

# **2025 Elwha River Chinook and Pink Salmon Escapement Estimates Based on ARIS Multi-Beam SONAR Data**



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## Executive Summary

We used an ARIS 1800 multi-beam SONAR unit to monitor Chinook salmon escapement in the Elwha River daily from June 11 through September 23, 2025. We reviewed 10 minutes of each hour-long file for 42 days and 20 minutes of each hour for the other 63 days. This resulted in an expanded raw SONAR count of 41,565 targets that then needed to be apportioned to species. Using a strict application of our species composition data and an alternative “pink salmon heavy” adjustment of the same data yielded Chinook salmon escapement estimates of 16,800 and 7,300, respectively. Both estimates are improbably high and are only provided to illustrate the difficulty in estimating a Chinook salmon population that was roughly one seventh the size of the pink population in 2025. Another method of only tabulating SONAR targets that measured 70 cm or greater yielded a Chinook escapement estimate of 4,800 fish and represents our most robust estimate. A final, SONAR independent, redd based method produced a Chinook escapement estimate of 4,676 fish, which roughly corroborates our most robust SONAR method.

Fifty percent of the Chinook salmon run passed the SONAR sites by August 7, which was 10 days later than the 15-year average, but is likely biased by the large pink salmon migration centered in mid-August that was difficult to differentiate from the Chinook salmon migration. We captured the first Chinook salmon during species composition netting on June 11, which was approximately a week later than the median date since 2013 (June 3).

The 2025 Chinook salmon estimate of 4,800 fish is the third highest return in the 15-year history of the SONAR project and about 900 fish larger than the average return since 2009. The estimate of 35,000 pink salmon continues the trend of a rapidly increasing population with returns of 650 in 2019, 2,300 fish in 2021 and 6,400 fish in 2023.

Our major recommendation this year is to assess the feasibility of using SONAR to enumerate Chinook salmon in pink salmon years and the alternative of relying on Chinook salmon redd surveys. Additionally, a larger conversation on linking Elwha River monitoring to management goals should be prioritized among the Elwha River fish management community to better focus monitoring efforts. Finally, the Elwha SONAR project has recently received support and funding from the Wild Salmon Center to integrate computer vision and machine learning tools into our data review pipeline and this new effort should be integrated throughout the project protocols.

## 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. Multiple methods have been used to estimate escapements of adults, including aerial surveys, counting towers, weirs, redd surveys, mark-recapture studies, and SONAR technology (reviewed by Cousens et al. 1982). While all these technologies and techniques have advanced to varying degrees, SONAR technology and application to escapement estimation have 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 numerous 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 the newer version, **ARIS** (**A**daptive **R**esolution **I**maging **S**onar).

Several studies have been conducted relating 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). DIDSON counts have consistently had relatively low error rates when compared to the more traditional methods. It is important to note, however, that almost all the fisheries applications of SONAR have been focused on large salmon runs that transpire over the course of only a few short weeks, which requires large technical staffs and operating budgets (e.g. Lilja et al. 2008, Enzenhofer et al. 2010). In this study, we attempt to enumerate a relatively small and protracted run of Chinook salmon (*Oncorhynchus tshawytscha*) using multi-beam imaging SONAR. In 2025 we had the added difficulty of parsing out the relatively small Chinook population from the much larger pink salmon (*O. gorbuscha*) population.

This project is focused on the enumeration of Chinook salmon in the Elwha River, Washington through its entire run which occurs from late May through mid-September (see Denton et. al. 2010-2024). The Elwha River, located on the north Olympic Peninsula in Washington State, provides a unique opportunity for fish enumeration using a multi-beam sonar system. Two dams had blocked fish passage to nearly 146 Km of main stem and tributary habitat since 1911, but removal of both dams began in September 2011 (Elwha River Fisheries and Ecosystem Restoration Act, 1992). The lower dam (Elwha) was completely removed in the spring of 2012. The upper dam (Glines Canyon) was removed by late summer 2014. In October 2014, shortly after the Glines Canyon Dam removal was complete, a large rockfall occurred in the canyon immediately downstream of the dam site near RKM 20.0 (Brenkman et al. 2019). The accumulation of rockfall debris and large boulders created a new barrier to upstream passage of adult salmonids. Rock blasting occurred in October 2015 to improve fish passage, and additional blasting in September 2016 eliminated the barrier (Brenkman et al. 2019).

As highlighted in the Guidelines for Monitoring and Adaptively Managing Restoration of Chinook salmon and steelhead on the Elwha River (Peters et al. 2014), a critical aspect to evaluating the success and rate of recolonization of anadromous fish during and after dam removal is estimating the abundance of adults returning to the entire river system each year. A major goal of the Elwha and Glines Canyon Dam removals is to increase salmon and steelhead populations. However, dam removal led to the release of large amounts of trapped sediment, which severely limited visibility in the river, at least for the five years post removal. This made the use of traditional enumeration methods (i.e. redd surveys) highly ineffective for specific species and time periods (Magirl et al. 2014). While limited visibility, at least during Chinook salmon spawning, is seldom an issue at this point post dam removal, SONAR estimates have been shown to be a more precise estimate of Chinook salmon escapement mainly due to redd superimposition. In addition, the removal of both dams opened access to approximately 90% of the watershed that was previously inaccessible to anadromous fish which is much more difficult to survey than the area below the former dams (Pess et al. 2008). Therefore, SONAR is the best technique for producing precise escapement estimates for anadromous salmon populations during and after dam-removal.

One of the species of most concern in the Elwha River is Chinook salmon, which is part of the Puget Sound Chinook Evolutionary Significant Unit (ESU) listed as threatened under the Endangered Species Act (ESA) (Montgomery 2003). Estimating adult Chinook salmon returns on the Elwha River presents several challenges. The Elwha River is a dynamic environment that includes consistently changing stream channel morphology due to relatively high stream power (Ritchie et al. 2016). Because of variable stream flows related to snowmelt during the Chinook salmon migration, the SONAR site requires constant attention, including removal and re-installation to avoid loss or damage to the equipment. Lastly, like other Puget Sound rivers, the Elwha River mainstem has an anastomosing or forested island morphology resulting in multiple channels for fish to migrate through (Beechie et al. 2006). These factors provide a unique opportunity to evaluate the ability of SONAR to estimate adult escapements, examine sources of estimation error, and advance understanding of how to improve the use of SONAR in future monitoring efforts. The objectives of this study are to: 1) provide a range of estimates of the Chinook salmon escapement to the Elwha River; 2) provide run timing information; 3) determine the proportion of Chinook salmon and other species of migrating salmon in the river during the course of the Chinook salmon run; 4) provide an estimate of pink salmon that passed the SONAR site during the Chinook migration period; 5) provide a comparison of the SONAR Chinook estimate to the redd based estimate over the 10 year history of the project; and 6) make recommendations on how to improve the use of SONAR to enumerate adult salmon in the Elwha in the future, particularly in pink years.

