RESTORING CHUM SALMON

RETURN OF THE REDDS

RESTORING WATERSHEDS

STRATEGIC ACTION PLAN

VOL. 2, JANUARY 2022

RETURN OF THE REDDS

Return of the Redds is exciting new collaboration between the North Coast Watershed Association, local landowners, the forest products industry, nonprofits, state and federal agencies all united around a common goal: **To revitalize the once abundant Big Creek and Youngs Bay watersheds and chum salmon populations.**

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ACRONYMS

BLM	Bureau of Land Management
BPA	Bonneville Power Administration
Clatsop SWCD	Clatsop County Soil and Water Conservation District
CLT	Columbia Land Trust
CREST	Columbia River Estuary Study Taskforce
CRS	Chum Recovery Strategy
dbh	Diameter at Breast Height
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
FWT	Fresh Water Trust
LCR Plan	Lower Columbia River Conservation and Recovery Plan
NPS	National Park Service
NCWA	North Coast Watershed Association
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
ODA	Oregon Department of Agriculture
ODFW	Oregon Department of Fish and Wildlife
ODF	Oregon Department of Forestry
ODOT	Oregon Department of Transportation
OEDD	Oregon Economic Development Department
OHW	Ordinary High Water (line)
OWEB	Oregon Watershed Enhancement Board
RREDDs	Return of the Redds
RM	River Mile
RME	Research, Monitoring and Evaluation
Skipanon WSC	Skipanon Watershed Council
SRP	Summer [Chum Salmon] Recovery Plan
USFWS	U.S. Fish and Wildlife Service

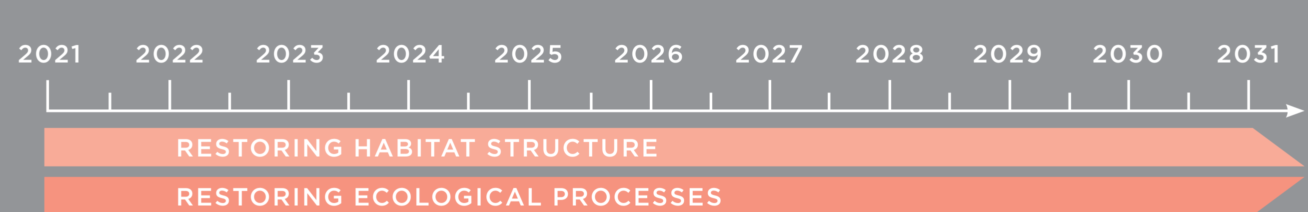
A BRIEF PROJECT OVERVIEW

Introducing **Return of the Redds**, an exciting new collaboration between the North Coast Watershed Association, local landowners, the forest products industry, nonprofits, state and federal agencies all united around a common goal: **To revitalize the once abundant Big Creek and Youngs Bay watersheds and chum salmon populations.**

This brief introduction to Return of the Redds (RREDDs) is the first in a series intended to welcome you to the project and explain the general idea and timeline. Our plan began in January 2021 and will continue into the future along two parallel tracks: restoring habitat, and protecting and restoring healthy ecological processes.

RESTORING STRUCTURE: A top priority is getting landowner permissions to add big trees, or what we call large wood (LW), to the river. Once in place, LW acts as an anchor of sorts, holding up gravel that might normally just wash downriver. Through a series of high-water events, LW can quickly turn a channelized, sluicing river back into the more natural, meandering pools and riffles we remember from way back when. While we're getting more LW into the lower-river reaches, we'll also be hard at work increasing off-channel wetlands, protecting riparian areas and floodplains, and even removing invasive species and replanting native vegetation.

RESTORING PROCESSES: A longer-term approach toward process-based restoration, again collaborating with landowners. Here, we'll work with private timber companies, landowners and land trusts to identify areas we can improve. That might include projects like stream surveys, building new partnerships, working together with private timber owners to decommission roads no longer in use, or conservation easements. It's a holistic approach to watershed rehabilitation that will depend on landowner support and involvement every step of the way.



PROJECT AREAS: Youngs Bay and Big Creek areas including: Big, Gnat, Little, and Bear Creeks and the Lewis and Clark, Skipanon, Youngs, Wallooskee, and Klaskanine Rivers.

BASIC PROJECT DETAILS:

- **Timing:** Begins January 1, 2021 with habitat restoration work starting in 2022
- **Project areas:** Youngs Bay and Big Creek watersheds
- **Goal:** To restore habitat and increase local chum salmon populations
- **Funded by:** State, federal and nonprofit partners
- **Cost to landowners:** $0
- **More Info:** The Return of the Redds Action Plan with complete info is available at ReturnoftheRedds.com

MEASURING SUCCESS: In the next 10 years, actions focused at the stream and river reach-scales are designed to rapidly improve spawning areas and key chum habitats. For a table detailing the metrics of how we'll measure performance, visit ReturnoftheRedds.com

BENEFITS TO LOCALS: At its core, more fish in the rivers close to home and a return to the good old days. More fish and better habitat means an increase in other native wildlife like birds, frogs, and salamanders. A healthier, more abundant watershed can significantly increase property values, as well.

EXECUTIVE SUMMARY

Once abundant, Columbia River chum salmon are listed as threatened under the federal Endangered Species Act (ESA). The 17 historical chum populations in Oregon and Washington comprising the Columbia River chum Evolutionarily Significant Unit (ESU) have declined more than any other Columbia River salmon population. The causes for the dramatic declines in abundance of Columbia River chum populations include overharvesting, loss or degradation of river spawning habitat, loss of access to spawning habitat, and changes to the estuary tidal wetlands (e.g., diking).

Return of the Redds is a collaboration of the North Coast Watershed Association and partners; residents, farmers, the forest products industry, nonprofits, and state and federal agencies cooperating to restore the rivers, streams, and watersheds supporting Oregon's Big Creek and Youngs Bay chum populations.

Return of the Redds (RREDDs) was created to help recover these historically significant chum populations through restoration in collaboration with local property owners and stakeholders. RREDDs is a 10-year plan from 2021 to 2031 that will be adaptively managed and updated periodically based on new information, monitoring, and evaluation results.

RREDDs restoration area (Plan Area) centers on two key Oregon lower Columbia River chum populations: The Big Creek Chum Population Area, which includes Big, Gnat, Little, and Bear Creeks; and the Youngs Bay Chum Population Area encompassing the Lewis and Clark, Skipanon, Youngs, Wallooskee, and Klaskanine Rivers.

Compared to other species such as coho salmon, chum fry spend little time in freshwater, typically migrating directly downstream soon after emergence to the estuary and then the ocean. Because chum spawn low in the watershed – often in large numbers just above tidal influence – they are especially vulnerable to degraded habitats, such as fine sediments deposited in spawning areas from upstream land-use activities.

Return of the Redds is an expression of long-term aspirations and commitment to recover this neglected and yet essential species. RREDDs restoration actions in the Plan Area address degraded stream and riparian habitats and the land management activities that have disrupted watershed processes that create and shape the habitats that chum and other salmon populations require. RREDDs strategy integrates (1) short-term, "structural" restoration actions (e.g., placing large wood in stream channels) designed to provide rapid improvements in chum spawning and rearing habitats, with (2) long-term, process-based restoration, which can take decades to affect aquatic habitats.

Restoration actions in rivers and streams in the Big Creek and Youngs Bay Chum Population Areas will help support natural chum recolonization. Most of the lands within the Plan Area are privately owned. Engaging property owners, residents, farmers, forest managers, and other stakeholders will be essential to restoring habitats and chum populations.

The strategy focuses on restoring the watersheds with historically robust chum populations: Big Creek and Lewis and Clark River watersheds and their associated estuarine habitats. The lower portions of these watersheds supported the largest concentration of spawning chum within the two Population Areas. Restoration actions in the Big Creek and Lewis and Clark Rivers emphasize active habitat restoration (e.g., restoring floodplain and off-channel habitats) in the lower watershed/estuary and process-based restoration (e.g., improving road drainage) in the upper portion of the watershed.

Geomorphic assessments in the lower portions of the Big Creek and Lewis and Clark River systems where chum historically spawned are necessary to understand channel dynamics, evaluate risks and benefits, assess habitat restoration approaches, and identify projects with willing landowners. In addition, assessing sediment sources will be necessary to identify actions that will improve watershed processes. Reach-specific habitat restoration and watershed process-based actions are equally important, and both activities will be implemented at the same time.

The second geographic priority includes other historically productive systems: key tributaries (e.g., Bear Creek) in the Big Creek Population Area and the Youngs and Klaskanine Rivers in the Young Bay Population Area. Restoration actions in these second-tier priority watersheds will emphasize working opportunistically as willing property owners become engaged with restoration projects and funding for work in these watersheds is secured.

RREDDs goal is to implement actions to restore the Youngs Bay and Big Creek watersheds to achieve healthy streams and rivers and thriving chum and other fish populations. The RREDDs partners will help recover these chum populations through comprehensive restoration actions and an engaged community of property owners and stakeholders participating in voluntary restoration.

RREDDs outlines priorities, strategies, actions, and objectives for restoration projects, property owner engagement, and other Partnership activities. See the priority implementation actions below.

RREDDS PRIORITY IMPLEMENTATION ACTIONS

PRIORITY 1:
Inform and Engage Property Owners and other Stakeholders

PRIORITY 2:
Address Information Needs and Data Gaps

PRIORITY 3:
Restore Historically Productive Chum Spawning Areas and Rearing Habitat in Lower Big Creek Subwatersheds and Lower Lewis and Clark Subwatersheds

PRIORITY 4:
Restore Watershed Processes in Upper Big Creek and Upper Lewis and Clark Subwatersheds

PRIORITY 5:
Restore Other Youngs Bay and Big Creek Population Watersheds with Chum Restoration Potential

PRIORITY 6:
Document Actions, Monitor Effectiveness, and Communicate Progress

"We're excited to help restore our creek. We want our kids to enjoy its bounty for years to come."

— Jenn Rasmussen, landowner near Big Creek

INTRODUCTION

Return of the Redds is led by the North Coast Watershed Association (NCWA) in collaboration with a broad partnership that includes residents, farmers, the forest products industry, nonprofits, and state and federal agencies to restore the rivers, streams, and watersheds supporting the Big Creek and Youngs Bay chum salmon populations in Clatsop County, Oregon.

The Return of the Redds partnership developed this Strategic Action Plan (Action Plan) to assist in the recovery of local chum populations and benefit other native aquatic species through restoration in collaboration with local property owners and stakeholders.

The name "chum" is from the Chinook Jargon word "tzum," meaning "speckled" or "marked" and refers to the distinctive markings on spawning chum adults. Globally, chum salmon populations (known scientifically as Oncorhynchus keta) are widespread in the North Pacific Rim and the Arctic Ocean. Columbia River chum salmon are listed as threatened under the federal Endangered Species Act (ESA). There are 17 historical chum populations in Oregon and Washington comprising the Columbia River chum Evolutionarily Significant Unit **(ESU; FIGURE 1)**. The chum populations within this ESU have declined more than any other Columbia River salmon population (ODFW 2010).

Historically, hundreds of thousands of chum returned to the Columbia River annually, and many thousands spawned in Big Creek, the Lewis and Clark River, and other lower Columbia River tributaries. The large concentrations of spawning chum in these tributaries supported watershed health in ways we are just beginning to understand.

Restoring watersheds by improving river and stream habitats that support chum and other salmon populations through landowner engagement has established precedent (Brewer et al. 2005). Restoring the watersheds that chum and other salmon populations depend on will take time. More than a century of land management activities in these watersheds has degraded stream and river habitats needed for spawning and rearing. But despite dramatic declines, chum populations persist – every year, a few chum return to spawn in local streams and rivers. However, the number of these returns is insufficient to sustain the Big Creek and Youngs

FIGURE 1. The 17 Historical Chum Populations in Oregon and Washington Comprising the Columbia River Chum Evolutionarily Significant Unit (ESU). Source: Wiley 2021

Bay chum populations. Restoring critical chum spawning and rearing habitats in historically productive areas is the first step in allowing natural populations to repopulate these watersheds.

Return of the Redds is an expression of long-term aspirations and commitment to recover this neglected and essential species. Return of the Redds is comprehensive and focused on short- and long-term actions to restore chum habitats and overall watershed health. These actions will restore watershed and stream habitat conditions to promote natural chum recolonization of historical habitats. Improving stream habitats and watershed processes for chum will also benefit coho and Chinook salmon, steelhead, Pacific lamprey, and other native fish and wildlife dependent on healthy streams and rivers. In return, healthy streams and rivers with thriving salmon populations help support our local economy and quality of life.

OVERVIEW OF THE CHUM RECOVERY STRATEGY

Return of the Redds was developed to guide restoration actions designed to improve river and stream habitat and watershed processes that sustain chum and other fish populations and contribute to overall watershed health. The map below **(FIGURE 2)** shows RREDDs's geographic area (Plan Area), which encompasses the Big Creek and Youngs Bay Chum Population Areas. The Big Creek Chum Population Area includes Big Creek, Gnat Creek, Little Creek, Bear Creek, and other lower Columbia tributaries. The Youngs Bay Chum Population Area consists of the Lewis and Clark River, Skipanon River, Youngs River, Wallooskee River, and Klaskanine Rivers.

Chum life history traits make a compelling case for comprehensive habitat restoration to aid population recovery. Compared to other salmon species such as coho salmon, chum fry spend little time in freshwater, typically migrating directly downstream to the estuary and then the ocean after emergence. While chum have a shorter estuary residence than, for example, Chinook salmon, estuary wetland foraging habitat is essential for juvenile chum as they transition into the ocean (Roegner et al. 2015). Because chum spawn low in the watershed – often in large numbers just above tidal influence – they are especially vulnerable to degraded habitats, such as fine sediments deposited in spawning areas from upstream land-use activities.

The Oregon Department of Fish and Wildlife's (ODFW) Lower Columbia River Chum Recovery Strategy (CRS) focuses on gathering information and developing techniques that will provide the framework for establishing viable chum populations on the Oregon side of the Columbia River. The CRS outlines two methods to recover chum populations: (1) identify and improve spawning and rearing habitat to encourage recolonization, and (2) develop a local conservation hatchery program to help establish chum populations in targeted watersheds with adequate habitat. Return of the Redds' objective is to identify and improve chum spawning and rearing habitats. Re-establishing chum populations through a local conservation hatchery program is beyond the scope of RREDDs, but this action may be considered in the future (e.g., Hood Canal Coordinating Council [HCC] 2005).

The construction of artificial side channels can also be extremely effective in significantly increasing chum egg survival rates. With our focus on restoring natural processes, artificial side channels are also not addressed in Return of the Redds but could be a future consideration.

Return of the Redds' planned restoration actions in the Youngs Bay and Big Creek systems address

FIGURE 2. Return of the Redds Big Creek and Youngs Bay Chum Population Areas

the land management activities that have disrupted watershed processes. Restoration of critical ecosystem processes – such as reducing erosion and associated fine sediments delivered to streams from land-use activities – enables stream habitats to evolve naturally and respond to changes from a dynamic environment. Return of the Redds' strategy integrates (1) active "structural" short-term restoration actions (e.g., placing large wood in stream channels) to provide more rapid improvements in chum spawning and rearing habitats, with (2) long-term, process-based restoration actions (e.g., reducing sediment delivery to stream channels), which can take decades for a response to improve aquatic habitat. Reach-specific habitat restoration and watershed process-based actions are equally important, and both activities will be implemented at the same time. These restoration actions will help support natural chum recolonization when spread across the Plan Area's watersheds, rivers, and streams.

Most of the lands within the Population Areas are privately owned. Engaging property owners, residents, farmers, forest managers, and other stakeholders will be essential to restoring habitats and chum populations.

Comprehensively recovering watershed habitat and process is a long-term and large-scale endeavor. RREDDs's strategy centers on two time frames and geographic scales: First, short-term actions (1-10 years) focused at the stream and river reach-scales designed to improve spawning areas and critical chum habitats rapidly; and, second, long-term (decades) efforts focused broadly at the subwatershed scale to improve processes that create and maintain habitat.

This Action Plan is a 10-year plan that describes Return of the Redds' activities through 2031. RREDDs will be adaptively managed and updated periodically based on new information, monitoring, and evaluation results. Return of the Redds' mission will be sustained for the long-term, addressing emerging threats to watershed health, water quality, and chum populations beyond 2031. The Partnership will revise the Strategic Plan in 2026 to incorporate lessons learned over the previous implementation period and address new priorities identified through research and other adaptive management measures.

RETURN OF THE REDDS PARTNERSHIP

The RREDDs partner organizations are all actively engaged in supporting restoration and conservation project planning, implementation, monitoring and reporting, and outreach in the Big Creek and Youngs Bay Chum Population Areas. The Partnership strives to support its partner organizations with a collaborative approach that promotes coordinated planning and implementation, a joint project accomplishment reporting framework, integrated funding strategies, and open communication.

To support collaborative planning efforts and ongoing restoration actions, the RREDDs partner organizations (Partners) share staff resources, data, and information on the factors that degrade watershed health and chum populations. Through coordination between the Partners, we have cooperatively identified priority restoration areas and actions.

RETURN OF THE REDDS PRIORITIES:

- Works in collaboration with property owners, agencies, and stakeholders to promote future watershed conditions that support restored Big Creek and Youngs Bay chum habitat and watershed processes.
- Provides information about chum and engages property owners and other stakeholders in understanding and implementing restoration opportunities.
- Designs restoration projects that focus on the unique habitat requirements of chum throughout their life cycle and address the needs of other native fish populations.
- Guides monitoring, data collection, and adaptive management activities to generate information on habitat and chum response to restoration actions and improve the knowledge about chum habitat requirements and recovery status.

RETURN OF THE REDDS PARTNERS:

North Coast Watershed Association (NCWA)
Watershed Residents
Oregon Department of Forestry (ODF)
Columbia Land Trust (CLT)
Hampton Lumber
Greenwood Resources
Oregon Department of Fish and Wildlife (ODFW)
NOAA Fisheries Clatsop County
National Park Service, Lewis and Clark National Historical Park
U.S. Fish and Wildlife (USFWS)

RETURN OF THE REDDS MISSION:

The Lower Columbia Chum Partnership collaborates on coordinated watershed restoration, conservation, and outreach actions to create resilient habitats that support the recovery and sustainability of chum salmon populations, and contribute to the region's vitality.

RETURN OF THE REDDS VISION:

The Youngs Bay and Big Creek watersheds have healthy streams and rivers, thriving chum salmon and other fish populations, and residents who are informed about chum salmon and enthusiastic about participating in voluntary restoration actions.

CHUM SALMON BACKGROUND AND HISTORY

Chum historically ranged across the northern Pacific Ocean from the Sacramento River in California north to Alaska, east to Russia and the Korean peninsula, and into the Arctic Ocean – a more extensive geographic distribution than all other Pacific salmon (Groot and Margolis 1991).

Chum are the second-largest salmon in size (Chinook are the largest), averaging 8 to 15 pounds, and may reach a length of 3 feet when they return to rivers to spawn.

Before the early 20th century, chum were the most abundant anadromous salmonid in the lower Columbia basin (ODFW 2010). Columbia River chum spawning populations were estimated to exceed one million adults in the 1920s (McElhany 2005). There were precipitous declines in chum abundance and distribution beginning in the 1930s and 1940s. An estimated 850,000 chum were caught in 1928 **(FIGURE 3; JOHNSON ET AL. 1997)**. By 1965, only 560 fish were caught (Fulton 1970). In recent years, only a hundred to several thousand Columbia River chum return to spawn (ODFW 2010). This dramatic decline in chum populations is the most significant population loss for any lower Columbia River salmon species (McElhany et al. 2007).

Chum harvest in the Columbia River was prohibited in 1992 in Oregon and 1995 in Washington. Since the probation on harvest, annual incidental take in the river is limited to 1–5% of the chum return to the Columbia River (Homel et al. 2019). The rate of chum ocean harvest is unknown but assumed to be zero (Homel et al. 2019). Harvest of chum is no longer a limiting factor.

Causes for the decline in chum populations – covered in detail later – include loss or degradation of river spawning habitat, modified tidal wetlands, and other factors. Most chum spawning now occurs in areas downstream of Bonneville Dam and the Grays River basin, Washington. All other populations, including the Big Creek and Youngs Bay populations, are considered to be functionally extirpated (i.e., lost), with very few fish returning to spawn.

