fish/m² was observed at RM 13.4. Density profiles exhibited an upward trend with proximity to the falls that ended anadromy at RM 14.14. Densities fell sharply above the end of anadromy.

In the lower ten miles of the inventory high counts of spawning gravel and low abundances of 0+ trout suggested that other limiting factors were reducing production. Avian predation was observed in several locations throughout the inventory and habitat complexity was low throughout the range of anadromy with limited refuge present in pools.

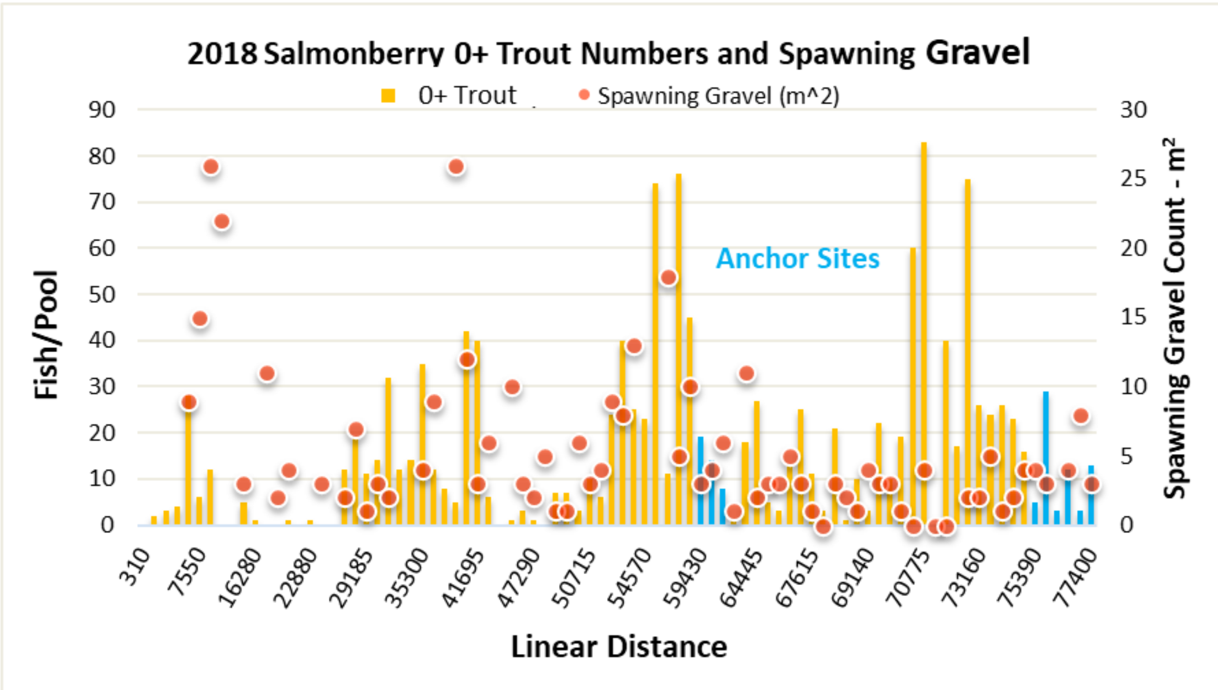

Figure 70: Salmonberry 0+ Trout Numbers with spawning gravel 2018

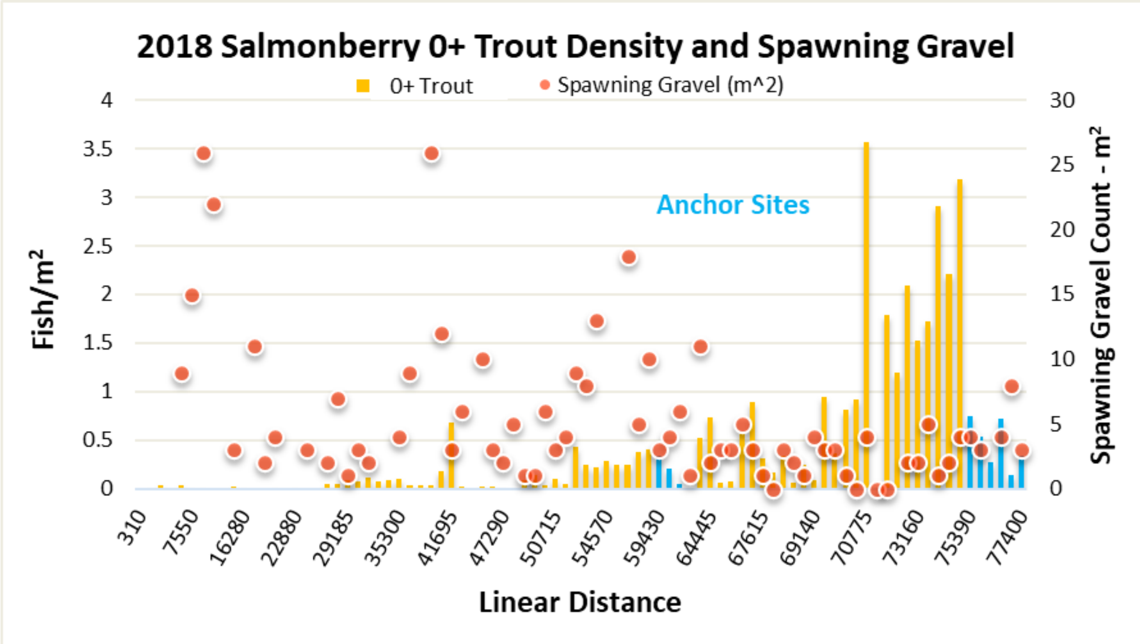

Figure 71: Salmonberry 0+ Trout Densities with spawning gravel 2018

Chinook

Chinook were observed with intermittent pool presence in the lower four miles of the inventory

Table 41: Salmonberry Mainstem - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	4,028	0.23	6,692	285	321	168

Minor Tributaries of the Salmonberry (Expanded Coho Counts of < 200)

Several named tributaries to the Mainstem Salmonberry were not surveyed due to lack of anadromous potential (steep gradients, low flows, etc). Several additional tributaries that exhibited anadromous potential for only a short reach were included in the inventory. Rather than including large sections for these streams, a condensed review is included below. See the Access database for additional information on these tributaries. See Table 10 for all tributaries surveyed for anadromy.

Belding

Belding enters the Salmonberry on the upstream right bank at RM 9.5. Anadromous distribution continued to a 30 foot log jam/falls at RM 0.30. The log jam had passable steps within it and was 100ft horizontally (slope of 30%). Above the falls, Belding was dry for 100 feet and only isolated pools were observed. Coho were not present in Belding, and 0+ trout densities were low (avg 0.24 fish/m2). 7m^2 of spawning gravel was observed and habitat was characterized by small log jams, exposed bedrock, and some braiding in the channel.

Pennoyer

Pennoyer enters the Salmonberry at RM 14.23 on the upstream right bank. The survey extended upstream to RM 0.09 to a 40-foot vertical falls, a permanent anadromous barrier. In the pool below the falls, 15 steelhead were observed (0.47 fish/m^2). No coho were observed in Pennoyer. One square meter of spawning gravel was noted.

Sappington

Sappington enters the Salmonberry on the upstream right bank at RM 11. The survey extended 0.63 miles upstream. Coho were only observed in 2 sampled pools, but 0+ trout densities were high (avg 2.25 fish/m^2). Anadromous potential extended to a massive log jam packed with woody debris and boulders at RM 0.50. This is an ephemeral anadromous barrier but anadromous potential did not extend far upstream. The jam had deep bedload accumulations above with subsurface flow through this bedload extending for 200ft.

Steam habitat was characterized by high gradient (avg. 7%); and a braided channel with dominant substrates of boulder and bedrock. 8m^2 of spawning gravel was documented. Habitat was suitable for steelhead and cutthroat but exhibited limited potential for coho. Low abundances of steelhead cutthroat were observed.

Tunnel

Tunnel enters the Salmonberry steeply on the upstream left bank at RM 5.44. The inventory extended 0.10 miles upstream. At RM 0.05, a 5ft bedrock falls with shallow jump-pool limits anadromous potential. Upstream of the falls is a narrow and steep canyon. No coho were observed in Tunnel. 0+ trout were seen in sample pool 2 at a high density of 5.56 fish/m^2.

Kinney

Kinney enters the Salmonberry at RM 11.17 on the upstream right bank. The RBA inventory extended 1.1 miles upstream where debris jams, falls, and subsurface flows limit further anadromous spawning and rearing potential. Anadromous fish distribution extended 0.57 miles to a 6ft falls in a bedrock slot with a shallow jump pool above. Passage at the falls appeared possible (but difficult) during adequate flows. Above the falls, debris flows and log jams had inundated the channel diminishing further anadromous potential.

Photo 73 Kinney Confluence with Salmonberry

Habitat was characterized by moderate to high gradient (avg. 4.6%); lateral channel migration confined by steep hillslope; low flows, subsurface in reaches with shallow pools; simplified channel with dominant substrates bedrock, boulder, and cobble; low overall wood complexity with large wood concentrated in log jams.

Anchor Sites:

No Anchor Sites were observed

Photo 74 Kinney Creek Habitat

Coho

Coho abundance was low with an average pool density of 0.66 fish/m² expanding to 638 fish/mile. The highest density of 1.34 fish/m² was observed at RM 0.26

Spawning Gravel and Escapement:

An estimated 4 adult (combined male and female) coho escaped into Kinney Creek to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 11- 32 coho.

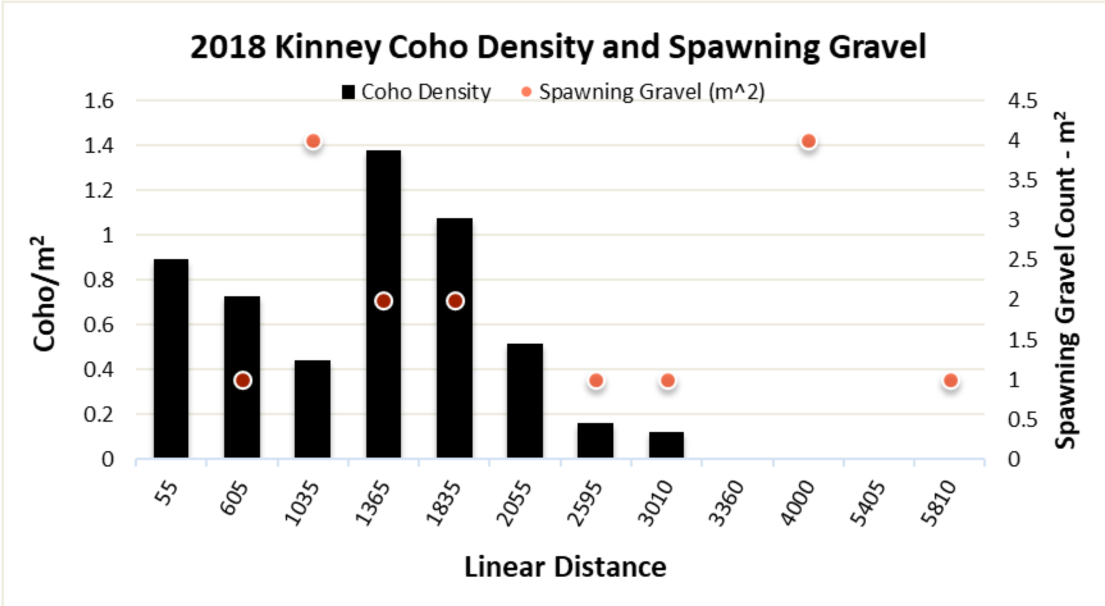

Figure 72: Kinney Coho Densities 2018

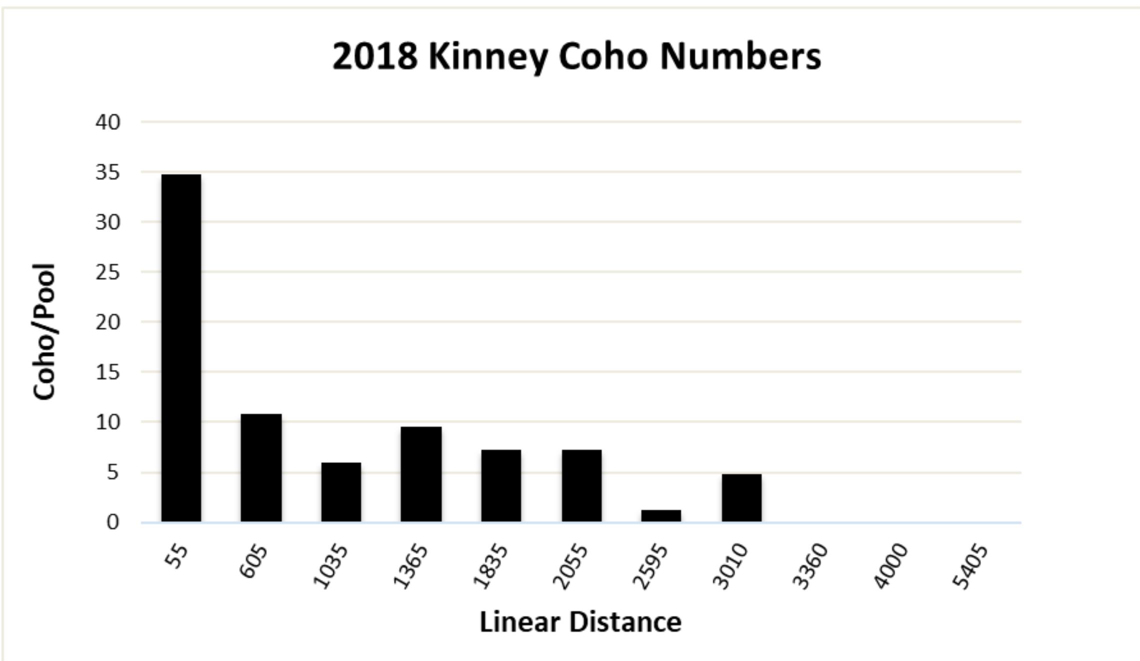

Figure 73: Kinney Coho Numbers 2018

Steelhead

Steelhead were only observed in two pools. Average pool density was 0.11 fish/m^2.

Cutthroat

Cutthroat were only observed in two pools. Average pool density was 0.07 fish/m^2.

0+ Trout

0+ trout abundance was moderate with an average density of 0.91 fish/m² expanding to 1000 fish/mile throughout the range of anadromy. The highest density of 1.61 fish/m² was observed at RM 0.49.

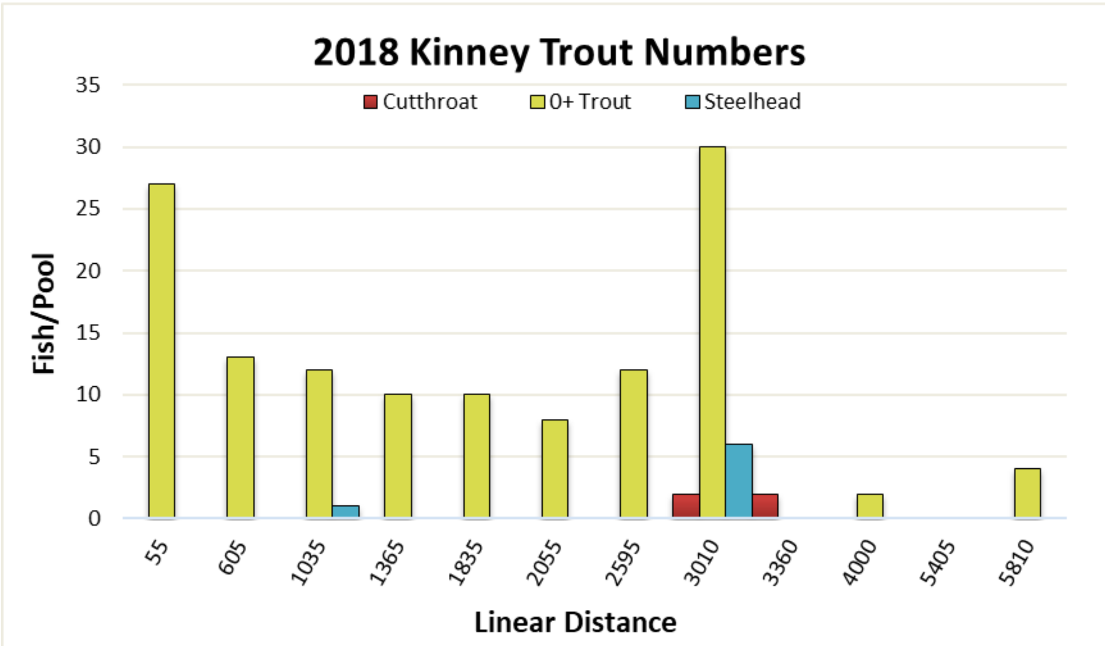

Figure 74: Kinney Trout Numbers 2018

Chinook

Chinook were not observed

Table 42: Kinney - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	408	0.66	640	35	20	0

North Fork Salmonberry

The North Fork Salmonberry enters the Salmonberry at RM 8.5 on the upstream left bank. The RBA inventory extended 7 miles. Coho were not present in the NF Salmonberry subbasin. A 9ft waterfall at RM 0.2 is a potential barrier to passage for adult coho. Steelhead distribution extended 6.5 miles to a 25-30ft debris/log jam with multiple steps and split flows over bedrock. Steelhead passage above the falls was historically possible but difficult. The debris jam in the current formation was functioning as an ephemeral barrier to adult passage. Three tributaries with short reaches of anadromous distribution were included in the inventory (Trib A, B, and C).

Photo 75 Lower North Fork Falls at RM 0.2

Photo 76 North Fork Falls (RM6.5) Debris Jam, Looking Downstream

Mainstem North Fork Habitat was characterized by low to moderate gradient (avg. 2.25%); dominant substrates of bedrock, boulder, cobble and gravel; lateral channel migration confined by steep hillslope and bedrock canyon; low summer temperature profiles (11.2C – 13.3C); and moderate large wood complexity consolidated in log jams and bank oriented accumulations with mobile legacy old growth fragments.

Photo 77 Lower North Fork Gorge

Photo 78 Gravel Accumulations below North Fork Falls at RM 0.4

Photo 79 Upper North Fork RM 6.3, Low Gradient with Deep Bedload

Anchor Sites:

No Anchor Sites were documented

Spawning Gravel and Adult Escapement:

Spawning gravel was abundant with 189 m² observed. Estimated adult (combined male and female) coho carrying capacity based on spawning gravel availability was 126 – 378 coho.

Coho

Coho were not observed.

Steelhead

Steelhead abundance was moderate with an average pool density of 0.13 fish/m² expanding to 255 fish/mile. The highest density of 0.55 fish/m² was observed at RM 2.75. Though pool habitats were seeded well below capacity, steelhead production in the mainstem North Fork Salmonberry still accounted for 25.9% of the 2018 lower Nehalem total while comprising only 5.65% of the inventoried linear stream miles.

Cutthroat

Cutthroat abundance was low with an average density of 0.03 fish/m² expanding to 31 fish/mile. The highest density of 0.07 fish/m² was observed at RM 4.68.

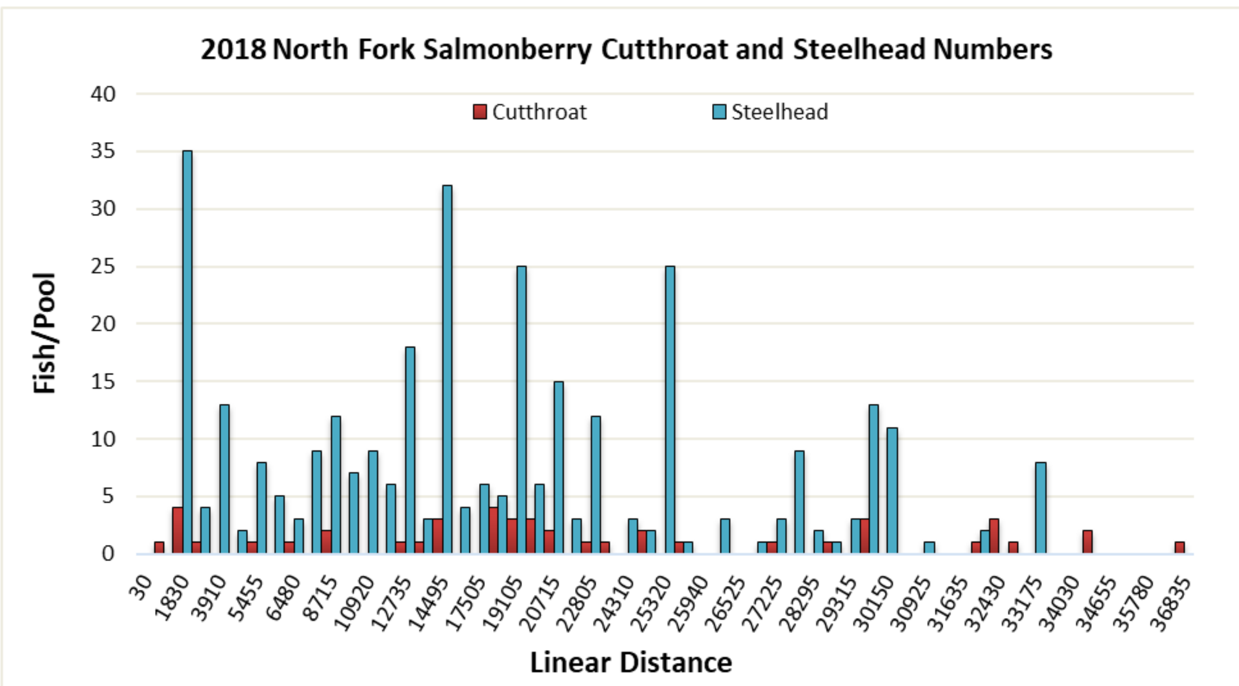

Figure 75: North Fork Salmonberry Steelhead and Cutthroat Numbers 2018

0+ Trout

0+ trout abundance was high with an average density of 1.44 fish/m² expanding to 3208 fish/mile. The highest density of 5.8 fish/m² was observed just above the confluence of Trib C and below a large log jam with deep bedload impoundment at RM 5.36. Abundance was reduced above the log jam and diminished further above the end of anadromy. 0+ trout production in the mainstem North Fork Salmonberry accounted for 30.9% of the 2018 lower Nehalem total while comprising only 5.65% of the inventoried linear stream miles.

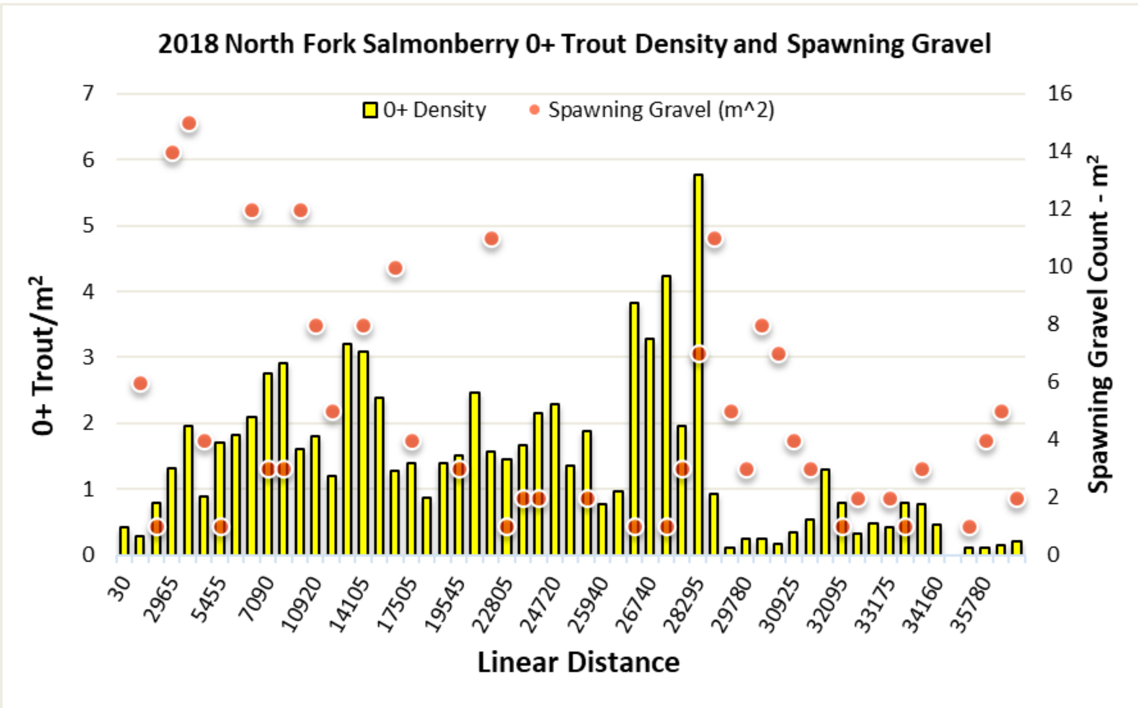

Figure 76: North Fork Salmonberry 0+ Trout Densities 2018

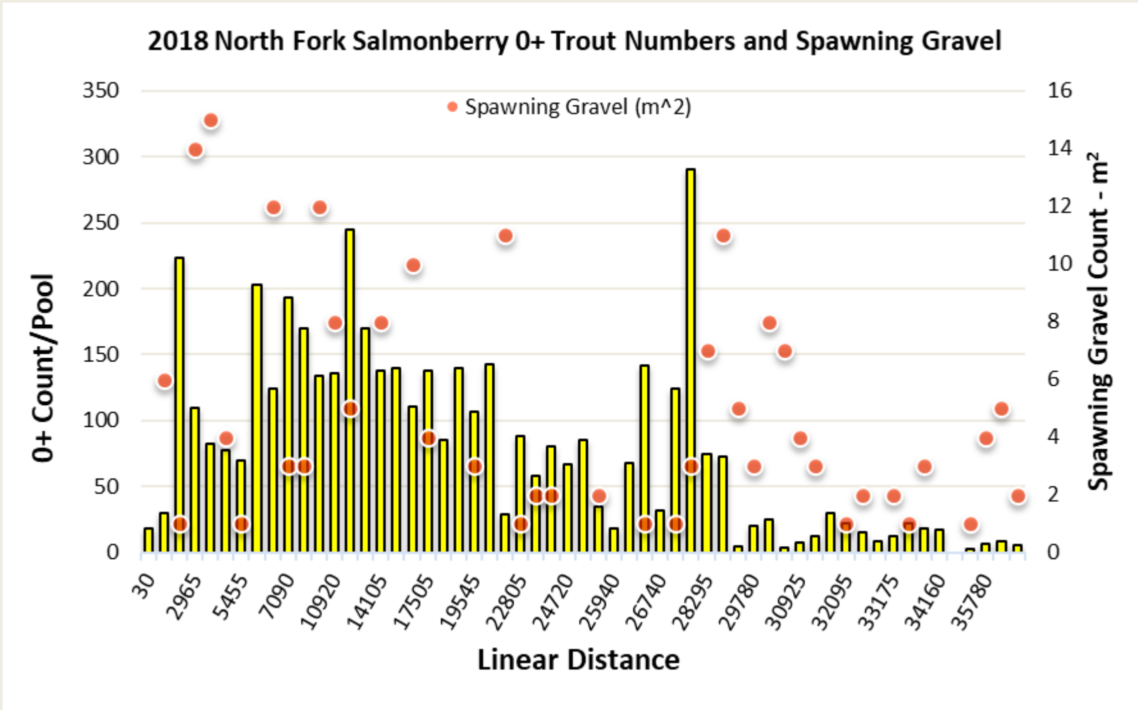

Figure 77: North Fork Salmonberry 0+ Trout Numbers 2018

Chinook

Chinook were not observed

Table 43: North Fork Salmonberry Subbasin- Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	0	N/A	22395	1650	215	0

Tributary A

Trib A enters the NF Salmonberry on the upstream left bank at RM 0.74. The survey extended 0.18 miles to a 30-foot bedrock falls terminating anadromous potential. Habitat was characterized by high gradient; low flows, subsurface in sections; and boulder and cobble substrates with legacy wood embedded in the channel. A high 0+ trout density was observed in the first sampled pool (2.66 fish/m^2). A total 4m^2 of spawning gravel was documented.

Photo 80 Trib A (North Fork) Falls

Tributary B

Trib B enters the NF Salmonberry on the upstream right bank at RM 4.15. The survey continued upstream 0.45 miles to three consecutive bedrock falls and log jams functioning as probable adult barriers to passage. Farther upstream (RM 0.8-0.9), two 15-20-foot waterfalls are a permanent barriers to anadromy. Steelhead and cutthroat were present at low densities and 0+ trout had an average density of 0.87 fish/m^2.

High quality habitat was documented in this tributary. Stream habitat was characterized by deep plunge pools; log and debris jams created by legacy old growth wood; and abundant spawning gravel (55m^2). Successive falls created by bedrock and logjams. Bedrock intrusions provided a good foundation for holding wood in the channel.

It is possible that a significant number of the 1+ steelhead found in the NF Salmonberry originated from spawning events that occurred in the lower 0.4 miles of this tributary.

Tributary C

Trib C enters the NF Salmonberry on the upstream left bank at RM 5.27. The survey extended 0.48 miles upstream to a 15-foot vertical falls, which is a permanent barrier to anadromy.

Steelhead and cutthroat were present in the first 2 pools at low densities and 0+ trout extended to RM 0.29 with moderate densities (avg. 1.26 fish/m^2).

Numerous log jams comprised of large legacy wood with sorted gravel accumulations were observed throughout the inventory. A total of 29 m^2 of gravel was documented in Trib C.

South Fork Salmonberry

The South Fork Salmonberry enters the Salmonberry at RM 6.87 on the upstream right bank. The RBA inventory extended 2.1 miles upstream where a full spanning log jam and confined channel above limited further anadromous spawning and rearing potential. Coho distribution extended 0.61 miles to a 5ft bedrock/boulder falls. Steelhead distribution extended above this falls to a series of log jams above RM 1.5. Ripple Creek entered at RM 1 exhibiting limited anadromous potential with low mostly subsurface flows.

Mainstem South Fork habitat was characterized by moderate gradient (avg. 4.06%); dominant substrates of bedrock, boulder, and cobble with gravel sorting in pool tailouts; moderate wood complexity of predominantly deciduous origin; channel braiding across broad terraces; and low summer temperature profiles (11C – 13.3C)

Photo 81 SF Salmonberry Broad Active Channel

Anchor Sites:

One Anchor Site was observed from RM 0.99 to 1.45. Lack of large wood complexity was documented. Beaver occupation, deep bedload retention with increased gravel sorting, and broad vegetated terraces were observed.

Photo 82 SF Salmonberry Channel Complexity

Coho

Coho abundance was low with an average pool density of 0.41 fish/m² expanding to 738 fish/mile. The highest density of 0.87 fish/m² was observed at RM 0.34.

Spawning Gravel and Escapement:

An estimated 4 adult (combined male and female) coho escaped to the South Fork to spawn. Estimated adult carrying capacity based on spawning gravel availability was 44 – 132 adult coho. Many Salmonberry aquatic habitats are currently limited by a lack of adult escapement.

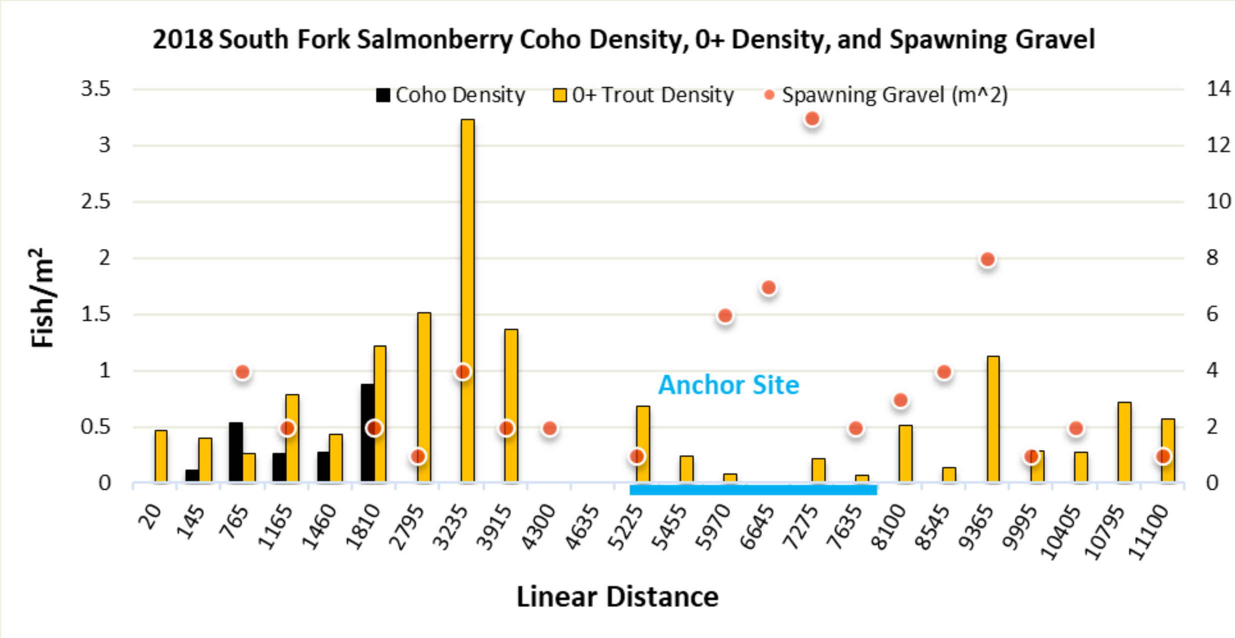

Figure 78: South Fork Salmonberry Coho and O+ Trout Densities 2018

Steelhead

Steelhead abundance was low at an average pool density of 0.14 fish/m² with intermittent pool presence throughout the range of anadromy. Steelhead counts expanded to 40 fish/mile.

Cutthroat

Cutthroat abundance was low with an average density of 0.09 fish/m² with intermittent pool presence throughout the inventoried reach. Cutthroat counts expanded to 24 fish/mile. The highest density of 0.36 fish/m² was observed at RM 1.03.

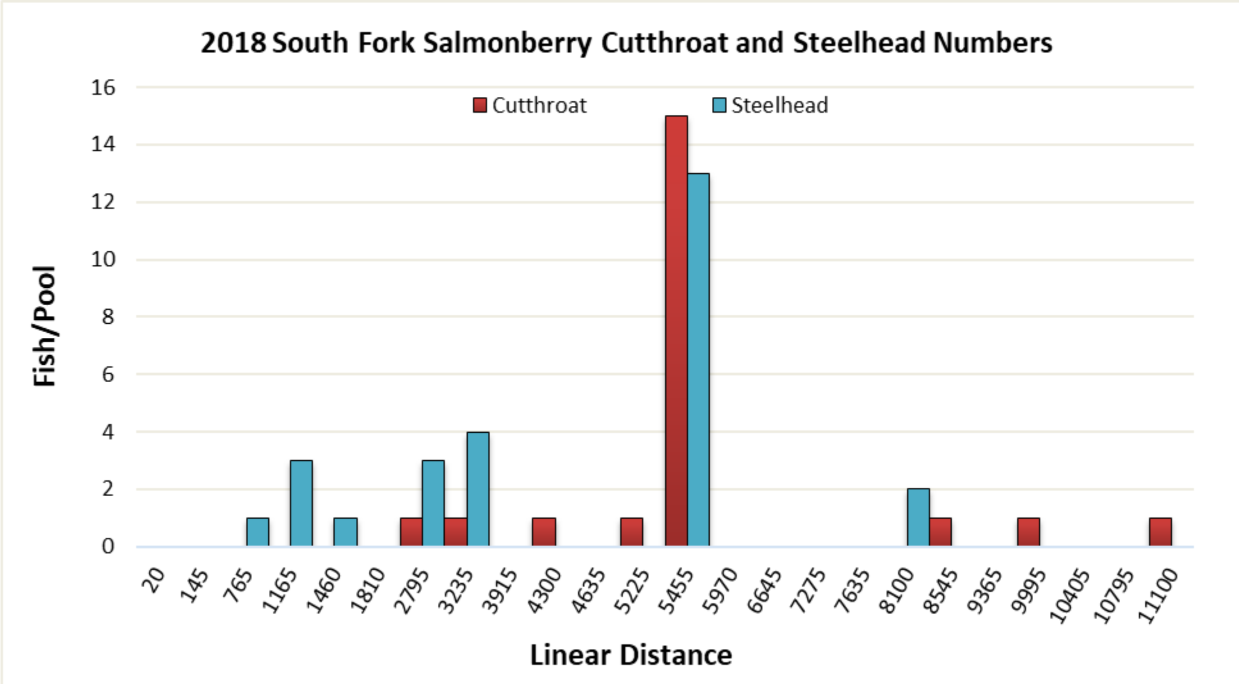

Figure 79: South Fork Salmonberry Steelhead and Cutthroat Numbers 2018

0+ Trout

0+ trout abundance was moderate with an average density of 0.69 fish/m² expanding to 974 fish/mile. The highest density of 3.22 fish/m² was observed at RM 0.61, at the 5ft falls. Abundance was reduced above a steep bedrock falls/slide at RM 0.74.

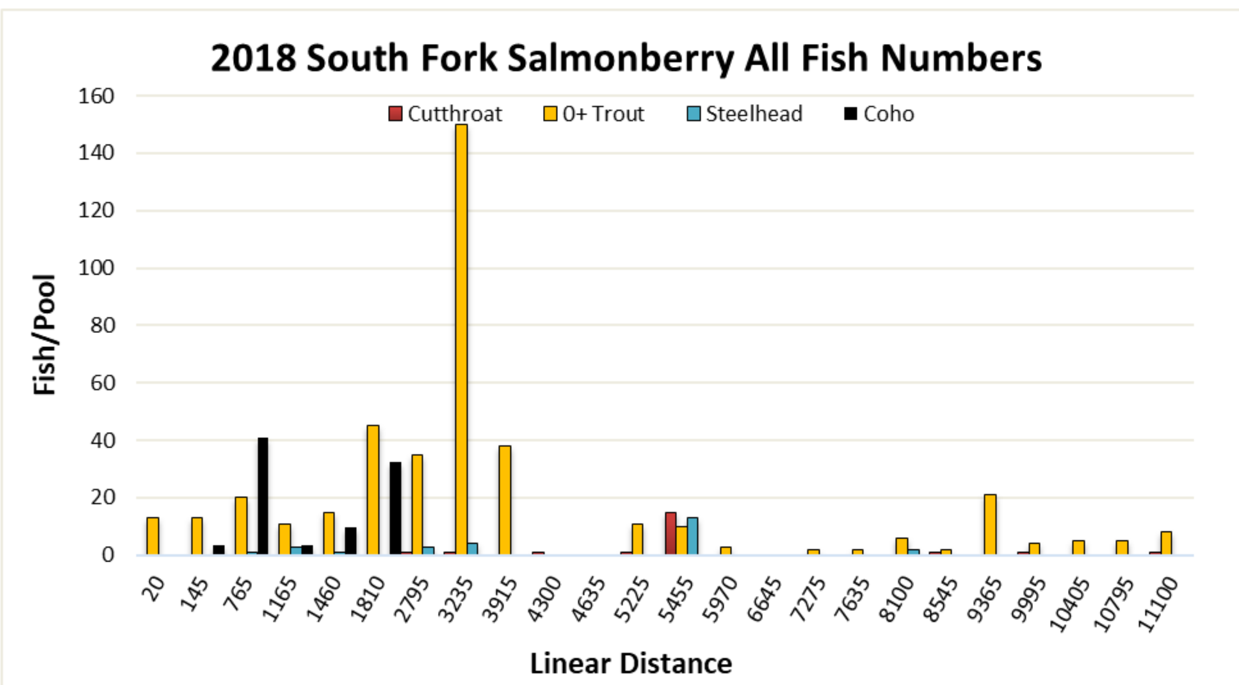

Figure 80: South Fork Salmonberry Fish Counts 2018

Chinook

Chinook were not observed

Table 44: South Fork Salmonberry - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	450	0.41	2045	83	50	0

Wolf

Wolf enters the Salmonberry at RM 12.65 on the upstream right bank. The RBA inventory extended 1.89 miles upstream to a 13ft bedrock falls that terminates anadromous potential. Anadromous fish distribution extended to the 13ft falls. A short reach of one tributary (Trib A) was included.

Photo 83 Wolf Creek Falls

Wolf Creek habitat was characterized by moderate gradient (avg. 3.1%); lateral channel migration confined by steep hillslope; dominant substrates of bedrock and boulder with gravel sorting associated with bedrock intrusions; lack of large wood complexity with some natural recruitment of conifers bank oriented; and shaded coniferous riparian. An enormous log jam was packed around the railroad tressle at Rm 0.8. This jam had a high composition of legacy old growth logs.

Anchor Sites:

No Anchor Sites were observed. The channel was hillslope confined throughout the inventoried reach.

Photo 84 Wolf Creek Habitat with Conifer Recruitment

Photo 85 Wolf Creek Spawning Gravel

Coho

Coho abundance was high with an average pool density of 1.20 fish/m² expanding to 2634 fish/mile. The highest density of 4.6 fish/m² was observed at RM 0.37.

Spawning Gravel and Escapement:

An estimated 45 adult (combined male and female) coho escaped to Wolf Creek to spawn. Estimated adult carrying capacity based on spawning gravel availability was 27 – 80 adult coho.

