Coho (*Oncorhynchus kisutch*) and Chum (*O. keta*) Salmon Spawning Escapement, Run Timing, and Origin in Two Central Puget Sound Streams: 2001-2022

Alex Brown

Introduction

Federal, tribal, state, and local efforts to restore many Pacific salmonid populations in the northwestern United States have been extensive and ongoing since the 1990s. In Washington state, fourteen population groups of salmon and steelhead are listed as “threatened” or “endangered” under the Endangered Species Act (NOAA 2023), three of which are in Puget Sound (Chinook, steelhead, and Hood Canal summer chum). Undoing a century of detrimental anthropogenic actions including degradation of habitat, construction of physical barriers, pollution, and overfishing is necessary for the successful recovery of these populations. Salmonids are ecologically valuable as prey for other protected species, such as pinnipeds (Chasco 2017) and southern resident killer whales (Williams et al. 2011).

Restoration of salmon spawning grounds and juvenile salmon rearing habitat is integral to recovery, and can include dam removal, fish ladder installation, stormwater runoff reduction, culvert removal, riparian planting, and instream structural additions, such as logs, logjams and boulders (Allen et al. 2016; Kiffney et al. 2023; Roni et al. 2002). Monitoring and evaluating these types of restoration projects can be costly because often a large area (e.g. watershed) needs to be studied for many years (Paulsen and Fisher 2003). Despite this, intensive long-term studies have been undertaken and proven the effectiveness of restoration (Clements et al. 2021; Kiffney et al. 2023).

Similar to the surrounding Puget Sound region, Vashon Island streams and watersheds have experienced degradation of critical salmonid spawning and juvenile rearing habitat as a result of logging, homestead clearing, farming, pollution, road construction, and development. Restoration efforts over the last 30 years included conservation acquisitions, watershed reforestation, riparian plantings, and placement of instream logs and logjams (Land Trust 2023). Studies have shown that salmon can quickly recolonize newly accessible habitat (Anderson et al. 2015). Increased canopy cover in riparian areas shades stream waters, lowering daytime temperatures (Moore et al. 2005). Reforesting the watershed stabilizes the land and reduces the amount of fine sediments that enter the stream, ultimately improving flow and gravel porosity required for salmonid eggs and alevins oxygenation (Cederholm and Reid 1987).

This report uses 22 years of Vashon Island stream monitoring data to complement a 2001-2009 summary (Perla 2014). Spawning salmon escapement, species composition, and run timing are presented and interpreted. Additionally, limited DNA samples collected from carcasses since 2018 provide hints of origins and their relation to past stocking efforts. Finally, future studies and consequent restoration projects to enhance salmonid populations on Vashon Island are suggested.

Methods

Geography

Vashon Island, located in central Puget Sound, has several salmonid-bearing streams. This report focuses on the two largest, Judd and Shinglemill Creek. Judd Creek flows south for roughly two and a half miles from headwaters in the center of Vashon Island, exiting into the northwest of Quartermaster Harbor (Figure 1). Shinglemill Creek is in the northwest of Vashon Island. Its headwaters start at Fisher Pond and flow north for approximately two and three-quarters miles, entering Puget Sound via Fern Cove (Figure 1). Both creeks are relatively small; streamflows at Judd and Shinglemill peak in the winter at ~20 cfs and ~15 cfs respectively. The lowest flows occur in late summer, dropping to <2 cfs for both (King County 2023).

Data collection

Judd and Shinglemill Creeks were monitored by volunteers trained in salmon identification by King County's Salmon Watcher Program (https://kingcounty.gov/services/environment/animals-and-plants/salmon-and-trout/salmon-watchers.aspx) from 2001 to 2011. Similar volunteer training and creek monitoring were organized by Vashon Nature Center's Salmon Watcher Program (https://vashonnaturecenter.org/project/salmonwatchers/) from 2012 to 2022. Data from both programs were combined for this report.

Volunteers monitored the creeks from stationary positions for 15 minutes, twice a week, from October through December. Live and dead individuals of each species were counted, and unidentified fish were categorized as such. Beginning in 2012, in addition to stationary observation, stream reaches, roughly one-quarter mile in length, were walked weekly in an upstream direction with observation data recorded. Beginning in 2015, salmon redds were enumerated, and starting in 2018, fin clips were collected from salmon carcasses and sent to the Washington Department of Fish and Wildlife (WDFW) Molecular Genetics Lab for DNA analysis.