## **Methods**

### *Data Collection*

Continually changing river conditions and two distinct stream channels (migratory pathways) in the lower Elwha River have historically necessitated two separate SONAR installations to accurately detect Chinook salmon passage, one in the east channel, also referred to as the Mainstem and the other in the west channel, also referred to as the Hunt Road Channel (HRC) (Fig. 1). Since 2023, due to stream channel

changes and the effects of multiple engineered logjams, only one channel on the east side of the valley was hydrologically active during the Chinook salmon migration season. Site selection was based on four criteria: 1) almost all fish would pass the site; 2) the location was downstream of the majority of Chinook 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.

Following the recommendations of the 2022 report, the Mainstem site was moved approximately 500 meters downstream to the location it had occupied previously to 2022, labeled as “Old OM Site” (Fig 1). It has become apparent that the “new” OM site is ideal for higher flow operations during steelhead and coho season while the “old” site is better for the lower flow Chinook season. The SONAR was operational at the “new” OM site until July 9, after which flows had dropped low enough to move it downstream to the “old” OM site where it remained until the end of the Chinook season. An ARIS 1800 was used to monitor the Mainstem site (1.1/1.8 Mhz, provided by Olympic National Park).

The “new” mainstem site (RKM 2.5, Fig. 2) was 25-30 m wide and 1.5 m deep in the thalweg and the “old” OM site (RKM 3, Fig. 3) was 20-25 m wide and 0.5 to 1 m deep in the thalweg. The SONAR was attached to a pole mount (Enzenhofer and Cronkite 2005) that was then mounted on a reinforced ladder. The SONAR and ladder were positioned just under the surface of the water with an average downward angle of approximately 4°. The goal of this placement was to ensonify the bottom of the river across the entire width of the channel in addition to clearly “seeing” the far bank (see Enzenhofer 2010 for details on aiming the beam).

Both mainstem sites were powered by a 24-volt, 400-amp hour battery bank that was continually charged by an array of solar panels. Chinook passage was recorded at the “new” mainstem site from June 11 through July 9 and at the “old” mainstem site from July 9 through September 23, 2025. During this time the SONAR ran continuously and there were no data gaps to fill.

The SONAR was in operation prior to June 11, 2025, throughout the winter and spring of 2025 to record steelhead passage. Data, analysis, and an estimate of steelhead passage for this time is available in the project's steelhead report (Denton et al., 2025). Additionally, the SONAR was in operation after September 23 to record coho salmon passage. Data, analysis, and an estimate of coho passage for this time is available in the project's coho report (Denton et al. *in prep*).

### **Species Composition**

Due to the high return of pink salmon to the Elwha River in 2025 and their temporally concurrent but longitudinally differing migration patterns from Chinook salmon, several different sources of species composition data were used to inform our abundance estimates, including tangle net surveys, snorkel surveys, and data from the tribal set net fishery.

We conducted tangle net surveys on 10 different days between June 11 and September 23 to capture live adult salmonids at 7 different sites in the lower three kilometers of the river. Two netting sites

were ~500 m above the Mainstem SONAR site, one site was at the Mainstem SONAR site and the other four were below the SONAR site and below the channel split at ~RKM 1. Effort was consistent across sampling dates. We used the tangle net data to determine both the beginning and end of the Chinook salmon run and also to differentiate species of salmonids passing by the SONAR sites during the run. Captured fish were measured for fork length and qualitatively categorized as “new” if they appeared to have been in the river for less than 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 or finished spawning. The tangle-net was approximately 20 m long and 4 m deep with a 10 cm mesh of 8# monofilament. We also used the in-stream netting data to compare SONAR measured targets to the lengths of Chinook, jack Chinook, and non-Chinook salmonids, which included bull trout, pink salmon, chum salmon, winter and summer run steelhead, and several coho salmon towards the end of the Chinook salmon run (Fig. 4).

We also conducted four snorkel surveys from ~RKM 5 to the mouth; one in July, two in August, and one in September. An estimate of the total number of each adult salmonid species was tallied separately for the river section above and below the SONAR. Finally, set net data from the tribal fishery from late September was used to determine the end of the Chinook salmon run.

It is important to note that Chinook and pink salmon appear to exhibit different migratory patterns through the lower Elwha River and therefore the species composition data from all our sources are likely biased towards Chinook salmon. This is because Chinook salmon, which are approximately 85% hatchery origin, generally enter the river throughout July and August and then hold in deep pools formed by engineered logjams in the lower 3 kilometers of the river, which is downstream of the location of the WDFW hatchery outlet that they are released from. A portion of them then move upstream to spawning grounds in September. Pink salmon, on the other hand, are all natural origin and enter the river beginning in late July, increasing throughout August and move through the lower river more quickly on their way towards upstream spawning grounds. This leads to a phenomenon, particularly in August, where we are likely sampling the same Chinook salmon population in the lower 5 KM of the river each week, whereas we are sampling a largely new population of pink salmon. Because of this phenomenon, we present three different methods of apportioning raw SONAR targets to species.

## **Data Analysis**

All ARIS data was processed using ARIS proprietary software (V2.8). All hour-long files were subsampled by reviewing the first 20 minutes of each hour-long file from June 11 through August 12 and the first 10 minutes of each hour-long file from August 13 through September 23. Both subsampling regimes fall within the recommended level (Lilja et al., 2008). Raw data was transformed in a two-step process that enabled empty periods of time to be efficiently reviewed, while 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.

An echogram is a graph of the SONAR data with distance from the SONAR head on the y-axis and time on the x-axis. If no targets are present, the echogram will be blank. If a fish swims through the ensonified area, the echogram will have 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. Raw data was then reviewed to ensure identified targets were indeed fish.

After determining that a pattern on the echogram was a fish, we noted several variables, including the date, time, direction (upstream or downstream), distance from SONAR head, and length (mm). Length was measured in centimeters using software specific procedures. During periods of high fish passage in August, when most of the fish were likely pink salmon based on species composition data, lengths were only measured for every 10<sup>th</sup> target. Because targets were only not measured during the peak of the pink run, all targets that were not measured were assumed to be pink salmon.

### **Escapement Estimation**

Due to the high number of pink salmon returning to the Elwha River in 2025 and their differing migration patterns as compared to Chinook salmon, which presented large biases in our species composition data, the simulation model we have used in each of the previous 11 years of the project was not applicable to this year's data. Therefore, to present the most transparent interpretation of the data, we calculated the Chinook escapement in four different ways and then compare these estimates to an independent estimate derived from a combination of redd surveys and broodstock removal.

The first three estimates involve the same basic fish passage tabulation, which was simply subtracting downstream passage events from upstream passage events (Xie et al. 2005):

$$N = U - D$$

In this equation N represents the net upstream movement of fish for a given period (10 or 20-minutes in this case), U is the sum of upstream fish for that time period and D is the sum of downstream moving fish for that time period. Then each 10-minute net passage (n = 1,008 files) was multiplied by six and each 20-minute net passage (n = 1,512 files) was multiplied by three to arrive at a complete passage data set.

In the first estimation scenario all targets were included and then subsequently apportioned to species daily with the netting and snorkel survey data (Table 1a). In the second scenario, the daily species apportionment was adjusted to reflect the above discussed likelihood that pink salmon made up a larger portion of the targets than the netting and snorkel data showed (Table 1a). The third scenario only included SONAR targets measuring over 70 cm and assumed they were all Chinook until apportioning some as coho in September based on the netting and snorkel data. While 70 cm is approximately 5 cm

bigger than the largest pink salmon sampled in the netting surveys, we feel it is a conservative length cutoff that should safely remove all the pink salmon from the SONAR data and focus primarily on Chinook salmon, other than the coho in September (Fig 4). We only provide run-timing information based on this estimate.