In recent years, chum have been observed sporadically in both populations, including in Big, Little, Little Bear, Mill and Ferris Creeks (Big Creek population) and Lewis and Clark, South Fork Klaskanine, and Wallooskee Rivers (Youngs Bay population; Derek Wiley, ODFW, Pers. Comm. 2020).

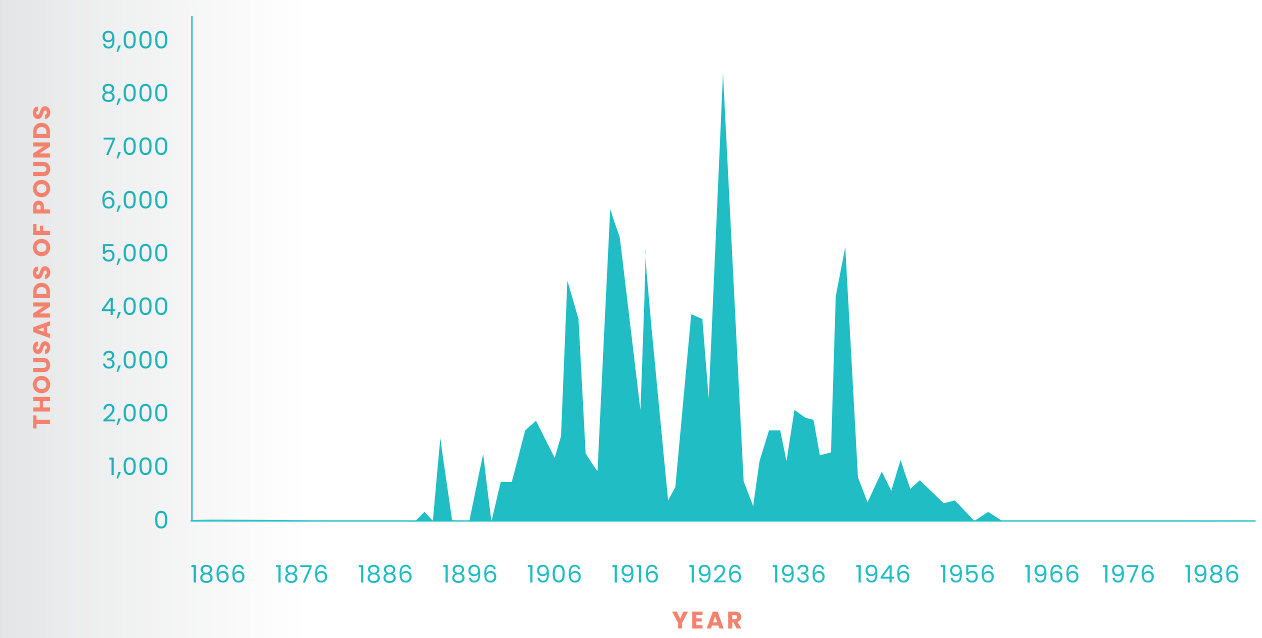


FIGURE 3. Columbia River Chum Processed in Thousands of Pounds, 1866 to 1986. By the 1960s, Very Few Chum Were Present. Source: Johnson et al. 1997

In response to the dramatic population declines, chum were listed as threatened under the federal ESA in 1999 (NMFS 1999). The Oregon Department of Fish and Wildlife (ODFW) created the Lower Columbia River Conservation and Recovery Plan ("LCR Plan"), which covers Oregon salmon and steelhead populations, including multiple chum populations (ODFW 2010). Return of the Redds builds on the chum conservation measures outlined in the federal and state recovery plans with a focus on the Big Creek and Youngs Bay populations.

WHY RECOVER CHUM POPULATIONS?

Chum play an essential role in the ecosystem. Historically spawning in extremely high densities, chum sweep fine sediments out of gravels when building redds **(I.E., NEST; FIGURE 4)**. The lower quantities of fines in the redd increase the flow of oxygenated water through the gravels, which improves chum egg survival. Chum salmon are also a food source for various wildlife, with carcasses providing essential nutrients that fortify the entire ecosystem's food web. Studies have shown significant increases in terrestrial nutrients (e.g., taken up by streamside vegetation) from chum carcasses (Bilby et al. 2003). For this reason, chum are a keystone species in aquatic and terrestrial ecosystems.

ECONOMIC IMPORTANCE

At one time, chum were a significant component of Columbia River fisheries, but overharvest and habitat degradation led to population decline over the years. Harvest has been prohibited since 1995 when Columbia River chum were listed as threatened under the ESA. However, chum remains an important fishery throughout the north Pacific basin, second only to pink salmon in biomass **(FIGURE 5)**.

Additionally, global chum fisheries are augmented by hatchery production throughout their range **(FIGURE 6)**, with hatchery production exceeding all other salmonid species by a wide margin (North Pacific Anadromous Fish Commission 2020). High hatchery production levels are in part driven by the lucrative chum roe (ikura or sujiko) that is targeted primarily toward Asian markets. Recent (2020) ikura roe prices range between $100-130/kg (e.g., www.fishandcaviar.com), which can be contrasted to spring Chinook salmon fillets valued between $50-115/kg. A recent economic analysis from an Alaskan hatchery cooperative determined that chum roe accounted for 60% of the total first wholesale value of all salmon harvested in 2012. Further study demonstrated the significant input the chum hatchery and fishery contributed to the region's economic viability (McDowell Group 2013). While restored lower Columbia River chum populations may never achieve these robust economic activity levels, industry forecasts expect the roe fishery to remain immensely profitable in the future.

FIGURE 4. Chum Spawn in Lower River and Stream Areas, Often Congregating in Large Numbers. Photo Source: Kristen Homel, ODFWSignificant Unit (ESU). Source: Wiley 2021

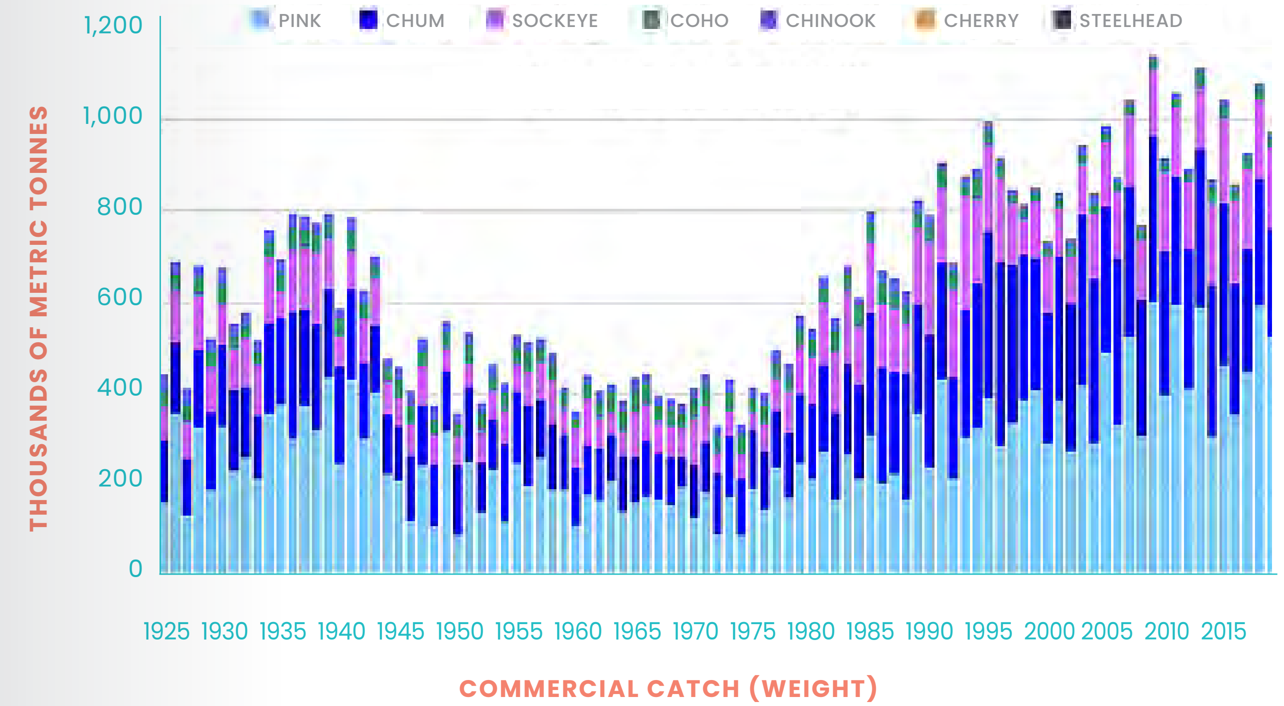


FIGURE 5. Annual Commercial Salmon Catch by Weight (Thousands of Metric Tonnes) 1951-2019. Source: North Pacific Anadromous Fish Commission 2020

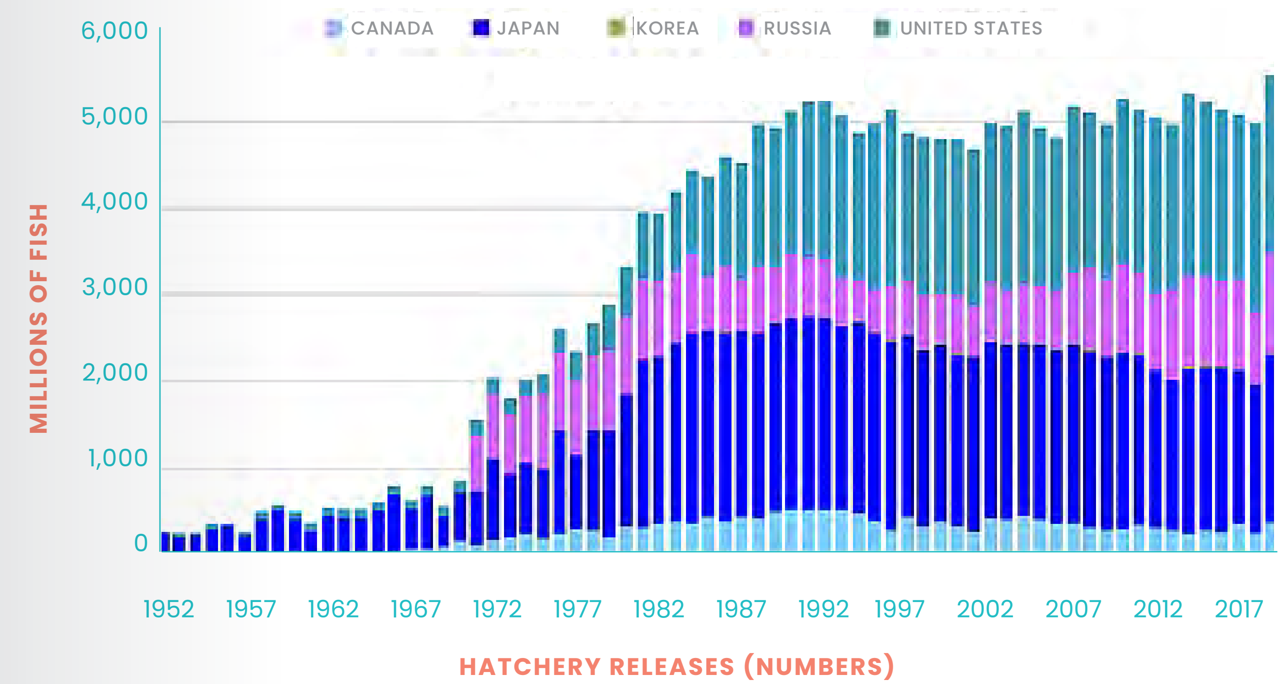


FIGURE 6. Total Hatchery Production (U.S., Canada, Korea, Russia, and Japan) of Pacific salmon, 1951-2019. Source: North Pacific Anadromous Fish Commission 2020

EXAMPLE OF A CHUM POPULATION SUCCESS STORY

The Hood Canal/Strait of Juan de Fuca Summer-Run Chum ESU is an outstanding success story for recovering other ESA-listed chum populations. The southern Juan de Fuca chum are a summer-run stock (in contrast to our fall-run chum) but similar in every way except run timing. The runs collapsed in the 1980s and were listed under the ESA in 1999. Under the "Summer Chum Recovery Plan," numerous watersheds were restored (HCCC 2005), and recent results demonstrate projects succeeded in returning some populations to target levels. From less than 1,000 returning chum in the late 1990s, by 2015, there were 20,000 to 40,000 summer chum returning to restored streams (https://nwtreatytribes.org/return-of-summer-chum/). This success has resulted in considerations for ESA de-listing for several of the runs (Lestelle et al. 2018). It is important to note that few other examples of a successful reintroduction (without continued hatchery supplementation) exist for any salmon species. This basic reintroduction strategy can serve as a model for the long-term recovery of many salmon stocks.

Specifics are found in the primary literature documenting the Summer Chum Recovery Plan (HCCC 2005), such as NOAA's evaluation (Sand et al. 2009) and recent status updates (NOAA 2016; Lestelle et al. 2018). In short, the strategy involves stream and watershed restoration, hatchery supplementation and reintroductions where and when prescribed, and monitoring and adaptive management to evaluate progress and recommend further action. Crucially, benchmark thresholds were established for a range of topics that allow restoration progress and chum population status to be ascertained (Sands et al. 2009). These agreed-upon quantitative thresholds enable partners to reach a consensus for implementing restoration actions (NOAA 2016; Lestelle et al. 2018).

Similar to the Lower Columbia River Chum Partnership, the southern Juan de Fuca Summer Chum Recovery program was designed and implemented as a decades-long endeavor that involved strategic partnerships between local landowners and councils and tribal, state, and federal organizations. It relies heavily on local volunteers in numerous roles. Progress for Columbia River chum restoration would greatly benefit in the long term from careful consideration of the Summer Chum Recovery program. Although the Hood Canal subpopulations also benefited from reintroduction efforts, and reintroduction is not the intent of our current strategy, similar watershed and stream restoration efforts utilized in Hood Canal could be used as a model to assist in the recovery of Columbia River chum.

CONSERVATION NEEDS AND OPPORTUNITIES

The Lower Columbia River Chum Partnership's restoration strategy builds on ODFW's Lower Columbia River Conservation and Recovery Plan (LCR Plan; ODFW 2010). RREDDs builds on the LCR Plan by identifying limiting factors and restoration actions specifically characterized and tailored to the Big Creek and Youngs Bay chum Population Areas. RREDDs is grounded on local stream habitat assessments, action plans, and other studies. RREDDs restoration approach complements local, regional, and statewide conservation strategies. Recovery of Columbia River chum will require tributary restoration actions for watersheds in Oregon and Washington. The RREDDs partners incorporates these regional initiatives and recovery plans into its restoration and conservation planning and project priorities development.

Return of the Redds augments other ongoing conservation, restoration, and natural resource management efforts. RREDDs focus on restoring watershed processes and habitat to improve chum populations will also create habitats and environmental conditions that benefit a variety of native aquatic and terrestrial wildlife species. Species that the Strategic Plan's improved ecological conditions will support include coho and Chinook salmon, steelhead trout, Pacific lamprey, and other native fish species. Improving local watershed conditions will enhance habitats for riparian-dependent amphibians such as the Columbia torrent salamander (Rhyacotriton kezeri), and the northern red legged frog (Rana aurora), which are on the state of Oregon's Endangered Species list and are currently under review by U.S. Fish and Wildlife Service (USFWS) for potential listing under the federal ESA.

The following state-wide or regional plans support RREDDs chum habitat restoration actions and the desired ecological outcomes:

REGIONAL PLANS IN SUPPORT RREDDS

OREGON CONSERVATION STRATEGY

www.oregonconservationstrategy.org
The Oregon Conservation Strategy is an overarching state strategy for improving and protecting fish and wildlife and the habitats they depend on. Lower Columbia chum is a strategy species, and there are two conservation strategy opportunity areas in the Big Creek and Youngs Bay Population Areas.

OREGON PLAN FOR SALMON AND WATERSHEDS

www.oregon-plan.org

The Oregon Plan for Salmon and Watersheds is a broad-based effort of citizens, watershed groups, the State of Oregon, and federal agencies to restore healthy salmon populations and their watersheds.

ODFW'S NATIVE FISH CONSERVATION POLICY

www.dfw.state.or.us/fish/crp/

The Native Fish Conservation Policy describes ODFW's efforts to understand, conserve, and restore native fish populations. The policy is guided by a conservation framework of plans, regulations, research, and voluntary, grass-roots efforts. Restoring native chum populations in the Big Creek and Youngs Bay Population Areas will improve chum and other native fish populations.

ODFW'S LOWER COLUMBIA RIVER CONSERVATION AND RECOVERY PLAN

www.dfw.state.or.us/fish/crp/lower_columbia_plan.asp

The Lower Columbia River Plan for Oregon Populations of Salmon and Steelhead (Oregon Lower Columbia Plan) describes the population status and recovery plans for salmon and steelhead in the Youngs Bay, Big Creek, Clatskanie, Scappoose, Clackamas, Sandy, Lower Gorge, Upper Gorge, and Hood River sub-basins.

The Oregon Lower Columbia Plan addresses legal requirements for recovery planning under the ESA and Oregon's Native Fish Conservation Policy. The Oregon Lower Columbia Plan covers the populations of the species listed below that occur in Oregon only. NOAA's National Marine Fisheries Service (NMFS) is responsible for creating a coordinated plan for the entire ESU encompassing Oregon and Washington.

ODFW'S LOWER COLUMBIA RIVER CHUM RECOVERY STRATEGY

https://www.dfw.state.or.us/fish/crp/docs/lower-columbia/OR_LCR_Plan_Appendices%20-%20Aug_6_2010_Final.pdf

Oregon's Columbia River Chum Recovery Strategy (CRS) is incorporated into the LCR Plan. The CRS supplements the recovery plan's chum information. The CRS represents the first step in the State of Oregon's plan for recovering chum in tributaries located on the ESU's Oregon side. Because there is little information in the LCR Plan on the factors limiting chum recovery, the CRS strategy is to gather information and develop techniques that will provide the framework for the establishment of viable chum populations on the Oregon side of the Lower Columbia River. The CRS explores two methods to recover chum populations: (1) identify and improve spawning and rearing habitat to encourage recolonization, and (2) develop a local hatchery brood source that can be used for reintroduction into a targeted watershed with adequate habitat. Oregon's strategy includes a suite of research, monitoring, and evaluation (RME) protocols that are designed to evaluate the effectiveness of actions taken and minimize adverse effects to existing chum stocks, as well as other salmon populations.

NOAA NATIONAL MARINE FISHERIES SERVICE (NMFS)RECOVERY PLAN FOR LOWER COLUMBIA RIVER COHO SALMON, LOWER COLUMBIA RIVER CHINOOK SALMON, COLUMBIA RIVER CHUM SALMON, AND LOWER COLUMBIA RIVER STEELHEAD

www.fisheries.noaa.gov/resource/document/recovery-plan-lower-columbia-river-coho-salmon-lower-columbia-river-chinook

The federal ESA recovery plan complements the LCR Plan by focusing on chum, other salmon species, and steelhead, which spawn and rear in Oregon and Washington's lower Columbia River or its tributaries.

Oregon's LCR Plan is part of NMFS's bi-state recovery plan.

U.S. FISH AND WILDLIFE SERVICE'S CONSERVATION AGREEMENT FOR PACIFIC LAMPREY

www.fws.gov/pacificlsmprey

The Pacific Lamprey Conservation Agreement is a cooperative effort among natural resource agencies and tribes to reduce threats to Pacific Lamprey and improve their habitats and population status. Improving habitat and watershed processes in the Big Creek and Youngs Bay Chum Population areas will benefit all native fish populations, including Pacific lamprey migration, spawning, and juvenile lamprey rearing.

A series of Regional Implementation Plans have been developed to highlight threats and conservation opportunities for Pacific lamprey. The 2020 Pacific Lamprey Regional Implementation Plan for the Lower Columbia/Willamette Regional Management Unit indicates that critical threats for Pacific lamprey in the Lower Columbia mirror those for chum, including impaired passage, stream and floodplain degradation, and water quality.

