



Summary and Analysis of Columbia River Harvest Reform Activities
2009 – 2017; including Transition Period 2013-2016 and 2017 Policy
Review by Oregon Fish and Wildlife Commission
(2018 mainstem commercial fishery data included)

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EXECUTIVE SUMMARY

As an alternative to a citizen's initiative seeking to ban non-tribal commercial gill nets and tangle nets in all inland waters of the State (Measure 81), in the summer of 2012 Governor John Kitzhaber asked the Oregon Fish and Wildlife Commission (hereafter, "Commission") to address the "perennial and divisive conflicts" that involve recreational and non-tribal commercial fisheries on the Columbia River, including gear conflicts, allocation of harvest and available wild fish impacts, and conservation needs. The Governor's request recognized the importance and economic value of both recreational and commercial fisheries to the State, including the importance of adaptive management, while acknowledging the need for management in a conservation-based framework. Consistent with this vision and direction, the Commission adopted administrative rules in December 2012 implementing guiding principles and management strategies for a new fisheries framework for lower Columbia River (LCR) non-tribal fisheries (CR Fisheries Reform). To resolve some concerns raised in litigation, in June 2013 the Commission reconsidered and readopted rules it had adopted in December 2012. As reconsidered, the stated objective of the Columbia River fish management and reform framework outlined in OAR 635-500-6700, et seq., is to:

1. Maintain or enhance the overall economic viability of commercial and recreational fisheries;
2. Optimize overall economic benefits to the State;
3. Promote conservation of native fish; and
4. Promote orderly and concurrent fisheries with the State of Washington.

Background materials and policy links for CR Reform can be found at

www.dfw.state.or.us/fish/OSCRP/CRM/LMCR_fisheries_mgmt_reform.asp.

The Washington Fish and Wildlife Commission adopted a similar policy in January 2013 (Policy C-3620; <http://wdfw.wa.gov/commission/policies/c3620.html>).

In general, key elements or "Guiding Principles" of CR Fisheries Reform include shifting allocations to provide a stronger recreational priority in the mainstem, enhancing off-channel hatchery releases to augment commercial harvest, limiting gill nets to off-channel fisheries, developing alternative gears and techniques for commercial mainstem fisheries, and strengthening conservation of native fish. These guiding principles are reflected in OAR 635-500-6705 as follows:

Guiding Principles

1. Promote the recovery of ESA-listed species and the conservation of wild stocks of salmon, steelhead, and sturgeon in the Columbia River.
2. Continue leadership on fish recovery actions, including improved fish survival through the federal Columbia River hydropower system, improved habitat conditions in the tributaries and estuary, hatchery reform, reduced predation by fish, birds, and marine mammals, and harvest management that meet conservation responsibilities.

3. Continue to meet terms of U.S. v. Oregon management agreements with Columbia River Treaty Tribes.
4. In a manner that is consistent with conservation and does not impair the resource, seek to enhance the overall economic well-being and stability of Columbia River fisheries in Oregon and Washington.
5. For steelhead, salmon and sturgeon prioritize recreational fisheries in the mainstem and commercial fisheries in off-channel areas of the lower Columbia River. Toward this end:
 - a) Assign mainstem recreational fisheries a sufficient share of ESA-impacts and harvestable surplus to enhance current fishing opportunity and economic benefit.
 - b) Assign commercial fisheries a sufficient share of the ESA-impacts and harvestable surplus to effectively harvest fish in off-channel areas and harvest surplus fish with selective techniques in the mainstem Columbia River.
6. Phase out the use of non-selective gill nets in non-tribal commercial fisheries in the mainstem Columbia River. Transition gill net use to off-channel areas.
7. Enhance the economic benefits of off-channel commercial fisheries, in a manner consistent with conservation and wild stock recovery objectives. Enhancements should include:
 - a) Providing additional hatchery fish for release in off-channel areas by shifting currently available production, and where possible providing new production for release in off-channel areas, emphasizing complementary conservation benefits in tributaries.
 - b) Expanding existing seasons and boundaries in off-channel areas and/or establishing new off-channel areas, allowing increased harvest in areas where the likelihood of impacting ESA-listed stocks is lower than the mainstem.
8. Develop and implement selective-fishing gear and techniques for commercial mainstem fisheries to optimize conservation and economic benefits consistent with mainstem recreational objectives. Provide incentives to commercial fishers to expand the development and implementation of these gear and techniques.
9. Maintain consistent and concurrent policies between Oregon and Washington related to management of non-tribal Columbia River fisheries, to ensure orderly fisheries as well as the sharing of investments and benefits.
10. To maximize economic return, develop a program that seeks to implement Marine Stewardship Council or other certification of commercial salmon and sturgeon fisheries in the Columbia River as sustainably managed fisheries.

OAD 635-500-6765 required “an initial review in 2014 and... a comprehensive review at the end of the transition period [January 2017]”. Members of the OFWC and WFWC began meeting jointly in August of 2016 to discuss analyses being conducted by ODFW and WDFW to review the transition period results. Three joint meetings were held, with the subgroup discussing implementation of the post-transition (also called ‘long-term’) phase of reform, as well as potential adaptive management measures that might be appropriate.

The OFWC began their comprehensive review of the transition period at their November 2016 hearing, with additional review at the January 2017 and March 2017 OFWC hearings. Oregon rules and statutes governing CR Fisheries Reform require adaptive management to best align policy implementation with policy objectives and expected outcomes. Staff assessments (which are included in this report) indicated that it was not possible at the time to concurrently enact, in full, all of the guiding principles outlined in the CR Fisheries Reform policy. In particular, elimination of the use of gillnets for harvest of fall Chinook would not meet the policy objective to enhance viability of commercial fisheries. A key factor in this was the inability of currently available alternative gears to substantively replace commercial ex-vessel value that would be lost with prohibition of gillnets in all fall fisheries. While it is possible to replace some of this value with seine gears, staff were not able to identify a scenario in which this action would not significantly reduce values to the fall commercial fishery from current conditions, and from expected outcomes during the original reform process. Staff recommended continuation of the allowance of gillnets in zones 4-5 for harvest of fall Chinook, not implementing the planned additional fall Chinook allocation shifts adopted in the original policy, as well as several other policy and rule changes to reflect adaptive management. The Commission adopted a set of adaptive management permanent rule changes in March 2017.

This report reviews the recreational and commercial fisheries affected by the Policy, highlights the results of evaluations conducted to determine the feasibility of implementing alternative gear commercial fisheries, and potential for expanded and/or new off-channel fisheries, and presents key findings related to the performance of the Policy during its implementation. The “post-Reform” period is defined as 2013 and subsequent years. Much of this material has been previously summarized in documents presented to OFWC by ODFW staff.

Some Reform related activities began in 2009, but the majority of activities summarized in this report are those that occurred beginning in 2013 with the onset of the “Transition Period” established by joint Oregon and Washington Commission policies.

Alternative Gear Feasibility Evaluations

- Research in the early 2000s identified small-mesh tangle nets as a viable alternative gear for mark-selective mainstem spring commercial fisheries, and these fisheries were successfully implemented during 2002-2016. While Oregon’s Harvest Reform Policy does make provisions for a future mainstem spring tangle net fishery under a very specific set of circumstances, it is not likely this fishery will occur very frequently. More recent alternative gear evaluations have focused on gears for use in summer and fall seasons.
- Thirteen combinations of alternative gears and seasons were evaluated during 2009-2017 to determine the feasibility of implementing mark-selective summer and fall commercial fisheries.
- Evaluation Results
 - No single gear type was successful in all evaluated categories; therefore, all alternative gears represented a set of trade-offs.
 - Fall purse and beach seines, shad purse seine, fall pound net (2017), and fall tributary weir had moderate target fish catch rates; most alternative gears had low catch rates of target fish.

- Summer and fall Chinook have relatively low mark rates, making commercially viable mark-selective fisheries challenging. The mark rate of late stock Coho targeted with tangle nets was high, consistent with past observations in gillnet fisheries.
- Condition of released non-target fish was relatively good in all alternative gears.
- Most alternative gears exhibited relatively high handle rates for non-target fish (including unmarked fish of the target species), resulting in ESA impact limitation issues even at low release mortality rates. This was particularly true for steelhead handled in fall seasons.
- Almost all alternative gears have a moderate to high gear investment cost relative to existing gear already possessed by most commercial fishers; the Coho tangle net had a similar cost to traditional gears.
- Most gears had low or moderate regulatory requirements and social issues at the level evaluated; however, fixed gears like the pound net, tributary weir, and fish wheel carry additional requirements for extensive coordination with regulatory agencies and permitting. Many gears have a high likelihood for social conflict with recreational anglers fishing in the same areas and times, but this may be especially true for commercial hook and line fishers, who may compete with recreational fishers for the most productive angling locations.
- The only alternative gears implemented for mark-selective commercial salmon fisheries during the 2013-2017 Harvest Reform implementation period were fall beach and purse seines, and the Coho tangle net.
- Due to high costs and limited harvest potential, alternative gears examined to date are neither likely to benefit the non-treaty commercial fishery overall, nor a large number of individual Columbia River commercial fishers. High handle of non-target fish, particularly steelhead (natural-origin and hatchery), in many of the gears also raises concerns regarding efficient use of limited ESA impacts. Alternative gears may be more effective in smaller scale mark-selective commercial fisheries in particular locations at certain times to achieve specific purposes (e.g. removal of surplus hatchery fish in or around a tributary mouth). Although alternative gear-caught fish may bring higher prices in high-value specialty markets, the extent of these niche markets have not been fully explored, and expansion of an alternative gear fishery into a large-volume fishery may have a dampening effect on prices.
- Alternative gears such as the pound net could serve as a monitoring and research tool in the lower Columbia.

Alternative Gear Post-Release Mortality Evaluations

- Post-release mortality studies were conducted by WDFW for fall beach and purse seines, ODFW for the Coho tangle net, and the Wild Fish Conservancy (WFC) in cooperation with WDFW for the fall pound net.
- Fall Seine Mortality Study (beach and purse)
 - Total mortality rate estimates for steelhead ranged from 3-5% for beach seines and 1-2% for purse seines, based on 2011-2013 mortality studies.
 - The 2011-2012 mortality studies generated higher than expected mortality rate estimates for fall Chinook and Coho caught in seines, and this result is believed to

have been affected by a violation of the mark-recapture study's assumptions (not all survivors from the treatment group had the same probability of recapture).

- A modified mortality study for Chinook and Coho in 2013 using radio-telemetry verified the recapture assumption violation observed in the 2011-2012 work, and an ODFW stock composition study conducted in 2015 indicated that the results were not due to a difference in the stock composition of treatment fish.
- The *U.S. v. Oregon* Technical Advisory Committee (TAC) took all available information into account and provided recommended release mortality rates for the seine gears. Chinook mortality rates currently used for fall seine fisheries are 33% for beach seines and 21% for purse seines. Coho mortality rates are 38% for beach seines and 29% for purse seines. Steelhead mortality rates are 5% for beach seines and 2% for purse seines.
- In 2017, WDFW conducted a net pen holding study in Zone 5 to assess short-term post-release mortality of Chinook and Coho captured in purse seines. Final results were not available as of the date of this report.
- Coho Tangle Net Mortality Study
 - Mortality rate estimates from the 2013-2014 mortality studies were likely confounded by a violation of the mark-recapture study's assumptions (not all survivors from the treatment group had the same probability of recapture).
 - The 2015-2016 net pen holding studies yielded a total mortality rate estimate of 23.6% for unmarked Coho and steelhead; this mortality rate was reviewed by TAC and approved by NOAA's National Marine Fisheries Service (NMFS) for use in future Coho tangle net fisheries.
- Fall Pound Net Mortality Study
 - Preliminary findings from a 2017 mortality study for Chinook and steelhead, based on WFC's initial analysis of the data, are presented in Gayeski and Tuohy (2018). As of the date of this report, final study results have not been reviewed by TAC.

Alternative Gear Fisheries Implementation

- Fall commercial seine fisheries were conducted in Zones 1-5 during 2014-2016. Fisheries were mark-selective for fin-clipped hatchery Chinook and Coho (except some very limited unmarked Chinook retention in 2016), and were conducted on a limited entry basis, with individual fisher quotas (IFQ) assigned to each permit holder.
 - All seine fishing trips were observed by WDFW or ODFW field staff.
 - Adult Chinook IFQ ranged from 400-600 for beach seines, 650-750 for purse seines; adult Coho IFQ ranged from 150-400 for beach, 200-600 for purse.
 - An average of 7 seine permits (4 beach, 3 purse) and 22 days were fished per year; the average crew size for both purse and beach seines was 4 fishers.
 - For all seine operations combined, annual Chinook landings averaged 2,301 (adults and jacks), with an average ex-vessel value of \$44,578; Coho landings averaged 754 fish, with an average ex-vessel value of \$7,067. The average annual ex-vessel value (Chinook and Coho combined) for the purse seine fishery was \$37,421 and \$14,224 for the beach seine fishery.
 - For purse and beach seine catches combined, mark rates averaged 36% for Chinook and 46% for Coho. Chinook catch in beach seines exhibited a higher mark rate, possibly due to a greater propensity to capture near-shore travelling tule stock fall

Chinook, which are marked at a high rate. Tule Chinook mature quickly upon river entry, and are considered to be of inferior market quality due to pale meat color and low fat content. Natural-origin Lower Columbia River (LCR) tule Chinook are ESA-listed.

- The ratio of steelhead to kept marked adult Chinook averaged 0.40 (4 steelhead handled for every 10 marked adult Chinook kept) for beach seines and 0.24 for purse seines; beach seines likely had a higher ratio due to a greater likelihood of capturing near-shore travelling steelhead.
- The seine fishery caught 48% of the provided Chinook quota, and 33% of the Coho quota, leaving the majority of the quotas unharvested.
- Immediate mortality rates observed for Chinook, Coho, and steelhead were all <0.5% for both beach and purse seines. Beach seines harvested 78 adult Chinook per LCR tule mortality and 388 adult Chinook per wild B-Index steelhead mortality, while purse seines harvested 109 adult Chinook per LCR tule mortality and 1,827 adult Chinook per wild B-Index steelhead mortality.
- During the 2014 seine fishery, fishers were evaluated on their ability to differentiate bright and tule stock Chinook, based on visual characteristics of live fish. The intent was to assess the feasibility of allowing retention of unmarked bright Chinook, while requiring the release of unmarked tule Chinook, which include ESA-listed LCR tules. No training or guidance was provided to fishers, and they relied on their own experience.
 - Stock identification accuracy for purse seiners was 68% and 35% for beach seiners; the lower accuracy for beach seiners may be related to a larger proportion of “bright” tules, which are more difficult to accurately identify, in the beach seine catch.
 - Many commercial fishers have a bias towards calling a fall Chinook “bright” based on a silvery appearance and how the fish will be graded by fish buyers, rather than on the biological origin of the fish. This bias confounds the results from the 2014 evaluation.
- To evaluate the potential return on investment and economic viability of the fall seine fishery, landings and ex-vessel values from 2014-2016 were compared to the estimated costs of harvesting salmon with beach and purse seine gear (from “2013 Fiscal and Economic Impact Statement”; ODFW 2013c).
 - The results of the analysis indicated that the low landings and ex-vessel value of the seine fishery, combined with the relatively high costs of procuring and operating seines (particularly for purse seines), made it difficult to achieve a positive net return in the fishery.
- Overall assessment of the 2014-2016 fall seine fisheries
 - Landings and ex-vessel value were modest. Allocating more impacts to the fishery, or expanding the number of permits or season length, would likely not have proportionately increased landings since existing quotas were underutilized, and seiners only fished on about half of the available fishing days.
 - The seine fishery was not economically viable for most individual fishers due to low ex-vessel values and high costs. Even if capital costs were excluded from the analysis, the fishery would have had negative net returns

- in 2 of 3 years. A small number of fishers did make a profit in the seine fishery, but they already had boats/gear from previous test fishing contracts or other seine fisheries.
- Immediate mortality rates for released non-target fish were low, but the handle of steelhead in seines was high compared to conventional gillnets. Low mark rates for fall Chinook also resulted in high handle of unmarked Chinook. Low landings and ex-vessel value, combined with the high handle of non-target stocks, especially steelhead, led to inefficient use of ESA impacts; because of this, and reduced run sizes in recent years, a seine fishery has not been implemented since the completion of the Transition Period.
 - Tables C4 and C5 of the “Management Strategies for Columbia River Recreational and Commercial Fisheries: 2013 and Beyond” (i.e. Harvest Reform Policy; ODFW 2012) outline expected commercial harvest and ex-vessel value, respectively, for alternative gear fisheries in each year of the post-Reform period. In 2014, the fall seine fishery met 22% of the expected combined harvest of Chinook and Coho for the fishery in Table C4, 21% of expected harvest in 2015, and 3% of the expected harvest in 2016. With respect to ex-vessel value in Table C5, the seine fishery met 25% of the expected seine value in 2014, 21% of the expected value in 2015, and 5% of the expected value in 2016.
- Commercial Coho tangle net fisheries were conducted in Zones 1-3 in October of 2013-2015. The tangle net fishery was mark-selective for fin-clipped hatchery Coho, and non-mark-selective for Chinook. Encounters of LCR tule and Snake River Wild (SRW) Chinook are expected to be low in October, allowing for full retention Chinook fisheries at that time.
 - ODFW and WDFW field staff observed an average of 9% of the landed Coho catch and 31% of the participating vessels in the tangle net fishery via on-board monitoring.
 - Annual Coho landings averaged 8,019 fish, with an average fleet-wide ex-vessel value of \$67,369; Chinook landings averaged 1,914 fish, with an average combined ex-vessel value of \$32,112.
 - Coho mark rates were high, averaging 76%, and were consistent with past data from late fall Coho fisheries.
 - The ratio of steelhead to kept marked adult Coho was 0.02 in 2013 and 2014, and 0.32 in 2015, possibly due to the extremely poor Coho run that year.
 - The observed immediate mortality rate for adult Coho averaged 12.5%.
 - To evaluate the potential return on investment and economic viability of the Coho tangle net fishery, landings and ex-vessel values from 2013-2015 were compared to the estimated costs of harvesting salmon with tangle net gear (from “2013 Fiscal and Economic Impact Statement”; ODFW 2013c).
 - The results of the analysis indicated that the volatility of annual Coho returns greatly affected average landings and ex-vessel value. Even with the relatively low implementation costs associated with tangle net gear, net returns were negative in 2 of 3 years, reflective of reduced Coho abundances in those years.

- Overall assessment of the 2013-2015 Coho tangle net fisheries
 - Landings and ex-vessel values varied considerably depending on the strength of the Coho return, which is consistent with catches in other Coho fisheries, both commercial and recreational.
 - The fishery had a positive economic return when the Coho run was strong, and harvest of Chinook was important in some years (e.g. 2015). Low gear cost and similarity to traditional fishing methods and equipment eases adoption by current commercial fishers.
 - Handle of non-target species such as steelhead and Chum salmon was relatively low, mostly due to the timing of the fishery. The immediate mortality rate was moderate, and the estimated total mortality rate (23.6%) is comparable to the assigned rate for fall season sport fisheries (19%).
 - In 2013, the Coho tangle net fishery met 24% of the expected Coho harvest for the fishery in Table C4 of the Management Strategies, 90% of expected harvest in 2014, and 5% of expected harvest in 2015. With respect to ex-vessel value in Table C5, the tangle net fishery met 22% of the expected value in 2013, 56% of the expected value in 2014, and 4% of the expected value in 2015.

Current Select Area Fisheries

- Select Area sites are currently located at Youngs Bay (OR), Tongue Point/South Channel (OR), Blind Slough/Knappa Slough (OR), and Deep River (WA).
- Total annual hatchery smolt releases into the Select Areas have been trending upward since 2006. The Harvest Reform Policy mandated enhanced production in existing Select Area sites to help offset the economic effects of reductions in the commercial allocation of ESA impacts and harvestable surpluses. For the 2013-2018 (through 2019 for spring Chinook and Coho) post-Harvest Reform period, average actual/projected releases of spring Chinook, Coho, and Select Area Bright (SAB) fall Chinook have been 86%, 98%, and 69% of their respective targets. Because of changes to Mitchell Act-funded production, beginning in 2017, release goals for Coho and SAB fall Chinook were significantly reduced from planned levels; SAB releases have been <50% of the reduced goals due to low broodstock returns. Experimental releases of spring Chinook into Cathlamet Channel by WDFW (2014-2018) ended after 2018 due to poor adult returns, with production (~200,000 smolts) switched back to Deep River in 2019.
- Median number of deliveries, used as an index of commercial fishing effort, in Select Area fisheries during the 2013-2017 post-Reform period were similar to the 2010-2012 pre-Reform period. This suggests that fishing effort in these areas has remained static, despite reduced commercial opportunities in the mainstem, and enhanced spring Chinook releases in off-channel areas. This could be due to limited space in the current Select Areas and/or difficulty for some fishers (especially non-local) to access them efficiently. Washington commercial fishers comprise ~50% of the active license holders on the Columbia, but only 25% of those fishing in all Select Area sites.
- Select Area landings (2010-2017) during the winter/spring season varied considerably, but have generally trended upward since 2014, possibly due to increased spring Chinook releases.

- Summer season landings (comprised mostly of late arriving spring Chinook in Youngs Bay) were high in 2017 due to the unusually late timing of the spring Chinook run; also, extended late-spring season landings in Tongue Point/South Channel and Blind Slough/Knappa Slough were included as part of the summer season beginning in 2017.
- Fall Chinook landings have declined since 2013, largely due to reduced returns of SABs.
- Coho landings fluctuated widely from a low of 15,354 in 2012 to a record high 168,497 in 2014. Even though Coho releases have trended upward since the 2003 brood year, adult returns and harvest have remained highly volatile. High volatility in Coho landings can be problematic for the economic stability of Select Area fisheries, where Coho often comprise the majority of the annual harvest.
- Although smolt production has been enhanced in the Select Areas due to the Policy, poor ocean survival likely dampened the effect of these increases on adult returns and harvest in recent years. Median Select Area landings (all seasons combined) decreased from 83,560 during the 2010-2012 pre-Reform period to 67,610 during the 2013-2017 post-Reform period. Compared to the expected Select Area harvest modelled prior to implementation of the Policy (Table C4 from the Management Strategies), actual Select Area harvest has met expectations about 50% of the time for the various salmon stocks.
- Total annual Select Area ex-vessel value (2010-2017) ranged from \$1.3 million in 2012 to \$2.6 million in 2010; the winter/spring season (spring Chinook) comprised an average of 41% of total annual ex-vessel value, followed by Coho (30%), fall SAB/tule Chinook (23%), and the summer season (spring/SAB Chinook) at 6%. The percentage of total annual Select Area ex-vessel value attributed to Harvest Reform-related production increases averaged 12% between 2013 and 2017. Select Area ex-vessel values during 2013-2017 have primarily exceeded expected values (from Table C5) for spring Chinook, but have not met expectations most of the time for fall Chinook and Coho. The higher than expected values for spring Chinook appeared to be largely driven by higher ex-vessel prices in recent years for salmon (especially Chinook) in West Coast fisheries, while lower than expected values for fall Chinook and Coho were heavily influenced by poor returns.
- Use of upriver spring Chinook ESA impacts in the current Select Areas exceeded the total annual impacts allocated to off-channel fisheries in 5 of 7 years from 2010 to 2016 under pre-Reform and Transition Period allocations and buffering. In 2017, when the commercial allocation changed to 20% (under the long-term phase of Policy implementation), with no buffering for Select Area fisheries (where most impacts were expected to be used), the Select Area fisheries still exceeded the allocated impacts. Although it is difficult to make conclusions from one year, if fisheries in existing Select Area sites continue to exceed the allocated impacts, it could make accommodating expanded or new Select Area sites challenging.
- To evaluate the potential return on investment and economic viability of current Select Area fisheries, landings and ex-vessel values (by season) from 2013-2017 were compared to the estimated costs of harvesting salmon with gill nets (from “2013 Fiscal and Economic Impact Statement”; ODFW 2013c).
 - The median net return per vessel, for all Select Area sites combined, was \$14,373 in the winter/spring fishery, \$1,963 in the summer fishery, and \$12,202 in the fall fishery (\$28,538 combined).
 - Although modest, the summer season provided an important “bridge” between the larger spring and fall fisheries.

- Select Area commercial gillnet fisheries, overall, are economically viable because of the variety of salmon stocks that are available for harvest, as well as the relatively low costs associated with salmon harvest using gill nets in these areas. Some of this diversity and value is at risk from the potential loss of high-value SAB fall Chinook production due to NMFS's concerns with straying of fish from this stock. While the annual ex-vessel value provided by SAB Chinook is, on average, a small proportion of annual ex-vessel in Select Areas, its contribution to the annual "portfolio" and aid to stability are important.
- As required by Oregon Senate Bill 830, the Youngs Bay Closure Zone (YBCZ) was established in 2014 to prohibit recreational fishing off the mouth of Youngs Bay. The closure has been implemented during August 1-September 15 to increase returns of locally-produced salmon to the Youngs Bay Select Area commercial fishery.
 - The YBCZ constitutes about 4% of the fishable area available to the Buoy 10 recreational fishery, but recreational boats sometimes concentrate downstream of it early in the season.
 - The proportion of SAB Chinook harvest in the Buoy 10 fishery increased significantly after implementation of the YBCZ (from an average of 21% in 2010-2013 to 42% in 2014-2017). This increase corresponds to increased angler effort in the Buoy 10 fishery during very large Columbia River fall Chinook returns that also occurred during much of this timeframe.
 - Because of multiple confounding factors, it is not possible to determine whether the YBCZ affected recreational catch of SAB fall Chinook.
- Spring and fall recreational fisheries in the Select Areas
 - Recreational harvest of spring Chinook is <1,000 in most years; however, it has been as high as 2,507 in 2015 and 1,999 in 2010, when returns were strong.
 - The percentage of the recreational spring Chinook harvest (mainstem and off-channel recreational fisheries downstream of Bonneville Dam) attributed to Select Area recreational fisheries increased from an average of 5% during the 2010-2012 pre-Reform period to 7% during the 2013-2017 post-Reform period.
 - Recreational fisheries accounted for an average of 7% of the Select Area winter/spring season Chinook harvest in 2010-2012 and 10% in 2013-2017.
 - Recreational spring Chinook harvest could increase in the future if the popularity of the fishery increases due to planned production enhancements, and if those releases translate into increased adult returns.
 - Select Area fall recreational fisheries harvest an average of 750 fall Chinook and 350 Coho annually.