The fourth and final Chinook escapement estimate, which was not reliant on SONAR targets or species apportionment, was performed by calculating the eleven-year percent difference between redd based and SONAR based estimates and applying the average difference between the two methods to the redd based method in 2025 (Table 2). To compare redd based estimates and SONAR estimates for each of the eleven years of the project, we took the number of redds counted in each year, multiplied that number by 2.5 (Orrell, 1976) and then added the number of fish that were removed from the river for broodstock. For each of these year specific redd based numbers, the percent difference from the same year's SONAR estimate was calculated. All 11 of these percentage difference values were then averaged to arrive at the eleven-year percent difference between redd based and SONAR based estimates. We then took this year's redd based estimate and adjusted it by the 11-year percent difference average to arrive at a redd adjusted SONAR estimate for 2025.

## Results

Between June 11 and September 23, 2025, there were a total of 2,520 hours (105 days) recorded on the Mainstem Elwha, which was 100% of the available hours. During this time, 15,374 fish passage events were recorded and analyzed. After expanding for subsampling, the net total number of fish migrating upstream passed the SONAR site was 41,595 (Fig. 6). Our four estimates of Chinook salmon passage were as follows: 1) 16,800 from the strict application of daily species apportionment data; 2) 7,300 from the "pink salmon heavy" adjusted application of the species apportionment data; 3) 4,800 from including only SONAR targets over 70 cm; and 4) 4,676 from the SONAR adjusted redd based method.

The SONAR data in combination with in-stream species composition netting provided information on run timing. We captured the first Chinook salmon on June 29 and, based on our SONAR targets larger than 70 cm method, 25%, 50%, and 75% of the run had passed the OM SONAR site by July 17, August 7, and September 1, respectively (Fig. 4).

Similar to previous years, the Chinook run appears to begin in earnest in early July on the descending limb of the snowmelt peak, although over 350 Chinook were counted migrating upstream in June (Fig. 4). The highest passage day of the season for Chinook (based on the larger than 70 cm method) was on September 4 (198 fish) (Fig. 4).

When using our SONAR targets greater than 70 cm method, which estimated approximately 4,800 Chinook salmon, we are left with a pink salmon escapement of approximately 35,000 fish, or five and a half times greater than the pink escapement estimate from 2023.

## Discussion

Although we provide four different methods of estimating Chinook salmon escapement to the Elwha River in 2025, we have the highest confidence in the SONAR targets larger than 70 cm method (~4,800 adult Chinook salmon). This estimate is corroborated by the redd adjusted SONAR method (4,676 adult Chinook), which is likely an undercount as discussed below. The first two methods, which involved a strict species apportionment and a “pink salmon heavy” apportionment of over 41,000 expanded raw SONAR targets, resulted in Chinook estimates (16,800 and 7,300, respectively). These two estimates are certainly over-estimates based on field collected data in the form of both redd counts and snorkel surveys. Almost 17,000 Chinook salmon would be twice as large as the largest return since modern records have been kept (1986), and 7,300 Chinook would be well above the 10-year average of 4,100 Chinook salmon and comparable to the 7,100 and 7,600 fish returns seen in 2018 and 2019. This project, and redd surveys, were ongoing during that time. Roughly twice as many redds were counted in both 2018 and 2019 as were counted in 2025. Therefore, the escapement estimates of 16,800 and 7,300 derived from the first two methods should only be used as evidence that using SONAR to enumerate a far less abundant Chinook salmon population with a run timing that mostly overlaps a much larger pink salmon population cannot be done using traditional species apportionment methods.

In previous years of the SONAR project, we were able to provide coefficients of variation for various sources of uncertainty: observer error, sub-sampling expansion error, species apportionment, and gap filling; and also a 95% confidence interval on the overall estimate. We could not do that this year, but all of the sources of uncertainty, except for the species apportionment, were either non-existent this year or likely minimal, based on several previous years of using similar data. The project has been using the same data review technician for more than ten years and the CV associated with observer error over the last 10 years has ranged from ~1-5%. While it is possible that the extremely high passage of pink salmon this year resulted in more observer error, the current technician is the best positioned person to provide the most accurate counts. To review SONAR data from the entire temporal period of Chinook salmon run in a timely manner in conjunction with the high passage rates of pink salmon in August which slowed review time, we subsampled at a higher rate for a portion of 2025 than in previous years, 10 minutes vs. 20 minutes. Nevertheless, the CV associated with sub sampling expansion over the last ten years of the project has ranged from only ~1-5%. It is unlikely that subsampling was a significant source of error in our 2025 Chinook estimate. Gap filling was not necessary in 2025 as we recorded data from the entire Chinook run.

Although it was not explicitly calculated, it was clear that the largest source of uncertainty in our 2025 Elwha Chinook salmon estimate was from the species apportionment of raw SONAR targets. In general, while the target species of the SONAR changes throughout the year, steelhead to Chinook salmon and finally to coho salmon, these target species are by far the most abundant during the times of year that they migrate and are also generally larger than other species that may migrate at the same time. Neither of these characteristics were present during the 2025 Chinook salmon season. There were roughly seven times as many pink salmon as Chinook salmon and the lengths of Chinook and pink salmon overlapped

more than in previous years. The much larger pink salmon run alone makes it extremely difficult to provide an accurate estimate of the Chinook salmon run. Misapportioning only 5% of the 41,000 raw SONAR targets (2,050 targets) would result in 42% error in a Chinook salmon run of 4,800 fish, which explains why our two estimates which relied on apportioning all the raw SONAR targets led to large overestimates.

In previous years of the SONAR project, we have relied on a SONAR measured length cutoff to exclude concurrent species that are smaller than the target species. This method has been particularly useful during previous pink salmon years, 2021 and 2023, when the largest pink salmon were ~500 mm and the smallest adult Chinook were ~600 mm (Denton et al. 2022, 2024). Unfortunately, there was much more length overlap between pink salmon and Chinook salmon in 2025, whereby 52% (102/196) of Chinook salmon were smaller than the largest pink salmon (650 mm). Using the natural break in the length frequency histogram of Chinook salmon to arrive at a length cutoff of 520 mm to differentiate adult and jack Chinook in 2025 still resulted in 23% (45/196) of adult Chinook salmon being smaller than the largest pink salmon.