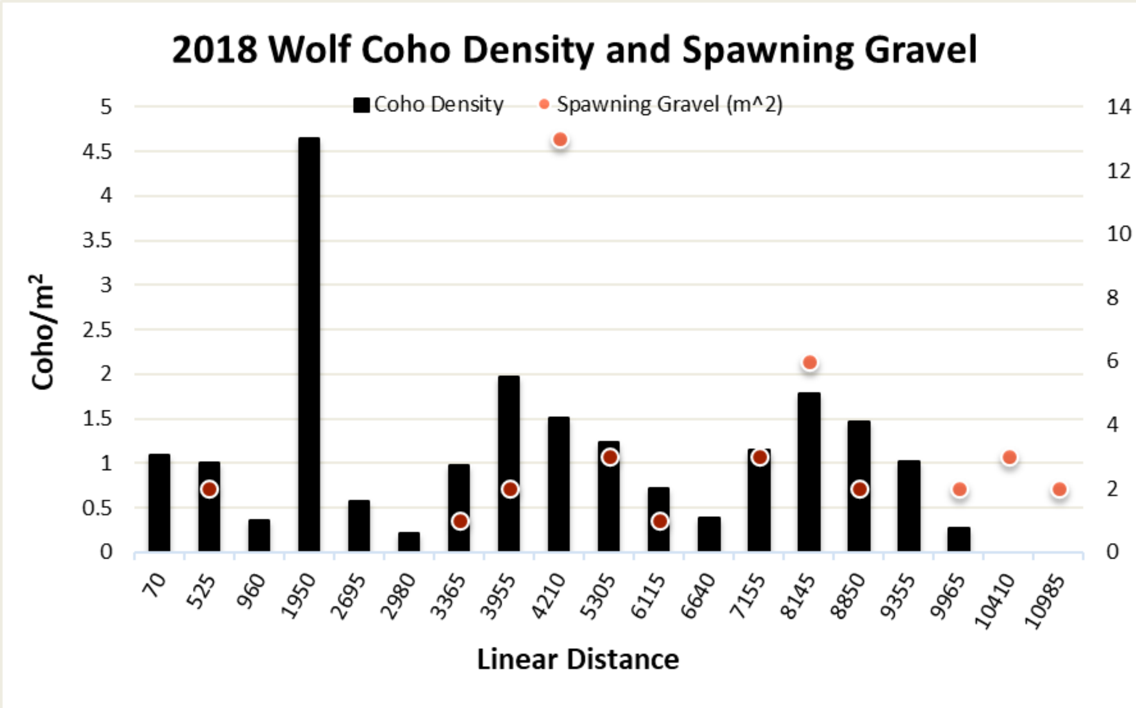

Figure 81: Wolf Coho Densities 2018

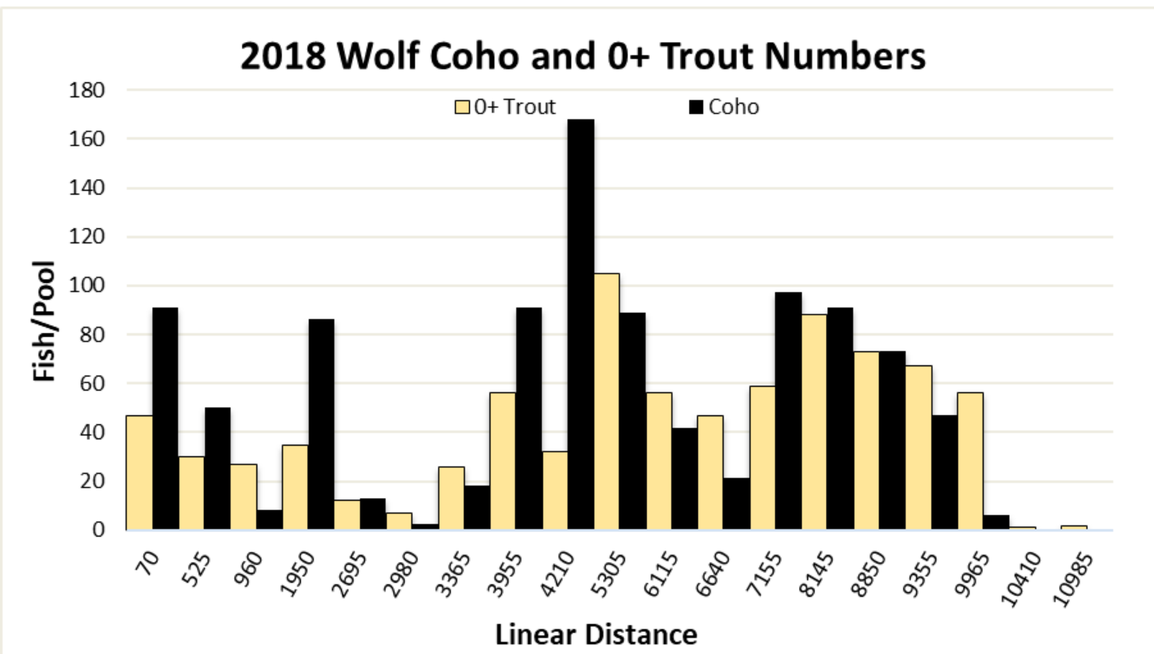

Figure 82: Wolf Coho and 0+ Trout Numbers 2018

Steelhead

Steelhead abundance was low at an average pool density of 0.08 fish/m² with intermittent pool presence throughout the range of anadromy. The highest density of 0.17 fish/m² was observed at RM 0.75. Steelhead counts expanded to 90 fish/mile.

Cutthroat

Cutthroat abundance was low with an average density of 0.04 fish/m² expanding to 24 fish/mile. The highest density of 0.09 fish/m² was observed at RM 0.18

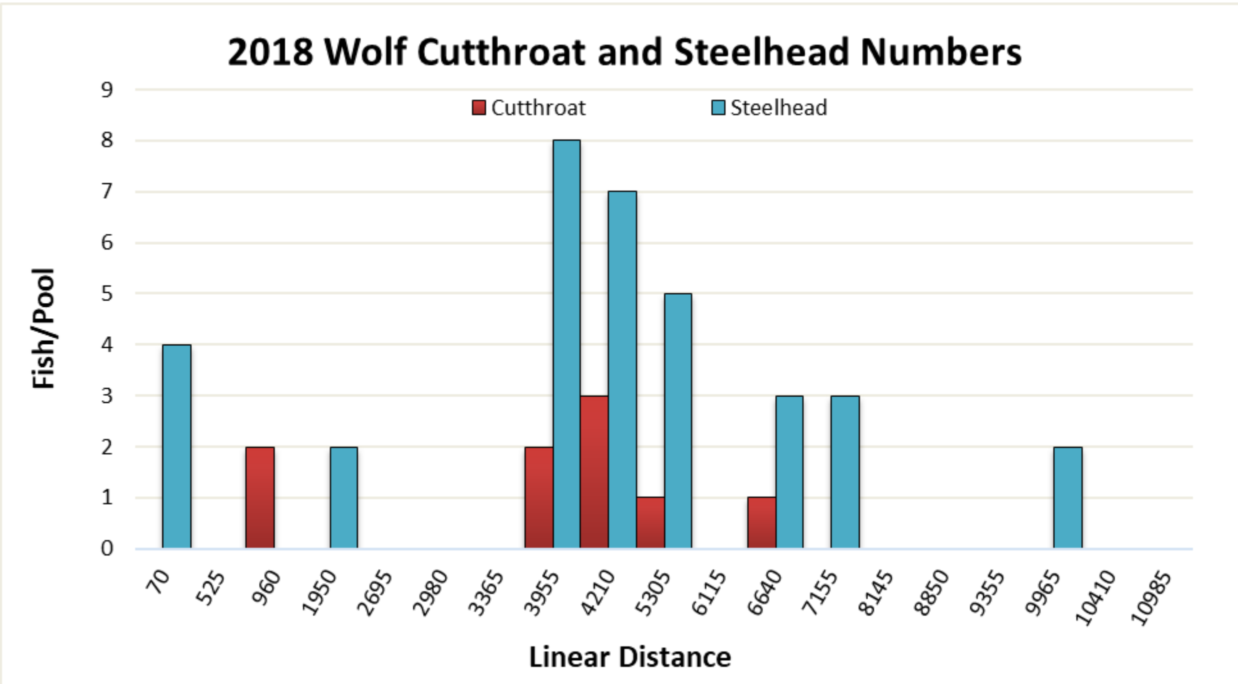

Figure 83: Wolf Trout Numbers 2018

0+ Trout

0+ trout abundance was high with an average density of 1.02 fish/m² expanding to 2185 fish/mile. The highest density of 2.46 fish/m² was observed at RM 1.89.

Chinook

Chinook were not observed

Table 45: Wolf (including Trib A)- Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	5070	1.2	4715	175	65	0

Tributary A

Trib A enters Wolf Creek on the upstream right bank at RM 1.6. The inventory extended 0.42 miles. Anadromous potential extended 0.22 miles to a series of 3ft, 4ft, and 5ft falls with shallow jump pools. A total of 3 m^2 gravel sites were documented within the range of anadromy. Coho abundance was low, likely the result of upstream juvenile migration. O+ trout abundance was high with an average density in the short reach of habitat below the falls of 2.9 fish/sqm. Steelhead and cutthroat abundance was low with intermittent pool presence.

Snark

Snark enters the Nehalem at RM 20.68 on the upstream left bank. The RBA inventory extended 0.32 miles upstream where gradient increases and flows were subsurface. Anadromous fish distribution extended 0.21 miles where surface flows diminish.

Habitat was characterized by high gradient (avg. 11.5%); low summer temperature profiles (16.5C); high wood complexity; low flows, subsurface in reaches; lateral channel migration confined by hillslope; and limited gravel sorting in pool tailouts.

Anchor Sites:

No Anchor Sites were observed. Hillslope confined throughout inventoried reach.

Photo 86 Hyporheicly Fed Pool at Confluence

Coho

Coho abundance was low overall. The highest density of 6.70 fish/m² was observed in the first pool sampled and the result of temperature dependent migrations from the Nehalem mainstem. This pool was to the side of the thalweg and fed by hyporheic flows collected in a bedrock/cobble pocket maintaining connectivity with the mainstem. In the main channel, subsurface flows through deep gravel accumulations at the confluence disconnected connectivity for temperature dependent fish migrations. Upstream, the three additional dive pools with coho presence had significantly lower abundance and densities averaging 0.49 fish/m².

Spawning Gravel and Escapement:

It is unlikely that any spawning event occurred in Snark creek. Distribution profiles suggest abundance upstream of the first sampled pool was also the result of an upstream temperature dependent migration. It is likely that juvenile coho accessed additional upstream habitats earlier in the year seeking refuge from high mainstem Nehalem flows. Estimated adult (combined male and female) carrying capacity based on spawning gravel availability was 3 – 10 adult coho.

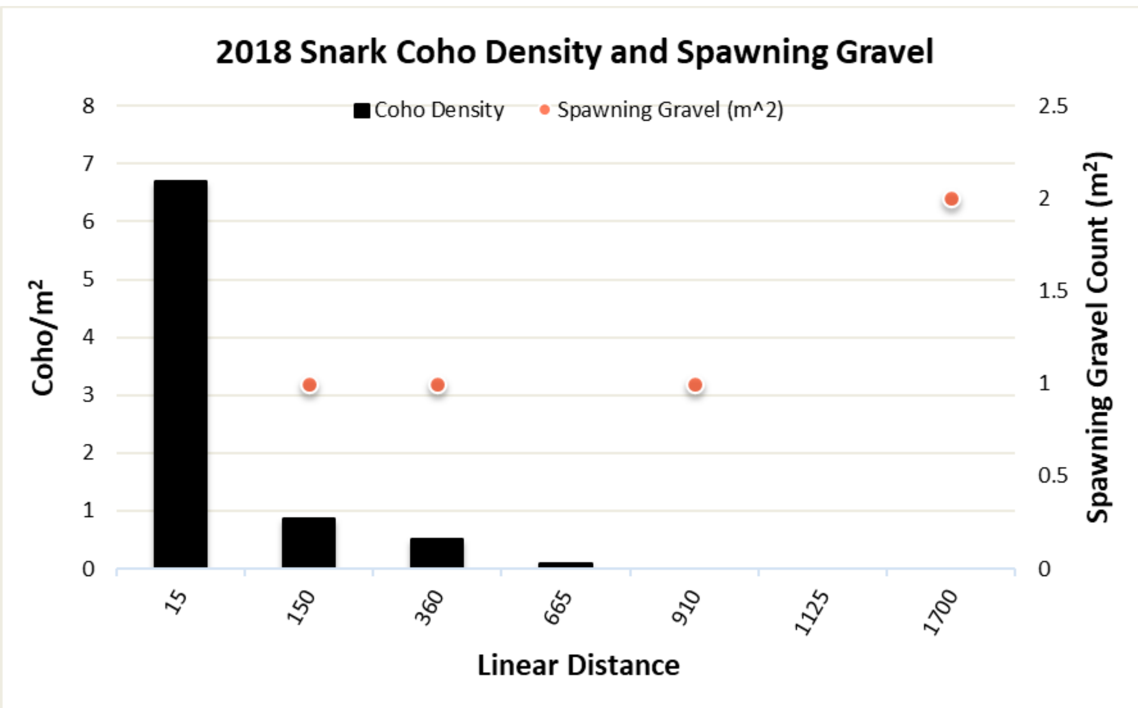

Figure 84: Snark Coho Densities 2018

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was moderate with an average density of 0.23 fish/m² expanding to 141 fish/mile. The highest density of 0.38 fish/m² was observed at RM 0.13.

0+ Trout

0+ trout abundance was low with an average density of 0.33 fish/m² expanding to 172 fish/mile. The highest density of 0.72 fish/m² was observed at RM 0.07.

Chinook

Chinook were observed in the first sampled pool (migrants from the mainstem).

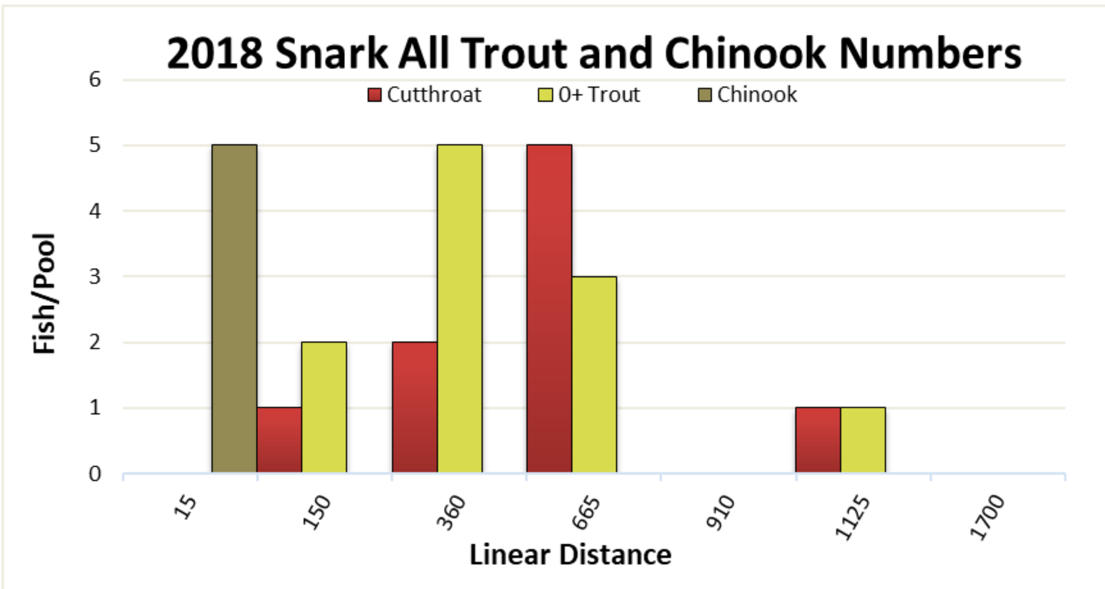

Figure 85: Snark Trout and Chinook Numbers 2018

Table 46: Snark - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	206	0.49	55	0	45	5

Spruce Run

Spruce Run enters the Nehalem at RM 30.04 on the upstream right bank. The RBA inventory extended 2.48 miles upstream. Anadromous fish distribution extended 2.35 miles where increased gradient and a 5-8ft boulder/ log jam falls limited further anadromous potential. Short reaches of three tributaries (South Fork, Trib A, and Trib B) exhibiting limited anadromous potential were included.

Spruce Run was identified as an important thermal refugia and rated as a high priority for future restoration efforts. Temperatures documented at the time of the inventory recorded a 7.7C differential from the mainstem Nehalem (15.6C – 23.3C). High numbers of coho, cutthroat and chinook were observed congregating in high densities in the mainstem Nehalem in the confluence plume. Channel complexity at the confluence plume was low providing very little cover and refuge from predation. Shallow flows through deep gravel and cobble depositions at the confluence limited access to temperature dependent migrants. Some evidence of upstream thermal migration was observed.

Stream habitat was characterized by moderate gradient (avg. 4%); low summer temperature profiles (15.6C – 17.2C); dominant substrates of boulder, cobble, and gravel with limited gravel sorting throughout most of the inventoried reach; moderate wood complexity of mostly deciduous origin; sinuous channel meander with braiding across floodplain terraces within Anchor Sites, hillslope confined throughout remainder; and alder dominated riparian.

Photo 87 Spruce Run Creek

Anchor Sites:

One Anchor Site extended above a boulder bedrock canyon pinch from RM 0.69 - RM 1.07. High densities of coho, steelhead, and cutthroat were documented rearing within this site. A function level rating of 2 (moderate) was given due to lack of large coniferous wood complexity. 82% of all estimated spawning gravels were observed within the Anchor site.

Coho

Coho abundance was high with an average pool density of 2.44 fish/m² expanding to 2415 fish/mile. This was the second highest average coho density documented in the 2018 Nehalem inventories. The peak density of 6.80 fish/m² was observed within Anchor Site #1 at RM 1.00. Spruce Run was a top producer of coho contributing 9.7% of the 2018 estimated coho population for the lower Nehalem while accounting for only 2.7% of the liner stream miles inventoried.

Spawning Gravel and Adult Escapement:

An estimated 53 adult (combined male and female) coho entered Spruce Run to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 16 – 44 coho indicating that adult escapement exceeded the subbasin's spawning gravel capacity for the 2017 brood year. This exceedance along with fully seeded pool rearing densities indicates that spawning gravel and summer rearing habitat (pool surface area) were functioning as co-limitations to coho production for the 2017 brood year.

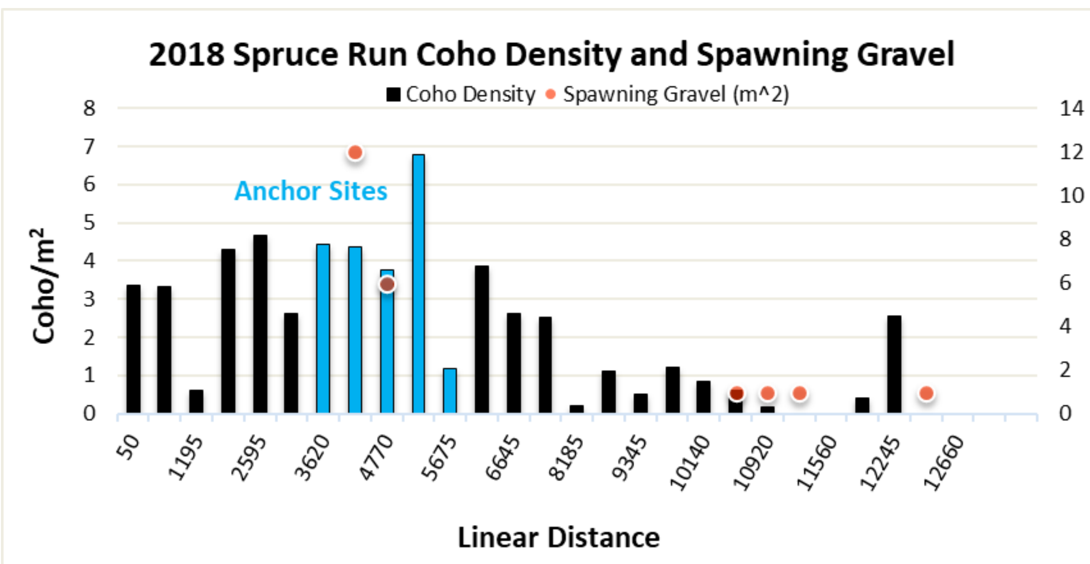

Figure 86: Spruce Run Coho Densities 2018

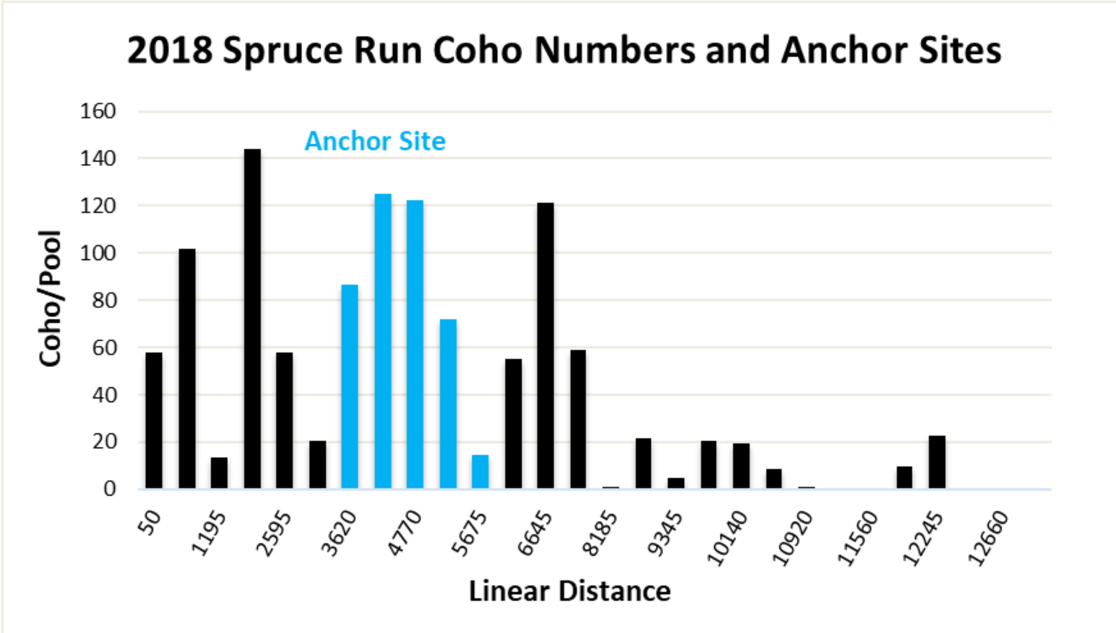

Figure 87: Spruce Run Coho Numbers 2018

Steelhead

Steelhead abundance was high at an average pool density of 0.29 fish/m² expanding to 206 fish/mile. This was the highest average steelhead density documented in the 2018 Nehalem inventories. The peak density of 0.77 fish/m² was observed at RM 0.6, just downstream of the anchor site.

Cutthroat

Cutthroat abundance was moderate with an average density of 0.19 fish/m² expanding to 105 fish/mile. The highest density of 0.66 fish/m² was observed at RM 1.07.

0+ Trout

0+ trout abundance was moderate with an average density of 0.64 fish/m² expanding to 605 fish/mile. The highest density of 1.42 fish/m² was observed at RM 1.00.

Chinook

Chinook were observed in the first two sampled pools.

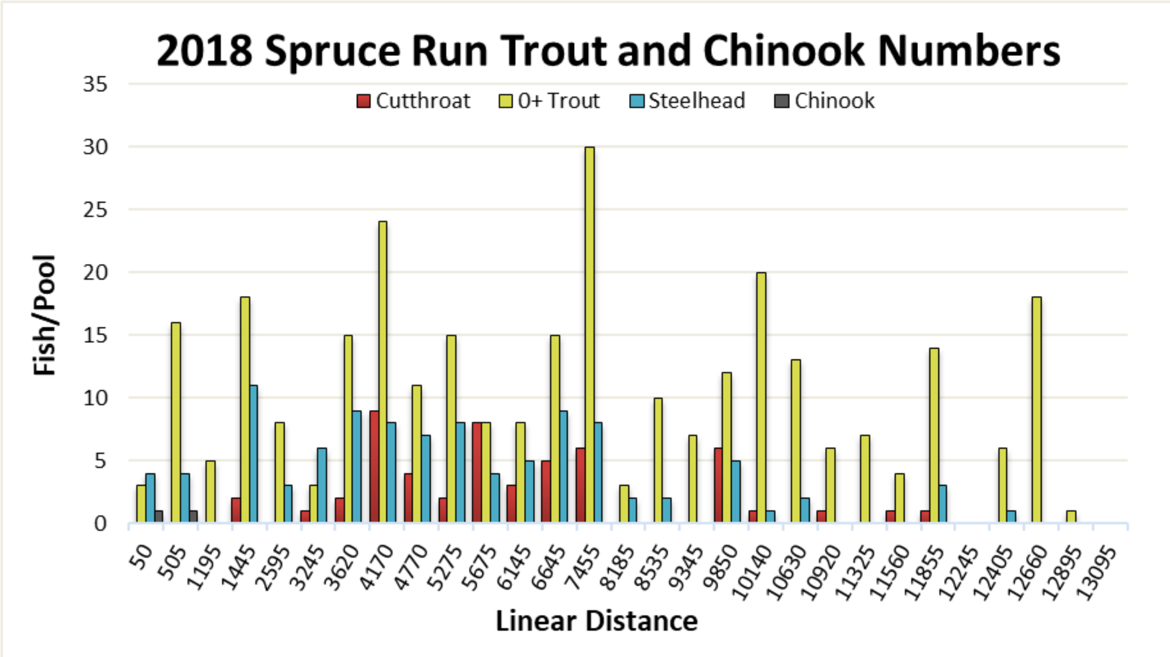

Figure 88: Spruce Run Trout Numbers 2018

Table 47: Spruce Run Subbasin- Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	5868	2.44	1645	510	285	10

South Fork Spruce Run

SF Spruce Run enters Spruce run on the upstream right bank at RM 1.62. The inventory continued 0.09 miles just upstream of a 4-foot boulder falls were channel flow disappears. No coho or steelhead were observed in this tributary, but 0+ trout and cutthroat were observed at low densities. Habitat exhibited low anadromous potential and was characterized by low flows, unsorted gravel, high gradient, and consecutive bedrock and boulder falls. 1 m^2 of spawning gravel was observed.

Tributary A

Trib A enters Spruce Run on the upstream right bank at RM 1.07. The survey continued 0.21 miles upstream where low flows and gradient increase over boulders limited further anadromous potential. No spawning sites were observed. Coho were present in low densities as well as 0+ trout and cutthroat. Trib A was characterized by low flows and low summer temperature profiles (12.8C) compared to the MS Spruce Run (17.2C), providing a significant cold-water contribution.

Tributary B

Trib B enters Spruce Run on the upstream right bank at RM 2.25. The survey extended 0.04 miles to a 10-foot bedrock falls, a permanent barrier to anadromy. Coho and 0+ were observed in Trib B below the falls. No spawning gravel was observed.

Nehalem Tributary P

Trib P enters the Nehalem at RM 28.4. The RBA inventory extended 0.94 miles upstream where a 4ft log jam falls and increased gradient limited further anadromous potential. Anadromous fish distribution extended to just below the falls.

Trib P was identified as an important thermal refugia and rated as a high priority for future restoration efforts. Temperatures documented at the time of the inventory recorded a 10C differential from the mainstem Nehalem (15C – 25C). The site covered a large area with high flows and high complexity in the form of brushy debris. Low numbers of coho (18 fish) were observed congregating in the mainstem Nehalem in the confluence plume. Simplified channel with low complexity pool habitats upstream from the mainstem Nehalem confluence limited potential for temperature dependent migrations. Some evidence of upstream thermal migration was observed with elevated densities documented in the first few sampled pools.

Photo 88 Trib P Confluence Plume

Stream habitat was characterized by moderate gradient (avg. 4%); lateral channel migration confined by hillslope; moderate wood complexity; dominant substrates of cobble and gravel with limited sorting in pool tailouts; and low summer temperature profiles (15C).

Anchor Sites:

No Anchor Sites were observed. Stream habitat was hillslope confined throughout inventoried reach.

Coho

Coho abundance was moderate with an average pool density of 0.83 fish/m² expanding to 709 fish/mile. The highest density of 2.86 fish/m² was observed at RM 0.75.

Spawning Gravel and Escapement:

An estimated 6 adult (combined male and female) coho escaped to Trib P to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was 9 – 28 coho.

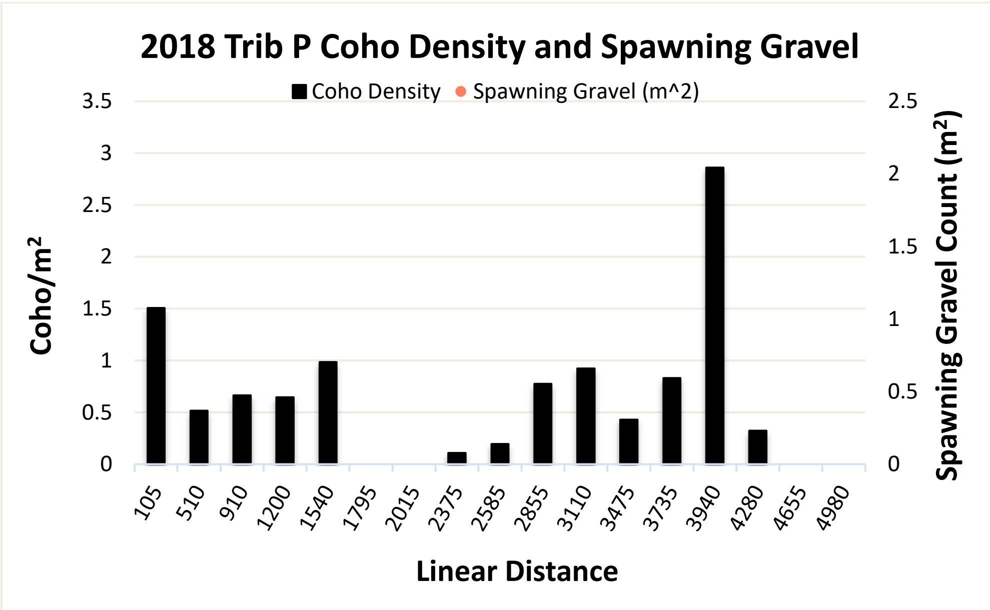

Figure 89: Nehalem Tributary P Coho Densities 2018

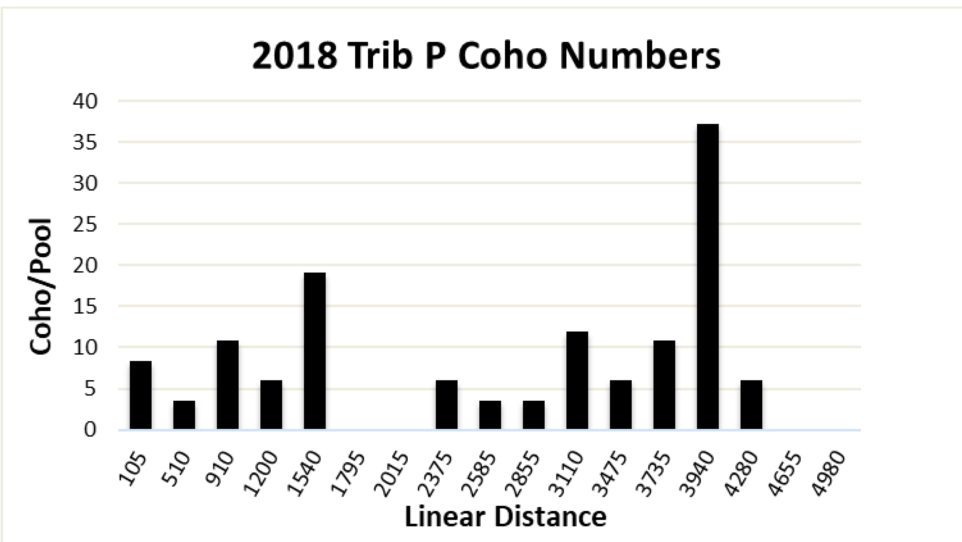

Figure 90: Nehalem Tributary P Coho Numbers 2018

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was low with an average density of 0.13 fish/m² expanding to 106 fish/mile. The highest density of 0.23 fish/m² was observed at RM 0.75.

0+ Trout

0+ trout abundance was low with an average density of 0.25 fish/m² expanding to 245 fish/mile. The highest density of 0.86 fish/m² was observed at RM 0.54.

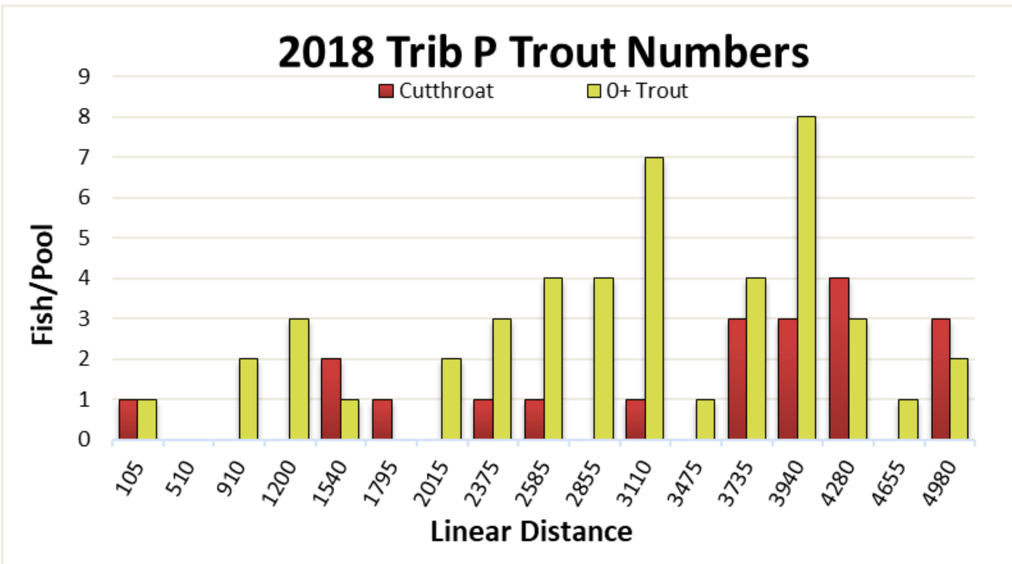

Figure 91: Nehalem Tributary P Trout Numbers 2018

Chinook

Chinook were not observed

Table 48: Nehalem Tributary P - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m²	0+ Trout	Steelhead	Cutthroat	Chinook
2018	666	0.83	230	0	100	0

North Fork Nehalem Subbasin

The NF drainage area above tidal influence encompasses 85 square miles in Tillamook County, Oregon (USGS Streamstats). Approximately 94% of the land cover is in timber production or forested/shrublands and only 1% is cultivated.

The 2019 RBA inventory of the North Fork Nehalem subbasin covered all stream habitats exhibiting anadromous potential. This amounted to 78 linear miles of streams, including 18.8 miles of mainstem North Fork Nehalem and 16 significant tributaries.

Coho and cutthroat production trends within the tributaries were consistent with that of the mainstem, rearing 78.54% of the subbasin totals for coho and 77.3% for cutthroat while comprising 75.9% of the total inventoried stream miles. This was not the case for steelhead, 0+ trout and chinook where only 29.3% of the subbasin totals for steelhead, 49.3% for 0+ trout, and 5.76% for chinook were observed rearing in the tributaries. Each of the tributaries will be reviewed separately below.

Spawning Gravel and Escapement for the Entire North Fork Nehalem Subbasin:

An estimated 639 adult (combined male and female) coho escaped into the North Fork subbasin to spawn for the 2018 brood year. Estimated adult carrying capacity based on spawning gravel availability was 798 – 2,394 adults.

Table 49: North Fork Nehalem and Tributaries – 2019 Expanded Fish Counts for all Salmonid Species

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
NF Nehalem (MS)	14900	21.19	10585	50.70	2715	70.68	1005	22.67	360	94.24
Side Channels	190	0.27			1	0.03				
Acey	2						1	0.02		
Anderson	318	0.45	240	1.15	15	0.39	95	2.14		
Boykin	3072	4.37	60	0.29			125	2.82		
Trib A	42	0.06	10	0.05						
Trib B	12	0.02	20	0.10			5	0.11		
Buchanan	1442	2.05	1545	7.40	150	3.91	29	0.65	10	2.62
Soapstone	7094	10.09	910	4.36	140	3.64	340	7.67		
Jack Horner	3150	4.48	320	1.53	20	0.52	70	1.58		
Trib A	54	0.08	5	0.02			11	0.25		
Trib B	3684	5.24	150	0.72	10	0.26	135	3.05		
Trib B1	6	0.01	20	0.10						
Trib C			20	0.10						
Trib D			5	0.02						

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
Trib E	18		10							
Trib F	60		10							
Coal	8328	11.9	2785	13.3	300	7.8	430	9.7	10	2.6
West Fork Coal	2466	3.5	1431	6.9	80	2.1	386	8.7		
Trib A	48		70				5			
Cougar							2			
Fall 1			75				5			
Fall 2	840	1.2	175		80	2.1	60	1.4		
God's Valley	4077	5.8	45		10		105	2.4		
Trib A	1010	1.4	30				20			
Trib B	132		15				15			
Trib C	114		30				30			
Trib D	246						5			
Trib D1	120		15				10			
Trib E	282		10				10			
Trib F	6		10				5			
Grassy Lake	71		55		45	1.2	7		2	
Gravel	1042	1.5	255	1.2			170	3.8		
Henderson	516		145				45	1		
Trib A			25				15			
Little North Fork	7070	10.1	380	1.8	90	2.3	350	7.9		
Side Channels	69									
Trib A			16							
Trib B			5				5			
Trib C	480		20				55	1.2		
Trib C1	30		5				30			
Trib D	606		20				55	1.2		
Trib D1			5							
Trib E	54						15			
Trib F	5						5			
Little Rackheap	690	1	30		10		80	1.8		
Big Rackheap	150		35				5			
Lost	588		355	1.7			125	2.8		
Trib A			5							
Sally	690	1	5				10			

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
Trib A	270		10				35			
Trib B	36									
Sean's	72		180				1			
Sweethome	4380	6.2	355	1.7	135	3.5	190	4.3		
Trib A			15				5			
Trib C	6		5				5			
Trib D	522		20				70	1.6		
Trib F			30							
Trail										
NF Trib B	720	1	100		40	1.04	130			
NF Trib B1	6		20				5			
NF Trib D	162		5				10			
NF Trib E	98						10			
NF Trib F	24									
NF Trib G	54									
Trib G1	180		5				1			
Inventory Total	**70304**		**20707**		**3841**		**4338**		**382**	

- Percent contributions are indicated for only those sub-basins that contributed 1% or greater of the total.

- 20% visual bias included for coho expansion

North Fork Nehalem Mainstem

North Fork Nehalem enters the Nehalem at RM 2.75 within tidal influence. The North Fork RBA began at the approximate end of tidal influence, at RM 5.8. The inventory extended 18.8 miles upstream to RM 25.1 where reduced channel size and low subsurface flows limited further anadromous spawning and rearing potential. Anadromous fish distribution extended 18.78 miles with no permanent barrier to adult passage observed. Several significant partial barriers to fish passage were documented.

Photo 89 North Fork Start point RM 5.8

Three natural waterfalls were observed at RM 8.4 (3ft falls); RM 12.2 Waterhouse Falls (9ft) with fish ladder and trap; and RM 16.75 Fall Creek Falls (15ft) with fish ladder and trap. None of these falls present a permanent barrier to adult migration. Because both Waterhouse Falls and Fall Creek Falls function as partial migration barriers, not all hatchery fish can be captured at these fish traps and significant numbers are observed upstream on the spawning beds. From 1995 – 2010, percentages of hatchery strays among all adult coho spawners (combined wild and hatchery) upstream of Waterhouse falls ranged widely from 4.7% - 68% (avg. 25.5%). Additionally, during most of these years (1995-1998, 2004-2010, and through 2016) significant numbers of hatchery strays had been removed from the spawning population at the Waterhouse Falls Fish trap. During this same period, stray rates from the hatchery were 15.6% - 61.7% (avg. 36.2%) of total returning hatchery adult coho (Salmonid Life Cycle Monitoring in Western Oregon Streams, 2015). Since spring of 2017, no hatchery strays have been sorted at the traps resulting in even higher percentages of hatchery fish on the spawning beds upstream of Waterhouse and Fall Creek Falls. As would be expected, percentages of hatchery fish spawning with wild fish in the lower North Fork system (downstream of the fish traps/falls), where trapping is not an option, have historically exceeded those documented in the upper North Fork system (upstream of fish traps/falls).

Photo 90 Waterhouse Falls and Fish Trap

Abundance profiles suggest that the lower falls at RM 8.4 (3ft) was functioning as barrier to temperature dependent upstream juvenile migration. The highest chinook count (45 fish) and second highest 1+ steelhead count (53 fish) were documented in the pool below this falls. Adult cutthroat however are able to pass this natural falls in an upstream temperature dependent migration only to be terminated at the hatchery dam two miles upstream.

Photo 91 North Fork Falls at RM 8.4

At the fish hatchery (RM 10.4) there is a 1ft low head dam constructed of concrete with a shallow jump pool at the base. In the summer months, this dam is expanded vertically with wooden boards stacked on top (adding an additional one foot in height) to provide additional depth to the dammed pool for diverting flow to the hatchery. This dam is also functioning as a juvenile and adult barrier to passage in a temperature limited reach (18.4C). The highest pool counts for steelhead (85 fish) and cutthroat (140 fish); and the second highest pool counts for coho (384 fish) and 0+ trout (250 fish) were documented in the pool below this dam. The cutthroat observed concentrated below the barrier were primarily adult fluvial or searun components of the population seeking critical thermal refuge upstream. Additionally, four fin-clipped rainbows (residualized precocial males), two adult chinook, and one fin-clipped adult summer steelhead were also observed.

Photo 92 North Fork Hatchery Dam

Stream habitat throughout most of the inventoried reach below RM 21.5 was characterized by low gradient (avg. 0.78%); long reaches of scoured bedrock (resultant legacy of splash damming); dominant substrates of bedrock, boulder, cobble, and gravel; low habitat complexity (a lack of large wood); lateral channel migration constrained by channel incision, sheer canyon walls, and steep hillslope; and mixed temperature profiles from 13.9C – 18.5C with temperature limitations observed upstream to about the confluence of Lost Creek (RM 14.25).

Photo 93 Lower Nehalem Scoured Bedrock at Cougar Creek Confluence

Photo 94 North Fork Mainstem RM 18.7

Upstream of RM 21.5 throughout the remaining 4.6 miles of the inventory stream habitat was characterized by low gradient (avg. 0.54); beaver occupation with 15 active full spanning dams; sinuous channel meander across wide floodplain; high channel complexity; high tannins; low flows, subsurface in sections; low summer temperature profiles; and dominant substrates of cobble, gravel, sand, and silt. It should be noted that above the Little North Fork confluence (RM 20.8) high tannins reduced snorkeler visibility and total salmonid abundance was likely underestimated.

Photo 95 North Fork LWD Treatment, Confluence Trib E

Photo 96 Upper North Fork

Anchor Sites:

Eight anchor sites were observed. Anchor sites #1 through #6 extended for short reaches and exhibited low functionality due to lack of large wood complexity and limited spawning gravel.

Anchor Site #1 extended about 500ft upstream from RM 9.6.

