

Estimating Coho Salmon Escapement and Origin in the Elwha River in 2025 Using Multi-beam SONAR Technology



Prepared For: Lower Elwha Klallam Tribe, Department of Natural Resources

Prepared By: Keith Denton, Oleksandr Stefankiv

K. Denton and Associates, LLC

Executive Summary

We used an ARIS 1800 multi-beam SONAR unit located at a combination of two different sites within 300 meters of each other to monitor coho salmon escapement on the Elwha River on a daily basis from September 2, 2025 through November 26, 2025. We analyzed 20-minutes of each hour-long file and then adjusted these raw counts for expansion to hourly counts, species composition, observer error, and filling data gaps. This process yielded an adult coho salmon (> 550 mm) escapement estimate passed the SONAR site of 2,900 fish, with a coefficient of variation of 3.7% (95% CI 2,690 – 3,110). Adding 347 fish from the combination of the hatchery returns and removal by the LEKT subsistence fishery yielded a total river escapement estimate of 3,247. Adding these fish to both the low and high ends of the 95% CI yielded upper and lower bounds of the total escapement of coho salmon greater than 550 mm to the Elwha River in 2025 of 3,037 and 3,457; respectively.

The first coho salmon was captured in the species composition sampling on September 2, 2025 and the last was captured on November 18, 2025. The fifty percent entry date (October 9) was about one and two weeks earlier than 2022 (October 31) and 2024 (October 22), respectively and within a week of 2023, 2021 and 2020 (October 11, 7 and 2) and two weeks later than 2019 (September 25). Species composition sampling throughout the run produced 25 coho salmon for mark rate tabulation. The LEKT tribal subsistence fishery provided an additional 65 coho for mark rate tabulation. Mark rates varied minimally between sources (<10%) and when all samples were combined, adipose clip only, CWT only, and fish exhibiting both marks represented 78%, 14%, and 8% of marked fish, respectively. Additionally, 59% of all captured fish in the lower river were not marked in any way and are considered natural origin fish. Mark rates varied longitudinally with 30% marked near the mouth, 36% marked in the entire lower river and only 12% marked in the middle river. The male: female ratio for adult coho salmon from all sources was 0.7:1 (101:142).

Our two recommendations this year relate to coordination with the coho management team. First, is a continuation of last year's recommendation, to coordinate data collection with the tribal fishery, especially because the project does not perform its tangle net sampling when the tribal fishery is active. It is highly recommended that data from both mark methods (CWT and adipose clip) are collected from every encountered coho to bolster the low sample sizes from the tangle net sampling. Second, communication with the larger Elwha coho management team could help focus deliverables and timetables for the SONAR project.

Introduction

One of the most important pieces of information for salmon fisheries managers is an accurate count of adults returning to spawn in a river system, hereafter referred to as escapement. Although in the case of coho salmon in the Elwha River, because of the removal of some coho salmon from an in-river tribal subsistence fishery, we also consider both the number of coho salmon that escaped the fishery and the total number that returned to the river. Multiple methods have been used to estimate adult escapement, including aerial surveys, counting towers, weirs, redd surveys, mark recapture, and SONAR technology (reviewed by Cousens et al., 1982). Over the years, the technology and techniques involved has remained basically static for most of these methods except SONAR, whose technology and application to escapement estimation has rapidly evolved over the last few decades (Maxwell 2008).

Single beam SONAR systems have been used to enumerate fish migration in rivers since the early 1960's. Similar technology is still being used to measure escapement in a number of commercial fisheries in Alaska (Westerman and Willette 2003; Dunbar and Pfisterer 2004; Dunbar 2001, 2003; McKinley 2002), and Canada (Levy et al. 1991, Cronkite et al. 2006). More recently, SONAR technology has greatly improved counting accuracy by incorporating multiple high frequency beams, producing "movie" quality images while also providing detailed data on several other fish characteristics including direction of travel, range, length, and swimming speed (Belcher et al. 2001, 2002). The main unit in use for fisheries applications today is the **D**ual-frequency **I**Dentification **S**ONar (DIDSON) and its newer version, the **A**daptive **R**esolution **I**maging **S**onar (ARIS).

Several studies have compared SONAR counts of adult salmon derived from DIDSON imaging systems to other enumeration methods such as weir passage (Holmes et al. 2006), visual counts (Enzenhofer et al. 1998), and mark-recapture (Cronkite et al. 2006, Holmes et al. 2006). These studies have shown that SONAR counts were more accurate (insignificant error calculations) when compared to more traditional methods. It is important to note; however, that almost all of the fisheries applications of SONAR are focused on large salmon runs that transpire over the course of only a few weeks, which requires large technical staff and operating budgets (eg. Lilja et al. 2008, Enzenhofer et al. 2010).

SONAR has been used to enumerate winter-timed steelhead (*Oncorhynchus mykiss*) and summer/fall Chinook salmon (*O. tshawytscha*) in the Elwha River, Washington from late January/early February through late September since 2010 (Denton et al. 2010-2025). This is the seventh year the project has continued operations throughout the fall and into the early winter to enumerate coho salmon (*O. kisutch*), as well as document the mark rates of the returning adults.

Although not listed under the Endangered Species Act, coho salmon are a stock of interest to various stakeholders on the Elwha. Attempts at enumerating escapement with redd surveys have been ongoing since at least 2013 but due to high flows and low visibility during their spawn timing, these surveys have not been useful for estimating total basin escapement which has led to this current effort to improve enumeration. Prior to dam removal, Elwha coho salmon were managed for hatchery production and returns were dominated by hatchery origin returns (HOR). Since dam removal, coho

salmon have reestablished themselves in the middle river and its tributaries and the lower portion of the upper river to at least Geyser Valley. Additionally, the stock is of regional concern for fisheries managers interested in assessing mark selective fisheries in salt water and has therefore been the subject of a targeted mark program whereby all hatchery releases are marked by a combination of two different marks, an adipose clip and/or a coded wire tag (CWT). Information on the relative proportions that these mark rates represent in the adult returns is critical to evaluating the effects of mark selective fisheries. Management of this stock took on particular importance in 2023, when the Lower Elwha Tribe (LEKT) held a ceremonial and subsistence fishery for coho, the first fishery on the Elwha since dam removal (>10 years).

The objectives of this study were 1) to enumerate the number of adult (>550 mm) coho salmon migrating passed the SONAR sites; 2) provide mark rate information on all captured coho, including from the tribal subsistence fishery; 3) provide run timing information; 4) incorporate and describe various sources of error in the estimate; 5) determine the proportion of coho salmon and other species in the river during the course of the run; and 6) make recommendations on how to improve the project in future years.

Methods

Data Collection

Continually changing river conditions and two distinct stream channels (migratory pathways) in the lower Elwha River in previous years have necessitated two separate SONAR installations to accurately detect coho salmon passage (Fig. 1). However, the Hunt Road Channel (HRC) on the west side of the valley has conveyed less flow in each successive year and beginning in 2023, flow down that channel was primarily groundwater. Therefore, SONAR monitoring only occurred in the Old Mainstem or East Channel (EC) in 2025. We did incorporate two different sites during the course of the coho run, moving the SONAR from the lower site (Old “OM” site, Fig 2) to the site ~300 meters upstream (New “OM” site, Fig 3) on October 20. An ARIS 1800 (Sound Metrics, Bellevue, WA) was used during the course of this study (1.1/1.8 Mhz, provided by the National Park Service – Olympic National Park). The SONAR was powered by a 24-volt, 200-amp hour battery bank that was continually charged by an array of solar panels.

Site selection was based on four criteria: 1) almost all fish would pass the site; 2) the location was downstream of the majority of coho spawning habitat; 3) the river channel was sufficiently narrow to accommodate the effective range of the SONAR; and 4) fish movement was primarily directed upstream with little milling in the location of the SONAR. Depending on stream flow, the lower site was 20-30 meters wide and 1 meter deep in the thalweg while the upper site was 28 – 32 meters wide and 1.5 meters deep in the thalweg.

The SONAR was attached to a pole mount (Enzenhofer and Cronkite, 2005) that was mounted on a reinforced aluminum step-ladder. The SONAR and ladder were positioned just under the surface of the water with a downward angle of approximately 4-6°. The goal of this placement was to ensonify

the bottom of the river across the entire width of the channel in addition to clearly identifying the far bank (see Enzenhofer et al. 2010 for details on aiming the beam).

Coho salmon passage was recorded from September 2 through November 26 with three recording gaps totaling 10 days (October 11-13, October 31-November 2, and November 6-9) (Fig. 4). These gaps were all due to high flows.

Species Composition

We conducted 9 tangle net surveys between September 2 and November 26, 2025 to capture live adult salmonids at seven different sites in the lower four kilometers of the river (Table 1 and 1a). We did this to differentiate the species of salmonids over the course of the run and to determine the total duration of the coho salmon run. Captured fish were measured for fork length and qualitatively categorized as “new” if they appeared to have entered the river within the previous 2 weeks, “holding” if they appeared to have been in the river for more than 2 weeks, or “spawned out” if they appeared to have initiated spawning or were already spawned out. The tangle-net was designed to snare fish from the jaw and not the gills in order to reduce encounter effects and limit sampling bias. The net was approximately 18 m long and 4 m deep with loosely hung 10 cm stretch mesh.