LIFE HISTORY AND FACTORS LIMITING LOWER COLUMBIA RIVER CHUM POPULATIONS

More than a century of land management activities in the lower Columbia River tributaries have degraded stream and river habitats and impacted chum and other salmon populations. Roads, historical forest harvest practices, dikes and levees, agricultural activities, water diversions, and other actions have altered habitats and watershed processes that create the array of habitats that chum depend on. For example, these activities affect the number and depth of pools, the quantity of large wood in the channel, and the quantity and quality of channel substrates for spawning. Watershed processes altered through land management activities include inputs of large wood to stream channels, erosion and sediment delivery and transport through the channel network, and floodplain inundation frequency and extent. Historically, large wood was removed from river channels with the misguided belief that wood removal would improve fish passage. While land-use management has improved, streams and rivers are still recovering from the historical legacy of past practices.

Rivers are dynamic environments, and it is challenging to untangle the variety of environmental factors that limit chum populations. The difficulty in understanding the factors affecting chum is illustrated in a 1970 salmon habitat survey of the Columbia Basin that included the Youngs Bay and Big Creek tributaries. The authors noted that lower Columbia chum populations have "failed to respond to an almost complete closure of the fishery in 1959. Chum stocks, in general, have declined, indicative of some common adverse factor" (Fulton 1970). The dramatic decline in chum populations is especially striking because, historically, chum comprised one of the largest spawning biomass of any salmon in the lower Columbia River (Good et al. 2005).

This section outlines what we know about the critical habitat factors broadly limiting the recovery of Lower Columbia River chum salmon populations summarized by life stage: Adult migration and spawning, egg incubation and emergence, and juvenile rearing and migration. The following section, Profile of the Population Area, builds on this general summary of limiting factors by identifying the specific habitat conditions affecting chum within the Big Creek and Youngs Bay Chum Population Areas.

ADULT MIGRATION AND SPAWNING

Factors Potentially Limiting Lower Columbia River Chum Adult Migration and Spawning:

- **Passage barriers**
- **Suitable spawning substrate, including groundwater upwelling**

After three to five years in the ocean, chum return to spawn, with four years observed as the most common period. Chum typically enter freshwater in October or November in a fully mature state, spawn within a few days in the low gradient (<1%), lower sections of rivers near tidewater, and die within a week or two after spawning (Quinn 2018). Excessive suspended sediment loads in the stream may delay upstream migration (Helle 1960). Chum are strong swimmers but poor jumpers. For this reason, chum are generally restricted to spawning areas below barriers, including minor barriers that are quickly passed by other species of salmon (Quinn 2018).

While passage barriers can prevent access to spawning areas, chum are less susceptible than other salmon species to migration barriers because they spawn low in the river system. As described in the profile of the Population Areas below, most of the historical spawning habitat in the Big Creek and Youngs Bay population areas is currently accessible to returning chum salmon (ODFW 2005).

Chum spawning typically peaks during the third week in November and may continue into January. It is thought that chum preferentially select spawning reaches or redd sites that have upwelling groundwater (Geist et al. 2002). This redd site selection pattern has been observed for a variety of chum spawning locations (Burril et al. 2010). Chum are assumed to select upwelling habitats because of their warmer and stable water temperatures in the winter (Geist et al. 2002). Other reasons cited for spawning chum selecting upwelling areas are increased oxygenation and removal of fine sediments due to the upwelling water (Hale et al. 1985).

EGG INCUBATION AND EMERGENCE

Factors Potentially Limiting Lower Columbia River Chum Egg Incubation and Emergence:

- **Fine sediment deposition**
- **Too few returning spawners to create optimal channel roughness to protect eggs from flood scour**

Chum have a fry migrant life history. Emergence occurs in early spring followed by rapid migration to the estuary (Salo 1991). Compared to other salmon, chum eggs are large and produce relatively large fry – from about 32 mm to 38 mm (Quinn 2018). Depending on water temperatures, eggs develop in the gravel for 50-130 days (Hale et al. 1985). Chum alevins remain within the gravels while the yolk sack is absorbing (Hale et al. 1985). Chum have much lower average percent egg-to-fry survival (12.9%) in comparison to Chinook (44.6%), steelhead (29.3%), and coho (25.30%; Quinn 2018).

Spawning chum move gravel and cobbles through the act of digging the redd. A by-product of this digging is gravel sorting and displacement of fine sediments from the redd. This facilitates chum egg respiration because the lower quantities of fines in the redd increase oxygenated water flow through the gravels (Quinn 2018).

Fulton et al. (1970) speculated that "...siltation caused by deforestation and by the flushing of logs down the channels of streams has destroyed [chum] spawning areas... more subtle changes in the lower portions of the stream such as siltation and compaction of gravel have had a more serious effect on the survival of [chum] eggs and fry." Erosion, sediment routing into stream channels, and transport downstream affect the quality of chum spawning habitat.

Chum's freshwater production is typically limited by streambed gravel quantity and character in spawning areas (reviewed by Salo 1991). Increasing amounts of fine sediment in spawning gravels have been shown to decrease chum eggs' survival to emergence. In a meta-analysis of published studies that evaluated fine sediment deposition and salmon egg-to-fry survival, the authors estimated that a 1% increase in fines (< 0.85 mm) results in a 13.6% reduction in the odds of survival for chum; a 1% increase in larger fines (3.4–4.6 mm) results in a 4.2% reduction in chum survival (Jensen et al. 2009). The act of chum spawning clears fine sediment away from the gravel in redds; consequently, it is sediment deposited after eggs are laid that could decrease survival (Chapman 1988).

Research has shown that variability in chum egg survival is associated with increased levels of fine sediment from roads, agricultural activities, and other land management (Scrivener and Brownlee 1989). In one case, the proportion of chum eggs surviving to emergence declined from 22.2% before timber harvest to 11.5% survival after harvest activities (Scrivener and Brownlee 1989). The annual mean survival to emergence was positively related to two indices of substrate composition – permeability and porosity – both of which are affected by fine sediment deposition in spawning areas. The precise reason for decreases in survival is not fully understood (Jensen et al. 2009).

Multiple mechanisms have been proposed to explain the negative impacts of fine sediment deposition on egg-to-fry survival: when the substrate pore spaces are filled with fine sediments, the fry become entombed in the bed with limited food resources and eventually starve to death (Scrivener and Brownlee 1989); the sediment impedes the flow of oxygenated water through the gravel in the egg pocket causing suffocation (Chapman 1988); or the layer of fine sediment may reduce interstitial spaces and physically prevent fry emergence (Beschta and Jackson 1979).

Artificial channels constructed for chum spawning underscore the impact of fine sediments on egg- to-fry survival. Pre-sorted gravels and regulated flows in artificial channels provide nearly ideal conditions for chum embryos, with up to 80% of the eggs surviving (Quinn 2018). Another factor that can limit egg incubation in spawning areas is flood events, which can effectively scour chum redds. There is evidence that stream-bed alteration caused by mass chum spawning positively influences egg survival in flood events (Montgomery et al. 1996). Mass chum spawning coarsens and sorts channel substrates, modifies channel hydraulics, and reduces the probability of stream-bed scour and excavation of buried chum eggs. This potential feedback between mass chum spawning and channel substrate mobility implies that it could become increasingly difficult to reverse declines in mass-spawning populations because decreased spawning activity would increase bed scour potential, leading to more mortality of chum eggs.

JUVENILE REARING AND OUTMIGRATION

Factors Potentially Limiting Lower Columbia Juvenile Rearing and Outmigration:

- **Degraded stream habitat**
- **Access and quality of tidal wetlands for refuge, rearing, and feeding**

Compared to most salmon species, chum fry spend little time in freshwater. Chum and pink salmon, which are tolerant of seawater at emergence, go to sea at the smallest size compared to other salmon species (Quinn 2018). In a study of juvenile salmon in the Grays River estuary, a lower Columbia River tributary in Washington State, most of the chum juveniles were less than 65 mm (fork length): 80% were recently emerged fish smaller than 45 mm (Roegner et al. 2010). Unlike chum, juvenile coho, Chinook, and steelhead can reside, feed, and grow for long periods in freshwater (Quinn 2018). While juvenile chum can migrate to the ocean quickly after emergence, freshwater and estuary wetland habitat quality and productivity (e.g., food sources) are still crucial for chum survival.

In the estuary, chum fry will usually feed for a few days to weeks before migrating to the ocean. In the study of juvenile salmon in the Grays River estuary, most of the chum juveniles were present for 2 to 3 weeks in March through April, with the numbers declining sharply by the first of May (Roegner et al. 2010). Data from this study suggest that although most chum in the Columbia River system migrate to the ocean as fry, some individuals stay in the estuary to grow to fingerling size before moving into the ocean (Roegner et al. 2010). Pearcy et al. (1989) found mean estuary residence times varied from 5-23 days for hatchery-reared chum juveniles.

Insects produced in wetlands are a dominant prey type for salmon foraging in tidal freshwater and estuarine environments (Roegner et al. 2010). Research indicates that insects are the primary food source for chum fry (Shreffer et al. 1992, Tanner et al. 2002).

Juvenile salmonids enter intertidal wetlands during high water to forage on emergent insects and other wetland food sources (Roegner et al. 2010). Most of the lower Columbia River's historical wetlands and the estuary have been disconnected from tidal and flood inundation. Barriers (e.g., dikes) and tide gates have reduced or eliminated salmonids' opportunity to use the once-extensive off-channel fresh-water and tidal wetland rearing habitat.

POPULATION AREAS AND CHUM HABITAT EVALUATIONS

HISTORICAL CONTEXT

A recent assessment of historical land cover changes in the Lower Columbia River floodplains over the past 140 years shows dramatic changes in vegetation and habitat types (Marcoe and Pilson 2017). The study noted massive (>50%) losses of tidal and fresh-water wetlands throughout the lower river, including estuary areas within the Big Creek and Youngs Bay Chum Population Areas. The majority of habitat loss was due to land conversion for agriculture and residential development. Most of the wetland losses are from the construction of dikes, channel alteration, and other measures that disconnect floodplain wetlands from tidal inundation. Functioning estuarine wetlands are critical habitats for juvenile salmonids, including chum (Bottom et al. 2005).

CURRENT LAND USES

TABLE 1 and **FIGURE 7** show the significant land ownership categories and land uses within the Big Creek and Youngs Bay Chum Population Areas. Private lands are the largest land ownership class, encompassing 69.2% and 85.7% of Big Creek and Youngs Bay Chum Population Areas, respectively. Forest management on private lands is the primary land use, covering nearly half of the two population areas.

Except for rural residential properties with pasture areas and livestock, there is minimal land zoned for commercial agriculture within the Big Creek Population Area. In contrast, agriculture is an important land use in the Youngs Bay Chum Population Area, encompassing approximately 38% of the area, primarily in the lower and estuarine portions of the Lewis and Clark, Youngs, and Wallooskee Rivers. Urban areas within the cities of Astoria and Warrenton cover a small proportion of the Big Creek and Youngs Bay Chum Population Areas.

The most extensive land use within the two Population areas is private timber management. In addition, a proportion of the two Population Areas – 24.8% for Big Creek and 8.4% for Youngs Bay – are State of Oregon-owned forest lands managed by the Oregon Department of Forestry (ODF). There are 5,000 acres of other state-owned lands in addition to state forest lands, with the majority in the Saddle Mountain State Natural Area in the Lewis and Clark drainage headwaters. There are no extensive tracts of federal forest lands within the Population Areas. The primary federal land ownership is more than 1,000 acres associated with the Lewis and Clark National Historical Park in the Youngs Bay Population Area (Lewis and Clark and Skipanon River Watersheds). Local municipalities manage over 5,000 acres, with the largest share within the City of Astoria's drinking water supply area in upper Bear Creek.

LAND USE/ OWNERSHIP (AND MANAGEMENT)	BIG CREEK POPULATION AREA ACRES (%)	YOUNGS BAY POPULATION AREA ACRES (%)	TOTAL
Federal	215 (0.3%)	1,213 (0.9%)	1,428
State Forest (Managed by ODF)	18,415 (24.8%)	11,307 (8.4%)	29,722
State (Other Agencies)	119 (0.2%)	5,205 (3.9%)	5,324
Clatsop County	51 (0.1%)	167 (0.1%)	219
Local Government	4,102 (5.5%)	1,309 (1.0%)	5,411
Private	51,381 (69.2%)	115,155 (85.7%)	166,537
TOTAL	**74,283**	**134,356**	**208,641**

TABLE 1. Land Use/Ownership within the Big Creek and Youngs Bay Chum Salmon Population Areas

FIGURE 7. Return of the Redds Big Creek and Youngs Bay Chum Population Areas Ownership Map

EVALUATING AQUATIC AND RIPARIAN HABITAT STATUS

The maps on the following pages show the Big Creek **(FIGURE 8)** and Youngs Bay Chum **(FIGURE 9)** Population areas. River and stream segments (reaches) where ODFW has collected information specific to chum spawning habitat suitability are illustrated on the maps. The Chum Spawning Habitat Evaluation Reaches were characterized for suitable substrate and groundwater upwelling (Alfonse et al. 2017). In addition, chum spawning habitat data and aquatic habitat inventories completed by ODFW and others characterize aquatic and riparian habitat for many of the streams in the Big Creek and Youngs Bay Chum Population Areas.

Figures 8 and 9 also show potential fish passage barriers with the Big Creek and Youngs Bay Chum Population Areas. The potential barriers were identified through two sources: (1) The ODFW state-wide fish passage dataset, which describes barriers that potentially affect multiple native fish species (ODFW 2020); and (2) ODFW's recent inventory of chum spawning areas, which identified potential barriers specific to chum passage requirements (Alfonse et al. 2017). Both fish passage datasets identify human infrastructure (road-crossing culvers, dams, etc.) and natural features (e.g., waterfalls) that are potential fish passage barriers. It is difficult to identify chum passage barriers because there is no accepted standard for the vertical height or gradient that can be successfully ascended by adult chum (Quinn 2018). For this reason, the ODFW chum spawning habitat inventory employed highly conservative criteria to identify potential adult chum migration barriers (Alfonse et al. 2017): "A potential barrier was defined as any natural or man-made structure at least 1 meter [~3 ft.] high and extending across the width of the watered channel. Culverts were recorded as potential barriers even if there was no drop to the stream (because they could be velocity barriers)."

ODFW has developed habitat benchmarks that describe desirable and undesirable stream and riparian habitats for salmon species in Oregon's northern coastal area (Kavanagh et al. 2006). **TABLE 2** describes habitat benchmarks for large wood (key pieces and number of pieces), pool frequency, number of riparian conifers, and percent fine substrate. The benchmarks provide: (1) a consistent framework for evaluating the current status of aquatic habitat across the two population areas; (2) habitat targets for restoration planning (e.g., describing how much large wood to place to meet the benchmark); and (3) a consistent framework for evaluating habitat uplift over time through restoration project monitoring and future stream habitat inventories.

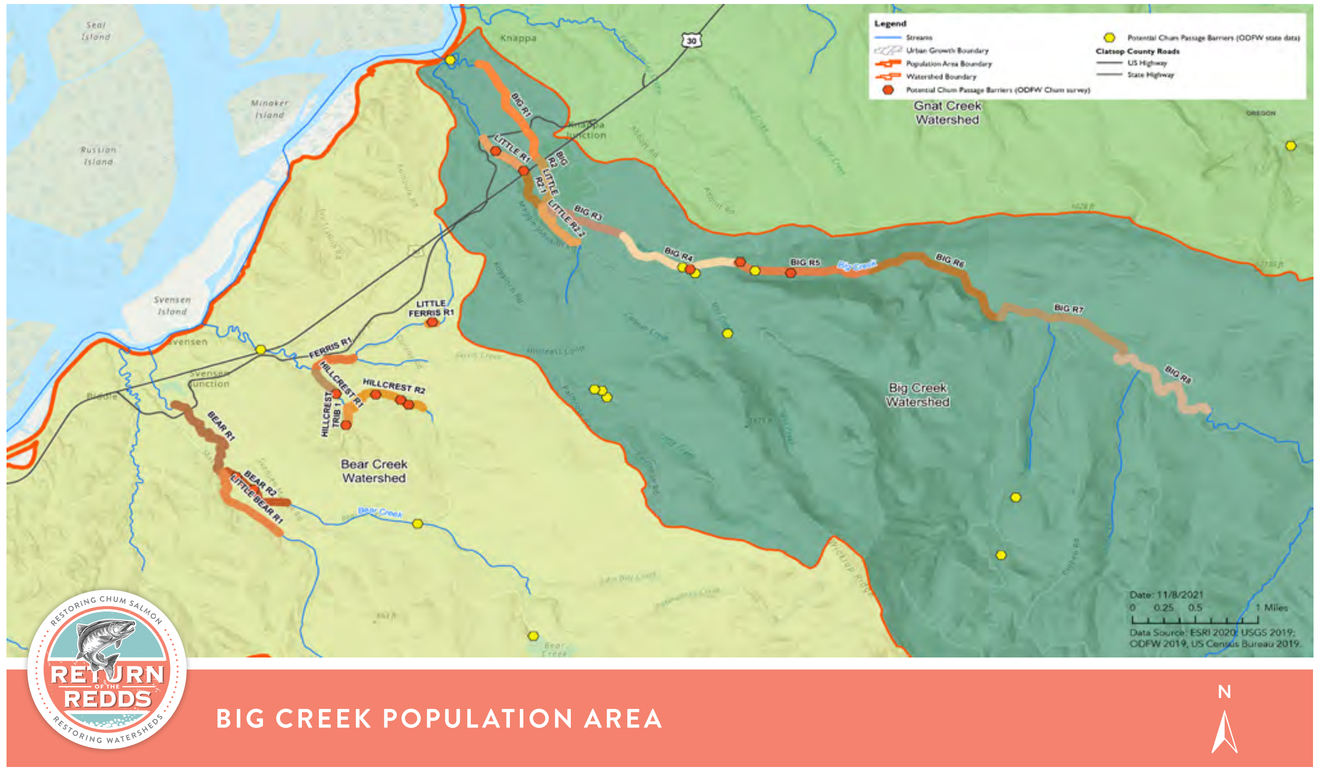


FIGURE 8. The Big Creek chum population area showing chum spawning habitat evaluation reaches and potential fish passage barriers. The variously colored reaches are to distinguish between reaches and the colors have no other significance

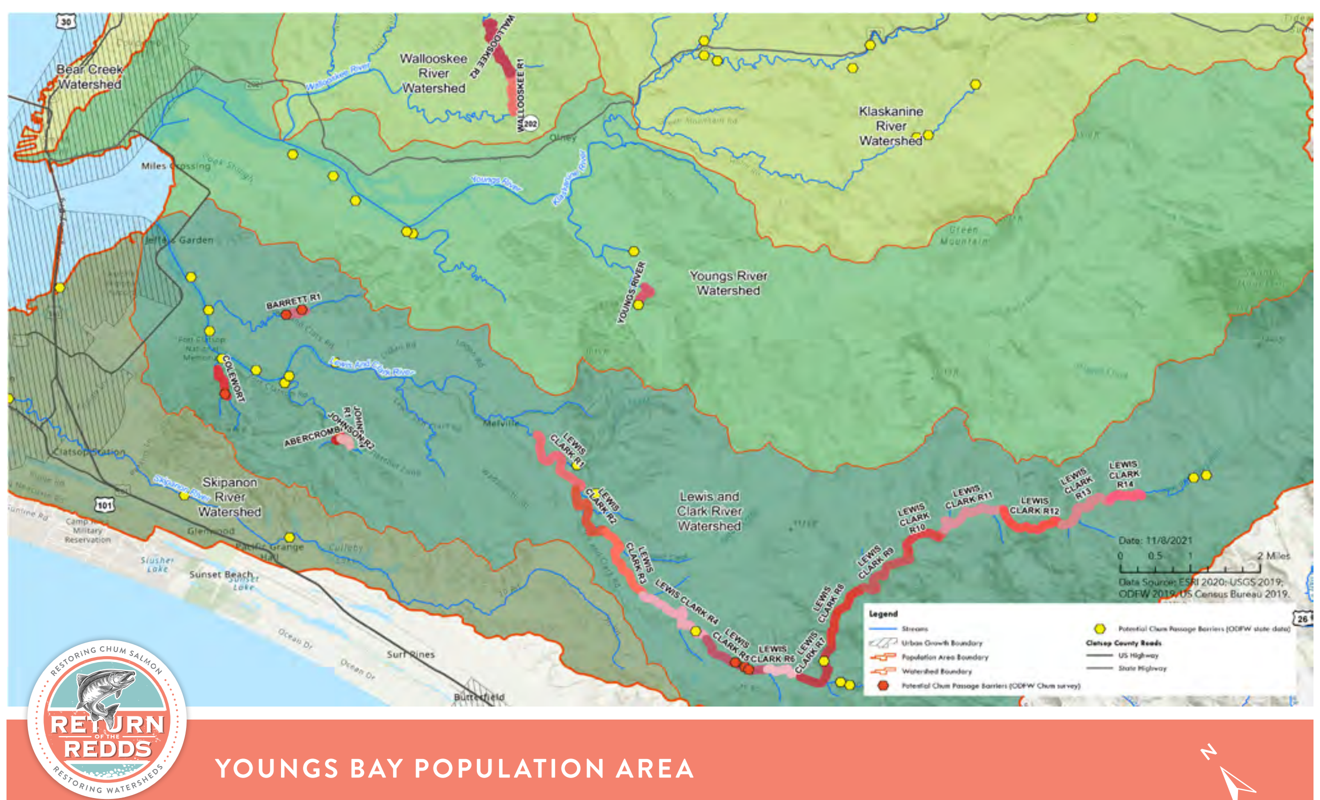


FIGURE 9. The Youngs Bay chum population area showing chum spawning habitat evaluation reaches and potential fish passage barriers. The variously colored reaches are to distinguish between reaches and the colors have no other significance

AQUATIC HABITAT BENCHMARK	UNDESIRABLE	DESIRABLE
LARGE WOOD:		
Key pieces (≥60 cm diameter and ≥10m long per 100 m (328 ft.)	≤1	≥3
Number of pieces (per 100 m/328 ft.)	≤10	≥20
POOLS:		
Pool frequency (number channel widths between pools)	≥20	≤5 - 8
RIPARIAN CONIFERS (30 m from both sides):		
Number>50-cm dbh/305m (1000 ft.) stream length	≤150	≥300
Number>90-cm dbh/305 m (1000 ft.) stream length	≤75	≥200
SUBSTRATE:		
% fines in riffles (≤2 mm diameter)	≥15%	≤8%
% gravel in riffles (2-64 mm diameter)	≥54%	≤10%

TABLE 2. ODFW Aquatic Habitat Benchmarks

The sections below apply the habitat benchmarks to evaluate aquatic inventory data collected in the Big Creek and Youngs Bay Chum Population Areas.