Anchor Site #2 extended about 400ft upstream from the confluence of Sweethome Creek at RM 15.5.

Anchor Site #3 extended about 0.2 miles upstream from RM 15.8

Anchor Site #4 extended about 950 ft upstream from RM 17.1.

Anchor Site #5 extended about 576ft upsteam from RM 17.3

Anchor Site #6 extended about 650ft upstream from RM 18.6.

Anchor sites #7 and #8 were almost back to back and extended from RM 23.4 to RM 24.3. These two anchor sites exhibited moderate to low functionality due to deep channel incision and reduced summer flows. Beaver occupation in this reach was functioning to elevate the active channel above the incised banks and reconnect with the historic floodplain. Without active beaver dams in this reach channel incision would negate anchor site classification.

Photo 97 North Fork Confluence with Sweethome Creek, Anchor Site #2

Side Channels

Side channel habitat was limited in the North Fork mainstem. Four short side channels included in the inventory were documented rearing a total of 190 coho. All but Side channel A consisted of one isolated pool. Side channel A entered at RM 6.9, consisted of four pools, and extended for 550ft.

Coho

Coho abundance was low overall with an average pool density of 0.28 fish/m^2 expanding to 793 fish/mile. The highest density of 4.52 fish/m^2 was observed at RM 24.4. This high density was located within a reach with low intermittently subsurface flows and likely the result of pool isolation and surface area reduction. Above the Little NF confluence (RM 20.8) density profiles increased though abundances decreased significantly.

Highest production was documented between the confluences of Sweethome (RM 15.5) and the Little North Fork (RM 20.8). Abundance in this 5.3 mile reach expanded to 1,462 fish/mile. Anchor Sites #2 – #6 were located within this reach.

The highest pool count (522 coho) was observed in the pool at the confluence of Buchannan Creek (RM 10.6). This confluence pool was the highest value thermal refugia documented in the

North Fork subbasin. A 2.3C temperature differential was observed at the time of the inventory with Buchanan at 16.1C and the NF mainstem at 18.4C.

Spawning Gravel and Adult Escapement for North Fork Nehalem Mainstem:

An estimated 138 adult (combined male and female) coho escaped into the North Fork Mainstem to spawn. Estimated adult carrying capacity based on spawning gravel availability was 136 - 408 adult coho.

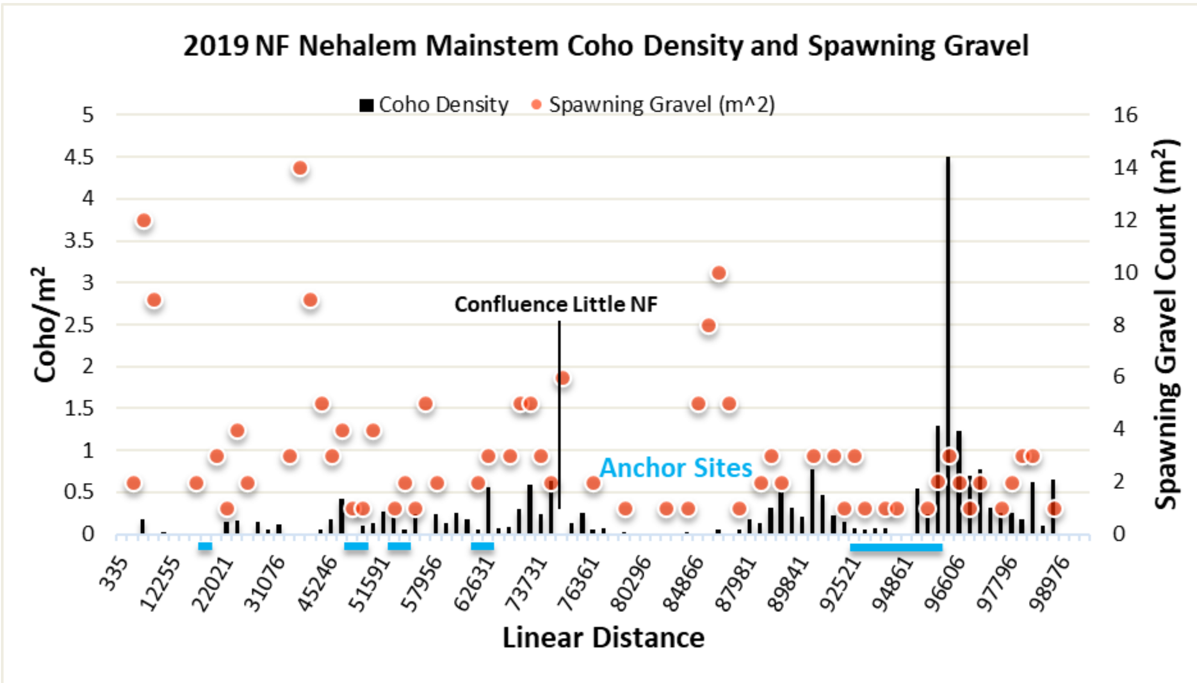

Figure 92: North Fork Nehalem Mainstem Coho Densities 2019

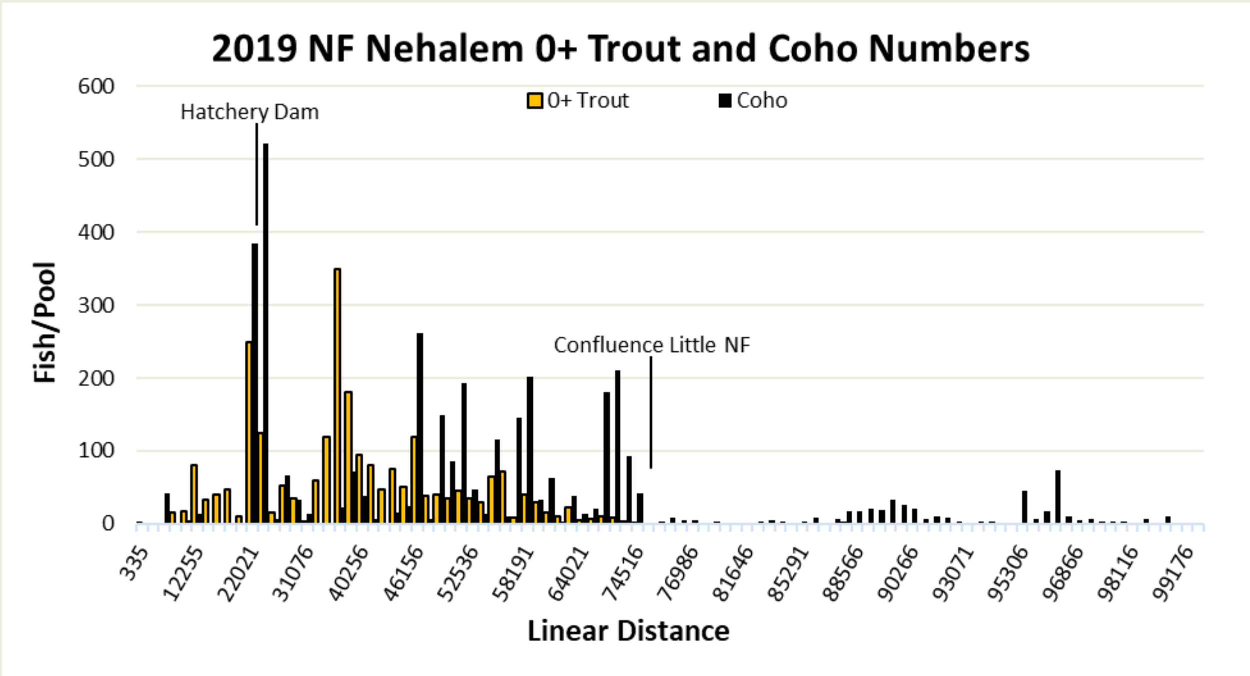

Figure 93: North Fork Nehalem Mainstem Coho and 0+ Trout Numbers 2019

Steelhead

Steelhead abundance was low at an average pool density of 0.03 fish/m^2 expanding to 190 fish/mile throughout their range of distribution. No steelhead were observed above the Little North Fork confluence. Highest production was documented between the hatchery pool at RM 10.4 and RM 13.5. Abundance in this 3.1 mile reach was high and expanded to 397 fish/mile, though densities were still well below full seeding capacities averaging 0.07 fish/m^2.

Additionally, two adult summer steelhead and eight resident rainbows (5 fin clipped precocious males) were observed in the lower mainstem below Waterhouse Falls RM 12.2.

Cutthroat

Cutthroat abundance was low with an average density of 0.02 fish/m^2 expanding to 54 fish/mile. The highest density of 0.14 fish/m^2 was observed at RM 20.7 just below the the Little North Fork confluence. The highest pool count (140 fish) was documented below the hatchery dam. This count was comprised of primarily large older age class fluvial and searun adults greater than 12 inches in length.

Above the Little North Fork abundances decreased significantly.

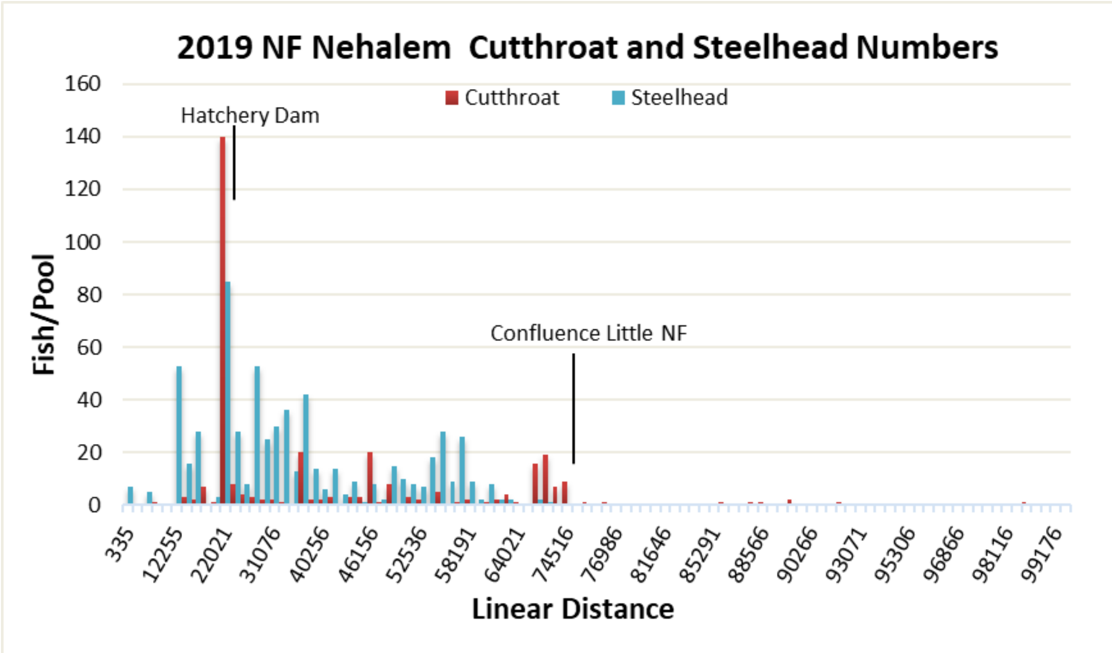

Figure 94: North Fork Nehalem Mainstem Steelhead and Cutthroat Numbers 2019

0+ Trout

0+ trout abundance was low with an average density of 0.11 fish/m^2 expanding to 745 fish/mile throughout their range of significant distribution. The highest density of 0.45 fish/m^2 was observed around RM 15.2. Highest production was documented between the confluences of God's Valley (RM 13.3) and Sweethome (RM 15.5). Abundance in this 2.2 mile reach expanded to 2,740 fish/mile and included the highest pool count of 350 fish. The lowest production was documented above the Little NF confluence where very few 0+ trout were observed.

Chinook

Chinook distribution extended to RM 14. Abundance was low and sporadic in pools. A total of 8 sampled pools within the NF Nehalem contained Chinook. The highest pool count was observed below the 3ft falls at RM 8.4.

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	15,090	0.28	10,585	2,716	1,005	360

Minor Tributaries of the North Fork Nehalem (Expanded Coho Counts of < 200)

Several inventoried tributaries exhibited anadromous potential but either lacked coho distribution or had low coho abundance (less than 200 expanded). A condensed review of these tributaries is provided below. See Table 49 for all tributaries surveyed for anadromy and the Access Database for additional information on tributaries.

Acey

Acey enters the NF Nehalem on the upstream right bank at RM 4.18. The creek consists of a tidal marshland for 0.22 miles with agricultural land on either side. Cows are fenced out of the marsh. Culverts with open tide gates were observed. Tannins and turbidity limited visibility in this reach. Coho may be present in this reach. The channel becomes defined but still stagnant at about RM 0.22.

Habitat is characterized by slow moving water, low visibility, blackberry and reed canary grass, aquatic vegetation in the channel, and beaver occupation. At RM 1.44 the channel begins to rise out of pastureland marsh with gravel and sand substrates in the active channel. Two coho were seen. Above RM 1.54, the channel is a blackberry ditch with low flows.

No definitive barriers were encountered, and the marshland section of this creek is likely providing rearing habitat for nomadic coho, however no spawning gravel was observed.

Fall 1

Fall (1) enters the NF Nehalem on the upstream left bank at RM 4.06. No Coho were observed in Fall. The survey began at the confluence, where no barrier to passage was encountered, but access for the survey was denied from just upstream of the confluence to RM 0.18. It is possible that a barrier to adult migration exists in this segment.

The survey continued upstream from RM 0.18 to RM 0.69 with high quality habitat observed. Abundant gravel was observed with limited sorting (total $5m^2$ of spawning gravel), and pools were generally shallow with moderate wood complexity. Two Anchor Sites were documented characterized by wide floodplains, alder flats, and sinuous channel meander. Anadromous potential extended to a geologic pinch with large log jams at RM 0.69.

Cougar

Cougar enters the NF Nehalem on the upstream left bank at RM 8.0 with substantial flow. A 12-foot bedrock falls at the mouth of Cougar is a permanent anadromous barrier. No coho were observed above the falls.

Cougar Creek was identified as a valuable cold-water contribution in a temperature limited reach of the mainstem North Fork. A 4C temperature differential was measured at the time of the inventory with Cougar at 14C and the mainstem NF Nehalem 18C. No pool exists below the 12-foot falls, and scoured bedrock in the NF Nehalem mainstem funnels much of the cold water from Cougar into a bedrock slot below the confluence which was 16C at the time of survey. In this cold-water plume, 4 coho, 38 0+ trout, 2 cuts, 2 steelhead were observed. Above the falls (up to RM 0.08), the channel was entirely bedrock with some pockets of gravel and sand. Young conifers were present outside the riparian.

Grassy Lake

Grassy Lake enters the NF Nehalem on the upstream left bank at RM 7.25. The confluence was low gradient with high flows over cobble and gravel. Grassy Lake was identified as a valuable cold-water contribution in a temperature limited reach of the mainstem North Fork. Surveyors recorded a 3C temperature differential measured at the time of the inventory with Grassy Lake 15C while mainstem NF Nehalem was 18C.The survey continued 0.09 miles upstream to a 30 ft bedrock falls functioning as a permanent anadromous barrier. High densities of coho 2.44 fish/m^2, 0+ trout 1.73 fish/m^2, and steelhead 1.15 fish/m^2; and low densities of cutthroat and chinook were observed in the plunge pool below the falls. Two fin-clipped steelhead were also documented, (one 1+ and one 2+ years old) indicating that the straying of residualized hatchery releases is resulting in competition for thermal refuge with natural stocks. No spawning gravel was observed.

Sean's

Sean's enters the NF Nehalem on the upstream left bank at RM 12.4. The survey continued 0.22 miles upstream where a 7-foot bedrock falls with shallow jump pool limits further anadromous potential. Throughout the short inventoried reach, 12 m^2 of spawning gravel was documented. Coho densities were low, however 0+ trout densities were high (avg. 2.22 fish/m^2) in pools above coho distribution. Habitat was characterized by reaches of scoured bedrock and moderate wood complexity with accumulations of sorted gravel associated with bedrock intrusions.

Trail

Trail enters the NF Nehalem on the upstream left bank at RM 8.2. At the Confluence is a 15-foot slide/falls terminating further anadromous potential. Trail Creek was identified as a valuable cold-water contribution in a temperature limited reach of the mainstem North Fork. Temp was 15C and the NF Mainstem was 17.5C. 54 0+ trout, 1 cutthroat, and 5 steelhead were observed in the cold-water plume at the confluence. Hundreds of tadpoles were noted in the shallow bedrock pockets around the confluence. The survey continued 0.29 miles upstream. Immediately above the bedrock slide was approximately 250 ft of scoured bedrock channel. At mile 0.22, the floodplain opens, and the stream flattens into a wide channel with a low terrace height. 0+ trout were observed throughout the survey with increased abundance in the higher quality habitat.

Trib C

Trib C enters the NF Nehalem on the upstream left bank at RM 22.8 with a 4 ft beaver dam at the mouth. The survey continued 0.06 miles upstream to a 1ft wide culvert with a beaver dam at the upstream end. Above the culvert is a huge beaver complex dominated by sedges and rushes. Coho were not observed.

Trib D

Trib D enters the NF Nehalem on the upstream right bank at RM 23.5. The survey extended 0.38 miles upstream where low flows and lack of spawning gravel limited further anadromous potential. Coho were present through the survey at low densities (0.79 fish/m^2) and 4 m^2 of spawning gravel was observed. Habitat was characterized by beaver activity, an incised channel (4ft), and substrates of cobble/gravel. Coho abundance was likely the result of one spawning event with low egg to fry survival.

Trib E

Trib E enters the NF Nehalem on the upstream left bank at RM 23.9. The survey extended 0.46 miles upstream where anadromous distribution is ended by a culvert perched 2 feet with water pouring directly onto boulder. Coho abundance was low with intermittent pool presence at an average density of 0.46 fish/m^2. Low intermittently subsurface flows with isolated pools were documented throughout the inventory. A total of 4m^2 of spawning gravel was documented. Limited anadromous potential extended above the culvert.

Trib F

Trib F enters the NF Nehalem on the upstream right bank at RM 24.1. The survey extended 0.06 miles upstream where small channel size and low flow (dry between pools) limited anadromous potential. Coho were only observed in the first sampled pool.

Anderson

Anderson enters the NF Nehalem on the upstream left bank at RM 1.5. The RBA inventory began at the head of tide and extended 1.82 miles upstream where a series of steep cascades with boulder and log jams limited further anadromous spawning and rearing potential. Anadromous fish distribution extended 1.36 miles.

Stream habitat was characterized by low gradient (avg. 2.5%); low summer temperature profiles (14.5C – 15C); thin riparian (blackberry and willow) in lower 0.39 miles of pasture lands and well forested riparian in upper reach; low large wood complexity; incised channel with sinuous meander across floodplain; and dominant substrates of cobble and gravel with lack of gravel sorting in pool tailouts. The first sampled pool contained the highest density of coho indicating usage of Anderson Creek as thermal refuge.

Anchor Sites:

One moderately functioning Anchor Site was observed on Anderson from RM 0.9 – 1.23. Lack of large wood complexity and lack of suitable spawning gravel was observed.

Coho

Coho abundance was low with an average pool density of 0.3 fish/m^2 expanding to 234 fish/mile. The highest density of 0.78 fish/m^2 and high pool count (34 coho) was observed in the first sample pool and accounted for 53% of the population estimate. This pool was within tidal influence. This distribution profile indicates upstream juvenile migration from the mainstem North Fork and the use of Anderson as thermal refugia by nomadic components of the coho population expressing an important alternate life history strategy. These estuary rearing fish were likely not the progeny of a spawning event in Anderson Creek

Spawning Gravel and Adult Escapement:

Coho abundance observed in the first sampled pool was likely the result of upstream juvenile migration and was not included in the adult escapement estimate. Coho abundance observed upstream of the first sampled pool was likely the result of one spawning event with low egg to fry survival. No spawning gravel sites were observed. Unsorted gravel was observed in pool tailouts within Anchor Site 1. A 0.5-mile section of the stream was not surveyed due to denied landowner access. It is possible that this reach contained suitable spawning gravel that was not included in our estimate.

This large tributary exhibited significantly much higher summer rearing capacity for juvenile coho than was observed in the 2019 inventory. Anderson Cr is currently spawning gravel limited from the lack of wood complexity required to sort the available mobile substrates.

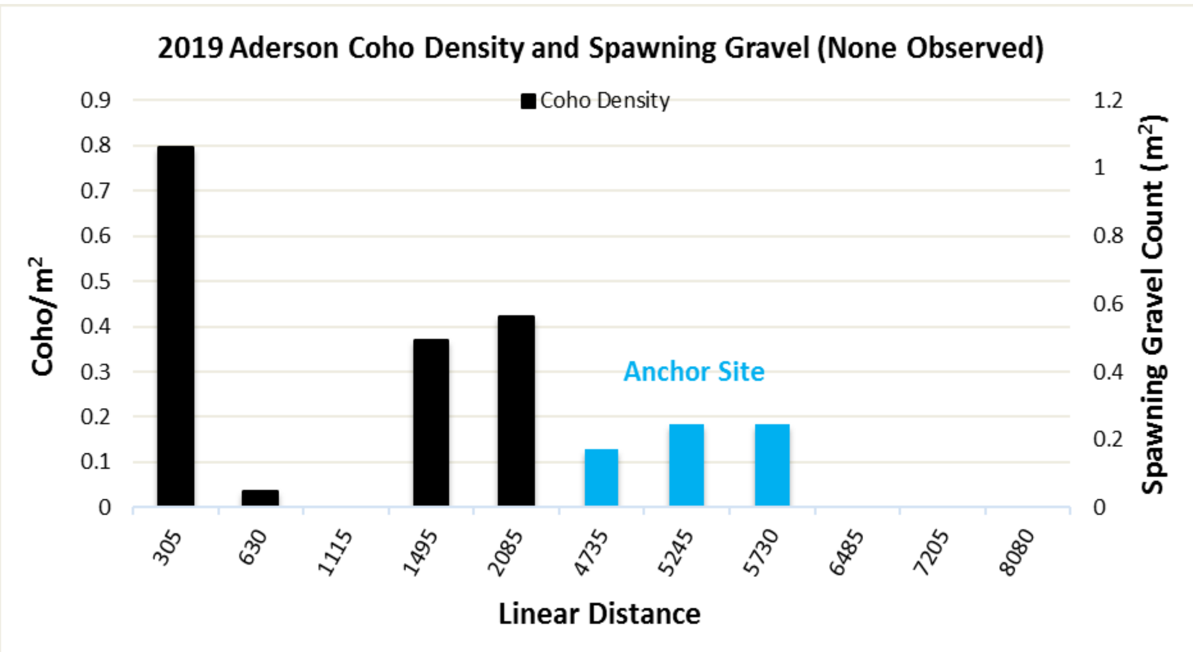

Figure 95: Anderson Coho Densities 2019

Steelhead

Steelhead were observed in only two sampled pools. Abundance was low at an average pool density of 0.06 fish/m^2.

Cutthroat

Cutthroat abundance was low with an average density of 0.18 fish/m^2 expanding to 52 fish/mile. The highest density of 0.43 fish/m^2 was observed at RM 1.53.

0+ Trout

0+ trout abundance was low with an average density of 0.22 fish/m^2 expanding to 131 fish/mile. The highest density of 0.10 fish/m^2 was observed at RM 1.23

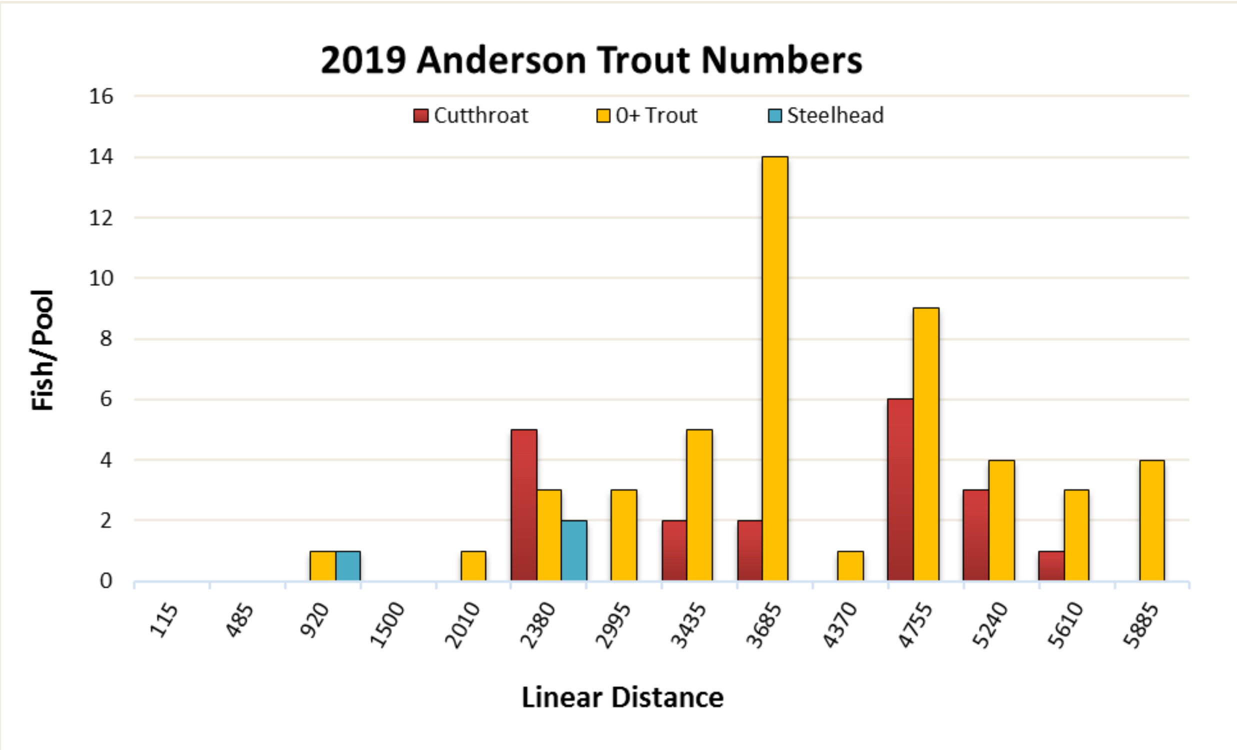

Figure 96: Anderson Trout Numbers 2019

Chinook

Chinook were not observed.

Table 50: Anderson - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	318	0.3	240	15	95	0

Boykin

Boykin enters the NF Nehalem on the upstream left bank at RM 5.1. The RBA of Boykin extended 1.69 miles upstream where increased gradient coupled with several four-foot bedrock steps limited further anadromous potential. Anadromous fish distribution extended to the bedrock steps. Short reaches of two tributaries were included in the inventory and are discussed below the expanded fish count table.

Stream habitat was characterized by moderate to high gradient (avg. 4.4%); high flows; dominant substrates of boulder, cobble, and gravel with gravel sorting in pool tailouts; low summer temperature profile (15C); sinuous channel meander across the floodplain; high wood complexity (LWD treatment); incised erodible banks; and an alder dominated riparian.

Photo 98 Boykin Creek High Channel Complexity

Anchor Sites:

None were observed on Boykin. Stream habitat was hillslope confined throughout most of inventoried reach.

Coho

Coho abundance was high with an average pool density of 1.04 fish/m^2 expanding to1828 fish/mile. The highest density of 2.58 fish/m^2 was observed at RM 1.14. The dominant spawning reach with the highest coho densities was observed within the LWD treatment reach. The highest pool count was documented in a beaver pool at RM 0.2.

Spawning Gravel and Escapement:

Estimated adult (combined male and female) coho escapement for Boykin was 28 coho. Estimated adult carrying capacity based on spawning gravel availability was 23 - 68 adult (combined male and female) coho.

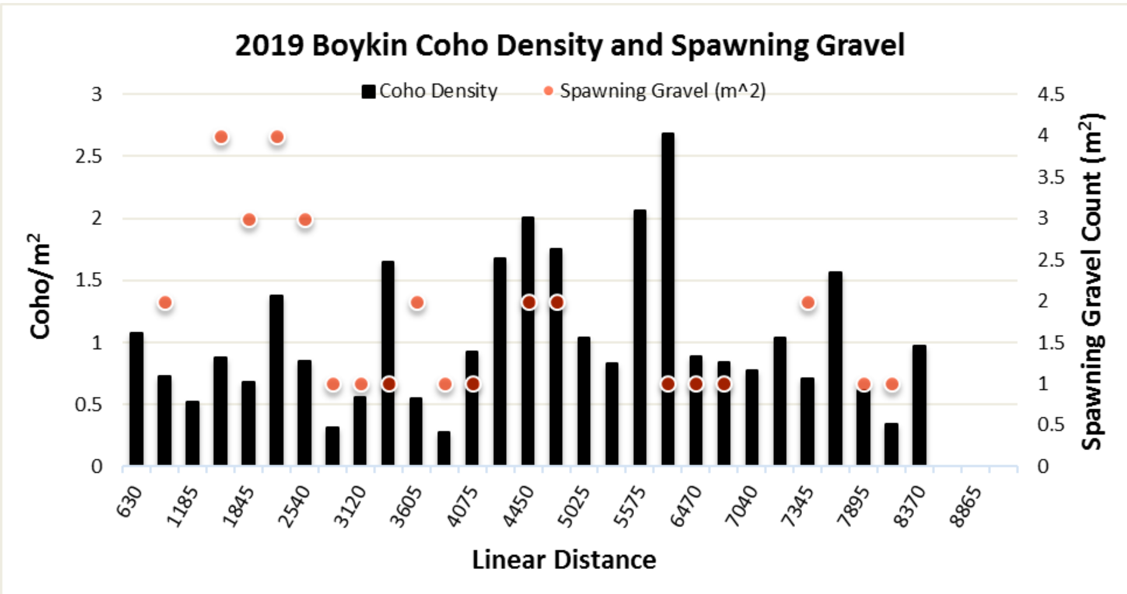

Figure 97: Boykin Coho Densities 2019

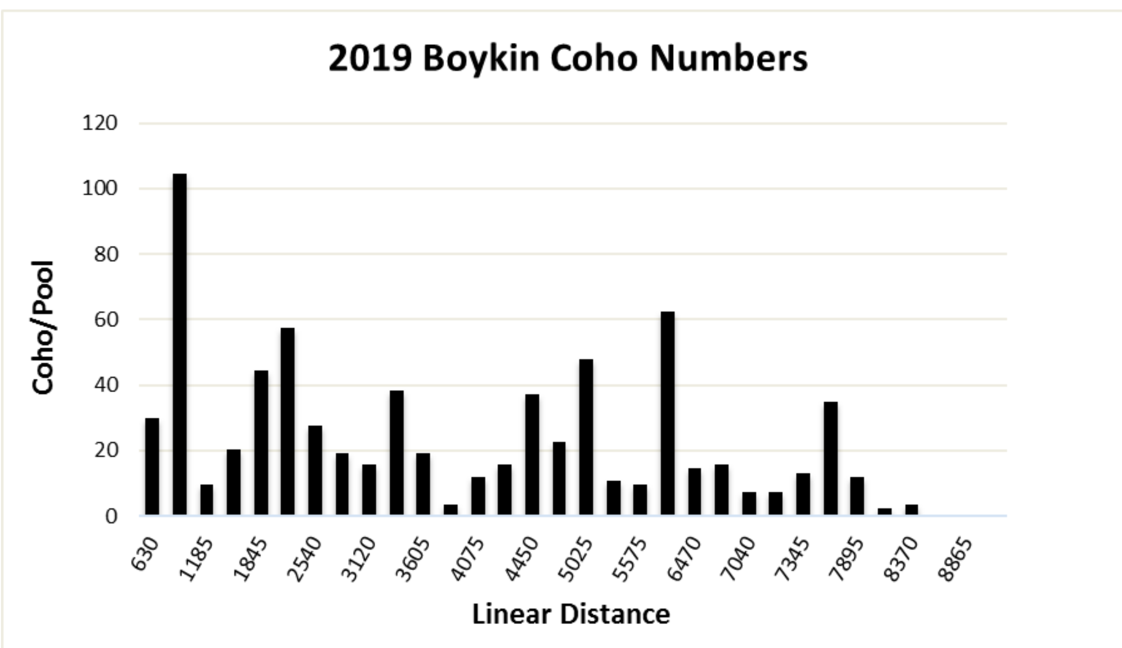

Figure 98: Boykin Coho Numbers 2019

Steelhead

No steelhead were observed in Boykin. The inventoried stream habitat exhibited high potential for steelhead spawning and juvenile rearing.

Cutthroat

Cutthroat abundance was very low with an average density of 0.08 fish/m^2 expanding to 74 fish/mile. The highest density of 0.18 fish/m^2 was observed at RM 1.23.

0+ Trout

0+ trout abundance was very low with an average density of 0.161 fish/m^2 expanding to 36 fish/mile. The highest density of 0.54 fish/m^2 was observed at RM 1.59, in the last sampled pool.

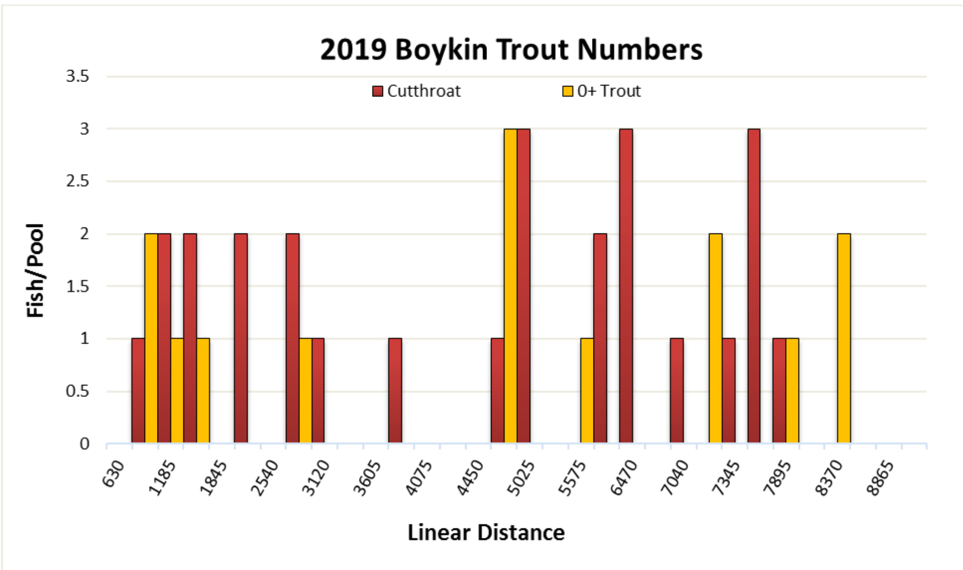

Figure 99: Boykin Trout Numbers 2019

Chinook

Chinook were not observed in Boykin.

Table 51: Boykin - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	3072	1.04	60	0	125	0

Tributaries A and B

Two tributaries of Boykin contained short reaches of anadromous potential with low abundances of coho. Trib A entered Boykin at RM 1.23 and Trib B entered Boykin at RM 1.5. Both tributaries increased in gradient shortly above confluences.

Buchanan

Buchanan enters the NF Nehalem on the upstream left bank at RM 10.6. The RBA inventory of the Buchanan subbasin contained 7.9 miles of stream habitat exhibiting anadromous potential. This included 1.56 miles of mainstem Buchanan and 6.36 miles of the Soapstone subbasin (Buchanan's only significant tributary) which included mainstem Soapstone, Jack Horner Creek, one large tributary (Trib B), and six additional smaller tributaries.

The RBA inventory on mainstem Buchanan extended 1.56 miles upstream where a 15ft bedrock falls terminates anadromous potential. Anadromous fish distribution extended up to this falls.

Buchanan Creek was identified as a valuable thermal refugia. A 2.3C temperature differential was observed at the time of the inventory with Buchanan at 16.1C and the NF mainstem at 18.4C. High abundances of salmonids were observed congregating around a fallen maple and undercut bank providing complex cover in the mainstem North Fork at the confluence plume. Additionally, an elevated coho density documented in the first sampled pool suggests that upstream juvenile migration out of the mainstem North Fork was occurring. Simplified channel characteristics in this lower stream reach limited the rearing capacity for temperature dependent migrants.

Photo 99 Buchanan Scoured Channel above North Fork Confluence

Stream habitat throughout the inventory was characterized by low gradient (avg. 1.68%); lateral channel migration constrained by steep hillslope and bedrock canyon; low summer temperature profiles (15C - 16C); dominant substrates of bedrock, boulder, and cobble with limited gravel sorting; low channel complexity; and shaded coniferous riparian.

Anchor Sites:

No anchor sites were observed in mainstem Buchanan.

Photo 100 Buchanan Falls

Coho

Coho abundance was low with an average pool density of 0.25 fish/m^2 expanding to 924 fish/mile. The highest density of 0.88 fish/m^2 was observed at RM 0.63

Spawning Gravel and Adult Escapement for Buchanan Mainstem:

An estimated 13 adult (combined male and female) coho escaped into mainstem Buchanan to spawn. Estimated adult carrying capacity based on spawning gravel availability was 11 – 32 adult coho.

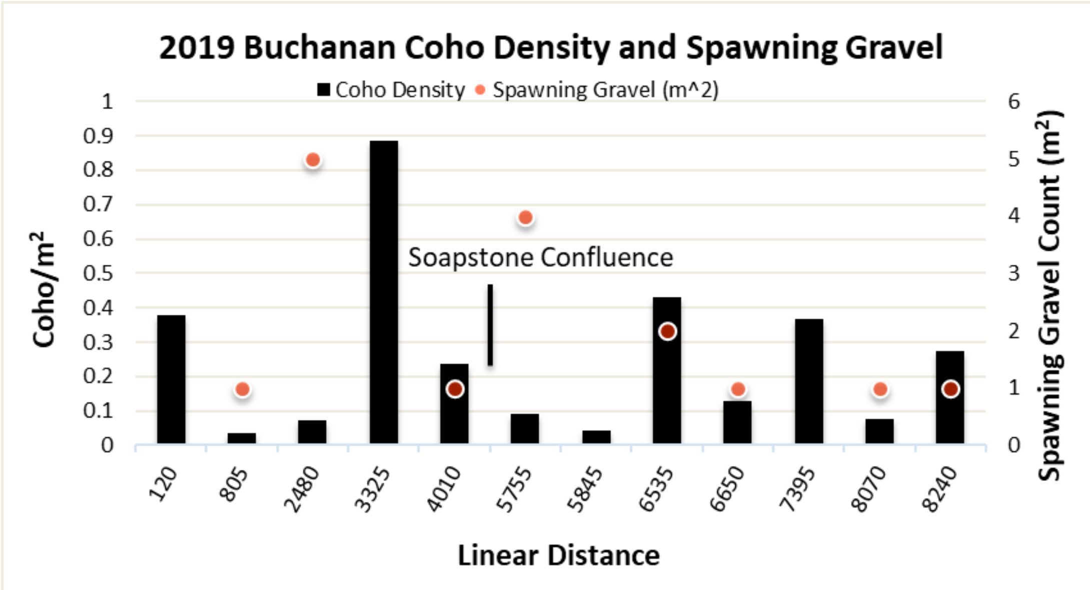

Figure 100: Buchanan Coho Densities 2019

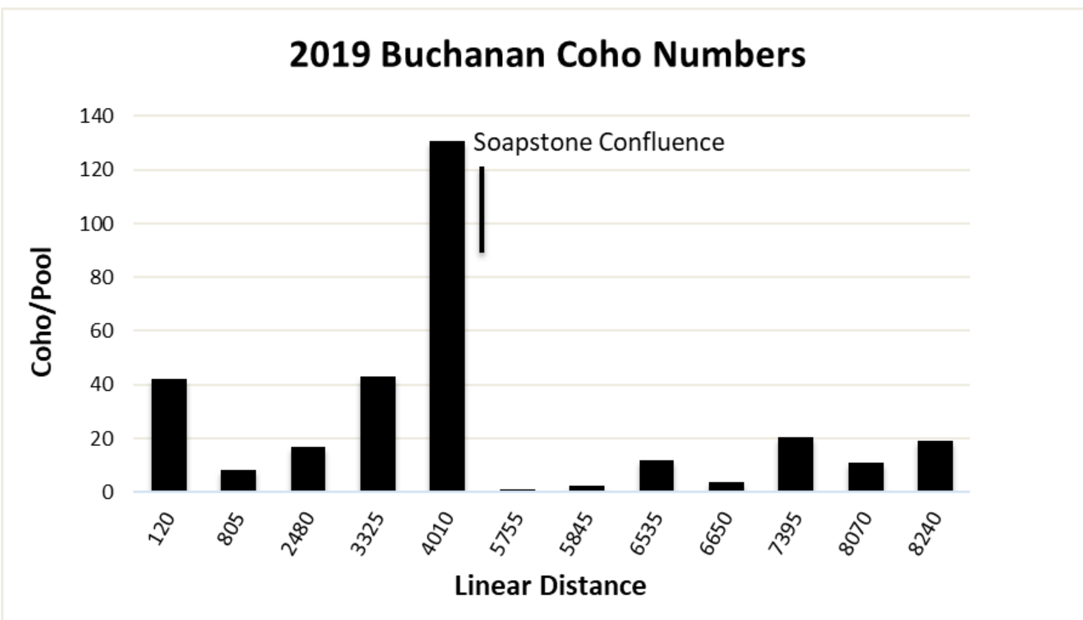

Figure 101: Buchanan Coho Numbers 2019

Steelhead

Steelhead abundance was moderate at an average pool density of 0.1 fish/m^2 expanding to 96 fish/mile. The highest density of 0.25 fish/m^2 was observed in a plunge pool below a 3ft bedrock falls at RM 1.24

Cutthroat

Cutthroat abundance was very low with an average density of 0.05 fish/m^2 expanding to 18.6 fish/mile. The highest density of 0.14 fish/m^2 was observed in a plunge pool below a 3ft bedrock falls at RM 1.24.

0+ Trout

0+ trout abundance was moderate with an average density of 0.71 fish/m^2 expanding to 990 fish/mile. The highest density of 1.79 fish/m^2 was observed in a plunge pool below a 3ft bedrock falls at RM 1.24. Expanded numbers of 0+ trout were second highest in the entire NF Nehalem watershed accounting for 7.4% of the total while comprising only 2% of the inventoried linear stream miles.

Chinook

Two Chinook were observed in mainstem Buchanan.