Data analysis

This report only presents data on the two most common salmonid species observed in Judd and Shinglemill Creeks: coho (*Oncorhynchus kisutch*) and chum (*O. keta*) salmon. Live and dead sightings from stationary and walking surveys were combined, and the counts for each species within each creek were analyzed for trends over time. Species count per observer was calculated each year to account for observation effort. The annual date of the first sighting of each species was presented for both creeks, and the 22-year average was calculated to compare the run timing between species and between creeks. Years in which no salmon were observed were removed from the average.

WDFW analyzed salmon carcass tissue DNA and compared the results to their database of SNP genetic baselines. Samples were assigned to existing populations when a 70% or greater match occurred. These population origins were compared with annual WDFW stocking reports for each creek.

Results

Judd Creek

The presence of both coho and chum salmon in Judd Creek has varied since 2001 (Figure 2.a). No coho salmon were observed in 2007, 2009, and 2010. The most coho salmon sightings (152) was in 2012 by 11 observers (13.8 coho/observer). No chum salmon were observed in 2005, 2007, 2008, and 2011. The most (228) were recorded in 2003 by 11 observers (20.7 chum/observer). The greatest number of chum salmon per observer (43.3) occurred a year later in 2004, when three observers spotted 130. Coho and chum salmon redds were observed in 2016 to 2018, 2020, and 2022.

Shinglemill Creek

From 2003 through 2012, only four coho salmon in total were spotted in Shinglemill Creek: two in 2003 and one each in 2005 and 2012 (Figure 2.b). The highest count of coho salmon (62) occurred in 2014 by 13 observers (4.8 coho/observer). No chum salmon were sighted in 2001, 2003 to 2006, and 2008 to 2013. Only one chum salmon was recorded in 2002 and 2007. In 2022, nine volunteers observed the most chum salmon (169), equal to 18.8 per observer. Coho and chum salmon redds were observed every year from 2016 to 2022, except in 2019, when no chum redds were recorded.

Run timing

The mean arrival date of spawning coho and chum salmon to Judd Creek over 22 years was October 21st (SD: 15 days) and November 5th (SD: 11 days) respectively (Figure 3.a). On average, spawning coho and chum salmon arrived Shinglemill Creek on October 31st (SD: 11 days) and October 27th (SD: 15 days) respectively (Figure 3.b). Only years when at least one fish was observed were included in the calculations.

Origin

Genetic analysis of DNA samples collected from carcasses in Judd and Shinglemill Creeks between 2018 and 2021 did not show a consistent origin for either creek. Many samples had a mix of several different populations' DNA. Thirty samples strongly correlated to one of six hatchery or wild populations (Table 1), of which five were located in Puget Sound and one (Hoh River) on the western coast of the Olympic Peninsula.

The Minter Creek Hatchery provided chum salmon eggs to a Vashon Island school for educational purposes from 2012 to 2020. Approximately 225 of these eggs developed into juveniles and were released into Shinglemill Creek each May during these years. Only one out of thirteen chum salmon carcasses in Shinglemill Creek from 2018 to 2021 genetically matched a Minter Creek Hatchery population.

A more substantial stocking program by a local club seeded Judd and Shinglemill Creeks each with 15,000 coho salmon juveniles annually beginning in 2005, though possibly earlier. From 2005 to 2016 the coho juvenile salmon origin stock was listed as “Big Soos Creek”, after which it was listed as “Green River Native”. Big Soos Creek Hatchery is on a tributary of the Green River. In 2020, a coho salmon carcass in Shinglemill Creek was assigned to a Green River population. No other carcasses strongly correlated with the coho juvenile stocking population.