BIG CREEK CHUM POPULATION AREA

The Big Creek Chum Population Area includes all the drainages flowing north into the lower Columbia River, including Big Creek, Little Creek, Farris Creek, Bear Creek, and Gnat Creek. This section describes what is known about aquatic habitat quality and the specific factors limiting adult chum migration, spawning, egg incubation and emergence, and juvenile rearing and outmigration.

According to ODFW's Native Fish Status Report and other sources, chum are functionally extirpated within the Big Creek Population Area (ODFW 2005 and McElhany et al. 2007). In recent years, spawning chum have been observed sporadically in both populations, including in Big, Little, Little Bear, Mill and Ferris Creeks (Big Creek population) and Lewis and Clark, South Fork Klaskanine, and Wallooskee Rivers (Youngs Bay population; Derek Wiley, ODFW, per. comm. 2020).

The annual return of chum to the Big Creek Hatchery and the other river systems varies dramatically. In 2006, 192 adult chum were captured in the Big Creek Hatchery trap (ODFW 2010b). In 2018, a total of 13 live chum and one carcass were observed in Big Creek over two survey dates (November 15 and 20), and one live chum was observed in Mill Creek (October 31; Wiley 2020). In 2019, four chum carcasses were found in Little Creek over two survey dates (November 25 and December 2; Wiley 2020). The 2020 chum run was more significant than average, but still only a small fraction of the historical population **(SEE SIDEBAR)**.

Most of the historical chum spawning habitat within the Big Creek population area is considered to be accessible (ODFW 2005). A dam located at Big Creek Hatchery (~RM 3) blocks access to some chum spawning habitat in the upper watershed. However, it is unknown how far – or if at all – chum historically migrated above the moderate-gradient gorge area located upstream of the hatchery (ODFW 2010).

TABLE 3 shows the Big Creek Chum Population Area habitat benchmark status for the 2017 chum spawning inventory streams and reaches. The habitat values are from the most recent aquatic habitat inventory data collected in 2005, 2007, and 2008 (Boswell 2005, 2007, and 2008). While the aquatic inventory data were collected 12 to 15 years ago, these data are the only systematically collected information on quantities of large wood, pool frequencies, and riparian conifers. The aquatic inventory information complements the 2017 data collected for the Chum Spawning Habitat Evaluation Reaches, which primarily focused on substrate quality and identifying areas of groundwater upwelling.

The aquatic habitat inventory data were summarized for each of the corresponding ODFW Chum Spawning Habitat Evaluation Reaches in the Big Creek Population Area. For each habitat value (e.g., pieces of large wood), it was determined if the value met (+) or did not meet (-) the established habitat benchmark. The numbers in parentheses indicate the observed habitat values. Measures of key pieces of large wood, the number of riparian conifers, and percent fine substrate in riffles were consistently below benchmark values for all of the stream reaches. Benchmarks for the number of large wood pieces and pool

2020 CHUM SALMON RETURN

In 2020 there was a strong return of chum at the Big Creek Hatchery. It is important to note that this exceptional year does not predict future returns. The returning fish allowed ODFW's Chum Reintroduction Project to spawn 160 pairs and reach a collection goal of 400,000 eggs to be released as fry into Big Creek during spring of 2021. Additionally, the project released more than 600 adults into the nearby Bear Creek watershed to evaluate spawning potential and freshwater survival. Spawning surveys showed released chum spawning throughout Bear and Little Bear Creeks and additional observations of chum were made in the Big Creek and Youngs Bay populations. It is important to note that although the 2020 chum run was significantly larger than observations in recent years, abundance still reflects only a small percentage of historical estimates (Wiley 2020a).

HABITAT BENCHMARKS

Chum Population Area	Subwatershed	ODFW Chum Stream & Reach Designation	Stream Survey Year	Length (m)	*LW Key Pieces/ 100 m (≥3)*	*Number of LW Pieces/ 100 m (≥20)*	*Pool Frequency (Channel Width b/t Pools) (≤5-8)*	*Number of Conifers/ 1000 ft > 50 cm dbh (≥300)*	*Substrate Condition (% Fine in Riffles) (≤8%)*
Big Creek	Lower Big Creek	Reach 1	2007	1555	- (0)	- (3.1)	- (12.1)	- (0)	- (25)
		Reach 2	2007	759	- (0.2)	- (8.1)	+ (7.6)	- (30)	- (15)
		Reach 3	2007	1200	- (0.1)	- (11)	+ (6.2)	- (30)	- (15)
		Reach 4	2007	1830	- (0.8)	+ (30.6)	+ (3.2)	- (122)	- (15)
	Upper Big Creek	Reach 5	2007	1729	- (0)	- (8.7)	+ (5.4)	- (15)	- (16)
		Reach 6	2007	2478	- (0.2)	- (8.1)	+ (4.6)	- (0)	- (17)
		Reach 7	2007	1950	- (0.1)	- (11)	+ (4.2)	- (12)	- (15)
		Reach 8	2007	2061	n/a	n/a	+ (4.4)	- (20)	n/a
Big Creek	Little Creek	Reach 1	2008	750	- (0.6)	- (7.3)	- (14.4)	- (49)	- (38)
		Reach 2.1	2008	666	- (0)	- (5.3)	- (90.5)	- (0)	n/a
		Reach 2.2	2008	805	n/a	n/a	n/a	n/a	n/a
	Bear Creek	Bear 1	2008	1516	- (0.9)	+ (20.0)	+ (6.3)	- (91)	- (12)
		Bear 2	2008	1112	- (1.7)	- (11.5)	- (20.5)	- (61)	- (13)
		Little Bear 1	2008	1434	- (1.1)	- (12.6)	+ (4.0)	- (0)	- (18)
	Ferris-Hill Crest Creek	Ferris Creek Reach 1	2008	550	- (0.4)	- (6.8)	- (8.8)	- (91)	- (31)
		Hill Crest Creek Reach 1	2008	436	- (0.5)	- (9.4)	- (15.4)	- (41)	- (55)
		Hill Crest Creek Reach 2	2008	1688	- (0.9)	- (5.6)	n/a	n/a	- (48)
		Little Ferris 1	2008	550	- (2.7)	+ (24.6)	- (19.0)	- (30)	- (20)
	Mill Creek	Reach 1	2008	668	- (0.6)	- (6.4)	+ (3.2)	- (61)	- (66)
		Reach 2	2008	496	- (1.0)	- (11.0)	n/a	- (0)	- (46)

TABLE 3. Habitat Benchmarks for ODFW Chum Spawning Habitat Evaluation Reaches within the Big Creek Chum Population Area. Table Header Number in Parenthesis = Benchmark Value. Minus Symbol (-) = Does Not Meet the Benchmark. Plus Symbol (+) = Meets or Exceeds Benchmark. Reach Habitat Numbers in Parentheses = Observed Habitat Value.

frequency were met for some stream reaches. Additionally, the inventoried reaches are within the low gradient (<1% slope), "response" portions of the stream network where fine substrates accumulate, a significant habitat stressor for chum salmon. Big Creek reaches 1 through 4 are response reaches with historical chum spawning. The habitat characteristics support the overall conclusion that most of the inventoried reaches are deficient in the key habitat elements – abundant large wood, deep pools, riparian conifers, and good substrate conditions – that support high-quality spawning and juvenile rearing habitat for chum and other salmon species.

As noted above, increasing amounts of fine sediment in spawning gravels has been shown to decrease chum eggs' survival. All of the inventoried reaches exceeded the benchmark of 8% fines in riffles, with some riffles exceeding 30% or more.

It is important to note that the summarized habitat data did not characterize all of the key factors that may limit chum. For example, there is not information summarizing access to off-channel and floodplain habitats, which could also limit chum.

In addition to degraded stream conditions, altered estuarine areas have reduced Big Creek Population Area juvenile chum rearing habitats. Lower Columbia estuarine habitats have been severely degraded through diking and filling (Marcoe and Pilson 2017; ODFW 2010).

FACTORS LIMITING BIG CREEK POPULATION AREA CHUM ADULT MIGRATION AND SPAWNING

- **Suitable spawning substrate, including groundwater upwelling**

FACTORS LIMITING BIG CREEK POPULATION AREA CHUM EGG INCUBATION AND EMERGENCE

- **Fine sediment deposition**
- **Too few returning spawners to create optimal channel roughness to protect eggs from flood scour**

FACTORS LIMITING BIG CREEK JUVENILE REARING AND OUTMIGRATION

- **Degraded stream habitat**
- **Access and quality of tidal wetlands for refuge, rearing, and feeding**

YOUNGS BAY CHUM POPULATION AREA

Major tributaries within Young's Bay Chum Population Area include the Wallooskee River, Klaskanine River, Youngs River, and Lewis and Clark Rivers. Historically, chum spawning was observed in all of these tributaries. The Skipanon River is also part of the Population Area where chum are considered historically present, but there are few historical records of spawning chum in this system.

This section describes what is known about aquatic habitat quality and the specific factors limiting adult chum migration, spawning, egg incubation and emergence, and juvenile rearing and outmigration.

Most of the historic chum spawning areas in the Young's Bay Population Area tributaries are considered to be accessible (ODFW 2005). A diversion dam associated with ODFW's North Fork Klaskanine Hatchery currently restricts passage to upstream habitat; this issue will be addressed in the future to improve fish access.

TABLE 4 shows the Youngs Bay Chum Population Area habitat benchmark status for the 2017 chum spawning inventory streams and reaches. The habitat values are from the most recent aquatic habitat inventory data collected in 2005 (Boswell 2005). The aquatic habitat inventory data were summarized for each of the corresponding ODFW Chum Spawning Habitat Evaluation Reaches in the Youngs Bay Population Area. It is important to note that there is no aquatic habitat inventory data for the Lewis and Clark River and a number of the Chum Spawning Habitat Evaluation Reaches.

Similar to the Big Creek Population Area, measures of key pieces of large wood, the number of riparian conifers, and the percent fine substrate in riffles were consistently below benchmark values for most of the stream reaches. Benchmarks for the number of large wood pieces and pool frequency were met for some stream reaches. These data support the overall conclusion that most of the inventoried reaches are deficient in the critical habitat elements – large wood, pools, riparian conifers, and substrate – that support high-quality habitat for chum and other salmon species.

Most of the inventoried reaches are within the low gradient, response portions of the stream network where fine substrates accumulate. For example, Lewis and Clark River reaches 1 through 4 are response reaches with historical chum spawning. As noted above, increasing amounts of fine sediment in spawning gravels has been shown to decrease chum eggs' survival to emergence. All but one of the aquatic inventory reaches met the benchmark of <8% fines in riffles, with some riffles exceeding 30% or more fines.

HABITAT BENCHMARKS

Chum Population Area	Subwatershed	ODFW Chum Stream & Reach Designation	Stream Survey Year	Length (m)	*LW Key Pieces/ 100 m (≥3)*	*Number of LW Pieces/ 100 m (≥20)*	*Pool Frequency (Channel Width b/t Pools) (≤5-8)*	*Number of Conifers/ 1000 ft > 50 cm dbh (≥300)*	*Substrate Condition (% Fine in Riffles) (≤8%)*
Youngs Bay	Estuary	Barrett	2005	512	- (0.1)	- (0.5)	n/a	- (0)	n/a
		Colewort	--	239	n/a	n/a	n/a	n/a	n/a
		Lewis and Clark Reach 1	--	2254	n/a	n/a	n/a	n/a	n/a
	Lewis and Clark River	Reach 2	--	1476	n/a	n/a	n/a	n/a	n/a
		Reach 3	--	2050	n/a	n/a	n/a	n/a	n/a
		Reach 4	--	2490	n/a	n/a	n/a	n/a	n/a
		Reach 5	--	1903	n/a	n/a	n/a	n/a	n/a
	Lower Lewis and Clark Tributaries	Stavebolt	--	n/a	n/a	n/a	n/a	n/a	n/a
		Loowit Creek Reach 1	2005	437	n/a	n/a	+ (3.1)	- (61)	- (64)
		Klickatat Creek	2005	371	- (0.3)	- (2.2)	- (12.2)	n/a	- (56)
		Shewash Reach 1	2005	205	- (0)	- (10.3)	+ (3.2)	- (61)	- (28)
		Shewash Creek Reach 2	2005	775	- (0.6)	+ (20.6)	- (9.1)	- (0)	- (10)
		Speelyai Creek Reach 1	2005	460	- (0.2)	- (2.8)	- (9.9)	- (0)	- (20)
	Youngs River	Reach below Falls	2005	768	- (0.7)	- (5.8)	+ (4.3)	- (0)	- (22)
Youngs Bay	Wallooskee River	Reach 1	2005	1287	- (1.0)	- (2.5)	- (15)	- (0)	- (25)
		Reach 2	2005	2489	- (0.1)	- (2.2)	- (15.1)	- (41)	- (23)
		Palmer Creek Reach 1	2005	1500	- (0.5)	- (4.8)	- (27)	- (0)	- (53)
		Trib A	2005	1707	- (1.0)	+ (21.1)	n/a	- (41)	n/a
		Little Wallooskee Reach 1	2005	801	- (0)	- (0.1)	- (616.2)	- (0)	- (25)
		Little Wallooskee Reach 2	2005	564	- (0)	- (0.1)	- (74.9)	- (0)	+ (5)
		Trib A Reach 1	2005	606	- (1.7)	+ (20.0)	+ (7.5)	- (0)	- (86)
		Trib A Reach 2	2005	1221	- (0.2)	- (5.0)	- (21.6)	- (0)	- (90)
	Klaskanine River	South Fork Reach 1	2005	511	- (1)	- (1.8)	+ (6.0)	- (0)	- (18)
		South Fork Reach 2	2005	3378	- (0.6)	- (4.1)	+ (5.3)	- (0)	- (13)

TABLE 4. Habitat Benchmarks for ODFW Chum Spawning Habitat Evaluation Reaches within the Youngs Bay Chum Population Area. Table Header Number in Parenthesis = Benchmark Value. Minus Symbol (-) = Does Not Meet the Benchmark. Plus Symbol (+) = Meets or Exceeds Benchmark. Reach Habitat Numbers in Parentheses = Observed Habitat Value.

In addition to degraded stream conditions, altered estuarine areas have reduced Youngs Bay Population Area juvenile chum rearing habitats. Lower Columbia estuarine habitats have been severely degraded through diking and filling (ODFW 2010).

FACTORS LIMITING YOUNGS BAY POPULATION AREA CHUM ADULT MIGRATION AND SPAWNING

- Suitable spawning substrate, including groundwater upwelling

FACTORS LIMITING YOUNGS BAY POPULATION AREA CHUM EGG INCUBATION AND EMERGENCE

- Fine sediment deposition
- Too few returning spawners to create optimal channel roughness to protect eggs from flood scour

FACTORS LIMITING YOUNGS BAY JUVENILE REARING AND OUTMIGRATION

- Degraded stream habitat
- Access and quality of tidal wetlands for refuge, rearing, and feeding

RESTORATION STRATEGY TO ADDRESS FACTORS LIMITING CHUM IN THE RREDDS PROJECT AREA

COMPREHENSIVE LONG-TERM RESTORATION AND PROPERTY OWNER ENGAGEMENT

RREDDs approach to recovering chum populations is to restore both key habitats and the processes that create and sustain the river, riparian, and floodplain habitats on which chum depend (Homel et al. 2019, Beechie et al. 2010). Chum are an indicator of the health of a stream. Our focus is on restoring watershed processes and habitats that support healthy streams to support chum and other fish populations. The approach encompasses a broad landscape- and process-based framework that evaluates watershed conditions and habitat suitability from the headwaters to the floodplain and estuarine zones.

RESTORATION ACTIONS IN THE BIG CREEK AND YOUNGS BAY CHUM POPULATION AREA WATERSHEDS OPERATE AT TWO SPATIAL AND TIME SCALES:

- **SHORT-TERM ACTIONS** emphasizing restoration in specific chum spawning reaches and estuarine rearing areas. These activities (e.g., adding large wood to create deep pools) will provide more rapid habitat responses and improve reach-specific conditions for adult spawning and juvenile rearing.

- **LONG -TERM ACTIONS** focusing on restoring watershed processes across the landscape. These restoration activities (e.g., maintaining road drainages to reduce sediment) will require more time to realize improvements (e.g., less fine sediments) in downstream chum spawning reaches.

Informing and engaging property owners are an essential part of the restoration strategy. Historical chum spawning areas are primarily in the lower watersheds where land uses are rural residential and agricultural. Informing these property owners about the chum population restoration strategy and gaining support to implement restoration projects on their properties will be crucial to RREDDs success.

RESTORING CHUM SPAWNING RESPONSE REACHES AND ESTUARY AREAS

Current and legacy upstream land uses have degraded chum spawning reaches. Fine sediments generated from roads and other activities flow downstream. Chum spawn in areas low in the watershed, usually in low gradient response reaches where fine sediments are deposited. As discussed above, excessive fine sediments can lead to chum egg mortality. Dikes, channelization, limited large wood, and other factors have also impacted chum salmon spawning areas. These channel structure changes alter the accumulation and sorting of suitable spawning substrate and increase water velocities, which can scour chum spawning areas and lead to egg mortality. Channelization and low quantities of large wood also reduce the number and depth of pools and access to off-channel areas during high flows – habitats that juvenile chum require during the vulnerable first few days or weeks after they emerge in early spring from spawning areas.

Access to off-channel estuarine tidal wetland areas is essential for juvenile chum growth and survival. During their first year at sea, Larger juvenile chum have a survival advantage over smaller juvenile chum from the same spawning cohort (Farley et al. 2007).

Restoration actions in response reaches and estuary areas will be developed and implemented in coordination with the property owners. Active restoration actions will focus on response reaches, mostly within the lower end of rivers. For example, lower Big Creek and Lewis and Clark River are dynamic areas subject to large flood events, channel migration, and land erosion. Identifying and implementing restoration projects in these areas requires careful planning, in coordination with property owners, that considers the geomorphic setting and channel dynamics throughout the reach or multiple reaches. Restoration actions may focus on placing large wood to improve spawning substrates and create pools and off-channel areas for juveniles to escape high-velocity flows and forage. In estuary areas, efforts include breaching dikes or other activities that restore fish access to and tidal processes to estuary wetlands.