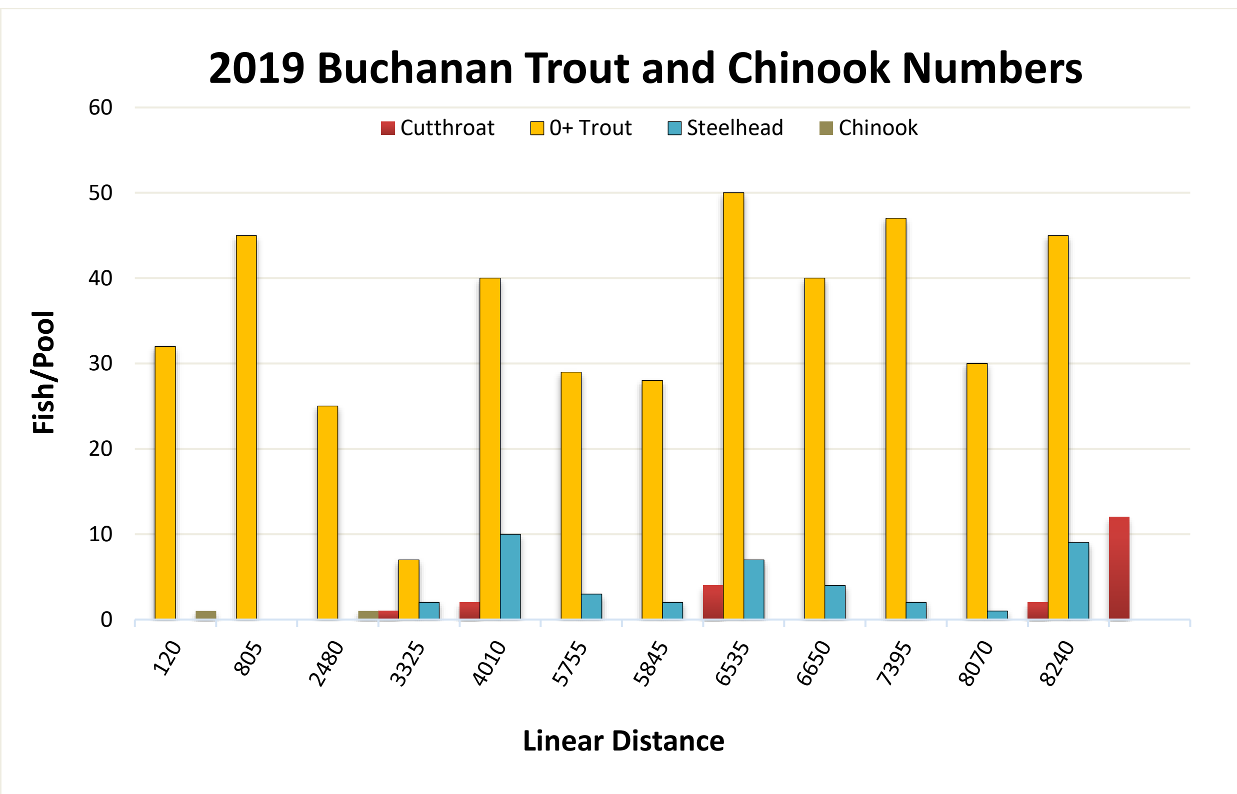

Figure 102: Buchanan Trout Numbers 2019

Table 52: Buchanan - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	1142	0.25	1545	150	29	10

Soapstone

Soapstone enters Buchanan on the upstream right bank at RM 1.1. The RBA inventory of the Soapstone subbasin included 6.38 miles of mainstem and tributary habitats (Jack Horner, one large tributary (Trib B), and six additional smaller tributaries). The soapstone subbasin was a top producer of coho accounting for 20.4% of the North Fork subbasin total while comprising only 8.2% of the inventoried linear stream miles.

The mainstem inventory extended 2.68 miles upstream where reduced flows, increased gradient and ephemeral woody debris jams limited further anadromous spawning and rearing potential. Anadromous fish distribution extended to 1.5 ft falls at RM 2.64.

Photo 101 Lower Soapstone Creek

Habitat was characterized by low gradient (avg. 1.6); sinuous channel meander; mixed coniferous and deciduous riparian; low summer temperature profiles (12C – 14.5C); moderate wood complexity of predominantly deciduous origin; and dominant substrates of bedrock, cobble, and gravel. Beaver occupation was observed with six active full spanning dams.

Photo 102 Soapstone Creek

Anchor Sites:

Five Anchor Sites were identified on mainstem Soapstone. All exhibited moderate functionality based on lack of large wood complexity and limited spawning gravel.

Anchor Site #1 extended from RM 0.37 – 0.47.

Anchor Site #2 extended 380ft upstream from RM0.6 and encompassed the LWD structures at confluence of Jack Horner Creek.

Anchor Site #3 extended from RM 1 – 1.25.

Anchor Site #4 extended from 300ft upstream from RM 2.06.

Anchor Site #5 extended 690ft upstream from RM 2.2.

Photo 103 Soapstone Anchor Site #1, Trib A

Coho

Coho abundance was moderate with an average pool density of 0.70 fish/m^2 expanding to 2647 fish/mile. The highest density of 2.03 fish/m^2 was observed at RM 1.70. Despite the high production level, summer rearing densities were still well below full seeding capacity.

Spawning Gravel and Adult Escapement:

An estimated 65 adult (combined male and female) coho escaped into mainstem Soapstone to spawn. Estimated adult carrying capacity based on spawning gravel availability was 25 – 76. This system exhibited significantly higher summer rearing capacity potential for juvenile coho than was observed in the 2019 inventory, yet estimated adult escapement was already at 85.5% of the upper threshold of estimated adult carrying capacity. This proximity indicates that spawning gravel may have functioned as a limiting factor in coho production for the 2018 brood year, a year of very low adult returns to the basin. In years of higher adult escapement, the lack of spawning gravel availability would function as the definitive limiting factor for production.

Photo 104 Soapstone High Quality Spawning Gravel RM 1.5

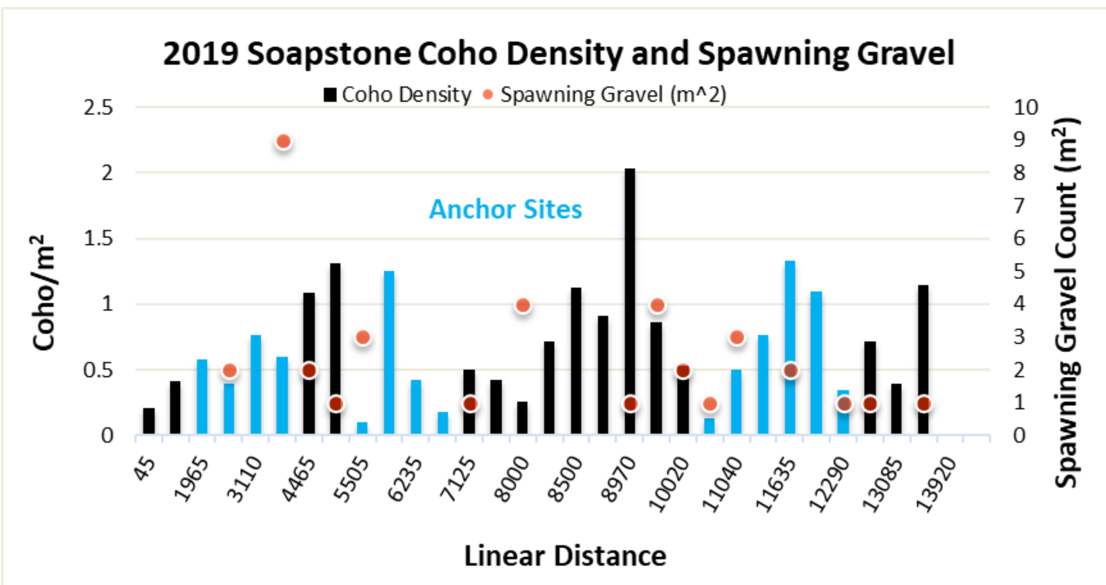

Figure 103: Soapstone Coho Densities 2019

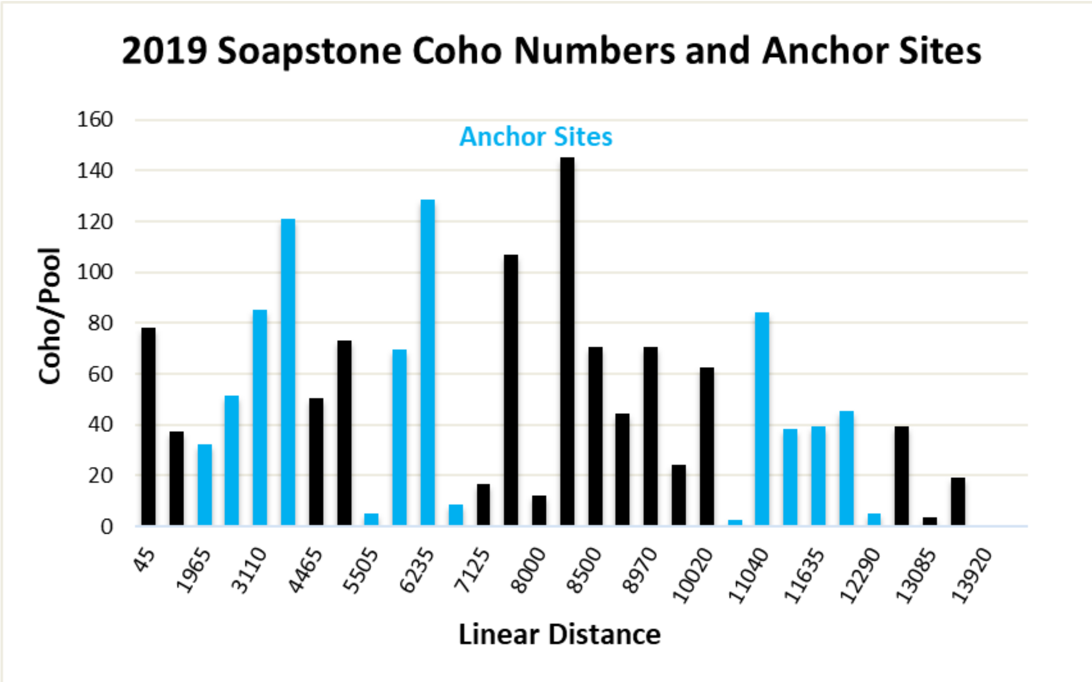

Figure 104: Soapstone Coho Numbers 2019

Steelhead

Steelhead abundance was low with an average pool density of 0.02 fish/m^2 with intermittent pool presence throughout the range of anadromy. Steelhead counts expanded to 52 fish/mile.

Cutthroat

Cutthroat abundance was low with an average density of 0.06 fish/m^2 expanding to 127 fish/mile. The highest density of 0.21 fish/m^2 was observed at RM 2.48.

0+ Trout

0+ trout abundance was low with an average density of 0.11 fish/m^2 expanding to 340 fish/mile. The highest density of 0.40 fish/m^2 was observed at RM 0.24.

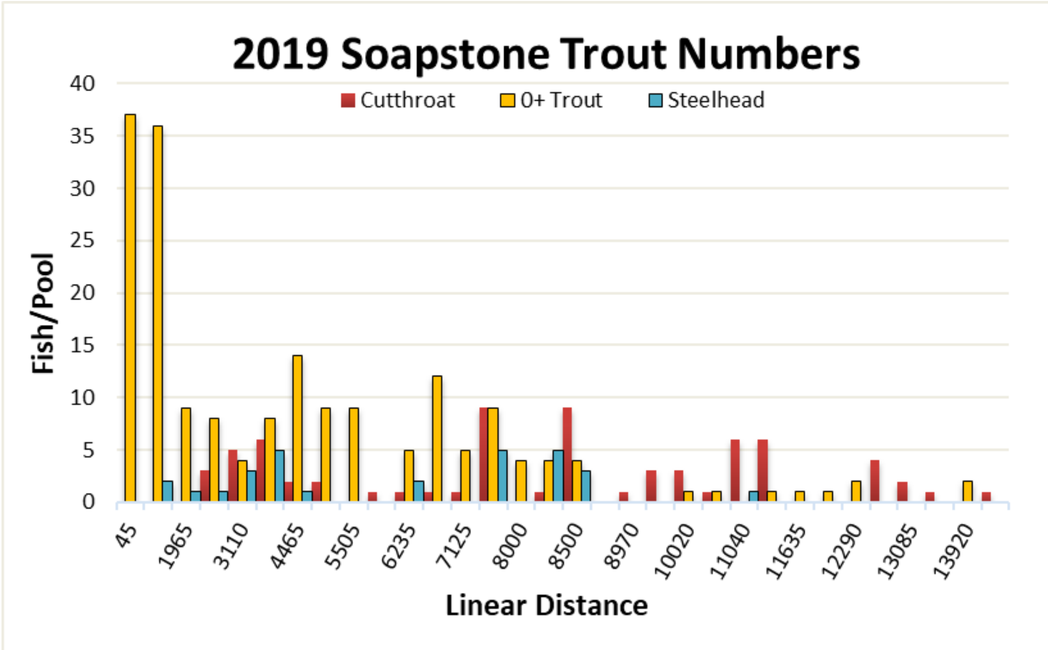

Figure 105: Soapstone Trout Numbers 2019

Chinook

Chinook were not observed.

Table 53: Soapstone Mainstem - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	7094	0.70	910	140	340	0

Minor Tributaries of Soapstone:

Tributary A

Trib A enters Soapstone on the upstream left bank at RM 0.4 within Anchor Site #1. The survey continued 0.18 miles upstream to a 3-foot-wide concrete culvert (HWY 53) perched 2 feet over a shallow pool functioning as a juvenile and adult barrier to passage. The trib parallels the mainstem for the first several pools within Soapstone Anchor Site #1 before exiting the floodplain and increasing in gradient. Above the Soapstone floodplain anadromous spawning and rearing potential is limited by shallow pools, successive debris jams, and lack of spawning gravel. Coho were seen in low densities in the first 2 survey pools.

Tributary C

Trib C enters Soapstone on the upstream right bank at RM 1.58. The survey continued 0.05 miles upstream where low flow and back to back log jams limited anadromous potential. Only 0+ trout were observed in this tributary.

Tributary D

Trib D enters Soapstone on the upstream left bank at RM 1.53. The survey continued 0.04 miles upstream where narrow stream channel and low flows limited anadromous potential. Only 0+ trout were observed in this tributary.

Tributary E

Trib E enters Soapstone on the upstream right bank at RM 1.59. The confluence of Trib E is low gradient and coho were observed in the first dive pool. The survey continued 0.13 miles where further reduction in flow and narrowing of the channel limited further anadromous potential.

Tributary F

Trib F enters Soapstone on the upstream right bank at RM 1.75. The confluence of Trib E is low gradient and low flow. Coho were observed (density of 2.15 fish/m^2) in only the first survey pool. The survey continued 0.07 miles upstream to a large log jam with difficult passage and subsurface flows above.

Jack Horner

Jack Horner enters Soapstone on the upstream left bank within Anchor Site #2 at RM 0.57. The RBA inventory extended 1.5 miles upstream where increased gradient and bedrock/ boulder dominated substrates limited further anadromous spawning and rearing potential. Anadromous fish distribution extended 1.3 miles to a log jam packed with debris and boulders.

Habitat was characterized by moderate to high gradient (5.4%); low summer temperature profiles (14.8C); lateral channel migration restricted by hillslope outside of anchor sites; well forested riparian; and dominant substrates of boulder, cobble, and gravel with long reaches of scoured bedrock and limited bedload retention outside of LWD structures.

Photo 105 Jack Horner Bedload Accumulation Associated with LWD Structure

Photo 106 Jack Horner Bedload impoundment Above Structure Debris Jam

Anchor Sites:

Three Anchor Sites were observed. The first anchor site extended upstream from the Soapstone confluence which was located within Soapstone Anchor Site #2 and has been incorporated into previous restoration treatments. Large wood treatments extended upstream through Anchor sites #2 and #3.

Coho

Coho abundance was high with an average pool density of 1.52 fish/m^2 expanding to 2100 fish/mile. The highest density of 2.72 fish/m^2 was observed at RM 0.93.

Spawning Gravel and Adult Escapement:

Estimated adult (combined male and female) coho escapement into Jack Horner was 29 coho. Estimated adult carrying capacity based on spawning gravel availability was 13 - 38. This large tributary exhibited higher summer rearing capacity potential for juvenile coho than was observed in the 2019 inventory. The proximity of estimated adult escapement to the upper threshold of estimated adult capacity suggests that spawning gravel availability may have functioned as the primary limiting factor for the 2018 brood year. Furthermore, in years of higher adult escapement, the lack of spawning gravel will definitively limit the subbasin's coho production potential.

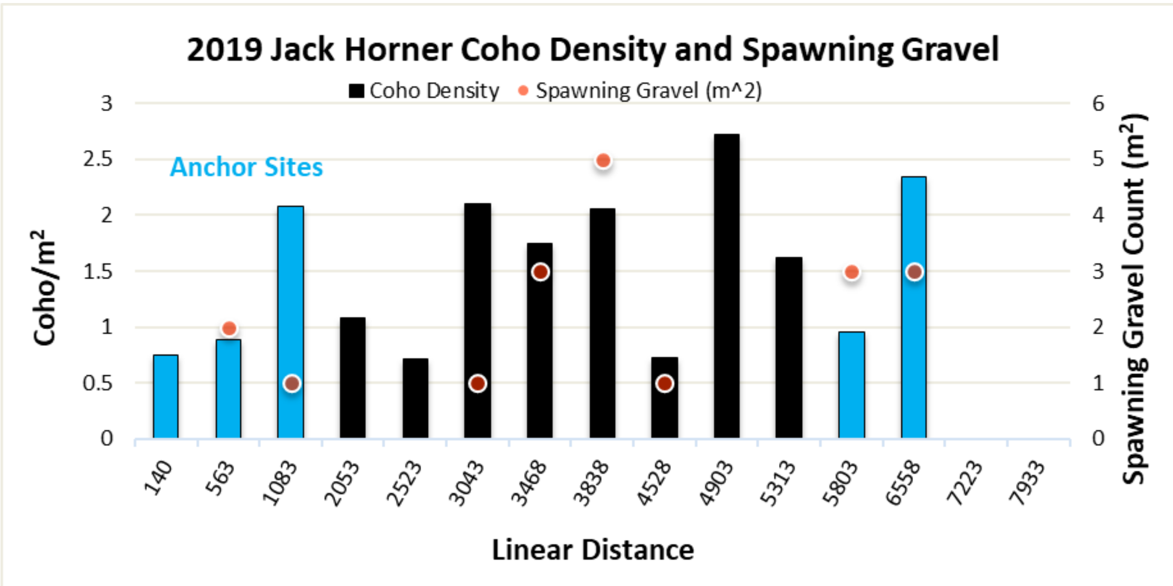

Figure 106: Jack Horner Coho Densities 2019

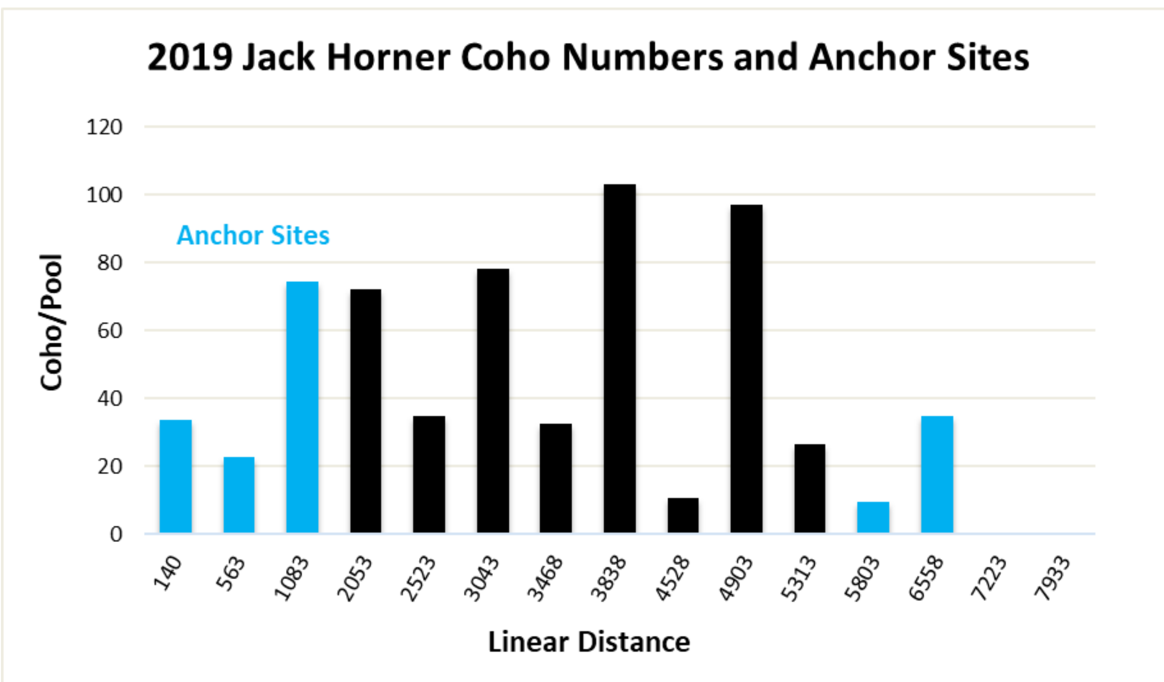

Figure 107: Jack Horner Coho Numbers 2019

Steelhead

Steelhead abundance was low at an average pool density of 0.03 fish/m^2 with intermittent pool presence throughout the range of anadromy. Steelhead counts expanded to 13 fish/mile.

Cutthroat

Cutthroat abundance was low with an average density of 0.06 fish/m^2 expanding to 47 fish/mile. The highest density of 0.12 fish/m^2 was observed at RM 1.

0+ Trout

0+ trout abundance was low with an average density of 0.22 fish/m^2 expanding to 213 fish/mile. The highest density of 0.74 fish/m^2 was observed upstream of coho distribution at RM 1.37

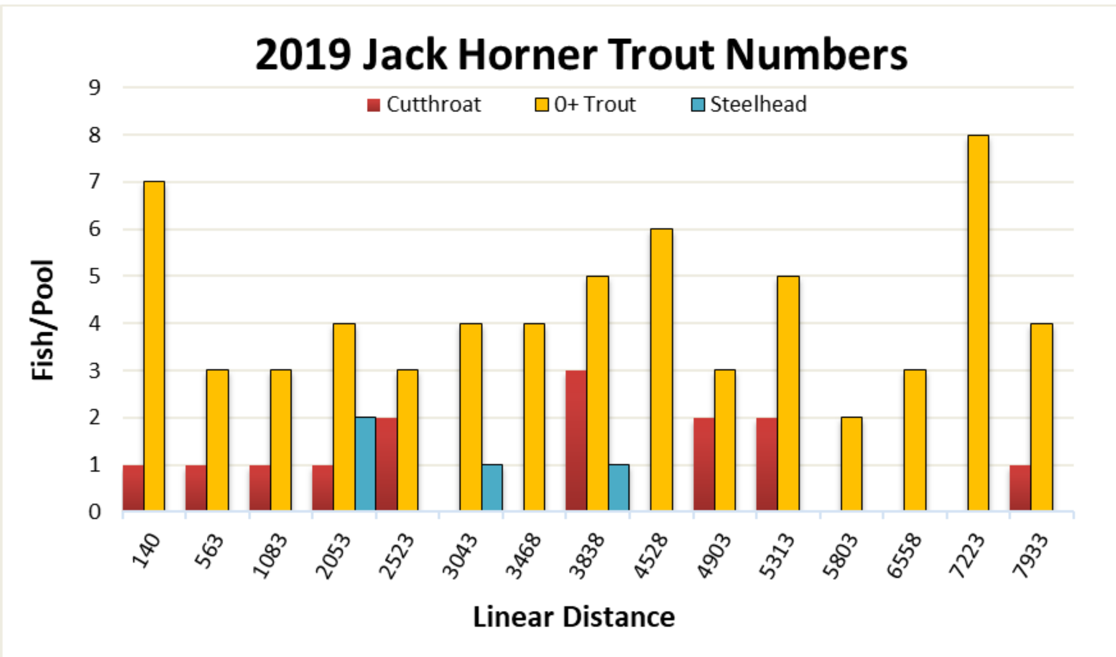

Figure 108: Jack Horner Trout Numbers 2019

Chinook

Chinook were not observed.

Table 54: Jack Horner - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	3150	1.52	320	20	70	0

Soapstone Tributary B

Tributary B enters Soapstone on the upstream left bank at RM 1.44 The RBA inventory extended 1.56 miles upstream where steep gradient, boulders, and a 6ft bedrock slide limited further anadromous spawning and rearing potential. Anadromous fish distribution extended 1.34 miles to an increase in gradient.

Stream habitat was characterized by moderate gradient (avg.3.8%); sinuous channel meander in lower half of the inventory, hillslope confined in the upper half; dominant substrates of scoured bedrock, cobble, and gravel with gravel sorting in pool tailouts throughout lower half of inventory; moderate wood complexity with a mix of deciduous and coniferous trees; and mature coniferous riparian throughout lower 1.1 miles with young conifers and alder in upper end. Above RM 1.1 gradient increases and channel exhibits more bedrock scour.

Photo 107 Trib B (Soapstone)

Anchor Sites:

Two short Anchor Sites were observed in the lower 0.4 miles of the inventory. Both received function level ratings of 2 (moderate) due to lack of large wood complexity. Gradient began to increase above the anchor sites.

Photo 108 Trib B (Soapstone) Anchor Site #1

Coho

Coho abundance was high with an average pool density of 1.04 fish/m^2 expanding to 2749 fish/mile. The highest density of 2.5 fish/m^2 was observed at RM 0.02 within anchor site #1. The top three highest pool counts were all documented within anchor site habitats.

Spawning Gravel and Escapement:

An estimated 34 adult (combined male and female) coho escaped into Trib B to spawn. Estimated adult carrying capacity based on spawning gravel abundance was 17 – 50 adult coho. This large tributary exhibited higher summer rearing potential for juvenile coho than was observed in the 2019 inventory and was limited by insufficient adult escapement. The proximity of estimated adult escapement for 2018 (a low adult return year) to the upper threshold of estimated adult capacity suggests that in years of higher adult escapement spawning gravel availability would function as the primary limiting factor for coho production.

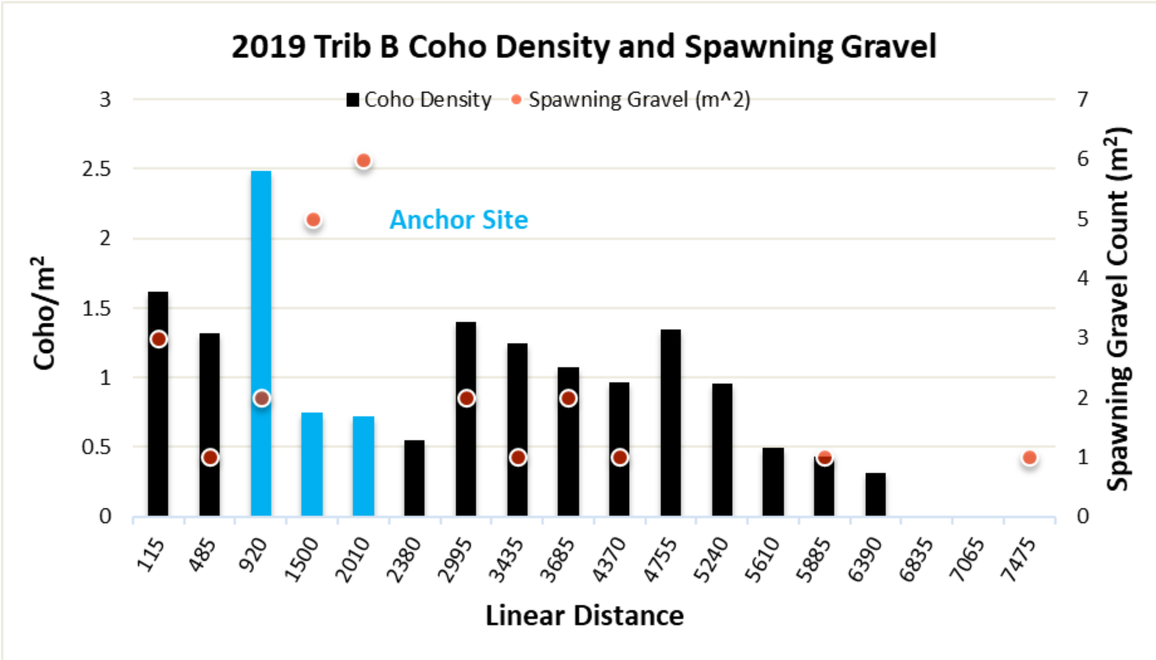

Figure 109: Soapstone Tributary B Coho Densities 2019

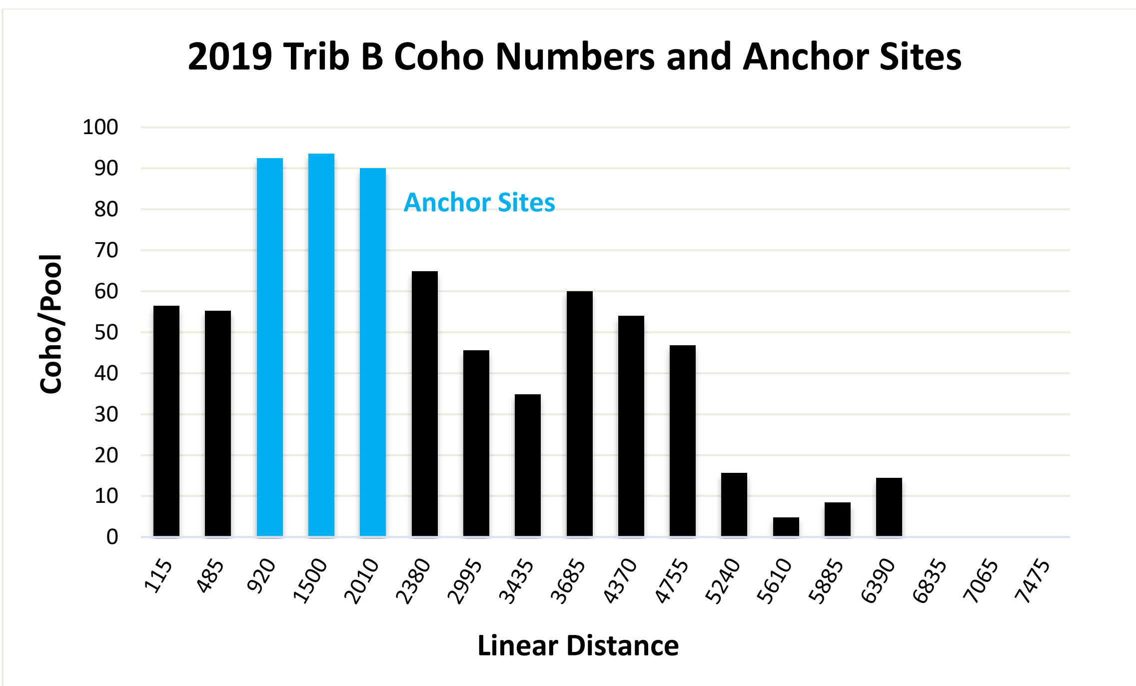

Figure 110: Soapstone Tributary B Coho Numbers 2019

Steelhead

Steelhead abundance was low at an average pool density of 0.01 fish/ m^2. Steelhead were only observed in two pools.

Cutthroat

Cutthroat abundance was low with an average density of 0.05 fish/m^2 expanding to 87 fish/mile. The highest density of 0.11 fish/m^2 was observed at RM 0.7.

0+ Trout

0+ trout abundance was low with an average density of 0.09 fish/m^2 expanding to 96 fish/mile. The highest density of 0.3 fish/m^2 was observed at RM 1.56, above the range of anadromy.

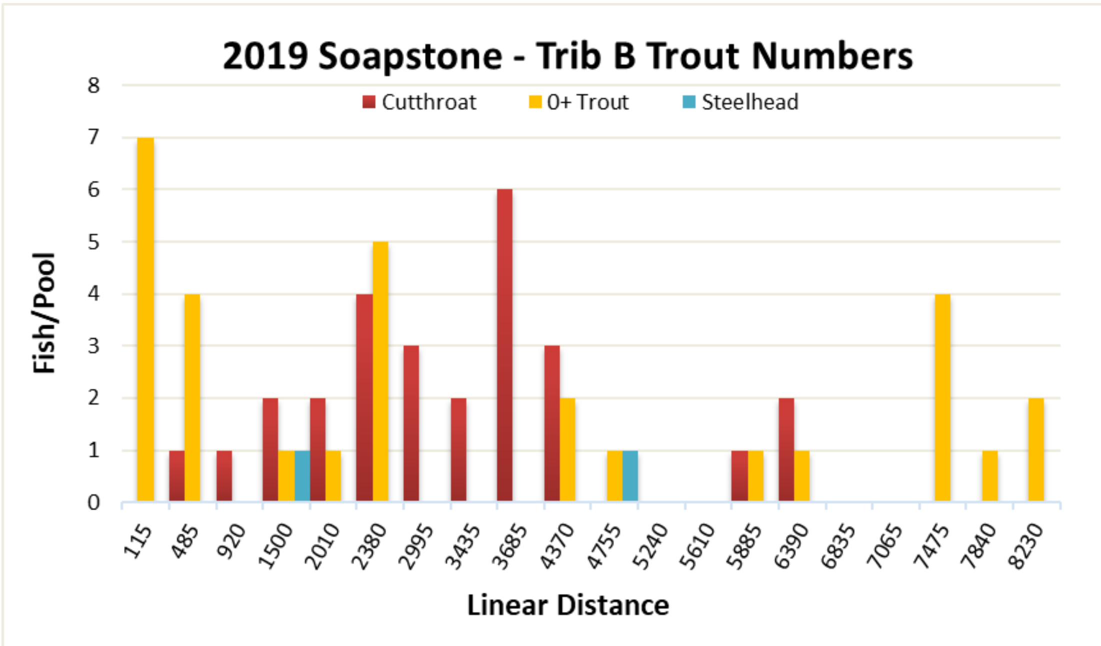

Figure 111: Soapstone Tributary B Trout Numbers 2019

Chinook

Chinook were not observed.

Table 55: Soapstone Tributary B - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	3584	1.04	150	10	135	0

Coal

Coal enters the NF Nehalem on the upstream left bank at RM 1. The RBA inventory of the Coal subbasin was conducted in 2018 (not 2019 like the remainder of the NF Nehalem RBA Inventory) and contained 6.67 miles of stream habitat exhibiting anadromous potential. This included 4.33 miles of mainstem Coal, 2.18 miles of West Fork Coal, and 0.16 miles of a small tributary (Trib A).

Photo 109 Coal Creek, West Fork Confluence

The RBA inventory on mainstem Coal started at the end of summer saltwater influence (still within tidal range) and extended 4.33 miles upstream where consecutive boulder and bedrock falls terminate anadromous potential. Anadromous fish distribution extended to the boulder falls.

Photo 110 Coal Creek Bedrock Gorge at End of Anadromy

Steam habitat was characterized by low gradient (avg. 0.7%); varying summer temperature profiles (13.4C – 15.9C); substrates of bedrock, boulder, cobble and gravel; lateral channel migration confined by channel incision and hillslope outside of anchor sites; and riparian canopy thin throughout lower mile of pastureland and well forested above. Deep channel incision was documented in lower mile of inventory overlapping pastureland.

Photo 111 Upper Coal Creek

Anchor Sites:

Five Anchor Sites of varying functionality were observed. Lack of sorted gravel and lack of large wood complexity was most commonly noted as reducing Anchor function levels.

Anchor Site #1 was short, extending only a few hundred feet upstream of RM 0.9 and was the only site to receive a high function rating.

Anchor Site #2 was also short, extending only a few hundred feet upstream of RM 1.6.

Anchor Site #3 extended from RM 1.8 – RM 2.5.

Anchor Site #4 extended from RM 2.7 – RM 2.9

Anchor Site #5 was short extending only a few hundred feet upstream of RM3.5.

Photo 112 Coal Creek Anchor Site #3

Coho

Coho abundance was moderate with an average pool density of 0.46 fish/m^2 expanding to 1923 fish/mile. The highest density of 1.26 fish/m^2 was observed just upstream of Anchor Site #4 at RM 3.08.

Coho were observed below the first hydraulic control in tidal estuary habitat backed up from the North Fork at the top edge of saltwater influence. Coho rearing in these estuarine connected habitats are representative of population components expressing alternative life history traits (nomadic).

Spawning Gravel and Adult Escapement:

An estimated 76 adult (combined male and female) coho escaped into mainstem Coal to spawn. Estimated adult carrying capacity based on spawning gravel abundance was 92 – 272 adult coho.

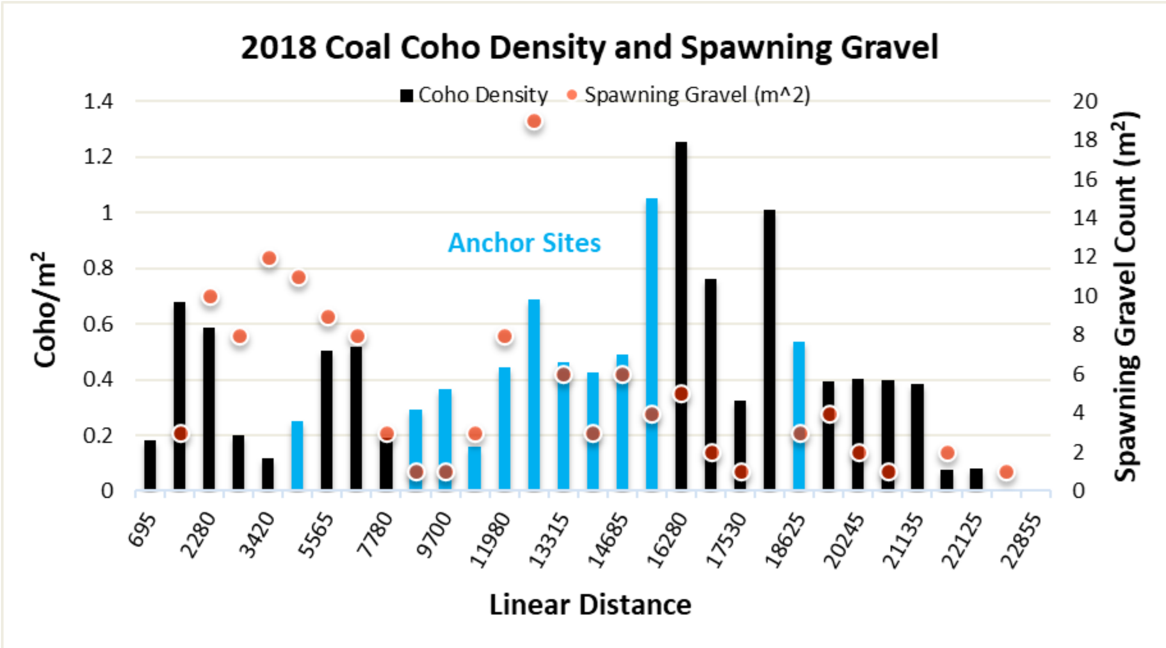

Figure 112: Coal Coho Densities 2018

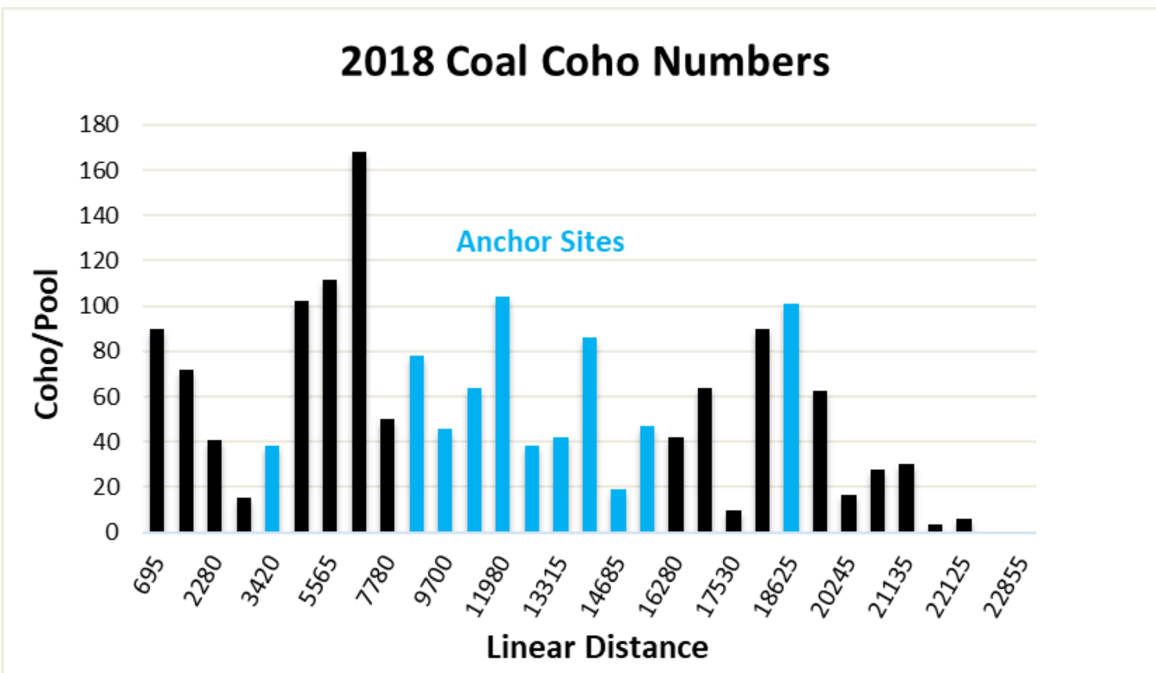

Figure 113: Coal Coho Numbers 2018

Steelhead

Steelhead abundance was low with an average pool density of 0.03 fish/ m^2 expanding to 69 fish/mile. The highest density of 0.08 fish/m^2 was observed at RM 2.94. Intermittent pool presence was observed above RM 3.5.

Cutthroat

Cutthroat abundance was low with an average density of 0.03 fish/m^2 expanding to 99 fish/mile. The highest density of 0.07 fish/m^2 was observed at RM 0.43. Highest production was observed in the lower 2.3 miles of the inventory where cutthroat were present at 139 fish/mile. Intermittent pool presence was observed above RM 3.41.

0+ Trout

0+ trout abundance was low with an average density of 0.22 fish/m^2 expanding to 643 fish/mile. The highest density of 0.65 fish/m^2 was observed at RM 4.26

Chinook

Chinook were observed in two pools (each with a single chinook).