Table 1. Genetic population assignments for chum and coho salmon carcasses found in Shinglemill and Judd Creeks from 2018 to 2021, and the genetic population of released juveniles for that creek and listed species. Data courtesy of WDFW Molecular Genetics Lab, Olympia, WA. *Italics designate potential returns of the released juveniles.*

Species	Return year	Creek	Num of samples	Population assignment [run year if available]	Stocking origin* (count)
Chum	2018	Shinglemill	7	Curley Creek	Minter Cr Hatchery (225)
		Judd	8	Minter Cr Hatchery	none
		Judd	1	Hoodsport Hatchery	none
	2019	Shinglemill	1	Curley Creek [02]	Minter Cr Hatchery (225)
		Judd	1	Minter Cr Hatchery [03]	none
	2020	Shinglemill	1	*Minter Cr Hatchery [03]*	*Minter Cr Hatchery (225)*
		Shinglemill	1	Curley Creek [02]	Minter Cr Hatchery (225)
		Shinglemill	1	Chico/Grovers [10-15]	Minter Cr Hatchery (225)
		Judd	1	Minter Cr Hatchery [03]	none
	2021	Shinglemill	1	Curley Creek [02]	Minter Cr Hatchery (225)
		Shinglemill	1	Chico/Grovers [10-15]	Minter Cr Hatchery (225)
		Judd	3	Minter Cr Hatchery [03]	none
		Judd	1	Chico/Grovers [10-15]	none
Coho	2020	Shinglemill	1	*Green River [19]*	*Green R Native (15,000)*
		Shinglemill	1	Hoh River [06]	Green R Native (15,000)

*The origin population used for stocking for at least 3 (coho) or 6 (chum) years prior to return year

Discussion

The results suggested (1) in Judd Creek, coho and chum salmon observations have not shown any pattern or trend since 2001, (2) in Shinglemill Creek, coho and chum salmon observations were minimal prior to 2013, but have since increased, (3) run timing differed between species and between creeks, and (4) individuals from varying regional populations stray into the creeks to spawn.

The presence of returning adult salmon during the last decade confirmed that both creeks had amenable flow and temperature, as well as traversable reaches. Furthermore, the presence of coho and chum salmon redds in both creeks since at least 2016 demonstrated that suitable spawning grounds with the requisite substrate were available (Mull and Wilzbach 2007), likely fostered by past restoration projects. The status of suitable rearing habitat for juveniles in each creek has been studied less. While juvenile chum salmon migrate out of freshwater shortly after emergence (Agha et al. 2021), juvenile coho salmon remain in the creek for 12-18 months (Quinn 2018). Nickelson et al. (1992) found that juvenile coho salmon were most abundant in pools during the spring and summer, and lower velocity areas such as alcoves and beaver ponds in the winter. They proposed that, with sufficient spawning escapement, adequate winter habitat could be a limiting factor for coho smolt production. A comprehensive assessment of juvenile salmonid habitat should be conducted for Shinglemill and Judd Creeks.

Deriving an accurate count of instream salmon through observational surveys is difficult due to several constraints: the creeks can only be monitored during the daytime; two 15-minute surveys only cover a fraction of the week's daylight hours; many stretches of each creek are inaccessible; and post-rainfall turbidity can obscure submerged salmon from view. Additionally, more salmon were often observed during reach walks than during stationary viewing. This likely resulted in higher fish counts beginning in 2012, when walking observations were started. Therefore, a comparison of annual salmon counts from 2001-2022 is most effective as a means of confirming yearly presence of each species in each creek.

Run timing

In Judd Creek, coho salmon arrived an average of 15 days before chum salmon. Surprisingly, the order was flipped for Shinglemill Creek, where chum salmon arrived an average of 4 days before coho salmon. Despite a lack of statistical significance, these results are worth investigating. Pacific salmon freshwater migration and spawning requires favorable habitat conditions, such as streamflow and water temperature (Sandercock 1991). Judd and Shinglemill Creeks differ in their headwaters, riparian vegetation, proximity to anthropogenic stressors and estuary structure, to name a few. Therefore, it is expected that they reach favorable conditions on different dates. The opposite order of creek entry is surprising because the creeks are close enough to experience the same weather conditions and therefore the same changes in streamflow and water temperature.

Origin

According to a WDFW summary that accompanied the genetic results, a self-sustaining population for both species in both creeks is possible though unlikely because the DNA analyses were consistent with the sampled carcasses being strays from nearby populations. Despite this, it is notable that in 2018, eight chum salmon carcasses in Judd Creek originated from the Minter Creek Hatchery, even though Shinglemill Creek had been populated with that hatchery's juvenile chum salmon. WDFW ran a second DNA analysis which concluded that none of the chum salmon carcasses linked back to the juveniles from Minter Creek Hatchery. This was not surprising due to the small number of juveniles (225) released and the low fry-to-recruit survival rate of chum salmon (Pyper et al. 2002). Seven chum salmon carcasses recovered from Shinglemill Creek in 2018 originated from Curley Creek, the closest wild chum salmon bearing creek. Straying behavior is an important strategy for salmon productivity because it allows the colonization of new habitat required for the expansion of nearby populations (Milner et al. 2000).