We also incorporated species composition data from the tribal set net fishery at the mouth of the river that occurred from September 23 to October 23 and from a snorkel survey that occurred in the lower 5 KM of the river on September 16 (Table 1 and 1a).

We also used both sources of netting data to determine a minimum threshold for SONAR measured targets to be included in the final escapement estimation by comparing the lengths of coho and all other salmonids (Fig 5). Additionally, fish captured during species composition netting, the tribal set net fishery and fish captured during additional sampling at supplemental upstream sites were used to determine mark rates of coho salmon.

Data Analysis

Post Processing

All ARIS data was processed using ARIS proprietary software (V2.8). There were 72, 20-minute long files for each day of operation. Twenty minutes of each hour was reviewed. Raw data was transformed in a four-step process that enabled empty periods of time to be efficiently reviewed, while still highlighting fish passage events for closer inspection. Files were background subtracted, using the default parameters, to remove rocks and make it easier to discern moving objects, such as migrating fish. Subsequently, each file was transformed into an echogram using the default parameters, with the exception that all 96 beams were included rather than only the center beam. This dramatically increases the probability that any fish entering the ensonified area was detected in the echogram.

An echogram is a graph of the data with distance from the SONAR head on the y-axis and time on the x-axis. If no targets are present, the echogram is blank. If a fish swims through the ensonified area, the echogram has a series of targets connected along the x-axis, whose overall length correlates with the length of time it took the fish to pass through the ensonified area. The string of targets along

the x-axis may trend up or down along the y-axis if the fish was swimming diagonally away or towards the sonar head during its passage. To count fish passage events, target echograms were simultaneously reviewed along with the raw video file. This enabled the reviewer to quickly scan through an echogram until a target pattern that could potentially represent a fish was encountered. The raw video imagery was then reviewed to ensure identified targets were indeed fish.

After determining that a pattern on the echogram was indeed a fish, we noted several variables, including the date, time, direction (upstream or downstream), distance from SONAR head and length (cm). Length was measured in centimeters using software specific procedures.

Escapement Estimation and Uncertainty Tabulation

Basic fish passage is tabulated by simply subtracting downstream passage events from upstream passage events (Xie et al. 2005):

$$N = U - D$$

Where N is the net upstream movement of fish for a given period of time, U is the sum of upstream fish for that time period and D is the sum of downstream moving fish for that time period.

In order to sum the upstream and downstream passage events for each twenty-minute file, we first had to determine which passage events to include in our analysis, namely the minimum length threshold. A length frequency histogram of the in-stream netting data revealed that coho were between 350 mm and 810 mm. There was a clear break between adult and jack coho in 2025. Only 6% (20/330) of sampled coho measured below 550 mm (Fig. 5). Based on this data, only SONAR targets recorded between 550 mm and 810 mm were included in the final escapement analysis.

Raw targets meeting the above criteria were then aggregated into six-hour chunks, four per day. Each six-hour chunk was then put through a four-step adjustment simulation to determine the final escapement. This simulation used collected data to correct raw counts for the four major adjustments that make up the total escapement estimate: 1) expanding the 20 minute counts to represent full hour passage; 2) down weighting the expanded counts to reflect the proportion of SONAR targets that were coho salmon; 3) adjusting the expanded coho counts to account for observer error; and 4) filling in any passage data for gaps in the expanded, corrected, coho data.

We used a simulation-based approach and replicated this simulation procedure a large number of times (10,000). We initialized the values in each cell (348 rows, representing each of the 6-hour chunks and 10,000 columns, representing the iterations) to the net passage based on the raw counts from the files. During each of the four steps in the adjustment procedure described below, we were able to generate updated estimates of escapement, and at varying temporal scales (6-hour estimates, daily estimates, and annual estimates). To determine the coefficient of variation for the final escapement, the standard deviation of all 10,000 estimates was divided by the mean of all 10,000 estimates. To generate CV estimates for each of the four individual adjustment procedures, we also applied each step of the procedure individually to the raw six-hour chunk counts from each channel.

20 Minute Count Expansion

Although counting 20 minutes of each hour is on the upper end of recommended sub-sampling regimes (Lilja et al. 2008), it requires treating two thirds of the total passage data as unknown. In order to expand our 20-minute counts and encompass the uncertainty inherent in the process we counted the full 60 minutes of 9 six-hour chunks (Fig 6). We regressed these 60-minute counts against those predicted from the first 20-minutes of the same six-hour chunks to create a vector of residuals. Each raw 20-minute count was then adjusted by multiplying by 3 and adding a randomly sampled value from the residual vector. The CV for escapement for this step was calculated by summing all six-hour chunks for each iteration, yielding 10,000 estimates. Then, the standard deviation of all 10,000 estimates was divided by the mean of all 10,000 estimates.

Species Composition

Calculation of the 2025 coho salmon escapement only included SONAR targets recorded from September 2, the date of the first coho capture, through November 26, the date when the SONAR was pulled for the season. One additional tangle net sampling event occurred on December 1 and no fish were captured.

In river tangle netting, tribal netting, and the snorkel survey provided the necessary data to adjust the raw counts to reflect just the number of coho moving past the SONAR sites (Table 1a). Because of the low numbers of fish caught during some of the sampling events, we summed fish between adjacent events to arrive at daily totals of “all fish” versus coho caught. For the EC, we simulated the proportion of coho for a given iteration and day as:

$$p_{i,j,k} = \text{Binomial}\left(\frac{N_{i,j}^{\text{coho}}}{N_{i,j}^{\text{total}}}, N_{i,j}^{\text{total}}\right) / N_{i,j}^{\text{total}}$$

where i represents the iteration (1 – 10,000) and j indexes the six-hour chunk (1 – 348). The total number of fish, $N_{i,j}^{\text{total}}$, and total number of coho, $N_{i,j}^{\text{coho}}$, were available on a daily basis, so the four six-hour chunks from each day were assumed to have the same species composition.

We then adjusted each of the raw counts for the proportion that were coho as a random draw from a Binomial distribution:

$$X_{i,j}^{\text{coho}} \sim \text{Binomial}(p_{i,j}, X_{i,j}^{\text{total}})$$

where X is the number of coho and total number of fish for each six-hour chunk.

The CV for escapement for this step was calculated by performing the correction directly on the net passage data. Then the counts of all six-hour chunks were summed for each iteration, yielding

10,000 estimates. Finally, the standard deviation of all 10,000 estimates was divided by the mean of all 10,000 estimates.

Observer Error

We quantified observation error by comparing counts for 11 six-hour chunks between the primary technician and an “expert” counter. Six-hour total passage counts by the expert counter were considered to be a measure of “actual” passage and were compared to the technicians “predicted” counts (Fig. 7). A trend line was fit to the data with an intercept of 0 and then a vector of observer error residuals was generated. Each cell of the coho matrix was then adjusted by multiplying it by the coefficient from the regression trend line and adding a random residual. The CV for escapement for this step was calculated by performing the correction directly on the net passage data as opposed to the species composition adjusted data used by the simulation. Then the counts of each six-hour chunk were summed for each iteration, yielding 10,000 estimates. Finally, the standard deviation of all 10,000 estimates was divided by the mean of all 10,000 estimates.

Filling Data Gaps

A number of different approaches could be used to fill in missing counts, we used a generalized additive modeling (GAM) approach to fill in missing values, because this approach also allowed us to include uncertainty estimates (gam in the ‘mgcv’ package in R). We fit a smoothing spline over time (days), which allowed both a flexible shape of return timing, and uncertainty to increase as the spline became further away from data. For example, if a five-day data gap exists, the uncertainty is highest on the mid-point (day 3) of the gap, and the uncertainty associated with passage during the gap would increase as the length of the gap increases. For each iteration of the simulation, we first fit the GAM to fill in the data gaps, then for each six-hour chunk generated random values (using the mean and corresponding standard error from the GAM). Because our approach does not include autocorrelation in missing values, but assumes each six-hour chunk to be independent, it represents upper bounds of uncertainty estimates.

Calculating Total River Escapement

While the SONAR estimate accounted for the vast majority of the coho that entered the river in 2025, two other sources of data must be used to calculate the total return to the river. First, the SONAR was moved to a location above the LEKT hatchery outfall on October 20 and the 82 fish that entered the hatchery facility after this date did not pass the SONAR and therefore must be added to the SONAR estimate. The LEKT subsistence fishery removed a total of 266 coho from the river in 2025 and all but one of these or 265 of these fish were removed from below the SONAR site (LEKT, unpublished data). These fish also must be added to the SONAR estimate. When combining these two additional coho counts, 347 fish must be added onto the SONAR estimate to arrive at the total return to the river.