Expansion of Existing Select Area Commercial Fisheries

- Expanded Select Area Commercial Seasons
 - The Harvest Reform Policy called for the evaluation of expanding Select Area seasons to provide additional fishing time for commercial fisheries.
 - Expanded winter seasons (early February to late March) in Tongue Point/South Channel and Knappa Slough were implemented during 2013-2017.
 - Expanded winter seasons added an average of 24 commercial fishing periods, 31 deliveries, and 77 landed spring Chinook per year, for both areas combined.

- Participation and harvest have been limited due to low fish abundance early in the year, but fish weights and price-per-pound are high.
 - Expanded winter season landings in Tongue Point/South Channel accounted for an average of 1% of the combined landings in all Select Area sites during the winter-spring seasons, while expanded winter season landings in Knappa Slough represented an average of 0.1% of the winter-spring landings.
 - The entire winter season accounted for 19% of total winter-spring ex-vessel value, but 27% of the winter-spring ESA impacts to listed upriver spring Chinook used in Select Area commercial fisheries; compared to the winter season, the spring season derives >4 times the ex-vessel value from each impact (%) used.
 - Expansion of time in the winter season is attractive to some fishers due to the opportunity to catch high-value fish; however, fishery managers will have to weigh that against less efficient use of limited impacts.
 - Expanded spring seasons (additional fishing periods interspersed between June 16 and July 28) were implemented in Tongue Point/South Channel (2016-2017) and Blind Slough/Knappa Slough (2015-2017).
 - Expanded spring seasons added an average of 20 commercial fishing periods, 147 deliveries, and 1,711 landed spring Chinook per year, for both areas combined. Fishing effort and harvest for each area trended upward over the years.
 - Participation and harvest were higher during the expanded spring season, relative to the expanded winter season, though prices per pound were higher in the winter.
 - Landings during the additional spring season periods in each of the areas accounted for an average of 6% of the combined landings in all Select Area sites during the winter-spring-summer seasons.
 - The expanded portion of the late spring season was re-categorized as part of the summer season beginning in 2017, but >99% of the catch is estimated to consist of late spring Chinook. These fish typically have lower value due to reduced quality and market conditions at this time of year; however, because the expanded season provides additional fishing time that did not exist in prior years, the value derived from this fishery is additive.
 - Based on the results of the evaluation, the additional fishing periods during the summer timeframe have been incorporated into the standard summer season structure because they give fishers the opportunity to harvest late-arriving spring Chinook, providing additional economic value that would otherwise be foregone.
- Expanded Select Area Commercial Boundaries
 - The Harvest Reform Policy also called for an evaluation of expanding Select Area site boundaries to provide additional fishing area for commercial fishers.
 - Expanded area boundaries were evaluated for the Youngs Bay Select Area, as well as waters adjacent to the South Channel and Blind Slough/Knappa Slough Select Areas.

- Spring season
 - The spring analysis focused on data for a “standard” season length (mid-February through mid-March and mid-April through mid-June); standard seasons are designed to maximize harvest while minimizing impacts to ESA-listed upriver spring Chinook.
 - Catch rates of upriver spring Chinook and steelhead were too high (under existing ESA impact limits and allocations) to allow a spring fishery in tested areas, except Outer Youngs Bay (OYB) and Grant Slough (GS).
 - Catch rates of ESA-listed stocks were low enough in OYB to fit within available impacts; however, because of the site’s location adjacent to the main Columbia River channel, catch of non-local stocks could be significant at times, making implementation of a spring fishery there risky in terms of ESA impact usage. It is possible, that under circumstances where the other Select Area sites were not expected to fully utilize upriver spring Chinook impacts available to the non-treaty commercial fishery, a fishery could be conducted in the OYB area with the “extra” impacts. But, this would have to be weighed against the alternative of using the surplus impacts to conduct a post-run update mainstem tangle net fishery, which is an option permitted in these circumstances under Oregon policy.
 - A fishery in GS would also fit within the available upriver spring Chinook impacts, so in terms of impact usage, it would be possible to conduct a spring fishery there. The GS area is small (approximately 0.35 mi²) and shallow, limiting a fishery there to relatively few fishers, with potentially difficult fishing conditions.
- Fall season
 - Catch rates of ESA listed salmon and steelhead were again too high in tested areas, except in OYB and GS, to allow for fall fisheries.
 - Similar to the spring season, catch rates of non-local stocks were low in OYB during fall test fishing; however, because of its proximity to the main Columbia River channel, there is some risk of intercepting and accumulating impacts on ESA-listed stocks during their upstream migration. Although a fall fishery could be implemented in OYB, the potential use of limited impacts there would have to be weighed against their use in mainstem commercial fisheries.
 - Because a fall fishery in GS would be dependent on returns from existing releases in the Blind Slough/Knappa Slough Select Area, the observed test-fishing catch rates of fall Chinook and Coho in GS were insufficient to justify expanding the Blind Slough/Knappa Slough Select Area into this location.

Potential New Select Area Fisheries

- In 2014, ODFW began an examination of all terminal and off-channel areas of the Columbia River below Bonneville Dam that exhibited characteristics desirable for a Select Area site.

- Twenty-nine areas were considered during an initial screening process. Sites evaluated included novel sites and sites considered during initial Select Area evaluations in the early 1990s.
- The initial screening, based on a suite of criteria important for a Select Area site, narrowed the sites for follow up field evaluation to: Clifton Channel (2014-2015), Westport Slough (2014-2016), Coal Creek Slough (2014-2015), and Bradbury Slough (2015-2016). Of these sites, Coal Creek Slough is the only one located on the Washington side of the Columbia.
- The evaluation of potential new sites was based on:
 - Test fishing to assess the presence of non-local/ESA-listed stocks
 - Assessment of each site's smolt rearing and acclimation potential including:
 - Presence of existing infrastructure to anchor/access net pens
 - Landowner permission to access potential net pen site
 - Minimum low tide depth; adequate water quality
 - Presence of a unique water source with sufficient discharge to successfully imprint juveniles and facilitate adult homing
- Clifton Channel and Bradbury Slough
 - Not recommended for implementation as a new Select Area site.
 - Catch rates of upriver Chinook and steelhead were high during spring and fall seasons in these side channel areas. Estimated upriver spring Chinook ESA impacts resulting from an implemented fishery were too high to fit within available impacts; impacts to fall ESA-listed stocks were also likely to be high.
 - The intended homing tributaries lacked sufficient discharge to provide a unique water source for imprinting smolts to the sites.
- Westport Slough
 - Further evaluation recommended prior to implementation as a new spring Select Area site.
 - Catch rates of upriver Chinook and steelhead were relatively low during spring and fall seasons in this terminal area; estimated upriver spring Chinook ESA impacts resulting from an implemented fishery would fit within available spring impacts. However, catch rates of unmarked tule Chinook and unmarked Coho were high in the fall, resulting in a high potential for impacting nearby ESA-listed tule Chinook and Coho stocks.
 - The intended homing tributary, Plympton Creek, had sufficient discharge in March, but flows dropped off sharply in April and May. In addition, Plympton Creek is located in the lower end of Westport Slough, potentially leaving the upper two-thirds of the area with very few returning adults to support fishing. Also, Westport Slough receives intermittent flows from the nearby Clatskanie River through an old channel, which could cause some smolts to imprint on that water source and stray to the Clatskanie as adults.
 - Westport Slough has some potential to be implemented as a new Select Area site for spring season fisheries; however, landowner permission for a rearing/acclimation site has not been secured, the fishable area is small (0.20 mi²) and narrow, limiting the number of fishers that would be able to fish there (further exacerbated by the location of the homing tributary).

Additionally, there are some concerns regarding possible interaction of released hatchery smolts with juvenile Chum salmon reintroduced into the Clatskanie River that need to be further evaluated before implementation.

- Coal Creek Slough
 - Implementation of this site would need to be done by WDFW.
 - Catch rates of non-local Chinook, Coho, and steelhead were low during spring and fall seasons in this terminal area. The estimated upriver spring Chinook ESA impacts resulting from an implemented fishery would fit within available spring impacts, and a fishery here would not be expected to negatively affect fall ESA-listed stocks.
 - The intended imprinting/homing tributary had sufficient discharge in March, but flows dropped off sharply in April and May, which could reduce the imprinting reliability of smolts acclimating during that time.
 - Coal Creek Slough has some potential to be implemented as a new Select Area site in spring and fall seasons; however, landowner permission for a rearing/acclimation site has not been secured, and the fishable area is small (0.25 mi²) and narrow, limiting the number of fishers that would be able to fish there.
- WDFW carried out an evaluation of Cathlamet Channel (WA) as a potential new Select Area site during the spring season, with test fishing conducted in 2013-2018, and experimental spring Chinook releases occurring in 2014-2018. Releases into Cathlamet Channel were discontinued after 2018 due to extremely poor adult returns.

Recreational Fisheries

- The total annual angler trips for salmon and steelhead in the recreational fishery downstream of Bonneville Dam increased significantly in the early 2000s as runs improved and mark-selective fisheries for hatchery spring and summer Chinook were implemented; angler trips are strongly and positively correlated with salmon run size ($R^2 = 0.83$).
- The total annual recreational harvest of salmon is also positively correlated with salmon run size ($R^2 = 0.65$), but the relationship is not as strong as it is for angler trips; other factors such as river conditions, angler skill/experience, and innovations in angling methods/tackle can have a significant effect on catch. An average of 68% of the annual Chinook harvest occurred in the fall mainstem and Buoy 10 fisheries; Coho harvest was highly variable, responding to large fluctuations in adult returns.
- Tables C1-C3 of the Management Strategies (ODFW 2012) outline expected open fishing days, angler trips, and catch in spring, summer, and fall Chinook recreational fisheries downstream of Bonneville Dam after implementation of the Harvest Reform Policy. Actual post-Reform numbers for these metrics largely met or exceeded expectations for the summer and fall seasons, but fell short of expectations in spring, despite the increased sport allocation. However, Table C1-C3 comparisons between pre- and post-Reform periods are confounded by run size effects and other factors.
- Since the catch balancing provision of the *U.S. v. Oregon* Management Agreement was implemented in 2010, it has become the limiting factor for spring recreational fisheries, rather than ESA impacts (the total allowable mortalities allowed in non-treaty fisheries is capped by the mortalities allowed for treaty fisheries). The recreational fishery has remained within its catch balance guideline in 6 of the last 8 years due to conservative

management practices (e.g. use of 30% buffer on the forecasted run size prior to an in-season run update).

- During 2013-2017, recreational summer Chinook fisheries downstream of Priest Rapids Dam used an average of 84% (range 73%-108%) of the allowed recreational harvest allocation, based on the post-season run size.
- LCR tule Chinook ESA impacts have usually been the primary constraint for fall recreational fisheries. The Buoy 10 fishery exceeded its allotted share of impacts in 3 of 5 years since implementation of the Policy; the Buoy 10 share of impacts available to the fall recreational fishery increased from 45% to 76% between 2012 and 2017, while the share of used impacts increased from 61% to 80%. Increased angler effort in the Buoy 10 fishery, along with a growing proportion of trips and kept catch within the guided angler component (a subgroup with higher than average catch rates), helps explain the increased use of ESA impacts in the fishery.
- Per the Harvest Reform Policy, the allocation of ESA impacts and/or harvestable fish in Chinook-target non-tribal fisheries shifted predominantly to recreational fisheries during 2013-2017. The effects of the allocation shifts on open fishing days and angler trips were analyzed.
 - Since a direct comparison of fishing days or angler trips before and after implementation of the Policy would be confounded by a variety of factors (especially run size), ODFW staff used year and season-specific fishery management models to compare 2013-2017 recreational fisheries (downstream of Bonneville Dam) at pre- and post-Reform allocations.
 - Modelled fishing days and angler trips at a pre-Reform allocation (2010-2012 average) were compared to actual days and trips for each fishery (at the post-Reform allocation); if the modelled “pre-Reform” fishing days and trips were lower, then the recreational fishery realized a gain due to the Policy.
 - The modelling approach holds non-allocation related factors (e.g. run size, river conditions, catch rates, etc.) constant since the only variable changed in the model is the allocation. The model uses actual data from each fishery and a “what was known when” approach to dealing with in-season management actions potentially affecting season structures and fishing opportunity.
 - Spring Chinook fishery downstream of Bonneville Dam
 - The fishery gained open fishing days and angler trips in 3 out of 5 years; additional fishing days ranged from 0 to 5 per year, and additional angler trips ranged from 0 to 10,788 per year; the percent gain in angler trips ranged from 0% to 8% per year.
 - Summer Chinook fishery downstream of Bonneville Dam
 - The fishery only gained open fishing days and angler trips in one year (2017); 25 fishing days and 5,594 trips were added (37% gain in trips from the pre-Reform level). The average trips gained per day (224) was low because open days were added in the last half of the season, when daily angler effort is rapidly diminishing due to declining summer Chinook abundance in the lower river.

- Prior to 2017, the allocation shifts did not affect summer Chinook seasons because the recreational fishery harvest was either above both the pre- and post-Reform guidelines (2013) or below them (2014-2016). Therefore, the season would have been the same under either guideline.
 - Fall Chinook fishery downstream of Bonneville Dam
 - For the years analyzed, LCR tule Chinook were usually the most constraining stock; therefore, allocation changes would be expected to primarily affect fisheries with the highest LCR Chinook impacts—the Buoy 10 and mainstem fisheries downstream of the Lewis River. The fishery upstream of the Lewis would not have been constrained in these years under pre-Reform allocations. Since 2012, fisheries managers have used MSF regulations for fall Chinook to extend recreational fisheries, rather than close them, in areas downstream of the Lewis, so it is appropriate to incorporate this management tool into our analysis. Thus, these fall Chinook fisheries were modelled in terms of angler trips on MSF and non-MSF days. Increased allocations for the fall recreational fishery would presumably result in fewer MSF and more non-MSF days if the allocation changes affected the season structure. The resulting differences in angler trips, if any, determined the gain in angler trips due to the allocation change. Comparison of actual angler trips to expected trips in Table C3 of the Management Strategies is problematic since the expected trips were modelled based on non-MSF open versus closed days.
 - Buoy 10
 - The fishery gained non-MSF fishing days and angler trips in 3 out of 5 years; additional non-MSF fishing days ranged from 0 to 6 per year, and additional angler trips ranged from 0 to 4,560 per year; the percent gain in angler trips ranged from 0% to 8% per year.
 - Mainstem (Below Lewis River)
 - This fishery also gained non-MSF fishing days and angler trips in 3 out of 5 years; additional non-MSF fishing days ranged from 0 to 6 per year, and additional angler trips ranged from 0 to 10,402 per year; the percent gain in angler trips ranged from 0% to 9% per year.
 - Total gains in non-MSF days for the fall recreational fishery ranged from 0 to 12 per year, and gains in angler trips ranged from 0 to 11,309 per year (0% to 5% per year gain).
 - Allocation shifts were not a factor for the 2016 and 2017 fall Chinook fisheries.
 - Unused Lower River Hatchery (LRH) tule impacts from ocean fisheries covered the higher than planned impact accrual in the Buoy 10 and mainstem fisheries during 2016 and 2017.
 - Buoy 10 and mainstem fishery season objectives set forth by Policy were still met when the fisheries were modelled using pre-Reform allocations for SRW Chinook.
 - For all seasons combined, the annual gain in fishing days ranged from 1 in 2016 to 25 in 2017, and the annual gain in angler trips varied from 5,594 in 2017 to 21,630 in 2015; the increase in angler trips from pre-Reform levels averaged 3% per year.

- Gains in fishing opportunity and potential economic value for the recreational fishery from Harvest Reform-related allocation shifts did not occur in all seasons, nor were they proportional to the increases in allocation share, because higher allocations did not always lead to changes in the season structure. Changes in angler trips are largely related to run-size, fishing conditions, and catch rates; gains in angler trips due to the allocation changes associated with Harvest Reform, though less than modeled pre-reform, are a small, additive percentage to the annual trip total.

Mainstem Commercial Fisheries

- Implementation of the Harvest Reform Policy resulted in reduced allocations, the removal of spring impact buffers, and requirements for use of alternative gears in some mainstem fisheries for non-treaty commercial fisheries. Beginning in 2017, the spring season ESA impact allocation for the non-treaty commercial fishery presumes no impact buffers and full use in Select Area fisheries (no spring mainstem fishery occurred in 2017 or 2018). The summer season harvest allocation requires use of an alternative gear in the mainstem starting in 2017 (no summer mainstem fishery in 2017 or 2018 due to lack of approved gear). Regarding fall Zone 4-5 gillnet fisheries, current Washington policy calls for gillnets to be discontinued after the 2018 fisheries; while current Oregon rules continue to rely on this fishery to help meet the economic goals of Harvest Reform. Fall commercial fisheries are functionally managed at $\geq 30\%$ for the most restrictive of either LCR tulle or SRW Chinook impacts, though technical allocation differences between the states remain. Fall seine fisheries and Coho tangle net fisheries occurred in 2014-2016 and 2013-2015, respectively. Future use depends upon adequate fall Chinook and steelhead impacts being available to prosecute these fisheries.
- The average number of deliveries for mainstem winter/spring and summer fisheries between the 2010-2012 pre-Reform period and 2013-2017 post-Reform period decreased as run sizes decreased, and commercial allocations were reduced and gear types disallowed. In spite of allocation reductions and regulatory changes, fall season fishery deliveries increased slightly between the pre- and post-Reform periods. These increases were largely driven by strong fall Chinook returns in 2013-2015, and an exceptional Coho run in 2014.
- Dockside price-per-pound for Chinook and Coho varied during 2010-2017, but has trended upward in recent years. Higher prices have been observed throughout West Coast salmon fisheries, and are not unique to the Columbia River. Average price-per-pound was highest for spring Chinook (\$6.92), followed by summer Chinook (\$4.05), fall Chinook (brights and tules combined, \$2.14), and Coho (\$1.66).
- Total annual mainstem ex-vessel value (2010-2017) ranged from \$3.7 million in 2014 to \$0.9 million in 2017; the low 2017 mainstem fishery value was due to a lack of spring and summer mainstem fisheries (anticipated), and limited fall fisheries because of natural-origin B-Index steelhead ESA impact constraints (unanticipated). The fall large-mesh gillnet fishery comprised the largest portion of mainstem ex-vessel value (average of 75% during 2010-2017, but there has been increased reliance on the fishery after Reform—e.g. 100% in 2017 when no other mainstem non-treaty commercial fisheries occurred), followed by the spring fishery (14%), summer fishery (6%), and fall small-mesh Coho-directed gillnet fishery (3%). Since their respective years of implementation in 2013 and

2014, the Coho tangle net and fall seine fisheries have accounted for 2% and 1% of the total annual mainstem ex-vessel value. The Coho tangle net fishery was not implemented in 2016 or 2017, and the fall seine fishery was not implemented in 2017 because available Chinook and steelhead impacts were prioritized by the industry in the Zone 4-5 fishery.

- ESA impacts/catch balancing (2010-2018)
 - Winter/Spring
 - The realized commercial share of the allowed ESA impacts for upriver spring Chinook decreased from 47% in 2010 to 20% in 2017 and 2018. Since 2017, the presumptive path (in Oregon) is that most commercial impacts will be utilized in the Select Areas, and mainstem fisheries with tangle nets would be allowed after an in-season run size update, if the Select Area fisheries were not projected to use the entire commercial ESA allocation.
 - The mainstem commercial fishery usually remained within, or was close to, the allocated impacts; in 2015 and 2016, the adaptive management provision of the Policy was enacted to provide additional commercial opportunity with gillnets after recreational fishery objectives were projected to be met. The mainstem commercial fishery remained within its catch balance guideline in all years during 2010-2018.
 - Summer Chinook
 - The commercial share of harvestable summer Chinook decreased from 50% in 2010-2012 to 20% in 2017-2018; since 2017, alternative gears have been required by Policy for summer mainstem commercial fisheries. No summer mainstem fisheries occurred in 2017 and 2018 due to the lack of an approved gear.
 - The mainstem commercial fishery usually remained within, or was close to, the allowed catch guideline; the policy allowed shifting of unused recreational impacts in 2016 which provided additional commercial opportunity after recreational fishery objectives were projected to be met. The incidental harvest of upper Columbia summer Chinook in Select Area fisheries averaged ~50 fish/year in 2017-2018.
 - Fall Chinook
 - The average actual commercial share of allowed LCR tule Chinook ESA impacts decreased from 41% in 2010-2012 to 14% in 2017 (the preseason expectation in 2017 was 31%, but the fishery was severely constrained by limited natural-origin B-Index steelhead impacts).
 - The average actual commercial share of allowed SRW Chinook ESA impacts increased from 48% during 2010-2012 to 54% in 2013-2016 due to large fall Chinook runs in 2013-2015 that provided additional commercial opportunity after recreational fishery objectives were projected to be met. The commercial fishery only used 27% of the allowed SRW impacts in 2017 (36% expected preseason) due to wild B-Index steelhead constraints.
 - Coho
 - The average actual use of Lower Columbia Natural (LCN) Coho ESA impacts allowed in commercial fisheries decreased from 78% in 2010-2012 to 32% in 2017; constraints imposed by SRW Chinook in 2016 and natural-

origin B-Index steelhead in 2017 contributed to the lower LCN impact usage, as no Coho-directed mainstem commercial fisheries occurred in 2016 or 2017.

- To evaluate the potential return on investment and economic viability of mainstem commercial gillnet fisheries, landings and ex-vessel values (by fishery) from 2013-2017 were compared to the estimated costs of harvesting salmon with gill nets (from “2013 Fiscal and Economic Impact Statement”; ODFW 2013c).
 - Spring mainstem fishery (gillnet and tangle net; 2013-2016)
 - The average net return per vessel was \$4,054 for ~6 fishing periods; average net return over a much longer season was \$12,897 in the Select Area spring fishery; net return per vessel-day was \$661 in the mainstem spring fishery and \$75 in the Select Area spring fishery.
 - Summer mainstem fishery (2013-2016)
 - The average net return per vessel was \$2,685 for ~3 fishing periods; average net return over a longer season was \$3,161 in the Select Area summer fishery; net return per vessel-day was \$930 in the mainstem summer fishery and \$118 in the Select Area summer fishery.
 - Fall Zone 4-5 fishery (2013-2017)
 - The average net return per vessel was \$32,207 for ~18 fishing periods, partly due to large fall Chinook runs in several of the years; average net return over a longer season was \$14,924 in the Select Area fall fishery; net return per vessel-day was \$1,711 in the Zone 4-5 fishery and \$90 in the Select Area fall fishery.
 - Coho 6-inch gillnet fishery (2013-2015)
 - The average net return per vessel was \$2,257 for ~7 fishing periods, but was driven by a very strong Coho run in 2014 (median net return per vessel was \$181), and net return per vessel was negative (-\$46) in 2013; large fluctuations in Coho returns were responsible for high variability in landings and economic value.
 - The average net return per vessel for all mainstem commercial fisheries combined was \$41,203. The Zone 4-5 fishery was the most productive commercial fishery in the lower Columbia; however, even relatively short spring and summer mainstem seasons provided significant economic returns to fishers. The viability of commercial gillnet fisheries are affected by the diversity and abundance of stocks available for harvest throughout the year, as well as the relatively low operating costs associated with gillnets.
- To assess the current capability of alternative gears to effectively replace gillnets in fall mainstem non-treaty commercial fisheries (per original Policy), the Zone 4-5 large-mesh gillnet fishery (2014-2017) was compared to the fall seine fishery (2014-2016) and a hypothetical fall commercial pound net fishery (2016-2017).
 - Total annual harvest, ex-vessel value, and value per fisher-day were substantially higher in the Zone 4-5 gillnet fishery.
 - Harvest and ex-vessel value in mark-selective seine and hypothetical pound net fisheries were negatively affected by low mark rates for fall Chinook and early stock Coho.

- The seine fishery was limited by IFQs, but this was not a factor in the analysis because most fishers did not achieve their quotas.
 - Catch rates of harvestable adult Chinook, total adult salmon, and total pounds of landed salmon were all highest for the Zone 4-5 fishery.
 - The catch composition in the Zone 4-5 fishery was more economically favorable than in the alternative gears.
 - Chinook comprised 95% of the gillnet catch, compared to 48% for the alternative gears.
 - Chinook have 2-3 times the value of Coho.
 - Steelhead have no economic value in non-treaty commercial fisheries because they cannot be retained; steelhead comprised 17% of the alternative gear catch, compared to 2% of the gillnet catch.
 - Low value jack salmon comprised 21% of the alternative gear catch and 1% of the gillnet catch.
 - The percentage of fall Chinook graded by buyers as “tule” (i.e. inferior flesh quality) was higher for the beach seine catch than for either purse seine or gillnets.
 - Tules appear to migrate closer to shore and may be more likely to be encountered by shore-oriented gears.
 - The average price-per-pound (2014-2017) for tule Chinook was \$0.57, compared to \$2.67 for bright Chinook.
 - The pound net may also catch a higher percentage of tules due to similarities in Chinook catch attributes between the pound net and beach seine.
 - The steelhead catch rate (steelhead/fisher-hour) and ratio of steelhead to adult Chinook were lowest in the Zone 4-5 gillnet fishery and highest for shore-oriented gears (beach seine and pound net).
 - The high handle of steelhead (especially ESA-listed natural-origin B-Index steelhead) in the alternative gears appears to be a primary limiting factor. While these gears have relatively low release mortality rates *per steelhead encountered*, their use can still create a significant impact since mortalities are a product of both the number of fish handled *and* the mortality rate *per fish*.
- “Selectivity” in fisheries management can have different meanings for different interest groups, fishery managers, and policy makers. The Department of Fisheries and Oceans Canada defined selective fishing as “the ability to avoid known, non-target species and stocks or, if encountered, to release them alive and unharmed” (DFO 1999). This definition of selectivity recognizes that there are multiple ways to reduce impacts on non-target species and stocks while conducting productive fisheries.
 - Fishery managers use time, area, and gear (TAG) regulations to design fisheries to avoid or reduce encounters with non-target species/stocks.
 - Commercial fishery examples:
 - Select Area fisheries conducted in off-channel areas (Area), and closed during most of April (Time)

- 8 or 9-inch minimum mesh size restriction (depending on season) in mainstem summer and fall Chinook-directed fisheries substantially reduces encounters of Sockeye and steelhead (Gear)
 - Mainstem fall large-mesh fishery restricted to Zones 4-5 to minimize encounters with LCR tule Chinook (Area)
 - Recreational fishery examples:
 - Spring Chinook fishery restricted to downstream of I-5 Bridge (Area), and closed after March 31 (Time), during 1990s to minimize encounters with depressed runs of upriver spring Chinook
 - Fall Chinook fishery between Tongue Point and the Lewis River closed starting in mid-September to reduce encounters with LCR tule Chinook (Area & Time)
 - Delayed opening of summer steelhead season in some years to avoid upriver spring Chinook (Time)
- Gears with relatively low release mortality rates can be used in mark-selective fisheries that harvest fin-clipped hatchery fish and release non-fin-clipped fish.
 - A major assumption in mark-selective fisheries is that mark rates of target species/stocks are high enough to promote commercially viable and recreationally satisfying fisheries.
 - The combined effects of release mortality and mark rate can create unique outcomes for specific fisheries; these should be evaluated independently from superficially similar fisheries
 - Commercial fishery examples: spring tangle net, Coho tangle net, fall seine, pound net
 - Recreational fishery examples: spring Chinook, summer Chinook, Coho, steelhead
- To evaluate the relative selectivity of TAG-selective gillnet and mark-selective alternative gear fisheries, we compared the ex-vessel value generated per natural-origin B-Index steelhead mortality for Zone 4-5 gillnet versus fall purse and beach seine fisheries.
 - The Zone 4-5 fishery consistently produced a substantially higher ex-vessel value per natural-origin B-Index steelhead mortality compared to the other gears evaluated. Despite having a lower post-release mortality rate, the alternative gears used comparatively *more* limited natural-origin B-Index steelhead impacts due to the larger number of steelhead handled. Because they reach their B-index steelhead impact limits before attaining the same level of Chinook catch, alternative gears have not been able to achieve an ex-vessel value equal to that of the gillnet fishery.
- A hypothetical non-mark-selective fall seine fishery in Zones 4-5, which would maximize harvest potential for seines, was compared to the Zone 4-5 gillnet fishery using data from 2014-2015.
 - The adult Chinook ex-vessel value per unmarked B-Index steelhead mortality produced by non-mark-selective purse seines was 61% of the value/mortality generated by the gillnet fishery, while beach seine value/mortality was 9% of the gillnet value.