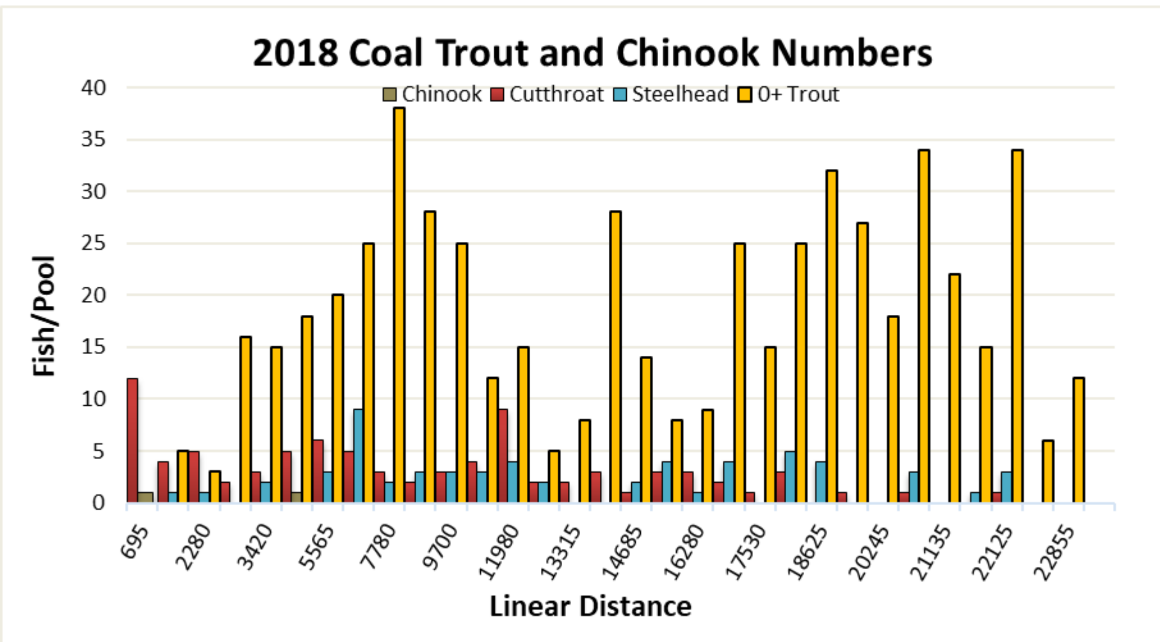

Figure 114: Coal Trout and Chinook Numbers 2018

Table 56: Coal - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2018	8328	0.46	2785	300	430	10

Tributary A

Trib A enters Coal at RM 0.16. The survey continued to an 8-foot boulder falls with a shallow jump pool at RM 0.08 functioning as an anadromous barrier. Above the falls, stream habitats were steep, boulder-dominated, and thick with woody debris. Coho were observed in low densities in the first three pools leading up to the falls.

West Fork Coal

West Fork Coal enters Coal on the upstream left bank at RM 2.5. The RBA inventory extended 2.18 miles upstream where a tight boulder jam with consecutive 5ft – 6ft falls terminates further anadromous potential. Anadromous fish distribution extended 2.03 miles to an increase in gradient and log jam impounding cobble and boulder with a 4ft sill.

Habitat was characterized by moderate gradient (avg. 3.1%); dominant substrates of bedrock, boulder, and cobble with limited gravel sorting; low summer temperature profiles (13.4C); lateral channel meander confined by hillslope outside of anchor sites; low large wood complexity; and mixed deciduous and coniferous riparian canopy.

Photo 113 West Fork Coal Creek

Anchor Sites:

Two Anchor Sites were documented. Function in both was limited by the lack of sorted spawning gravel and large wood complexity.

Anchor Site #1 was contiguous with Coal Creek Anchor Site #3 and extended upstream from the confluence to RM 0.12. Anchor Site #2 extended from RM 0.29 – 0.5.

Photo 114 West Fork Coal Anchor Site #1

Coho

Coho abundance was moderate with an average pool density of 0.49 fish/m^2 expanding to 1215 fish/mile. The highest density of 1.25 fish/m^2 was observed at RM 0.19.

Spawning Gravel and Escapement:

An estimated 22 adult (combined male and female) coho escaped into West Fork Coal to spawn. Estimated adult carrying capacity based on spawning gravel abundance was 6 - 16 adult coho. Our estimates indicate that adult abundance exceeded adult carrying capacity and that lack of high-quality spawning gravel was functioning as the primary limiting factor for coho production in West Fork Coal for the 2018 brood year.

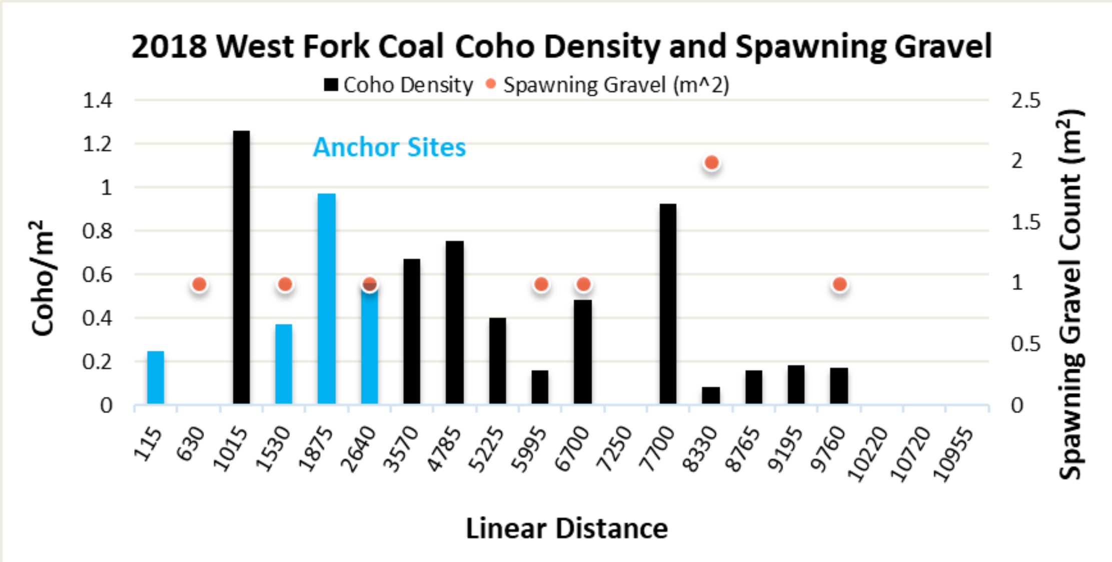

Figure 115: West Fork Coal Coho Densities 2018

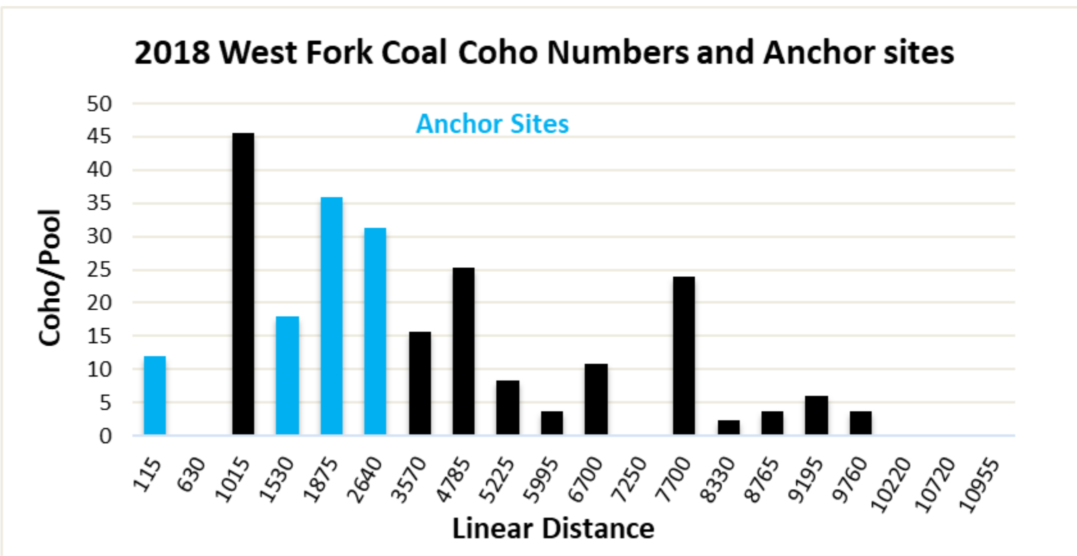

Figure 116: West Fork Coal Coho Numbers 2018

Steelhead

Steelhead abundance was low at an average pool density of 0.04 fish/m^2 with intermittent pool presence throughout the range of anadromy. Steelhead counts expanded to 39 fish/mile.

Cutthroat

Cutthroat abundance was high with an average density of 0.21 fish/ m^2 expanding to 177 fish/mile. The highest density of 1.72 fish/m^2 was observed at RM 2.18, above anadromous distribution.

0+ Trout

0+ trout abundance was low with an average density of 0.19 fish/m^2 expanding to 656 fish/mile. The highest density of 0.61 fish/m^2 was observed at RM 2.18, above anadromous distribution. This pool also had the highest density of cutthroat.

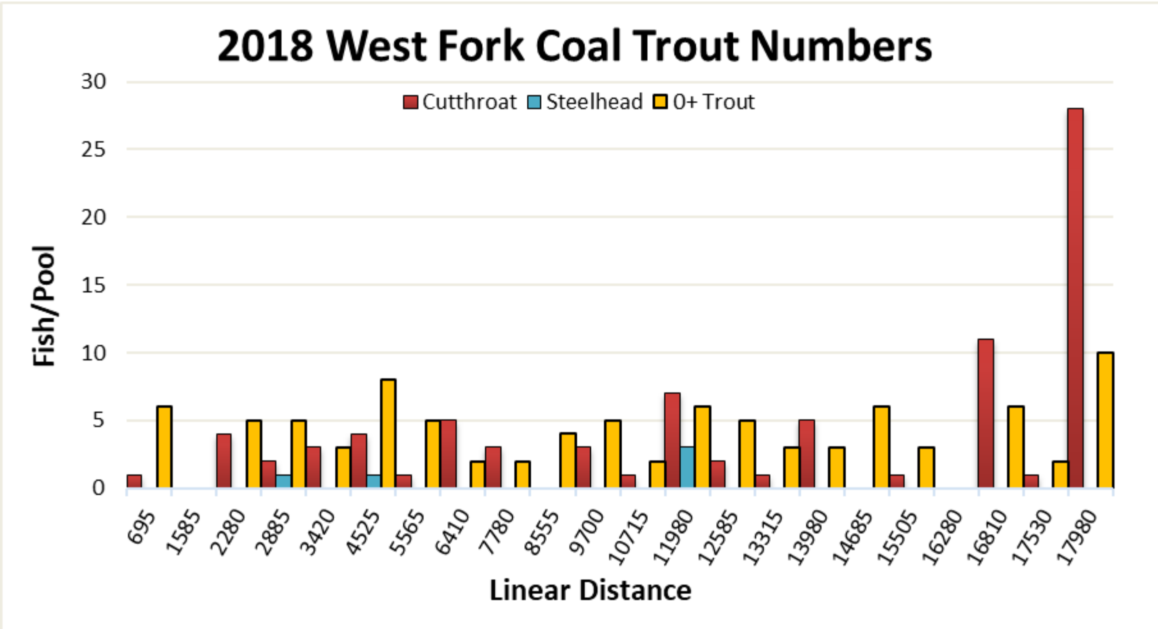

Figure 117: West Fork Coal Trout Numbers 2019

Chinook

Chinook were not observed.

Table 57: West Fork Coal - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	2466	0.49	1413	80	386	0

Fall 2

Fall 2 enters the NF Nehalem on the upstream left bank at RM 16.25. Fall 2 enters the NF Nehalem at a large, deep pool about 0.2 miles below the Fall Creek falls with fish trap. The RBA inventory extended 1.04 miles upstream. At RM 0.85, a series of bedrock falls (2ft, 5ft, and 8ft) terminates further anadromous potential. Anadromous distribution extended to these falls. Above the first set of falls, a 20ft bedrock falls was observed at RM 1.04.

Photo 115 Fall Creek End of Anadromy

Stream habitat was characterized by moderate gradient (avg. 2.5%); moderate summer temperature profile (16C); a mature coniferous riparian; dominant substrates of scoured bedrock, boulder, cobble, and gravel; moderate wood complexity; channel braiding across wide floodplain with lateral channel meander constrained by roadbed and hillslope.

Photo 116 Fall Creek Scoured Bedrock

Bank oriented LWD treatment logs and boulder structures were noted above the Fall Creek Rd. bridge. These structures were observed impounding bedload and sorting gravel.

A significant cold-water contribution was noted at RM 0.5 with a 2C temperature differential (Fall 16C, trib 14C).

Photo 117 Fall Creek Boulder Weir Impounding Gravel

Anchor Sites:

None were observed. A near Anchor Site was noted shortly above the bridge. The road paralleling fall confines the floodplain.

Coho

Coho abundance was moderate with an average pool density of 0.46 fish/m^2 expanding to 1000 fish/mile. The highest density of 1.55 fish/m^2 was observed at RM 0.84, in the last sampled pool with coho presence, in a plunge pool below a 5ft falls.

Spawning Gravel and Escapement:

22m^2 of spawning gravel was documented during the inventory. Of this 22, only 11m^2 was below the permanent anadromous barrier. The other 11m^2 was observed between the first and second falls, where low gradient and the hydraulic control of the downstream falls contributed to deep bedload accumulations of gravel. Most spawning gravel within the range of anadromy was observed in the anchor habitat upstream of the Fall Creek Rd. bridge.

Estimated adult (combined male and female) coho escapement based on expanded fish counts was 8 coho. Estimated adult carrying capacity based on spawning gravel availability was 8 - 22 adult coho.

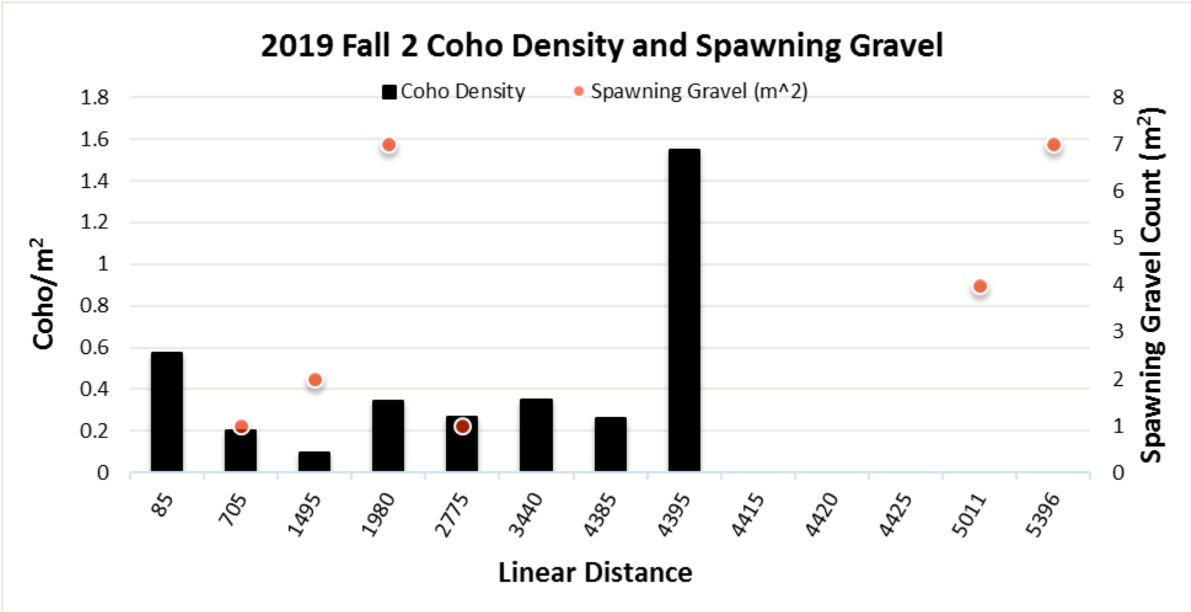

Figure 118: Fall 2 Coho Densities 2019

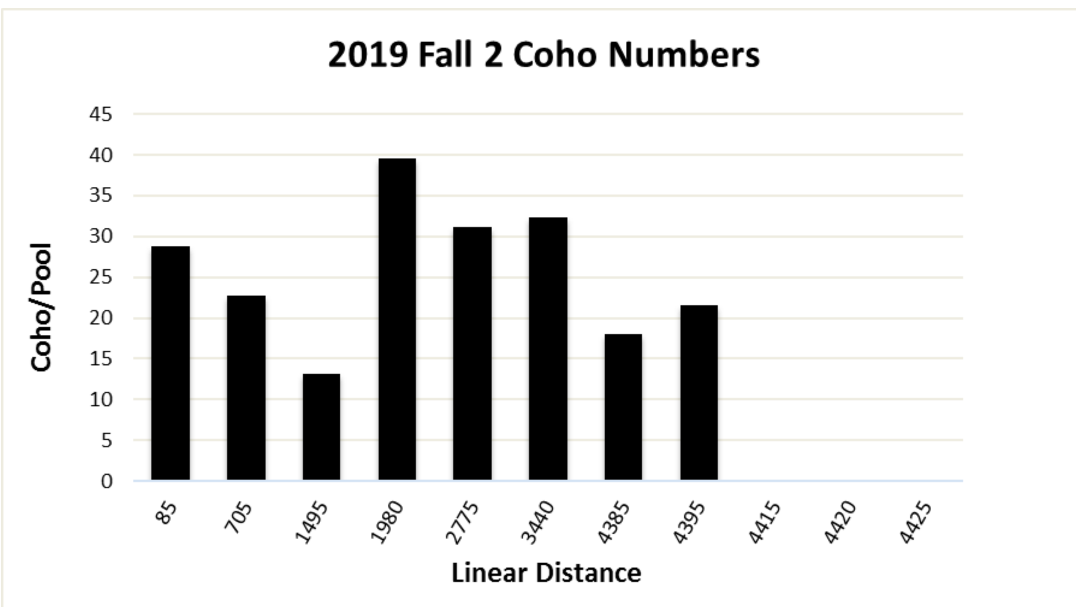

Figure 119: Fall 2 Coho Numbers 2019

Steelhead

Steelhead were present throughout the range of anadromous distribution. Abundance was low at an average pool density of 0.05 fish/m^2 with consistent pool presence up to the anadromous barrier. Steelhead counts expanded to 95 fish/mile. The highest density of 0.09 fish/m^2 was documented below the falls at the end of anadromy

Cutthroat

Cutthroat abundance was low with an average density of 0.065 fish/m^2 expanding to 58 fish/mile. The highest density of 0.22 fish/m^2 was observed at RM 0.85 in a plunge pool below an 8ft falls above anadromous distribution.

0+ Trout

0+ trout abundance was low with an average density of 0.08 fish/m^2 expanding to 168 fish/mile. The highest density of 0.31 fish/m^2 was observed at RM 0.85 in a plunge pool below an 8ft falls above anadromous distribution.

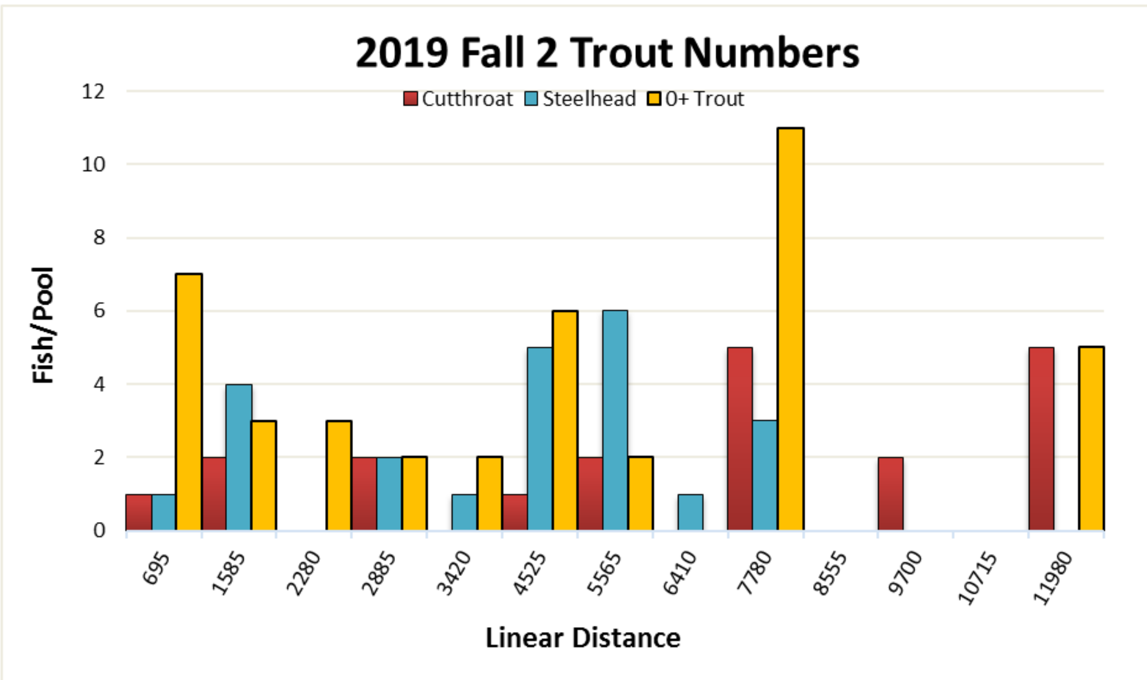

Figure 120: Fall 2 Trout Numbers 2019

Chinook

Chinook were not observed.

Table 58: Fall 2 - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	840	0.46	175	80	60	0

God's Valley

God's Valley enters the NF Nehalem on the upstream right bank at RM 13.3. The RBA inventory of the God's Valley subbasin contained 9.6 miles of stream habitat exhibiting anadromous potential. This included 6.06 miles of mainstem God's Valley, 2.51 miles of significant tributaries (A - 1.25, D - 0.79, and E - 0.47), and 1.03 miles of three additional tributaries (B - 0.31, C - 0.59, and F - 0.13).

The RBA inventory on mainstem God's Valley continued 6.06 miles upstream where canyon confinement, gradient increase, narrowing valley and boulders limited further anadromous spawning and rearing potential. Anadromous fish distribution extended to this geologic pinch.

Habitat was characterized by low gradient (avg. 0.4%); sinuous channel meander across wide floodplain with broad grassy meadows and extensive wetlands; incised channel (up to 8ft); low large wood complexity; tannic water; low summer temperature profiles (14.5C – 15.5C); dominant substrates of gravel, sand, and silt; and varying riparian cover with high solar exposure in floodplain meadows and mature coniferous canopy in forested reaches.

Photo 118 Lower God's Valley

Photo 119 God's Valley Channel Entrenchment

Anchor Sites:

Four large anchor Sites were observed. These anchor sites exhibited low functionality due to lack of large wood complexity, lack of sorted gravel, and deep channel incision. A large majority of the inventoried reach once functioned as anchor habitat with extensive floodplain width observed throughout, but deep channel incision has disconnected the active channel from its historic floodplain. Increased beaver occupation in this system could help to restore anchor site function by elevating the active channel above the incised banks and reconnecting it with the historic floodplain.

Photo 120 God's Valley Anchor Site #2

Spawning Gravel and Escapement for the Entire God’s Valley Subbasin:

An estimated 54 adult (combined male and female) coho escaped into the God’s Valley subbasin to spawn. Estimated adult carrying capacity based on spawning gravel abundance was 100 - 298 adult coho. Based on juvenile rearing densities and spawning gravel estimates the God’s valley subbasin was functioning well below capacity for coho production.

Coho

Coho abundance was low with an average pool density of 0.28 fish/m^2 expanding to 672 fish/mile. The highest density of 1.25 fish/m^2 was observed at RM 5.24, in Anchor Site #4. The highest production of 1,558 fish/mile was observed from RM 0.2 – RM 1.7. This reach exhibited low density profiles due to low gradient and high pool surface area.

Spawning Gravel and Escapement for God’s Valley Mainstem:

An estimated 38 adult (combined male and female) coho escaped into mainstem God’s Valley to spawn. Estimated adult carrying capacity based on spawning gravel abundance was 66 - 188 adult coho.

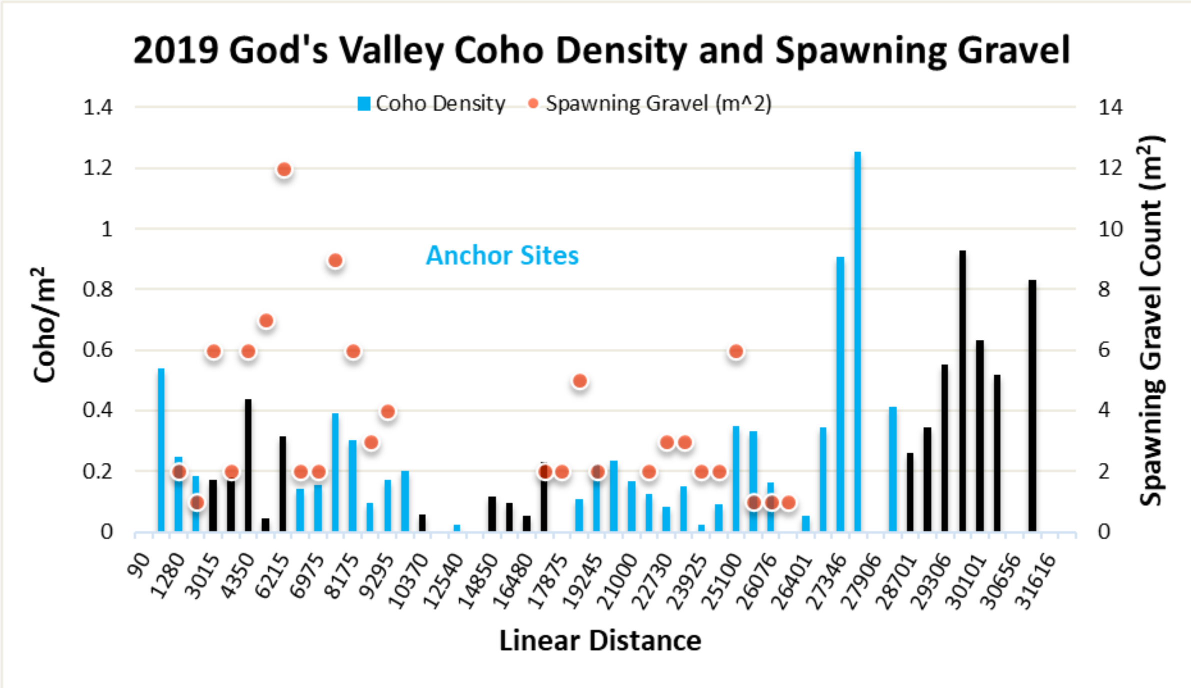

Figure 121: God's Valley Coho Densities 2019

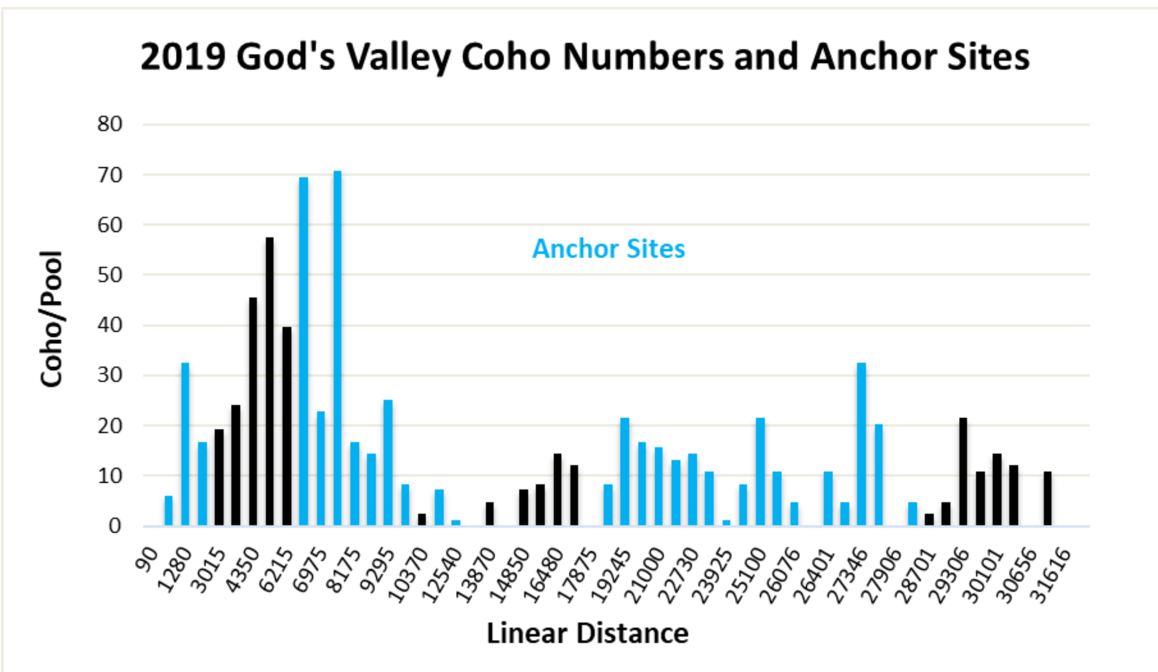

Figure 122: God's Valley Coho Numbers 2019

Steelhead

Steelhead abundance was low with pool presence only observed in only one sample pool.

Cutthroat

Cutthroat abundance was low with an average density of 0.01 fish/m^2 expanding to 17 fish/mile. The highest density of 0.03 fish/m^2 was observed at RM 3.49. A majority of production was observed from RM 0.2 – 0.7 (same as coho) with abundance expanding to 50 fish/mile.

0+ Trout

0+ trout abundance was low with intermittent pool presence at an average density of 0.07 fish/m^2.

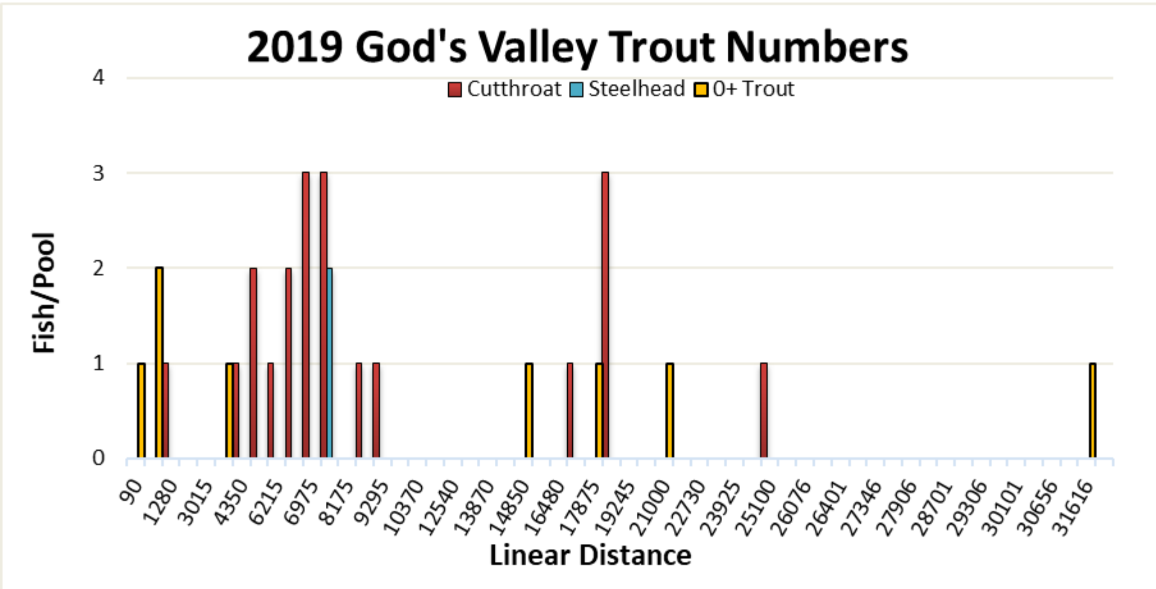

Figure 123: God's Valley Trout Numbers 2019

Chinook

Chinook were not observed.

Table 59: God's Valley Mainstem - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	4077	0.28	45	10	105	0

Minor Tributaries of God's Valley:

Tributary B

Trib B enters God's Valley on the upstream left bank at RM 3.55. The entirety of survey reach of Trib B was within an Anchor Site contiguous with God's Valley. The survey extended 0.31 miles upstream where an increase in gradient and lack of spawning gravel limited further anadromous potential. Stream habitat was characterized by dominant substrates of gravel and cobble; low terrace heights with floodplain connectivity (not incised like God's Valley); sinuous channel meander; and riparian of small to mid-sized conifers and alders.

Low abundances of coho observed were likely the result of one spawning event with low egg to fry survival. 4m^2 of spawning gravel was noted in the lower half of the survey with estimated adult (combined male and female) coho carrying capacity based on availability of spawning gravel between 4 – 8 coho. Low densities cutthroat and 0+ trout were also observed.

Tributary C

Trib C enters God's Valley on the upstream left bank at RM 4.6. The survey reach of Trib C was within an Anchor Site contiguous with God's Valley. The survey extended 0.59 miles upstream where an increase in gradient and lack of spawning gravel limited further anadromous potential.

Habitat was characterized by low flows; dominant substrates of cobble and gravel; low summer temperature profiles (14C – 15.5C); and broad grassy floodplain/wetland complex. At RM 0.14, flows were subsurface throughout a broad wetland complex. Flow continued upstream.

Coho were observed in low densities throughout the survey. Abundances of coho observed were likely the result of one spawning event with low egg to fry survival. 0+ and cutthroat were also observed. Estimated adult coho carrying capacity based on availability of spawning gravel between 8 - 20 coho

Tributary F

Trib F enters God's Valley on the upstream right bank at RM 5.77 over a bedrock step falls. Flow was approximately 40% that of God's Valley. The survey continued 0.13 miles upstream to where high gradient and boulder dominated channel limited further anadromous potential. No spawning gravel was observed. Coho were observed in two pools and likely the result of upstream juvenile migration. Cutthroat and 0+ trout were also observed. Three active full spanning beaver dams were present in the 0.13 miles survey reach.

God's Valley Tributary A

Tributary A enters God's Valley on the upstream right bank at RM 0.55 The RBA inventory extended 1.25 miles upstream where a small streambed, incised banks, and many log jams limit further anadromous spawning and rearing potential. Coho distribution extended to near the end of the inventoried reach with no barriers to passage observed.

Habitat was characterized by low gradient (avg. 1.28%); low flows, subsurface in sections; sinuous channel meander across wide floodplain/wetland complex; high channel complexity (LWD Treatment); dominant substrates of fine gravel and silt; high solar exposure; and high beaver occupation in the lower 0.6 miles with 7 active full spanning dams.

Photo 121 Trib A (God's Valley) Beaver Complex

Anchor Sites:

Most of the inventoried reach was within an anchor site. LWD structure logs were observed throughout the surveyed reach. Anchor sites received a high functionality rating but lacked high quality spawning gravel due to high concentrations of silts and sands.

Coho

Coho abundance was high with an average pool density of 1.43 fish/m^2 expanding to 808 fish/mile. The highest density of 3.39 fish/m^2 was observed at RM 0.39, just downstream of the beaver complex. The secondary density peak of 3.23 fish/m^2 at RM 0.8 was associated with the dominant spawning reach. This reach exhibited a lack of high-quality spawning gravel and indicates that coho are utilizing sub optimal gravel sites with high percentages of silt and sand.

Spawning Gravel and Escapement:

Estimated adult (combined male and female) coho escapement into Trib A was 9 coho. Estimated adult coho carrying capacity based on spawning gravel availability was between 8 – 24 coho.

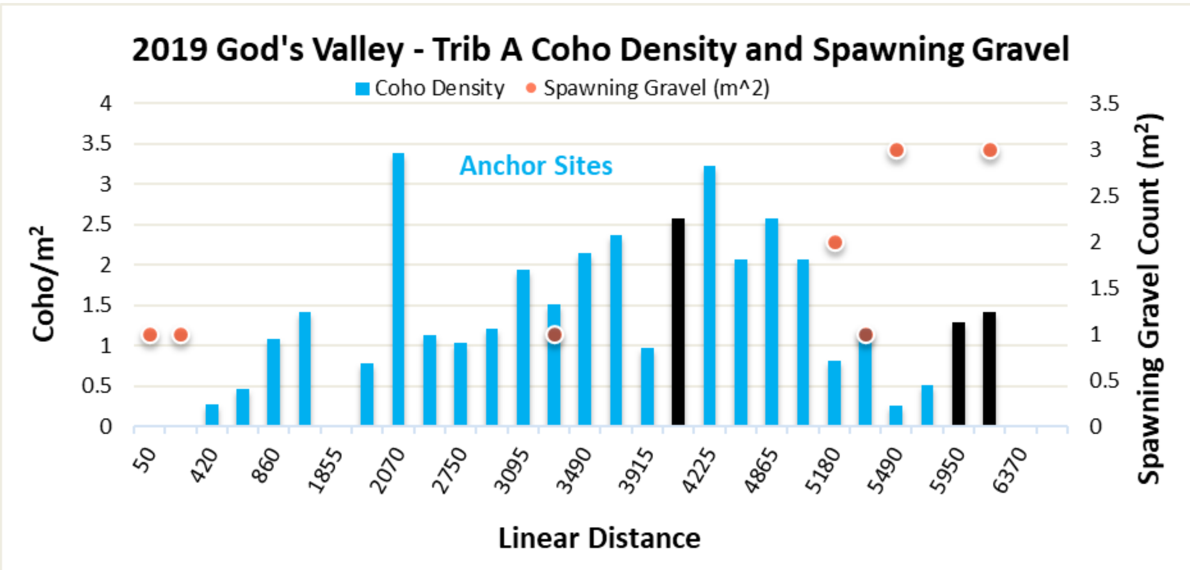

Figure 124: God's Valley Tributary A Coho Densities 2019

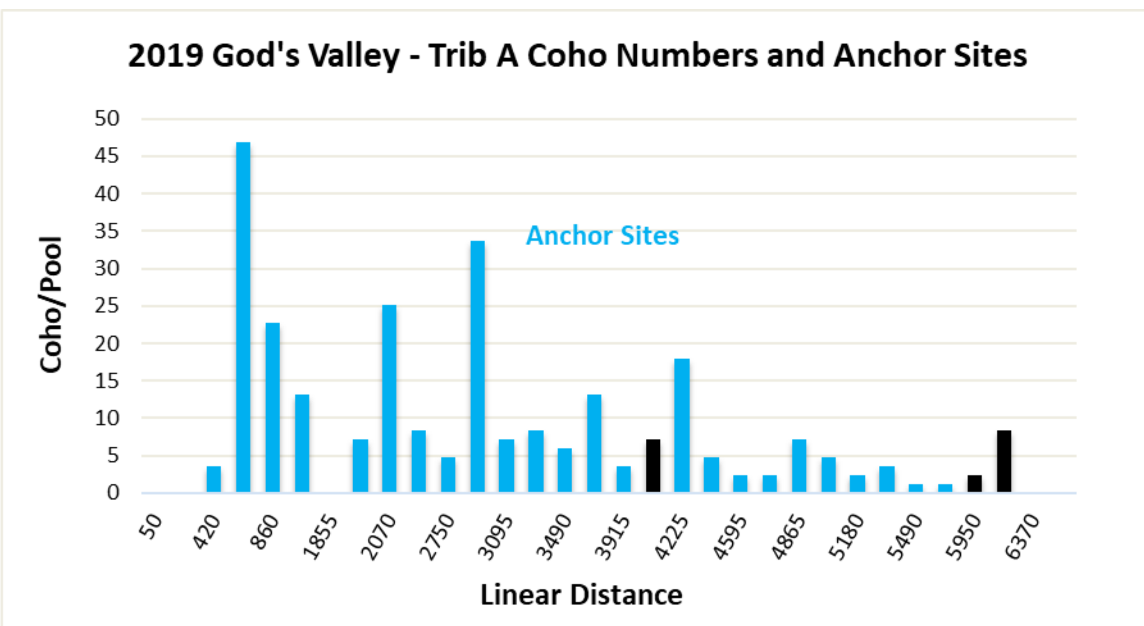

Figure 125: God's Valley Tributary A Coho Numbers 2019

Steelhead

No steelhead were observed.

Cutthroat

Cutthroat abundance was low with an average density of 0.23 fish/m^2 expanding to 16 fish/mile. The highest density of 0.5 fish/m^2 was observed at RM1.17.

0+ Trout

0+ trout abundance was low with an average density of 0.51 fish/m^2 expanding to 24 fish/mile. The highest density of 1.44 fish/m^2 was observed above anadromous distribution at RM 1.25 in the last pool sampled.

Chinook

Chinook were not observed.

Table 60: God's Valley Tributary A - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	1010	1.43	30	0	30	0

God’s Valley Tributary D and D1

Tributary D enters God’s Valley on the upstream left bank at RM 4.73 The RBA inventory extended 0.79 miles upstream were increased gradient and canyon pinch limited further spawning and rearing potential. Coho distribution extended to the end of the inventory. One tributary was included in the inventory (Trib D1) and is reviewed below.

Habitat in Trib D was characterized by moderate gradient (avg.2.2%); tannic water; high wood complexity; wide floodplain; low temperature profiles (14C – 14.5C); and dominant substrates of gravel, sand, and silt. High beaver occupation was documented above RM 0.5 with five active full spanning dams.

Photo 122 Trib D Confluence with God's Valley

Anchor Sites:

Most of the inventoried reach was within a moderately functioning anchor site. Limited abundance of well sorted spawning gravel was noted.

Coho

Coho abundance was low with an average pool density of 0.32 fish/m^2 expanding to 318 fish/mile. The highest density of 0.74 was observed at RM0.12.

Spawning Gravel and Escapement for D and D1:

An estimated 4 adult (combined male and female) coho escaped into Trib D and Trib D1 to spawn. Estimated adult coho carrying capacity based on spawning gravel abundance was 7 – 22 coho.