Results

Between September 2 and November 26, 2025 there were a total of 1,824 hours (76 days) recorded on the EC (88% of the total possible). During this period 9,130 fish passage events were recorded and analyzed. The best estimate for coho salmon (> 550 mm) passage passed the SONAR site

in the Elwha River in 2025 was 2,900 fish with a coefficient of variation (CV) of 3.7% (95% CI 2,690 – 3,110) (Figs 8 and 9, Table 2). Adding 347 fish from the combination of the hatchery returns after October 20 (+82) and removal from the LEKT fishery (+265) yielded a total river escapement estimate of 3,247. Adding these fish to both the low and high ends of the 95% CI yielded upper and lower bounds of the total escapement of coho salmon greater than 550 mm to the Elwha River in 2025 of 3,037 and 3,457; respectively. We calculated four sources of uncertainty for the estimate of passage up the EC, in decreasing order they are: (1) adjusting for species composition (2.9%), (2) error in the gap filling procedure (1.8%), (3) the uncertainty associated with adjusting for observer error (1.5%) and (4) expanding 20-minute counts to full hour counts (1.1%) (Table 2).

The SONAR data in combination with in-stream species composition netting provided detailed information on run timing. We captured the first coho salmon on September 2 and 25%, 50%, and 75% of the run had passed the SONAR site by October 1, October 9, and October 21, respectively (Fig. 11). Daily coho passage was also plotted against flow (Fig 10). The run began in earnest during the last week of September, coinciding with the first rise in flows of the season even though this flow increase was relatively modest (~185 cfs). Throughout the run, there were periods when high passage rates were clearly linked to increases in flow but also several days of high passage that did not appear to be linked to a flow increase (Figure 10).

Species composition netting provided 25 coho from the lower river for mark rate tabulation (Table 3a). The tribal ceremonial and subsistence fishery provided an additional 65 coho from the set nets near the mouth (Table 3b). Mark rates between these two sources were generally similar although the species composition netting estimated more unmarked fish (64%, 16/25) than the set net fishery 57% (37/65). Combining both data sources and comparing different mark types showed 78% adipose clip only (29/37), 14% CWT only (5/37) and 8% (3/37) of the marked fish exhibiting both an adipose clip and a CWT. An additional 53 coho (59% of the total, 53 of 90) were not marked in any way and can be considered natural origin. Mark rates were also investigated longitudinally (Table 3d). Seventeen coho were sampled in the middle river in 2025 and 2 of them (12%) were marked, a much smaller proportion than the lower river tangle net sampling (36% marked, 9/16). When only considering fish sampled within 1 KM of the mouth of the river from the tangle net sampling; below the channel split; at locations with presumably the least hatchery influence, 30% (3/7) were marked. Differences in mark rates were also apparent on a temporal scale among the tangle net sampled fish whereby the proportion of marked fish increased as the run progressed (Table 3e). November had the highest mark rate but only two fish were sampled (50% marked, 1/2), followed by October (40% marked, 6/15), and then September (25% marked, 2/8).

Male to female ratios from the tangle netting and the tribal fishery were similar at a 1.37:1 (22:16) and 1.53:1 ratio (164/107), respectively.

Discussion

We were successful at estimating the coho escapement to the Elwha River for the seventh consecutive year. We believe our estimate of the total return to the river of 3,247 coho salmon is robust for several reasons. Most importantly, we recorded data for what was likely the majority of the coho salmon run. Net sampling occurred for weeks prior to the first coho salmon being sampled and net sampling towards the end of the run showed declining catches and raw SONAR data showed little fish

passage. We were also able to produce coefficients of variation for the four measured sources of uncertainty in our estimate. In decreasing order these sources were (1) adjusting for species composition (2.9%), (2) error in the gap filling procedure (1.8%), (3) the uncertainty associated with adjusting for observer error (1.5%) and (4) expanding 20-minute counts to full hour counts (1.1%) (Table 2)

The highest source of uncertainty was associated with adjusting raw passage totals to reflect just coho salmon passage (2.9%). Most of the cause of the CV associated with assigning species to raw SONAR targets was the number of pink salmon that returned to the Elwha River year. The projects Chinook and pink salmon report estimated that approximately 35,000 pink salmon returned in 2025, seven times more than 2 years previous (Denton et al, 2026). Although the majority of pink salmon passage occurs in August, there were still thousands and possibly ten thousand still migrating upstream in September, after the first coho had been sampled. Therefore, thousands of SONAR targets in September needed to be correctly apportioned to species, and in this case, to the relatively few coho salmon present in the system during this time period. Fortunately, the tangle net data in early and mid-September, and perhaps most importantly, the snorkel survey on September 16, indicated that very few coho salmon were present reducing the need to apportion the vast majority of SONAR targets during that time period. Catches of coho did not dramatically increase until the pink salmon had almost entirely moved upstream passed the SONAR to spawn. Additionally, we were able to focus the species apportionment analysis on targets that measured between 55 cm and 81 cm, thus removing many of the targets that were either in the smaller pink salmon size range or the larger Chinook salmon size range. Nevertheless, it is possible that a significant portion of the hundreds of coho salmon that we estimated passing in the week following the snorkel survey on September 16 could have been pink salmon that were simply measured in a few centimeters too long in the SONAR software. Differentiating salmon lengths that are less than 10 cm apart with the SONAR is not very reliable (Denton et al. 2026). Finally, there appeared to be a relatively weak return of fall chum salmon to the Elwha River in 2025, which simplifies apportioning SONAR targets for the majority of the coho salmon run. Only twelve were sampled in the tangle nets, far fewer than the 42 sampled in 2024, and only five were sampled in the tribal fishery. Far fewer chum salmon were seen spawning in lower river side channels compared to 2024.

The second highest source of measured uncertainty came from the gap filling procedure (1.8%). The CV associated with this procedure in 2025 was similar to the last three years and is higher than the Chinook salmon or steelhead estimates. This was due to the highly variable hydrograph typical during the coho salmon run which necessitated removing the equipment during three different high flow events. The gaps from a high flow events occurred both when there was significant passage occurring and after the bulk of the run had passed. There were approximately 450 coho (14% of the total run) estimated to have passed during the combined ten days of data gaps. It is important to note that the gap filling procedure makes no attempt to estimate passage after the SONAR was removed for the season, November 26. However, based on fish passage rates during the week before removal it is unlikely that many coho entered the system after November 26. The sampling event on November 26 sampled no coho (and one steelhead) and another event on December 1 also captured no coho, and no other salmonids

The third highest source of measured uncertainty came from the adjustment for observer error. The measured CV (1.5%) of this adjustment was relatively low and similar to most other years and

species of this project. The project has been using the same data review technician for the last fourteen years and, at this point, this person has more experience than any other person involved in this project.

The smallest source of uncertainty was due to expanding 20-minute counts to full hour counts (1.1%). This is expected to be low as there is no reason why passage during the first 20 minutes of an hour should be any different than passage during the following 40 minutes, especially when averaged out over more than 2,000 hours. The project's 2024 steelhead report includes an analysis of ten years of steelhead SONAR counts where the whole hour was counted. Expanding the first 20 minutes of each hour and comparing them to the actual full hour counts across a decade of data indicated that on a yearly basis, the expansion can result in an error range of -16.8% to +11.4%, with an average across all ten years of an overestimation of 3.1% (Denton et al., 2024).

Redd surveys conducted on most of the middle and upper river tributaries below Rica Canyon during the 2025 coho salmon season may be useful to compare to our escapement estimate, although high water and staffing issues led to limited coverage in 2025. Olympic National Park staff counted a total of 81 redds in tributaries in the middle and upper river, much lower than the average of 2019-2024 (173) (Olympic National Park, pers. comm., 3/30/25). Similarly, redd numbers in the middle river tributaries of Little River and Indian Creek were lower than previous years. Little River had 10 redds (33 in 2021, 56 in 2022 and 21 in 2023) while 0 redds were counted in Indian Creek (79 in 2021, 55 in 2022 and 43 in 2023). It is important to note that only one redd survey was completed in each reach for both Little River and Indian Creek, with the lower section of Indian Creek not being surveyed until mid-January.

Fifty-nine percent of all coho salmon sampled (53/90) (Table 3c) were natural origin returns. This would represent a return of approximately 1,915 NOR adult coho. However, using all fish to calculate pHOS could bias the return towards hatchery fish because the NOR proportion in the species composition net sampling is biased low due to the proximity of several capture sites to the LEKT hatchery. Mark rates near the hatchery have been shown to be biased towards hatchery origin returns (HOR) for steelhead on the Elwha (Peters et al. 2020-2023). From 2021 to 2023, mark rates were longitudinally similar regardless of how they were grouped, however in 2024, and to a lesser degree in 2025, there was a lower mark rate when only using fish sampled at the lowest species composition site (30% pHOS, 3/10, Table 3d). Unfortunately, the majority of the coho captured in the tribal subsistence fishery (76%, 202/266) were not checked for a CWT and could therefore not be included in any further mark rate analysis. When investigated at a larger longitudinal scale, mark rates drop dramatically when comparing the lower river (36%, 9/16) to the middle river (12%, 2/17). This phenomenon of a lower proportion of hatchery origin fish moving passed the former lower dam is typical of other years of the project and has also been documented in steelhead in the Elwha River (Denton et al. 2025).