The low number (2) of definitive population assignments of coho salmon leaves the effectiveness of the stocking effort unanswerable. The one coho salmon assigned to a Hoh River population is noteworthy because the river is far from Puget Sound. WDFW reported that their SNP baseline for coho salmon was in the early stages of creation and prone to errors. The other coho salmon matched a Green River population, the same as the stocking population. An increase in coho salmon samples in future years, along with a larger and more refined SNP baseline, will provide insight into the origins of Judd and Shinglemill Creek's spawning coho salmon. When attempting to restore a creek's salmon population, Anderson et al. (2014) suggested that releasing hatchery-produced juveniles may help reintroduction efforts in the short-term but risks altering evolutionary processes in the long-term. Weber and Fausch (2003) found that studies of competition between hatchery and wild juvenile salmonids vary in their experimental design and findings, but most conclude that after the addition of hatchery juveniles, density-dependent competition would negatively affect resident wild juveniles.

Conclusion

For the past nine years, Judd and Shinglemill Creeks have not experienced the prolonged (3+ years) absences of salmon observations that the prior decade encountered. It remains to be seen if self-sustaining populations can become established. Deredec and Courchamp (2007) found that a colonizing population's density was initially low and prone to failure if a critical abundance threshold was not exceeded. Restoration efforts in and around both creeks has and will be an essential component of increasing spawning salmon populations in Judd and Shinglemill Creek. The community science monitoring program has led to a solid baseline of understanding and, if continued, will lead to clarifying some of the unknowns.

Acknowledgments

Thanks go to the numerous volunteers who monitored the creeks, to the landowners who allowed volunteers onto their properties, and to the WDFW Molecular Genetics Lab. Thank you Kelly Keenan for running the Vashon Nature Center's Salmon Watcher Program and helping with data clarification. Thanks especially to Bianca Perla for suggesting this project, providing access to the data, and answering many questions along the way.

References

Agha, M., J. P. Losee, M. N. C. Litz, C. Smith, J. J. Schaffler, W. S. Patton, A. M. Dufault, and G. M. Madel. 2021. Temporal patterns and ecosystem correlates of Chum Salmon (*Oncorhynchus keta*) migration phenology in the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 78:1565–1575.

Allen, M.B., R.O. Engle, J.S. Zendt, F.C. Shrier, J.T. Wilson, and P.J. Connolly. 2016. Salmon and steelhead in the White Salmon River after the removal of condit dam–planning efforts and recolonization results. Fisheries 41(4):190–203.

Anderson, J.H., G.R. Pess, R.W. Carmichael, M.J. Ford, T.D. Cooney, C.M. Baldwin and M.M. McClure. 2014. Planning Pacific salmon and steelhead reintroductions aimed at long-term viability and recovery. North American Journal of Fisheries Management 34(1): 72–93.

Anderson, J. H., P. L. Faulds, K. D. Burton, M. E. Koehler, W. I. Atlas, and T. P. Quinn. 2015. Dispersal and productivity of Chinook (*Oncorhynchus tshawytscha*) and coho (*Oncorhynchus kisutch*) salmon colonizing newly accessible habitat. Canadian Journal of Fisheries and Aquatic Sciences 72(3):454–465.

Cederholm, C. and L. Reid. 1987. Impact of forest management on coho salmon (*Oncorhynchus kisutch*) populations of the Clearwater River, Washington: a project summary. Seattle, Wash. (USA): College of Forest Resources. Univ. of Washington (USA).

Chasco, B., I. Kaplan, A. Thomas, A. Acevedo-Gutierrez, D.P. Noren, M.J. Ford, M.B. Hanson, J. Scordino, S.J. Jeffries, S.F. Pearson, K. Marshall, and E.J. Ward. 2017. Estimates of Chinook salmon consumption in Washington State inland waters by four marine mammal predators from 1970 to 2015. Canadian Journal of Fisheries and Aquatic Sciences. 74(8):1173-1194.