RESTORING WATERSHED PROCESSES

Landscape - and watershed - scale processes deliver water, sediment, and large wood to streams, which modify channel habitat conditions such as the quality and quantity of substrate in spawning areas. Stream channels transport water, sediment, and large wood downstream through the channel network. Sediment generating processes such as landslides and erosion run-off from roads are episodic and highly variable because they are driven by storm events that vary from year to year (Beechie et al. 2010). Similarly, fluxes of wood into channels and the formation of side channels, floodplains, and other dynamic habitats are formed by floods and other episodic events. These processes operate at different time and landscape scales – basin, watershed, stream network, and individual habitats (e.g., pool formation). The stream network links processes – for example, the transport of sediment and water – across the range of landscape scales, from the headwaters to the estuary **(FIGURE 10)**.

Watershed processes are affected by location in the watershed, underlying geology, land use practices, type and extent of vegetation, and other factors. Mountainous, forested upland areas with steep and often unstable slopes have quite different natural patterns of watershed processes – for example, the rate and location of erosion and landslides – than less-steep lowland and estuary areas. Imposing land management activities upon a landscape changes the rate of natural processes.

Timber harvest activities, with associated harvest units and access roads, can accelerate the rate of natural erosion processes and promote excess sediment delivery to stream channels. There is often a delay between the impacts of the land use activities and the stream channel network's response to the process changes.

It can take long periods of time for natural erosion processes and downstream channel habitats to respond to land use practices **(FIGURE 11)**. Sediment generated in upland areas can take decades to be transported through the channel network and for downstream habitats to respond to the increased sediment load. A long-term, "generational" approach will be necessary for re-setting watershed processes – such as sediment regimes, large wood inputs, and floodplain connectivity.

Restoration of critical ecosystem processes (e.g., enhancing riparian areas with native trees and associated inputs of large wood to stream channels over time) enables stream habitats to evolve naturally and respond to changes from a dynamic environment. Restoring watershed processes also helps to buffer against climate change and other future threats to watershed health (Beechie et al. 2012).

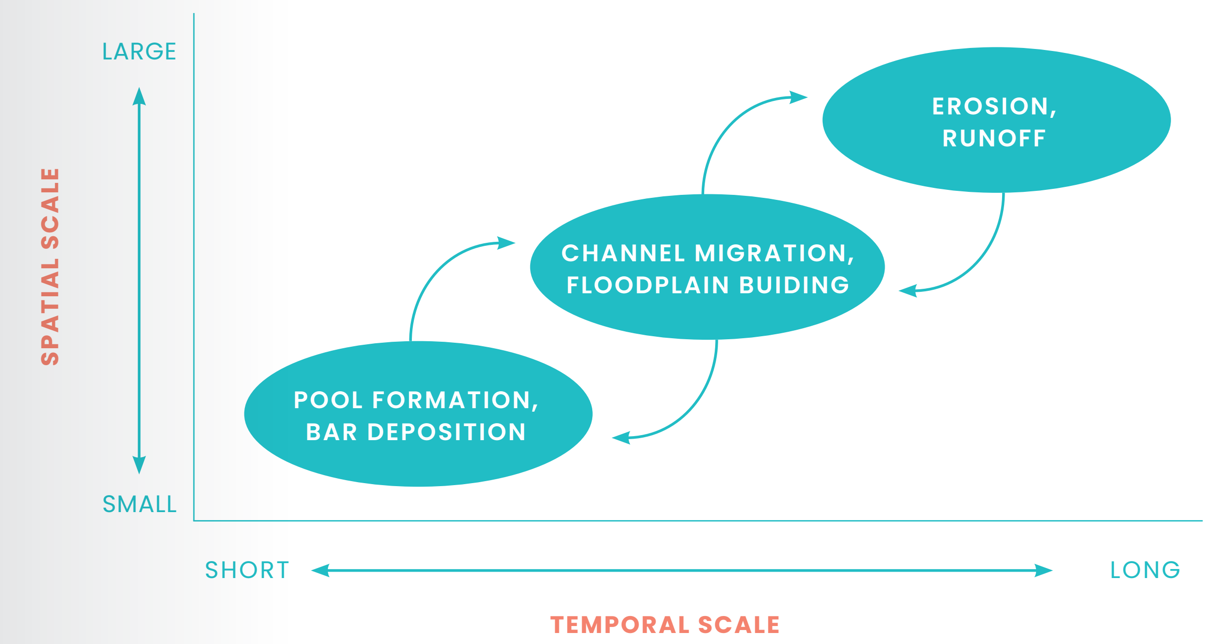


FIGURE 10. Watershed Processes Operate at a Variety of Space and Time Scales, with Processes Operating at Larger Spatial Scales and Influencing Processes Operating at Smaller Scales (Heavy Arrows). In this Case, Large-scale Erosion and Water Runoff Influence Channel Migration and Floodplain Formation at Medium-Spatial Scales, and Pool Formation and Bar Sediment Deposition at Fine-Scales. Source: Beechie et al. 2010

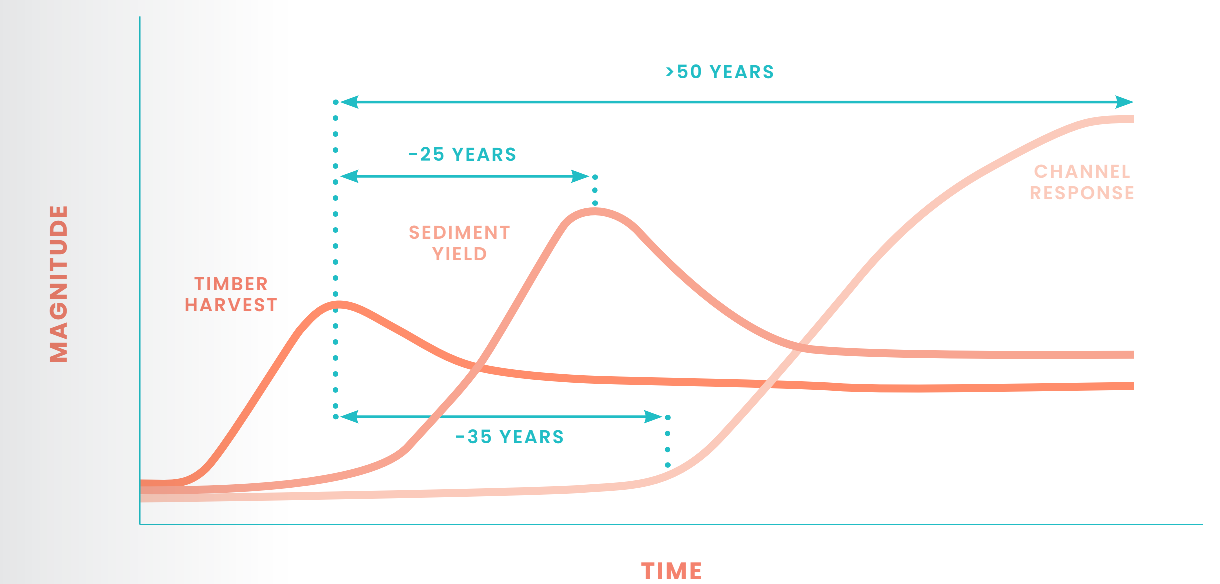


FIGURE 11. Conceptual Model of Trends of Sediment Yield in the Upper Grays River Channel Network and Channel Response over Time from Historical – Before Modern Forest Practices Rules – Timber Harvest and Forest Roads. Source: May and Geist 2006

PRIORITY RESTORATION WATERSHEDS AND REACHES

TABLE 5 outlines the geographic (subwatershed and reach) restoration priority areas. The restoration strategy's highest priority (1st-Tier Priority) is on restoring the watersheds with historically robust chum salmon spawning populations: Big Creek and Lewis and Clark River Watersheds and their associated estuarine habitats. The lower portions of these 1st-Tier watersheds supported chum spawners' largest concentration within the two Population Areas. Restoration actions in the Big Creek and Lewis and Clark emphasize active habitat restoration (e.g., restoring floodplain and off-channel habitats) in the lower watershed/estuary and process-based restoration (e.g., improving road drainage) in the upper portion of the watershed. Reach-specific habitat restoration and watershed process-based actions are equally important, and both activities will be implemented at the same time.

The second geographic priority (2nd-Tier Priority) includes other historically productive systems: key tributaries (e.g., Bear Creek) in the Big Creek Population Area and the Youngs and Klaskanine Rivers in the Young Bay Population Area. Restoration actions in 2nd-Tier watersheds emphasize adopting targeted actions as willing property owners become engaged with restoration projects and funding for work in the watershed is secured.

Gnat Creek, Skipanon River, and Wallooskee River, all of which had historically fewer spawning chum, are lower priority (3rd-Tier Priority) restoration areas for this effort. Restoration actions in 3rd-Tier priority watersheds will emphasize working opportunistically as willing property owners become engaged with restoration projects and funding for work in these watersheds is secured.

POP. AREA	WATERSHED/ PRIORITY	SUBWATERSHED AND REACH	NOTES / RESTORATION APPROACH
Big Creek	Big Creek /1st-Tier Priority (Higher Priority)	Estuary Transition (R1)	Most of the area is protected
		Lower (R2-4)	Key historical chum spawning area and habitat restoration
		Middle	Process-based restoration
		Upper	Process-based restoration
	Little Creek /2nd-Tier Priority		Targeted Opportunities: Process-based and habitat restoration
	Farris Creek /2nd-Tier Priority		Targeted Opportunities: Process-based and habitat restoration
	Bear Creek /2nd-Tier Priority		Targeted Opportunities: Process-based and habitat restoration
	Gnat Creek /3rd-Tier Priority (Lower Priority)		Targeted Opportunities: Process-based and habitat restoration
Youngs Bay	Lewis and Clark River /Highest Priority	Estuary Transition	Key historical spawning area: Habitat restoration in the estuary and lower ends of tributaries
		Lower (R1-5)	Key historical spawning area: Habitat restoration in the river and lower ends of tributaries
		Middle	Process-based restoration
		Upper	Process-based restoration
	Klaskanine River /2nd- Tier Priority		Targeted Opportunities: Process-based and habitat restoration
	Youngs River /2nd-Tier Priority		Targeted Opportunities: Process-based and habitat restoration
	Wallooskee River /3rd-Tier Priority		Targeted Opportunities: Process-based and habitat restoration
	Skipanon River /3rd-Tier Priority (Lower Priority)		Targeted Opportunities: Process-based and habitat restoration

TABLE 5. The Geographic (Subwatershed and Reach) Chum Restoration Priority Areas

EXAMPLE OF HABITAT AND PROCESS-BASED RESTORATION IN THE REDDS PROJECT AREA

This example for the Lewis and Clark River and Big Creek Watersheds illustrates the approach to reach-scale habitat restoration and watershed-scale process-based restoration in high priority watersheds. This example can be applied to all the watersheds within the Youngs Bay and Big Creek Chum Population Areas. The maps on the following pages show the Lewis and Clark River (Figure 12) and Big Creek (Figure 13) watersheds divided into functional subwatersheds: Upper, Middle, Lower, and Estuary Transition. The sections below characterize the subwatersheds and outline how natural watershed processes have been modified through land-use practices. Restoration strategies are outlined that address the modified habitat processes that contribute to the factors limiting the recovery of chum populations.

UPPER SUBWATERSHED: LAND USE FORESTRY

The Upper Lewis and Clark and Upper Big Creek subwatersheds are predominately managed by industrial forest practices with a landscape characterized by young forest stands, multi-aged clear-cuts, and an extensive road network. Past harvest activities, mainly harvest before the implementation of the mid- 1990s Oregon Forest Practice Riparian Rules, have resulted in fewer riparian trees, shifted the composition in many areas from conifers to hardwoods, and impacted associated riparian processes, including less shade over streams and reduced large wood delivery to stream channels. The current guidelines for protecting riparian habitat result in wider buffers of standing trees to streams. Timber companies are addressing limited riparian conifers by converting alder stands, for example, to conifer stands. Historical logging and other land use practices that included removing wood from streams and splash-dams with associated log drives down channels have dramatically reduced the quantity of large wood in stream channels. In some cases, limited trees on unstable slopes have increased the frequency and magnitude of landslides. Current forest practices have addressed many of these issues through expanded riparian buffers, leave trees on unstable slopes, and improved road management, but the historical legacy of past practices persists on the landscape.

Road networks for forest harvest can increase sediment in streams through episodic and chronic processes. Poorly maintained roads can increase the magnitude and frequency of episodic peak flood flows, landslides, and debris flows, all of which contribute sediment to stream channels (Jones et al. 2000). Poorly maintained roads can be associated with sediment generation from road surfaces (Grace 2002).

THREATS TO ECOSYSTEM PROCESSES

- Altered sediment regime, including fine sediment in streams from current and past practices
- Loss of historical riparian vegetation and minimal large wood in streams from past practices

PROCESS-BASED RESTORATION STRATEGY

- Assess road drainages for potential sediment delivery to streams
- Where issues are identified, improve road drainage and other actions (e.g., limiting hauling during extreme precipitation events) to reduce sediment
- Where identified, decommission unnecessary roads
- Explore expanding riparian buffers in sensitive portions of the stream network
- Continue to maintain road networks to avoid drainage issues and erosion
- Explore conservation easements, acquisition, and other measures in critical areas that protect habitat and watershed processes
- Where there are identified deficiencies in large wood, add large wood to channels to retain sediment and enhance habitat complexity

MIDDLE SUBWATERSHED: LAND USE FORESTRY

The middle subwatershed in both systems is characterized by a canyon that divides the upper watershed from the lower chum spawning reaches. Where the Lewis and Clark River and Big Creek flow through the steeper canyon gradients, small fish passage obstacles may limit chum migration into the upper watershed, but the precise fish passage status is unknown. Chum currently cannot pass above the Big Creek Hatchery. While chum may not utilize the middle subwatershed for spawning habitat, the confined channel rapidly transports sediment through the canyons and into the lower subwatersheds' channel system. Past harvest practices and potentially roads can contribute to sediment deposition in stream channels.

THREATS TO ECOSYSTEM PROCESSES

- Altered sediment regime, including fine sediment in streams from current and past practices
- Loss of historical riparian vegetation and minimal large wood in streams from past practices

PROCESS-BASED RESTORATION STRATEGY

- Assess road drainages for potential sediment delivery to streams
- Where issues are identified, improve road drainage and other actions (e.g., limiting hauling during extreme precipitation events) to reduce sediment
- Where identified, decommission unnecessary roads
- Explore expanding riparian buffers in sensitive portions of the stream network

Estuary Transition Subwatershed

Threats to Ecosystem Processes:

-Tidal floodplain disconnection
-Loss of riparian and floodplain habitat from land use conversion
-Altered sediment regime
-Loss of riparian vegetation and minimal large wood in tributary streams

Restoration Strategies:

-Promote tidal floodplain and wetland connectivity through dike breaching and other actions
-Enhance native riparian/floodplain vegetation
-Where issues are identified, improve road drainage to reduce sediment
-Where identified, put unnecessary roads to bed to reduce sediment
-Where there are deficiencies, add large wood to channels to retain sediment and enhance habitat complexity
-Explore conservation easements in key areas that protect watershed processes

Lower Subwatershed

Threats to Ecosystem Processes:

-Floodplain disconnection
-Loss of riparian and floodplain habitat from land use conversion
-Altered sediment regime
-Loss of riparian vegetation and minimal large wood in streams

Restoration Strategies:

-Assess the road network to identify areas for improvement
-Promote floodplain connectivity through dike breaching and other actions
-Enhance native riparian/floodplain vegetation
-Where issues are identified, Improve road drainage to reduce sediment
-Where identified, decommission unnecessary roads to reduce sediment
-Where there are deficiencies, add large wood to channels to improve habitat complexity
-Explore conservation easements in key areas that protect watershed processes

Middle Subwatershed

Threats to Ecosystem Processes:

-Altered sediment regime, including fine sediment in streams from current and past practices
-Loss of historical riparian vegetation and minimal large wood in streams from past practices

Restoration Strategies:

-Assess road drainages for potential sediment delivery to streams
-Where issues are identified, improve road drainage to reduce sediment
-Where identified, decommission unnecessary roads
-Explore expanding riparian buffers in sensitive portions of the stream network
-Continue to maintain road networks to avoid drainage issues and erosion
-Explore conservation easements and other measures in key areas that protect watershed processes
-Where there are identified deficiencies in large wood, add large wood to channels to retain sediment and enhance habitat complexity

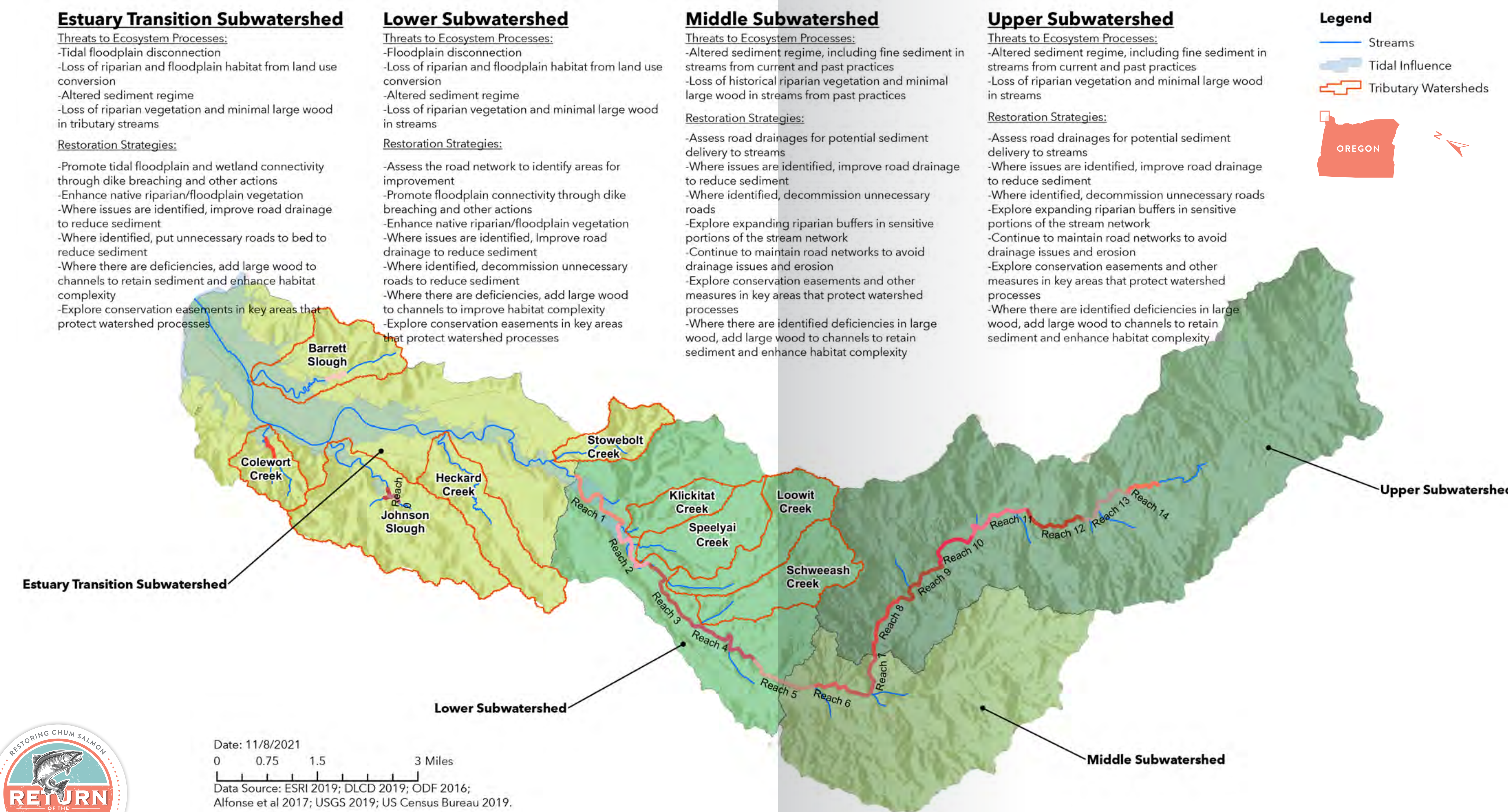
Upper Subwatershed

Threats to Ecosystem Processes:

-Altered sediment regime, including fine sediment in streams from current and past practices
-Loss of riparian vegetation and minimal large wood in streams

Restoration Strategies:

-Assess road drainages for potential sediment delivery to streams
-Where issues are identified, improve road drainage to reduce sediment
-Where identified, decommission unnecessary roads
-Explore expanding riparian buffers in sensitive portions of the stream network
-Continue to maintain road networks to avoid drainage issues and erosion
-Explore conservation easements and other measures in key areas that protect watershed processes
-Where there are identified deficiencies in large wood, add large wood to channels to retain sediment and enhance habitat complexity



LEWIS AND CLARK RIVER CHUM POPULATION AREA

FIGURE 12. Lewis and Clark River Chum Population Area: Threats to Ecosystem Processes and Examples of Restoration and other Activities to Improve Habitat and Watershed Processes

Estuary Transition Subwatershed

Threats to Ecosystem Processes:

-Tidal floodplain disconnection
-Loss of riparian and floodplain habitat from land use conversion
-Altered sediment regime
-Loss of riparian vegetation and minimal large wood in tributary streams

Restoration Strategies:

-Promote tidal floodplain and wetland connectivity through dike breaching and other actions
-Enhance native riparian/floodplain vegetation
-Where identified, improve road drainage to reduce sediment
-Where identified, put unnecessary roads to bed to reduce sediment
-Where there are deficiencies, add large wood to channels to retain sediment and enhance habitat complexity
-Explore conservation easements in key areas that protect watershed processes

Lower Subwatershed

Threats to Ecosystem Processes:

-Floodplain disconnection
-Loss of riparian and floodplain habitat from land use conversion
-Altered sediment regime
-Loss of riparian vegetation and minimal large wood in streams

Restoration Strategies:

-Assess the road network to identify areas for improvement
-Promote floodplain connectivity through dike breaching and other actions
-Enhance native riparian/floodplain vegetation
-Where issues are identified, improve road drainage to reduce sediment
-Where identified, decommission unnecessary roads to reduce sediment
-Where there are deficiencies, add large wood to channels to retain sediment and enhance habitat complexity
-Explore conservation easements and other measures in key areas that protect watershed processes

Middle Subwatershed

Threats to Ecosystem Processes:

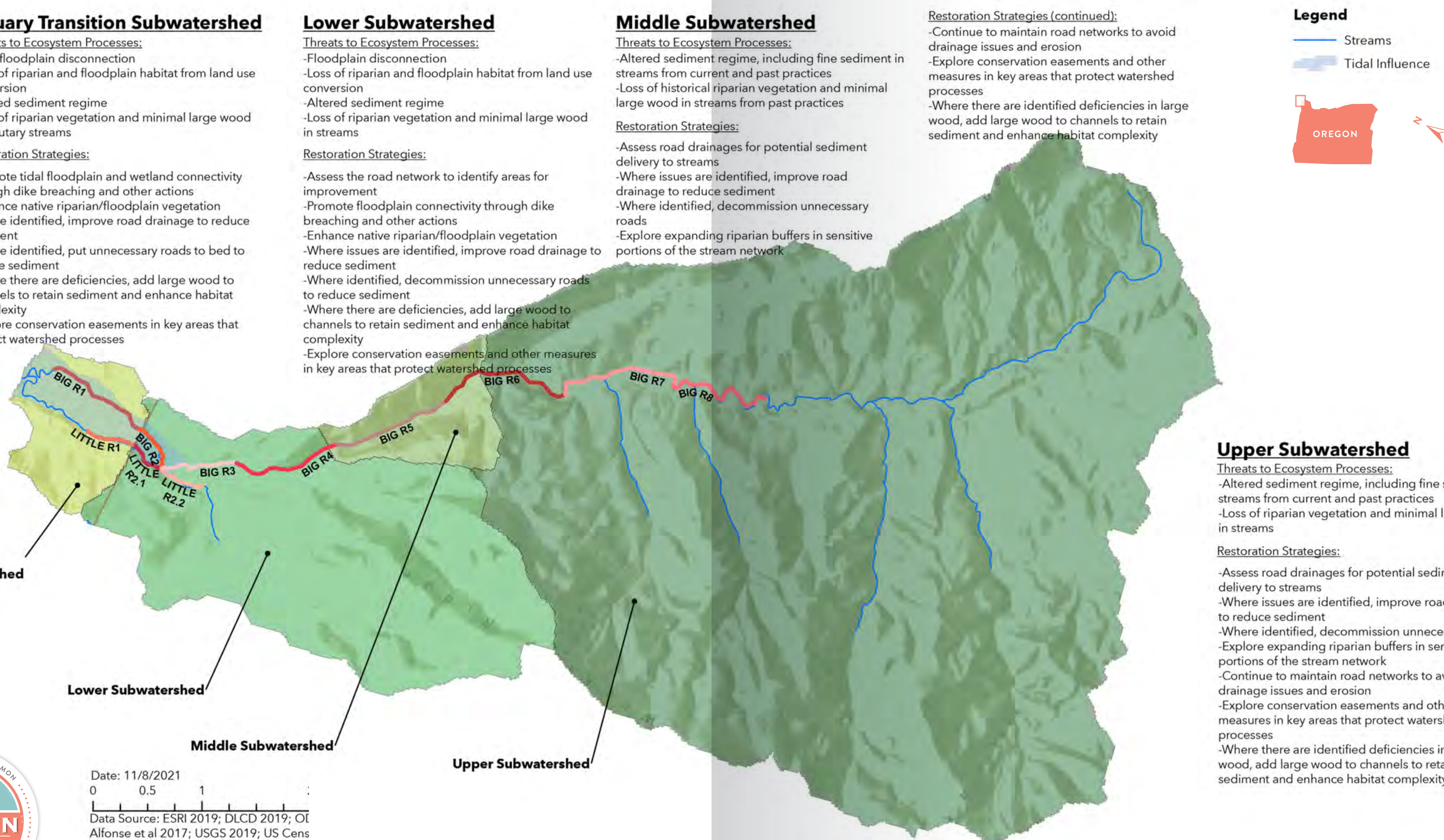
-Altered sediment regime, including fine sediment in streams from current and past practices
-Loss of historical riparian vegetation and minimal large wood in streams from past practices

Restoration Strategies:

-Assess road drainages for potential sediment delivery to streams
-Where issues are identified, improve road drainage to reduce sediment
-Where identified, decommission unnecessary roads
-Explore expanding riparian buffers in sensitive portions of the stream network

Restoration Strategies (continued):

-Continue to maintain road networks to avoid drainage issues and erosion
-Explore conservation easements and other measures in key areas that protect watershed processes
-Where there are identified deficiencies in large wood, add large wood to channels to retain sediment and enhance habitat complexity



Upper Subwatershed

Threats to Ecosystem Processes:

-Altered sediment regime, including fine sediment i streams from current and past practices
-Loss of riparian vegetation and minimal large wooc in streams

Restoration Strategies:

-Assess road drainages for potential sediment delivery to streams
-Where issues are identified, improve road drainage to reduce sediment
-Where identified, decommission unnecessary road
-Explore expanding riparian buffers in sensitive portions of the stream network
-Continue to maintain road networks to avoid drainage issues and erosion
-Explore conservation easements and other measures in key areas that protect watershed processes
-Where there are identified deficiencies in large wood, add large wood to channels to retain sediment and enhance habitat complexity

RESTORING CHUM SALMON · RETURN OF THE REDDS · RESTORING WATERSHEDS

BIG CREEK CHUM POPULATION AREA

FIGURE 13. Big Creek Chum Population Area: Threats to Ecosystem Processes and Examples of Restoration and other Activities to Improve Habitat and Watershed Processes

- Continue to maintain road networks to avoid drainage issues and erosion
- Explore conservation easements, acquisition, and other measures in critical areas that protect habitat and watershed processes
- Where there are identified deficiencies in large wood, add large wood to channels to retain sediment and enhance habitat complexity

LOWER SUBWATERSHED: LAND USE MIXED FORESTRY, AGRICULTURE, AND RURAL RESIDENTIAL

The lower Lewis and Clark and Big Creek subwatersheds are characterized by forested wetlands and lowland floodplains, some of which were cleared and converted to pasture and other agricultural activities. Dikes built to contain floods reduce or eliminate fish access to off-channel habitat. Unimproved dirt and gravel roads in forestry, farming, and rural residential areas can contribute to sediment in streams. Paved roads create impervious areas that accelerate runoff and contribute oils and other substances to the stream system. In addition to mainstem river restoration actions, there are opportunities to improve habitat in the tributary systems.

Tributaries entering the lower Lewis and Clark subwatershed include Klickitat Creek, Speelyai Creek, and Loowit Creek.

THREATS TO ECOSYSTEM PROCESSES

- Floodplain disconnection
- Loss of riparian and floodplain habitat from land use conversion
- Altered sediment regime
- Loss of riparian vegetation and minimal large wood in streams

HABITAT- AND PROCESS-BASED RESTORATION STRATEGIES

- Assess the road network to identify areas for improvement
- Promote floodplain connectivity through dike breaching and other actions
- Enhance native riparian/floodplain vegetation
- Where issues are identified, improve road drainage and other actions (e.g., limiting hauling during extreme precipitation events) to reduce sediment
- Where identified, decommission unnecessary roads to reduce sediment
- Where there are deficiencies, add large wood to channels to retain sediment and enhance habitat complexity
- Explore conservation easements, acquisition, and other measures in critical areas that protect habitat and watershed processes

ESTUARY TRANSITION SUBWATERSHED: MIXED AGRICULTURE, RURAL RESIDENTIAL, FORESTRY

In the estuary transition subwatershed, tidal influences shape the lower Lewis and Clark River in particular. Tidal wetlands and floodplains were cleared and converted to pasture. Dikes and tide gates that were built to contain flooding and improve pasture drainage have reduced or eliminated fish access to off-channel habitat. Unimproved dirt and gravel roads in forestry, farming, and rural residential areas contribute to sediment in streams and create fish passage barriers at road crossings. Tributary streams entering the lower Lewis and Clark estuary offer opportunities for restoration actions: Barrett Creek, Colewort Creek, Johnson Creek, and Heckard Creek.

THREATS TO ECOSYSTEM PROCESSES

- Tidal floodplain disconnection
- Loss of riparian and floodplain habitat from land-use conversion
- Altered sediment regime
- Loss of riparian vegetation and minimal large wood in tributary streams

HABITAT- AND PROCESS-BASED RESTORATION STRATEGIES

- Promote tidal floodplain and wetland connectivity through dike breaching and other actions
- Enhance native riparian/floodplain vegetation
- Where issues are identified, improve road drainage and other actions (e.g., limiting hauling during extreme precipitation events) to reduce sediment
- Where identified, put unnecessary roads to bed to reduce sediment
- Where there are deficiencies, add large wood to channels to retain sediment and enhance habitat complexity
- Explore conservation easements, acquisition and other measures in key areas that protect watershed processes

COMPLETED AND PLANNED RESTORATION ACTIONS

This section describes past and current land management and restoration actions implemented to address both current and legacy habitat impacts across the Big Creek and Youngs Bay Chum Population Areas. There has been substantial restoration work completed in the two Population Areas. RREDDs builds on these accomplishments to comprehensively restore key watersheds in support of chum and other salmon population recovery.

TIMBER INDUSTRY ACCOMPLISHMENTS

Private timber companies within the Big Creek and Youngs Bay Chum Population Areas manage legacy impacts from past timber harvest activities. As described above, stream habitat condition and function have been impacted as a result of excessive sediment deposition and other changed processes resulting from past upland activities. Historic practices such as splash dam construction, poor road building, and large wood removal from stream channels shifted drainage patterns and contributed to excessive sedimentation of instream habitat. Current state forest practices rules require best management practices designed to reduce sediment inputs and improve stream habitat through wider riparian buffers and other actions. In addition to applying sound forest practices, timber companies within the Big Creek and Lewis and Clark Chum Population Areas are using various strategies to mitigate legacy impacts and proactively address the impacts from the current harvest, road-building, and logging activities.

This section summarizes the range of forest management activities designed to minimize impacts to watershed processes and habitats.

HARVEST MANAGEMENT

STREAM BUFFERS: A buffer of trees and vegetation is left around fish bearing streams, rivers, lakes, and wetlands to create a natural sediment filter, provide stream shade, and to promote inputs of large trees to the stream channel over time. Under Oregon Forest Practices Rules, streamside buffers for fish-bearing streams range from 50 to 100 feet in width. The buffers along medium and large non-fish-bearing streams range from 20 to 70 feet in width, but no buffer is required for most smaller non-fish bearing streams.

EQUIPMENT USE: Modern logging systems have been improved to create a lighter touch on the landscape. Examples include machinery designed to reduce ground pressure and the increased use of vegetation mats, and other measures to prevent soil erosion.

TIMING OF ACTIVITIES: Road building and hauling on roads is limited during rain events.

ROAD PLANNING AND MAINTENANCE

SITE ASSESSMENT: Appropriate siting of the road to avoid stream crossings and riparian areas.

MAINTENANCE: Proper road surface drainage and maintenance to minimize sediment entrainment to streams and rivers.

REHABILITATION: Established guidelines for road repairs (i.e., side-cast failures, slope stability, adequate road surfacing).

DECOMMISSIONING: Roads that are no longer necessary are decommissioned, and native vegetation and natural drainage networks are restored. Decommissioning roads entails ripping the surface to restore natural drainage, removing culverts and ditches that direct water into streams, and planting native vegetation within the former road bed. Locally, the timber industry has replaced poor culverts with new culverts and bridges designed to pass high water events and fish. Greenwood Resources, for example, has replaced more than 100 culverts within RREDDs Area with improved structures designed to pass flood flows and juvenile and adult fish.

HARVEST PLANNING AND ASSESSMENT ACTIVITIES

SITE ASSESSMENT: Proper site assessment that includes potential stream impacts and landslide risk.

MAPPING SENSITIVE RESOURCES: Improved mapping techniques (i.e., LiDAR, GIS) to track broader watershed impacts.

MONITORING: On-going on-the-ground monitoring of existing road infrastructure to identify drainage issues and other problems.

COMPLETED AND PLANNED RESTORATION PROJECTS IN CHUM RESTORATION AREAS

NCWA, Columbia River Estuary Study Taskforce (CREST) Clatsop Soil and Water Conservation District (CSWCD), the National Park Service (NPS), timberland owners, and other organizations have completed restoration projects within the Big Creek and Youngs Bay Chum Population Areas. The restoration work has been diverse, including restoring tidal wetlands through dike breaching, fish passage improvements, riparian plantings, and other actions. The tables below show completed **(TABLE 6)** and planned restoration projects **(TABLE 7)**. The corresponding map shows the project locations **(FIGURE 14)**.

FIGURE 14. Completed and Planned Return of the Redds Restoration Projects

MAP #	COMPLETED PROJECT NAME	LOCATION	PROJECT TYPE	PARTNERS
1	Bickmore Riparian	Skipanon River	Riparian plantings	NCWA
2	Skipanon Floodplain Reconnection	Skipanon River	Floodplain enhancement	NCWA, CREST, OWEB
3	Perkins Creek	Skipanon River	Barrier removal	NCWA, CREST, USFWS
4	Skipanon River Dam Retrofit	Skipanon River	Tidegate retrofit	Clatsop SWCD, OWEB, NRCS, NCWA
5	Skipanon Watershed Improvement – Private Landowner	Skipanon River	Riparian fencing & planting, off-channel livestock watering	Clatsop SWCD, ODFW, OWEB, NRCS, Skipanon WSC
6	Skipanon River Riparian Planting	Upper Skipanon River	Riparian planting	Clatsop SWCD, OWEB
7	Otter Point Estuarine Restoration	Lewis & Clark, Estuary	Dike removal, tidal channel enhancement	NPS, CREST, BPA, USFWS
8	City of Seaside	Lewis & Clark, Estuary	Dike removal, tidal channel enhancement	City of Seaside, CREST, BPA
9	Vera Slough Tidegate Retrofit	Lewis & Clark, Estuary	Tidegate retrofit	Port of Astoria, CREST
10	Riparian Improvement project -Private Landowner	Lower Lewis & Clark	Riparian fencing and planting	Clatsop SWCD, OWEB, FWT
11	Lewis & Clark River Restoration -Private Landowner	Lower Lewis & Clark	Riparian planting, . large wood placement, streambank stabilization, off-channel alcoves	Clatsop SWCD, OEDD, USFWS
12	LCRR-Private Landowner	Lower Lewis & Clark	Riparian fencing & planting	Clatsop SWCD, USFWS
13	Riparian/Exclusion Fencing -Private Landowner	Lower Lewis & Clark	Riparian fencing & planting	Clatsop SWCD, OWEB
14	NRCS-WHIP -Private landowner	Lower Lewis & Clark	LW placement, bank shaping, riparian planting	Clatsop SWCD, NRCS-WHIP, OWEB, Longview Fiber Co.
15	Lewis & Clark Wetland -Private Landowner	Lower Lewis & Clark	Riparian enhancement and debris removal	Clatsop SWCD, OWEB
16	Riparian/Exclusion Fencing -Private Landowner	Lower Lewis & Clark	Riparian fencing & planting	Clatsop SWCD, USFW
17	Riparian Planting -Private Landowner	Youngs River/ Tucker Creek	Riparian planting	Clatsop SWCD, OWEB, BLM, Job Corps
18	Youngs Walllooskee	Youngs/ Wallooskee Rivers	Tidegate & dike removal, tidal channel enhancement	Cowlitz Tribe, BPA, USFWS
19	Wallooskee North	Wallooskee River	Levee removal, large wood	CLT, BPA

20	Wallooskee Headwaters Restoration Fish Passage/ Large Wood Placement	Wallooskee River	Fish barrier removal, large wood placement	NCWA
22	Haven Island	Youngs River, Estuary	Levee removal	CLT, BPA, USFWS
23	Fee-Simon Wetland Enhancement	Youngs River, Estuary	Dike removal, tidal channel enhancement	CREST, BPA, OWEB, USFWS, NRCS
24	South Fork Klaskanine Fish Passage	Youngs/ Klaskanine Rivers	Dam removal, fish screen, channel enhancement	NRCS, USFW, Clatsop SWCD, CREST, CEDC, C. County, OWEB, NOAA
25	Klaskanine River Watershed Restoration	Youngs/ Klaskanine Rivers	Riparian fencing and planting, off-channel livestock watering	Clatsop SWCD, OEDD
26	North Fork Klaskanine	Youngs/Klaskanine	Riparian plantings, dam removal	ODFW, USFWS
27	Youngs River Fencing	Youngs River	Riparian fencing and planting, off-channel livestock watering	Clatsop SWCD, OWEB
28	Mill Creek	Mill Creek	Barrier removal, channel enhancement	ODOT
29	Mill Creek Road Decommission	Mill Creek	Road decommission, culvert removal	NCWA, NOAA
30	Mary-Ferris Tidal Enhancement	Mary-Ferris Creek	Levee removal, tidal channel enhancement	CREST, BPA
31	Big Creek County Park	Lower Big Creek	Riparian plantings	CREST, Clatsop County
32	Blackberry Bog	Bear Creek	Riparian plantings	Clatsop SWCD, NCWA, ODA
33	Bear Creek Fencing & Riparian Planting -Private Landowner	Bear Creek	Riparian fencing and planting	Clatsop SWCD, OWEB
39	Colewort Creek Tidal	Lower Lewis & Clark River	Tidegate removal, tidal channel enhancement, native plantings	NPS, CREST, BPA, NOAA, USFWS, TNC, LCEP
40	Culvert Removal -Private Timber	Upper Lewis & Clark	Culvert removal	Greenwood Resources
42	Mabel Creek Road Decommission	Upper Youngs River	Road crossing decommission, channel enhancement, large wood placement, riparian plantings	Campbell group, NWCA, USFWS
43	Gnat Creek Tidal	Gnat Creek/ Blind Slough	Levee removal, large wood placement	CREST, USFWS, BPA
44	Gnat Creek Fluvial	Gnat Creek/ Blind Slough	Small dam removal	CREST, ODF, BPA
46	Instream Habitat	South Fork Klaskanine	Large wood placement	Greenwood Resources
47	Culvert Removal	Marys Creek	Barrier removal	Greenwood Resources

TABLE 6. Completed RREDDS Restoration Projects (2001 - 2019)

MAP #	PLANNED PROJECT NAME	LOCATION	PROJECT TYPE	PARTNERS
34	Bear Creek Riparian Planting	Bear Creek	Riparian Planting	Clatsop SWCD
35	East Netul Landing	Lewis & Clark, Estuary	Dike removal, tidal channel enhancement	NPS, CREST, BPA
36	Lewis & Clark Planting	Lower Lewis & Clark River	Riparian Planting	Clatsop SWCD, OWEB
37	North Fork Klaskanine Hatchery Passage	Youngs River/ Klaskanine	Fish passage, roughened channel, riparian planting	ODFW, USFWS, NCWA
38	Hwy 202 Crossel Creek Fish Passage	Youngs Bay	Tidegate retrofit	ODOT
41	Upper Big Creek Camp 7 Riparian Restoration & Bridge Removal	Upper Big Creek	Riparian Restoration, Road Decommissioning	Hampton Lumber
45	Tongue Point Preservation /Restoration	Columbia River Estuary	Habitat protection, enhancement	CLT, USFWS, others

TABLE 7. Planned RREDDS Restoration Projects (as of January 2021)

RESTORATION OUTPUTS, ECOLOGICAL OUTCOMES, AND GOALS

As described in the previous section, a number of restoration actions have been completed within the Big Creek and Youngs Bay Chum Population areas. While these diverse restoration activities have improved stream, floodplain, and riparian habitats, there is much more to do. Recovering chum populations and watershed health will require restoration actions across the landscape implemented over decades. The strategy of short-term, reach-specific actions will yield rapid habitat responses in key chum spawning and rearing reaches from activities such as adding large wood to capture spawning gravels to improving access to tidal wetlands. The strategy of restoring watershed process will require more time to see responses in habitat quality as riparian areas, sediment levels, and other processes recover from more than a century of landscape alterations.