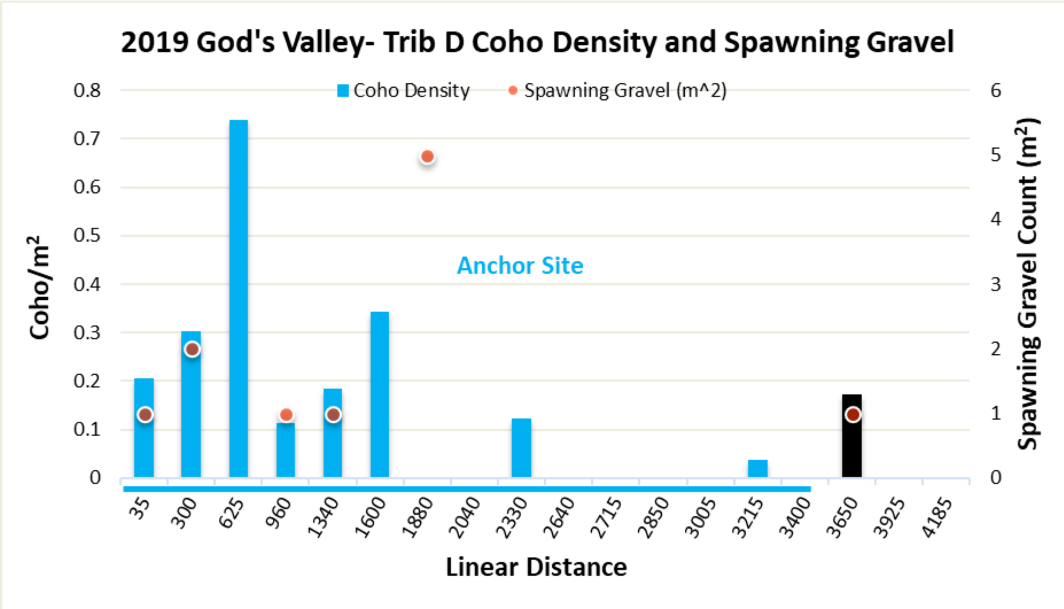

Figure 126: God's Valley Tributary D Coho Densities 2019

Steelhead

No steelhead were observed

Cutthroat

Cutthroat abundance was low with an average density of 0.15 fish/m^2 expanding to 13 fish/mile. Cutthroat were only observed in three pools in the survey reach. The highest density of 0.22 fish/m^2 was observed at RM 0.74.

0+ Trout

0+ trout abundance was low with an average density of 0.14 fish/m^2 expanding to 13 fish/mile. The highest density of 0.28 fish/m^2 was observed at RM 0.35 of D1, upstream of anadromous distribution.

Chinook

Chinook were not observed.

Table 61: God's Valley Tributary D and D1 - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	366	0.32	15	0	15	0

Tributary D

Tributary D1 enters Trib D at RM 0.22 on the upstream left bank. The RBA inventory extended 0.36 miles upstream were increased gradient and lack of spawning gravel limited further anadromous salmonid potential. Coho distribution extended to the end of the inventory. The coho abundance observed in Trib D1 was likely the result of one spawning event with low egg to fry survival. Estimated adult (combined male and female) coho capacity based on spawning gravel availability was 5 – 16 coho.

God's Valley Tributary E

Tributary E enters God's Valley on the upstream left bank at RM 4.95. The RBA inventory extended 0.47 miles upstream where increased gradient and lack of spawning gravel limited further anadromous potential. Coho distribution extended 0.43 miles.

Habitat was characterized by low gradient (avg. 1.9%); wide floodplain; dominant substrates of cobble and clean sorted gravel; low summer temperature profiles (14.5C); and riparian of young timber and alder.

Photo 123 Trib E (God's Valley)

Anchor Sites:

One anchor site contiguous with mainstem God's Valley Anchor #4 extended to the end of coho distribution.

Coho

Coho abundance was moderate with an average pool density of 0.88 fish/ m^2 expanding to 600 fish/mile. The highest density of 1.38 fish/ m^2 was observed at RM 0.14

Spawning Gravel and Escapement:

An estimated three adult (combined male and female) coho escaped into Trib E to spawn. Estimated adult coho carrying capacity based on spawning gravel availability was Spawning Gravel 7 – 20 adults.

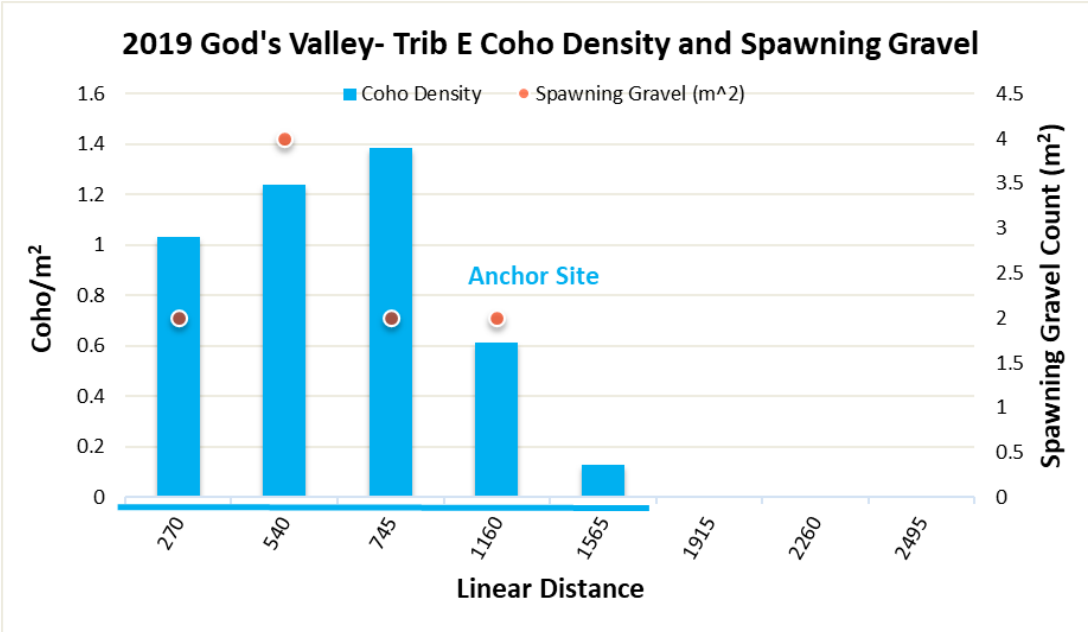

Figure 127: God's Valley Tributary E Coho Densities 2019

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was very low with an average density of 0.08 fish/ m^2 expanding to 22 fish/mile. Cutthroat were only observed in two pools in the survey Site.

0+ Trout

0+ trout abundance was very low with an average density of 0.13 fish/m^2 expanding to 21 fish/mile. 0+ trout were only observed in two pools in the survey Site.

Chinook

Chinook were not observed.

Table 62: God's Valley Tributary E - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	282	0.88	10	0	10	0

Gravel

Gravel enters the NF Nehalem at RM 2.4 on the upstream right bank. The RBA inventory extended 1.38 miles upstream where a 6ft falls followed by a 20ft log/boulder jam pinch limited further anadromous potential. Coho distribution extended 0.7 miles to two full spanning beaver dams and a 30ft log jam.

Habitat in the lower 0.33 miles was characterized by thin riparian cover and deep bedload retention of gravel and cobble with hyporheic flows feeding small isolated pools. Salmonid abundance in this lower reach was limited with only low numbers of coho observed in 2 out of 8 sampled pools.

Photo 124 Lower Gravel Creek

Upstream of RM 0.33 surface flows returned and stream habitat was characterized by moderate gradient (avg. 3.5%); abundant spawning gravel (36m^2) with deep bedload retention behind log jams; high wood complexity with coniferous content; low summer temperature profiles (13C – 14.1C); and mature coniferous riparian. Beaver activity was noted in Anchor Site #1 with four active full spanning dams.

Photo 125 Gravel Creek Beaver Pond

Anchor Sites:

Two Anchor Sites were observed.

Anchor Site 1 extended from RM 0.33-0.96. Anchor 1 contained 97% of all coho observed in Gravel Creek. This Anchor had high beaver activity and a wide riparian buffer. It received a function level rating of 2 (moderate) based on lack of large coniferous wood complexity.

Anchor Site 2 extended from RM 1.27-1.35. It received a function level rating of 2 (moderate) based on lack of sorted spawning gravel.

Coho

Coho abundance was high throughout the limited reach of distribution with an average pool density of 1.61 fish/m^2 expanding to 1489 fish/mile. The highest density of 4.16 fish/m^2 was observed at RM 0.41, within Anchor Site 1. Coho densities observed in gravel were likely affected by juvenile concentration as summer flows receded into the deep bedload reducing pool surface area.

Spawning Gravel and Escapement:

An estimated 10 adult (combined male and female) coho returned to Gravel Creek to spawn. A total of 36m^2 of Spawning Gravel was documented. 35m^2 of these occurred downstream of RM 0.80. Estimated adult coho carrying capacity based on spawning gravel availability was between 24 - 72 adults. Subsurface flows in the lower 0.33 miles significantly limits summer rearing potential for salmonids. With that in mind, Gravel Creek was still functioning well below capacity for coho production.

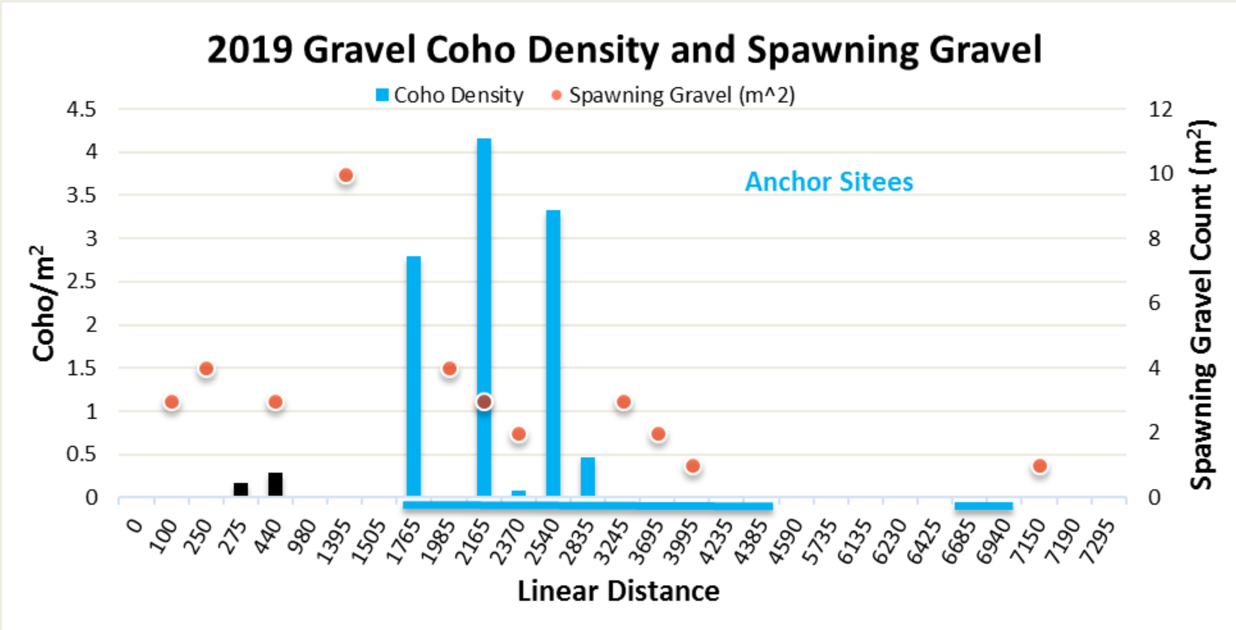

Figure 128: Gravel Coho Densities 2019

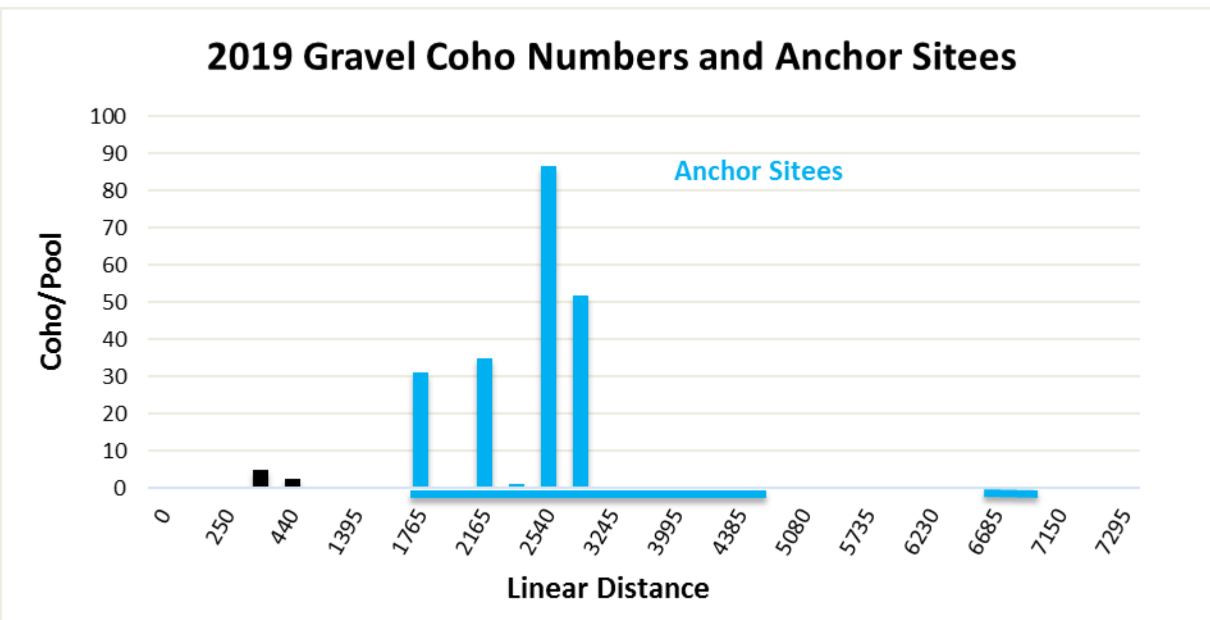

Figure 129: Gravel Coho Numbers 2019

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was high throughout the range of distribution with an average density of 0.37 fish/m^2 expanding to 175 fish/mile. The highest density of 1.19 fish/m^2 was observed above anadromous distribution at RM 1.22.

0+ Trout

0+ trout were not observed below RM 0.33. 0+ trout abundance was low with an average density of 0.56 fish/m^2 expanding to 160 fish/mile. The highest density of 1.61 fish/m^2 was observed above anadromous distribution at RM 1.31.

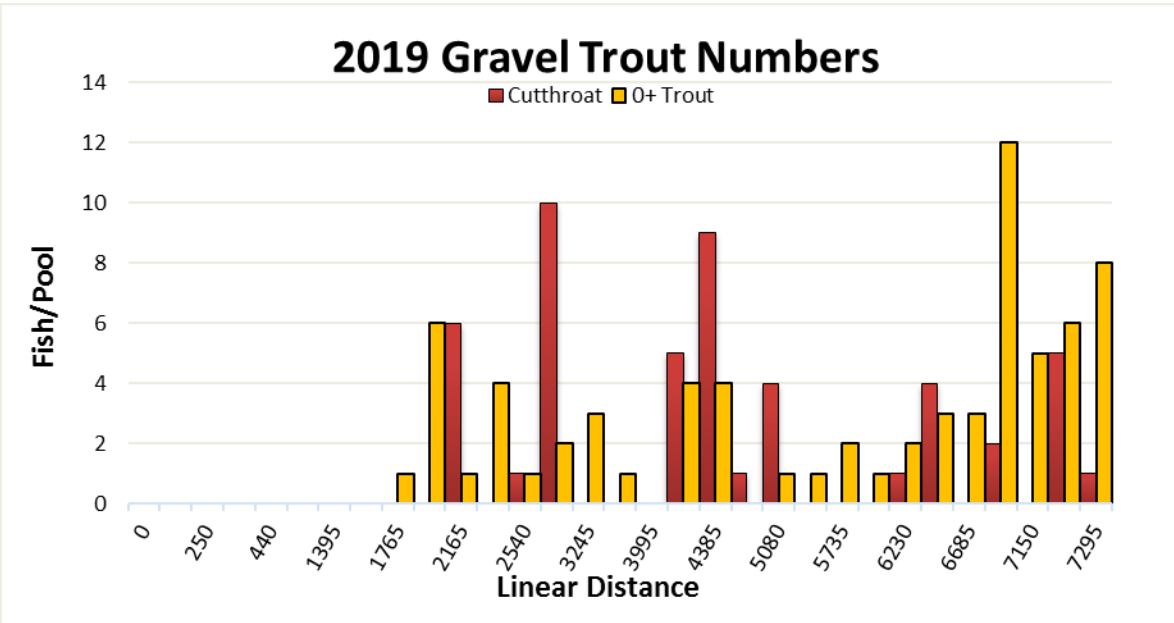

Figure 130: Gravel Trout Numbers 2019

Chinook

Chinook were not observed.

Table 63: Gravel - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	1042	1.61	155	0	170	0

Henderson

Henderson enters the NF Nehalem at RM 4.7 on the upstream left bank. The RBA inventory extended 1.33 miles upstream where a 10ft bedrock slide, rapids, and boulder jams limited further anadromous spawning and rearing potential. Anadromous fish distribution extended 1.07 miles with no barrier to passage observed.

Stream habitat was characterized by moderate gradient (avg. 2.5%); moderate wood complexity of predominantly deciduous origin; channel braiding across wide floodplain with low terrace heights; forested riparian of alder, hemlock, and spruce; low summer temperature profile (14C – 15C); and dominant substrates of cobble and gravel with reaches of scoured bedrock.

Photo 126 Henderson Creek

Anchor Sites

Two Anchor sites were documented in the Henderson RBA. Both anchor sites were given a moderate functionality rating based on a lack of large coniferous wood complexity.

Anchor Site #1 extended from the North Fork confluence to RM 0.57. Anchor Site #2 extended from RM 0.96 – 1.03.

Photo 127 Henderson Creek Anchor Site

Coho

Coho abundance was low with an average pool density of 0.42 fish/m^2 expanding to 482 fish/mile. The highest density of 1.12 fish/m^2 was observed at RM 0.45. Only one coho was observed in the first 0.31 miles of the survey.

Spawning Gravel and Escapement:

53m^2 of Spawning Gravel was observed throughout the Henderson Survey. Estimated adult (combined male and female) coho escapement into Henderson was 5 adults. Estimated coho carrying capacity based on spawning gravel availability was 36 - 108 adult (combined male and female). Based on juvenile rearing densities and spawning gravel estimates Henderson Creek was functioning well below current capacity for coho production and limited by low adult escapement.

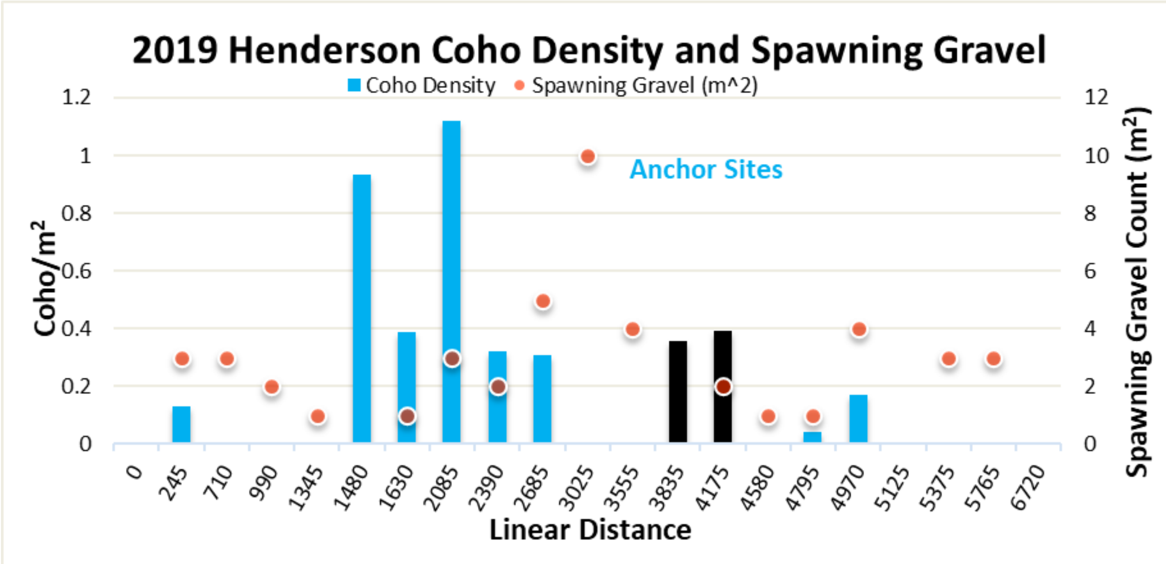

Figure 131: Henderson Coho Densities 2019

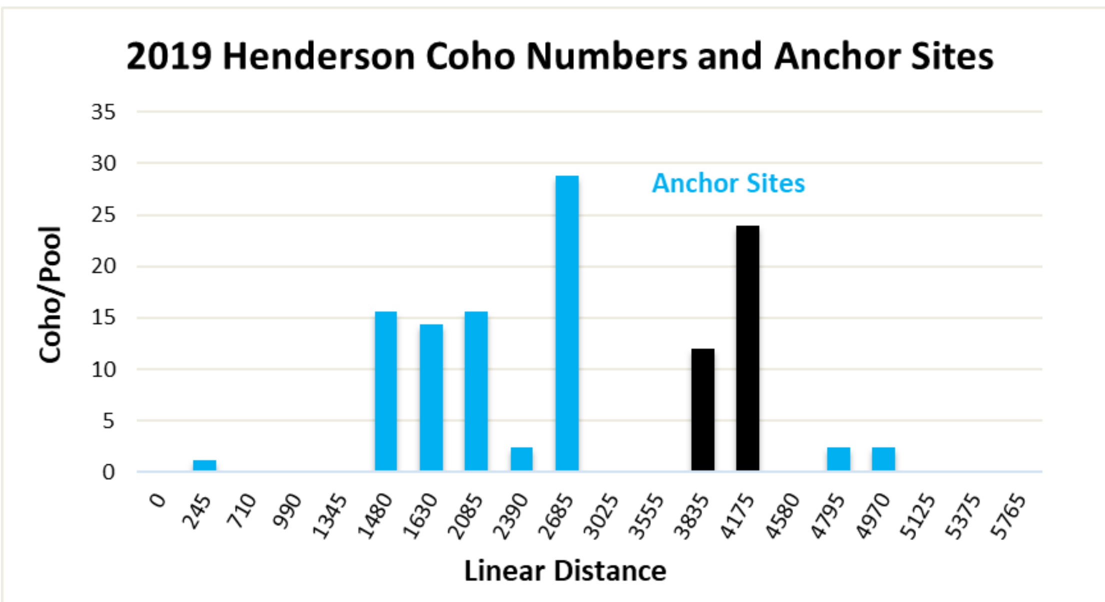

Figure 132: Henderson Coho Numbers 2019

Steelhead

Steelhead were not observed in Henderson.

Cutthroat

Cutthroat abundance was low with an average density of 0.06 fish/m^2 expanding to 34 fish/mile. The highest density of 0.13 fish/m^2 was observed at RM 0.51.

0+ Trout

0+ trout abundance was low with an average density of 0.12 fish/m^2 expanding to 109 fish/mile. The highest density of 0.4 fish/m^2 was observed at RM 0.51.

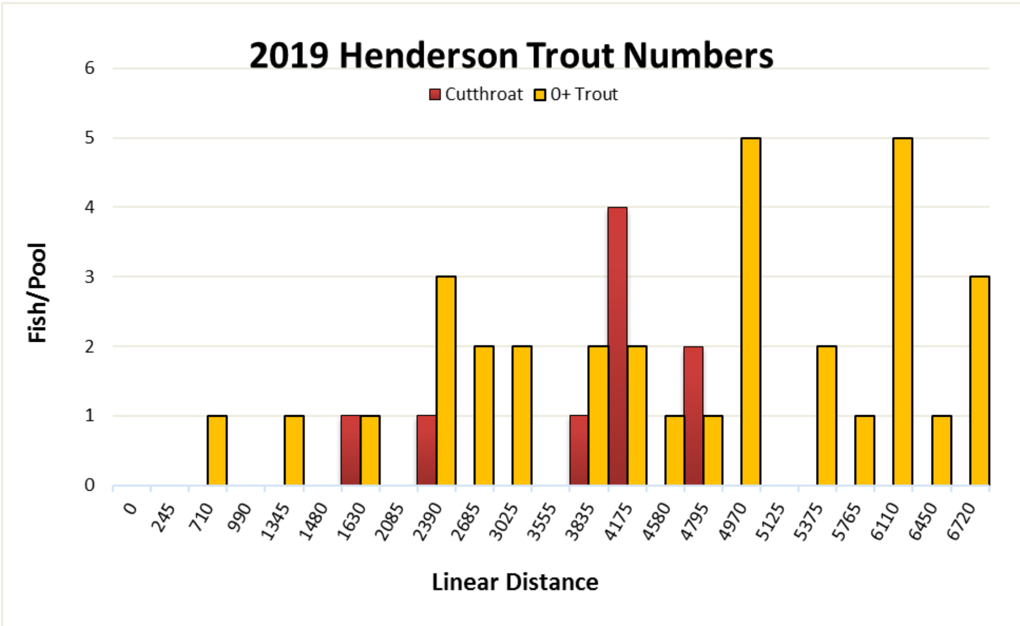

Figure 133: Henderson Trout Numbers 2019

Chinook

Chinook were not observed.

Table 64: Henderson - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	516	0.42	145	0	45	0

Tributary A

Trib A enters Henderson on the upstream right bank at RM 0.6. The survey extended 0.23 miles upstream to a 4ft sill log. Low flows limited anadromous potential. Coho were not observed in this tributary and limited anadromous potential exists. Cutthroat and 0+ trout were present.

Little North Fork Nehalem

The Little North Fork (LNF) Nehalem enters the NF Nehalem at RM 21.05 on the upstream right bank. At the confluence, the LNF contributes more summer flows than the mainstem North Fork. The RBA inventory of the LNF Nehalem subbasin encompassed a total of 9.71 miles of stream habitat exhibiting anadromous potential. This included 5.96 miles of mainstem LNF Nehalem, 2.91 miles in two large tributaries: Trib C and C1 (1.23 miles); Trib D and D1 (1.68 miles); and an additional 0.75 miles within five smaller tributaries with less than 200 (expanded) coho each.

The RBA inventory on mainstem LNF Nehalem extended 5.96 miles. Anadromous fish distribution extended 5.7 miles upstream where an 8ft high boulder cascade with log jam limited further anadromous potential. The inventory extended an additional 0.26 miles above the end of anadromy to include Anchor Site #7.

Habitat in the mainstem LNF was characterized by a low gradient (avg. 1.18%); channel meander across wide floodplain (several anchor sites); dominant substrates of cobble and gravel with abundant available spawning gravel (157m^2 total); moderate channel complexity with lack of large coniferous wood; mixed riparian of well forested reaches and thin buffers along lower residential properties and clearcuts; and low summer temperature profiles (13.5C – 14C).

Photo 128 Little North Fork

Thin riparian buffers were observed throughout several reaches of the LNF inventory. Low in the system, residential and agricultural lands lack adequate riparian buffers. Farther upstream, reaches throughout private timberlands with narrow riparian buffers provided limited cover overall with higher exposure in several sections where high percentages of the riparian corridor post logging have blown down into the creek.

Photo 129 Little North Fork, Inadequate Riparian buffer

Anchor Sites:

Over half the Little North Fork inventoried reach was within anchor habitat. A total of seven anchor sites were observed.

Anchor Sites #1 through #5 extend from the confluence to RM 4.4 and were given function level ratings of 2 (moderate) due to a lack of large-diameter wood complexity, though previous LWD treatments were noted in Anchor Site #1.

Anchor Site #2 was the longest extending from 1.3 - 3.6 and exhibited the highest potential for restoration. This anchor site encompassed the highest production reaches for coho, 0+ trout, and steelhead. Abundant spawning gravel ($157m^2$) was documented in this Anchor.

Anchor Site 6 runs from RM 4.9 - 5.08 and was given a function level rating of 3 (low) due to lack of available spawning gravel and lack of large wood complexity.

Anchor Site 7 runs from RM 5.75-5.89, and was above 2019 anadromous distribution, though not above available potential. It was given a function rating of 2 due to the lack of usable spawning gravel.

Photo 130 Little North Fork Anchor Site #2

Spawning Gravel and Escapement for the Entire Little North Fork Subbasin:

The LNF Subbasin contained abundant spawning gravel (262m^2). 97% of that spawning gravel was observed in the Mainstem LNF. Based on Spawning Gravel, estimated carrying capacity for this system is from 175 - 524 adult coho (combined male and female). Based on expanded coho counts the estimated adult (combined male and female) coho escapement into the LNF Subbasin for the 2018 brood year was 76 coho.

Coho

Coho abundance was moderate with an average pool density of 0.40 fish/m^2 expanding to 1240 fish/mile. The highest density of 1.48 fish/m^2 was observed at RM 5.25. The LNF mainstem contributed 10% of the total NF Nehalem coho population estimate and accounted for 7.3% of the total inventoried linear stream miles.

Spawning Gravel and Escapement for the Little North Fork Mainstem:

Estimated adult coho escapement into the LNF mainstem was 64 coho (combined male and female). The mainstem Little North Fork contained 255m^2 of Spawning Gravel. Based on spawning gravel availability, estimated adult (combined male and female) coho carrying capacity was from 170 - 510 coho. Based on juvenile rearing densities and spawning gravel availability the LNF was functioning well below current capacity and limited by low adult escapement.

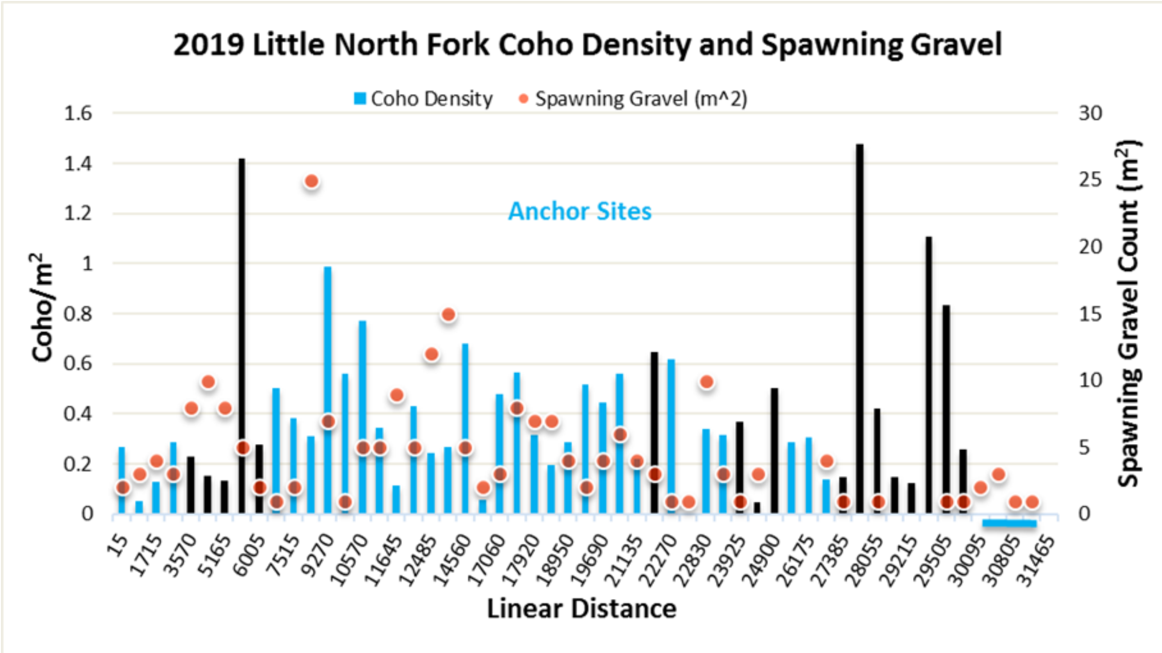

Figure 134: Little North Fork Nehalem Coho Densities 2019

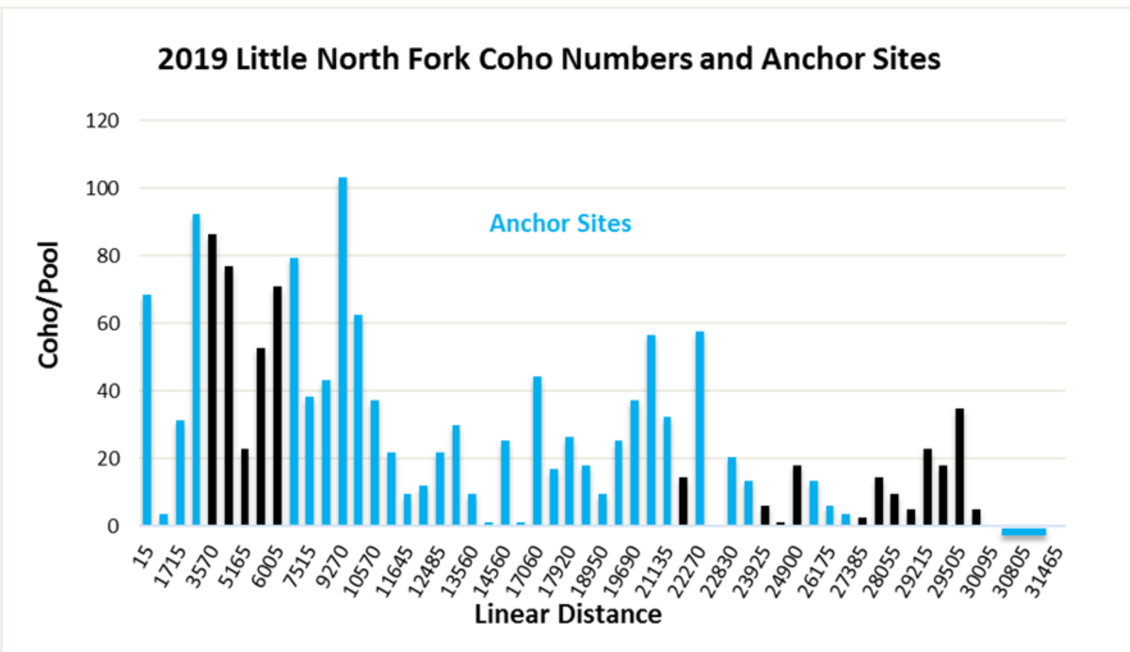

Figure 135: Little North Fork Nehalem Coho Numbers 2019

Steelhead

Steelhead abundance was low at an average pool density of 0.02 fish/m^2 with intermittent pool presence throughout most of the range of distribution. Steelhead abundance expanded to 16 fish/mile throughout the range of anadromy. Peak production was observed from RM 1.76 - RM 2.76 with abundance expanding to 65 fish/mile.

Cutthroat

Cutthroat abundance was low with an average density of 0.05 fish/m^2 expanding to 59 fish/mile. The highest density of 0.22 fish/m^2 was observed at RM 5.83, above anadromous distribution.

0+ Trout

0+ trout abundance was low with an average density of 0.05 fish/m^2 expanding to 64 fish/mile. The highest density of 0.13 fish/m^2 was observed at RM 4.13.

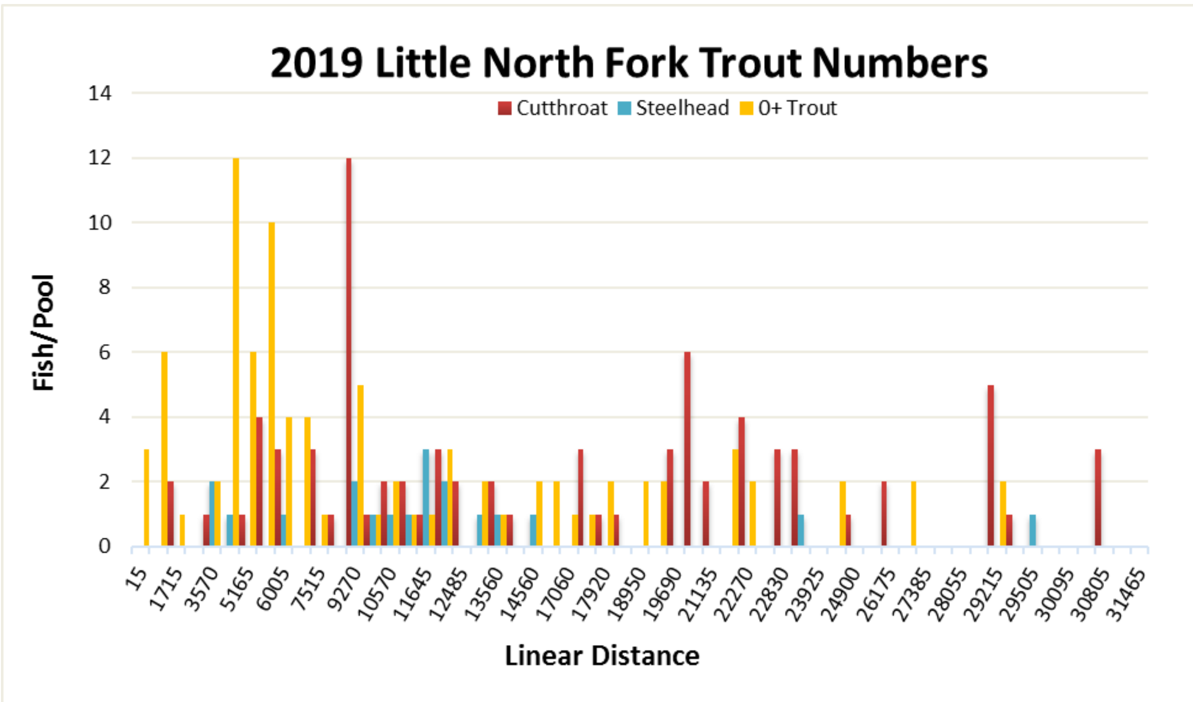

Figure 136: Little North Fork Nehalem Trout Numbers 2019

Chinook

Chinook were not observed.

Table 65: Little North Fork Nehalem - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	7070	0.40	380	90	350	0

Minor Tributaries of Little North Fork:

Tributary A

Trib A enters the LNF on the upstream right bank at RM 0.58. The survey continued 0.05 miles where the tributary divides into two small channels. According to the landowner, coho spawning occurred in Trib A during 2018. Coho were not observed during the inventory, and it is not likely anadromous distribution would extend far above the divided flows.

Tributary E

Trib E enters the LNF on the upstream right bank at RM 4.23. The survey continued 0.53 miles upstream to where increased gradient and canyon confinement limited further anadromous potential. Coho were observed in low densities. Habitat was characterized by low flows and high gradient with dominant substrates of boulder and cobble.

Tributary F

Trib F enters the LNF on the upstream left bank at RM 4.48. The survey extended 0.1 miles upstream to where reduced flows limited further anadromous potential. Coho were observed in the first sample pool. Habitat was characterized by low flows and beaver activity.

Tributary G

Trib G enters the LNF on the upstream right bank at RM 5.85. The survey extended 0.02 miles upstream. The tributary is low gradient at the confluence and contributes approximately 40% of the flow to the LNF. Upstream, increased gradient limited further anadromous potential. No coho were observed in Trib G.

Little North Fork Nehalem Tributary C

Tributary C enters the LNF Nehalem at RM 1.53 on the upstream right bank. The RBA inventory extended 1.05 miles upstream where increased gradient limited further anadromous potential. Anadromous fish distribution extended to RM 0.94.

Habitat was characterized by followed by high gradient (avg 5.8%); simplified channel with low wood complexity; low summer temperature profiles (12.5C – 13C); and dominant substrates of bedrock, cobble, gravel and fine silt/sand.

Anchor Sites:

One Anchor Site was observed. The site was low gradient and contiguous with LNF Anchor Site #2 extending from RM 0.0-0.18. A function level rating of 3 (low) was given due to a lack of riparian buffer, lack of channel complexity, and the lack of available spawning gravel.

Coho

Coho abundance was moderate with an average pool density of 0.63 fish/m^2 expanding to 421 fish/mile. The highest density of 1.39 fish/m^2 was observed at RM 0.25.

Spawning Gravel and Adult Escapement:

An estimated 5 adult (combined male and female) coho escaped into Trib C to spawn. No spawning gravel was documented in Trib C. Coho distribution profiles suggest that abundance was not the result of upstream juvenile migration and that spawning events occurred in Trib C despite the lack of high-quality spawning sites. Surveyors notes indicate the presence of unsorted gravel with high concentrations of finer substrates. The lack of adequate spawning gravel is currently functioning as the primary habitat limitation for coho production.