Clements, W. H., D. B. Herbst, M. I. Hornberger, C. A. Mebane, and T. M. Short. 2021. Long-Term Monitoring Reveals Convergent Patterns of Recovery from Mining Contamination across 4 Western US Watersheds. Freshwater Science 40:407–26.

Deredec, A., and F. Courchamp. 2007. Importance of the Allee effect for reintroductions. Ecoscience 14:440–451.

Fausch, K. D. and T. G. Northcote. 1992. Large Woody Debris and Salmonid Habitat in a Small Coastal British Columbia Stream. Canadian Journal of Fisheries and Aquatic Sciences 49(4):682–693.

Kiffney, P. M., P. J. Lisi, M. Liermann, S. M. Naman, J. H. Anderson, M. H. Bond, G. R. Pess, M. E. Koehler, E. R. Buhle, T. W. Buehrens et al. 2023. Colonization of a Temperate River by Mobile Fish Following Habitat Reconnection. Ecosphere 14(2):e4336.

King County. 2005. Vashon Maury Island Watershed Plan. Available: https://your.kingcounty.gov/dnrp/library/2005/kcr1865.pdf (May 2023).

King County. 2023. Hydrology. Available: https://green2.kingcounty.gov/hydrology/ (May 2023).

Land Trust. 2023. Vashon-Maury Island Land Trust. Available: https://www.vashonlandtrust.org/ (April 2023).

Milner, A.M., E.E. Knudsen, C. Soiseth, A.L. Robertson, D. Schell, I.T. Phillips, and K. Magnusson. 2000. Colonization and development of stream communities across a 200-year gradient in Glacier Bay National Park, Alaska, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences 57(11):2319–2335.

Moore, R.D., D.L. Spittlehouse, and A. Story. 2005. Riparian microclimate and stream temperature response to forest harvesting: a review. Journal of the American Water Resources Association 41(4):813-834.

Mull, K.E., and M.A. Wilzbach. 2007. Selection of Spawning Sites by Coho Salmon in a Northern California Stream. North American Journal of Fisheries Management 27(4):1343–1354.

NOAA. 2023. Endangered Species Act Listings. Available: https://www.fisheries.noaa.gov/species-directory/threatened-endangered (May 2023).

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:783–789.

Paulsen, C. M., and T. R. Fisher. 2003. Detecting juvenile survival effects of habitat actions: power analysis applied to endangered Snake River spring-summer Chinook (*Oncorhynchus tshawytscha*). Canadian Journal of Aquatic Science 60:1122–1132.

Perla, B. 2014. Quick summary of Vashon Salmon Observations 2001-2009. White paper. n. Available: https://vashonnaturecenter.org/wp-content/uploads/2014/05/Salmon_summary2001-2008.pdf. (April 2023).

Pyper, B. J., F. J. Mueter, R. M. Peterman, D. J. Blackbourn, and C. C. Wood. 2002. Spatial Covariation in Survival Rates of Northeast Pacific Chum Salmon. Transactions of the American Fisheries Society 131:343–363.

Quinn, T. P. 2018. The Behavior and Ecology of Pacific Salmon and Trout. 2nd ed. University of Washington Press.

Roni, P., T. J. Beechie, R. E. Bilby, F. E. Leonetti, M. M. Pollock, and G. R. Pess. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. North American Journal of Fisheries Management 22:1–20.

Sandercock, F.K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). In Pacific Salmon Life Histories. Edited by C. Groot and L. Margolis. UBC Press, Vancouver pp. 395-446.

Weber, E. D., and K. D. Fausch. 2003. Interactions Between Hatchery and Wild Salmonids in Streams: Differences in Biology and Evidence for Competition. Canadian Journal of Fisheries and Aquatic Sciences 60(8):1018-1036.

Williams, R., M. Krkošek, E. Ashe, T.A. Branch, S. Clark, P.S. Hammond, E.Hoyt, D.P. Noren, D. Rosen, and A. Winship. 2011. Competing conservation objectives for predators and prey: estimating killer whale prey requirements for Chinook salmon. PloS ONE 6(11):e26738.

Figure 1. The location of Judd and Shinglemill Creeks on Vashon Island in Puget Sound, Washington state.