Based on the length frequency comparison of Chinook and pink salmon described above, a logical SONAR target length cutoff would be 650 mm (Fig.4). Unfortunately, this would lead to a Chinook salmon estimate of approximately 8,000 fish which is roughly similar to the 7,300 estimate derived from the pink heavy apportionment of all 41,000 raw SONAR targets. It is important to note, that while a 70 cm length cutoff provides the most credible Chinook escapement estimate, because it is 5-10 cm larger than smallest adult Chinook salmon, it likely excludes some proportion of the raw SONAR targets that are adult Chinook, thus making the 4,800 escapement estimate derived from this method a likely undercount of true escapement. The large jump in the escapement estimate to 8,000 fish when including SONAR targets down to 65 cm suggests that the length measurements taken from the SONAR target are not accurate enough to discern targets that are within 5-10 cm of each other. This is not surprising based on the physics of the beam geometry whereby each beam (i.e. the max resolution) increases from ~1 to 15 cm as the beam spreads across the 30-meter cross section of the river. Additionally, simultaneously recording accurate counts while also precisely measuring those targets when some days in August had almost 1,500 targets hand marked and measured targets is simply not possible with the current resources available to the project. Although see the recommendation section for artificial intelligence tools that will be coming online soon and may alleviate data review burdens.

Due to the apparent error in measuring SONAR targets as described above, we chose a SONAR length cutoff of 70 cm as it was 5 cm longer than the largest pink salmon which should safely exclude them from further analysis and greatly simplify the species apportionment procedure. This allowed us to assume all SONAR measured targets over 70 cm were Chinook salmon until the first coho was captured on September 2. Only 1 coho was captured on September 2 and 9, while 71 Chinook salmon were sampled during the same two events. Therefore, the proportion of SONAR targets assigned as coho did not ramp up until September 15, when 6 were sampled as compared to 7 Chinook salmon. The final new or holding Chinook salmon of the season was sampled only a week later on September 23, indicating that there was only a week of overlap between the 2025 Chinook and coho seasons.

The final method, adjusting the redd count \* 2.5 adults plus the broodstock removal number based on its historical undercount as compared to the SONAR estimate, yielded a Chinook escapement estimate of 4,676 fish. This method provides an important independent check on our SONAR based methods given the issues with the SONAR estimates in 2025. However, there are two major reasons why this estimate is likely an undercount of the true escapement. First, the 2.5 fish per redd estimator is over 50 years old and potentially has numerous biases associated with it, primarily it assumes a sex ratio of 1.5 males per female. Data on the sex ratio of Chinook salmon on the Elwha in 2025 varies greatly from 4:1 to 7:1 for broodstock collections (WDFW: 759/189 and LEKT: 226/31) to 1.2:1 from the carcass surveys (140:108). Because male salmon do not dig redds, a male biased sex ratio would lead to a scenario where the redd surveys underestimate the number of fish in the river. The second reason that redd surveys likely undercounted the true Chinook escapement in 2025 is that the roughly 35,000 pink salmon in the river spawned at the same time and in most of the same locations that Chinook. Multiple redd surveyors reported spawning riffles that were completely turned over with dozens of pink salmon in addition to several Chinook salmon in the vicinity, making it very difficult to accurately identify and count Chinook salmon redds. Although expanding the redd based estimate by 17% to arrive at an adjusted SONAR estimate attempts to characterize the 11-year pattern of the SONAR count consistently being higher than the redd survey, the two factors presented above likely indicate that the redd based estimate was more than a 17% undercount of the SONAR based number in 2025.

An additional source of error in our species apportionment correction is the presence of summer run steelhead in the Elwha. Although this population is too small to be a factor when apportioning over 40,000 raw SONAR targets, they are an important life history expression of an ESA listed species. Since 2017, upriver snorkel surveys in September have counted between approximately 80 and 340 (average ~175) adult summer run steelhead, indicating that a self-sustaining population of this distinct run timing of steelhead now migrates upriver each year. These fish likely migrate past our SONAR sites from late May until the snorkel surveys in mid-September. We captured three summer steelhead in our net sampling in 2025. One each on June 16, July 15, and July 23. Due to the overwhelming number of Chinook and pink salmon also sampled during that time, we are not able to provide a SONAR based summer steelhead estimate. Upstream snorkel surveys across the range of summer steelhead holding habitat occurred once again in 2025. Between September 8 and 11 from near the former Glines Canyon dam (~RKM 22) upstream to Camp Wilder (~RKM 57), 385 individual summer steelhead were counted. This represents the highest number encountered during the eight years of surveys. In addition to these thorough surveys, two non-biologist kayakers went through the Grand Canyon (the only major area not snorkeled in the above referenced surveys) the week after the snorkel surveys and attempted to count summer steelhead in approximately half of the habitat with a mask and snorkel. They only counted six summer steelhead, indicating that the upriver snorkel surveys covered the vast majority of summer steelhead habitat. The U.S. Fish and Wildlife Service is in the process of analyzing the mark recapture data from the snorkel surveys and will have a more precise estimate of summer steelhead than the peak counts provided here.

As the Elwha SONAR project progresses, it is important to compare its escapement estimates and run timing information to previous years' data. The 2025 Chinook escapement estimate of 4,800 is the

third largest since 2009 and 900 fish larger than the average of the project (~3,900) since 2009 (Table 3). Most Elwha Chinook salmon out-migrate as age 0+ subyearlings and spend three to five years at sea before returning to spawn (Weinheimer et al. 2018). Therefore, a majority of the 2025 returning adults were spawned, incubated, and subsequently out-migrated during the fall, winter, and spring of 2021-2022 and 2022-2023. While most of the sediment in the reservoirs has stabilized (Ritchie et al. 2018), egg survival is still related to flow and sediment dynamics (Pess et al. 2023). These impacts resulted in low numbers of naturally produced juvenile outmigrants between 2014 and 2018 (McHenry et al. 2020). However, in 2020, 2021, 2022, 2023, 2024, and 2025 approximately 1,000,000; 292,000; 115,000; 507,000; 606,000; and 475,000 natural 0+ outmigrants were estimated to have been produced in the river, respectively, indicating that significant natural production is occurring (McHenry et al. 2025). Additionally, while most adult returns have been hatchery origin through 2021 (~95%), the upper reaches of the middle river and the former Mills reservoir saw mark rates drop to ~75% in 2022 with further declines (61%) in the former Mills reach in 2023 and these trends are generally continuing as of 2024 (Weinheimer et al., 2018, Joe Anderson, WDFW, pers. comm.). Therefore, while variability in hatchery releases is likely the major driver in adult returns three to five years later, at this point in Chinook recovery post dam removal, smolt trapping of naturally produced juveniles and dropping mark rates of adults in the upper river from 2022 onward indicate that NOR adults are beginning to reestablish themselves.