- The adult Chinook ex-vessel value per LCR tulle Chinook mortality produced by non-mark-selective purse seines was 67% of the value/mortality generated by the gillnet fishery, while beach seine value/mortality was 45% of the gillnet value.

Harvest Reform Policy Effects on Commercial Fishery Economics

- When assessing the effects of the Policy on commercial fishery economics, it is natural to compare actual post-Reform ex-vessel values to those predicted in Tables C4 and C5 of the Management Strategies. However, factors unrelated to the Policy (e.g. run size, average fish weights, prices) confound this direct comparison, making the proportional change in catch or value presented in Tables C4 and C5 an additional important metric of interest. Since run size has a strong positive correlation with ex-vessel value ($R^2 = 0.72$), and higher prices have an obvious positive effect on value, a modelling approach that isolates variables affected by the Policy such as allocation share or additional Select Area production, while holding non-Policy variables constant, is needed.
 - ODFW staff used year- and season-specific fishery management models to compare 2013-2018 non-treaty commercial fisheries at pre- and post-Reform allocations and Select Area releases.
 - Commercial fishery values at a pre-Reform allocation (2010-2012 average) and pre-Reform Select Area hatchery fish releases were compared to actual values for the fishery (at the post-Reform allocation and releases); if the modelled “pre-Reform” values were higher, then the commercial fishery realized a loss due to the Policy.
 - Models used actual data from each fishery, and a “what was known when” approach to in-season management actions potentially affecting season structures.
 - Mainstem spring Chinook (2013-2018)
 - Economic losses from this fishery occurred in every year during the post-Reform period; losses increased from \$60,269 in 2013 to \$461,599 in 2018, and averaged \$233,552 annually.
 - Since mainstem spring Chinook fisheries did not occur in 2017 and 2018, expected ex-vessel values were generated based on modelling potential catch and value specific to each year, given pre-Reform assumptions.
 - Mainstem summer Chinook (2013-2018)
 - Economic losses occurred in every year during the post-Reform period; losses ranged from \$31,903 in 2014 to \$222,122 in 2017, and averaged \$115,491 annually
 - Since mainstem summer Chinook fisheries did not occur in 2017 and 2018, expected ex-vessel values were generated based on modelling potential catch and value specific to each year, given pre-Reform assumptions.
 - Zone 4-5 fall Chinook (2013-2018)
 - Economic losses occurred in 4 of 6 years during the post-Reform period; losses ranged from a low of \$190,314 in 2018 to a high of \$1,032,775 in 2015, and averaged \$363,215 annually.

- No estimated economic loss occurred in 2016 or 2017 due to constraints on fisheries from factors not affected by the Policy (significant URB/SRW fall Chinook run downgrade in 2016; record low 2017 natural-origin B-Index steelhead return). These factors had a greater effect on fisheries than the policy changes.
- Mainstem Coho-directed gillnet (2013-2018)
 - Economic gain of \$10,744 in 2013 (under pre-Reform assumptions, fewer LCN Coho impacts would have been available for Coho-directed fisheries), and losses of \$73,926 in 2014 and \$24,197 in 2015; net average loss of \$14,563 annually. Due to constraints on other ESA-listed stocks, Coho-directed fisheries did not occur in 2016-2018.
 - Volatility in performance of Coho stocks is a significant driver in the economic performance of mainstem commercial Coho fisheries, under pre- or post-Reform scenarios.
- Select Area spring Chinook (2013-2018)
 - Economic gains occurred in every year during the post-Reform period; gains increased from \$16,766 in 2013 to \$334,467 in 2018, and averaged \$161,799 annually.
- Select Area fall Chinook (2015-2018)
 - Increased SAB fall Chinook releases from the Policy did not influence adult returns until 2015. Unrelated to the Policy, beginning in 2017, SAB production was significantly reduced due to federal hatchery reforms and Mitchell Act cuts; therefore, Reform-related benefits from SABs are likely to diminish in the future.
 - Economic gains occurred in all four years; gains ranged from \$5,090 in 2018 to \$60,866 in 2016, and averaged \$20,960 annually.
 - Tule fall Chinook production in Select Areas was not addressed in the Policy, but the ex-vessel value of harvested tule Chinook is included in the economic analysis.
- Select Area Coho (2014-2018)
 - Increased releases from the Policy did not influence adult returns until 2014.
 - Economic gains occurred in all five years; gains ranged from a low of \$24,705 in 2018 to a high of \$166,058 in 2014, and averaged \$73,669 annually.
 - Volatility in performance of Coho stocks is a significant driver in the economic performance of Select Area commercial Coho fisheries, even under post-Reform increased releases.
- Mainstem fall seine (beach and purse; Chinook and Coho; 2013-2018)
 - The pilot 2014 seine fishery used research ESA impacts so it was not included in the analysis as a true fishery; the seine fishery did not occur in 2013 or 2017-2018.
 - Economic gains ranged from \$33,286 in 2016 to \$56,649 in 2015.
- Mainstem Coho tangle net (2013-2018)

- The fishery did not occur in 2016-2018.
- Economic gains ranged from \$49,624 in 2015 to \$162,732 in 2014.
- As in other Coho-directed fisheries, volatility in returns was a significant driver in the performance of the Coho tangle net fishery.
- For all non-treaty commercial fisheries combined, the actual vs. predicted (C5) economic deltas were:
 - 2013: -11% actual; +6% predicted
 - 2014: -4% actual; +7% predicted
 - 2015: -16% actual; +9% predicted
 - 2016: +1% actual; +19% predicted
 - 2017: -3% actual; +5% predicted
 - 2018: -18% actual; +10% predicted
 - 2013-2018 average: -8% actual; +9% predicted

Key Findings

- The following summarizes key findings to date with respect to the three main approaches (Select Areas, Alternative Gears, and Allocation Shifts) to implementing the Harvest Reform Policy.
 - Select Areas
 - Goals for Reform-mandated increases in smolt production have been met for some stocks (Coho and Oregon spring Chinook), but not for others (SAB fall Chinook, Washington spring Chinook); there is the potential for SAB production, unrelated to harvest reform, to be eliminated due to NMFS's concern with straying of fish from this stock.
 - Adult returns of Oregon spring Chinook have largely met expectations, but Washington spring Chinook returns have been poor and have not contributed to meaningful commercial harvest; SAB returns have also been poor in recent years.
 - There has been an inconsistency between increasing releases and highly variable adult returns for Coho.
 - If we assume that survival rates are constant between base and enhanced releases, then adult returns are proportionally to increased over what they would've been without enhanced production.
 - Often, survival rates are variable and unpredictable, resulting in realized adult returns that may not be an increase in proportion to releases. For example, if a hypothetical 10,000 fish were forecast to be harvested by models due to an increase in releases by 20%, but due to variable ocean survival only 8,000 were actually harvested, the 8,000 harvest would still be 20% higher than would've been expected without the additional releases.
 - Adult returns associated with Reform-related releases contributed an average of 12% to total annual Select Area ex-vessel value, indicating that most Select Area value was derived from base production.

- Lack of change in overall Select Area commercial fishing effort after implementation of the Policy suggests there has not been a large influx of fishers into Select Area fisheries. It is unclear whether this lack of increased participation is due to overcrowding (i.e., the existing Select Area sites may be at or near capacity), proximity (i.e., since most Select Area sites are located in the estuary, it may not be economically feasible for non-local fishers to travel to these sites on a regular basis), or if other, as yet undetermined, factors are in play.
- Multi-year evaluations conducted to assess the feasibility of implementing expanded or new Select Area sites identified two potential new sites— Westport Slough (OR) and Coal Creek Slough (WA). Coal Creek Slough has potential for both spring and fall season fisheries, while Westport Slough would only be viable in the spring season. If logistical issues can be addressed, implementation of a Select Area site in Coal Creek Slough would provide a second off-channel fishery in Washington for a small number of fishers.
- As indicated in prior staff reports, Select Area fisheries cannot be alone cannot be expected to provide full economic stability for the commercial fishing community. The Reform policy recognized a continued need for some level of mainstem harvest by the commercial fishery, and the OFWC actions in March 2017, particularly those to allow the continued use of large mesh gillnets to target healthy upriver stocks of fall Chinook reflects the recognition of this need. Economic stability is improved by having fisheries that are diversified across several stocks, both Select Area and mainstem, and are capable of benefitting a broad spectrum of commercial fishers.
- Alternative Gears
 - Many alternative gears have been evaluated over almost two decades, but it has been difficult identifying a gear that can provide additional conservation benefits while producing an economic value equivalent to gillnet fisheries.
 - With some exceptions, condition of non-target fish released from alternative gears has been relatively good; however, large numbers of non-target fish are often handled. Since overall mortalities are a product of both handle and release mortality rate, gears that handle a large number of non-target fish may not be viable economically, even at a low mortality rate for individual fish.
 - Most alternative gears had low target fish catch rates, and mark rates for summer and fall Chinook were low, making mark-selective commercial fisheries during the summer and fall seasons challenging. Of the gears tested for initial feasibility, the fall purse seine and pound net (2017) had the highest catch rates.
 - Mark-selective fall seine and Coho tangle net fisheries were implemented during the transition period, and resulted in modest landings and ex-vessel

values. These alternative gear fisheries contributed an average of 1% and 2%, respectively, to total annual mainstem value.

- The majority of seine fishery quotas for adult Chinook and Coho went unharvested due to low catch rates, with many fishers opting to cut their season short; the seine fishery was not economically viable for most fishers because of low ex-vessel value and high costs.
 - The Coho tangle net fishery provided positive economic benefits in 1 of 3 years implemented (2014), when the return was large. Nevertheless, because of its low handle of non-target fish, relatively low mortality rate for released catch, low cost, and moderately high participation in 2013-2015 fisheries, it is a suitable alternative to small-mesh gillnets for Coho-directed fisheries.
 - With the exception of open fishing days for the seine fishery (though limited to a few participants), neither alternative gear fishery met expectations in Tables C4 and C5 of the Management Strategies.
- An analysis of the current capability of alternative gears (purse and beach seines) to effectively replace gillnets in fall mainstem Chinook-directed commercial fisheries indicated that catch rates, harvest, and ex-vessel value were lower in alternative gears, and that the catch composition was less favorable economically (more Coho, steelhead, jacks, and tule Chinook). Relatively high ratios of steelhead to harvestable adult Chinook in the alternative gear catch also indicated that these gears used limited ESA impacts for steelhead inefficiently.
 - There are multiple approaches to “selectivity” in fisheries management--Time/Area/Gear or TAG-selective fisheries and mark-selective fisheries.
 - An analysis of selectivity for mark-selective alternative gears and TAG-selective gillnets indicated that alternative gears generated significantly lower ex-vessel value per natural-origin B-Index steelhead mortality than gillnets. In addition, a hypothetical non-mark-selective seine fishery in Zones 4-5 could not generate an ex-vessel value per unmarked B-Index steelhead mortality (or LCR tule mortality) equivalent to the existing gillnet fishery.
 - The evaluated alternative gears do not appear capable of replacing the economic value of the fall large-mesh gillnet fishery while remaining within the ESA impacts allocated to the commercial fishery. High cost alternative gears such as purse seines are also not likely to be broadly adopted by current or new Columbia River commercial fishers given limited potential for landings and ex-vessel value. Although it may be possible to sell alternative gear-caught fish in high-value specialty markets, the extent to which these niche markets might be available to alternative gear fisheries has not been fully explored. Alternative gears may be most appropriate for small-scale mark-selective fisheries, where the participants are primarily

fishers who already have the boats and/or gear. These fisheries could be used to lower hatchery-wild fish ratios in specific locations (e.g. tributary mouths) to provide conservation benefits, while contributing to commercial fishery economics. In addition, alternative gears such as the pound net could serve as a monitoring and research tool in the lower Columbia.

- One alternative gear with a mortality rate comparable to recreational fisheries, and with a proven track record of being economically viable, is the spring Chinook tangle net. Current Oregon policy does not make implementation of a mainstem spring tangle net fishery consistently likely after 2016.
- Allocation Shifts
 - The recreational allocation of ESA impacts and harvestable summer Chinook increased from 2010-2012 pre-Reform averages of 60% for spring Chinook, 50% for summer Chinook, and 59% for fall Chinook to 80% for spring Chinook, 80% for summer Chinook, and $\leq 70\%$ for fall Chinook in 2017-2018.
 - The shifting of allocation shares from the commercial to recreational fisheries resulted in an average annual gain in angler trips of 3% for the recreational fishery (all seasons combined) during 2013-2017. This suggested that the number of angler trips made annually during the post-Reform years was primarily affected by factors unrelated to the allocation shift (e.g. run sizes, fishing conditions, catch rates, etc.).
 - Allocation changes did not always affect the season structure of recreational fisheries because fishery harvest and effort in a particular season were sometimes constrained by factors other than allocation, or in some cases, were able to reach full seasons within per-Reform allocations (some summer Chinook seasons). Therefore, gains in angler trips due to the Policy were not proportional to changes in the allocation, and did not provide the full level of benefits expected for the recreational fishery.
- Conclusion
 - As a result of implementation of the Harvest Reform Policy, the commercial allocation has been significantly reduced, and gillnets (along with spring tangle nets) have essentially been phased out of mainstem spring and summer commercial fisheries.
 - Current Washington policy requires the use of alternative gears in mainstem fall commercial fisheries after 2018. Mark-selective commercial fisheries conducted during the transition period using some of the most promising alternative gears developed to date, have not met expectations, indicating that the lost economic value of mainstem fall gillnet fisheries cannot be replaced by these gears.
 - Expanded and new Select Area sites were expected to provide additional off-channel fishing area and economic value for commercial fishers; however, multi-year evaluations identified only two, relatively small,

candidate sites for fishery implementation (neither of which has been implemented due to logistical and/or conservation issues). Furthermore, although planned increases in Select Area production have been met for some stocks, they have not always translated into proportional increases in adult returns and harvest due to variable survival rates.

- Gains in ex-vessel value during the post-Reform period did occur due to increased Select Area production, and the limited contribution of alternative gear fisheries. However, total annual commercial ex-vessel values (across all fisheries and seasons) under the Policy were less than what would have been produced without the Policy. While this information has been updated for this report, this outcome was also shown in prior documents presented to the OFWC by ODFW. The average annual economic loss to the commercial fishery between 2013 and summer 2018 was -\$387,269. This equates to an 8% loss for the commercial fishery, compared to the 9% gain expected as a result of Policy implementation.
- [CURRENT DOCUMENT DOES NOT INCLUDE DISCUSSION OF OVERALL ECONOMIC IMPACT TO OREGON IN TERMS OF LPII THAT WAS PRESENTED TO THE OFWC IN JANUARY AND MARCH 2017 – UNDER DEVELOPMENT]

INTRODUCTION

Columbia River recreational and commercial fisheries are an integral part of the social and economic fabric of Oregon and Washington, providing valuable jobs and economic resources to rural and urban communities. Optimizing the economic value of both of these fisheries, within a conservation-based framework that assists recovery of Columbia and Snake River fish species listed under the federal Endangered Species Act (ESA), is a management priority (ODFW 2012).

Thirteen stocks of salmon and steelhead are currently listed under the ESA in the Columbia River basin. Limits on the allowable incidental take of these stocks (ESA impacts) significantly constrain access by recreational, commercial, and tribal fisheries to hatchery stocks and healthy natural-origin fish runs. Since the early 1990s, efforts have been made to find ways to target harvest on abundant hatchery and natural-origin stocks, while limiting impacts to ESA-listed stocks. Initially, these efforts focused on regulating the timing, area, and/or gears of fisheries to minimize encounters with ESA-listed stocks in the mainstem Columbia, but also included identifying and developing terminal and off-channel fishing areas in the lower Columbia where specific hatchery stocks could be targeted. Furthermore, the advent of mark-selective fisheries (MSF) in the Columbia allowed the harvest of fin-clipped hatchery fish while requiring the release of natural-origin fish. More recently, in 2009, the Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW) began to investigate alternative commercial fishing gears that could allow for the live release of non-target salmon and steelhead in non-treaty summer and fall commercial fisheries in the mainstem Columbia.

These efforts to refocus lower Columbia River fisheries gained added attention in 2012 when petitioners collected enough signatures to place a measure on the Oregon ballot which would have banned gillnets in inland waters of the State of Oregon, including the Columbia River. In August of that year, then-Oregon Governor John Kitzhaber requested that a working group consisting of members of the Oregon and Washington Fish and Wildlife Commissions (hereafter referred to as Working Group) conduct a comprehensive review of non-tribal fisheries on the Columbia River, with input from representatives of the recreational and commercial fishing industries. Governor Kitzhaber further asked that the Working Group formulate a plan to: 1) prioritize recreational fisheries in the mainstem Columbia and non-tribal commercial fisheries in off-channel areas, 2) phase out the use of non-tribal commercial gillnets in the mainstem Columbia, while retaining their use in off-channel areas, 3) improve off-channel fisheries by increasing hatchery production in those areas, as well as expanding fishery areas and/or seasons and developing new off-channel fisheries, and 4) continue development and use of alternative fishing gears for mainstem non-tribal commercial fisheries. The resulting recommendations of the Working Group were presented to the full commissions of both states in the document “Management Strategies for Columbia River Recreational and Commercial Fisheries: 2013 and Beyond” (ODFW 2012). The Management Strategies, collectively known as the “Harvest Reform Policy” were approved by the Oregon and Washington Fish and Wildlife Commissions in late 2012 and early 2013, respectively.

The Harvest Reform Policy was to be phased in over five years, with a 4-year transition period from 2013 through 2016, and full implementation in 2017. A full review of the policy was conducted, as required, at the end of the transition period. In early 2017, the OFWC considered

this analysis and implemented changes to the policy by adaptive management. In this report, we provide an updated review of lower Columbia River recreational and commercial fisheries prior to, and during, the Harvest Reform implementation period (the “post-Reform” period is defined as 2013 and subsequent years). We also summarize and assess the results from all of the alternative commercial fishing gear evaluations, as well as evaluations to determine the feasibility of establishing expanded and new off-channel commercial fisheries. Furthermore, we analyze alternative gear commercial fisheries that were implemented during the transition period, and assess the current capability of alternative gears to replace conventional gillnets in non-tribal mainstem commercial fisheries. Finally, we present key findings related to the performance and effects of the Policy during its implementation.

DRAFT

ALTERNATIVE GEAR FEASIBILITY EVALUATIONS

A key provision in the Harvest Reform Policy is the development of alternative commercial gears that would allow the implementation of mark-selective regulations in all non-tribal commercial fisheries in the mainstem Columbia River. These gears would conceptually provide an opportunity to target commercial harvest on hatchery stocks, while permitting the release of natural-origin salmon and all steelhead. A major assumption of the Policy was that, as gillnets were transitioned off the mainstem lower Columbia River and allocations shifted from commercial to recreational fisheries, the combination of alternative gears and increased catches in Select Areas would replace the lost economic value for the commercial fishery.

Well before implementation of the Harvest Reform Policy, ODFW, in coordination with WDFW, began investigating the feasibility of employing gears other than gillnets in commercial salmon fisheries in the mainstem Columbia River downstream of Bonneville Dam. Research in the early 2000s indicated that natural-origin spring Chinook could be released from small-mesh tangle nets at relatively low mortality rates, while harvesting economically viable numbers of hatchery spring Chinook (Whisler 2003; Vander Haegen et al. 2004; Ashbrook et al. 2008). As a result, successful mark-selective commercial tangle net fisheries for spring Chinook were conducted in the mainstem lower Columbia from 2002 through 2016. As part of the Harvest Reform associated allocation shifts adopted by the OFWC in March of 2017, these mainstem spring Chinook MSFs with tangle-nets are limited to post-run update situations when sufficient impacts are available; this situation is expected to occur infrequently.

Given these allocation shifts, the alternative gear feasibility evaluations we report on here will focus on gears evaluated more recently for use during the summer and fall seasons. These evaluations, spurred by the need to reduce the percentage of hatchery fish on the spawning grounds, started in 2009, and took place in Columbia River Commercial Fishing Zones (hereafter shortened to “Zone”) 1 through 5 (Figure 1), though they were not distributed randomly or equally amongst the Zones.

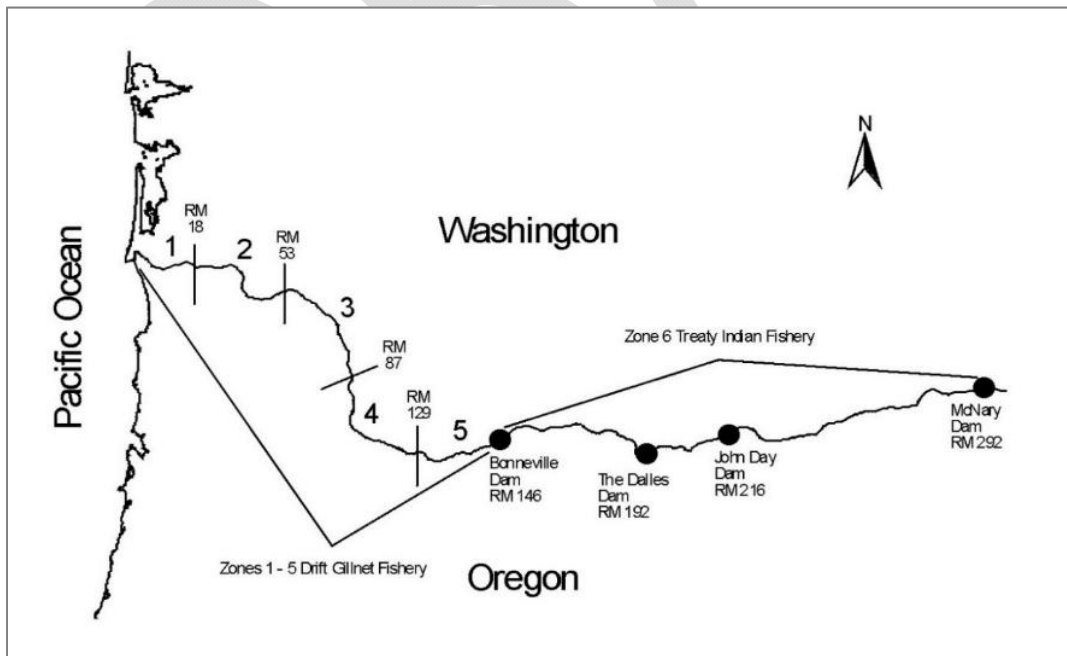


Figure 1. Commercial fishing zones of the jointly managed Columbia River.

Most gears evaluated were historically used to commercially harvest salmon in the Columbia River. To facilitate the live release of non-target fish, gears needed to have a design suggesting the potential to release fish in good condition.

The alternative commercial gears described in this report were evaluated based on eight key criteria:

Catch Rate of Target Species/Stock: Can the gear catch commercially viable numbers of fish of the target species/stock for a given unit of fishing effort? If catch rates are insufficient, can modifications be made to improve the catchability of the gear? Catch rates were measured in terms of marked (fin-clipped) adult salmon since unmarked salmon would not be harvestable in a mark-selective fishery, and jacks have very little commercial value due to low weight and price per pound.

Mark Rate of Target Species/Stock: Are mark rates high enough to allow efficient harvest of fin-clipped hatchery fish in a mark-selective fishery? Mark rates determine the proportion of the target species catch that is available for harvest, and contributes to the ex-vessel value of a commercial fishery. It also affects the handle of unmarked (non-target) fish, and resulting ESA impacts.

Handle of Non-Target Species/Stock: How many fish of key non-target species/stocks (e.g. steelhead, Sockeye, Chum, and unmarked Chinook and Coho) are encountered by the gear? This is an important factor in determining mortalities for a given species/stock attributed to a particular gear type since the number of mortalities is a product of total handle and mortality rate.

Condition of Non-Target Catch: What is the condition of fish of key non-target species/stocks at capture/release? Can they be released alive, and what is the post-release survival? If the mortality rate – immediate or post-release – of non-target fish captured in the gear is too high, can modifications be made to the gear to improve condition and survival? For the initial gear feasibility evaluations, post-release survival was assumed to be qualitatively related to the average condition at release of fish captured by the gear. However, for some of the more promising gear types, statistically rigorous post-release survival studies were designed and implemented to determine more precise estimates of survival. These studies are described later in this report (see Alternative Gear Post-Release Mortality Evaluations).

Potential Effect on ESA Impacts: How would gear-related mortalities in a full scale commercial fishery potentially affect the use of ESA impacts available to non-treaty commercial fisheries?