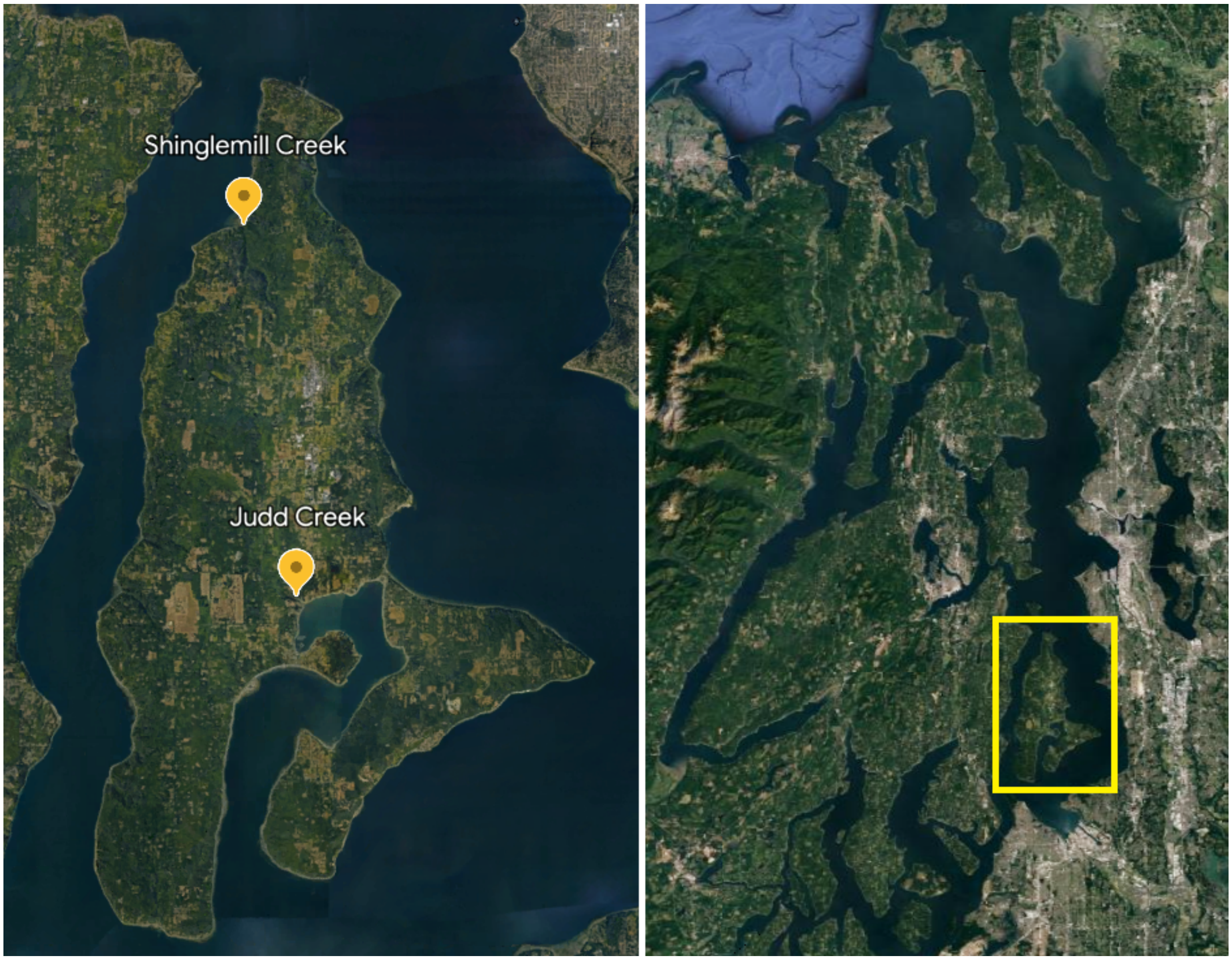