Over time, restoration outputs lead to ecological outcomes. For example, restoring native riparian vegetation helps provide shade that cools streams, while large wood inputs into channels will shape habitats over time. And activities that enhance fish access to side-channels, tidal-wetlands, and other off-channel habitats will have multiple ecological outcomes, including:

- restoring fish access to off-channel areas where juvenile chum and other salmon species can feed and escape high flows;
- enabling natural channel movement and habitat creation;
- promoting increased sediment deposition in the floodplain and lessening sediment deposition in spawning areas; and
- improving fresh-water and estuary food web connections and productivity.

Return of the Redds Action Plan also has social outcomes that result from engaging stakeholders and property owners in voluntary restoration actions – fostering community understanding, support, and engagement in the recovery of chum populations.

The goal for RREDDs builds on the partners vision, which focuses on restoring ecological conditions and promoting social outcomes: **"Healthy streams and rivers, thriving chum and other fish populations, and residents who are informed about chum and enthusiastic about participating in voluntary habitat restoration actions."**

RETURN OF THE REDDS GOAL:

Recover self-sustaining Big Creek and Youngs Bay chum populations through comprehensive restoration actions and an engaged community of property owners and stakeholders participating in voluntary restoration.

RREDDs goal incorporates the LCR Plan's broad-sense goals for recovery of chum populations. To achieve benefits for salmon populations and current and future generations of people, the goal of the LCR Plan is more significant than restoring ESA-listed Lower Columbia River salmon, including chum, to the point where their protection under the ESA is no longer needed – the goal also states that restoration actions will exceed ESA recovery objectives and a range of societal benefits will be met (ODFW 2010):

Oregon populations of naturally produced salmon and steelhead are sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) so that the ESU as a whole (a) will be self-sustaining, and (b) will provide significant ecological, cultural, and economic benefits.

Recently, a group with representation from agencies, environmental groups, and commercial interests was convened by NOAA Fisheries' Marine Fisheries Advisory Committee to develop a vision and goals to restore thriving salmon and steelhead to the Columbia River Basin (Columbia Basin Partnership Task Force 2020). The group's vision includes chum **(SEE SIDEBAR)**. The Columbia River Basin Partnership Task Force's vision complements and expands on the LCR Plan's broad-sense goals to recover chum populations. RREDDs overarching goal for chum recovery incorporates the LCR Plan's broad-sense goals and the Columbia Basin Partnership's vision.

It is important to note that for LCR Plan framework and Return of the Redds, implementation of restoration projects is likely to result, first, in chum populations that can be removed from their protected status under the ESA, and second, a broad range of benefits for citizens of the region over time (ODFW 2010).

TABLE 8 shows the LCR Plan restoration outputs necessary to achieve broad-sense recovery for Big Creek and Youngs Bay salmon populations (ODFW 2010).

A VISION FOR LOWER COLUMBIA RIVER CHUM POPULATIONS

A healthy Lower Columbia River chum population that is "abundant, productive, widely distributed, diverse, and resilient to environmental perturbations including climate change; can sustain significant levels of harvest; and support a full range of ecological benefits including the needs of dependent species. Generally, healthy refers to a point substantially above ESA delisting on the spectrum from threatened/endangered to extremely low extinction risk." (Columbia Basin Partnership Task Force 2020)

The restoration outputs are based on assessments of ecological outcomes essential to achieve broad-sense recovery of coho salmon, Chinook salmon, and steelhead. Chum were not included in the habitat assessments because there was little information during the LCR Plan's development on the factors limiting chum populations[1].

The RREDDs partners are adopting the LCR Plan restoration outputs for the Big Creek and Youngs Bay systems as a marker of the habitat improvements necessary to comprehensively restore watershed health for all salmon and steelhead species, including chum. As the table shows, there has already been substantial progress (though 2019) in meeting the restoration outputs for large wood placement, off-channel enhancements, side-channel creation, and riparian planting. The RREDDs partners intend to complete the Big Creek and Youngs Bay Chum Population Areas' habitat outcomes by the end of RREDDs' lifespan, 2031.

The Columbia Basin Partnership Task Force's vision guides chum population goals to meet the broad recovery vision. **TABLE 9** shows the recent and historical abundance and the potential cumulative recovery goal range for the numbers of chum adults returning to the four Oregon Population Areas (Columbia Basin Partnership Task Force 2020).

[1] Table 8 restoration outputs are based on ODFW's threat scenario analysis for Columbia River salmon and steelhead populations – with the exception of chum populations. This scenario analysis was thought to be a path to reduce the tributary habitat mortality rate to be commensurate with a threat reduction needed for tributary habitat to achieve a broad sense goal. This was only one of six general threats modeled and simply achieving the habitat restoration targets in Table 8 will not necessarily achieve broad sense recovery of Columbia River chum (Jim Brick, ODFW, Pers. Comm. 2021).

POPULATION	FISH BARRIERS ADDRESSED (#)	LARGE WOOD PLACEMENT (MI)[1]	FLOODPLAIN/ OFF-CHANNEL ENHANCEMENT (ACRES)	SIDE-CHANNEL CREATION (MI)	RIPARIAN PLANTING (MI)[2]
RESTORATION OUTPUTS FOR BROAD SENSE RECOVERY					
Youngs Bay	NA	46	1.3	0	19
Big Creek	NA	58	5.1	5	19
ACCOMPLISHMENTS (THROUGH 2019)					
Youngs Bay	4	3.01	0.1	0.75	2.27
Big Creek	4	0.75	2.1	0.42	2.15

TABLE 8. LCR Plan Restoration Outputs Necessary to Achieve Broad-Sense Recovery and Accomplishments through 2019 for Big Creek and Youngs Bay Salmon Populations
NOTES: 1. Large wood placement volume – 706 ft.3 (20 m3) of large wood per 328 ft. (100 m) of stream channel
2. Riparian Planting 98 ft. (30 m) width on each side of the stream channel

OREGON LOWER COLUMBIA RIVER POPULATION AREA	ABUNDANCE		POTENTIAL RECOVERY GOAL RANGE (CUMULATIVE FOR THE FOUR POPULATION AREAS)		
	RECENT	HISTORICAL	LOW	MEDIUM	HIGH
Youngs Bay	15	9,000	2,500	5,000	7,500
Big Creek	299	5,000			
Clatskanie	3	6,000			
Scappoose	0	500			

TABLE 9. Recent and Historical Abundance and the Potential Cumulative Recovery Goal Range for the Numbers of Chum Adults Returning to the Four Oregon Population Areas (Columbia Basin Partnership Task Force 2020)

STRATEGIES, ACTIONS, AND OBJECTIVES

PRIORITY 1: INFORM AND ENGAGE PROPERTY OWNERS AND OTHER STAKEHOLDERS

STRATEGIES:

- Reach out to residents, property owners, and other stakeholders to provide information on the value of chum salmon, the importance of the Youngs Bay and Big Creek chum populations, factors leading to population declines, and Return of the Redds vision and restoration strategies
- Reach out to property owners adjacent to lower Big Creek, provide information about chum and restoration opportunities, provide information on the local reach assessment, and engage them in exploring opportunities for restoration actions
- Reach out to property owners adjacent to lower Lewis and Clark River, provide information about chum and restoration opportunities, provide information on the local reach assessment, and engage them in exploring opportunities for restoration actions
- Develop restoration projects with supportive property owners adjacent to lower Big Creek and lower Lewis and Clark River
- Periodically update residents, agricultural producers, business owners, and other stakeholders on Youngs Bay and Big Creek chum population status, habitat restoration actions, and accomplishments

ACTIONS AND OBJECTIVES:

ACTION: Develop and circulate stakeholder engagement and outreach materials for broad and specific audiences

1.1 OBJECTIVE: Develop and deliver a 2-page summary designed for general audiences describing chum populations, recent chum spawning information, and the restoration strategy
MEASURES: Outreach summary completed and updated annually; and a count of outreach materials delivered to various audiences

1.2 OBJECTIVE: Develop a chum project webpage on the NCWA website
MEASURE: Webpage developed and periodically updated

1.3 OBJECTIVE: Develop and maintain chum project social media presence
MEASURE: Social media presence developed and frequently updated

1.4 OBJECTIVE: Develop and give a presentation describing chum populations, the restoration strategy, and restoration actions
MEASURE: At least one presentation delivered per year

Action: Engage lower Big Creek and lower Lewis and Clark River property owners in the river-reach assessment process and restoration actions

1.5 OBJECTIVE: Develop and deliver an introductory letter and landowner interest survey to property owners adjacent to lower Big Creek
MEASURE: The number of property owners responding to the letter and survey

1.6 OBJECTIVE: Develop and deliver an introductory letter and landowner interest survey to property owners adjacent to the lower Lewis and Clark River
MEASURE: The number of property owners responding to the letter and survey

1.7 OBJECTIVE: Engage lower Big Creek landowners to understand the history of their property, explore restoration opportunities, and share information at each stage of the assessment
MEASURE: Percent of property owners along the lower Big Creek study reach engaged in the assessment

1.8 OBJECTIVE: Engage lower Lewis and Clark River landowners to understand the history of their property, explore restoration opportunities, and share information at each stage of the assessment
MEASURE: Percent of property owners along the Lower Lewis and Clark River study reach engaged in the assessment

1.9 OBJECTIVE: Enroll supportive lower Big Creek landowners in restoration actions identified in the assessment
MEASURE: Percent of property owners along the lower Big Creek study reach engaged in restoration projects identified in the assessment

1.10OBJECTIVE: Enroll supportive lower Lewis and Clark River landowners in restoration actions identified in the assessment
MEASURE: Percent of property owners along the lower Lewis and Clark River study reach engaged in restoration projects identified in the assessment

PRIORITY 2: ADDRESS INFORMATION NEEDS AND DATA GAPS

STRATEGIES:

- Conduct Reach Assessments: In collaboration with property owners, evaluate habitats and geomorphic conditions and trends to identify restoration projects to improve key chum spawning and rearing reaches in the lower Big Creek and Lewis and Clark River systems
- In collaboration with timber companies and other property owners, comprehensively assess sediment sources and identify mitigation measures to reduce sediment delivery to stream channels
- Identify and map priority reaches, tributaries, and upland areas for conservation easements or acquisitions

ACTIONS AND OBJECTIVES:

ACTION: Complete geomorphic assessment to evaluate the watershed, channel, and floodplain processes in Lower Big Creek, engage property owners, and identify floodplain connectivity and other projects

2.1 OBJECTIVE: Engage property owners to understand issues and to share information at each stage of the assessment
MEASURES: Percent of property owners along the study reach engaged in the study

2.2 OBJECTIVE: Complete technically sound geomorphic assessment to set the stage for detailed restoration designs
MEASURES: Technical products accepted by NCWA and The RREDDs partners

2.3 OBJECTIVE: Restoration project areas and restoration actions identified
MEASURES: Floodplain or side-channel area (acres) proposed for reconnection; volume (ft3), channel length, and number of pieces per mile of large wood proposed for placement; area (acres) and channel length of proposed invasive plant removal; proposed native vegetation planting area (acres) and channel length

2.4 OBJECTIVE: Property owners support implementing projects on their property Measure: Number of property owners supportive of projects on their property
ACTION: Complete geomorphic assessment to evaluate the watershed, channel, and floodplain processes in Lower Lewis and Clark system, engage property owners, and identify floodplain connectivity and other projects

2.5 OBJECTIVE: Engage property owners to understand issues and to share information at each stage of the assessment
MEASURES: Percent of property owners along the study reach engaged in the study

2.6 OBJECTIVE: Complete technically sound geomorphic assessment to set the stage for detailed restoration designs
MEASURES: Technical products accepted by NCWA and The RREDDs partners

2.7 OBJECTIVE: Restoration project areas and restoration actions identified
MEASURES: Floodplain or side-channel area (acres) proposed for reconnection; volume (ft3), channel length, and number of pieces per mile of large wood proposed for placement; area (acres) and channel length of proposed invasive plant removal; proposed native vegetation planting area (acres) and channel length

2.8 OBJECTIVE: Property owners support implementing projects on their property
MEASURES: Number of property owners supportive of projects on their property
ACTION: In collaboration with timber companies and other property owners, comprehensively assess sediment sources and identify mitigation measures to reduce sediment delivery to stream channels

2.9 OBJECTIVE: Engage property owners to understand issues and to share information at each stage of the sediment source assessment
MEASURES: Percent of property owners along the study reach engaged in the study

2.10 OBJECTIVE: Complete technically sound sediment source assessment to set the stage for detailed mitigation approaches
MEASURES: Technical products accepted by NCWA and The RREDDs partners

2.11 OBJECTIVE: Sediment source areas identified and mitigation actions identified
MEASURES: Sediment source areas and mitigation actions (e.g., improving road drainage) identified

2.12 OBJECTIVE: Property owners support implementing projects on their property
MEASURES: Number of property owners supportive of the assessment and sediment mitigation measures on their property
ACTION: Identify, map, and describe priority reaches, tributaries, and upland areas for conservation easements or acquisitions

2.13 OBJECTIVE: Engage property owners to understand issues and to share information at each stage of the conservation area assessment
MEASURES: Number of property owners in the area engaged in the assessment

2.14 OBJECTIVE: Complete technically sound conservation area assessment to set the stage for detailed mitigation approaches
MEASURES: Technical products accepted by NCWA and The RREDDs partners

2.15 OBJECTIVE: Conservation areas identified
MEASURES: Priority conservation areas are identified and described

2.16 OBJECTIVE: Property owners support implementing conservation measures on their property
MEASURES: Number of property owners supportive of conservation measures on their property

PRIORITY 3: RESTORE HISTORICALLY PRODUCTIVE CHUM SPAWNING AREAS AND REARING HABITAT IN LOWER BIG CREEK SUBWATERSHEDS AND LOWER LEWIS AND CLARK SUBWATERSHEDS

STRATEGIES:

- Promote floodplain connectivity through dike breaching, side-channel reconnection, and other actions
- Enhance channel function and habitats
- Enhance native riparian and floodplain vegetation
- Improve road drainage to reduce sediment
- Add large wood to retain sediment and enhance habitat complexity
- Explore conservation easements and other measures to protect habitat and watershed processes in key areas

ACTIONS AND OBJECTIVES:

ACTION: Implement lower Big Creek mainstem, floodplain/side-channel connectivity, and complexity projects

3.1 OBJECTIVE: Floodplain and side-channel connectivity and complexity improved
MEASURES: Floodplain and/or side-channel area (acres) reconnected; volume (ft3), channel length, and number of pieces per mile of large wood placed within side channels, off-channel habitat, and floodplain areas

3.2 OBJECTIVE: Mainstem spawning and rearing habitat improved
MEASURES: Spawning area substrate area with less than 8% fines; floodplain and/or side-channel area (acres) reconnected; volume (ft3), channel length, and number of pieces per mile of large wood placed; access to off-channel wetland habitats (acres)

3.3 OBJECTIVE: Floodplain and riparian vegetation enhanced
MEASURES: Floodplain and riparian invasive plant removal (acres) and channel length completed, native vegetation planting area (acres) and channel length completed

3.4 OBJECTIVE: Property owners successfully implement restoration on their properties
MEASURES: The number of property owners completing projects on their property
Action: Implement Lower Lewis and Clark system mainstem, floodplain/side-channel connectivity, and complexity projects

3.5 OBJECTIVE: Floodplain and side-channel connectivity and complexity improved
MEASURES: Floodplain and/or side-channel area (acres) reconnected; volume (ft3), channel length, and number of pieces per mile of large wood proposed for placement in side channels, off-channel habitat, and floodplain areas

3.6 OBJECTIVE: Mainstem spawning and rearing habitat improved
MEASURES: Spawning area substrate area with less than 8% fines; floodplain and/or side-channel area (acres) reconnected; volume (ft3), channel length, and number of pieces per mile of large wood placed; access to off-channel wetland habitats (acres)

3.7 OBJECTIVE: Floodplain and riparian vegetation enhanced
MEASURES: Floodplain and riparian invasive plant removal (acres) and channel length completed, native vegetation planting area (acres) and channel length completed

3.8 OBJECTIVE: Property owners successfully implement restoration on their properties
MEASURES: The number of property owners completing projects on their property
Action: Conservation easements, acquisition, or other conservation measures implemented in lower Big Creek or Lewis and Clark areas that protect vital habitats and watershed processes

3.9 OBJECTIVE: Conservation easement, acquisition, or other conservation measures implemented
MEASURES: Conservation measures implemented (acres) and types of habitats and watershed process protected

3.10 OBJECTIVE: Property owners successfully implementing conservation measures

MEASURES: The number of property owners implementing conservation measures on their property

PRIORITY 4: RESTORE WATERSHED PROCESSES IN UPPER BIG CREEK AND UPPER LEWIS AND CLARK SUBWATERSHEDS

STRATEGIES:

- Implement sediment mitigation measures identified in the sediment source assessment
- Where issues are identified, improve road drainage and other actions (e.g., limiting hauling during extreme precipitation events) to reduce sediment
- Where identified, put unnecessary roads to bed to reduce sediment
- Where there are deficiencies, add large wood to channels to retain sediment and enhance habitat complexity
- Implement conservation easements or other conservation measures in key areas that protect watershed processes

ACTIONS AND OBJECTIVES:

ACTION: Improve road drainage to reduce sediment

4.1 OBJECTIVE: Property owners successfully implementing road drainage improvements on their properties

MEASURES: Roads decommissioned (miles) or road sediment reduction Best Management Practices (BMPs) applied (type of BMP and area where applied)

Action: Where there are deficiencies, add large wood to channels to retain sediment and enhance habitat complexity

4.2 OBJECTIVE: Large wood placed

MEASURES: Volume (ft3), channel length, and number of pieces per mile of large wood placed in channels, side channels, off-channel habitat, and floodplain areas

4.3 OBJECTIVE: Property owners successfully implementing large wood placement projects

MEASURES: The number of property owners and area treated

ACTION: Conservation easements, acquisition or other conservation measures implemented in key areas that protect watershed processes

4.4 OBJECTIVE: Conservation easement, acquisition or other conservation measures implemented

MEASURES: Conservation measures implemented (acres) and types of habitats and watershed process protected

4.5 OBJECTIVE: Property owners successfully implementing conservation measures

MEASURES: The number of property owners implementing conservation measures on their property

PRIORITY 5: RESTORE OTHER YOUNGS BAY AND BIG CREEK POPULATION WATERSHEDS WITH CHUM RESTORATION POTENTIAL

STRATEGIES:

- Emphasize targeted projects with property owners in the Big Creek Population Area tributaries with an emphasis on Little Creek, Farris Creek, and Bear Creek
- Emphasize targeted projects with property owners in the Youngs Population Area rivers and tributaries with a focus on Klaskanine River and Youngs River systems
- Promote floodplain connectivity through dike breaching, side-channel reconnection, and other actions
- Enhance channel function and habitats
- Enhance native riparian and floodplain vegetation
- Improve road drainage to reduce sediment
- Add large wood to retain sediment and enhance habitat complexity

ACTIONS AND OBJECTIVES:

ACTION: Implement tributary, floodplain/side-channel connectivity, and complexity projects in Big Creek and Youngs Bay Watersheds with Chum Restoration Potential

5.1 OBJECTIVE: Floodplain and side-channel connectivity and complexity improved

MEASURES: Floodplain and/or side-channel area (acres) reconnected; volume (ft3), channel length, and number of pieces per mile of large wood placed within side channels, off-channel habitat, and floodplain areas

5.2 OBJECTIVE: Spawning and rearing habitat improved

MEASURES: Spawning area substrate area with less than 8% fines; floodplain and/or side-channel area (acres) reconnected; volume (ft3), channel length, and number of pieces per mile of large wood placed; access to off-channel wetland habitats (acres)

5.3 OBJECTIVE: Floodplain and riparian vegetation enhanced
MEASURES: Floodplain and riparian invasive plant removal (acres) and channel length completed, native vegetation planting area (acres) and channel length completed

5.4 OBJECTIVE: : Property owners successfully implement restoration on their properties
MEASURES: The number of property owners completing projects on their property

PRIORITY 6: DOCUMENT ACTIONS, MONITOR EFFECTIVENESS, AND COMMUNICATE PROGRESS

STRATEGIES:

- Document restoration project outputs: Large wood placed, side channels reconnected, etc.
- Evaluate ecological outcomes with post-project habitat inventories to document changes in habitat benchmarks
- Annually report on projects implemented and monitoring findings

ACTIONS AND OBJECTIVES:

ACTION: Document restoration project outputs

6.1 OBJECTIVE: Annual report completed that describes restoration projects and outputs
MEASURES: Annual documentation showing key restoration outputs: floodplain or side-channel area (acres) reconnected, volume (ft3) and number of pieces of large wood placed in the side channels, off-channel habitats, and floodplain areas, etc. (See next section for metrics.)
ACTION: Evaluate ecological outcomes with post-project habitat inventories to document changes in habitat benchmarks

6.2 OBJECTIVE: Annual report completed that describes restoration projects and outputs
MEASURES: Annual reporting on the number of projects where post-project aquatic inventories are completed and documentation of the evaluated habitat benchmarks (e.g., post-project riffle fine sediments)

MONITORING AND EVALUATION

TABLE 10 outlines the metrics to document habitat restoration outputs. Restoration project success and overall habitat response will be evaluated with these metrics combined with post-project monitoring to demonstrate the achievement of habitat benchmarks for implemented restoration projects.