Gear/Boat Investment Costs: Economic assessments for the initial gear feasibility evaluations were qualitative in nature and focused primarily on the capital investment costs associated with gear conversion. More detailed and quantitative economic analyses, that include annual and daily operating costs, as well as the effects of catch composition on ex-vessel value, were conducted for alternative gears that were- or had the potential to be-implemented in commercial fisheries. These analyses are summarized later in this report (see Alternative Gear Fisheries Implementation; Mainstem Commercial Fisheries—Comparative Commercial Gear Analysis).

Regulatory Requirements: What are the regulatory requirements that would need to be met for the gear to be implemented in a full scale commercial fishery? Can these requirements be met relatively easily and at a reasonable cost?

Social Issues/Concerns: Are there any social issues or concerns that could make implementation of a full scale commercial fishery with the gear difficult or impossible? For example, is there potential for conflict with recreational fishers or other river users and landowners?

For each alternative gear evaluated, we briefly describe the gear and its history (if applicable), summarize the results of test fishing or simulation modelling, and provide an assessment of the gear's feasibility for potential fishery implementation or further investigation. In addition, we provide a gear comparison and overall assessment of alternative gears within the framework of the criteria described above.

Beach Seine - Summer

Native Americans used seines made from wild grasses and spruce roots to capture salmon on the Columbia River for subsistence and trade. The first commercial beach seine catches of Columbia River salmon were reported in 1877. These early commercial beach seines were hauled by hand onto shore. In 1895, horses began to be used to haul the seines as seining operations expanded (Figure 1a). Up to seven teams of horses could be used by a single seining crew consisting of 2 to 40 people. The size of the seine also increased over the years, as some became as long as 400 fathoms (2,400 ft) and as deep as 7 fathoms (42 ft). By the late 1920s, approximately one hundred beach seines were in use on the Columbia. Most seining sites were owned or leased by salmon-canning companies (Oregon Historical Society 2016). During the late 1920s and early 1930s, beach seines accounted for about 15% of the catch of salmon and steelhead from the Columbia River (Craig and Hacker 1938). Horse and hand (beach) seines were outlawed in Washington and Oregon in 1934 and 1948, respectively (Oregon Historical Society 2016).



Figure 1a. Hauling in a beach seine with horses near Astoria, Oregon, circa 1938 (source: NOAA 2018).

Modern beach seines adapted for use in the Columbia River are typically comprised of a net made of knotted nylon twine with a relatively small mesh size (e.g. 3½ inches bar measure), and have a float line and lead line. Most beach seines are 125-150 fathoms (750-900 ft) in length and 30-40 ft in depth. In modern beach seining, one end of the net is anchored on the beach and the other end is towed out into the river and in a downstream direction (or upstream if the tide has reversed river flow) using a conventional gillnet boat. The end of the seine attached to the boat is brought back to shore approximately 75-100 yards downstream of the anchor point. This can be challenging to accomplish without losing fish when the river current is strong and wants to “pull” the seine downstream. Once back onshore, the seine is pulled through a block anchored on the beach using the boat (Figure 1b), or hauled in with a truck.



Figure 1b. Beach seine set by gillnet boat, lower Columbia River.

As the area enclosed by the seine gets smaller, captured fish are herded by the net towards the beach. Once the lead line is pulled onto the beach, the seine is considered “pursed” and fish can no longer escape. Captured fish can then be sorted by crew members (Figure 1c). Typically, 3-5 fishers are needed to conduct beach seining operations, depending on the size of the operation.



Figure 1c. Sorting fish captured in the beach seine (source: WDFW).

Because of the gear’s history of successfully harvesting salmon in the Columbia River, in 2011, ODFW began to evaluate beach seines as a potential alternative commercial gear for harvesting hatchery Chinook salmon in the lower Columbia River during the summer season (June 16–July 31). Test fishing objectives included: 1) determining whether sufficient numbers of hatchery summer Chinook could be caught using beach seine gear, 2) assessing the handle and condition of non-target species/stocks, and 3) evaluating modifications to the beach seine intended to help improve the capture condition of Sockeye salmon. The third objective was added after large catches of Sockeye were observed in 2012.

ODFW contracted with three commercial fishers in 2011 and 2012 to test fish with beach seines in Zone 2, and one commercial fisher in 2013 and 2014 to test fish in Zone 4. Each year, test fishing was conducted from mid-June through mid-July. Each test fisher was required to make at least four sets per day. Beach seine lengths varied from 125 to 240 fathoms (750-1,440 ft), with 150 fathoms (900 ft) the most common length. Net depths ranged from 30 to 45 ft, with 40 ft the most common depth. The seine was constructed of 3½-in mesh. However, in response to high Sockeye catches in 2012, the test fisher modified his net in 2013 and 2014 by adding a section of 2½-in mesh in the middle of the seine in an attempt to reduce injuries to Sockeye caused by the webbing.

During the 4-year summer beach seine evaluation, the contracted test fishers made a total of 309 beach seine sets over the course of 78 fisher-days, and caught 480 marked and 365 unmarked adult Chinook. Catch rates of marked adult Chinook ranged from 1.1 to 2.8 fish per set, with an average of 1.6 fish per set (Table 1a). The mark rate of adult Chinook caught in beach seines varied from 43% to 76%, and averaged 57% during the evaluation. Sockeye were, by far, the most numerous non-target species in the beach seine catch, with a total of 7,567 handled. Sockeye catch rates ranged from 1.7 fish per set to 76.7 fish per set, with an average of 24.5 fish per set (Table 1a). The number of Sockeye handled per marked adult Chinook ranged from 1.4 in 2011 to 44.6 in 2014, with an overall average of 15.8. Figure 1d shows that there was a only a moderate positive relationship between Sockeye catch in beach seines and annual Sockeye passage at Bonneville Dam ($R^2 = 0.48$).

Table 1a. Summer beach seine evaluation test fishing summary, 2011-2014.

Year	Mesh Size (in)	Fisher-		Avg Water Temp °F	Adult Chinook		Chinook Mark Rate	Mkd Adult CH/Set	Sockeye	Sockeye/ Mkd Adult		Steelhead /Set	
		Days	Sets		Marked	Unmarked				Set	CH		
2011	3.5	22	84	62	102	70	59%	1.2	141	1.7	1.4	107	1.3
2012	3.5	28	111	61	126	40	76%	1.1	921	8.3	7.3	79	0.7
2013	3.5, 2.5	12	50	--	142	110	56%	2.8	1,596	31.9	11.2	53	1.1
2014	3.5, 2.5	16	64	64	110	145	43%	1.7	4,909	76.7	44.6	143	2.2
Total		78	309	63	480	365	57%	1.6	7,567	24.5	15.8	382	1.2

*Table does not include any fish whose life stage or fin-mark status could not be determined.

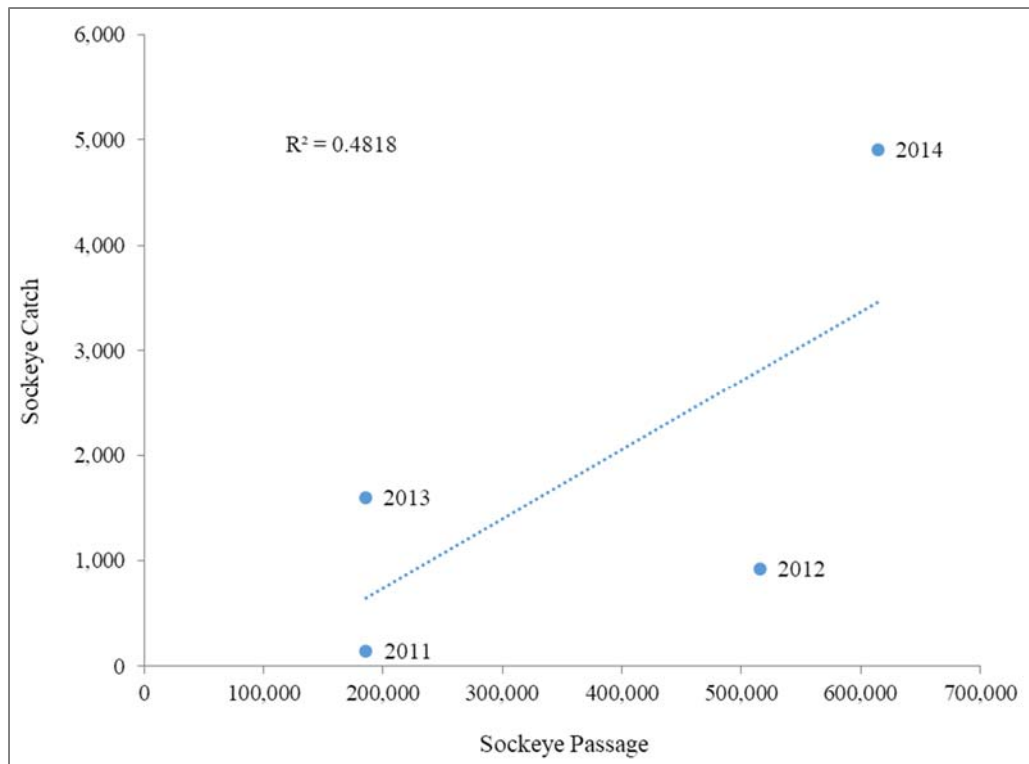


Figure 1d. Relationship between Sockeye passage at Bonneville Dam and Sockeye catches in beach seines during the summer seine evaluation, 2011-2014.

Other notable incidental catches included 382 adult steelhead, 20 White Sturgeon, and 283 adult Shad. The catch rate of steelhead in beach seines ranged from 0.7 fish per set to 2.2 fish per set, and averaged 1.2 fish per set during the course of the study—nearly as high as the overall catch rate for marked adult Chinook (Table 1a).

The condition of adult salmonids captured in beach seines is shown in Table 1b. All Chinook and almost all steelhead were released from the beach seine in a lively condition; however, up to 16% of Sockeye were released in a lethargic condition, and immediate mortalities for Sockeye ranged from 0.1% to 3.1%.

Due to the elevated Sockeye handle and mortality rate observed in 2012, the test fisher modified his beach seine for 2013 and 2014 so that it had a section of smaller 2½-in mesh in the middle of the net where the fish are concentrated. The beach seine crew also used a home-made plunger (to disturb the water surface in an attempt to scare Sockeye towards the section of the seine with smaller mesh).

The Sockeye immediate mortality rate appeared to improve in 2013 after the gear modification was first implemented (Table 1b). However, 2.3% of Sockeye were still released in a lethargic condition. Anecdotal observations by ODFW field staff indicated that several Sockeye that were released in a “lethargic” condition were later seen dead on the river bottom. In 2014, the percentage of lethargic and dead Sockeye increased once again, likely due to very large Sockeye catches and elevated water temperatures.

Table 1b. Condition of adult salmonids captured in beach seines during the summer seine evaluation, 2011-2014.

Year	Mesh Size (in)	Avg Water		Species	Fish Condition			
		Temp °F			<i>n</i>	Lively	Lethargic	Dead
2011	3.5	62		Chinook	245	100.0%	0.0%	0.0%
				Sockeye	141	97.2%	0.7%	2.1%
				Steelhead	107	100.0%	0.0%	0.0%
				Subtotal	493	99.2%	0.2%	0.6%
2012	3.5	61		Chinook	187	100.0%	0.0%	0.0%
				Sockeye	921	80.8%	16.1%	3.1%
				Steelhead	79	98.7%	1.3%	0.0%
				Subtotal	1,187	85.0%	12.6%	2.4%
2013	3.5, 2.5	--		Chinook	356	100.0%	0.0%	0.0%
				Sockeye	1,595	97.6%	2.3%	0.1%
				Steelhead	52	100.0%	0.0%	0.0%
				Subtotal	2,003	98.1%	1.8%	0.1%
2014	3.5, 2.5	64		Chinook	314	100.0%	0.0%	0.0%
				Sockeye	4,904	92.2%	5.2%	2.5%
				Steelhead	143	99.3%	0.0%	0.7%
				Subtotal	5,361	92.9%	4.8%	2.3%
Study Total		63			9,044	93.3%	4.9%	1.8%

Between the 2011-2012 and 2013-2014 test fisheries, there appeared to be changes in the way that Sockeye were captured in the beach seine, potentially as a result of the gear modifications made in 2013 and 2014. The percentage of gilled Sockeye dropped from an average of 16.1% prior to the gear modification to 4.1% after the change was made (Table 1c). At the same time, the percentage of Sockeye wedged in the mesh increased from 6.5% to 16.3%, although the average was heavily influenced by the exceptionally high percentage of wedged fish in 2014. The percentage of wedged fish in 2014 may have been associated with the larger Sockeye catches that year. On average, the condition of Sockeye captured in beach seines appeared to improve after the gear modification.

Table 1c. Capture method and condition of Sockeye salmon caught in beach seines during the summer seine evaluation, 2011-2014.

Mesh Size (in)	Year	Capture Method			Fish Condition			
		<i>n</i>	Gilled	Wedged	<i>n</i>	Lively	Lethargic	Dead
3.5	2011	141	12.1%	8.5%	141	97.2%	0.7%	2.1%
	2012	921	20.2%	4.5%	921	80.8%	16.1%	3.1%
	Avg	531	16.1%	6.5%	531	89.0%	8.4%	2.6%
3.5, 2.5	2013	1,596	4.1%	7.8%	1,595	97.6%	2.3%	0.1%
	2014	4,909	4.2%	24.7%	4,904	92.2%	5.2%	2.5%
	Avg	3,253	4.1%	16.3%	3,250	94.9%	3.7%	1.3%
Study Avg		1,892	10.1%	11.4%	1,890	91.9%	6.1%	2.0%

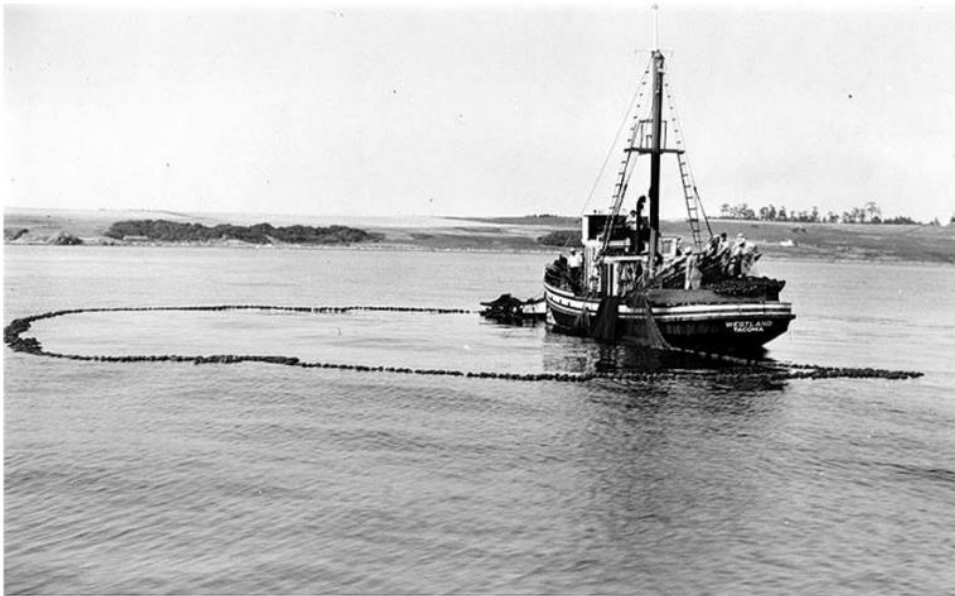
In addition to the biological data from test fishing, there are also important non-biological issues to consider regarding the feasibility of beach seines as an alternative gear for summer Chinook commercial fisheries. Although beach seines can be set with conventional gillnet boats, the boat would need to have sufficient power to work the seine gear in strong river currents. Assuming that the gillnet boat had adequate power, capital costs would primarily consist of the beach seine and associated gear, like a block and anchors to pull the gear onto the beach (ODFW 2013c). Regulatory requirements for use of beach seines in a commercial salmon fishery are minimal, consisting primarily of legalizing the gear for commercial salmon harvest in Oregon and/or Washington. Social issues are not likely to be an impediment to gear implementation, although some conflicts with recreational anglers may occur in popular fishing areas.

Based on a 4-year evaluation of summer beach seines, use of this gear type for a mark-selective commercial summer Chinook fishery in the lower Columbia River is unlikely. Catch rates of hatchery adult Chinook were relatively low, particularly in relation to catch rates of non-target Sockeye and steelhead. Although a gear modification implemented half-way through the evaluation did appear to improve the condition of Sockeye captured in beach seine gear, the large number of Sockeye likely to be handled by a full scale commercial beach seine fishery during the summer timeframe could result in significant impacts to ESA-listed Snake River Sockeye. Sockeye impacts are currently limited to 1% of the Columbia River return, with 20% of the allowable ESA impacts allocated to commercial fisheries (as of 2018). With an average Sockeye run size of 385,771 during 2011-2014 summer beach seine testing, the allowable Sockeye handle in a summer Chinook fishery (at a 10% mortality rate) would have been 7,715 fish. Given that nearly 5,000 Sockeye were handled during 16 fisher-days of beach seine test fishing in 2014, full fleet summer commercial fisheries using beach seines would be severely restricted by the allowable Sockeye handle.

Purse Seine - Summer

Purse seines were first used to commercially harvest salmon in the Columbia River in 1905. Early Columbia River purse seines, which were pulled from scows, were fished in the estuary between Sand Island and Point Ellice from 1905 to 1911. They could land as much as 3½ tons of salmon (equivalent to about 470 Chinook salmon weighing 15 lbs each) per boat per day. More sophisticated purse seine boats from Puget Sound arrived in 1917, but by then, were restricted by law to fishing just outside of the Columbia River mouth (Figure 2a). Nevertheless, approximately 77,000 Chinook salmon were landed by “Columbia River” purse seines in the state of Washington in 1919 (Craig and Hacker 1938). Purse seines were completely outlawed, both in the Columbia and outside its mouth, in 1922 by Oregon and Washington (Oregon Historical Society 2016).

Purse Seine Fishing Boat, Puget Sound (n.d.)



Source: UW Libraries Digital Collections - Industries & Occupations Collection

Figure 2a. Purse seine vessel of the type used historically outside the mouth of the Columbia River (source: University of Washington Libraries Digital Collections).

Modern purse seines adapted for use in the Columbia River are typically comprised of a net made of knotted nylon twine with a relatively small mesh size (e.g. 3½ inches bar measure), and have a float line, lead line, and ring line. Unlike beach seines, most purse seines also have a pocket, or “bunt”, comprised of smaller 1-in mesh, in the middle of the net where captured fish collect as the seine is pursed. Most purse seines are 150-250 fathoms (900-1,500 ft) in length and 35-50 ft in depth. In modern purse seining, one end of the net is pulled off the stern of a purse seine vessel by a skiff and is towed across the river and in a downstream direction as the purse seiner moves with the current. The entire seine is then towed with the current for a period of time (e.g. 30 minutes, Figure 2b) before the skiff brings the outer end of the net back to the purse seiner, encircling fish within the seine. Although capable of fishing in the main channel, purse seines can also be fished in shallower water along beaches, similar to a beach seine.



Figure 2b. Purse seine fishing in the lower Columbia River.

The seine is pulled through a power block or onto a drum and retrieved back onto the purse seiner as it drifts. Care must be taken to keep the seine webbing as vertical as possible in the water column to prevent fish from escaping--a difficult task in strong currents. The skiff is often used to help maintain the purse seiner in the proper position and at the correct drift speed to accomplish this. Once most of the seine has been retrieved onto the purse seiner and the ring line is closed, the rings are lifted out of the water and the seine is considered pursed. At this time, fish can no longer escape the seine. Captured fish are concentrated in the seine's small mesh bunt alongside the purse seine vessel, and crew members brail fish out of the seine using a rubberized dip net (Figure 2c). Typically, 4-5 fishers are needed to conduct purse seining operations, depending on the size of the operation.



Figure 2c. Purse seine catch.

Because of the gear’s history of successfully harvesting salmon in the Columbia River, in 2011, ODFW began to evaluate purse seines as a potential alternative commercial gear for harvesting hatchery Chinook salmon in the lower Columbia River during the summer season (June 16 – July 31). Objectives included: 1) determining whether sufficient numbers of hatchery summer Chinook could be caught using purse seine gear, 2) assessing the handle and condition of non-target species, and 3) evaluating modifications to the purse seine intended to help improve the capture condition of Sockeye salmon. The third objective was added after large catches of Sockeye were observed in 2012.

From 2011 to 2014, ODFW contracted with three commercial fishers in 2011, and one commercial fisher in each of the following years, to test fish with purse seines in Zones 2 and 3 from mid-June through mid-July. Each test fisher was required to make at least four sets per day. Purse seine lengths varied from 165 to 200 fathoms (990-1,200 ft), with 200 fathoms the most common length. Net depths ranged from 38 to 50 ft, with 50 ft the most common depth. The seine was constructed of 3½-in mesh with a 1-in bunt. However, in response to high Sockeye catches in 2012, the test fisher modified his net in 2013 and 2014 by adding a 20 fathom section of 2-in mesh adjacent to the bunt in an attempt to reduce injuries to Sockeye caused by the webbing.

During the 4-year summer purse seine evaluation, the contracted test fishers made a total of 281 purse seine sets over the course of 69 fisher-days, and caught 845 marked and 739 unmarked adult Chinook. Catch rates of marked adult Chinook ranged from 1.7 to 4.7 fish per set, with an average of 3.0 fish per set (Table 2a). The mark rate of adult Chinook caught in purse seines varied from 46% to 60%, and averaged 53% during the evaluation. Sockeye and adult Shad were the most numerous non-target species in the purse seine catch, with a total of 11,743 and 10,168 fish handled, respectively. Sockeye catch rates ranged from 4.1 fish per set to 97.9 fish per set, with an average of 41.8 fish per set (Table 2a). The number of Sockeye handled per marked adult Chinook ranged from 2.5 in 2011 to 26.7 in 2014, with an overall average of 13.9. Figure 2d shows that there was a strong positive relationship between Sockeye catch in purse seines and annual Sockeye passage at Bonneville Dam ($R^2 = 0.82$), suggesting that the number of Sockeye encountered in purse seines is closely associated with the abundance of Sockeye in the river.

Table 2a. Summer purse seine evaluation test fishing summary, 2011-2014.

Year	Mesh Size (in)	Fisher-		Avg	Adult Chinook		Chinook	Mkd	Sockeye/			Steelhead/	
		Days	Sets	Water Temp °F	Marked	Unmarked	Mark Rate	Adult	Sockeye	Mkd Adult	Steelhead	Set	
2011	3.5, 1.0 bunt	30	120	61	202	162	55%	1.7	495	4.1	2.5	71	0.6
2012	3.5, 1.0 bunt	12	48	61	178	120	60%	3.7	3,148	65.6	17.7	63	1.3
2013	3.5, 2.0, 1.0 bunt	12	49	63	230	184	56%	4.7	1,836	37.5	8.0	65	1.3
2014	3.5, 2.0, 1.0 bunt	15	64	64	235	273	46%	3.7	6,264	97.9	26.7	272	4.3
Total		69	281	62	845	739	53%	3.0	11,743	41.8	13.9	471	1.7

*Table does not include any fish whose life stage or fin-mark status could not be determined.

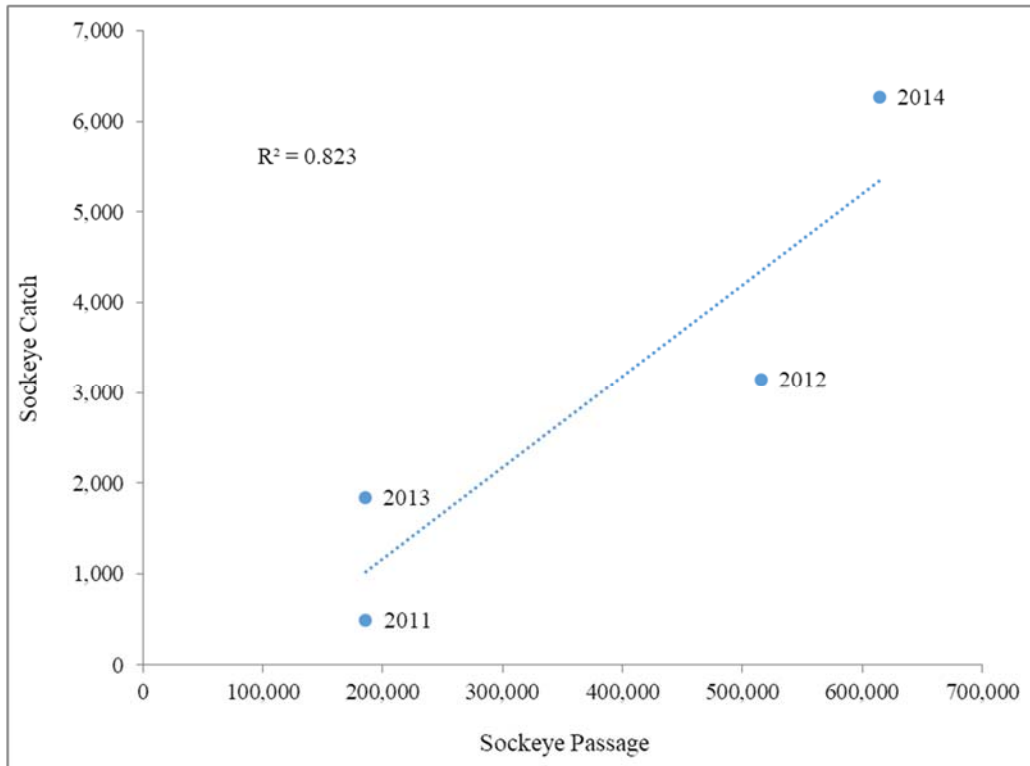


Figure 2d. Relationship between Sockeye passage at Bonneville Dam and Sockeye catches in purse seines during the summer seine evaluation, 2011-2014.

Other notable incidental catches included 471 adult steelhead, 107 White Sturgeon, and 3,437 unidentified smolts. The catch rate of steelhead in purse seines ranged from 0.6 fish per set to 4.3 fish per set, and averaged 1.7 fish per set during the course of the study—over half the overall catch rate for marked adult Chinook (Table 2a).

The condition of adult salmonids captured in purse seines is shown in Table 2b. The percentage of Chinook and steelhead that were in a lively condition was high, and ranged from 98.4% to 100.0%. In contrast, up to 7.8% of Sockeye were released in a lethargic condition, and immediate mortalities for Sockeye ranged from 0.1% to 1.2%. ODFW field staff often observed dead sockeye floating belly-up after being released alive from the purse seine, indicating that post-release survival may have been poorer than initial examination of fish condition might have suggested. During evaluations of purse seines in the upper Columbia River by the Colville Confederated Tribes, Sockeye were often found gilled or wedged in the 3½-in seine mesh (WDFW 2016).