In comparison to prior years, this year's date at which 50% of the run had passed the SONAR site, August 7, was five days later than the next latest date during the entirety of the project and 10 days later than the 15-year average (Table 3) (Denton et al. 2013-2024). However, this year's 50% date should be used with caution as it is certainly affected by the large pink population migrating concurrently with the Chinook. Because the bulk of the pink return occurs in August, it is not surprising that they could shift the apparent Chinook run timing later than it was simply through the passage of tens of thousands of SONAR targets after the historical 50% migration date. It is remarkable that, other than this year, the past 15 years of timing data have produced an estimated 50% passage date within a nine-day range (earliest: July 25 in 2013; latest: August 2 in 2009 and 2010). The first Chinook salmon was captured during the in-stream netting operations on May 7 but was not considered for inclusion in any analysis because it was subsequently recaptured (it was floy tagged) on each of the next two sampling events in the same location (just downstream of the WDFW hatchery outlet) and was also adipose clipped. Only ~10-20% of Elwha Chinook are adipose clipped depending on the release year. The next Chinook sampled was not until over a month later, on June 11. The presence of a Chinook in the river two weeks earlier than any previous Chinook capture across 11 years of sampling combined with its recapture at the same location for three straight weeks, all of which were weeks before the next Chinook was sampled and the relatively few Chinook that are adipose clipped in the Elwha led us to conclude that this fish was likely a stray from a Puget Sound hatchery program and did not represent the Elwha Chinook population. The first Chinook that was from the Elwha population was captured on June 11, which was a week later than the average first capture date since 2013 (June 3). The date of first Chinook salmon capture has varied by a month between late May and late June since netting operations started in 2013. However, the Chinook salmon run usually does not begin in earnest until July and, other than this year, the date at which 50% of the run has passed the SONAR sites remains within roughly a week of each other year (Table 3). In 2025, an

estimated 350 Chinook (7% of the total) passed the SONAR before July 1, a larger percentage of the run than any previous year other than 2024 (~525 fish and 12% of the run). Genetic samples of fish captured in June are currently being processed by WDFW to investigate the potential existence of a genetic legacy to the historical spring run timing of Elwha Chinook. Preliminary results suggest that an early timed (spring-run) marker not only exists in the Chinook population but is more prevalent in fish sampled earlier in the season (Joe Anderson, WDFW, pers. comm.).

## **Recommendations**

Our primary recommendation for 2025 is a repeat from 2023 and 2024 and concerns the growing pink salmon population. Our previous recommendations called for a more nuanced species apportionment procedure if pink salmon populations swelled into the 10's of thousands. That was exactly the situation we encountered this year and while our most robust Chinook estimate involved picking a length cutoff that was safely larger than the largest pink salmon, it had an unknown and large amount of uncertainty. Furthermore, its credibility was grounded in its proximity to the redd based survey as much as the rigor of its methodology. Finally, data review resources are not infinite and the amount of time needed to accurately review files with passage rates of hundreds of fish in ten minutes disrupts the annual flow of the project and will delay the release of our coho estimate, potentially passed a timeframe that is useful for managers. For all of these reasons, co-managers should discuss the pros and cons of simply relying on a redd based Chinook estimate in pink years

Our second recommendation is a new one but extremely important. Considering several stressors on the SONAR project and fish monitoring on the Elwha in general, we recommend a reinvigoration of some form of the Elwha Fish Committee. While it is outside the scope of the authors of this report to suggest what a framework for conducting meaningful dialog between the monitoring community and the co-managers would look like, the vast network of collaboration and communication that was a hallmark of the Elwha science community for decades has significantly faded and should be reenergized. This dialog could help focus monitoring efforts to directly inform management actions, thereby maximizing monitoring funds and simultaneously providing relevant and timely information to co-managers to make science-based decisions.

Our final recommendation is related to making the project more time and cost-effective and potentially more accurate. Artificial intelligence and machine learning tools have found their way into the SONAR sphere and offer incredible opportunities to both streamline data review and reduce observer error. The project recently received a small amount of funding and support to become part of a collaborative project led by the Wild Salmon Center's Salmon Vision pipeline. While automated counting is still years off, this is an exciting development. We recommend integrating AI into all aspects of the review process.

## **Acknowledgments**

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Table 1. Total number of all salmonids sampled in tangle net surveys, counted in snorkel surveys (highlighted in gray), or captured in tribal set nets (highlighted in red) on the Elwha River between June 11, 2025 and September 23, 2025. The % Chinook column reflects the true percentage of Chinook in each sample while the % Chinook\_2 column represents the percentage of Chinook used in the “pink salmon heavy” species apportionment method.

| Date     | Bulltrout | Chinook | Chum | Coho | Pink  | Steelhead | Snorkel Location            | % Chinook | % Chinook_2 |
|----------|-----------|---------|------|------|-------|-----------|-----------------------------|-----------|-------------|
| 06/11/25 |           | 1       |      |      |       |           |                             | 100%      | 100%        |
| 06/16/25 |           | 2       |      |      |       | 1         |                             | 67%       | 100%        |
| 06/25/25 | 1         | 5       |      |      |       |           |                             | 83%       | 85%         |
| 07/10/25 |           | 10      |      |      |       |           |                             | 100%      | 70%         |
| 07/15/25 |           | 8       |      |      | 2     | 1         |                             | 73%       | 70%         |
| 07/16/25 |           | 250     |      |      |       |           | Below SONAR, bad visibility | 100%      | 70%         |
| 07/23/25 |           | 41      |      |      | 16    | 1         |                             | 71%       | 50%         |
| 07/29/25 |           | 1,200   |      |      | 300   |           | Above SONAR                 | 80%       | 40%         |
| 07/29/25 |           | 1,500   |      |      | 600   |           | Below SONAR                 | 71%       | 40%         |
| 07/29/25 |           | 2,700   |      |      | 900   |           | Combined                    | 75%       | 40%         |
| 08/07/25 |           | 39      |      |      | 17    |           |                             | 70%       | 30%         |
| 08/18/25 |           | 700     |      |      | 300   |           | Above SONAR                 | 70%       | 10%         |
| 08/18/25 |           | 400     |      |      | 2,000 |           | Below SONAR                 | 17%       | 10%         |
| 08/18/25 |           | 1,100   |      |      | 2,300 |           | Combined                    | 32%       | 10%         |
| 08/25/25 |           | 800     |      |      | 1,500 |           | Above SONAR                 | 35%       | 5%          |
| 08/25/25 |           | 500     |      |      | 2,500 |           | Below SONAR                 | 17%       | 5%          |
| 08/25/25 |           | 1,300   |      |      | 4,000 |           | Combined                    | 25%       | 5%          |
| 09/02/25 |           | 51      | 1    | 1    | 50    |           |                             | 50%       | 5%          |
| 09/08/25 |           | 20      | 1    | 1    | 13    |           |                             | 57%       | 5%          |
| 09/15/25 |           | 7       |      | 6    | 40    |           |                             | 13%       | 5%          |
| 09/16/25 |           | 1,200   |      | 20   | 3,500 |           | Above SONAR                 | 25%       | 5%          |
| 09/16/25 |           | 300     |      | 100  | 1,400 |           | Below SONAR                 | 17%       | 5%          |
| 09/16/25 |           | 1,500   |      | 120  | 4,900 |           | Combined                    | 23%       | 5%          |
| 09/23/25 |           | 4       |      | 37   | 1     |           | Set nets                    | 10%       | 5%          |

Table 2. Number of redds, broodstock removal and combined redd based estimate (redds \* 2.5 plus broodstock removal) and SONAR estimates for Chinook salmon for each year of the SONAR project. Also included is the percentage undercount of the redd based estimate for each year. In 2025, the SONAR estimate is calculated by taking the average % difference of all other years (17%) and applying that to the redd based estimate. These numbers are highlighted in gray.