Our timing information can be compared to the entry timing data from 2019 through 2024 (Figure 11). The fifty percent entry date (October 9) was about one and two weeks earlier than 2022 (October 31) and 2024 (October 22), respectively and within a week of 2023, 2021 and 2020 (October 11, 7 and 2) and two weeks later than 2019 (September 25). There was a slight trend of the 50% passage data moving later each year until this year, when it became earlier. In the seven years of the project, coho salmon passage had either stopped or significantly slowed by late November (although that was difficult to ascertain in 2021), much earlier than other streams in Western Juan de Fuca. Pess et al. (2020) found that the average return date for coho salmon from NOR populations in three Western Juan

de Fuca stream was during the middle of November, over a month later than our 50% return date recorded during other years of the project, except in 2022 and 2024 when it was approximately two weeks later. In previous years we have seen a greater proportion of NOR fish in the system in November as compared to earlier months and any trend towards later run timing could be a sign of a natural population rebuilding towards a historical timing pattern seen in nearby streams lacking a hatchery population. While we did not see a higher proportion of natural origin fish in November in 2025, we only sampled two fish during that month.

It is important to compare this year's coho salmon escapement estimate to the six previous years of the project (Figure 12). The coho escapement in 2025 was the second smallest recorded during the six years of the project and was roughly 2,800 fish lower than the average of the previous six years of the project (5,034). The average return of the last six years is striking when compared to the coho population data before 2019 when few redds were identified that were dug by non-transplanted coho (Mike McHenry, pers. comm. 3/27/2023). Thousands of coho that returned to the LEKT hatchery during periods of high turbidity in the years immediately following dam removal were transplanted to both Little River and Indian Creek, complicating the evaluation of the naturally spawning coho population during those years. While coho redd counts are not a feasible method to estimate whole river population sizes, especially during the high turbidity years following dam removal, it is clear that the coho salmon population in the Elwha has been generally increasing since the SONAR project began in 2019 and that the population was likely much smaller in the years before the SONAR project began. That being said, 2025 continues a three-year downward trend in the Elwha coho population numbers and 2025 in particular represents a dramatic drop from the previous six year average run size.

Recommendations

Last year's first recommendation of better accounting for the chum salmon population was not necessary as very few chum salmon were encountered in any survey method. Unfortunately, our other recommendation, coordinating with the tribal fishery to collect SONAR relevant data actually became a larger issue due to the lack of CWT data collected from 75% of the sampled coho which rendered these fish useless for mark rate analysis.

The tribal fishery is already a source of valuable data to the SONAR project that not only greatly boosts the sample sizes for species apportionment and mark rates but also provides a level of effort and community involvement that the SONAR project cannot replicate. In an effort to bolster this collaboration, we recommend these specific data collection items: 1) Every fisheries data collection personnel should carry a CWT wand with them and check every kept coho, 2) Ask fisherman to record the "status" of released salmonids as "spawning" (has initiated or completed spawning, "holding" (is colored up but has not yet started spawning) or "new" (still relatively bright and entered the river within the previous two weeks). Specifically, this data is crucial to determining the end of the Chinook run as the tribal fishery moves earlier each year and SONAR personnel can no longer tangle net in deference to tribal fishers. The SONAR project needs to know the status of any Chinook (or pink salmon in odd years) encountered by tribal fishers.

Finally, better communication with the larger coho management team could help focus deliverables and timetables for the SONAR project. For example, when do co-managers need an escapement number for out year forecasting and what is the most useful way to present mark rate information?

Acknowledgements

The authors would like to thank several people who helped with the species composition netting portion of this project including Ray Moses, Wilson Wells and Gabe Ritchie from the LEKT. Katie Furey collated the redd survey data. Mike McHenry from the LEKT provided valuable edits to the final manuscript.

The 2025 Elwha coho SONAR project was funded through the BIA ESA program.

Literature Cited

- Belcher, E. O., B. Matsuyama, and G. M. Trimble. 2001. Object identification with acoustic lenses. Pages 6–11 in Conference proceedings MTS/IEEE oceans, volume 1, session 1. Honolulu, Hawaii.
- Belcher, E. O., W. Hanot, and J. Burch. 2002. Dual-frequency identification sonar. Pages 187–192 in Proceedings of the 2002 International Symposium on underwater technology. Tokyo, Japan.
- Cousens, N. B., Thomas, G. A., Swann, C. G., and Healy, M. C. 1982. A review of salmon estimation techniques. Can. Tech. Rep. Fish. Aquat. Sci. No. 1108.
- Cronkite, G. W., Enzenhofer, H. J., Ridley, T. Holmes, J., Lilja, J. and Benner, K. 2006. Use of high-frequency imaging sonar to estimate adult sockeye salmon escapement in the Horsefly River, British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 2647: vi + 47p.
- Cronkite, G.M.W., Enzenhofer, H.J., and Holmes, J.A. 2008. Evaluation of the BlueView ProViewer 900 Imaging Sonar as a tool for counting adult sockeye salmon in the Adams River, British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 2798: iv + 21 p.
- Denton, K.P. and Liermann, M.M. 2010. Estimation of the 2010 Summer Chinook Escapement in the Elwha River Using BlueView Multi-beam Sonar Technology. Prepared for the Lower Elwha Tribe.
- Denton, K.P. and Liermann, M.M. 2012. Estimation of the 2012 Chinook Escapement in the Elwha River Using DIDSON Multi-beam Sonar Technology. Prepared for the Lower Elwha Tribe.
- Denton, K.P., Moses, R., McHenry, M., McMillan, J., Liermann, M., Pess, G. 2013. Final Report: 2013 Elwha River Chinook escapement estimation based on DIDSON multi-beam SONAR data. Prepared for the Lower Elwha Tribe.
- Denton, K., Moses, R., McHenry, M., McMillan, J., Ward, E., Stefankiv O., Wells, W. Liermann, M., Pess, G. 2014. Elwha River Chinook escapement estimate based on DIDSON/ARIS multi-beam SONAR data. Prepared for the Lower Elwha Tribe.
- Denton, K., Moses, R., McHenry, M., McMillan, J., Ward, E., Stefankiv O., Wells, W. Liermann, M., Pess, G. 2015. Elwha River Chinook escapement estimate based on DIDSON/ARIS multi-beam SONAR data. Prepared for the Lower Elwha Tribe.
- Denton, K., Moses, R., McHenry, M., McMillan, J., Ward, E., Stefankiv O., Wells, W. Liermann, M., Pess, G. 2016. Elwha River Chinook escapement estimate based on DIDSON/ARIS multi-beam SONAR data. Prepared for the Lower Elwha Tribe.
- Dunbar, R. 2001. Copper River Hydroacoustic Salmon Enumeration Studies, 2000 and 2001. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A01-3, Anchorage.

- Dunbar, R. 2003. Anvik River sonar chum salmon escapement study, 2003. Regional Information Report No. 3A03-14. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.
- Dunbar, R. and C.T. Pfisterer. 2004. Sonar estimation of fall chum salmon abundance in the Sheenjek River, 2002. Regional Information Report No. 3A04-10. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.
- Enzenhofer, H. J., Olsen N., Mulligan, T. J. 1998. Fixed-location riverine hydroacoustics as a method of enumerating migrating adult Pacific salmon: comparison of split-beam acoustics vs. visual counting. *Aquat. Living Resour.* 11:61-74.
- Enzenhofer, H.J., and Cronkite, G. 2005. A simple adjustable pole mount for deploying DIDSON and split-beam transducers. *Can. Tech. Rep. Fish. Aquat. Sci.* 2570: iv + 14 p.
- Enzenhofer, H. J., Cronkite, G. M. W., Holmes, J. A. 2010 Application of DIDSON Imaging SONAR at Qualark Creek on the Fraser River for Enumeration of Adult Pacific Salmon: An Operation Manual. *Can. Tech. Rep. Fish. Aquat. Sci.* 2869.
- Holmes, J. A., Cronkite, G. W., Enzenhofer, H. J., Mulligan, T. J. 2006. Accuracy and precision of fish-count data from a “dual-frequency identification sonar” (DIDSON) imaging system. *Journal of Marine Science.* 63:543-555.
- Levy, D. A., Nealson, P. A., and Cheng, P. 1991. Fixed-aspect hydroacoustic estimation of Fraser River sockeye salmon abundance and distribution at Mission, B. C. *in* 1986. *Pac. Salmon Comm. Tech. Rep. No. 4.*
- Lilja, J, Ridley, T., Cronkite, G. M., Enzenhofer, H. J., and Holmes, J. A. 2008. Optimizing sampling effort within a systematic design for estimating abundant escapement of sockeye salmon (*Oncorhynchus nerka*) in their natal river. *Fisheries Research* 90:118-127
- Maxwell, S. L. 2008. Hydroacoustics: Rivers. Pgs 133-152 *in: Salmonid Field Protocols Handbook Techniques for Assessing Status and Trends in Salmon and Trout Populations.* Amer. Fish. Soc., Bethesda, MD.
- McKinley, W.L. 2002. Sonar enumeration of Pacific salmon into the Nushagak River, 2001. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A02-25, Anchorage.
- Pess, G., McHenry, M., Ehinger, W., Bennett, T., Hanson, K., Liermann, M. 2020. Strait of Juan de Fuca Intensively Monitored Watersheds 2019 Annual Report. Prepared for the Salmon Recovery Funding Board. 52 pgs.
- Peters, R.J., Denton, K., Liermann, M. 2020. Proportion of Hatchery Origin Steelhead and Broodstock Collection in the Elwha River: 2019. Report to the Lower Elwha Klallam Tribe.