Due to the elevated Sockeye handle observed in 2012, the test fisher modified his purse seine for 2013 and 2014 so that it had a section of smaller 2-in mesh adjacent to the bunt where the fish are concentrated. The Sockeye immediate mortality rate appeared to improve in 2013 after the gear modification was first implemented (Table 2b). However, 4.6% of Sockeye were still released in a lethargic condition in 2013. In 2014, the percentage of dead Sockeye increased back up to 0.4%, likely due to very large Sockeye catches and elevated water temperatures.

Table 2b. Condition of adult salmonids captured in purse seines during the summer seine evaluation, 2011-2014.

Year	Mesh Size (in)	Avg Water Temp °F	Species	Fish Condition			
				<i>n</i>	Lively	Lethargic	Dead
2011	3.5, 1.0 bunt	61	Chinook	517	99.6%	0.4%	0.0%
			Sockeye	489	91.0%	7.8%	1.2%
			Steelhead	71	100.0%	0.0%	0.0%
			Subtotal	1,077	95.7%	3.7%	0.6%
2012	3.5, 1.0 bunt	61	Chinook	355	98.6%	1.4%	0.0%
			Sockeye	3,148	95.9%	3.6%	0.4%
			Steelhead	63	98.4%	1.6%	0.0%
			Subtotal	3,566	96.2%	3.4%	0.4%
2013	3.5, 2.0, 1.0 bunt	63	Chinook	634	99.7%	0.3%	0.0%
			Sockeye	1,823	95.4%	4.6%	0.1%
			Steelhead	65	98.5%	1.5%	0.0%
			Subtotal	2,522	96.6%	3.4%	0.0%
2014	3.5, 2.0, 1.0 bunt	64	Chinook	645	100.0%	0.0%	0.0%
			Sockeye	6,264	98.3%	1.3%	0.4%
			Steelhead	272	99.3%	0.7%	0.0%
			Subtotal	7,181	98.5%	1.2%	0.3%
Study Total				14,346	97.4%	2.3%	0.3%

Between the 2011-2012 and 2013-2014 test fisheries, there appeared to be changes in the way that Sockeye were captured in the purse seine, potentially as a result of the gear modifications made in 2013 and 2014. The percentage of gilled Sockeye dropped from an average of 4.4% prior to the gear modification to 2.4% after the change was made (Table 2c). At the same time, the percentage of Sockeye wedged in the mesh increased from 10.3% to 14.1%. The improvement in average fish condition after gear modification was likely due to the decrease in gilling of Sockeye.

Table 2c. Capture method and condition of Sockeye salmon caught in purse seines during the summer seine evaluation, 2011-2014.

Mesh Size (in)	Year	Capture Method		Fish Condition				
		<i>n</i>	Gilled	Wedged	<i>n</i>	Lively	Lethargic	Dead
3.5, 1.0 bunt	2011	495	5.7%	18.6%	489	91.0%	7.8%	1.2%
	2012	3,148	3.0%	2.1%	3,148	95.9%	3.6%	0.4%
	Avg	1,822	4.4%	10.3%	1,819	93.5%	5.7%	0.8%
3.5, 2.0, 1.0 bunt	2013	1,836	3.1%	18.8%	1,823	95.4%	4.6%	0.1%
	2014	6,264	1.8%	9.4%	6,264	98.3%	1.3%	0.4%
	Avg	4,050	2.4%	14.1%	4,044	96.8%	2.9%	0.2%
Study Avg		2,936	3.4%	12.2%	2,931	95.2%	4.3%	0.5%

In addition to the biological data from test fishing, there are also important non-biological issues to consider regarding the feasibility of purse seines as an alternative gear for summer Chinook commercial fisheries. Because purse seines are deployed and fished from a specialized boat, and

require an additional skiff to set the gear, capital investment costs for the fisher would be relatively high if they did not already have these boats. This would be in addition to the cost of the purse seine and associated gear (ODFW 2013c). Regulatory requirements for use of purse seines in a commercial salmon fishery are minimal, consisting primarily of legalizing the gear for commercial salmon harvest in Oregon and/or Washington. Social issues are not likely to be an impediment to gear implementation, although some conflicts with recreational anglers may occur in popular fishing areas.

Based on a 4-year evaluation of summer purse seines, use of this gear type for a mark-selective commercial summer Chinook fishery in the lower Columbia River is unlikely. Catch rates of hatchery adult Chinook were relatively low, particularly in relation to catch rates of non-target Sockeye and steelhead. Although a gear modification implemented half-way through the evaluation did appear to improve the condition of Sockeye captured in purse seine gear, the large number of Sockeye likely to be handled by a full scale commercial purse seine fishery during the summer timeframe could result in significant impacts to ESA-listed Snake River Sockeye. Sockeye impacts are currently limited to 1% of the Columbia River return, with 20% of the allowable ESA impacts allocated to commercial fisheries (as of 2018). With an average Sockeye run size of 385,771 during 2011-2014 summer purse seine testing, the allowable Sockeye handle in a summer Chinook fishery (at a 10% mortality rate) would have been 7,715 fish. Given that nearly 6,300 Sockeye were handled during 15 fisher-days of purse seine test fishing in 2014, full fleet summer commercial fisheries using purse seines would be severely restricted by the allowable Sockeye handle. In addition, the high costs associated with investment in a purse seine vessel and gear would be prohibitive for most current Columbia River commercial fishers.

Purse/Beach Seine – Late Spring (American Shad)

The historical use of purse and beach seines in the Columbia River, and their current configuration and method of operation, were previously described in the sections on summer purse and beach seines. This section covers the testing and evaluation of purse and beach seines for use as an alternative gear for commercial American Shad fisheries during the late spring season (mid-May to late June) in the mainstem lower Columbia River.

Under permanent regulations, the lower Columbia River is open to commercial fishing for American Shad in Area 2S (navigation aid #50 near Gary Island upstream to the Beacon Rock commercial fishing deadline) from May 10 through June 20. Since 1996, regulations for the Area 2S American Shad fishery have included the following gear specifications designed to minimize the handle of salmonids: mesh size restriction of $5\frac{3}{8}$ to $6\frac{1}{4}$ -inches, 10-pound mesh breaking strength, and net not to exceed 40 meshes (approximately 17 ft) in depth or 150 fathoms (900 ft) in length. The shallower and shorter nets have proven to substantially reduce the handle of salmonids compared to gear used in shad fisheries prior to 1996. Only American Shad may be kept and sold, and all salmon, steelhead, walleye, and sturgeon are required to be released immediately. The recent trend of low harvest in this fishery is likely due to a weak market for American shad.

Although the gillnet regulations adopted in 1996 significantly reduced the handle of adult salmonids in the Area 2S shad fishery, in 2011, ODFW began to issue Experimental Gear Permits (EGP) to commercial fishers that were willing to use an alternative gear such as purse or beach seines in the shad fishery. ODFW issued EGPs in 2011, 2012, and 2016 to evaluate the capability of purse and beach seines to harvest shad while minimizing the handle and mortality of adult salmonids. Fishers were allowed to sell any shad caught during the experimental fishery; however, all other fish were required to be released unharmed. Permits also required ODFW observers to be on board during all fishing operations to enumerate catch and assess the condition of adult salmonids. Limits were also placed on the number of unmarked Chinook, Sockeye, and steelhead that could be handled during the fishery. Two purse seiners fished for shad in 2011, and one purse seiner fished in 2012 and 2016. One of the purse seiners fished in all three years. In addition, one beach seiner participated in the fishery for a brief time in 2012. Purse seine lengths ranged from 190 to 200 fathoms (1,140-1,200 ft), with depths of 35 to 45 ft, while the beach seine was 150 fathoms (900 ft) long and 35 ft deep. Seines were constructed of $3\frac{1}{2}$ -in webbing, with purse seines having a 1-in bunt. Shad seining was conducted in late spring during May 31-June 15 in 2011, May 31-June 10 in 2012, and June 2-3 in 2016. The purse seiners fished primarily in Zone 2 (one set in Zone 3), while the beach seiner fished in Zone 4.

During the 3-year shad seining evaluation, the EGP purse seiners made a total of 81 sets during 27 fisher-days. Purse seine catches of the target species, American Shad, were 6,668 in 2011 and 18,784 in 2012, but dropped off to 302 in 2016 (Table 3a). Shad passage at Bonneville Dam was 0.9 million in 2011, 2.4 million in 2012, and 1.8 million in 2016, so it appears that shad catch in the purse seines was proportional to abundance in 2011 and 2012, but not in 2016. However, the presence of a sea lion in very close proximity to the purse seine during many of the sets in 2016 may at least partly explain the low shad catch that year. Shad catch rates in the purse seine ranged

from 27 fish per set to 470 fish per set, with an average of 318 fish per set during the evaluation. Catch rates of non-targeted adult Chinook, Sockeye, and steelhead averaged 8.1 fish per set, 6.7 fish per set, and 1.0 fish per set, respectively. The average catch rate of *unmarked* adult Chinook was 2.9 fish per set. Mark rates of Chinook captured in the purse seines averaged 64% during the course of the evaluation. Incidental catch of White Sturgeon was relatively low with 24 handled during all years. The ratio of target fish (shad) to non-target fish (Chinook, Sockeye, steelhead, and sturgeon) for purse seines ranged from a low of 2.8 in 2016 to a high of 23.6 in 2012, and averaged 19.8 (Table 3a).

Table 3a. Late spring American Shad purse and beach seine evaluation test fishing summary, 2011-2012 and 2016.

Gear	Year	# Fishers	Fisher-Days	Sets	American Shad	Shad/Set	Adult Chinook					Sockeye/Set	Steelhead /Set	White Sturgeon	Target to Non-Target Ratio	
							Marked	Unmarked	Mark Rate	Chinook/Set	Sockeye					
Purse	2011	2	16	30	6,668	222	165	104	61%	9.0	116	3.9	5	0.2	7	16.8
	2012	1	9	40	18,784	470	206	118	64%	8.1	388	9.7	69	1.7	14	23.6
	2016	1	2	11	302	27	44	16	73%	5.5	35	3.2	10	0.9	3	2.8
	Subtotal	4	27	81	25,754	318	415	238	64%	8.1	539	6.7	84	1.0	24	19.8
Beach	2012	1	1	4	55	14	6	0	100%	1.5	8	2.0	3	0.8	0	3.2
Total		5	28	85	25,809	304	421	238	64%	7.8	547	6.4	87	1.0	24	19.6

The one EGP beach seiner made only 4 sets on the one day fished in 2012. During those 4 sets, he caught 55 shad, 6 adult Chinook, 8 Sockeye, and 3 steelhead. The ratio of target to non-target fish for the beach seine was 3.2, similar to the purse seine in 2016. Because of the limited beach seine effort, it is difficult to assess the effectiveness and efficiency of the gear in a shad fishery, although it appears that Sockeye and steelhead catch rates were somewhat high for the number of shad that were harvested.

In 2011 and 2012, over 96% of the combined Chinook, Sockeye, and steelhead handled in EGP purse seines targeting shad were captured in a lively condition (Table 3b). Direct gear-related mortalities in 2011 and 2012 were limited to Sockeye, and the immediate mortality rate averaged 1.5% over the two years. However, in 2016, the percentage of combined lively salmonids decreased to 92.4%, and immediate mortalities included not only Sockeye, but Chinook and steelhead as well. The 2016 immediate mortality rates ranged from 2.9% for Sockeye to 10.0% for steelhead (Table 3b). It is likely that much warmer water temperatures in 2016 (average of 63° F vs. 55° F in 2011-2012) contributed to the poorer condition of incidentally caught salmonids that year.

Table 3b. Condition of adult salmonids caught during the late spring American Shad purse seine evaluation, 2011-2012 and 2016.

Year	Avg Water Temp °F	Species	Fish Condition			
			<i>n</i>	Lively	Lethargic	Dead
2011	56	Chinook	269	98.5%	1.5%	0.0%
		Sockeye	116	92.2%	6.0%	1.7%
		Steelhead	5	100.0%	0.0%	0.0%
		Subtotal	390	96.7%	2.8%	0.5%
2012	54	Chinook	324	98.5%	1.5%	0.0%
		Sockeye	388	95.4%	3.4%	1.3%
		Steelhead	69	89.9%	10.1%	0.0%
		Subtotal	781	96.2%	3.2%	0.6%
2016	63	Chinook	60	90.0%	1.7%	8.3%
		Sockeye	35	97.1%	0.0%	2.9%
		Steelhead	10	90.0%	0.0%	10.0%
		Subtotal	105	92.4%	1.0%	6.7%
Study Total			1,276	96.0%	2.9%	1.1%

Non-biological issues related to use of purse and beach seines in commercial shad fisheries are similar to those already mentioned in this report for summer purse and beach seines. Capital investment costs would be relatively low for beach seiners able to use their current gillnet boats; however, capital costs for aspiring purse seiners without a purse seine vessel or skiff would be substantial. Given the uncertainty of shad catches and markets, and high capital investment costs, only fishers already possessing a purse seine vessel and gear would likely consider participating in a commercial purse seine fishery for shad. As experimental commercial shad fisheries using seine gear have already been conducted, meeting any remaining regulatory requirements for a full scale commercial fishery would be relatively easy.

Purse seines fished in the late spring appear capable of capturing adequate quantities of American Shad (at least in some years), with a modest handle of some non-target species. Due to the timing of the shad fishery, average Sockeye catch rates in 2011 and 2012 for the EGP purse seines were not as high as they were for purse seines test fished during the summer in the same years (Tables 2a and 3a). However, average steelhead catch rates for purse seines were similar in both late spring and summer of 2011 and 2012. Because of the lack of beach seine data, it is difficult to fully assess the gear's feasibility for use in a commercial shad fishery, although the limited data collected in 2012 appears to suggest that the ratio of target fish to non-target fish is not as favorable in the beach seine as it is in the purse seine. The condition of non-target adult salmonids captured in EGP purse seines was acceptable when water temperatures were relatively cool, but immediate mortality rates increased significantly when water temperatures were elevated. This could be a potential problem for a late spring purse seine fishery as water temperatures typically begin to rise steadily in late spring, especially in low water years. The harmful effects of elevated water temperatures on adult salmonids is well documented in the literature (Martins et al. 2012, Raby et al. 2015). Increased mortalities during the late spring timeframe could affect use of impacts for ESA-listed Snake River spring/summer Chinook. Overall, purse seines have some potential to be a viable gear for late spring commercial shad fisheries, although fishery participation is likely to be very limited due to relatively high capital investment costs and the uncertain nature of shad

markets. Currently, ODFW intends to issue EGPs as needed to continue to evaluate the use of seines as an alternative gear for commercial shad fisheries.

DRAFT

Arrow Net – Summer/Fall

An “arrow net” is a passive gear consisting of a small arrow-shaped tangle net trap placed at the offshore end of a large-mesh lead running perpendicular to the shore. The design tested in the Columbia River was modified from a set gillnet configuration used around Kodiak Island, Alaska. The idea of the Columbia River arrow net is that fish migrating upstream along shore will encounter the lead and follow it into the tangle net trap, where fish are entangled in the mesh and attendant fishers can remove them before they are negatively impacted by the gear (Figures 4a and 4b). Potential benefits of the arrow net are its relatively low cost and portability, allowing it to be moved from one fishing site to another. The mesh size of the lead is important because it must be large enough to minimize drag on the net from the river current, but small enough so that targeted Chinook and Coho salmon will not swim through it. The arrow net design tested in the Columbia consisted of a lead with 15-in (bar measure) seine mesh and a 10-30 fathom (60-180 ft) long shackle of 3½-in (stretched measure) monofilament tangle net that formed the trap. The arrow net would need a crew of 2-3 fishers to deploy the gear and check the trap for fish.

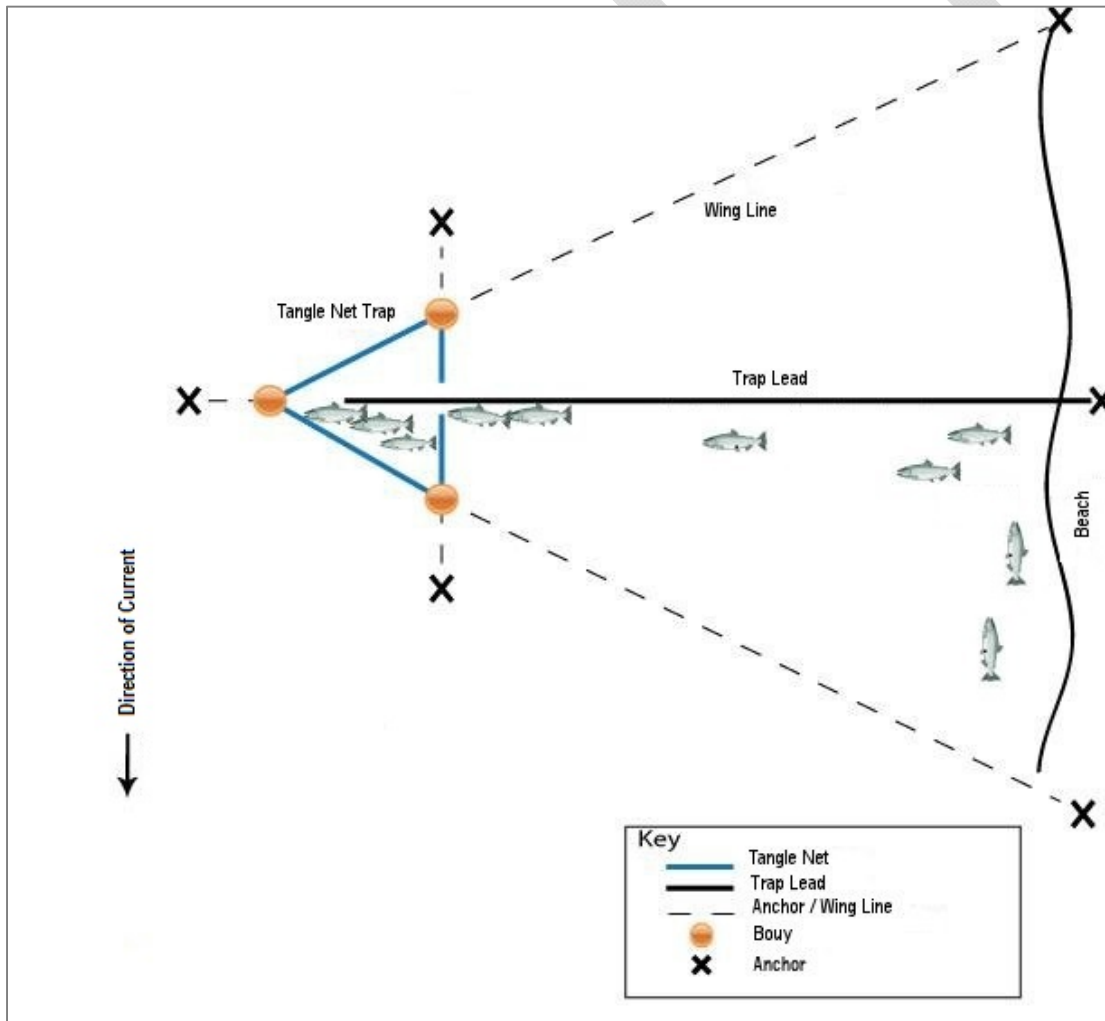


Figure 4a. Stylized schematic showing parts, set-up, and orientation of a Columbia River arrow net.



Figure 4b. Checking a Columbia River arrow net trap, 2013.

The arrow net was deployed and tested in 2013 by ODFW field staff and by a contracted commercial fisher in 2014. In 2013, it was deployed on seven days between mid-July and late August, and in 2014, it was tested on 11 days from mid-August to mid-September. Because of the time involved in traveling to the fishing site and setting up/breaking down the arrow net (2-3 hours total), only one “set” (complete deployment) was made during each test fishing day. Test fishing sites were located in Zone 2 (Wallace Island and Prairie Channel), Zone 3 (Warrior Beach), and Zone 4 (Bachelor Island) in 2013, and in Zone 4 (Bachelor and Caterpillar islands) in 2014 (Figure 4c).



Figure 4c. Arrow net set off of Caterpillar Island, Washington, 2014.

The arrow net was fished for a total of 14 hours (tangle net soak time) in 2013. Adult salmonids were caught on two of the seven fishing days, and catch rates of marked adult Chinook and Coho were very low (Table 4a). Mark rates for adult Chinook and Coho were 50% and 100%, respectively, although only one Coho was caught. Non-target catch included 11 steelhead, 8 Sockeye, and 1 adult American Shad. The catch rate of steelhead was 6-8 times higher than the catch rates of Chinook and Coho.

In 2014, the arrow net was fished for a total of 47 hours. Catch rates of marked adult Chinook and Coho improved considerably from 2013 (Table 4a). Mark rates for adult Chinook and Coho were 49% and 32%, respectively. Almost as many steelhead were handled as Chinook, and the steelhead catch rate was approximately twice the catch rates of Chinook and Coho. No Sockeye were caught in 2014 due to the later timing of test fishing that year.

Table 4a. Arrow net evaluation test fishing summary, 2013-2014.

Year	Dates	Sets / Fished ²	Hours Fished ²	Adult Chinook ³		Chinook Mark Rate	Marked Adult Chinook Per Hour		Adult Coho ³		Coho Mark Rate	Marked Adult Coho Per Hour		Steelhead Per Hour	Sockeye
				Marked	Unmarked		Marked	Unmarked	Marked	Per Hour		Steelhead			
2013	Jul 11 - Aug 21	7	14	2	2	50%	0.14	1	0	100%	0.07	11	0.8	8	
2014	Aug 15 - Sep 10	11	47	31	32	49%	0.66	27	58	32%	0.57	57	1.2	0	
Total		18	61	33	34	49%	0.54	28	58	33%	0.46	68	1.1	8	

¹ One set made per fishing day.

² Only includes time when the tangle net was deployed (soak time).

³ Table does not include any Chinook or Coho whose life stage or fin-mark status could not be determined.

During 2013 test fishing of the arrow net, all Coho and steelhead, and most Chinook, were tangled in the trap net; however, all eight Sockeye captured that year were wedged in the 3½-in mesh due to their much smaller size (Table 4b). Because of the small sample sizes for the individual species evaluated for condition in 2013, which resulted in immediate mortality rates ranging from 0% for Chinook and steelhead to 100% for Coho, and the lack of condition data for Sockeye, it is difficult to assess mortality rates for salmonid species captured in the arrow net in 2013.

In 2014, almost 95% of all adult salmonids captured in the arrow net were entangled in the trap net mesh, with very few gilled or wedged. Immediate mortality rates ranged from 6.3% for adult Chinook to 28.2% for adult Coho. The average water temperature during test fishing in 2014 was around 70 degrees, and this likely had a negative effect on fish condition.

During the first year of arrow net testing in 2013, a considerable amount of time was spent experimenting with different net configurations and deployment techniques as staff sought to adapt the arrow net concept to the challenging environment of the Columbia River. Although the large-mesh lead net was able to lead fish towards the trap, strong currents during both the ebb and flood tides made it difficult to maintain the position and fishing integrity of the lead and trap net. A common problem was for the lead and/or the tangle net to “flag” upwards in the current which allowed fish to swim under the net. Consequently, the arrow net was really only able to fish effectively during the short period of reduced current at slack tides. According to anecdotal observations from field staff, this is when most of the fish were caught.

Table 4b. Capture method and condition of adult salmonids caught during the arrow net evaluation, 2013-2014.

Year	Species	Capture Method			Fish Condition				
		<i>n</i>	Tangled	Gilled	Wedged	<i>n</i>	Lively	Lethargic	Dead
2013	Chinook	5	80.0%	20.0%	0.0%	5	80.0%	20.0%	0.0%
	Coho	1	100.0%	0.0%	0.0%	1	0.0%	0.0%	100.0%
	Steelhead	11	100.0%	0.0%	0.0%	8	87.5%	12.5%	0.0%
	Sockeye	8	0.0%	0.0%	100.0%	*	--	--	--
	Subtotal	25	64.0%	4.0%	32.0%	14	78.6%	14.3%	7.1%
2014	Chinook	65	98.5%	1.5%	0.0%	64	75.0%	18.8%	6.3%
	Coho	86	91.9%	3.5%	4.7%	85	42.4%	29.4%	28.2%
	Steelhead	57	94.7%	1.8%	3.5%	57	71.9%	17.5%	10.5%
	Subtotal	208	94.7%	2.4%	2.9%	206	60.7%	22.8%	16.5%
Study Total		233	91.4%	2.6%	6.0%	220	61.8%	22.3%	15.9%

* No sockeye were assessed for condition.

The combination of a season of experience and use of a commercial gillnet vessel to deploy the nets in 2014 reduced deployment times from an average of 2 hours in 2013 to 1 hour in 2014, and increased soak time from an average of 2 hours per day in 2013 to 4 hours per day in 2014. However, the arrow net was still only able to fish effectively during a small part of the fishing period. This limited the catch substantially, and even in 2014 when catch rates for Chinook and Coho improved, it took between 1½ and 2 hours of fishing time to catch one marked adult Chinook or Coho. In contrast, catch rates for non-target steelhead in 2014 were approximately twice as high as they were for marked adult Chinook and Coho. The high steelhead catch rate was likely due to the lead net beginning at the shore, which increases the likelihood of intercepting steelhead since numerous anecdotal observations indicate that steelhead tend to travel in shallower water near shore.

Non-biological issues related to potential use of the arrow net in a commercial salmon fishery are relatively minor. In 2013, ODFW's estimate of the cost for materials and gear required to deploy an arrow net by a commercial fisher was approximately \$6,600, about twice the cost of a conventional gillnet. Successful deployment of the arrow net in 2014 using a conventional gillnet boat indicated that commercial fishers could use their current gillnet boats to deploy the gear, although an additional skiff would be required to check the trap for fish. Regulatory requirements for implementation of the arrow net in a commercial salmon fishery would consist of legalizing trap nets for commercial salmon harvest in Oregon and/or Washington. Since the arrow net is mobile and not fixed to a particular site, no additional land use permits or permits from regulatory agencies such as the US Army Corps of Engineers (USACE) would be necessary. Social issues are not likely to be an impediment to gear implementation, although some conflicts with recreational anglers may occur in popular fishing areas during gear deployment.