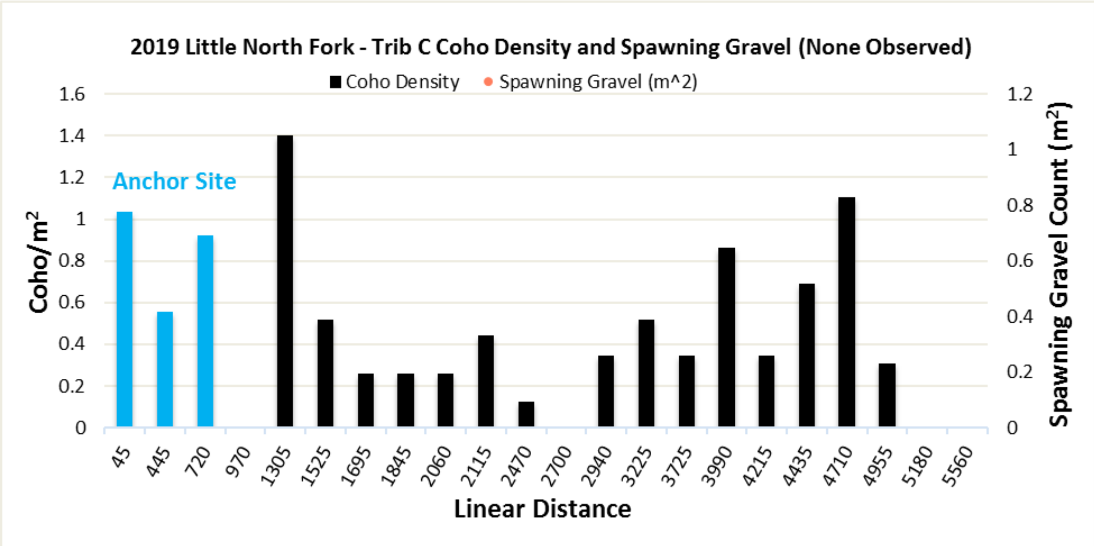

Figure 137: Little North Fork Nehalem Tributary C Coho Densities 2019

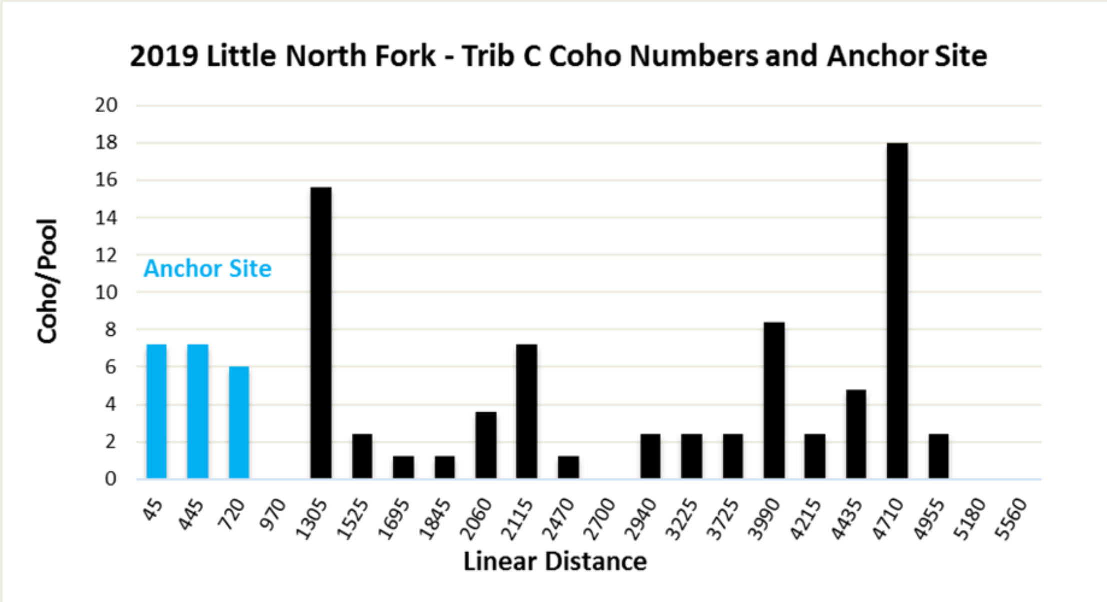

Figure 138: Little North Fork Nehalem Tributary C Coho Numbers 2019

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was moderate with an average density of 0.22 fish/m^2 expanding to 70 fish/mile. The highest density of 1.08 fish/m^2 was observed above coho distribution.

0+ Trout

0+ trout abundance was low with an average density of 0.13 fish/m^2 expanding to 21 fish/mile. The highest density of 0.22 fish/m^2 was observed at RM 0.09 of Trib C1.

Chinook

Chinook were not observed.

Table 66: Little North Fork Nehalem Tributary C - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	510	0.63	25	0	85	0

Little North Fork Nehalem Tributary D (Grand Rapids)

Little North Fork Nehalem Tributary D enters the LNF Nehalem at RM 1.9 on the upstream right bank within Anchor Site #2 of the LNF. This tributary contributed about 1/3 the summer flow of the LNF at the confluence. The RBA inventory extended 1.61 miles upstream where increased gradient, reduced channel size, and boulders substrate limited further anadromous spawning and rearing potential. Coho distribution extended to the increase in gradient. A short reach of a significant tributary (Trib D1) was included in the inventory and is reviewed below the expanded fish count table.

Stream habitat was characterized by a moderate average gradient (2.6%); dominant substrates of cobble and gravel; sinuous channel meander across a wide floodplain; moderate wood complexity of predominantly deciduous origin with a LWD treatment reach in the upper segment; mixed riparian of deciduous trees and conifers; and low summer temperature profiles (12C). Beaver activity was observed just above the LNF confluence.

Photo 131 Trib D (Little North Fork) Anchor Site

Anchor Sites:

One anchor site contiguous with LNF mainstem Anchor Site #2 extended from the confluence up to RM 1.1. Anchor Site 1 was given a function level rating of 2 (moderate) due to limited gravel sorting and lack of large wood complexity.

Coho

Coho abundance was low with an average pool density of 0.46 fish/m^2 expanding to 552 fish/mile. The highest density of 1.0 fish/m^2 was observed at RM 0.31.

Spawning Gravel and Adult Escapement:

Based on expanded coho counts, an estimated 6 adult (combined male and female) coho escaped into Trib D to spawn. Estimated adult coho carrying capacity based on availability of spawning gravel was 4-12 coho. This relatively large tributary exhibited potential for significantly higher summer rearing of coho than observed in the 2019 inventory. In years of higher adult escapement, it is likely that spawning gravel availability would function as the primary limiting factor in restricting summer rearing habitat from being seeded to capacity.

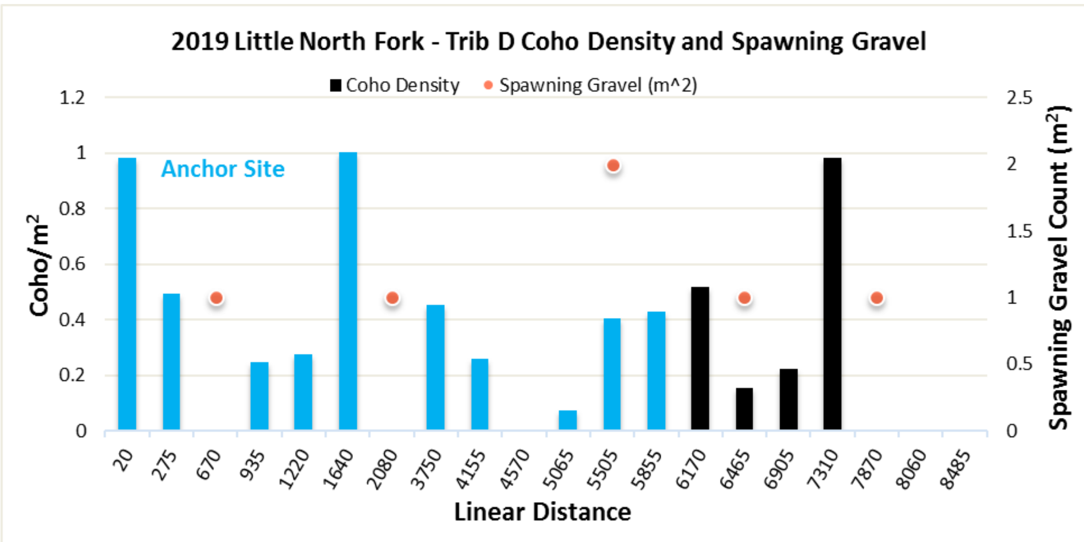

Figure 139: Little North Fork Nehalem Tributary D (Grand Rapids) Coho Densities 2019

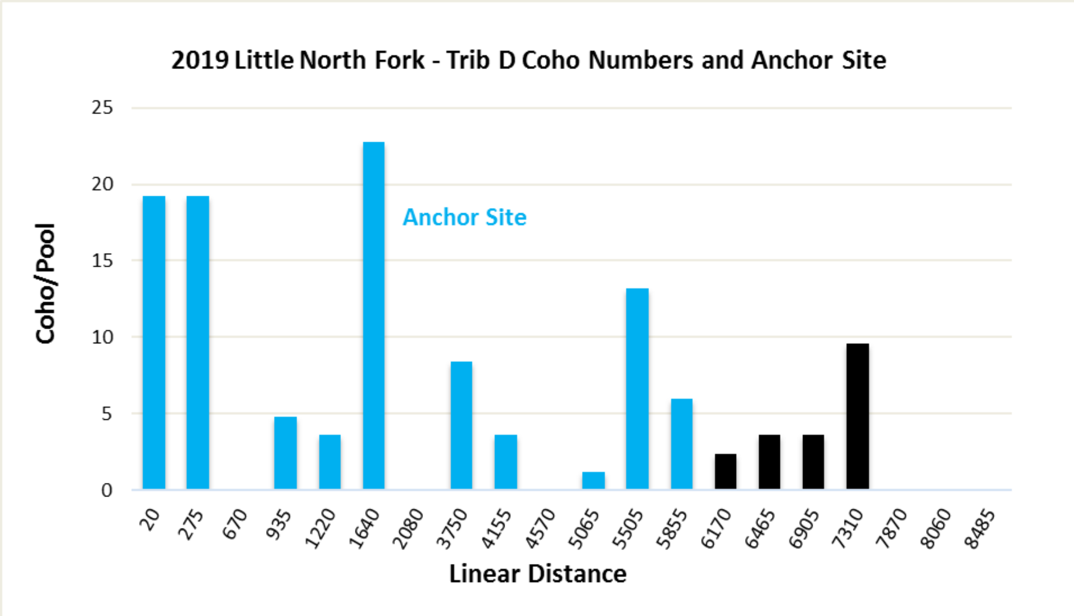

Figure 140: Little North Fork Nehalem Tributary D (Grand Rapids) Coho Numbers 2019

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was low with an average density of 0.09 fish/m^2 expanding to 44 fish/mile. The highest density of 0.29 fish/m^2 was observed at RM 1.11.

0+ Trout

0+ trout abundance was low with an average density of 0.10 fish/m^2 expanding to 20 fish/mile. The highest density of 0.18 fish/m^2 was observed at RM 1.49.

Chinook

Chinook were not observed.

Table 67: Little North Fork Nehalem Tributary D and D1 (Grand Rapids) - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	696	0.46	25	0	55	0

Tributary D1

Trib D1 Enters Trib D at RM 1.08 with approximately 40% of the summer flows. The RBA extended 0.07 miles upstream. No coho were observed in D1. Gradient profiles suggest that suitable habitat may extend an additional 0.25 miles upstream of our endpoint.

Little Rackheap

Little Rackheap enters the NF Nehalem at RM 3.2 on the upstream right bank The RBA inventory extended 1.86 miles upstream where a 6ft bedrock slide falls, increased gradient, and reduced flows limited further anadromous spawning and rearing potential. Anadromous fish distribution extended 1.75 miles to a narrowing valley and increased gradient in the channel. Average gradient for the inventoried channel was 2.78%.

One tributary was included in the inventory. Big Rackheap enters Little Rackheap at Rm 0.25 within a degraded stream reach. Big Rackheap is discussed in more detail below.

The confluence of Little Rackheap with the NF Nehalem was within tidal influence. A 2C temperature differential was measured at the confluence, with Little Rackheap at 14C and the NF Nehalem at 16C. Habitat near the confluence was characterized by stagnant water and a modified channel with livestock access provided to the creek by the adjacent dairy farm. The riparian was dominated by invasive knotweed and blackberry.

Photo 132 Lower Little Rackheap

Little Rackheap passes under Highway 53 at RM 0.55. Habitat upstream of the highway was characterized by moderate gradient (avg. 2.8%); a wide riparian buffer of knotweed, blackberry, and alder; sinuous channel meander; dominant substrates of boulder and cobble; low large wood complexity; and low temperature profiles (13.5C – 14C).

Double culverts at RM 0.68 under a private, residential road (Little Rackheap Acres) complicate fish passage. One 4ft and one 6ft culvert set into concrete under the road are both skewed downstream. The 4ft culvert is rusted through the bottom with a 1 inch drop at the lip. These are likely functioning as juvenile barriers to passage during low summer flow regimes.

Photo 133 Little Rackheap Failing Culverts

Anchor Sites:

One Anchor Site was observed from RM 1.10-1.29. This site was given a moderate functionality rating based on lack of spawning gravel and large wood complexity.

Coho

Coho abundance was low with an average pool density of 0.45 fish/m^2 expanding to 394 fish/mile. The highest density of 1.48 fish/m^2 was observed at RM 1.10, within Anchor Site #1.

Spawning Gravel and Escapement:

Adult escapement estimate based on expanded coho counts was 6 coho. Estimated coho carrying capacity based on spawning gravel availability in Little Rackheap was 4-12 adults (combined male and female).

A total of 6 m^2 of Spawning Gravel was observed in Little Rackheap. Most (5m^2) was observed directly upstream of the Highway 53 bridge (RM 0.55-0.60). With such low availability of suitable spawning gravel throughout most of the stream habitat within the range of anadromy it's likely that in years with higher adult coho escapement spawning gravel availability functions as a limiting factor for coho production in this creek.

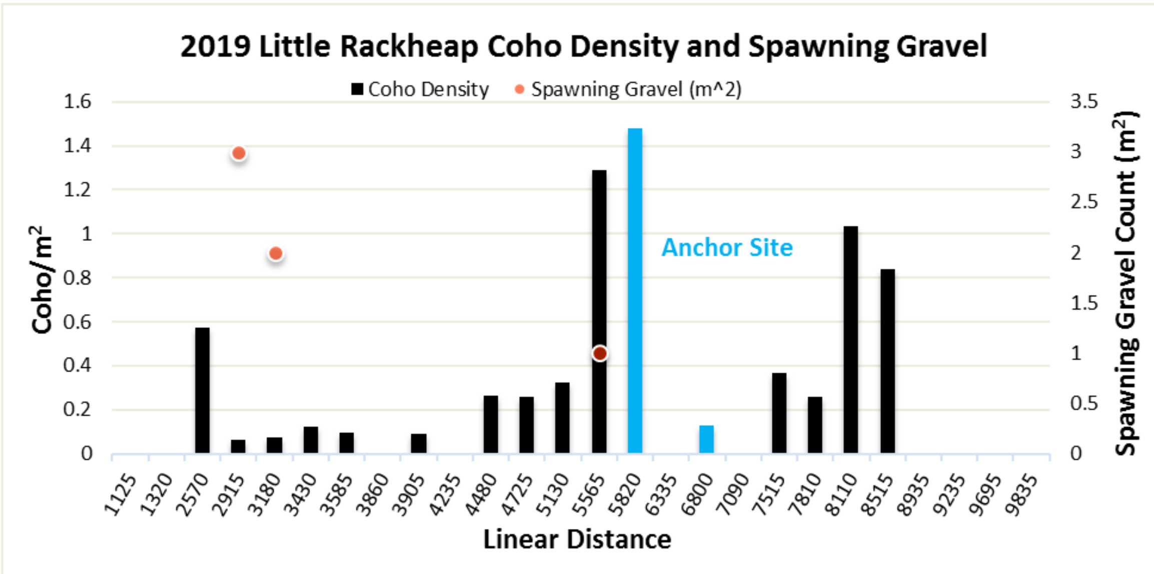

Figure 141: Little Rackheap Coho Densities 2019

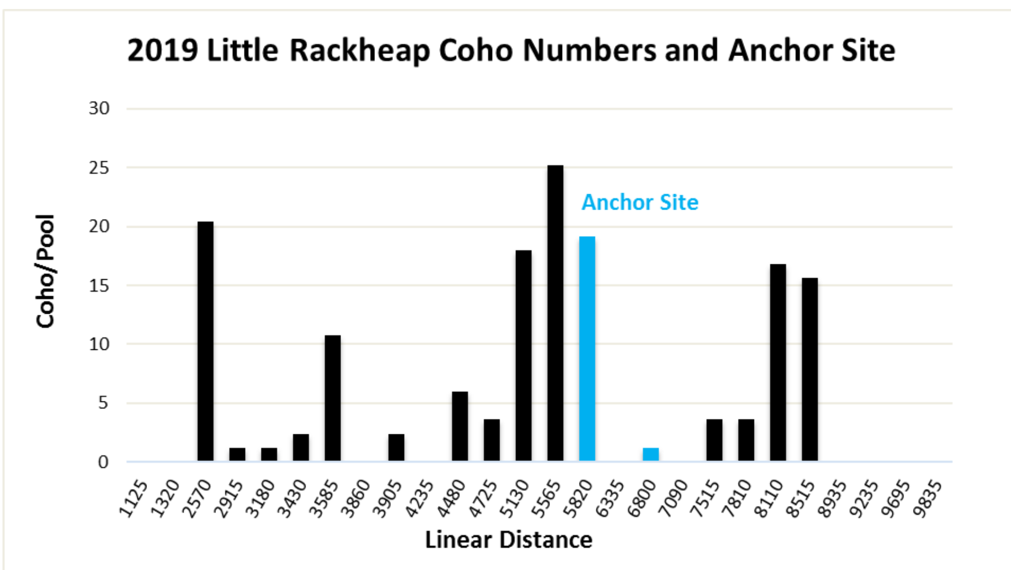

Figure 142: Little Rackheap Coho Numbers 2019

Steelhead

Two steelhead was observed in one pool at RM 0.49. This pool had a density of 0.06 fish/m^2.

Cutthroat

Cutthroat abundance was low with an average density of 0.10 fish/m^2 expanding to 43 fish/mile. The highest density of 0.31 fish/m^2 was observed in two pools, RM 1.05 and 1.10.

0+ Trout

0+ trout abundance was low with an average density of 0.15 fish/m^2 expanding to 16 fish/mile. The highest density of 0.22 fish/m^2 was observed at RM 1.29.

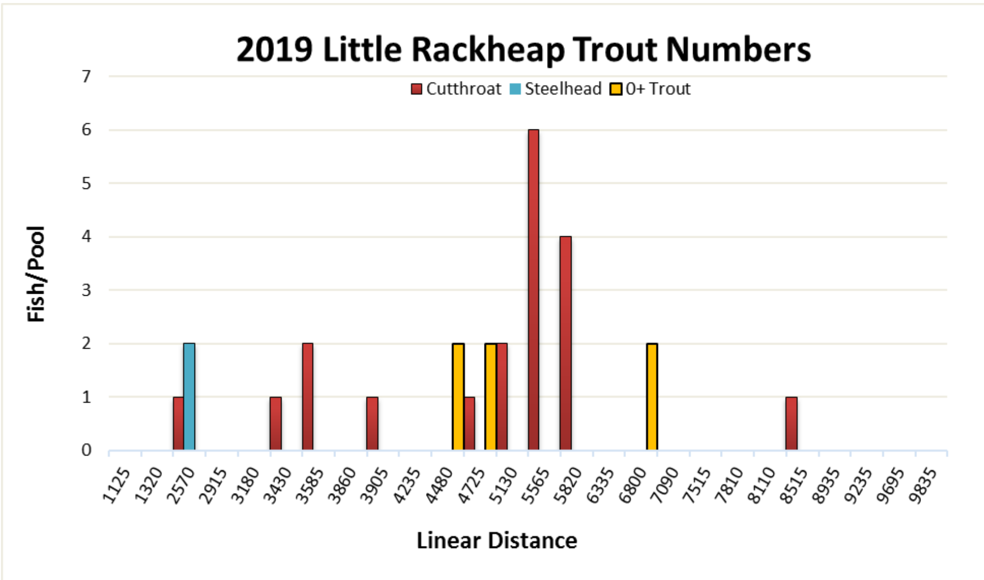

Figure 143: Little Rackheap Trout Numbers 2019

Chinook

Chinook were not observed.

Table 68: Little Rackheap - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	690	0.45	30	10	80	0

Big Rackheap

Big Rackheap enters Little Rackheap at RM 0.38 The RBA inventory extended 0.59 miles upstream where a 12-15ft falls with a 9ft bedrock slide above terminated further anadromous salmonid potential. Anadromous fish distribution extended to the falls. A total of 150 coho (expanded) were documented suggesting that one spawning event with low egg to fry survival occurred.

One Anchor Site extended from RM 0.24 to 0.52. This site was given a moderate functionality rating based on lack of spawning gravel and large wood complexity.

Habitat was characterized by low gradient; sinuous channel meander; riparian of Japanese knotweed with some mature spruce trees; dominant substrates of gravel and cobble, with a Spawning Gravel count of $7m^2$; and low summer temperature profiles (12C – 12.3C). The surveyor noted an abundance of invasive knotweed, especially in downstream segments. Cattle had access to the creek both upstream and downstream of the confluence with Little Rackheap. Beaver activity was observed with two full spanning dams.

Lost

Lost enters the NF Nehalem at RM 14.25 on the upstream right bank. The RBA inventory extended 2.12 miles upstream where increased gradient over cobble and boulder, reduced flows, and a lack of suitable spawning gravel limited further anadromous spawning and rearing potential. Coho distribution extended 0.66 miles to a series of log and debris jams with no adult barrier to passage observed.

Stream habitat was characterized by moderate to high gradient (avg. 4.6%); Lateral channel migration largely hillslope confined with reaches of floodplain expansion and sinuosity; moderate large wood complexity with several large wood jams and LWD treatment reaches; dominant substrates of bedrock, cobble, and gravel (38 m^2 spawning gravel); and low summer temperature profiles (14C).

Photo 134 Lost Creek

Photo 135 Lost Creek LWD Treatment

Anchor Sites:

One Anchor Site was observed from RM 0.27 - 0.53. This site was given a low functionality rating based on simplified stream channel, lack of large wood complexity, and low abundance of spawning gravel. Beaver activity was documented within the Anchor.

Coho

Coho abundance was low with an average pool density of 0.52 fish/m^2 expanding to 891 fish/mile. The highest density of 0.97 fish/m^2 was observed at RM 0.10. Coho distribution in 2019 extended only 0.66 miles, while significant potential for spawning and rearing extended an additional mile to the confluence of Trib A.

Spawning Gravel and Escapement for Lost and Trib A:

Estimated adult (combined male and female) escapement into Lost was 5 Coho. Estimated adult carrying capacity based on spawning gravel availability was 26 - 78 coho.

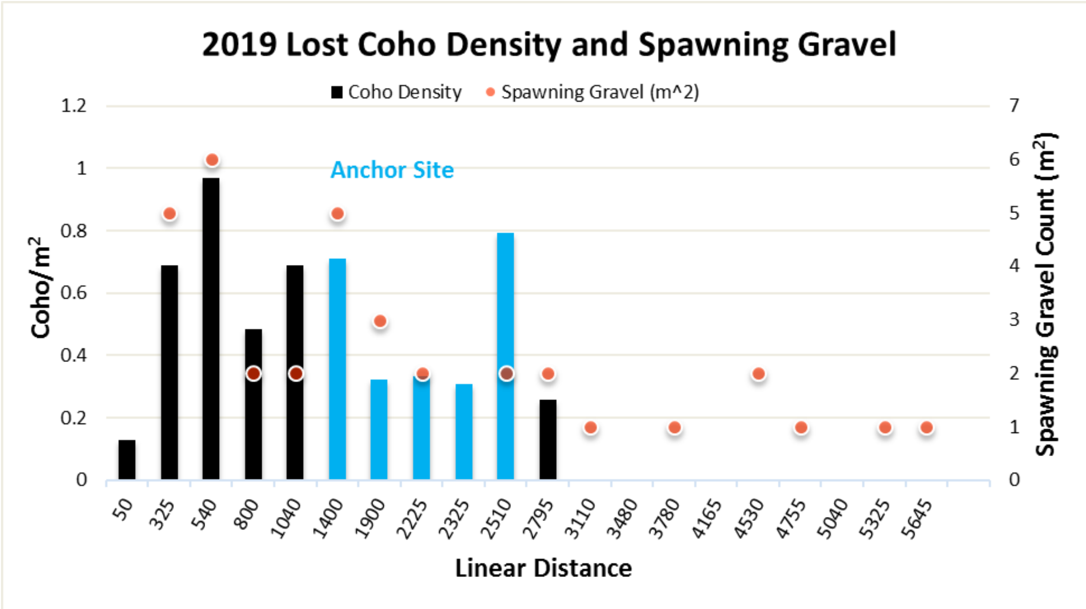

Figure 144: Lost Coho Densities 2019

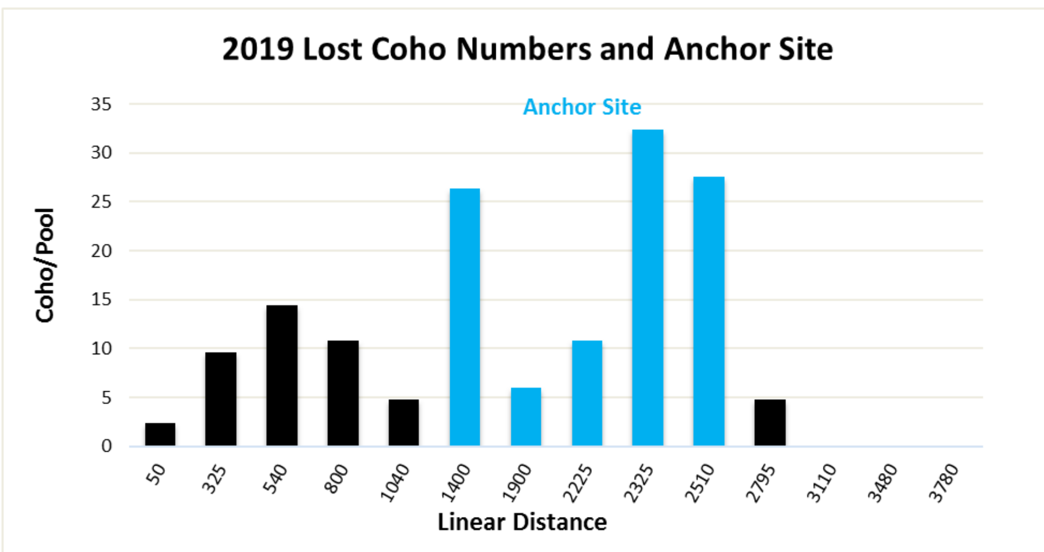

Figure 145: Lost Coho Numbers 2019

Steelhead

Steelhead were not observed on Lost.

Cutthroat

Cutthroat abundance was low with an average density of 0.08 fish/m^2 expanding to 89 fish/mile. The highest density of 0.29 fish/m^2 was observed at RM 0.2.

0+ Trout

0+ trout abundance was low with an average density of 0.22 fish/m^2 expanding to 167 fish/mile. The highest density of 1.38 fish/m^2 was observed at RM 0.66 above anadromous distribution.

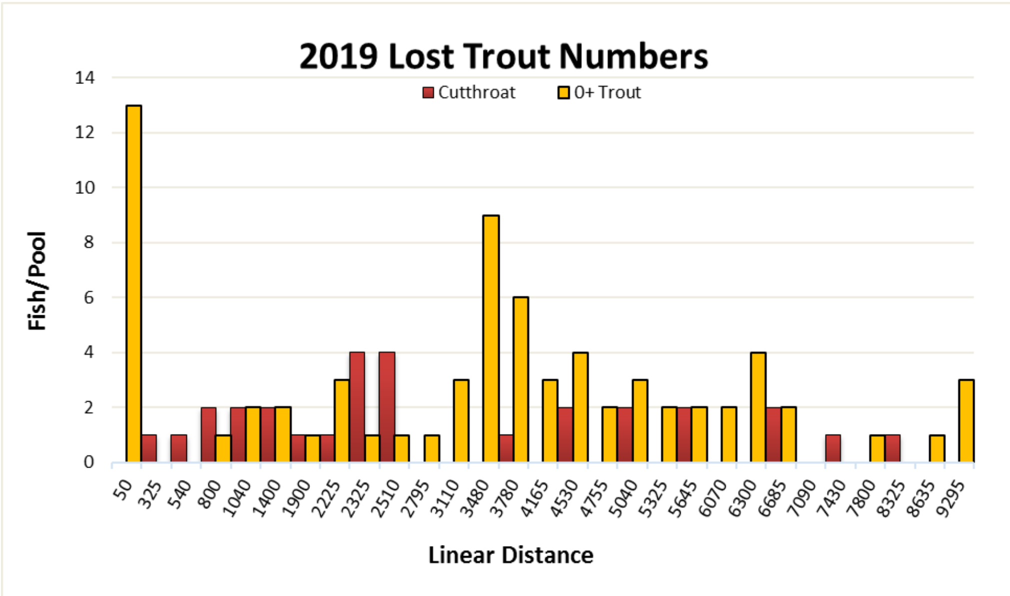

Figure 146: Lost Trout Numbers 2019

Chinook

Chinook were not observed on Lost.

Table 69: Lost - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	588	0.52	355	0	125	0

Tributary A

Trib A enters Lost on the upstream left bank at RM 1.7, above anadromous distribution. The survey extended 0.11 miles upstream to a failed culvert with water spilling onto bedrock and water emerging through boulders. No coho were observed, though the creek exhibited some coho potential. Habitat was characterized by old growth sill-logs embedded in the channel, and long cobble riffles. 1m^2 of Spawning Gravel was observed.

Sally

Sally enters the NF Nehalem at RM 12.3 on the upstream left bank. The RBA inventory extended 0.86 miles upstream where reduced flows and increased gradient limited further anadromous spawning and rearing potential. Coho distribution extended 0.65 miles with no adult barrier to passage observed. Two significant tributaries (Trib A and B) supported anadromy and were included in the inventory.

Habitat was characterized by moderate gradient (avg. 2.82); sinuous channel meander across wide floodplain with erodible banks; high wood complexity of predominantly deciduous composition; dominant substrates of cobble, gravel (14 m^2 spawning gravel), and fine sediment/sand; low summer temperature profiles (15C); and mixed riparian of deciduous and coniferous trees. Beaver activity was observed in the lower 0.3 miles with three active full spanning dams.

Photo 136 Sally Creek Confluence Trib A

Anchor Sites:

One Anchor Site was documented from RM 0.35 – RM 0.6. This site exhibited moderate functionality based on lack of large coniferous wood complexity and small shallow pools.

Coho

Coho abundance was low with an average pool density of 0.56 fish/m^2 expanding to 802 fish/mile. The highest density of 1.16 fish/m^2 was observed at RM 0.03. Density profiles suggest that the increased abundance documented in the first two sampled pools were the result of a temperature dependent migration into Sally Creek from the mainstem North Fork.

Spawning Gravel and Escapement:

An estimated 6 adult (combined male and female) coho escaped into Sally Creek to spawn. Estimated adult capacity based on spawning gravel abundance was 9 – 28 coho. Sally exhibited potential for significantly higher coho production than observed in 2019.

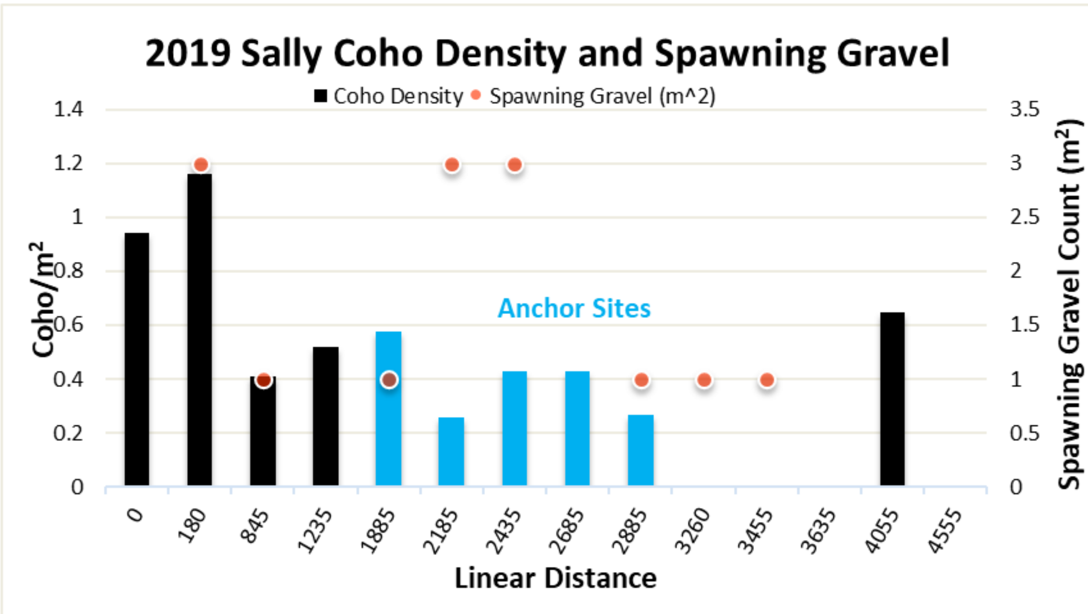

Figure 147: Sally Coho Densities 2019

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was extremely low with an average density of 0.20 fish/m^2 expanding to 12 fish/mile. Cutthroat were only observed in two pools in mainstem Sally.

0+ Trout

0+ trout abundance was extremely low expanding to 6 fish/mile. 0+ trout were only observed in one pool in mainstem Sally.

Chinook

Chinook were not observed.

Table 70: Sally - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	690	0.56	5	0	10	0

Tributary B

Trib B enters Sally on the upstream right bank at RM 0.57. The survey continued 0.09 miles upstream where subsurface flows and increased gradient limited further anadromous potential. Coho were observed in the first three pools (avg density 0.80 fish/m^2). Habitat was characterized by a bedrock creek bottom with low flow running through a wide floodplain alder flat (Sally Anchor Site 1).

Sally Tributary A

Trib A enters Sally on the upstream right bank at RM 0.32 within Sally Anchor Site #1. The survey continued 0.54 miles upstream to an increased gradient over cobble, and a confined hillslope, limiting anadromous potential. Coho distribution extended 0.30 miles to a canyon pinch and 1.5ft sill log with subsurface flows for a short reach above.

Stream habitat was characterized moderate gradient (avg. 2.95%); dominant substrates of cobble, abundant gravel (27 m^2), and sand; sinuous channel meander; high wood complexity of predominantly deciduous composition; and forested riparian of alder and spruce.

A failed 3-foot diameter culvert at RM 0.19 is perched 6 inches and rusted out. Subsurface flows were observed at the top of the culvert.

Photo 137 Trib A (Sally) Failing Culvert

Anchor Sites:

Two Anchor Sites were documented in Trib A. The first beginning at the confluence (contiguous with Sally Anchor Site #1) extending to RM 0.16 and the second upstream of the canyon pinch (RM 0.38-0.50) where the floodplain opens into a broad legacy beaver flat that extended for most of the remainder of the inventoried reach. Anchor Site #1 was given a moderate functionality rating based on lack of large coniferous wood complexity and channel incision (3ft). Anchor Site #2 was given a high functionality rating.

Photo 138 Trib A (Sally) Anchor Site #2

Coho

Coho abundance was moderate with an average pool density of 1.24 fish/m^2 expanding to 900 fish/mile. The highest density of 2.15 fish/m^2 was observed at RM 0.08.

Spawning Gravel and Escapement:

Trib A exhibited potential for significantly higher coho production than observed in 2019. An estimated 3 adult (combined male and female) coho escaped into Trib A to spawn. Estimated adult capacity based on spawning gravel availability was 18 – 54 coho.

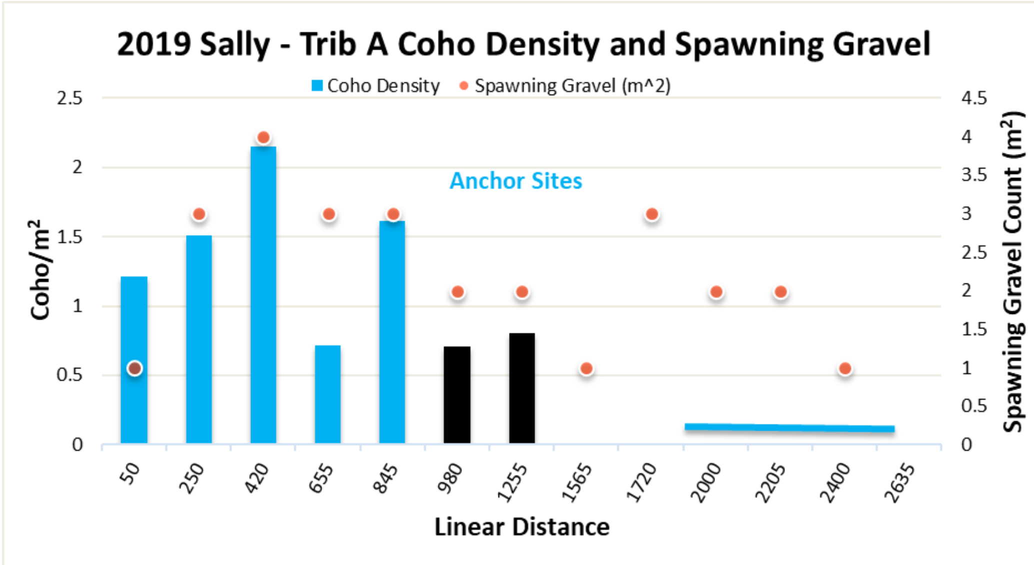

Figure 148: Sally Tributary A Coho Densities 2019

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was low with an average density of 0.37 fish/m^2 expanding to 65 fish/mile. The highest density of 0.72 fish/m^2 was observed at in the last sampled pool at RM 0.54.

0+ Trout

0+ trout abundance was extremely low with presence observed in only two sampled pools.

Chinook

Chinook were not observed.

Table 71: Sally Tributary A - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	270	1.24	10	0	35	0

Sweethome

Sweethome enters the NF Nehalem on the upstream right bank at RM 15.6. The RBA inventory of the Sweethome subbasin contained 3.49 miles of stream habitat exhibiting anadromous potential. This included 2.38 miles of mainstem Sweethome, 0.34 miles of Tributary D (Sweethome's largest tributary), and 0.77 total miles of five smaller tributaries. Significant tributaries are outlined in detail following the Sweethome mainstem data. The confluence of Sweethome with the NF Nehalem was located within an anchor site and high complexity wetland complex.

The RBA inventory on mainstem Sweethome extended 2.38 miles upstream where increased gradient with stretches of scoured bedrock limited further anadromous spawning and rearing potential. Anadromous fish distribution extended 2.28 miles to an increase in gradient and divided flows above a tributary confluence.

Steam habitat on Sweethome was characterized with a moderate gradient (avg. 3.0%); a wide active channel; palmate drainage with numerous tributaries; lateral channel migration constrained by road bed; dominant substrates of cobble, boulder, gravel, and bedrock; low summer temperature profiles (12C – 13.5C); and moderate wood complexity. Beaver activity was noted throughout the mainstem survey.

Photo 139 Sweethome Creek

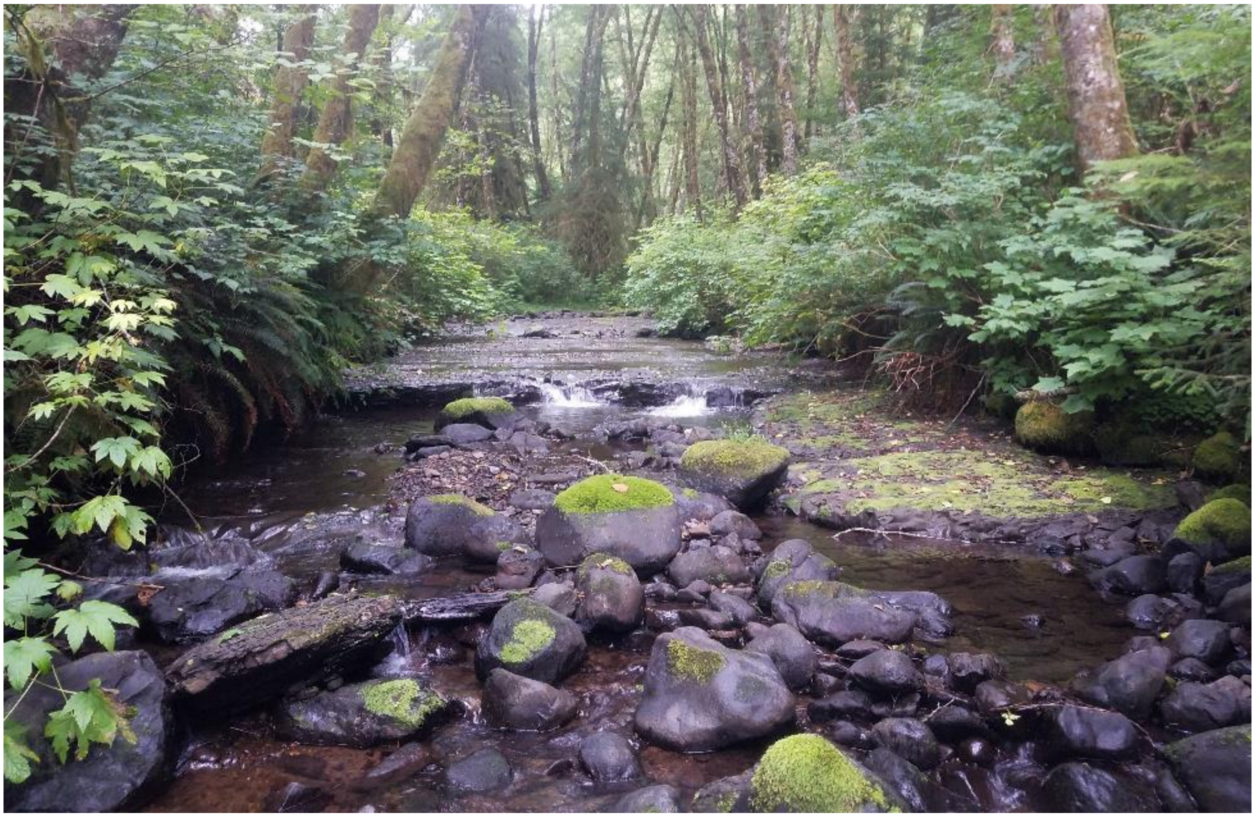

Photo 140 Upper Sweethome Creek

Anchor Sites:

Three Anchor Sites were observed on mainstem Sweethome.

Anchor Site 1 occurred from RM 0.0-0.3. It received a function level rating of 2 (moderate) due to lack of spawning gravel and an absence of large-diameter coniferous wood complexity.

Anchor Site 2 occurred from RM 0.62-0.86. It received a function level rating of 2 (moderate) due to a lack of large coniferous wood complexity. This anchor had abundant spawning gravel ($18m^2$ counted). Beaver occupation was observed with large pools above beaver dams (up to 165 feet) and high coho counts.

Anchor Site 3 occurred from RM 0.93-1.03. It also received a function level rating of 2 (moderate) due to lack of large coniferous wood complexity. Beaver occupation was observed with two active full spanning dams with large pools above dams (up to 100 feet) and high coho counts.

Photo 141 Sweethome Creek Anchor Site #1

Coho

Coho abundance was moderate with an average pool density of 0.94 fish/m^2 expanding to 1921 fish/mile. The highest density of 2.68 fish/m^2 was observed in a beaver dammed pool within Anchor Site #3 at RM 1.04. The two highest pool counts (299 and 186) were also observed in beaver pools within Anchor Site #2 and #3.

Spawning Gravel and Adult Escapement for Sweethome Mainstem:

An estimated 40 adult (combined male and female) coho escaped into mainstem Sweethome to spawn. Adult carrying capacity based on spawning gravel availability was 27 - 80 fish. A total of 40 m^2 of Spawning Gravel was documented.