Weinheimer, J., Anderson, J., Cooper, R., Williams, S., McHenry, M., Crain, P., Brenkman, S., and Hugunin, H. 2018. Age structure and Hatchery Fraction of Elwha River Chinook Salmon: 2017 Carcass Survey Report.

Westerman, D. L., and T. M. Willette. 2003. Upper Cook Inlet salmon escapement studies, 2002. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report 2A03-24, Anchorage.

Xie, Y., A. P. Gray, F. J. Martens, J. L. Boffey and J. D. Cave. 2005. Use of Dual-Frequency Identification Sonar to Verify Salmon Flux and to Examine Fish Behaviour in the Fraser River. Pacific Salmon Comm. Tech. Rep. No. 16: 58 p.

Table 1a. Total number of “new” and “holding” captured salmonids measuring over 550 mm at 7 sites during in-river netting operations, snorkel surveys, and tribal set nets in the lower 4 KM of the Elwha River in 2025. The blue shaded data was from a snorkel survey. The grey shaded data was collected from the tribal net fishery conducted near the mouth of the river. This data was collated into one week bins with the listed date at the midpoint of the week bin. This is the data that was used to apportion raw SONAR targets.

Date	Chinook	Chum	Coho	Pink	Steelhead	Location	% Coho
9/2/2025	36	1	1	10	0		2%
9/8/2025	15	1	1	2	0		5%
9/15/2025	12	0	5	12	0		17%
9/16/2025	1,200		20	3,500		Above SONAR	0%
9/16/2025	300		100	1,400		Below SONAR	6%
9/16/2025	1,500		120	4,900		Combined	2%
9/26/2025	0	0	152	0	0		100%
10/4/2025	0	0	66	0	0		100%
10/7/2025	0	0	3	0	0		100%
10/14/2025	0	4	8	0	0		67%
10/14/2025	0	0	23	0	0		100%
10/21/2025	0	0	15	0	0		100%
10/27/2025	0	2	4	0	0		67%
11/4/2025	0	0	1	0	0		100%
11/18/2025	0	1	1	0	0		50%
11/26/2025	0	0	0	0	1		0%

Table 1b. Total number of captured salmonids measuring over of all sizes and all conditions at 7 sites during in-river netting operations, snorkel surveys, and tribal set nets in the lower 4 KM of the Elwha River in 2025. The blue shaded data was from a snorkel survey. The grey shaded data was collected from the tribal net fishery conducted near the mouth of the river. This data was collated into one week bins with the listed date at the midpoint of the week bin.

Date	Chinook	Chum	Coho	Pink	Steelhead	Location	% Coho
9/2/2025	51	1	1	50	0		1%
9/8/2025	15	1	1	13	0		3%
9/15/2025	21	0	6	43	0		9%
9/16/2025	1,200		20	3,500		Above SONAR	0%
9/16/2025	300		100	1,400		Below SONAR	6%
9/16/2025	1,500		120	4,900		Combined	2%
9/26/2025	4	0	155	5	0		95%
10/4/2025	3	0	73	3	0		92%
10/7/2025	0	0	3	0	0		100%
10/14/2025	0	4	10	1	0		67%
10/14/2025	0	0	24	0	0		100%
10/21/2025	0	5	18	0	0		78%
10/27/2025	0	2	5	0	0		71%
11/4/2025	0	0	1	0	0		100%
11/18/2025	0	1	1	0	0		50%
11/26/2025	0	0	0	0	1		0%

Table 2. Individual coefficients of variation for each adjustment procedure. The overall CV reflects the uncertainty incorporating all four sources of uncertainty and the individual CV estimates represent the uncertainty correction applied to the raw data to reflect the CV for each individual step.

Source of Uncertainty	OM (Total)
Expansion	1.1%
Species Composition	2.9%
Observer Error	1.5%
Gap Fill	1.8%
Overall	3.7%

Table 3a. Mark rates for all coho sampled in the lower 4 KM of the Elwha River between September 2 and November 26, 2025, during species composition tangle net sample.

Mark	Ad Clip Only	CWT Only	Both	Neither	Total
Raw Number	6	1	2	16	25
Percentage of Marked Fish	67%	11%	22%		
Percentage of Total	24%	4%	8%	64%	

Table 3b. Mark rates for all coho greater sampled in the tribal fishery near the mouth of the river between September 23 and October 23, 2025.

Mark	Ad Clip Only	CWT Only	Both	Neither	Total
Raw Number	23	4	1	37	65
Percentage of Marked Fish	82%	14%	4%		
Percentage of Total	35%	6%	2%	57%	

Table 3c. Combined mark rates from the tangle net and tribal fishery. This data is a combination of tables 3a and 3b.

Mark	Ad Clip Only	CWT Only	Both	Neither	Total
Raw Number	29	5	3	53	90
Percentage of Marked Fish	78%	14%	8%		
Percentage of Total	32%	6%	3%	59%	

Table 3d. Mark rates for coho sampled in species composition tangle netting from different sections of the river. All fish presented in table 3a are included here in addition to the middle river fish. HOR fish can exhibit any combination of an adipose clip and/or CWT.

River Section	HOR	NOR	pHOS
Below Channel Split	3	7	30%
All Lower River	9	16	36%
Middle River	2	15	12%

Table 3e. Mark rates for all coho captured in species composition netting in different months in the lower 4 KM of the Elwha River in 2025.

Month	HOR	NOR	pHOS
September	2	6	25%
October	6	9	40%
November	1	1	50%

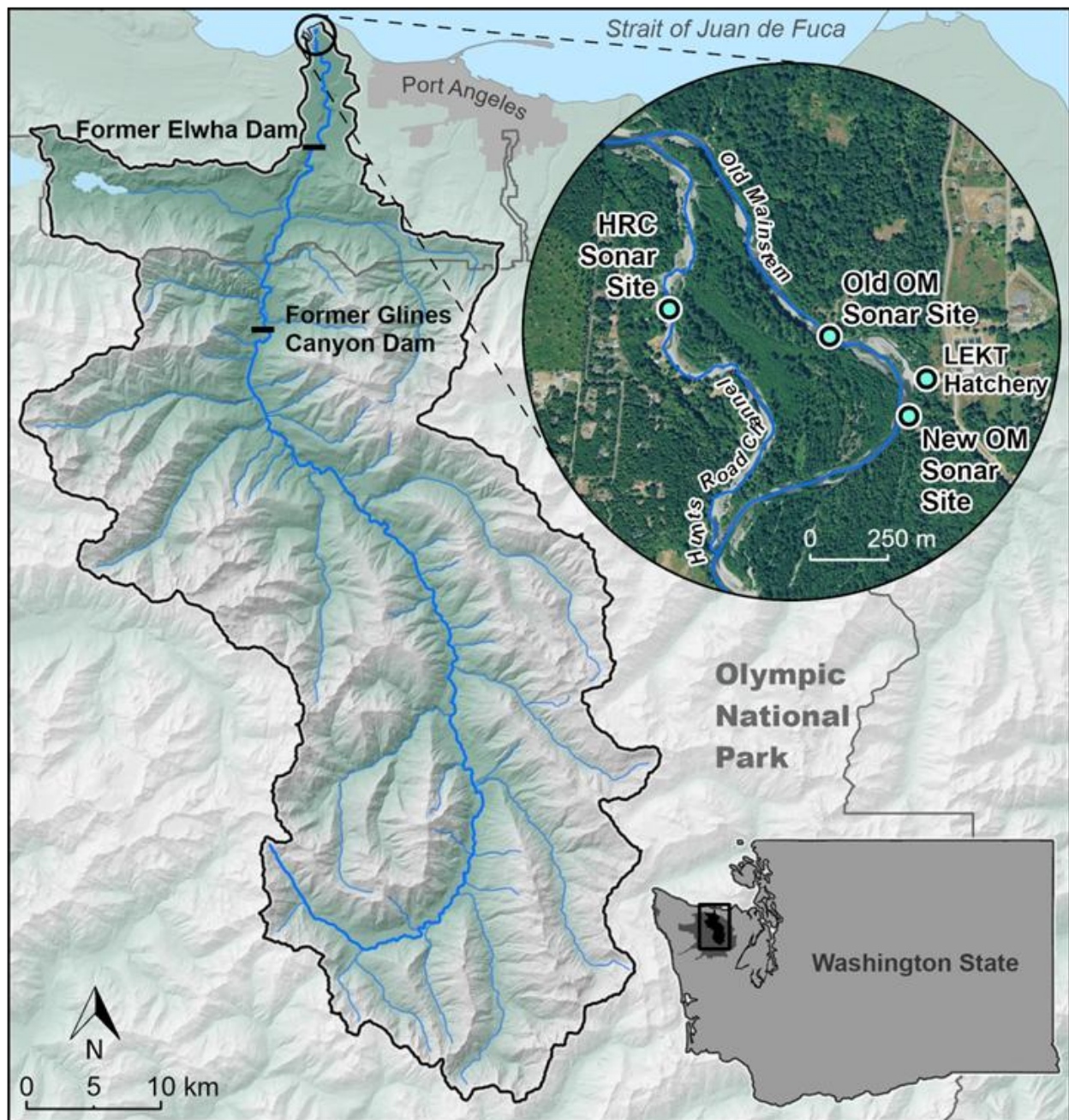


Figure 1. Map of the Elwha River, depicting the former dam sites, SONAR sites, Elwha Tribal Hatchery, and the two distinct migratory pathways near the mouth of the river. No SONAR was installed at the HRC site in 2025. The SONAR was located at the “Old OM Sonar Site” from September 2 until October 20, 2025. On October 20 it was moved upstream to the “New OM Sonar Site” where it remained until the end of the season on November 26, 2025.