Based on a 2-year evaluation of the arrow net, use of this gear type for a mark-selective commercial summer/fall Chinook and Coho fishery in the lower Columbia River is unlikely. Catch rates of hatchery adult Chinook and Coho were very low, particularly in relation to catch rates of non-

target steelhead. Although Sockeye handle in the arrow net in July of 2013 was not exceptionally high, all of the captured Sockeye were wedged in the trap net mesh. In addition, condition of Chinook, Coho, and steelhead captured in the arrow net in 2014 was not favorable, which potentially has implications for impacts to ESA-listed stocks. One of the primary problems for the arrow net is the very short window in which it can fish effectively. In both years of the evaluation, almost all fish were captured during the brief period of slow current at slack tides. If the arrow net was fished in a location that had minimal current for longer periods, it is possible that catch rates of target fish would improve. However, given the difficulty of finding that type of site in the lower Columbia River in an area where the potential to intercept migrating salmon is also high, widespread use of this gear type in a large-scale commercial fishery does not appear likely.

DRAFT

Commercial Hook and Line – Summer/Fall

During the Harvest Reform transition period, ODFW investigated the potential of using hook and line gear (similar to that used by recreational anglers) for mark-selective commercial salmon fisheries during the summer and fall seasons in the lower Columbia River. Initially, we planned to estimate the Catch-Per-Unit-Effort (CPUE) for this type of fishery using contracted fishers or on-the-water observation of recreational anglers. It became apparent, however, that there was already a large dataset for this gear type during these seasons in ODFW's recreational fishery database. The sample size provided by this existing database far outweighs that of any attempt at collecting new data in the field. Therefore, we chose to model hypothetical mark-selective commercial hook and line fisheries in the summer and fall seasons using existing data in order to assess the gear type's feasibility for real-world implementation.

Fall Hook and Line

We used data from the 2010-2014 Buoy 10 recreational fisheries to model a hypothetical mark-selective commercial hook and line fishery for fall Chinook and Coho in the Columbia River estuary. The Buoy 10 area was selected for a fall commercial hook and line fishery because catch rates in the Buoy 10 area are typically higher than in the lower mainstem (Tongue Point/Rocky Point upstream to Bonneville Dam) during the fall season. The Buoy 10 creel survey program interviews anglers to determine their target species, number of rods fished, hours fished, total fish kept and released by species, and whether or not the fishing event was a guided trip. Boat numbers are recorded and used to identify individual trips. Because we were interested in the greatest potential for a hook and line commercial fishery, we focused our analysis on guided trips as they essentially represented catch rates of professional anglers. The species-specific CPUE was calculated as fish (kept and released) per rod-hour (e.g. 6 rods fished for 8 hours = 48 rod-hours). Average CPUE was calculated for all guided trips during August 1 – September 30 for years 2010 through 2014. We also considered restricting our analysis to the top 20% of the guides (based on CPUE) for each year, and although their average CPUE was slightly higher than for guides in general, the sample size was considerably smaller, so we opted to use the entire guide dataset.

The guide catch rate was then multiplied by a hypothetical daily effort for a commercial fisher to estimate daily catch for each species. We used 64 rod-hours for the daily commercial effort since we believed that a commercial fisher, and deckhand, could probably fish a maximum of eight rods for eight hours per day. This is probably at the upper end of potential daily effort; however, it is consistent with our interest in determining the greatest potential for a commercial hook and line fishery. Mark rates (percentage of adipose fin-clipped fish; left ventral fin-clip for Select Area Bright fall Chinook) and fall Chinook stock composition (bright vs. tule) from post-season summaries for the 2010-2014 Buoy 10 fisheries were used to calculate the daily catch of marked salmon by species and stock. This modelling exercise assumed that a commercial hook and line fishery in the Columbia River estuary would be mark-selective. Because of the typical fall Chinook stock composition in the estuary (relatively large percentage of tules), and lower ESA impact allocations available to the commercial fishery due to the Harvest Reform Policy, a non-mark-selective commercial fishery in that area would be very "costly" in terms of ESA impacts used. Average weight (pounds) and price per pound for each species/stock were gleaned from

commercial landings and sampling data for the corresponding year. The daily landings per boat were multiplied by the average weight and price per pound for the respective species/stocks to estimate the daily ex-vessel value of the catch by species and stock.

Table 5a summarizes the results of our modelling of hypothetical mark-selective hook and line fall commercial salmon fisheries during 2010-2014. Analysis of recreational hook and line data for the 2010-2014 Buoy 10 fisheries indicated that catch rates, even for professional fishing guides, and mark rates were too low to harvest an adequate number of fin-clipped hatchery Chinook and Coho for sale in a mark-selective commercial hook and line fishery. The daily ex-vessel value for each boat ranged from \$121 to \$227, with an average of \$168 for the five modelled years. Operating expenses, including deckhand pay, would need to be subtracted from the daily value to estimate net daily income for the fisher. While mark rates for tule Chinook were relatively high (average of 88%), mark rates for Coho and bright stock Chinook were substantially lower, averaging 63% and 36%, respectively. The stock composition of fall Chinook in the estuary, averaging 41% tule, and prices paid for tules (\$0.55 per pound average), also constrained daily ex-vessel values accruing to commercial hook and line fishers. Figure 5 shows how, in 4 out of the 5 modelled years, relatively low value tule Chinook and Coho comprised the majority of the daily ex-vessel value.

Table 5a. Summary of a hypothetical mark-selective fall commercial salmon fishery in the Columbia River estuary modelled with hook and line gear, 2010-2014.

Year	<i>n</i> ¹	Avg CPUE (fish per rod-hour)		Daily Marked Landings Per Boat ²				Daily Value of Marked Catch			
		Coho	Chinook	Coho	CHF Bright	CHF Tule	Total	Coho	CHF Bright	CHF Tule	Total
2010	272	0.09	0.08	3	1	2	6	\$33	\$42	\$47	\$121
2011	405	0.12	0.11	6	2	2	9	\$59	\$77	\$33	\$169
2012	405	0.08	0.15	2	1	5	8	\$21	\$47	\$88	\$155
2013	304	0.05	0.16	2	3	3	8	\$24	\$143	\$60	\$227
2014	394	0.23	0.09	10	2	2	14	\$75	\$61	\$34	\$170
Avg	356	0.11	0.12	5	2	3	9	\$42	\$74	\$52	\$168

¹ Number of creel interviews used to calculate hook and line CPUE.

² Based on 64 rod-hours fished per day, as well as year-specific mark rates and Chinook stock composition.

Handle of non-target species (e.g. steelhead) and release mortalities would likely be low in a commercial hook and line fishery as analysis of the Buoy 10 data indicated that steelhead were encountered at a very low rate in the fishery, and a 19% hooking mortality rate is typically used for management of the Buoy 10 fishery ().

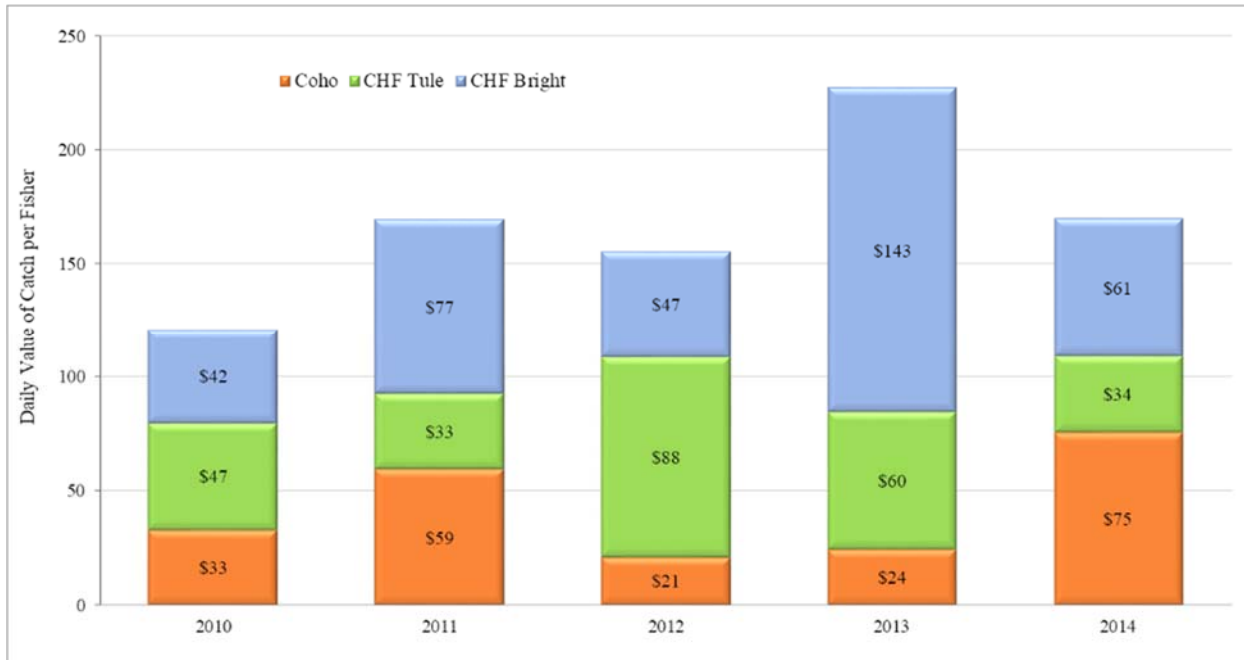


Figure 5. Estimated daily ex-vessel value per boat of fall Chinook and Coho salmon harvested in a hypothetical mark-selective commercial hook and line fishery in the Columbia River estuary, 2010-2014.

One of the non-biological issues related to potential implementation of a commercial hook and line fishery is the cost associated with procuring the necessary gear and tackle, as well as potentially a boat large enough to fish up to eight rods. Although it may be possible to fish a limited number of rods from a fisher's current gillnet vessel, most Columbia River gillnet boats are "bow pickers", with the gillnet reel forward and cabin aft, and are designed to deploy and retrieve gear off the bow (Figure 10c). This boat configuration is not conducive to trolling with a large number of rods. In addition, a gillnet vessel would not likely have the capability to troll at the proper speeds for successful fishing in the estuary (see Commercial Troller section). Capital investment costs for a potential commercial hook and line fisher that did not already have a boat capable of trolling with 6-8 rods could be significant. Fishing guides typically use large (23 ft+) open hulled boats to be able to spread out that many rods. Fishing rods/reels and assorted fishing tackle would represent additional costs. Regulatory requirements for a commercial hook and line fishery would be minimal; however, conflicts with recreational anglers could be possible, as they would need to share the more productive fishing grounds.

Overall, our modelling exercise indicated that, even at a high hypothetical daily commercial fishing effort level of 64 rod-hours per boat, various factors, i.e., catch rates, mark rates, stock composition, and price, appear to severely limit the economic potential for a substantive mark-selective fall commercial hook and line fishery in the Columbia River estuary. It should be noted model assumptions also included no reduction in CPUE with expanded effort, and that two people could effectively fish eight rods for eight hours per day. The model also used data from years when the fall Chinook and Coho runs were average to above average. These results then probably represent "best-case" scenario for a potential fall mark-selective commercial hook and line fishery. Although a hook and line fishery is probably not economically feasible as a replacement for an existing commercial fishery, it may be able to provide supplemental income to commercial fishers

as a small-scale, value-added fishery that would be open during the entire fall season. This would especially benefit fishers who already have the boat and much of the gear required to participate in such a fishery.

Summer Hook and Line

We used data from the 2002-2016 lower Columbia River (below Bonneville Dam) recreational summer Chinook fisheries to model a hypothetical commercial hook and line fishery for summer Chinook under both mark-selective and non-mark-selective scenarios. Creel data collected from the recreational summer Chinook fishery is similar to that collected from the Buoy 10 fishery, as stated above, except that angler trips are not categorized as guided or unguided. Therefore, to approximate a “guide” catch rate for the summer Chinook fishery, we analyzed summer season data for interviewed boats fishing with five or more rods, since analysis of the Buoy 10 data indicated that the majority of boats fishing with five or more rods were guide boats. We used the ratio of the “guide” catch rate to the average angler catch rate (including guides) for the 2016 recreational summer Chinook fishery, which spanned the entire season from June 16 through July 31, and was mark-selective for the duration of the fishery, to estimate the “guide” catch rate for other seasons. We used average catch rates for guides, as well as all anglers, to model hypothetical mark-selective and non-mark-selective commercial summer Chinook fisheries using hook and line gear. For the non-mark-selective commercial fishery scenario, we used the total handle (kept and released catch) in recreational fisheries to estimate the catch rate of all (marked and unmarked) adult summer Chinook. For the commercial hook and line fishery, we assumed 2 fishers per boat were fishing 6 rods for 8 hours per day. We chose to model a summer Chinook fishery with two fewer rods than we had for the fall fishery in the estuary to reduce the risk of tangling when all rods are fishing on the bottom, as is typically done for summer Chinook.

We estimated the number of adult summer Chinook that could be harvested in mark-selective and non-mark-selective commercial hook and line fisheries by multiplying the respective catch rates (marked and total adult summer Chinook per boat-day) by the expected number of participating boats and days fished. Based on professional judgement, we assumed that a maximum of 75% (42 boats) of the average number of participating vessels during the 2013-2016 summer gillnet fisheries would participate in a commercial hook and line fishery. We further assumed that each boat would likely fish on an average of 75% (34 days) of the 45 open fishing days available during the summer season. To calculate the ex-vessel value of the hook and line fishery, we multiplied the estimated landings by the 2012-2016 average value per summer Chinook of \$72 (ODFW unpublished data).

The results of our modelling of hypothetical commercial hook and line summer Chinook fisheries are summarized in Table 5b. Analysis of hook and line data for recreational summer Chinook fisheries below Bonneville Dam indicated that catch rates, even for presumed professional fishing guides, and mark rates were too low to harvest an adequate number of fin-clipped hatchery summer Chinook in a mark-selective commercial hook and line fishery. The daily ex-vessel value per boat in a mark-selective fishery ranged from \$20 to \$59, depending on whether the catch rate for an average angler or guide was used. Operating expenses would need to be subtracted from the daily value to estimate net daily income for the fishers.

Table 5b. Summary of hypothetical commercial summer Chinook fisheries in the lower Columbia River modelled with hook and line gear.

Type of Fishery	Assumed CPUE	Avg CPUE		# Days Fished	CHR Landings	\$/Fish	Ex-Vessel Value	Value/Boat-Day	Value/Fisher-Day ¹
		(Adult CHR/Boat-Day)	# Boats						
Mark-Selective	Average Angler	0.28	42	34	393	\$72	\$28,274	\$20	\$10
	Guide	0.83	42	34	1,180	\$72	\$84,926	\$59	\$30
Non-Mark-Selective	Average Angler	0.52	42	34	737	\$72	\$53,053	\$37	\$19
	Guide	1.55	42	34	2,211	\$72	\$159,159	\$111	\$56

¹ Assumes two fishers per boat.

Even if non-mark-selective commercial hook and line fisheries were allowed for summer Chinook, the daily ex-vessel value per boat would exceed \$100 only if we assumed that all commercial hook and line fishers had expertise and experience similar to a recreational fishing guide. Ex-vessel value in a potential summer commercial hook and line fishery appears to be primarily limited by catch rate and mark rate (for a mark-selective fishery), as average fish weight (16.2 lb during 2012-2016) and price-per-pound (\$4.41 during 2012-2016) for upriver summer Chinook is generally favorable.

The current policies of the Oregon and Washington commissions regarding mainstem commercial summer Chinook fisheries differ slightly. The policies of both states require the use of an alternative gear beginning in 2017; however, Oregon policy allows for the possibility of a non-mark-selective fishery, while Washington policy does not. To assess the effects of these differing policies on a potential commercial hook and line fishery for summer Chinook, we modelled a fishery where half of the anglers (assumed to be licensed in Washington) were required to release unmarked Chinook, while the other half (assumed to be licensed in Oregon) were allowed to keep unmarked Chinook. We further assumed that the catch rate for commercial hook and line fishers would most likely be similar to that of an average recreational angler. The total ex-vessel value generated by this hybrid fishery was \$40,365, or an average daily value of \$28 per boat.

Capital investment costs for a summer commercial hook and line fishery would be similar to those stated above for a fall fishery. Regulatory requirements would be minimal; however, the likelihood for conflicts with recreational anglers would be high. Because the hook and line fishery for summer Chinook is generally an “anchor fishery” where boats anchor in a limited number of productive locations, commercial and recreational fishers would be in direct competition for these coveted spots, and would be fishing in very close proximity to each other.

Overall, our modelling exercise indicates that a mark-selective commercial summer Chinook fishery using hook and line gear would have limited utility due to low catch rates and mark rates. Even if the entire fishery was non-mark-selective and all commercial hook and line fishers had a catch rate equivalent to recreational fishing guides, each boat would make a little over \$100 per day (~\$50 per fisher). After expenses, the net economic return would be substantially lower than what a commercial fisher was making in mainstem gillnet fisheries for summer Chinook (see Mainstem Commercial Fisheries section). While this is not critical in the overall context, it is another example of where reduced economic returns would need to be made up elsewhere.

Beach Seine - Fall

The historical use of beach seines in the Columbia River, and their current configuration and method of operation, were previously described in the section on summer beach seines. This section covers the testing and evaluation of beach seines for use as an alternative gear for mark-selective commercial fisheries during the fall season (August 1-October 31 or early November) in the mainstem lower Columbia River.

During 2009-2011, WDFW contracted with commercial fishers to test fish with beach seines in Zones 1-5, although most test fishing effort was concentrated in the area upstream of the Cowlitz River. In 2011 and 2012, ODFW also contracted with commercial fishers to test beach seines in Zones 1 and 2. Fall test fishing start dates varied from year to year, beginning as early as August 7, and as late as September 7. Similarly, test fishing concluded anywhere from September 26 to November 4. The length of beach seines used in the evaluations ranged from 50 to 200 fathoms (300-1,200 ft); the most commonly fished length was 150 fathoms (900 ft). Seines were constructed of 3½-in webbing and ranged from 25 to 42 ft in depth, with 37 ft being most common. Fishing style and net configuration varied by fisher and geographic locale.

During the 4-year fall beach seine evaluation, the contracted test fishers made a combined 2,333 beach seine sets over the course of 537 fisher-days. Catch rates of marked adult Chinook ranged from 0.3 to 4.8 fish per set, with an average of 2.8 fish per set (Table 6). The mark rate of adult Chinook caught in beach seines varied from a low of 34% to a high of 57%, and averaged 52% during the evaluation. The catch rate of marked adult Coho ranged from 1.2 to 3.0 fish per set, with an average of 2.0 fish per set. The mark rate of adult Coho varied from 58% to 62%, and averaged 59%. During the evaluation, nearly 3,400 steelhead were handled (1.5 fish/set) in beach seines, resulting in an average of one steelhead handled for every 1.9 marked adult Chinook. Other notable incidental catches included 136 White Sturgeon, 44 Chum salmon, 33 adult American Shad, 18 Pink salmon, and 3 Sockeye.

Table 6. Fall beach seine evaluation test fishing summary, 2009-2012.

Year	Fisher-Days	Sets	Chinook				Coho				Steelhead	Marked Chinook Per Steelhead
			Adult Chinook		Chinook Mark Rate	Chinook Per Set	Adult Coho		Coho Mark Rate	Coho Per Set		
2009	11	44	11	21	34%	0.3	67	43	61%	1.5	17	0.6
2010	181	557	2,689	2,028	57%	4.8	1,689	1,035	62%	3.0	1,315	2.0
2011	293	1,359	3,089	3,054	50%	2.3	2,560	1,884	58%	1.9	1,742	1.8
2012	52	373	758	832	48%	2.0	463	336	58%	1.2	310	2.4
Total	537	2,333	6,546	5,936	52%	2.8	4,779	3,298	59%	2.0	3,384	1.9

**Table does not include any fish whose life stage or fin-mark status could not be determined.*

The vast majority (98.7%) of captured and examined Chinook, Coho, and steelhead were released from fall beach seines in a lively condition without any bleeding. Gear-related immediate mortalities were low, with 0.1% of Chinook (3 out of 3,766) and 0.2% of Coho (2 out of 1,116) recorded as mortalities. There were no immediate mortalities for steelhead captured in beach seines that were examined for condition ($n = 323$).

In addition to the biological data from test fishing, there are also important non-biological issues to consider regarding the feasibility of beach seines as an alternative gear for fall commercial fisheries. Capital investment costs and regulatory/social issues related to potential implementation of a fall beach seine fishery are similar to those already described in the section on summer beach seines. Assuming the fisher had a current gillnet boat with sufficient power to work the seine gear in strong river currents, capital costs would be relatively low, and regulatory requirements would be minimal. As with summer beach seines, some conflicts with recreational anglers could occur in popular fishing areas.

Based on a 4-year evaluation of fall beach seines, use of this gear type for a small-scale mark-selective commercial fishery during the fall season in the lower Columbia River may be feasible. Although catch rates of marked adult Chinook and Coho averaged 2.8 and 2.0 fish per set, respectively, the combined average catch rate of almost 5 hatchery adult salmon per set could provide an adequate harvest in a limited mark-selective commercial fishery. Mark rates for fall Chinook and Coho captured in beach seines were relatively low, averaging 52% and 59%, respectively. Therefore, almost half of the adult Chinook and 41% of adult Coho captured in fall beach seines would have been required to be released in a mark-selective fishery. In addition, the handle of steelhead in fall beach seines, relative to the catch of the primary target fish--hatchery adult Chinook--was high. The relatively high handle of non-target species/stocks in fall beach seines could have implications for the use of ESA impacts. Although the condition of captured Chinook, Coho, and steelhead appeared to be good overall, with a low number of immediate mortalities, investigation of post-release mortality rates would be necessary to fully assess the potential use of ESA impacts by this gear type during the fall season. A post-release mortality study for fall beach seines is described later in this report (see Alternative Gear Post-Release Mortality Evaluations—Fall Seine Mortality Study). Given the relatively low gear conversion costs associated with beach seines, and minimal regulatory requirements, non-biological issues do not appear to be a serious impediment to potential implementation of this gear type in a commercial fishery.

Because of a satisfactory overall target fish catch rate and acceptable condition of non-target fish captured in fall beach seines during the evaluation, limited mark-selective fall commercial beach seine fisheries were implemented in 2014-2016. This alternative gear fishery is discussed later in this report (see Alternative Gear Fisheries Implementation —Fall Seine Fishery).

Purse Seine - Fall

The historical use of purse seines in the Columbia River, and their current configuration and method of operation, were previously described in the section on summer purse seines. This section covers the testing and evaluation of purse seines for use as an alternative gear for mark-selective commercial fisheries during the fall season (August 1-October 31 or early November) in the mainstem lower Columbia River.

During 2009-2011, WDFW contracted with commercial fishers to test fish with purse seines in Zones 1-5, although most test fishing effort was concentrated in the area upstream of the Cowlitz River. In 2011 and 2012, ODFW also contracted with commercial fishers to test purse seines in Zones 1 and 2. Fall test fishing start dates for purse seines varied from year to year, beginning as early as August 7, and as late as September 21. Similarly, test fishing concluded anywhere from October 20 to November 4. The length of purse seines used in the evaluations ranged from 170 to 180 fathoms (1,020-1,080 ft); the most commonly fished length was 180 fathoms. Seines were constructed of 3½-in webbing and ranged from 25 to 42 ft in depth, with 35 ft being most common. Fishing style and net configuration varied by fisher and geographic locale.

During the 4-year fall purse seine evaluation, the contracted test fishers made a combined 1,658 purse seine sets over the course of 388 fisher-days. Catch rates of marked adult Chinook ranged from 0.7 to 5.7 fish per set, with an average of 3.9 fish per set (Table 7). The mark rate of adult Chinook caught in purse seines varied from a low of 29% to a high of 40%, and averaged 39% during the evaluation. The catch rate of marked adult Coho ranged from 0.4 to 7.5 fish per set, with an average of 5.3 fish per set. The mark rate of adult Coho varied from 51% to 63%, and averaged 61%. During the evaluation, nearly 2,300 steelhead were handled (1.4 fish/set) in purse seines, resulting in an average of one steelhead handled for every 2.8 marked adult Chinook. Other notable incidental catches included 496 White Sturgeon, 41 Chum salmon, 53 adult American Shad, 27 Pink salmon, 3 Green Sturgeon, and 1 Sockeye.

Table 7. Fall purse seine evaluation test fishing summary, 2009-2012.

Year	Fisher-Days	Sets	Adult Chinook		Chinook Mark Rate	Marked Chinook Per Set	Adult Coho		Coho Mark Rate	Marked Coho Per Set	Steelhead	Marked Chinook Per Steelhead
			Marked	Unmarked			Marked	Unmarked				
2009	15	70	48	115	29%	0.7	215	157	58%	3.1	54	0.9
2010	151	481	2,760	4,140	40%	5.7	3,590	2,495	59%	7.5	975	2.8
2011	196	921	3,357	5,229	39%	3.6	4,974	2,863	63%	5.4	1,171	2.9
2012	26	186	234	354	40%	1.3	81	78	51%	0.4	98	2.4
Total	388	1,658	6,399	9,838	39%	3.9	8,860	5,593	61%	5.3	2,298	2.8

*Table does not include any fish whose life stage or fin-mark status could not be determined.

The vast majority (96.9%) of captured and examined Chinook, Coho, and steelhead were released from purse seines in a lively condition without any bleeding. Gear-related immediate mortalities were low, with 1.1% of Chinook (10 out of 905) and 1.3% of Coho (5 out of 301) recorded as mortalities. There were no immediate mortalities for steelhead captured in purse seines that were examined for condition ($n = 105$).

In addition to the biological data from test fishing, there are also important non-biological issues to consider regarding the feasibility of purse seines as an alternative gear for fall commercial fisheries. Capital investment costs and regulatory/social issues related to potential implementation of a fall purse seine fishery are similar to those already described in the section on summer purse seines. Most current Columbia River commercial fishers do not have a specialized purse seine vessel, and some likely do not have a skiff, to properly set and fish a purse seine in the Columbia River. These capital items, along with the purse seine gear, would represent substantial start-up costs for a fisher considering participation in a potential fall purse seine fishery. Although regulatory requirements for implementation of a commercial purse seine fishery would be minimal, as with summer purse seines, some conflicts with recreational anglers could occur in popular fishing areas.