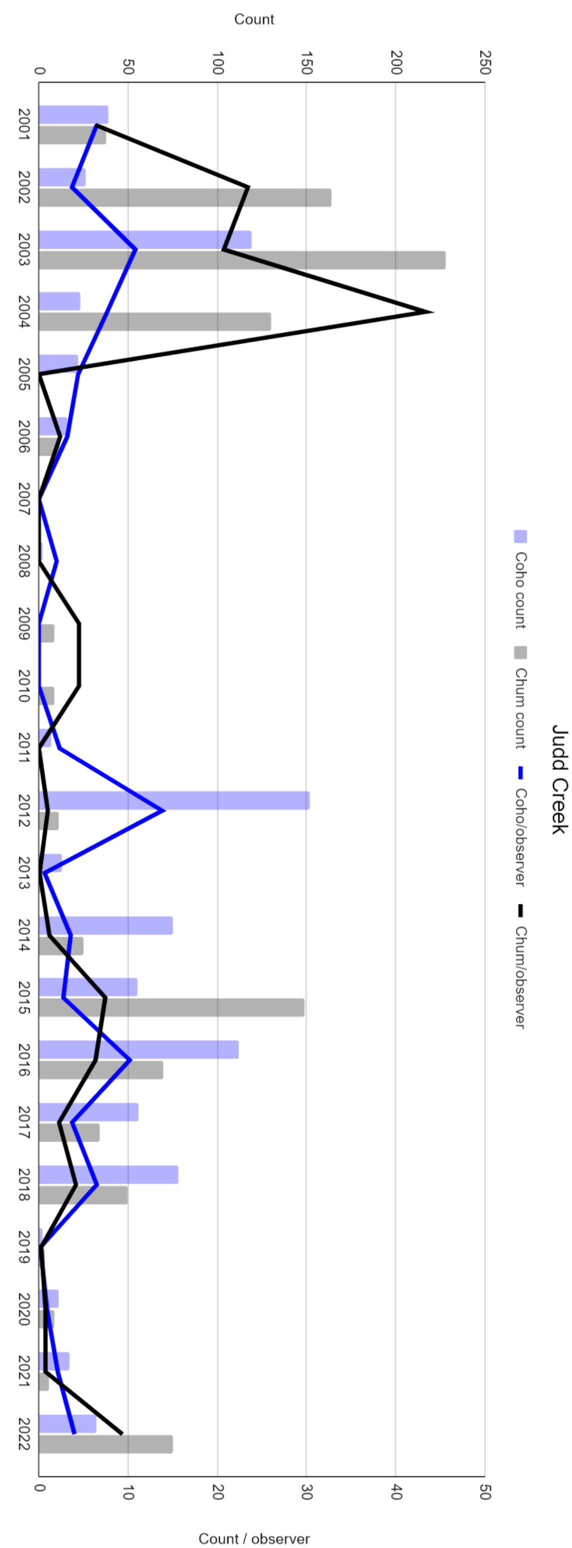