Figure 2. Looking downstream at the lower SONAR site, labeled “Old OM Sonar Site” in Figure 1. The SONAR is attached to the pole mount which is in turn attached to the ladder. The SONAR recorded data at this site from September 2 through October 20, 2025.



Figure 3. Upper SONAR site looking upstream. This site is labeled as “New OM Sonar Site” in Figure 1. The SONAR is attached to the pole mount which is in turn attached to the ladder. The SONAR recorded data at this site from October 20 through November 26, 2025.

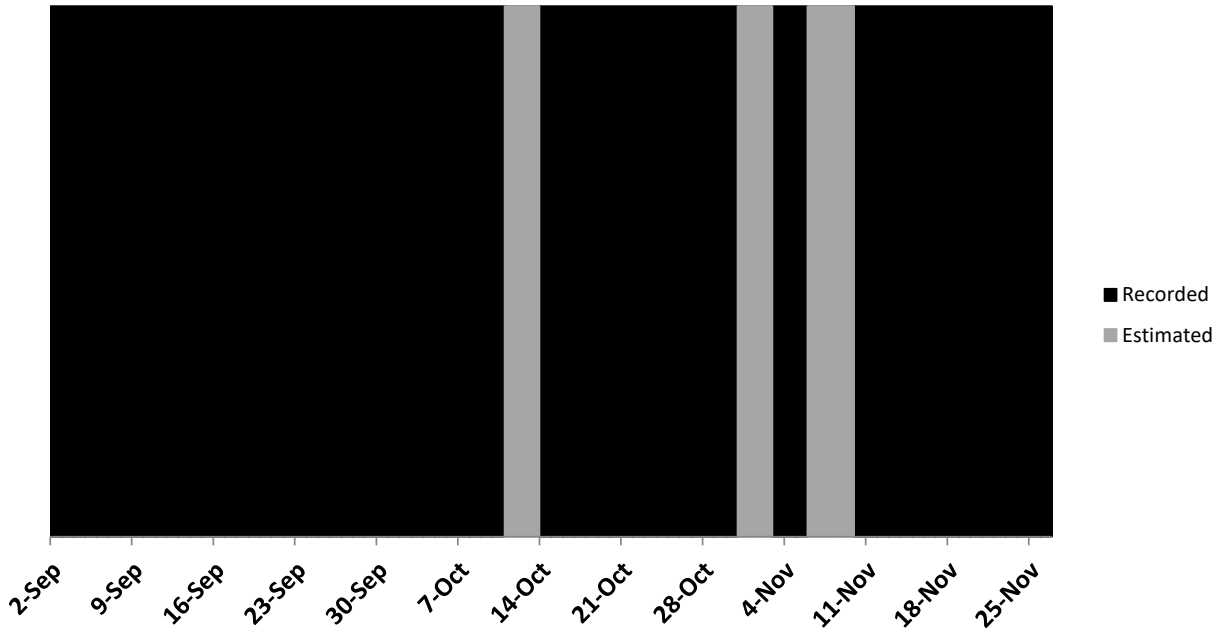


Figure 4. Dates for which data was recorded or estimated during the coho salmon season on the Elwha River in 2025.

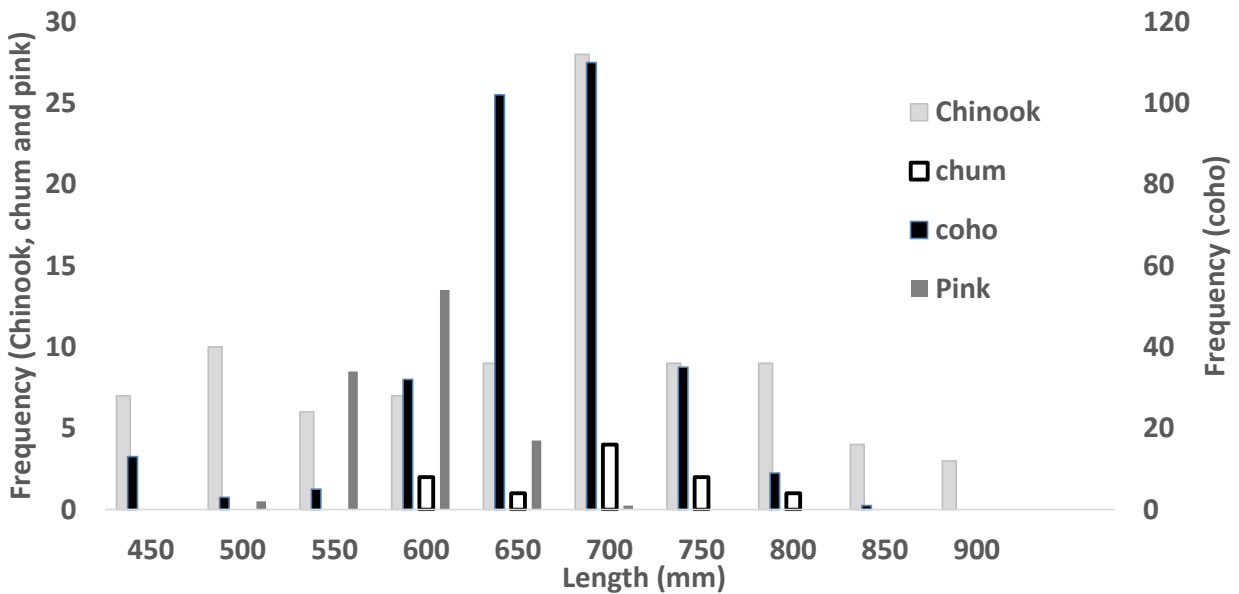


Figure 5. Length frequency histogram for all salmonids (except one steelhead sampled on November 26) caught between September 2, 2025 and November 26, 2025 in the Elwha River. The figure includes coho sampled during both species composition netting (n = 46) and the tribal fishery (n = 266).

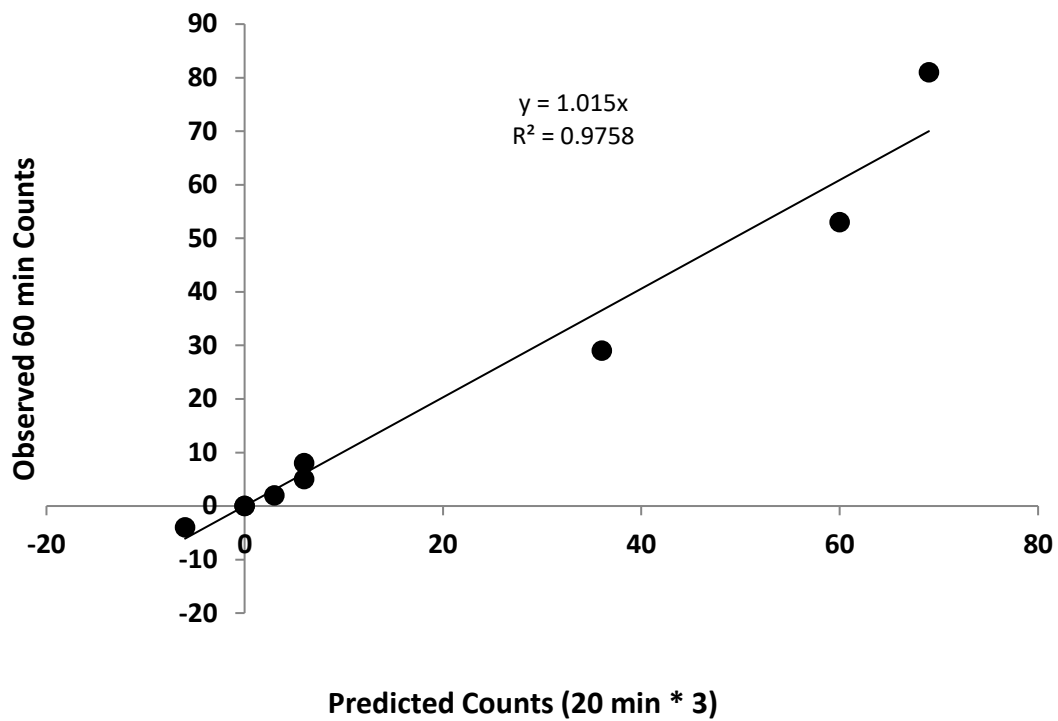


Figure 6. Predicted (20 minutes * 3) vs. observed (actual 60-minute counts) for 9 six-hour chunks of full hour counts. There are two points at (0,0).