Based on a 4-year evaluation of fall purse seines, use of this gear type for a small-scale mark-selective commercial fishery during the fall season in the lower Columbia River may be feasible. Catch rates of marked adult Chinook and Coho for fall purse seines were higher than they were for fall beach seines (3.9 vs. 2.8 and 5.3 vs. 2.0 fish per set, respectively), and the combined average catch rate of approximately 9 hatchery adult salmon per set could provide an adequate harvest in a limited mark-selective commercial fishery. Mark rates for fall Chinook and Coho captured in purse seines were relatively low, averaging 39% and 61%, respectively. Therefore, almost $\frac{2}{3}$ of the adult Chinook and 39% of adult Coho captured in fall purse seines would have been required to be released in a mark-selective fishery. In addition, the handle of steelhead in fall purse seines, relative to the catch of the primary target fish--hatchery adult Chinook--while lower than it was in fall beach seines, was still high. The relatively high handle of non-target species/stocks in fall purse seines could have implications for the use of ESA impacts. Although the condition of captured Chinook, Coho, and steelhead appeared to be good overall, with a low number of immediate mortalities, investigation of post-release mortality rates would be necessary to fully assess the potential use of ESA impacts by this gear type during the fall season. A post-release mortality study for fall purse seines is described later in this report (see Alternative Gear Post-Release Mortality Evaluations—Fall Seine Mortality Study). Given the high gear conversion costs associated with purse seines, it is unlikely that this gear type could be adopted on a large scale by current Columbia River commercial fishers. However, there appears to be some potential to use purse seines in more limited mark-selective commercial fisheries during the fall season.

Because of a satisfactory overall target fish catch rate and acceptable condition of non-target fish captured in fall purse seines during the evaluation, limited mark-selective fall commercial purse seine fisheries were implemented in 2014-2016. This alternative gear fishery is discussed later in this report (see Alternative Gear Fisheries Implementation —Fall Seine Fishery).

Coho Tangle Net - Fall

Tangle nets can be constructed of either monofilament or multifilament nylon, similar to conventional gillnets, but their mesh size (stretched measure) is smaller. They are designed to capture fish by entanglement of the teeth and/or jaw rather than by the opercles (gill covers). Small mesh (4¼-inch) multifilament tangle nets have been used for live-capture mark-selective commercial spring Chinook fisheries in the mainstem lower Columbia River since 2002 (ODFW and WDFW 2014-2018b). An important component of the spring tangle net fishery is the mandatory use of onboard fish recovery boxes, which allow lethargic and/or bleeding fish to recover prior to being released back into the river. The recovery boxes consist of one or two chambers and are plumbed with flowing river water intended to force fresh oxygenated water past the fish's gills. Post-release mortality studies conducted during 2001-2003 indicated that adult spring Chinook released from tangle nets survived at a higher rate than those released from larger mesh gillnets (Whisler 2003; Vander Haegen et al. 2004; Ashbrook et al. 2008). Applying this same concept to Coho could provide a means to implement live-capture mark-selective mainstem commercial Coho fisheries during the late fall (October) season.

From 2009 to 2011, ODFW contracted with two to five commercial fishers each year to test fish using various tangle net gears and drift times. Each test fisher was required to make four drifts per day. During the three years of the study, the number of test fishing days ranged from 7 to 16 days per year. With the exception of 2009, when fishing did not begin until mid-October, test fishing generally occurred throughout the month of October when the late stock of Coho typically returns to the Columbia River. Test fishing was conducted in Zones 1 and 2 between the Astoria-Megler Bridge (river mile (RM) 13) and Eureka Bar (RM 51), as well as in the Tongue Point Select Area (Zone 71 near RM 18). Tangle nets were 150 fathoms (900 ft) in length with depth ranging from 30 to 35 feet. Each net assigned to a fisher consisted of two 75-fathom (450 ft) sections with different mesh sizes and/or types (3½-in monofilament, 3½-in multifilament, 3¾-in multifilament, or 4¼-in multifilament). The net was rotated after each drift so that over the course of the day each section was given an approximately equal amount of time in the water (soak time). The net was always laid out in the same direction during the drift so that the sections were fished in both nearshore and offshore waters. "Set" times (elapsed time from end of net layout to beginning of net pickup) varied from 10 to 20 minutes, depending on the abundance of Coho and environmental conditions. This is roughly equivalent to total drift/soak times of 25 to 35 minutes. Fish recovery boxes, similar to those used in spring live-capture tangle net fisheries, were used on each test fishing boat to assist in reviving lethargic and injured fish (Figure 8a).

During the 3-year Coho tangle net evaluation, the contracted test fishers made a combined 838 tangle net drifts during 204 fisher-days. Catch rates of marked adult Coho ranged from 0.4 fish per drift for the 3½-in multifilament gear in 2010 to 2.5 fish per drift for the 4¼-in multifilament gear in 2009 (Table 8a). Coho mark rates ranged from 69% to 80%, with an average of 77%. Incidental catches of steelhead and Chum salmon in the tangle nets were low, with encounter rates averaging 67 marked adult Coho handled for every steelhead, and 28 marked adult Coho handled for every Chum. In addition to Coho, a total of 46 adult Chinook were caught in tangle nets during the evaluation, and these fish would also be available for harvest.



Figure 8a. Left, Coho tangle net test fishing; right, 2-chamber fish recovery box.

Table 8a. Coho tangle net evaluation test fishing summary, 2009-2011.

Year	Gear	Fisher-Days	Drifts	Avg Water Temp °F	Adult Coho		Coho Mark Rate	Mkd Adult COH/Drift	Adult Chinook	Steelhead	Mkd COH/		
					Marked	Unmarked					Steelhead	Chum	
2009	3 1/2" Mono	14	56	59	96	26	79%	1.7	2	0	--	2	48.0
	4 1/4" Multi	14	56	59	141	35	80%	2.5	2	2	70.5	5	28.2
	Subtotal	28	112	59	237	61	80%	2.1	4	2	118.5	7	33.9
2010	3 1/2" Mono	48	204	60	269	77	78%	1.3	8	4	67.3	15	17.9
	3 1/2" Multi	19	83	60	36	16	69%	0.4	2	0	--	3	12.0
	3 3/4" Multi	29	121	60	162	51	76%	1.3	6	1	162.0	8	20.3
	Subtotal	96	408	60	467	144	76%	1.1	16	5	93.4	26	18.0
2011	3 1/2" Mono	40	159	61	130	47	73%	0.8	18	4	32.5	1	130.0
	3 1/2" Multi	40	159	61	102	28	78%	0.6	8	3	34.0	0	--
	Subtotal	80	318	61	232	75	76%	0.7	26	7	33.1	1	232.0
Total		204	838	60	936	280	77%	1.1	46	14	66.9	34	27.5

*Table does not include any fish whose life stage or fin mark status could not be determined.

The vast majority of adult salmon and steelhead were captured in the tangle net gear by means of entanglement. Jack Coho and Chinook were also primarily tangled, but proportionally more jacks were wedged and gilled compared to adults. This is probably due to the smaller jacks being more susceptible to wedging and gilling in the relatively small mesh. Regardless of capture method, most fish did not have their mouths or opercles clamped shut by the mesh.

For all tangle net gears tested, average fish condition at release was much better than at initial capture. The percentage of fish (all species and gear types combined) that were in a “lively” condition at release was 87%, compared to 59% at the time of capture (Table 8b). The percentage of fish in a “lethargic” condition dropped from 33% at capture to 3% at release. This general improvement in condition for most of the fish is likely a result of benefits derived from time spent in the recovery box (Farrell et al. 2001; Buchanan et al. 2002). However, the percentage of dead fish increased slightly from 8% at capture to 10% at release. This may reflect the fact that some fish declined in condition from lethargic to dead, while very few fish showing “no signs of life” upon initial capture were able to recover to a lively or lethargic condition after a period of time in the recovery box. The net effect was an increase in the percentage of dead fish.

Table 8b. Condition of adult salmonids caught during the Coho tangle net evaluation, 2009-2011.

Gear	Species	Capture Condition				Release Condition			
		<i>n</i>	Lively	Lethargic	Dead	<i>n</i>	Lively	Lethargic	Dead
3 1/2" Mono	Coho	629	61%	30%	9%	619	86%	4%	11%
	Chinook	28	57%	36%	7%	27	93%	4%	4%
	Steelhead	8	50%	38%	13%	8	100%	0%	0%
	Chum	16	75%	25%	0%	16	100%	0%	0%
	Subtotal	681	61%	30%	9%	670	86%	4%	10%
3 1/2" Multi	Coho	180	46%	47%	7%	179	84%	7%	9%
	Chinook	9	78%	11%	11%	9	89%	0%	11%
	Steelhead	3	33%	67%	0%	3	100%	0%	0%
	Chum	3	33%	67%	0%	3	100%	0%	0%
	Subtotal	195	47%	46%	7%	194	85%	6%	9%
3 3/4" Multi	Coho	207	69%	25%	7%	205	91%	0%	8%
	Chinook	6	17%	67%	17%	6	83%	17%	0%
	Steelhead	1	0%	100%	0%	1	0%	0%	100%
	Chum	8	100%	0%	0%	8	100%	0%	0%
	Subtotal	222	68%	25%	7%	220	91%	1%	8%
4 1/4" Multi	Coho	175	54%	39%	7%	175	83%	1%	15%
	Chinook	1	0%	100%	0%	1	100%	0%	0%
	Steelhead	2	0%	100%	0%	2	50%	0%	50%
	Chum	5	80%	20%	0%	5	100%	0%	0%
	Subtotal	183	54%	39%	7%	183	84%	1%	15%
Study Total		1,281	59%	33%	8%	1,267	87%	3%	10%

*Table does not include recaptures, marine mammal predation, or any fish whose condition could not be determined.

A comparison of adult Coho immediate mortality rates for the various tangle net gears at different drift time ranges indicated that mortality rates were lowest for the 3³/₄-in multifilament gear type at all drift times (Figure 8b). All gear types exhibited an increased mortality rate as drift time increased.

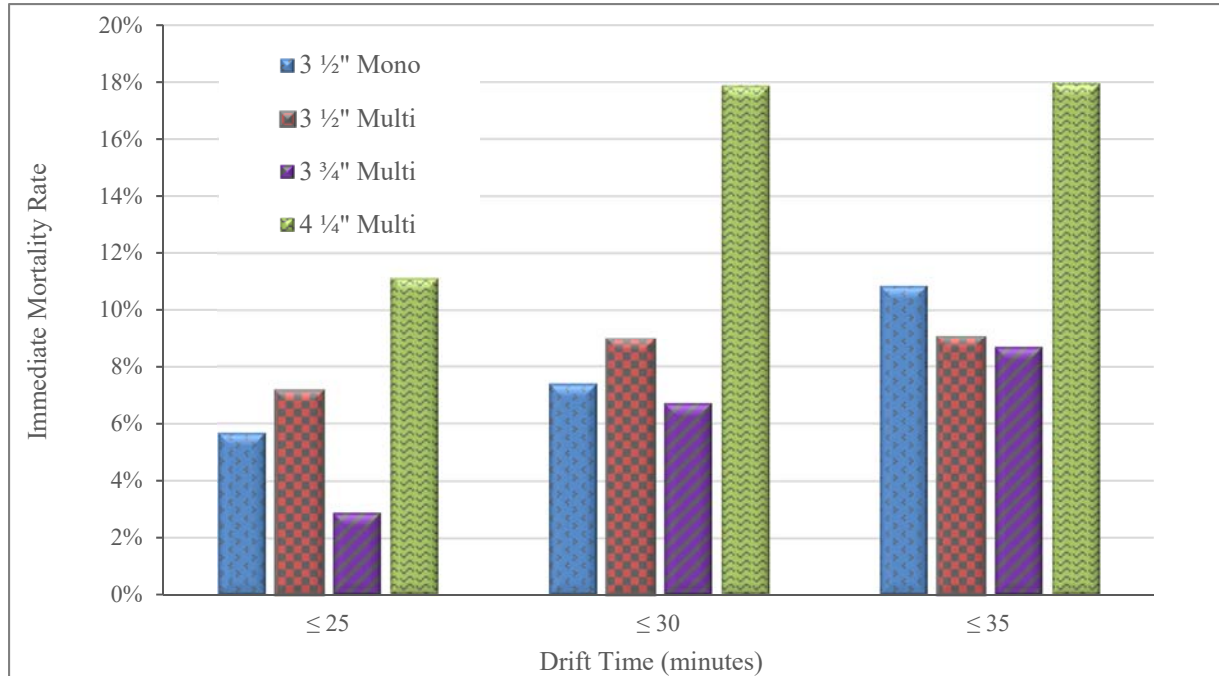


Figure 8b. Comparison of adult Coho immediate mortality rates by tangle net mesh size/type and drift time, 2009-2011.

In addition to the biological data from test fishing, there are also important non-biological issues to consider regarding the feasibility of tangle nets as an alternative gear for mark-selective commercial Coho fisheries. With regard to capital investment costs, tangle nets would not be a costly gear to implement as they can be fished from conventional Columbia River gillnet boats, and are similar in cost to nets currently being used (ODFW 2013c). In addition, most current Columbia River commercial fishers already have fish recovery boxes, which have been used in spring tangle net fisheries for many years. Regulatory requirements for use of tangle nets are minimal, and social issues are not likely to be an impediment to gear implementation. Since a Coho tangle net fishery would occur in October when angling effort is greatly reduced, conflicts with recreational anglers should be minimal.

Based on a 3-year evaluation of Coho tangle nets, use of this gear type for a mark-selective commercial Coho fishery during the late fall season in the lower Columbia River may be feasible. Tangle nets appear to be capable of capturing adult Coho salmon; however, catch rates were relatively low during the evaluation, and may depend heavily on the strength of the Coho run in a given year. Nevertheless, mark rates were high in all years, averaging close to 80% overall, so a large proportion of the Coho encountered in a mark-selective tangle net fishery could be harvested. Furthermore, encounters with other species such as Chinook, Chum, and steelhead were relatively infrequent. All Chinook (marked and unmarked) captured in an October tangle net fishery would be eligible for harvest as very few natural-origin Lower Columbia River (LCR) tule fall Chinook are still in the mainstem Columbia at that time, and that is normally the most constraining Chinook stock in this fishery. The relatively low handle of steelhead and Chum in tangle nets would also help to minimize impacts on other ESA-listed stocks. In some years, such as 2017 and 2018, very low abundance of ESA-listed steelhead stocks can constrain mainstem commercial Coho opportunity, and this situation would exist for both gillnet and tangle net gears. The condition of

non-target fish was good at the time of fish release, largely due to the benefits of using a recovery box. Immediate mortality rates varied by tangle net gear type and drift time, with the 3¾-in multifilament gear having the lowest mortality rate at all tested drift time ranges. An investigation of post-release mortality rates is necessary to fully assess the potential use of ESA impacts by this gear type during the late fall season, and a post-release mortality study for Coho tangle nets is described later in this report (see Alternative Gear Post-Release Mortality Evaluations—Coho Tangle Net Mortality Study). The relatively low gear conversion cost associated with tangle nets, and the lack of regulatory or social impediments, suggest that this gear type could be broadly adopted by current Columbia River commercial fishers.

Although the catch rate of targeted marked adult Coho was relatively low during the tangle net evaluation, with consistently high mark rates observed for late season Coho, there is potential for catch rates to be higher in years with stronger returns. In addition, the handle of non-target fish was low, and the release condition of fish captured in tangle nets was acceptable. Because of these biological factors and the low gear conversion cost of tangle nets, limited mark-selective commercial tangle net fisheries targeting hatchery Coho salmon during the late fall season in Zones 1-3 were implemented in 2013-2015. This alternative gear fishery is discussed later in this report (see Alternative Gear Fisheries Implementation —Coho Tangle Net Fishery). Although the 4¼-in multifilament gear tested during the evaluation had the highest catch rate for marked adult Coho, it also had the highest mortality rate at all drift times. Since the 3¾-in multifilament gear seemed to have a satisfactory combination of catch rate and mortality rate, it was recommended for use in the pilot commercial tangle net fishery in 2013. A maximum drift time of 30 minutes was adopted for the pilot fishery because it offered a balance between enough time to capture fish and deploy/retrieve gear, while still minimizing mortality.

Floating Fish Trap - Fall

Prior to the arrival of European settlers, Native Americans had used “pole-and-brush” weirs to capture salmon in tributaries of the Columbia River. The first traps constructed for commercial salmon harvest on the mainstem Columbia River in 1853 were large, modern versions of the Native American traps that used pilings and wooden slats, or pickets, to lead and impound salmon and steelhead. These wooden traps were floated into position and sunk to the bottom with heavy stone weights to form underwater walls. Wooden traps were deployed in the Columbia in significant numbers by the 1870s, but soon began to be replaced by “pile-and-web” traps (pound nets). By 1889, all of the wooden traps were concentrated between Astoria, Oregon and the lower end of Sauvie Island, and within five years, pound nets (discussed later in this report) had completely replaced the early wooden traps (Craig and Hacker 1938).

A floating fish trap is similar to wooden and pile-and-web traps in that it shares similar components: a lead(s), pot, spiller(s), and sometimes, outer and inner hearts. It also requires some type of anchoring system or structure (e.g. pilings) to secure and maintain the trap’s position and configuration at the fishing site. However, a floating fish trap differs from a wooden or pile-and-web trap in that the pot, spiller, and heart are suspended from a floating frame. Presumably, this increases the mobility of the trap, and makes it easier to change fishing locations. Very large floating traps (180 ft x 110 ft) were successfully used to commercially harvest salmon in nearshore waters of Southcentral and Southeast Alaska during the late 19th and early 20th centuries (Figure 9a). An Alaskan floating trap in a prime fishing location could harvest as many as 100,000 salmon in a single day. Their extraordinary efficiency was one of the reasons why they were eventually outlawed in Alaska when salmon runs began to decline in the 1950s (Hipkins 1968).



Figure 9a. Large floating fish trap in Southeast Alaska, circa 1938 (source: US Fish and Wildlife Service Fisheries Collection).

The intent of the experimental floating trap designs tested in the Columbia River is that fish migrating upstream along shore will encounter the trap lead and follow it to the trap. Fish are then guided through a series of narrow openings (tunnels) into the trap. The trap design tested in 2009 and 2010 did not use outer or inner hearts (Figures 9b-d), while the design tested in 2016 did (Figures 9e-g). The traps incorporated a separate or combined pot and spiller to retain captured fish, and allow for their removal from the trap by an attendant fisher. Spillers could be temporarily closed off to prevent fish from escaping while the trap was checked. The trap tested in 2009 used anchors to maintain its position, while traps tested in 2010 (1 of 2 traps) and 2016 used pilings and a “spud” barge, respectively, to secure their position. All trap designs used some type of frame (wood and abs plastic pipe) and various amounts of weights/anchors to maintain the integrity of the trap’s mesh structure. If the trap opening was off the river bottom, a mesh ramp was used to guide the fish up to the opening. The mesh used for the lead ($\leq 3\frac{1}{2}$ -in stretched measure monofilament or > 12 -in bar measure knotted twine) and walls of the trap ($\leq 3\frac{1}{2}$ -in bar measure knotted twine) was of a size that would avoid gilling or wedging of adult salmonids. The floating fish trap would need a crew of 2-3 fishers to deploy the gear and check the trap for fish.

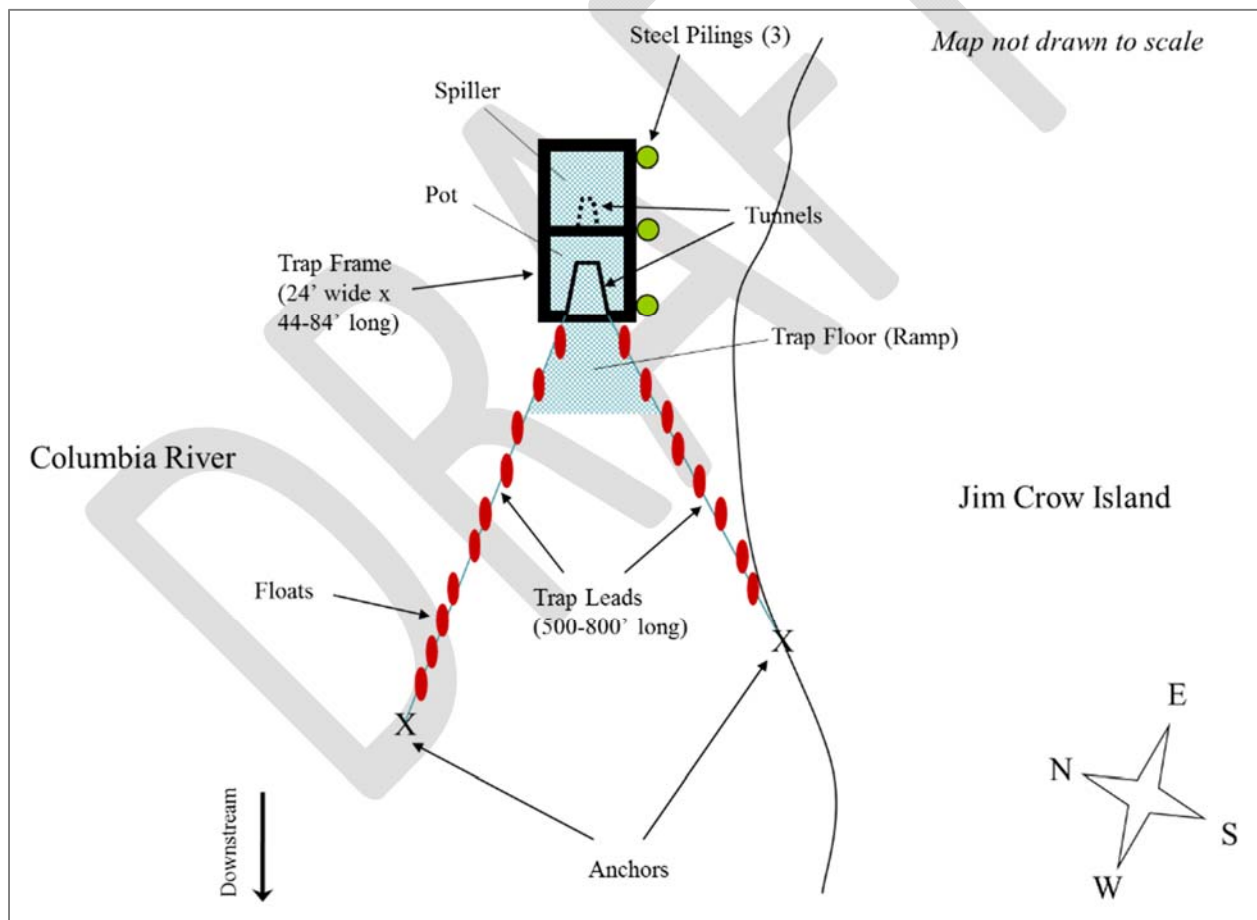


Figure 9b. Stylized schematic showing parts, set-up, and orientation of floating fish trap tested at Jim Crow Island, Oregon in 2010.



Figure 9c. Experimental floating fish trap at Jim Crow Island, Oregon, 2010.



Figure 9d. Leads (in background) and pot on experimental floating fish trap, 2010.

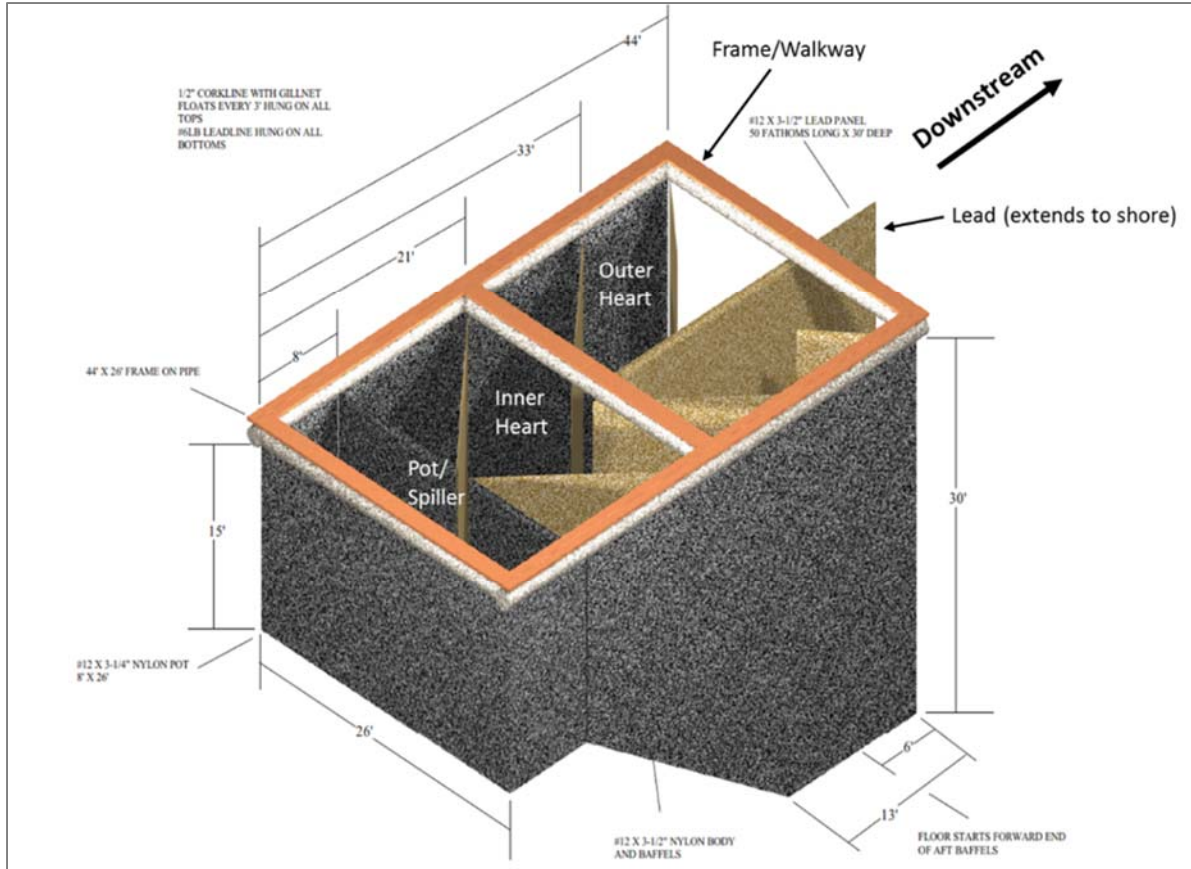


Figure 9e. Three-dimensional schematic of floating fish trap design tested in 2016.



Figure 9f. Experimental floating fish trap (looking upstream) near Jim Crow Creek, Washington, 2016.



Figure 9g. Hearts and lead of experimental floating fish trap (looking downstream) near Jim Crow Creek, Washington, 2016.