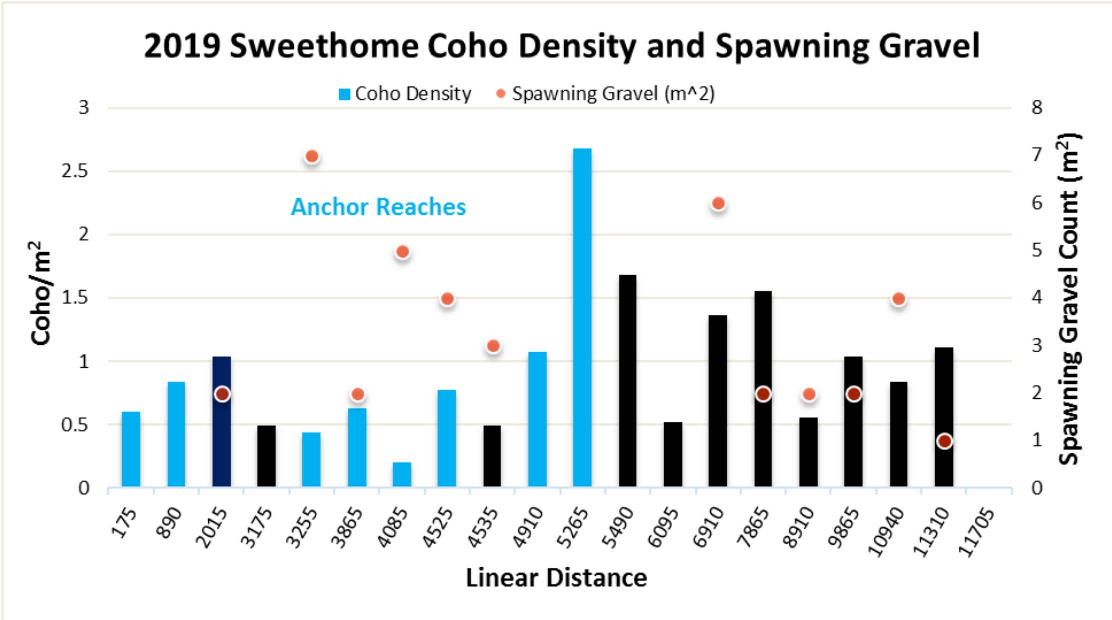

Figure 149: Sweethome Coho Densities 2019

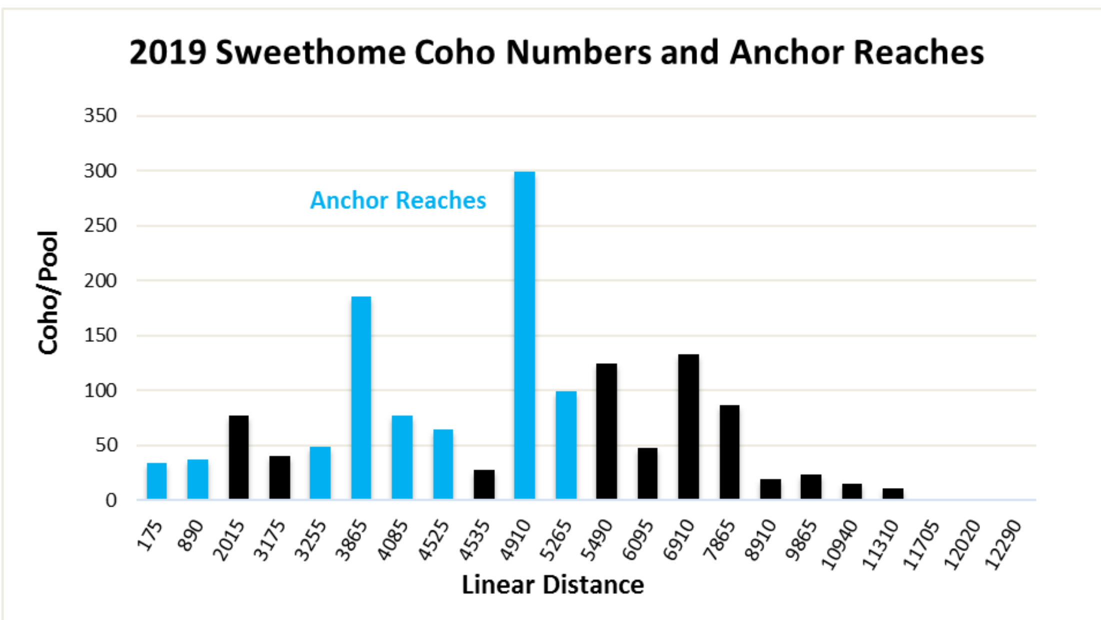

Figure 150: Sweethome Coho Numbers 2019

Steelhead

Steelhead abundance was low at an average pool density of 0.04 fish/m^2 expanding to 59 fish/mile. The highest production was documented from RM 0.38-0.86 where steelhead were present at 219 fish/mile

Cutthroat

Cutthroat abundance was low with an average density of 0.09 fish/m^2 expanding to 80 fish/mile. The highest density of 0.72 fish/m^2 was observed at RM 2.33, above anadromous distribution. The highest count (28 fish) was observed along with the highest coho count in a beaver pool at RM 0.93. The highest production was documented in the lower mile of the inventory where abundance expanded to 111 fish/mile.

0+ Trout

0+ trout abundance was low with an average density of 0.13 fish/m^2 expanding to 149 fish/mile. The highest density of 0.57 fish/m^2 was observed at RM 2.33, above anadromous distribution.

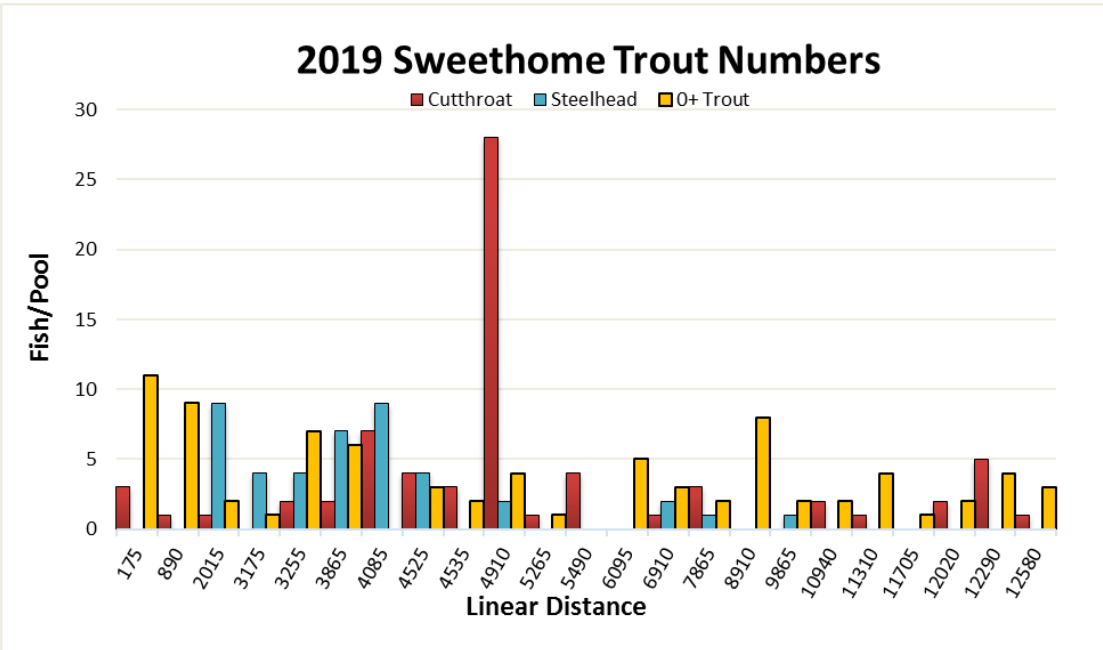

Figure 151: Sweethome Trout Numbers 2019

Chinook

Chinook were not observed.

Table 72: Mainstem Sweethome - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	4380	0.94	355	135	190	0

Tributary B

Trib B enters Sweethome on the upstream right bank at RM 0.77. The survey continued 0.19 miles upstream where the canyon tightens and gradient increases. No Coho were observed, but 5m^2 of Spawning Gravel was documented within anadromous potential.

Tributary C

Trib C enters Sweethome on the upstream left bank at RM 0.95. The survey continued 0.13 miles upstream where the canyon tightens and gradient increases. Coho were only observed in the first sampled pool upstream of the confluence. 2m^2 of Spawning Gravel was documented in this tributary.

Sweethome Tributary D

Tributary D enters Sweethome at RM 1.55 on the upstream right bank. The RBA inventory extended 0.34 miles upstream where increased gradient and a narrowing valley limits further anadromous potential. Coho distribution extended 0.19 miles to a 4ft full-spanning beaver dam.

Habitat was characterized by high gradient (avg. 4.5%) with beaver augmentation reducing gradient in sections of occupation (6 active dams); moderate wood complexity of deciduous origin; low summer temperature profiles (12C); and sinuous channel meander across broad floodplain.

Photo 142 Trib D (Sweethome)

Anchor Sites:

One large anchor site was documented extending the full length of the inventory. This site was given a function level rating of 2 (moderate) due to a lack of large-diameter wood complexity.

Coho

Coho distribution extended for only a short reach. Coho abundance was low overall with only one pool exhibiting high production and seeded to capacity. The highest density of 3.64 fish/m^2 and high pool count (79 fish) was observed at RM 0.02 in a beaver dammed pool. Abundance in this pool accounted for 90.8% of the total expanded population estimate for Trib D. Expansion of this pool count likely resulted in an overestimation of coho abundance in Trib D.

Spawning Gravel and Escapement:

Estimated adult (combined male and female) coho escapement based on expanded coho counts was 5 adults. Estimated adult coho carrying capacity based on spawning gravel availability was 4-12 adults.

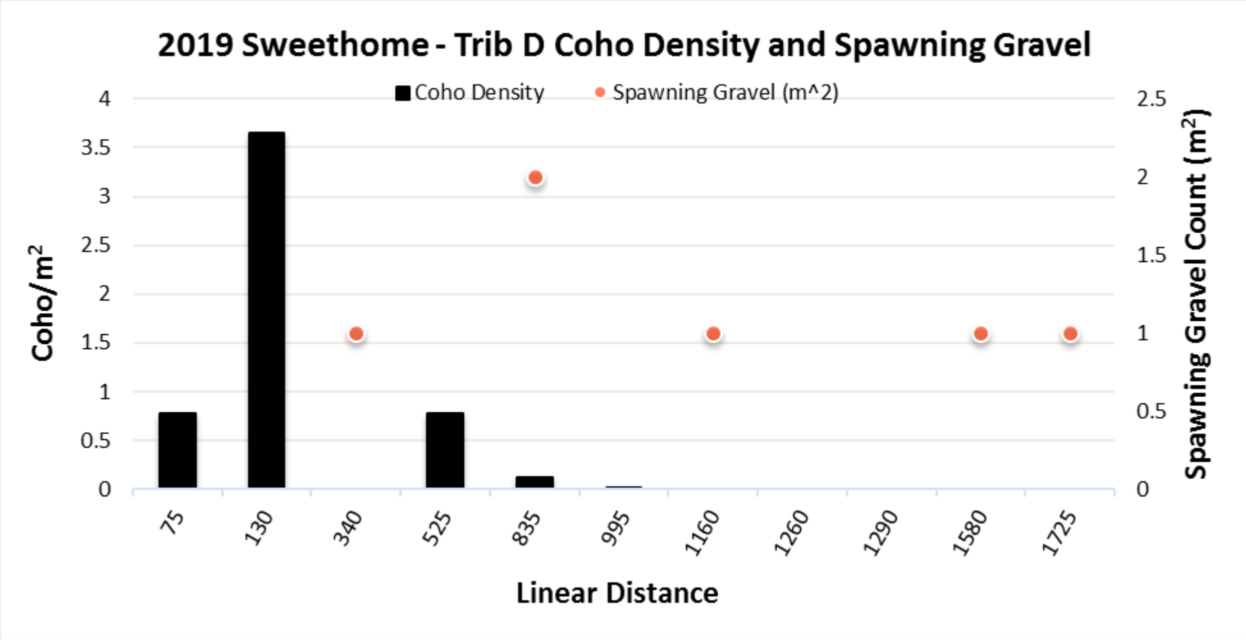

Figure 152: Sweethome Tributary D Coho Densities 2019

Steelhead

Steelhead were not observed.

Cutthroat

Cutthroat abundance was moderate with an average density of 0.18 fish/m^2 expanding to 206 fish/mile. The highest density of 0.23 fish/m^2 was observed at RM 0.02 in a beaver dammed pool.

0+ Trout

0+ trout were only observed in two pools. 0+ trout abundance was low with an average density of 0.28 fish/m^2.

Chinook

Chinook were not observed.

Table 73: Sweethome Tributary D- Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	522	1.07	20	0	70	0

North Fork Nehalem Tributary B

Tributary B enters the NF Nehalem at RM 18.4. The RBA inventory extended 1.25 miles upstream where decreased flows above a tributary junction and confined stream channel limited further anadromous potential. Coho distribution extended 0.96 miles with no barriers to passage observed. One tributary (Trib B1) exhibited anadromous potential and is described in further detail below.

Habitat was characterized by moderate gradient (avg. 3.3%); wide floodplain with high channel connectivity; wide riparian buffer of spruce and alder; high channel complexity; low summer temperature profiles (15C); and dominant substrates of bedrock, cobble, and gravel. A LWD treatment reach was observed just upstream from confluence.

Photo 143 Trib B (NF Nehalem)

Anchor Sites:

Three Anchor Sites were observed on Trib B.

Anchor Site #1 extended from RM 0.35-0.43. It received a moderate functionality rating based on lack of large coniferous wood complexity and limited spawning gravel availability.

Anchor Site #2 extended from RM 0.70-0.78. It received a high functionality rating.

Anchor Site #3 extended from RM 1.03-1.10. It received a moderate functionality rating based on limited spawning gravel availability.

Photo 144 Trib B (NF Nehalem) Anchor Site #1

Coho

Coho abundance was moderate with an average pool density of 2.03 fish/m^2 expanding to 750 fish/mile. The highest density of 10.33 fish/m^2 was observed at RM 0.70 in a small plunge pool with a count of 24 coho. This was the highest coho density documented in the entire NF Nehalem system. A more representative average rearing density, excluding this extremely high density spike, is 1.2 fish/m^2.

Spawning Gravel and Escapement for Trib B:

Estimated adult (combined male and female) coho escapement into Trib B was 7 adults. Total Spawning Gravel in Trib B was 9 m^2 with estimated adult carrying capacity based on Spawning Gravel availability from 6-18 adults.

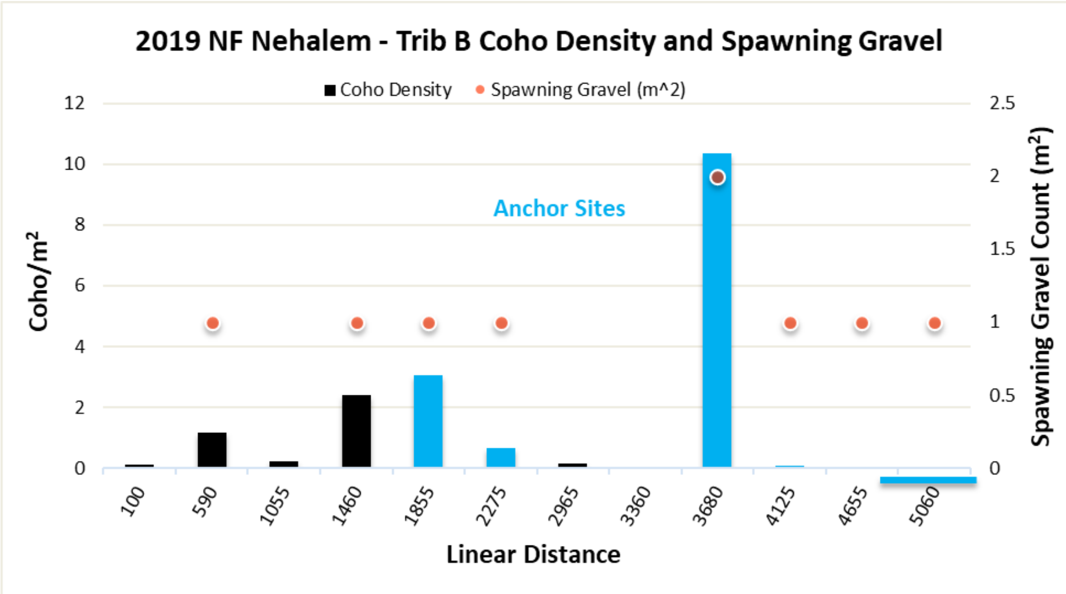

Figure 153: North Fork Nehalem Tributary B Coho Densities 2019

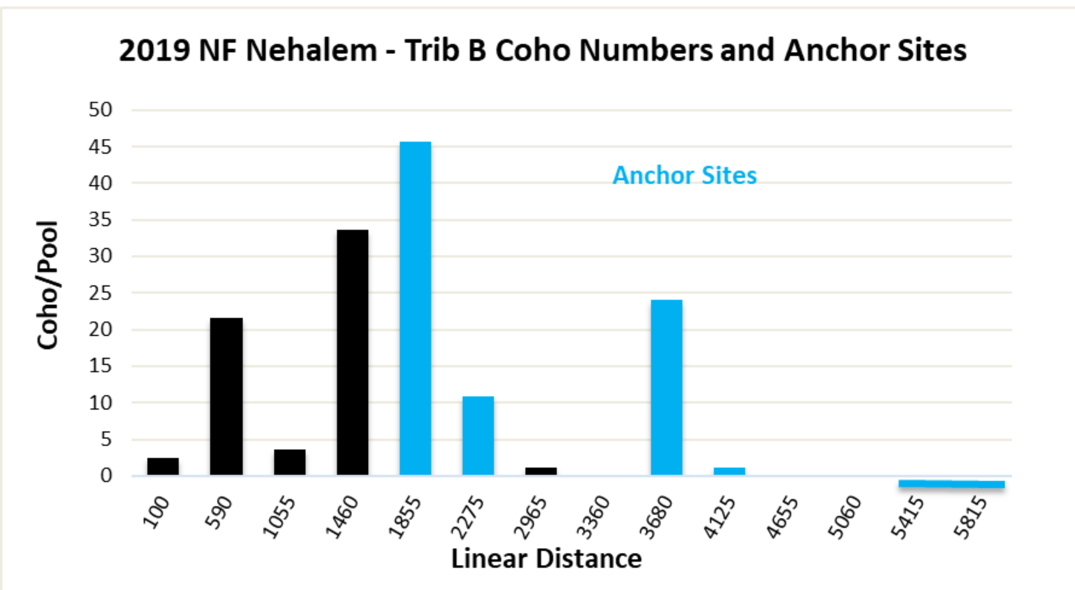

Figure 154: North Fork Nehalem Tributary B Coho Numbers 2019

Steelhead

Steelhead were observed in a single pool near just upstream from the North Fork Nehalem confluence. Density in this pool was 0.38 fish/m^2.

Cutthroat

Cutthroat abundance was low with an average density of 0.29 fish/m^2 expanding to 104 fish/mile. The highest density of 0.65 fish/m^2 was observed at RM 0.78.

0+ Trout

0+ trout abundance was low with an average density of 0.20 fish/m^2 expanding to 80 fish/mile. The highest density of 0.43 fish/m^2 was observed at RM 1.03, upstream of anadromous distribution.

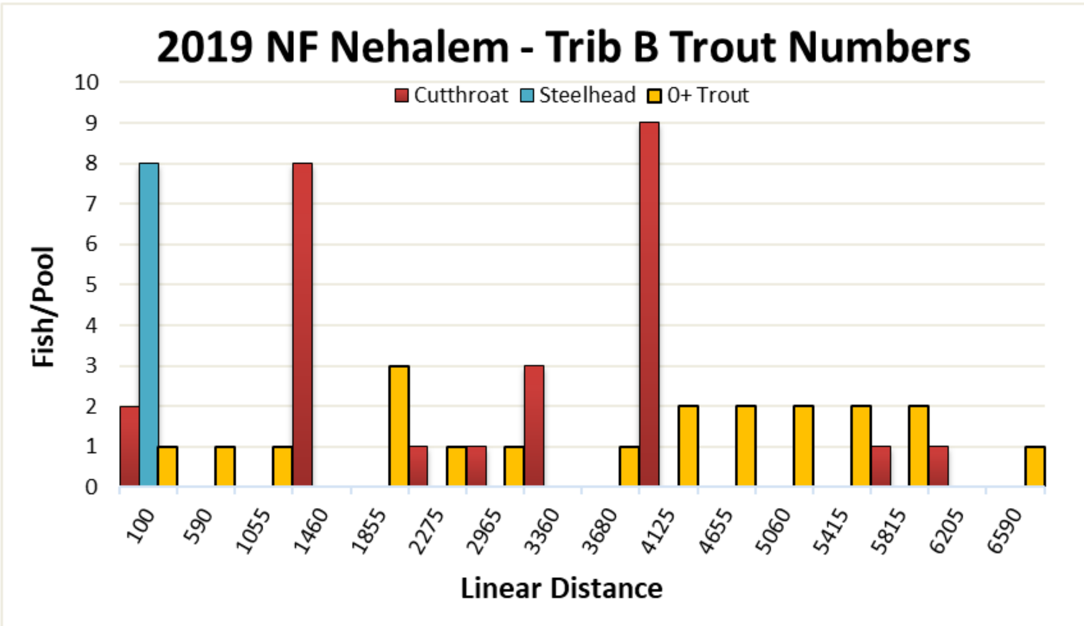

Figure 155: North Fork Nehalem Tributary B Trout Numbers 2019

Chinook

Chinook were not observed.

Table 74: North Fork Nehalem Tributary B and B1 - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	726	2.03	120	40	135	0

Tributary B1

Trib B1 enters Trib B on the upstream right bank at RM 0.58. Trib B1 lacked anadromous potential due to high gradient but contributed significant flows. Water temperature of B1(16.5C) was 1.5C higher than that of Trib B (15C). This temperature differential may be a result of high solar exposure from clearcuts observed in the upper watershed. One coho was observed in the first dive pool. 0+ trout and cutthroat were also observed.

North Fork Nehalem Tributaries G & G1

Tributary G enters the NF Nehalem on the upstream right bank at RM 24.2. Tributary G1 enters G on the USRB just upstream of the confluence with the NF, at RM 0.22. The RBA inventory on Trib G extended 0.27 upstream, where a broad legacy beaver flat wetland with numerous back to back active dams limited further anadromous spawning and rearing potential. High beaver occupation with a total of 11 full spanning active dams were observed throughout the short inventory of Trib G. Coho distribution extended a total of 0.52 miles, including both G and G1.

The inventory on Trib G1 extended 0.28 miles upstream where an increase in gradient and reduction in flows above a tributary confluence limited further anadromous potential. Stream habitat in G1 was characterized by moderate gradient (avg. 2.7%); thin riparian buffer from clearcut; and low flows.

Photo 145 Trib G

Anchor Sites:

No Anchor Sites were observed on Trib G or G1

Coho

Coho abundance was moderate with an average pool density of 1.06 fish/m^2 expanding to 450 fish/mile. The highest density of 1.94 fish/m^2 was observed at RM 0.01 of G1, downstream of the Hamlet Road culvert.

Spawning Gravel and Escapement for Tributaries G and G1:

A total of 7 m^2 of Spawning Gravel was observed – all in G1. Estimated adult (combined male and female) carrying capacity based on gravel availability was 5 - 14 coho. Estimated adult coho escapement into G and G1 was 2 adults, suggesting one spawning event.

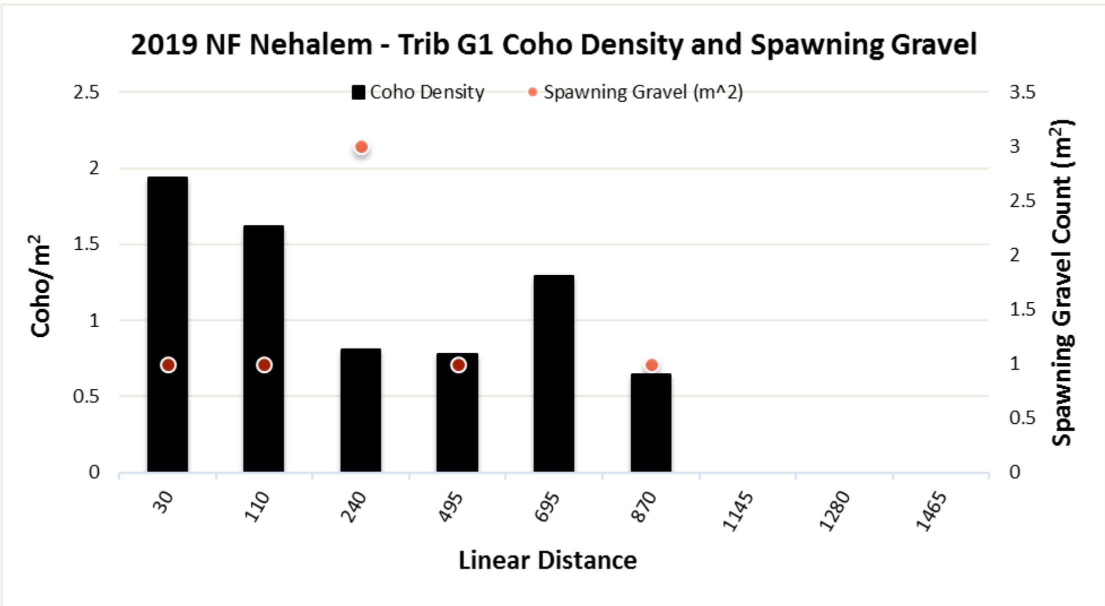

Figure 156: North Fork Nehalem Tributary G1 Coho Densities 2019

Steelhead

Steelhead were not observed in Trib G nor G1.

Cutthroat

Cutthroat abundance was very low with pool presence only observed above the end of coho distribution.

0+ Trout

0+ trout abundance was very low with pool presence only observed above the end of coho distribution.

Chinook

Chinook were not observed in Trib G or G1.

Table 75: North Fork Nehalem Tributary G1 - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2019	235	1.06	5	0	1	0

Recommendations

- Address known manmade barriers to upstream migration in the forms of perched/failing culverts and reservoir dams lacking fish passage and impeding temperature dependent migration. Below Table 76 lists sites in order of priority.

Table 76: Lower Nehalem Manmade Barriers to Fish Passage

Stream	River Mile	Priority	Details
NF Nehalem	4.71	High	3ft wood barrier inserted into low head dam at NF Nehalem Fish Hatchery - blocking path of fish traveling upstream. Temp was high (18.5C) in pool. 851 salmonids were counted backed up behind this dam including coho, fin clipped rainbows, adult chinook, juvenile steelhead, 0+ trout, and sea-run cutthroat.
Nehalem (MS)	13.18	High	Fish ladder dry at pool below Nehalem Falls. Falls are a potential juvenile barrier to upstream migration in a temperature limited reach.
Little Rackheap	0.68	High	Double culverts at pool head under residential road (Little Rackheap Acres). 4ft and 6ft diameter culverts are both slanted downstream. Smaller culvert rusted through the bottom with 1in drop at lip. Potential juvenile barrier. 1.06 miles of suitable habitat above.
Trib A of Sally	0.19	High	3ft culvert perched 6 inches. Completely rusted out. Subsurface flow at top of culvert. Barrier to juvenile passage and a hazard to adults. 0.35 miles of suitable habitat above. Anchor Site documented above culvert.
Trib B of Foley	0.43	High	Culvert perched 1ft over a deep pool - Juvenile Barrier. Coho observed above culvert with 0.4 miles of suitable habitat.
Bob's	1.56	Med	6 ft culvert perched 5 ft above water in this plunge pool. Pool 4 feet deep. 0.16 miles of suitable habitat above culvert to low head dam of City of Nehalem Reservoir (no fish passage).
McPherson	0.02	Med	Culvert perched 6 in over 2 ft deep pool. Juvenile barrier. No coho observed above in 2018. 0.58 miles of potential habitat above.
Peterson	0.36	Med	4 ft cement culvert perched 4 ft. Juvenile barrier, possible adult barrier. No coho observed above. 0.65 of potential (spawning gravel limited) habitat above.

Stream	River Mile	Priority	Details
Harliss	0.07	Med	Culvert perched 10 ft over shallow pool, adult barrier. 0.3 miles of potential (spawning gravel limited) habitat above.
Nehalem Trib M	0.08	Med	Railroad bridge culvert broken and leaking throughout, perched 2 ft. Juvenile and possible adult barrier, adult hazard. Coho observed downstream. Miles of suitable habitat upstream undetermined - landowner access restricted survey.
God's Valley USRB Trib	0.25	Low	Trib At God's Valley RM 2.7. Culvert on decommissioned road blocked by debris upstream, perched 1.5 ft downstream. Water trickling through. Barrier to adults and juveniles. Likely suitable coho habitat.
Messhouse	0.31	Low	Culvert with rusted out bottom and 6ft beaver dam at top. beaver dams observed on Messhouse. Coho not present in 2018.
Nehalem Trib N	0.03	Low	Two culverts under roadbed 300 ft apart with hyporheic flow through roadbed. Both culverts are barriers to juvenile and adult fish passage. 1ft boulder falls below downstream culvert with low flow, steep bedrock and boulder below upstream culvert with no flow. Above downstream culvert a massive beaver complex extends 1000ft. Clearcut all around swamp with low flat connecting to scoured channel that leads to upstream culvert. Main channel completely dry. Swamp fed hyporheicly through hillslope with no headwaters. Passage would provide good coho rearing habitat and thermal refuge from Mainstem. 0.2 miles of suitable rearing habitat upstream of barriers.
Trib A of Lost (NF Trib)	0.06	Low	Old culvert with water spilling onto bedrock, water emerging through boulders. 0.05 miles of suitable habitat above.
Trib A of Soapstone	0.18	Low	3ft concrete culvert perched 2ft over pool. Adult and juvenile barrier. Limited anadromous potential above culvert.
Trib C of NF Nehalem	0.06	Low	1 ft culvert with beaver dam at top. Above is a huge beaver flat extending 0.25 miles. Could use a beaver deceiver to open area for juvenile coho rearing habitat.
Trib E of NF Nehalem	0.44	Low	Culvert perched 2 ft. Water pours onto boulder. Barrier to juvenile and adult passage. Limited anadromous potential above culvert.

- LWD treatments in tributary reaches that displayed the potential for significant fish production first and lesser tributaries second. Prioritization focuses on protecting and enhancing those remnant habitats that currently exhibit the highest function (Anchor Sites). This stabilizes populations in their current anchors so that expansion from these high priority reaches can be achieved. These efforts would be designed to: dissipate hydraulic potential during winter flows; increase the frequency and size of pools; provide complex cover; aggrade mobile gravels to boost spawning and incubation habitat; and for smaller tributaries with less potential for fish production, build deep accumulations of bedload that are capable of developing a hyporheic lens of summer flow to mitigate for elevated mainstem temperatures. Below Table 77 lists all documented anchor sites with prioritizations for restoration based on highest coho production.

Table 77: Anchor Sites Identified in the Lower Nehalem and North Fork Nehalem

Stream	*Anchor Site #	Function Level	Priority for Restoration
Nehalem Tributaries			
Bob's	1	Low	
Bob's	2	Low	
Cook	1	Med	
Cook	2	Low	
Cook	3	Med	**X**
Cook	4	Med	**X**
Cook	5	Med	
Cook	6	Med	**X**
Strahm	1	Med	**X**
East Fork Cook	1	Med	**X**
East Fork Cook	2	**High**	
Houvet	1	Low	
Houvet	2	Low	
Cronin	1	Low	**X**
Cronin	2	Low	**X**
North Fork Cronin	1	Low	**X**
Foley	1	low	**X**
Foley	2	Low	**X**
Foley	3	Med	**X**
Foley	4	Med	
Crystal	1	Med	
Trib B	1	Med	
East Fork Foley	1	**High**	**X**
Lost	1	**High**	**X**
Lost	2	**High**	**X**
Lost	3	Low	**X**
Lost	4	**High**	

Stream	*Anchor Site #	Function Level	Priority for Restoration
Neahkahnie (Trib of Alder)	1	Med	
Roy	1	Low	
Roy	2	Low	
Salmonberry	1	Low	
Salmonberry	2	**High**	
South Fork Salmonberry	1	Med	
Spruce Run	1	Med	X
Nehalem Trib Q	1	Med	
North Fork Nehalem			
NF Nehalem (MS)	1	Low	
NF Nehalem (MS)	2	Low	X
NF Nehalem (MS)	3	Low	X
NF Nehalem (MS)	4	Low	X
NF Nehalem (MS)	5	Med	X
NF Nehalem (MS)	6	Med	X
NF Nehalem (MS)	7	Low	
NF Nehalem (MS)	8	Med	
Anderson	1	Med	
Soapstone (Buchanan Trib)	1	Med	X
Soapstone	2	Med	X
Soapstone	3	Med	X
Soapstone	4	Med	
Soapstone	5	Med	
Jack Horner	1	Med	
Trib B	1	Med	X
Trib B	2	Med	X
Coal	1	**High**	
Coal	2	Med	
Coal	3	Med	X
Coal	4	Med	X
Coal	5	Low	
West Fork Coal	1	Med	X
West Fork Coal	2	Low	
Fall 1	1	Med	
Fall 1	2	Med	
God's Valley	1	Med	
God's Valley	2	Low	X
God's Valley	3	Low	
God's Valley	4	Med	
Trib A	1	**High**	
Trib A	2	**High**	
Trib A	3	**High**	

Stream	*Anchor Site #	Function Level	Priority for Restoration
Trib B	1	Low	
Trib C	1	Low	
Trib D	1	Low	
Trib D1	1	Low	
Trib E	1	Low	
Gravel	1	Med	**X**
Gravel	2	Med	
Henderson	1	Med	
Henderson	2	Med	
Little North Fork	1	Med	
Little North Fork	2	Med	**X**
Little North Fork	3	Med	**X**
Little North Fork	4	Med	**X**
Little North Fork	5	Med	
Little North Fork	6	Low	
Little North Fork	7	Med	
Trib C	1	Low	**X**
Trib D	1	Med	**X**
Little Rackheap	1	Med	
Big Rackheap	1	Low	
Lost	1	Low	
Sally	1	Med	**X**
Trib A	1	Med	
Trib A	2	**High**	
Sweethome	1	Med	
Sweethome	2	Med	**X**
Sweethome	3	Med	**X**
Trib D	1	Med	
NF Nehalem Trib B	1	Med	**X**
NF Nehalem Trib B	2	**High**	
NF Nehalem Trib B	3	**High**	

*Anchor Sites #'s are assigned from the confluence, upstream. Thus, Anchor Site 1 is always downstream of Anchor Site 2.

- Expand complexity and the refuge surface area of pool habitats at tributary confluences and cold-water seeps in mainstem pools where fish populations are concentrating to seek thermal refugia during low flows and peak summer temperatures. Increase access for temperature dependent migrations in larger tributaries with salmonid rearing potential. These dependable sources of cool water are critically valuable to all salmonid species and age classes for use as refugia during high temperature periods. Increasing the complexity and rearing capacity of these identified habitats is high priority. This strategy may include anchoring of root wads that remain oriented in the confluence plume for cover; full spanning log structures with rootwads intact; and boulder structures designed to provide cover and to provide scour and improve access at confluences with shallow subsurface flows through deep cobble and gravel accumulations. Below is a list of prioritized sites.

Table 78: Lower Nehalem Thermal Refugia Sites with priority listing 2018

TRIB NAME or RIVER MILE (RM)	PRIORITY
VOSBURG (ESTUARY)	MED
FOLEY	**HIGH (6)**
ANDERSON	LOW
RM 11.8, UPSTREAM LEFT BANK TRIB	MED
COOK	**HIGH (2)**
LOST	**HIGH (8)**
FALL	**HIGH (1)**
RM 16.2, UPSTREAM RIGHT BANK TRIB	MED
RM 16.51, UPSTREAM LEFT BANK SEEP	LOW
RM 16.65, UPSTREAM LEFT BANK TRIB	LOW
RM 17.73, UPSTREAM LEFT BANK SEEP	LOW
HELOFF	**HIGH (3)**
RM 19.07, UPSTREAM RIGHT BANK TRIB	LOW
RM 20.58, UPSTREAM RIGHT BANK TRIB	LOW
SALMONBERRY	**HIGH (7)**
CRONIN CREEK	MED
RM 25.5, UPSTREAM LEFT BANK TRIB	MED
CANDYFLOWER	**HIGH (5)**
TRIB O	LOW
TRIB P	**HIGH (10)**
RM 29, UPSTREAM RIGHT BANK TRIB	LOW
TRIB N	MED
Spruce Run	**HIGH (4)**
LOST LAKE	MED
RM 32.23, UPSTREAM LEFT BANK TRIB	LOW
GEORGE	**HIGH (9)**

HUMBUG	MED
ANDERSON (NF)	MED
BUCHANAN (NF)	**HIGH (11)**
COUGAR (NF)	LOW
COAL (NF)	MED
GRASSY VALLEY (NF)	MED
TRAIL (NF)	LOW

- The RBA has provided temperature data and fish distribution trends that suggest severe summer temperature limitations exist in several mainstem reaches. Consider the deployment of thermistors during the summer of 2020 to validate relationships documented in this inventory between lethal mainstem temperature profiles and key thermal refugia. Additional temperature data will be critical in crafting a basin scale restoration plan that addresses actual seasonal habitat limitations and will establish a baseline for recovery monitoring. To record the full seasonal temperature range, data loggers should be deployed early in the season by June 1rst. A paired deployment of data loggers (one in tributary and one in mainstem above tributary confluence) would be the most effective in capturing the temperature differential. The highest priority confluences are listed above in Table 78.

- Consider the importance of the tributaries identified in this document as critical cold-water contributions and thermal refugia, as well as warm-water contributions, an important upslope management objective. Develop a strategy to encompass these streams (no matter their size) and their headwaters in a conservation easement for protecting and enhancing high value thermal refugia for resident and anadromous salmonids. Tactics should include: Focused riparian planting in areas of weak riparian; conservation easements to expand the riparian buffer on type N stream channels in the headwaters to protect water quality and quantity; removing impoundments that surface spill and elevate stream temps; and establish instream water rights for stream segments with excessive water withdrawals. A complete inventory of tributary flow contributions (volume / temperature) would be required to prioritize all high value targets.
- Establish an annual snorkel inventory in a subset of the highest quality reaches of aquatic habitat to monitor trends in salmonid abundance over time. Conduct these surveys at an identical time each year.

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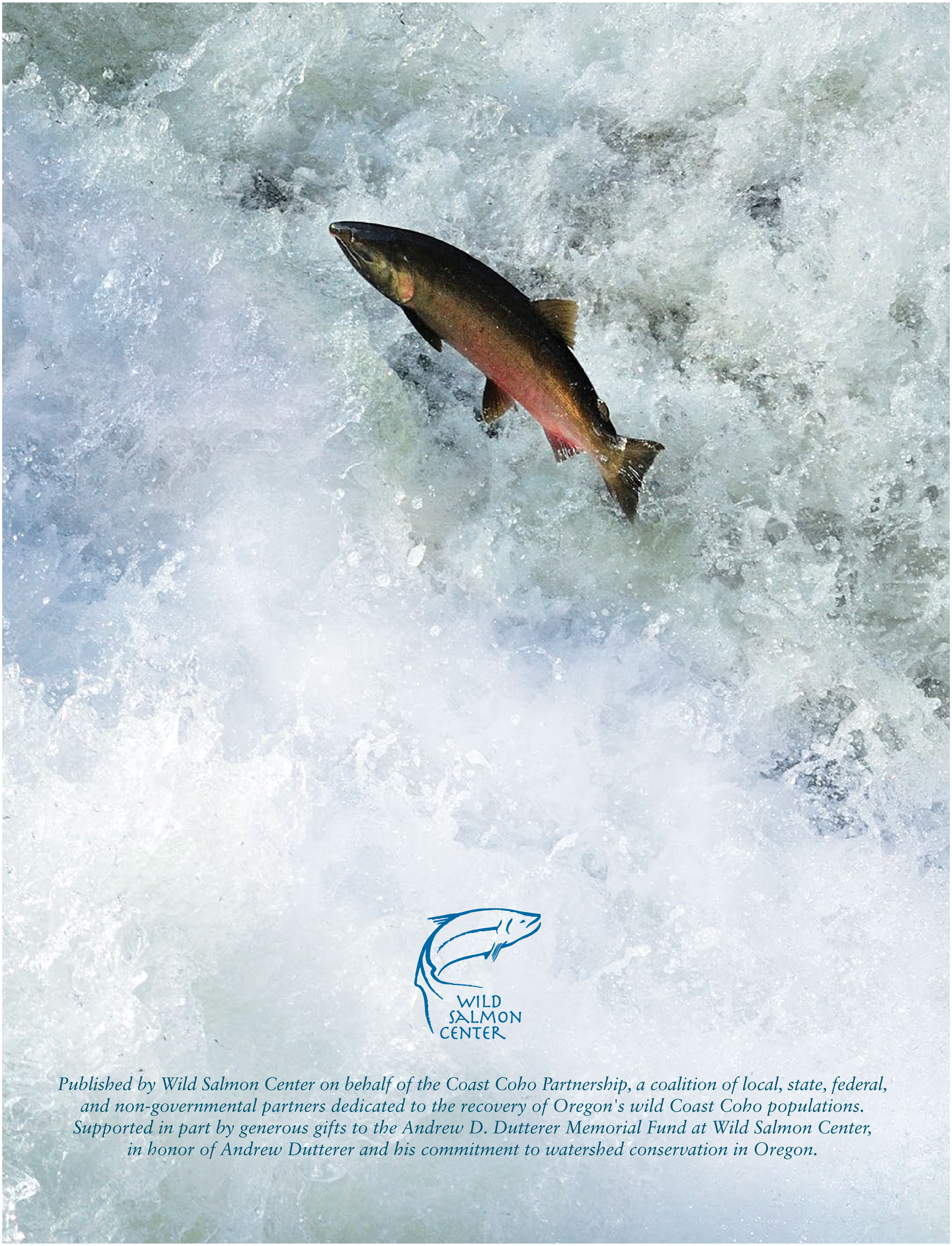
Appendix 11

Nehalem Basin Partnership MOU

Memorandum of Understanding

The Nehalem Basin Partnership Memorandum of Understanding is still being drafted at this time. A finalized MOU will be provided as soon as it is complete.



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