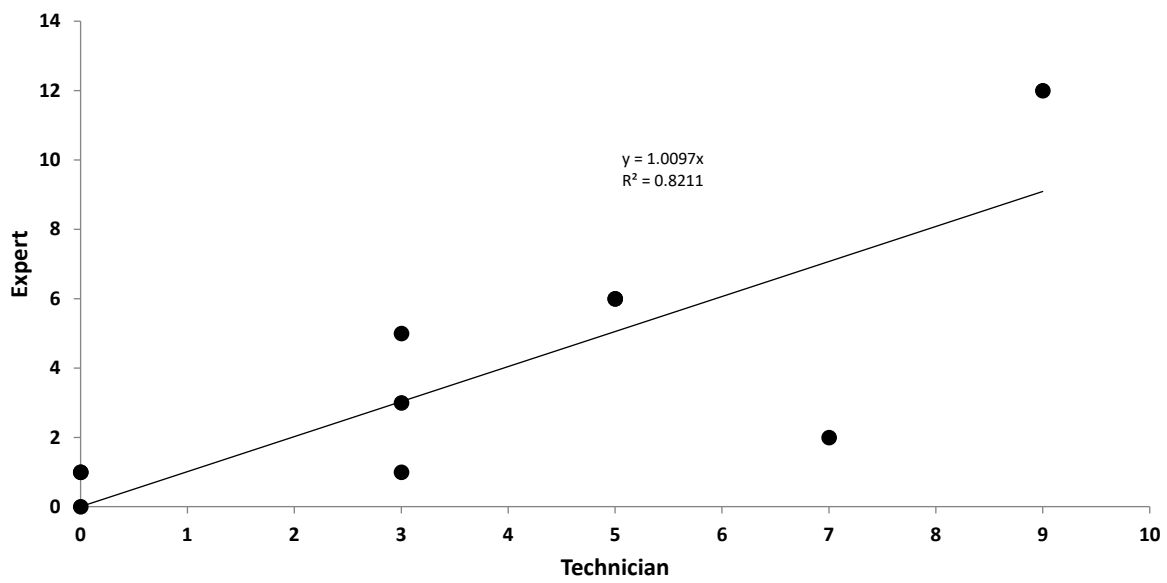


Figure 7. Total upstream passage counted by a technician and expert for 11 six-hour chunks. There are two points at both (1,0) and (6,5).

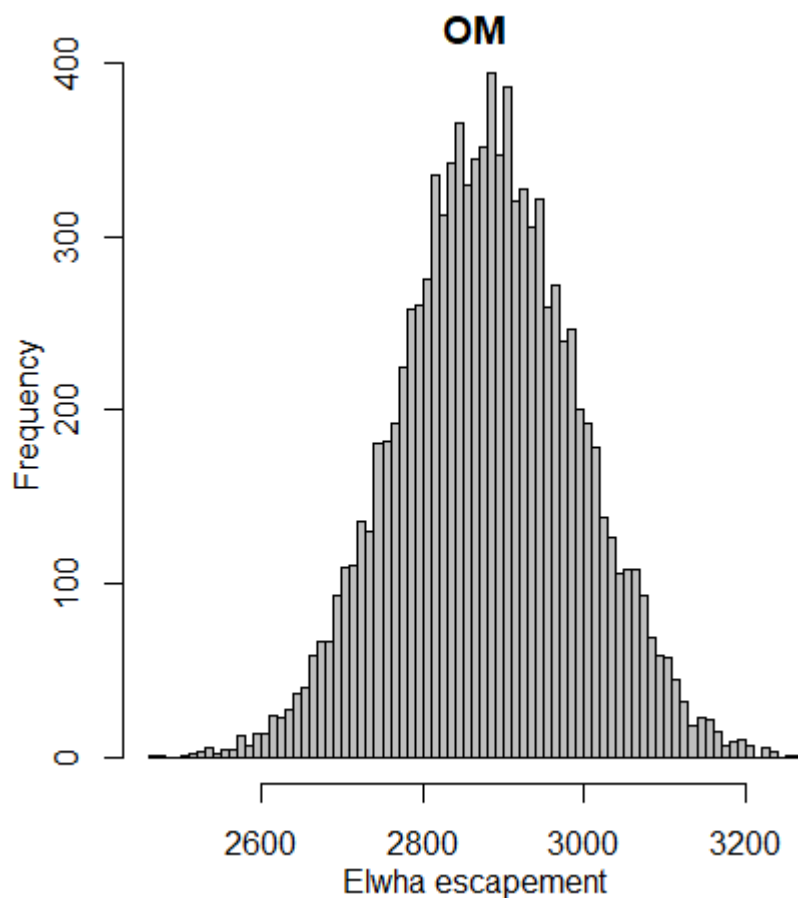


Figure 8. Coho salmon run size estimates passed the SONAR site for the Elwha River in 2025 based on 10,000 model runs. This shows only non-jack (>550 mm) coho salmon numbers and does not include the rack return to the Lower Elwha Tribe Hatchery (82 coho) after the SONAR was moved upstream of the outfall on October 20, or the 265 coho that were removed from the below the SONAR during the tribal fishery.

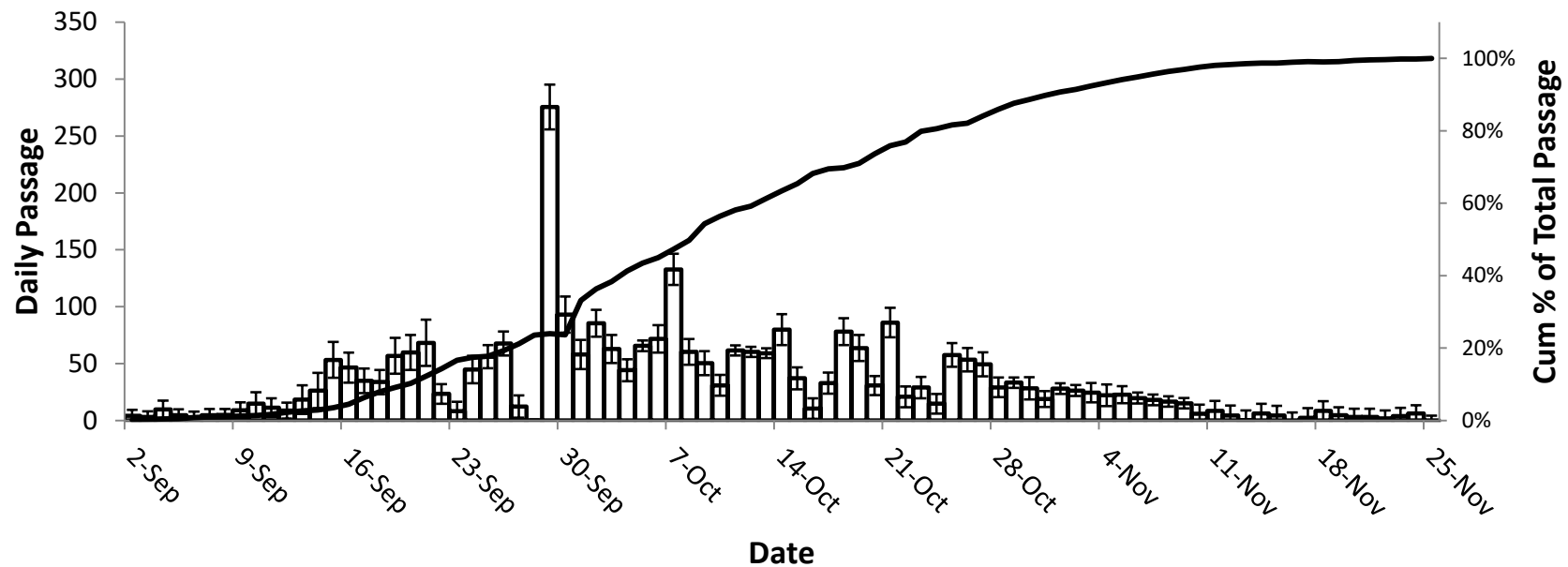


Figure 9. Daily coho salmon passage (> 550 mm) and cumulative percent of total run in the Elwha River in 2025. Daily passage values have been adjusted for subsampling expansion, species composition, observer error, and data gaps. Error bars represent the standard deviation of passage for each day. Total passage estimate for the EC was 2,900 coho salmon. This does not include the additional total of 347 fish that were removed from the river during the tribal fishery or that returned to the LEKT hatchery after October 20.