| Year | # of Redds | Broodstock Removal | Combined | SONAR | % Difference |
|------|------------|--------------------|----------|-------|--------------|
| 2014 | 1,337      | 1,849              | 5,200    | 4,360 | -16%         |
| 2015 | 937        | 1,564              | 3,906    | 4,112 | 5%           |
| 2016 | 615        | 613                | 2,150    | 2,628 | 22%          |
| 2017 | 767        | 1,077              | 2,994    | 3,083 | 3%           |
| 2018 | 1,601      | 2,300              | 6,300    | 7,107 | 13%          |
| 2019 | 1,673      | 1,903              | 5,800    | 7,600 | 31%          |
| 2020 | 625        | 659                | 2,209    | 3,250 | 47%          |
| 2021 | 494        | 933                | 2,170    | 2,630 | 21%          |
| 2022 | 963        | 718                | 3,118    | 3,998 | 28%          |
| 2023 | 789        | 1,275              | 3,275    | 3,850 | 18%          |
| 2024 | 976        | 1,071              | 3,511    | 4,156 | 18%          |
| 2025 | 867        | 1,829              | 3,997    | 4,676 | 17%          |

Table 3. Escapement estimates, 95% confidence estimates, date of first Chinook capture during in-stream tangle netting, and date when 50% of the run had entered the river for all years of the Elwha SONAR project.

| <b>Year</b> | <b>Estimate</b> | <b>95% CI</b> | <b>First Capture</b> | <b>50% Entry</b> |
|-------------|-----------------|---------------|----------------------|------------------|
| <b>2009</b> | 3,152           | 2,552 - 3,752 | N/A                  | 2-Aug            |
| <b>2010</b> | 1,372           | 1,122 - 1,622 | N/A                  | 2-Aug            |
| <b>2011</b> | N/A             | N/A           | N/A                  | N/A              |
| <b>2012</b> | 2,638           | 2,238 - 3,038 | N/A                  | 31-Jul           |
| <b>2013</b> | 4,243           | 3,743 - 4,743 | 24-Jun               | 25-Jul           |
| <b>2014</b> | 4,360           | 4,060 - 4,660 | 4-Jun                | 20-Jul           |
| <b>2015</b> | 4,112           | 3,857 - 4,372 | 20-May               | 30-Jul           |
| <b>2016</b> | 2,628           | 2,543 - 2,715 | 14-Jun               | 30-Jul           |
| <b>2017</b> | 3,083           | 2,818 - 3,348 | 13-Jun               | 1-Aug            |
| <b>2018</b> | 7,107           | 6,495 - 7,719 | 6-Jun                | 31-Jul           |
| <b>2019</b> | 7,600           | 7,085 - 8,119 | 21-May               | 26-Jul           |
| <b>2020</b> | 3,250           | 3,015 - 3,487 | 3-Jun                | 31-Jul           |
| <b>2021</b> | 2,630           | 2,330 - 2,890 | 7-Jun                | 30-Jul           |
| <b>2022</b> | 3,998           | 3,813 - 4,183 | 23-May               | 29-Jul           |
| <b>2023</b> | 3,850           | 3,700 - 4,000 | 7-Jun                | 30-Jul           |
| <b>2024</b> | 4,156           | 3,860 - 4,458 | 29-May               | 31-Jul           |
| <b>2025</b> | 4,800           |               | 11-Jun               | 7-Aug            |

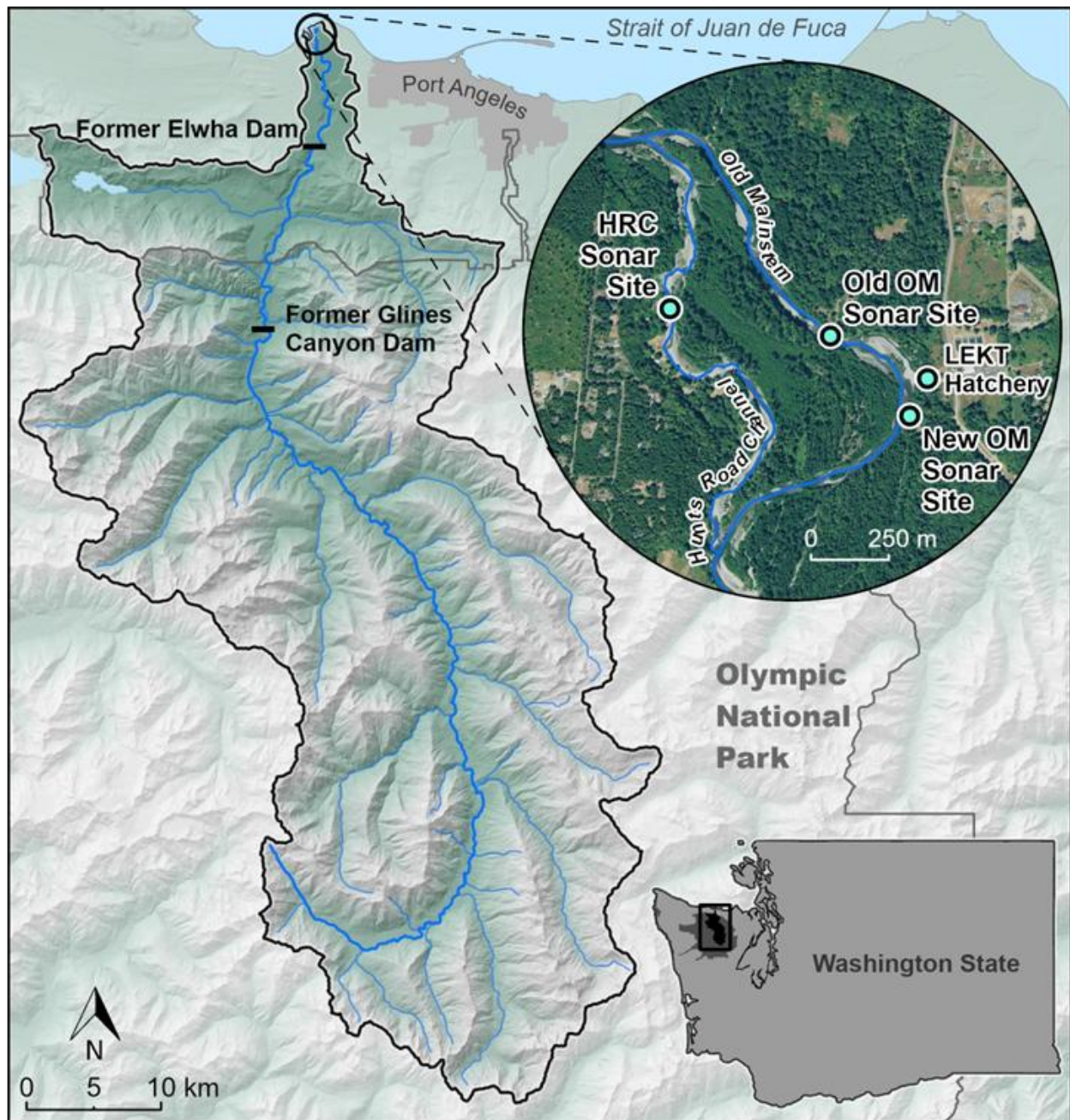


Figure 1. Map of the Elwha River, depicting the former dam sites, SONAR sites, Elwha Tribal Hatchery, and the two distinct migratory pathways near the mouth of the river. The SONAR was located at the “New OM SONAR site” from June 11 through July 9 and located at the “Old OM SONAR site” from July 9 through September 23 during the 2025 season. The Hunt Road Channel did not convey enough water in 2025 to allow Chinook passage and therefore no SONAR data was collected on that channel.