Figure 2. Total count and count/observer of coho and chum salmon in (a) Judd Creek and (b) Shinglemill Creek.

(a)



(b)

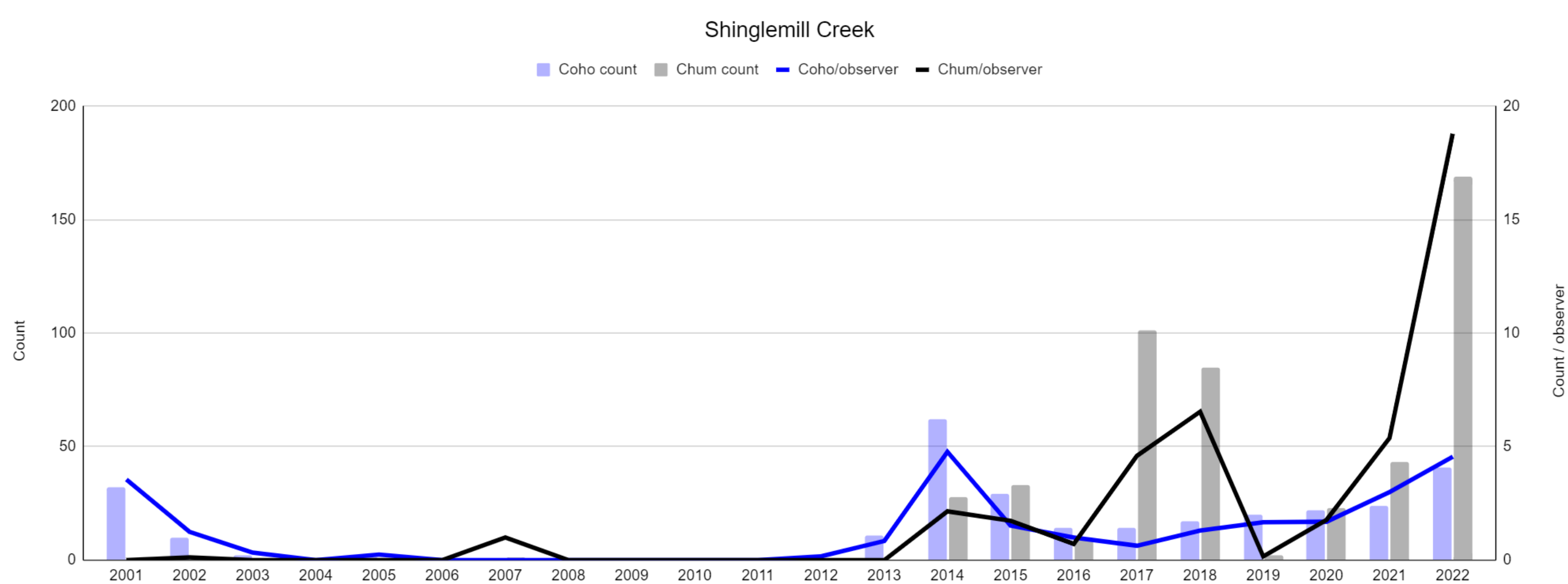
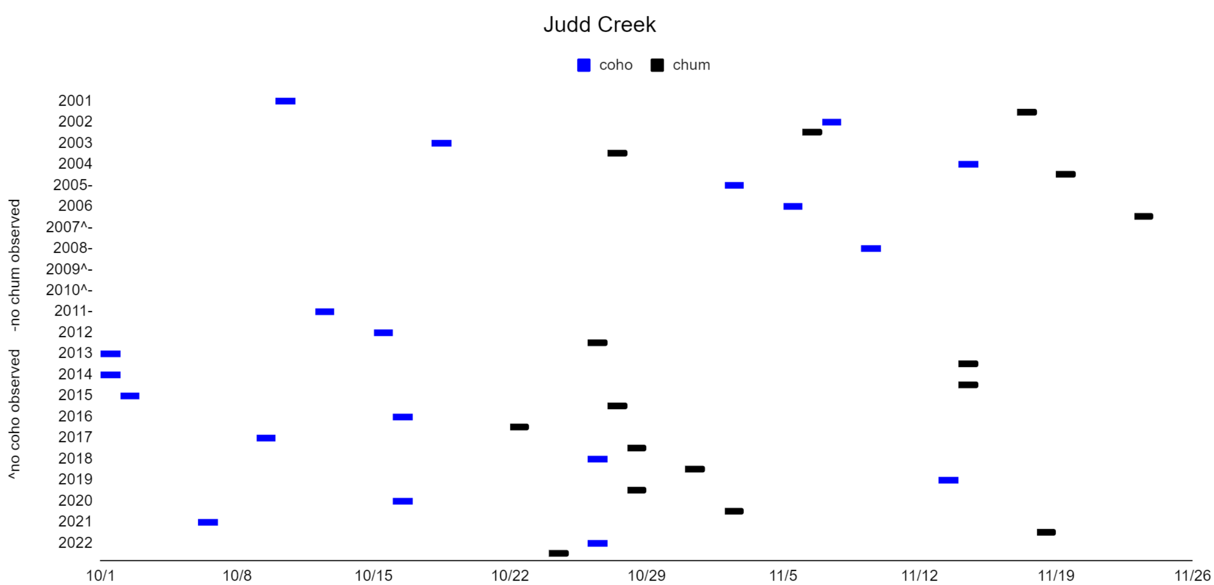

Shinglemill Creek
Coho count
Chum count
Coho/observer
Chum/observer
Count
Count / observer
0
50
100
150
200
0
5
10
15
20
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022

Figure 3. The first day that coho and chum salmon were sighted each year for (a) Judd Creek [coho mean: 10/21, SD 15 days; chum mean: 11/5, SD 11 days] and (b) Shinglemill Creek [coho mean: 10/31, SD 11 days; chum mean: 10/27, SD 15 days].

(a)



(b)