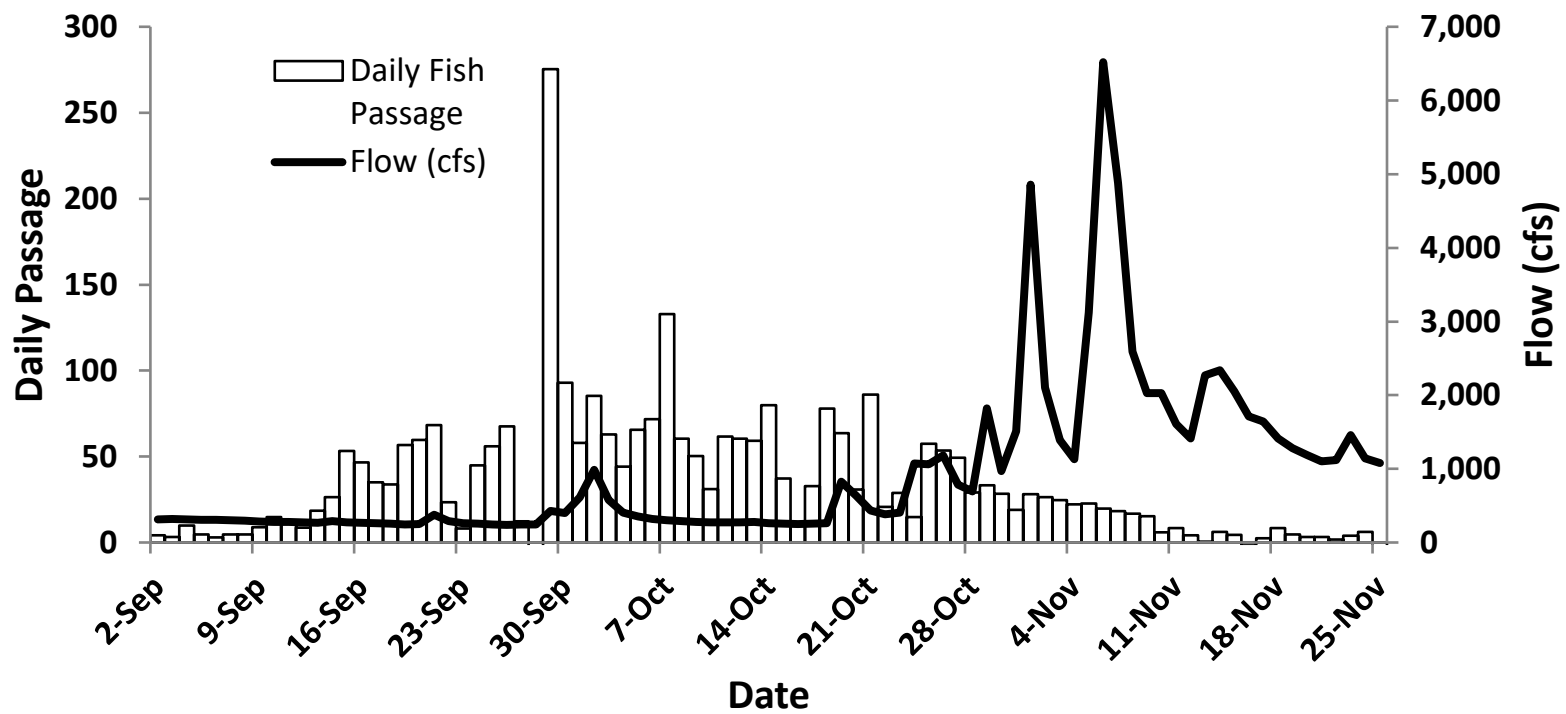


Figure 10. Daily coho passage and flow (cfs) for the Elwha River in 2025.

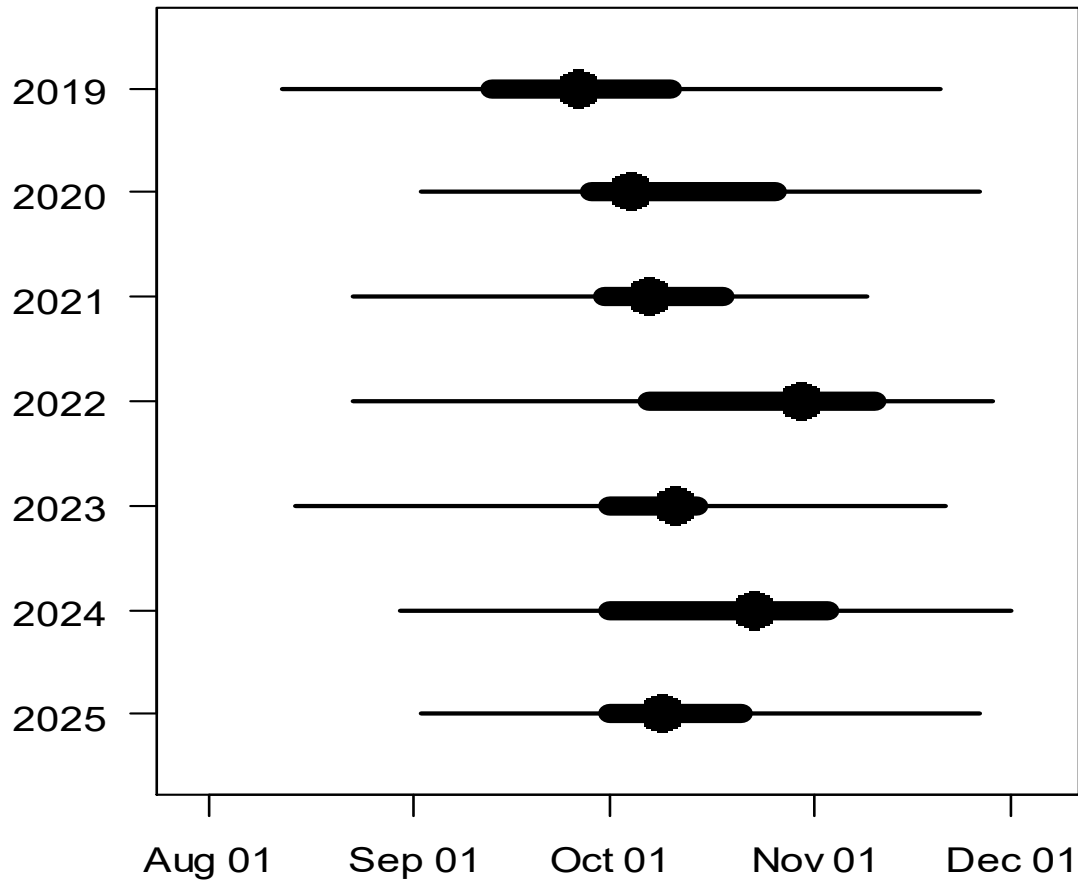


Figure 11. Run timing of coho salmon in the Elwha River from 2019 to 2025. For each year, the long thin black line encompasses the first coho sampled until the date at which the SONAR was pulled for the season. The thick black line shows the time period during which 25% to 75% of the run passed the SONAR sites. The black dot shows when 50% of the run had passed.

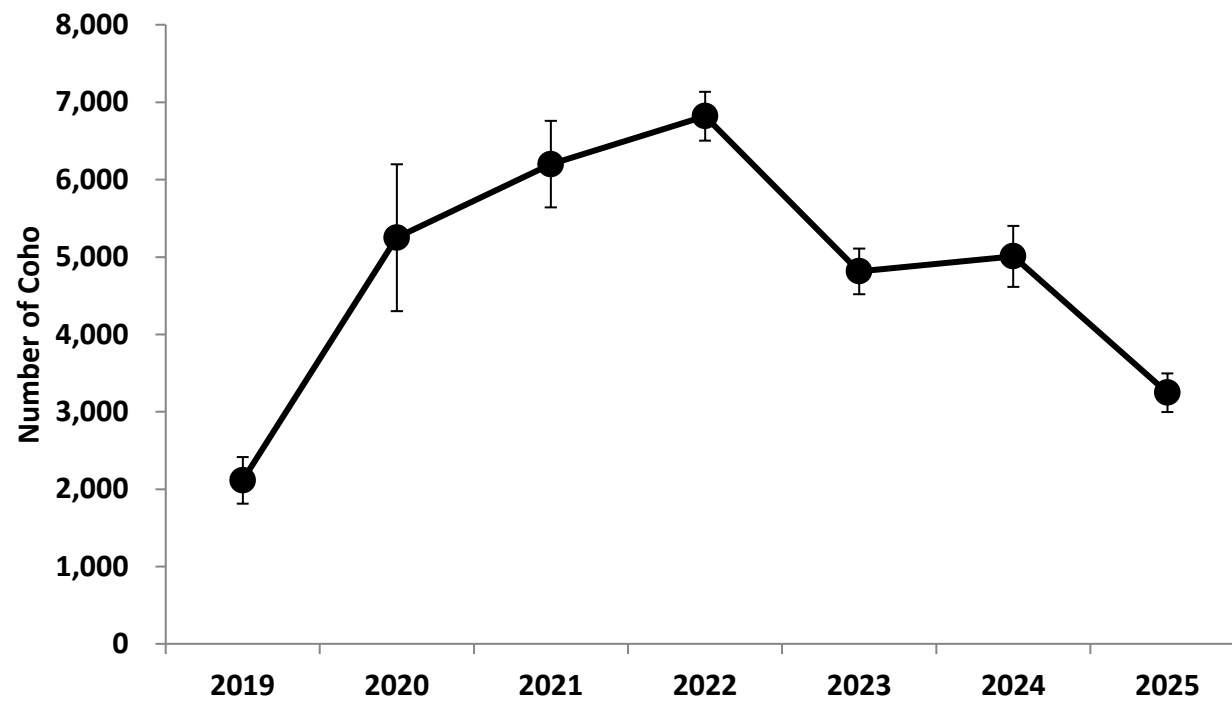


Figure 12. Escapement estimates for adult coho salmon (year specific length cutoffs) to the Elwha River from 2019-2025. Error bars show upper and lower bounds of each estimate based on year specific methods. The 2023, 2024 and 2025 estimates include 152, 104, and 265 fish that were removed during the LEKT fishery and therefore do not represent a true escapement.