Figure 2. New Old Mainstem SONAR site looking upstream. The SONAR itself is attached to the pole mount which is in turn attached to the ladder. The solar panels and top side box are just out of sight on the logjam in the upper left-hand corner of the picture. The SONAR was operational at this site from June 11 through July 9, 2025.



Figure 3. "Old OM SONAR site". The SONAR was operational in this location from July 9 through September 23, 2025. The SONAR is attached to the pole mount which is in turn attached to the ladder. The river is moving from left to right.

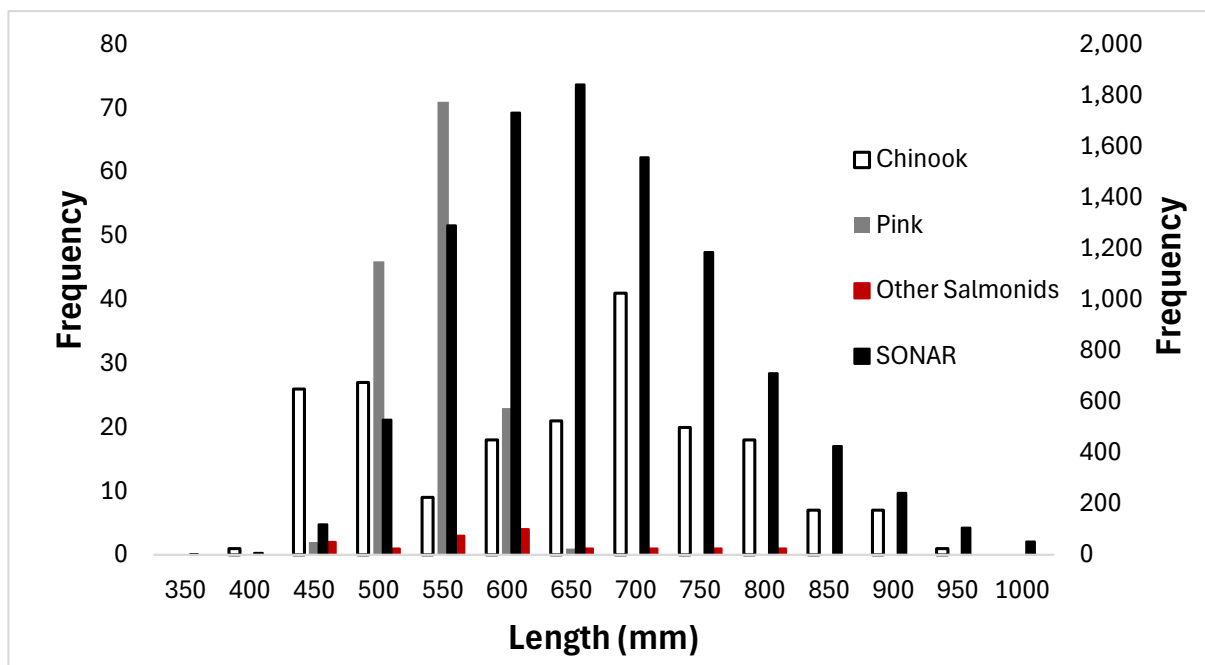


Figure 4. Length frequency histogram for all salmonids caught during 10 different sampling days between June 11 and September 23, 2025 in the Elwha River (left hand y-axis) and all SONAR measured targets during the same time period (right hand y-axis).

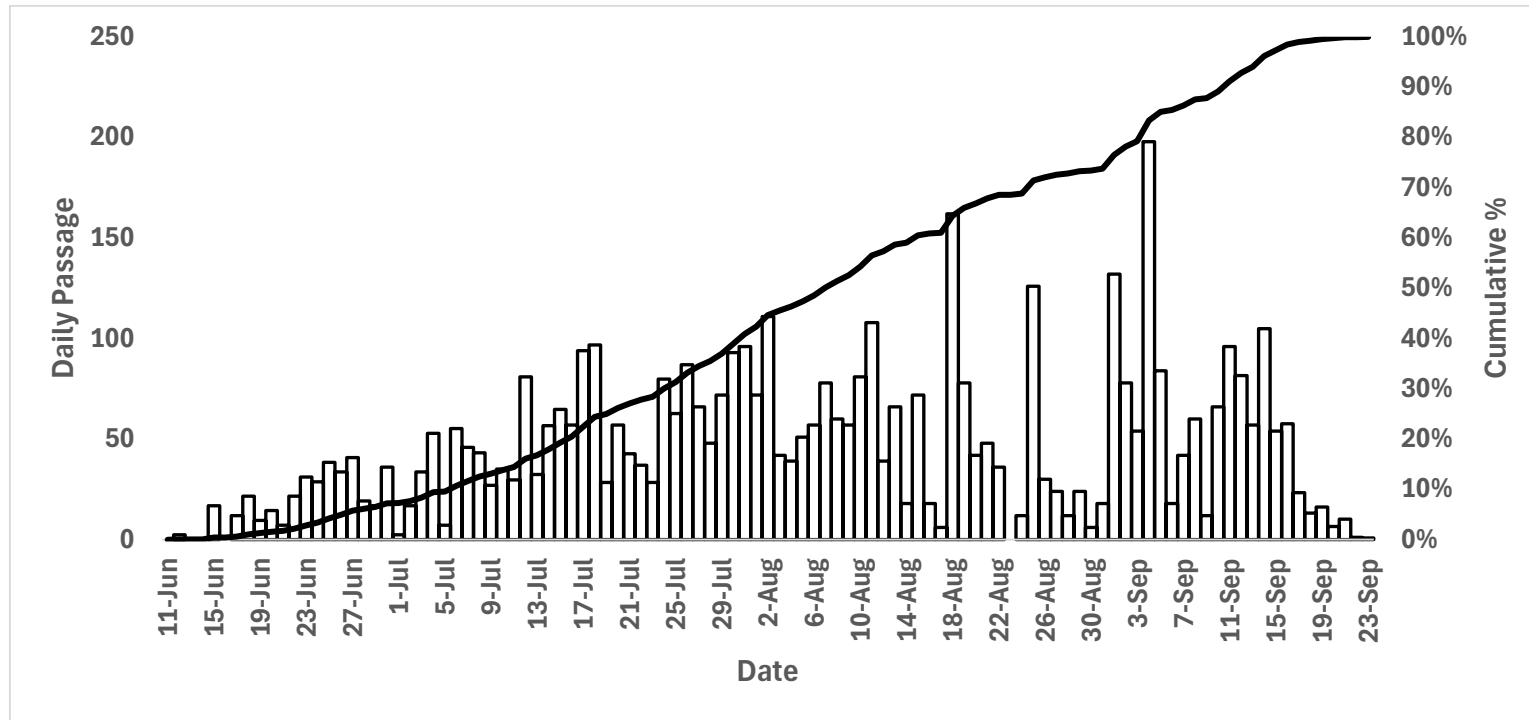


Figure 5. Daily Chinook passage and cumulative percent of total run in the Elwha River in 2025. This graph is based on the SONAR targets larger than 70 cm method. The total escapement estimate for this method was 4,800 Chinook.