RESTORATION OUTPUTS PERFORMANCE MEASURES	UNITS	DESCRIPTION
Large Wood Placement	linear ft./miles/ft^3	Length of stream with large wood placement, categorized by: 1) placement location: in-channel (at or below OHW) or floodplain (above OHW); and 2) number and volume (ft.3) of key and other pieces per 328 ft. (100 m)
Off-Channel Wetland Area Increase	sq ft./acres	Area of off-Channel Wetland Increase
Riparian/Floodplain Habitat Protected	Acres	Area of riparian or floodplain habitat protect-ed through a conservation easement, acquisi-tion, or other actions in acres
Riparian/Floodplain Invasive Species Removal Area	Acres	Area of riparian/floodplain invasive species removal area covered
Riparian/Floodplain Invasive Species Removal Length	linear ft./miles	Length of riparian/floodplain invasive species removal along the channel
Riparian/Floodplain Native Planting Area	Acres	Area of riparian/floodplain native plantings
Riparian/Floodplain Native Planting Channel Length	linear ft./miles	Length of riparian/floodplain native planting
Roads Decommissioned or BMPs Applied to Reduce Sedimentation and Improve Hydrology	Miles	Length of roads decommissioned to a natural state. BMPs applied (e.g., add culverts), list BMPs
Side Channel Habitat Increase	linear ft./miles	Length of side-channel created or reconnected in linear feet
Stream Habitat Accessible	linear ft./miles	Length of stream channel habitat made accessible to fish species by barrier removal

TABLE 10. Restoration Outputs and Performance Measures

ODFW will continue to assess spawning chum numbers and location within the Big Creek and Youngs Bay Population Areas in addition to The RREDDs partners monitoring habitat improvements. While the number of returning chum are subject to factors out of control of The RREDDs partners (e.g., ocean conditions), assessing chum return will continue to be an essential metric for evaluating chum population recovery over the long- term. Documenting trends in habitat conditions over short- and long-term time scales, combined with assessing spawning fish trends, will help evaluate Return of the Redds efforts' success.

RESTORATION PROJECT PHASING

Table 11 outlines the restoration outputs estimated to be necessary for broad-sense recovery. The output goals incorporate past restoration accomplishments. RREDDs goals are ambitious. The table describes what is needed annually to achieve these goals over the 10-year lifespan of RREDDs. For example, the large wood placement goal: 43 miles in the Youngs Bay Population Area and more than 57 miles in the Big Creek Population Area. To achieve these goals by 2031 requires completing 4.3 and 5.7 miles of large wood placement annually in the Youngs Bay and Big Creek Population Areas, respectively.

Achieving the restoration outputs outlined below will support the comprehensive restoration of habitat and watershed process. This effort will benefit chum populations while also meeting the goals for broad-sense recovery of steelhead, coho and Chinook salmon populations.

Achieving RREDDs' ambitious goals by 2031 will require close coordination and cooperation of The RREDDs partners organizations in order to identify, sequence, and implement projects. A key consideration for the timing of the projects is engaging property landowners to implement voluntary restoration on their lands. Engaging property owners, particularly in the Big Creek and Lewis and Clark River emphasis areas, will take time. Geomorphic assessments in the lower portions of these systems where chum historically spawned are necessary to understand channel dynamics, evaluate risks and benefits, assess habitat restoration approaches, and identify projects with willing landowners. In addition, evaluating sediment sources will be necessary to identify actions that will improve watershed processes. It is important to sequence these assessments early in the implementation of RREDDs to identify projects.

Table 12 outlines the sequencing of projects over the lifespan of RREDDs. The phasing of projects is conceptual at this time. Completing geomorphic and sediment source assessments will be essential for determining the project types, locations, and phasing.

POPULATION	CULVERTS REPLACED (#)	LARGE WOOD PLACEMENT (MI)[1]	FLOODPLAIN/ OFF-CHANNEL ENHANCEMENT (ACRES)	SIDE CHANNEL CREATION (MI)	RIPARIAN PLANTING (MI)[2]
RESTORATION OUTPUTS FOR BROAD SENSE RECOVERY (2021 – 2031) INCORPORATING PASTACCOMPLISHMENTS					
Youngs Bay	NA	43	1.2	0	16.7
Big Creek	NA	57.3	3.0	4.6	16.9
ANNUAL ACCOMPLISHMENTS NECESSARY TO ACHIEVE RESTORATION OUTPUTS BY 2031					
Youngs Bay	NA	4.3	0.1	0	1.7
Big Creek	NA	5.7	.3	0.46	1.7

TABLE 11. Restoration Outputs for Broad-Sense Recovery (2021 – 2031) Incorporating Past Accomplishments
NOTES: 1. Large wood placement volume – 706 ft.3 (20 m3) of large wood per 328 ft. (100 m) of stream channel
2. Riparian Planting 98 ft. (30 m) width on each side of the stream channel

RREDDS STRATEGIC RESTORATION PLAN PROJECT PHASING	2021	'22	'23	'24	'25	'26	'27	'28	'29	'30
Ongoing property owner and stakeholder outreach	■	■	■	■	■	■	■	■	■	■
Lower Lewis & Clark River geomorphic assessment: Property owner outreach	■									
Lower Lewis & Clark geomorphic assessment in collaboration w/ property owners	■	■								
Lower Big Creek geomorphic assessment: Property owner outreach	■	■								
Lower Big Creek geomorphic assessment in collaboration w/ property owners		■								
Lewis & Clark and Big Creek watershed sediment source assessment			■							
Implement lower Lewis & Clark River restoration projects w/ voluntary property owner participation		■	■	■	■	■	■	■		
Assess priority areas to apply conservation easements or other measures to protect watershed processes				■						
Implement lower Big Creek restoration projects w/ voluntary property owner participation			■	■	■	■	■	■		
Implement Lewis & Clark and Big Creek watershed sediment mitigation measures identified in the sediment source assessment				■	■	■	■	■	■	■
Implement opportunistic projects in the Youngs Bay & Big Creek Population area lower priority watersheds		■	■	■	■	■	■	■	■	■
Implement priority conservation protections					■	■	■	■	■	■
Document outreach and project implementation, monitoring and evaluation	■	■	■	■	■	■	■	■	■	■

TABLE 12. Sequencing of Projects over the Lifespan of RREDDs

REFERENCES

Alfonse, B., K. Homel, J.E. Nunnally, and E. Suring. 2017. Chum Salmon Spawning Habitat Report for the Youngs Bay and Big Creek Populations. Oregon Department of Fish and Wildlife, Clackamas, Oregon.

Beechie T.J., D.A. Sear, J.D. Olden, G.R. Pess, J.M. Buffington, H. Moir, P. Roni, and M. Pollock. 2010. Processed-based principles for restoring river and ecosystems. BioScience, 60: 209–222.

Beechie, t., H. Imaki, J. Greene, A. Wade, H. Wu, G. Pess, P. Roni, J. Kimball, J. Stanford, P. Kiffney, and N. Mantua. 2012. Restoring salmon habitat for a changing climate. River Research and Applications. 29: 939-960.

Beschta, R. L., and W. L. Jackson. 1979. The intrusion of fine sediments into a stable gravel bed. Journal of Fisheries Research Board Canada. 36: 204–210.

Bilby, R.E., E.W. Beach, B.R. Fransen, J.K. Walter, and P.A. Bisson. 2003. Transfer of Nutrients from Spawning Salmon to Riparian Vegetation in Western Washington. Transactions of the American Fisheries Society 132:733–745.

Bottom, D.L., C.A. Simenstad, J. Burke, A.M. Baptista, D.A. Jay, K.K. Jones, E. Casillas, and M.H. Schiewe. 2005. Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon. US Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-68, 246 p.

Brewer, S., J. Watson, D. Christensen, and R. Brocksmith. 2005. Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Recovery Plan. Report prepared for the Hood Canal Coordinating Council http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhe ad/domains/puget_sound/chum/hcc_plan.pdf

Brick, J. 2021. ODFW salmon Population Threat Reduction Analysis and Broad Sense Recovery: Personal Communication, January 18, 2021. ODFW, Clackamas, Oregon.

Burril, S.E., C.E. Zimmerman, and J.E. Finn. 2010. Characteristics of fall chum salmon spawning habitat on a mainstem river in Interior Alaska: U.S. Geological Survey Open-File Report 2010- 1164.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society. 117: 1–21.

Columbia Basin Partnership Task Force. 2020 A vision for Salmon and Steelhead -- Goals to Restore Thriving Salmon and Steelhead to the Columbia River Basin. Phase 2 Report of the Columbia Basin Partnership Task Force of the Marine Fisheries Advisory Committee,
https://www.fisheries.noaa.gov/west-coast/partners/columbia-basin-partnership-task-force

Farley, E.V., J.H. Moss, and R.J. Beamish. 2007. A review of the critical size, critical period hypothesis for juvenile Pacific salmon. North Pacific Anadromous Fish Commission

Fulton, L.A. 1970. Spawning Areas and Abundance of Steelhead Trout, and Coho, Sockeye, and Chum Salmon in the Columbia River Basin–Past and Present. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Washington, D.C.

Geist, D.R., T.P. Hanrahan, E.V. Arntzen, G.A. McMichael, C.J. Murray, and Y. Chien. 2002. Physicochemical characteristics of the hyporheic zone affect redd site selection by chum salmon and fall Chinook salmon in the Columbia River. North American Journal of Fisheries Management, 22: 1077-1085

Good, T.P., R.S. Waples, and P. Adams (eds.). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS- NWFSC-66.

Grace, J.M. 2002. Sediment movement from forest road systems-roads: a major contributor to erosion and stream sedimentation. American Society of Agricultural Engineers: 13-14.
Groot, C. and E. Margolis (eds). 1991. Pacific Salmon Life Histories. British Columbia University Press, Vancouver, BC.

Hale, S.S., T.E. McMahon, and P.C. Nelson. 1985. Habitat suitability index models and instream flow suitability curves: Chum Salmon. U.S. Fish and Wildlife Service Biological Report 82.

Helle, J.H. 1960. Characteristics and Structure of Early and Late Spawning Runs of Chum Salmon Oncorhynchus keta (Walbaum) in streams of Prince William Sound, Alaska. M.S. Thesis.

University of Idaho, Moscow.

Hood Canal Coordinating Council. 2005. Hood Canal & Eastern Strait of Juan de Fuca Summer Chum Salmon Recovery Plan. Hood Canal Coordinating Council, Poulsbo, WA

Homel, K.M, C.M. Lorion, B.J. Clemens.2019. Challenges and Opportunities to Apply Process-Based Restoration at Scales Appropriate to Anadromous Fishes. American Fisheries Society Symposium 91:479–514.

Homel, K. 2015. Addressing limiting factors and critical uncertainties in the reintroduction of chum salmon to Oregon tributaries of the Columbia River. Proceedings of the Northeast Pacific Pink and Chum Salmon Workshop, Vancouver, British Columbia.

Johnson, O.W., W S. Grant, R.G. Kope, K. Neely, F.W. Waknitz, and R.S. Waples. 1997. Status Review of Chum Salmon from Washington, Oregon, and California. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-NWFSC No. 32.

Jones, J.A.; F.J. Swanson, F. J.; B.C. Wemple, and K.U. Snyder. 2000. Effects of roads on hydrology, geomorphology, and disturbance patches in stream networks. Conservation Biology. 14: 76-85.

Jensen, David W., E.A. Steel, A.H. Fullerton, and G.P. Pess. 2009. Impact of Fine Sediment on Egg-To-Fry Survival of Pacific Salmon: A meta-analysis of published studies. Reviews in Fisheries Science,17: 348-359.

Kavanagh, P, P. Jacobsen, K Jones, and K. Anlauf. 2006. Fish Habitat Assessment in the Oregon Department of Forestry Astoria North Study Area. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Lestelle, L., N. Sands, T. Johnson, M. Downen. 2018. Recovery Goal Review and Updated Guidance for the Hood Canal Summer Chum Salmon ESU. Prepared for the Hood Canal Coordinating Council.
http://hccc.wa.gov/sites/default/files/resources/downloads/HC%20Summer%20Chum%20Reco very%20Goal%20Guidance_08312018%20FINAL_0.pdf

Marcoe, K., and S. Pilson. 2017. Habitat change in the lower Columbia River estuary, 1870– 2009. Journal of Coastal Conservation 21, 505–525.

May, C., Geist D. 2006. Grays River Watershed and Biological Assessment. Report prepared by the Pacific Northwest National Laboratory for the Bonneville Power Administration (BPA Report DOE/BP-00000652-38), Portland, Oregon.

Montgomery, D.R., J.M. Buffington, N.P. Peterson, D. Schuett-Hames, and T.P. Quinn. 1996. Stream-bed scour, egg burial depths, and the influence of salmonid spawning on bed surface mobility and embryo survival. Can. J. Fish. Aquat. Sci. 53: 1061-1070.

NMFS (National Marine Fisheries Service). 1999. Endangered and Threatened Species: Threatened Status for two ESUs of Chum Salmon in Washington and Oregon. Federal Register 64:57 14508–14517.

NOAA. 2016. 5-Year Review: Summary & Evaluation of Puget Sound Chinook Salmon, Hood Canal Summer-run Chum Salmon, and Puget Sound Steelhead. National Marine Fisheries Service, West Coast Region Portland, OR

Oregon Department of Fish and Wildlife (ODFW). 2005. Oregon Native Fish Status Report. Volume II. Assessment Methods and Population Results. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife (ODFW). 2010. Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife (ODFW). 2010b. Lower Columbia River Conservation and Recovery Plan for Oregon populations of Salmon and Steelhead. Appendix I: Oregon's Columbia River chum salmon recovery strategy. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife (ODFW). 2020. ODFW Fish Passage Barrier Dataset. Oregon Department of Fish and Wildlife, Salem, Oregon.
https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=fishbarrierdata

Oregon Department of Fish and Wildlife (ODFW). 2021. ODFW Chum Reintroduction Project. Oregon Department of Fish and Wildlife, Salem, Oregon.
https://odfwchum.forestry.oregonstate.edu/columbia-river-chum-esu

North Pacific Anadromous Fish Commission. 2020. Pacific Salmonid Catch and Hatchery Release Data. North Pacific Anadromous Fish Commission, Vancouver, BC. www.npafc.org

Parkhurst, Z.E., F.G. Bryant, and R.S. Nielson. 1950. Survey of the Columbia River and Its Tributaries, Part 3. Special Scientific Report, Fisheries, No. 36. U.S. Dept. of the Interior, Fish and Wildlife Service, Washington, D.C.

Pearcy, W.G., C.D. Wilson, A.W. Chung, and J.W. Chapman. 1989. Residence times, distribution, and production of Juvenile chum salmon, Oncorhynchus keta, in Netarts Bay, Oregon. Fishery Bulletin 87:3 553-568.

Quinn, T.P. 2018. The Behavior and Ecology of Pacific Salmon and Trout. Second edition. University of Washington Press, Seattle, WA.

Roegner, G.C., E.W. Dawley, M. Russell, A. Whiting, and D.J. Teel. 2010. Juvenile salmonid use of reconnected tidal freshwater wetlands in Grays River, lower Columbia River basin. Transactions of the American Fisheries Society 139: 1211–1232.

Roegner, G.C., D. Bottom, A. Baptista, L. Campbell, P. Goertler, S. Hinton, R. McNatt, C. Simenstad, D. Teel, and K. Fresh. 2015. Salmon Habitat Use of Tidal-Fluvial Habitats of the Columbia River Estuary, 2010-13. Final Report. Report of research by NOAA Fisheries, Northwest Fisheries Science Center to US Army Corps of Engineers, Portland District, Oregon.

Salo, E.O. 1991. Life History of Chum Salmon. pp. 231–309. In: C. Groot & L. Margolis(ed.) Pacific Salmon Life Histories. University of British Columbia Press, Vancouver.

Sands, N. J., K. Rawson, K. P. Currens, W. H. Graeber, M. H. Ruckelshaus, R. R. Fuerstenberg, and J. B. Scott. 2009. Determination of independent populations and viability criteria for the Hood Canal Summer Chum Salmon ESU. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-101.

Scrivener, J.C. and M.J. Brownlee. 1989. Effects of forest harvesting on spawning gravel and incubation survival of chum (Oncorhynchus keta) and coho salmon (O. Kisuch) in Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Science. 46: 681-696.

Shreffer, D.K., C.A. Simenstad, and R.M. Thom. 1992. Foraging by juvenile salmon in a restored estuarine wetland. Estuaries 15:204–213.

Sweeting, R.M., R.J. Beamish, and C. Cooper. 2007. Comparison of juvenile salmon diets in the Strait of Georgia and Puget Sound 1997-2006. Report prepared by the Pacific Biological Station, Nanaimo, BC.

Tanner, C.D., J.R. Cordell, J. Rubey, and L.M. Tear. 2002. Restoration of freshwater intertidal habitat functions at Spencer Island, Everett. Washington Restoration Ecology 10:564–576.

Wiley, D. 2020. Chum Spawning Distribution Observations: Personal Communication, December 21, 2020. ODFW, Clackamas, Oregon.

Wiley, D. 2020. ODFW Chum Salmon Reintroduction Project – 2019/20 End of Season Presentation. Salmonid Life Cycle Monitoring Annual Meeting, Corvallis, Oregon.

Wiley, D. 2020a. ODFW Chum Salmon Reintroduction Project: December 2020 Chum Salmon Sampling Updates. ODFW, Clackamas, Oregon.

Wiley, D. 2021. ODFW Chum Salmon Reintroduction Project: Chum Salmon ESU Map. ODFW, Clackamas, Oregon.

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