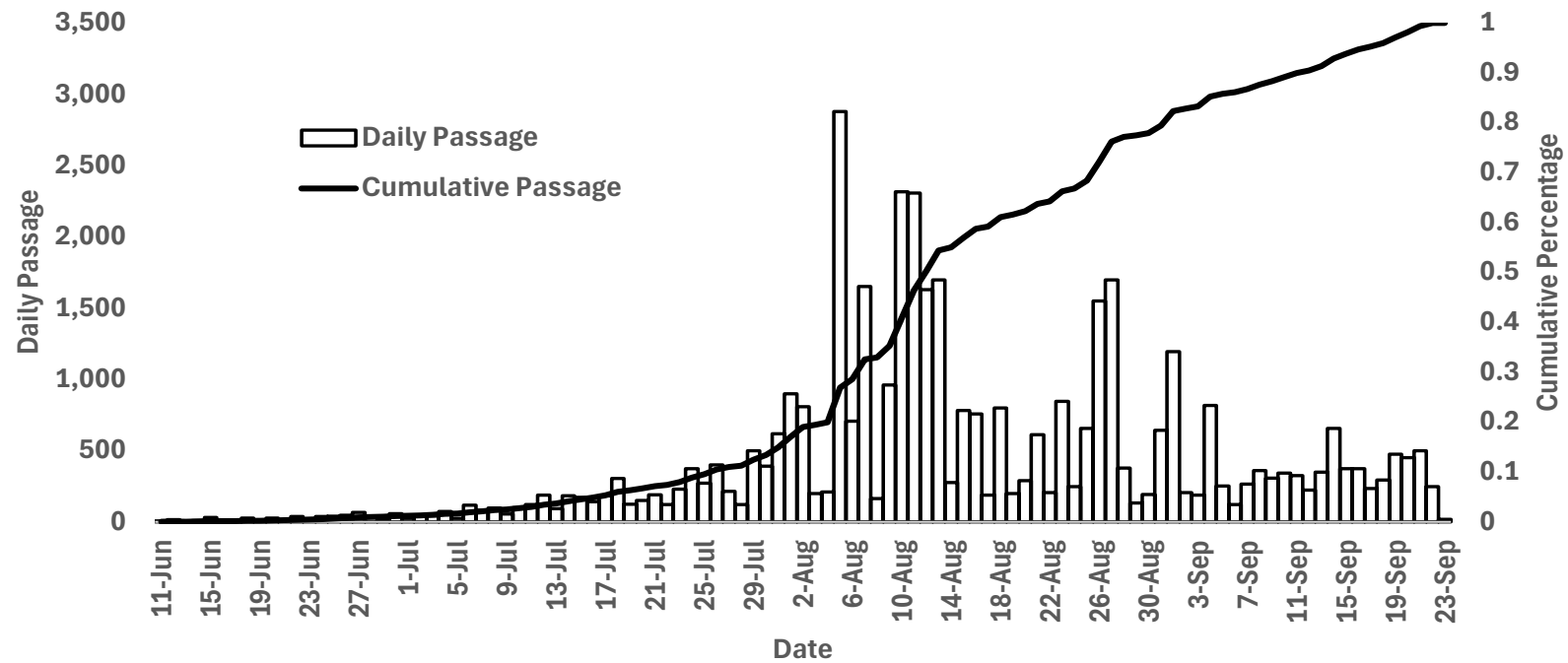


Figure 6. Daily passage (left hand y-axis) and cumulative percent of the total (right hand y-axis) for SONAR targets of all lengths. These counts were expanded from their original 10 or 20-minute on the hour subsampling regime to represent full hour passage. The total of all targets across the shown time period was 41,565

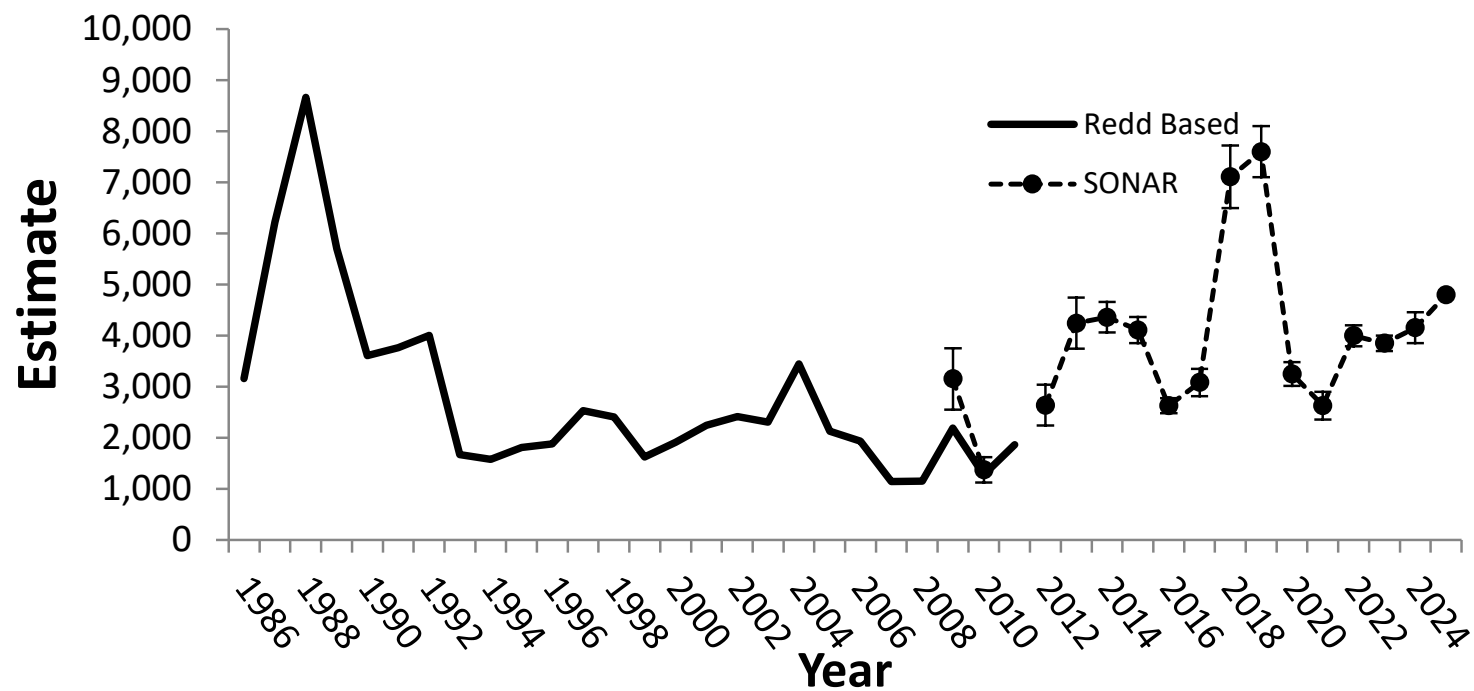


Figure 7. Historical Chinook escapement estimates from the Elwha River based on two different enumeration methods, redd counts and SONAR.