ODFW and WDFW jointly worked on an evaluation of the potential of employing floating fish traps in mark-selective fall commercial fisheries in the mainstem lower Columbia River. In 2009, WDFW contracted with a commercial fisher to test a floating trap in Zone 2, and ODFW paid for the materials needed to construct it. In 2010, two commercial fishers were contracted to test separate traps in Zones 1 and 2. ODFW obtained the necessary permits and paid for installation of three pilings to secure the trap at the Zone 2 site in 2010. In 2016, ODFW contracted with one commercial fisher to test a floating fish trap in Zone 2 using a spud barge to secure the trap at the fishing sites (Jim Crow Point, Washington (RM 29) and Woody Island, Oregon (RM 29)). All experimental floating traps were designed, built, and configured by the contracted fishers, with the exception of the trap frames, which were net pen frames borrowed from Select Area rearing/acclimation sites. For all years, test fishing of the floating traps took place between mid-August and the end of October.

During the 3-year floating fish trap evaluation, the contracted test fishers made a combined 148 trap sets during the course of 91 fisher-days. Catches of adult Chinook and Coho (marked and unmarked) totaled 26 and 95, respectively, for the three years of testing (Table 9). The catch rate of marked adults was 0.1 fish per set for Chinook and 0.5 fish per set for Coho, with the test fishers averaging less than two sets made per fishing day. The only target fish captured in 2016 were 7 Coho jacks (5 marked). Overall mark rates were 54% for adult Chinook and 75% for adult Coho.

Incidental catches were also low with 7 steelhead, 1 Chum, and 2 White Sturgeon captured during the three years of the evaluation. On average, 12 marked adult salmon were handled in the traps for every steelhead. Based on testing of similar types of trap nets in the lower Columbia (e.g. Arrow Net and Pound Net), we suspect that the low catch rates for the floating fish trap were largely due to fish swimming under the lead, rather than following it into the trap. The strong currents of the Columbia make it extremely difficult to keep the bottom of the lead net on the riverbed, especially for trap designs that rely solely on anchors or weights to accomplish this.

Table 9. Floating fish trap evaluation test fishing summary, 2009-10 and 2016.

Year	Fishers	Fisher-Days	Sets	Adult Chinook ¹		Adult	Marked	Adult Coho ¹		Adult Coho	Marked	Total Steelhead	Marked Adult
				Marked	Unmarked	Chinook	Chinook/Set	Marked	Unmarked	Mark Rate	Coho/Set		Salmon Per Steelhead
2009	1	15	15	0	1	0%	0.0	26	8	76%	1.7	0	--
2010	2	60	100	14	11	56%	0.1	45	16	74%	0.5	4	14.8
2016	1	16	33	0	0	--	0.0	0	0	--	0.0	3	0.0
Total	4	91	148	14	12	54%	0.1	71	24	75%	0.5	7	12.1

¹ Table does not include any adult Chinook or Coho whose fin-mark status could not be determined.

We did not collect detailed condition data on fish captured during the floating fish trap evaluation. However, observations by ODFW field staff indicated that most captured adult salmonids were free-swimming in the trap, as intended, and appeared to be in good condition, while the smaller jack salmon were often gilled or wedged in the relatively small (3¼-3½ inch) mesh of the leads or hearts. As a result, jacks appeared to be in much poorer condition.

In addition to the biological data from test fishing, there are also important non-biological issues to consider regarding the feasibility of floating fish traps to be used as an alternative gear for mark-selective fall commercial fisheries. Floating fish traps can be expensive to construct and deploy, depending on the complexity of the design. If new pilings must be driven, this can add substantially to the investment cost, as well as place significant regulatory hurdles in the path to implementation. The new pilings for one of the floating traps tested in 2010 required a lengthy and difficult permitting process, with a significant amount of coordination between ODFW staff and regulatory agencies such as the US Army Corps of Engineers and the US Coast Guard. Furthermore, reliance on a fixed structure such as pilings to “anchor” the trap makes it difficult to relocate the trap should river and fishing conditions change. Other options such as using a barge to moor the trap might be less prohibitive from a financial or regulatory standpoint, and provide greater mobility, but could still present their own challenges. In 2016, the spud barge used to secure the trap at the fishing location sustained serious damage to its anchoring spuds while deploying the trap and leads in strong currents. Socially, there is potential for conflict with recreational anglers in popular fishing areas.

Based on a 3-year evaluation of floating fish traps, use of this gear type for a mark-selective commercial fishery during the fall season in the lower Columbia River remains unlikely. The primary problem is the extremely low catch rate of target fish observed during the floating trap evaluation. This is likely related to the gear’s inability to fish effectively in the strong currents of the Columbia River due to the lead net shifting or “flagging” off the bottom and the trap net losing its structural integrity—issues that also plagued the arrow net. Anecdotal observations by ODFW field staff also suggested that large accumulations of algae on the floating trap mesh may also have deterred fish from entering the trap. In addition, the relatively high gear conversion cost associated

with the floating fish trap, particularly if pilings or a barge are needed to secure the trap, would make it difficult for this gear type to be broadly adopted by current Columbia River commercial fishers.

DRAFT

Commercial Troll - Fall

Commercial trolling for salmon off the west coast of North America began in the early 1900s near Monterey, California and in southeast Alaska. As gasoline motors became more common in boats, commercial salmon trolling spread along the coast. Trolling for Chinook and Coho off the mouth of the Columbia River began in 1912, and by 1919, over 1,000 boats participated in the fishery. In 1926, 1.2 million pounds of Chinook and 5.1 million pounds of Coho were landed by commercial trollers in the Columbia River district, which extended approximately 25 miles to the west, and 40 miles to the north and south from the mouth of the Columbia. Some commercial trollers operated in the lower few miles of the Columbia River estuary, but few fished farther upstream than RM 10. In general, commercial trolling was not considered a Columbia River fishery (Craig and Hacker 1938).

Trolling vessels currently used in commercial ocean salmon fisheries range in size from 18-ft “day boats” which fish closer to shore and deliver their catch daily, to larger diesel powered “trip boats” up to 60 feet in length and capable of staying at sea for several days over a large area. Like their recreational counterparts, commercial trollers fish for salmon by towing a variety of artificial lures and baits through the water. Two to six stainless steel fishing lines are run off of outriggers to spread out the lines and minimize tangles. Float bags off the outriggers may also be used to spread out the lines even farther. Each line has up to four monofilament leaders (spreads) with a lure or bait. A 10-50 lb lead “cannonball” weight is used to get the lines down to the desired fishing depth. Commercial trollers use hydraulic gurdies to set and retrieve the lines (Figure 10a; Oregon Sea Grant 2003). Larger trolling vessels typically have a crew of two or three fishers; however, smaller boats and some larger ones can be fished by a single fisher.

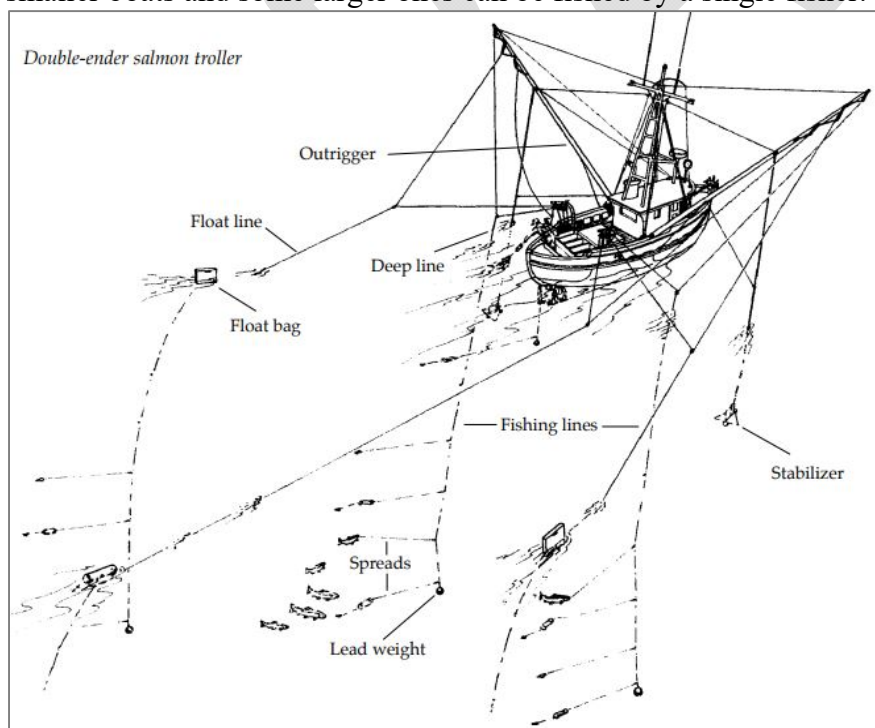


Figure 10a. Schematic of a typical modern-day commercial salmon troller (source: Oregon Sea Grant 2003).

Even though a commercial troller is generally considered to be a gear for ocean fisheries (salmon and Albacore Tuna), because mark-selective commercial troll fisheries have been successfully implemented for Coho since 1999, ODFW investigated the possibility of using this gear type in the Columbia River. In 2010, ODFW contracted with two commercial fishers to evaluate the potential of using commercial trolling vessels for mark-selective commercial fisheries in the lower Columbia River during the fall season (Figure 10b). The vessels made a combined 30 test fishing trips between August 12 and September 14. More than 90% of the test fishing effort occurred in the estuary, downstream of the Astoria-Megler Bridge (RM 15) in Zone 1; a small pilot effort (2 fisher-days) was made in Zone 3 near Rainier, Oregon (RM 67). Each fishing vessel was outfitted with outriggers that fished, on average, 12 spreads/leaders (range 4-23) with terminal tackle attached. A landing net was used to bring captured fish onboard for evaluation of hooking location and condition.



Figure 10b. Left, contracted commercial trolling vessel test fishing in the Columbia River estuary, 2010; right, removing hook from troll-caught Chinook salmon.

Total gear-in-water fishing time during the 30 fisher-days of test fishing in 2010 was 212 hours. Of the 30 test fishing trips, 7 (23%) resulted in zero salmon catch. A total of 18 adult Chinook and 21 adult Coho were caught by the trollers in 2010 (Table 10a). Catch rates were very low for adult Chinook and Coho, at 0.06 and 0.07 fish per hour, respectively. Approximately 72% of Chinook and 71% of the Coho were fin-marked. The only non-target species caught during trolling were one steelhead and one Kelp Greenling.

Table 10a. Commercial troller evaluation test fishing summary, 2010.

Year	Dates	Fisher-Days	Hours Fished ¹	Adult Chinook ²		Chinook Mark Rate	Marked Adult Chinook		Adult Coho ²		Coho Mark Rate	Marked Adult Coho		Steelhead Per Hour
				Marked	Unmarked		Marked	Unmarked	Marked	Per Hour		Steelhead		
2010	Aug 12 - Sep 14	30	212	13	5	72%	0.06	15	6	71%	0.07	1	0.005	

¹ Only includes time when the terminal tackle was in the water and fishing.

² Table does not include any Chinook or Coho whose life stage or fin-mark status could not be determined.

Approximately 88% of troll-caught adult Chinook and 85% of adult Coho were hooked completely or partially in the lower jaw, mouth, or maxillary. The remaining 12% of adult Chinook were

hooked in the eye or gills, and 15% of adult Coho were hooked in the eye or snout. The condition of troll-caught Chinook and Coho was generally good, with 88% of adult Chinook and 95% of adult Coho in a lively condition upon first coming onboard the trolling vessel (Table 10b). However, it should be noted that 27% of the lively Chinook and 15% of the lively Coho were bleeding during the initial assessment. After a period of time in a recovery box/holding tank, Chinook condition improved by the time the fish was released, but Coho condition declined. It is unknown why Coho condition decreased between capture and release, although small sample sizes can sometimes lead to unexpected results.

Table 10b. Condition of adult salmon captured during the commercial troller evaluation, 2010.

	Capture Condition			Release Condition		
	Lively	Lethargic	Dead	Lively	Lethargic	Dead
Chinook	88%	12%	0%	94%	6%	0%
Coho	95%	5%	0%	90%	10%	0%

In addition to the biological data from test fishing, there are also important non-biological issues to consider regarding the feasibility of commercial trolling vessels to be used as an alternative gear for mark-selective fall commercial fisheries. The cost to buy or lease a commercial trolling vessel or retro-fit a gillnet boat for commercial trolling would be substantial. In addition, most Columbia River gillnet boats are “bow pickers”, with the gillnet reel forward and cabin aft, and are designed to deploy and retrieve gear off the bow (Figure 10c). This boat configuration is not conducive to trolling, where gear is typically fished from the stern. Lines, weights, and assorted fishing tackle would represent additional investment costs for a potential commercial troller in the lower Columbia. Given the relatively high gear conversion cost associated with commercial trolling, except for fishers who already have a commercial trolling vessel (and also a license to commercially fish in Columbia River fisheries), the cost would likely be prohibitive for most current Columbia River commercial fishers. Although regulatory requirements for an in-river commercial troll fishery would be minimal, conflicts with recreational anglers would be likely, as both commercial and recreational trollers would need to share the more productive trolling grounds in the estuary. During the 2010 evaluation, the contracted test fishers sometimes tangled lines with recreational anglers in the crowded waters of the popular Buoy 10 fishery.



Figure 10c. Typical Columbia River gillnet boat.

Based on the 2010 commercial troller evaluation, use of this gear type for a mark-selective commercial fishery during the fall season in the lower Columbia River is unlikely. The primary problem is the extremely low catch rate of target fish observed during test fishing in the Columbia. This is likely related to the gear's difficulty fishing the relatively shallow and constantly changing depths of the river. The commercial trolling vessels also did not appear to be able to troll slowly enough or fish close enough to the bottom to keep the gear in front of the salmon--particularly during ebb tides. Both ODFW staff and the contracted fishers believed that smaller, recreational style boats were more suitable for trolling in the Columbia River.

DRAFT

Pound Net - Fall

A “pound net” designed for use in the Columbia River is a passive gear that utilizes pilings and attached nets to form a fence that leads upstream migrating fish into a trap, which is also formed by pilings and nets. The first Columbia River pound net (aka “pile-and-web” trap) was built in 1879, and was based on the design of similar traps used in the Great Lakes (Figure 11a). It was extremely successful in capturing salmon in the Columbia, and the number of pound nets quickly expanded, soon replacing wooden slat traps. In 1889, there were 121 pound nets in Baker Bay alone. By 1934, there were 238 pound net-type traps operating in the Columbia River. From 1927 to 1934, pound nets accounted for approximately 21% of the total salmon and steelhead catch, second only to the gillnet fishery. In 1935, the state of Washington outlawed the use of pound nets (and other fixed gear), greatly curtailing the fishery as almost 90% of the pound nets operated on the Washington side of the river (Craig and Hacker 1938). Oregon banned fixed gear in 1949 (NPCC 2016).



Taking Salmon out of Pound Net on the
Columbia River, Washington.

Figure 11a. Removing salmon from a pound net trap in the lower Columbia River, circa 1897 (source: University of Washington Libraries Digital Collections).

The pound net most often consists of a lead (usually extending from shore to the trap), heart, pot/tunnel, and spiller. There may also be ancillary sections of mesh (“kickers” or “jiggers”) designed to deter fish from going around the trap (Figure 11b). Fish are guided along the lead, and through the heart and pot/tunnel to the spiller, where harvestable fish are removed from the trap by an attendant fisher (Craig and Hacker 1938). Presumably, any non-harvestable fish could

also be removed from the spiller and released back into the river. A pound net requires a crew of at least three fishers to operate the trap (Tuohy 2018).

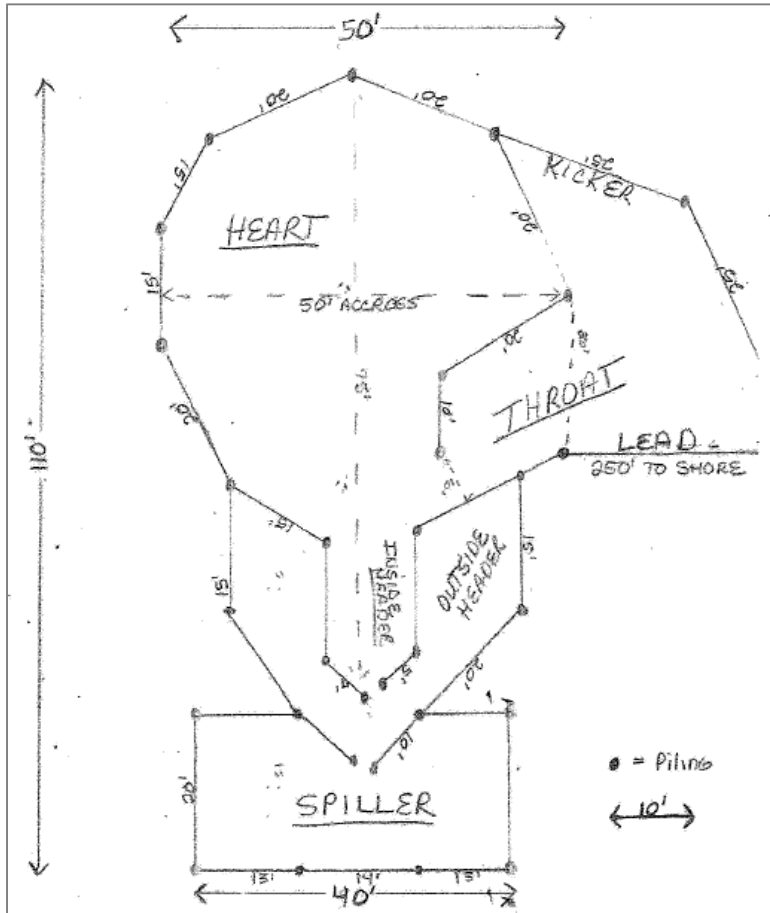


Figure 11b. Draft diagram of an experimental pound net proposed for testing in the lower Columbia River, 2013 (source: WDFW).

Because of the gear’s successful history of harvesting salmon from the Columbia River, and the potential to minimize gear interaction with and handling of non-target fish, WDFW partnered with a contracted commercial fisher in 2013, and the fisher and Wild Fish Conservancy (WFC) in 2016, to test an experimental pound net for possible use as an alternative gear for mark-selective commercial fisheries during the fall season in the mainstem lower Columbia River. Further testing was conducted by WFC and the fisher in 2017. Test fishing occurred on 10 days between September 16 and October 18 in 2013, on 30 days between August 26 and September 29 in 2016, and 33 days from August 26 to September 29 in 2017. The test fishing site was located approximately 2 miles downstream of Nassa Point (RM 45) at a historic pound net site in the Cathlamet Channel (Zone 2) near Cathlamet, Washington (Figure 11c). After permits were obtained and 40 large wooden pilings were driven into the riverbed, the contracted fisher set up and operated the pound net trap, with assistance from WDFW/WFC personnel or volunteers (Figure 11d). Nets comprising the lead and heart were constructed of 3½-3¼ inch (bar measure) knotted nylon mesh, while the spiller netting consisted of ¾-in mesh and/or 2½-in knotless nylon mesh. A perforated aluminum live well was positioned next to the spiller door to facilitate sorting

and sampling of captured fish. Details of the pound net designs tested in the Columbia River during 2016 and 2017 can be found in WFC 2016 and Gayeski and Tuohy 2018.



Figure 11c. Location of experimental pound net near Cathlamet, Washington, 2013 and 2016-2017.

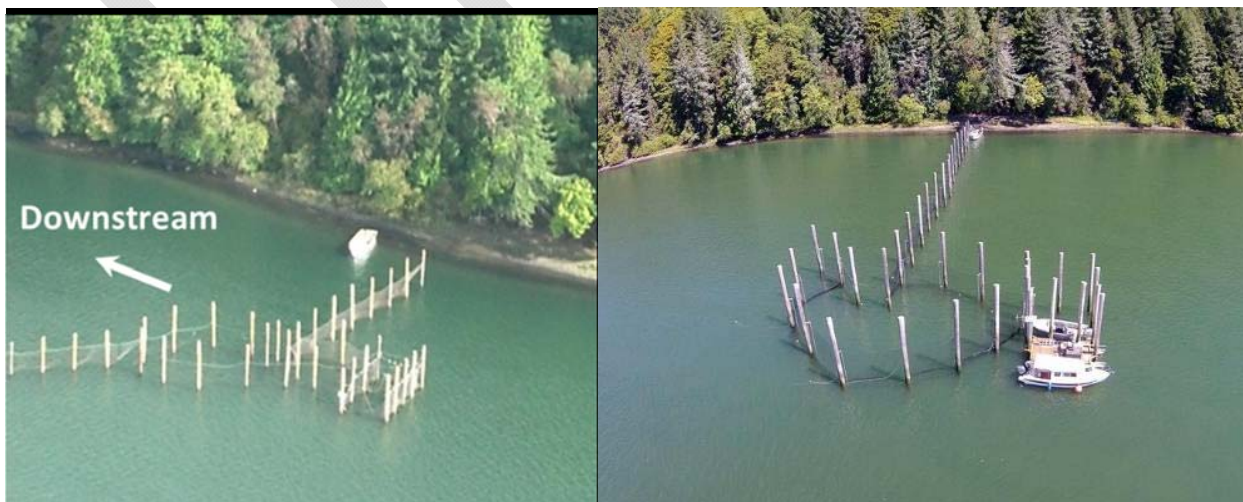


Figure 11d. Left, experimental pound net design tested near Cathlamet, Washington in 2013 (source: Oregon State Police); right, reconfigured pound net design tested in 2016-2017 (source: WFC 2017).

In 2013, testing of the pound net was primarily limited to the feasibility of deploying the gear in the Columbia River, and developing procedures for operation of the trap (Gayeski and Tuohy 2018). Approximately 10 days were devoted to the initial setup and adjustment of the gear to get the trap into “fishing” condition, and to improve the catchability of the trap once test fishing began. During the 10 days when the pound net was actually fishing in 2013, a total of 1 adult Chinook and 7 jack Coho were captured (A. Stephenson, WDFW, personal communication). The low observed catch rate may have been due to the lead and/or trap nets not extending fully to the bottom in stronger currents. Six of the jacks were immediate mortalities, likely due to being gilled/wedged in the trap mesh. The adult Chinook also died in the trap, but the cause of mortality was unknown.

Due to the extremely low catch rate and high mortality observed in 2013, a re-designed pound net was tested by WDFW, WFC, and the contracted fisher in 2016. The configuration of the pilings and nets was changed (Figure 11d), and the lead and trap primarily utilized 3¼-in nylon mesh (some slightly larger 3½-in mesh may have been used in 2013), with 2½-in knotless mesh incorporated into the spiller to reduce the chance of smaller fish, like jacks, becoming gilled or wedged. In addition, to improve the catchability of the trap, efforts were made to ensure that the bottom of the nets stayed on the riverbed.

During 30 days of test fishing in 2016, the pound net trap was fished for a total of 258.2 hours (Gayeski and Tuohy 2018). As three fishers are needed to operate the trap (Tuohy 2018), this equates to 775 fisher-hours of labor, or fishing effort. Pound net catches in 2016 included 245 marked and 180 unmarked adult Chinook, and 374 marked and 172 unmarked adult Coho (Table 11a; A. Tuohy, WFC, personal communication). Catch rates of marked adult Chinook and Coho averaged 0.3 and 0.5 fish per fisher-hour, respectively. Aggregate mark rates were 58% for adult Chinook and 68% for adult Coho. An additional 109 jack Chinook (55 marked) and 250 jack Coho (206 marked) were caught in 2016. The percentage of jacks in the combined Chinook and Coho catch was relatively high—27%. For comparison, 11% of Chinook and Coho passing Bonneville Dam during the timeframe fished by the pound net in 2016 were jacks. Catches of non-target species included 816 steelhead, 5 Chum, and 2 Sockeye (Tuohy 2018). Approximately 1.3 steelhead were handled/encountered in the pound net trap for each marked adult salmon (Chinook and Coho combined; Table 11a). Steelhead comprised the largest percentage of the total salmonid catch (37.9%), followed by Coho (37.0%), and Chinook (24.8%; Table 11b). Of the over 2,100 salmonids captured in the pound net trap in 2016, 99.6% were in a lively condition, with a total of 9 salmonids (7 marked and 2 unmarked jack Coho) recorded as immediate mortalities (Gayeski and Tuohy 2018).

Table 11a. Pound net evaluation test fishing summary, 2016-2017.¹

Year	Fishing Days	Fisher-Hours ²	Adult Chinook ³		Chinook Mark Rate	Marked Adult Chinook/Chinook/ Fisher-Hour		Adult Coho ³		Adult Coho Mark Rate	Marked Adult Coho/ Coho/ Fisher-Hour		Total Steelhead	Steelhead Per Marked Adult Salmon
			Marked	Unmarked		Marked	Unmarked	Marked	Unmarked					
2016	30	775	245	180	58%	0.3	374	172	68%	0.5	816	1.3		
2017	33	872	1,089	1,121	49%	1.2	1,464	1,439	50%	1.7	921	0.4		
Total	63	1,647	1,334	1,301	51%	0.8	1,838	1,611	53%	1.1	1,737	0.5		

¹ Based on preliminary data provided by WFC as of the date of this report.

² Assumes three fishers operating the trap.

³ Table does not include any adult Chinook or Coho whose fin-mark status could not be determined.

Table 11b. Species composition of the pound net salmonid catch, 2016-2017.¹

	Chinook	Coho	Steelhead	Other ²
2016	24.8%	37.0%	37.9%	0.3%
2017	37.4%	49.2%	13.0%	0.4%
Aggregate	34.4%	46.3%	18.8%	0.4%

¹ Based on preliminary data provided by WFC as of the date of this report.

² Includes Sockeye, Chum, and rainbow trout/residualized steelhead smolts.

Although much improved from initial testing in 2013, catch rates of target fish in 2016 were still relatively low, with an average of 3.3 fisher-hours of effort required to catch one marked adult Chinook, and 2.0 fisher-hours required to catch one marked adult Coho. As result, WFC and the contracted fisher made further refinements to the pound net design in 2017, including installation of a marine mammal exclusion gate at the tunnel entrance, and another gate to prevent fish from escaping from the heart during lifting of the spiller (Gayeski and Tuohy 2018).

During 33 days of test fishing in 2017, the pound net trap was fished for a total of 290.5 hours (Gayeski and Tuohy 2018). Again, assuming three fishers operating the trap, this equates to 872 fisher-hours of labor/fishing effort. The trap refinements made in 2017 appeared to improve the catchability of the pound net as catches included 1,089 marked and 1,121 unmarked adult Chinook, and 1,464 marked and 1,439 unmarked adult Coho (Table 11a; A. Tuohy, WFC, personal communication). Catch rates of marked adult Chinook and Coho averaged 1.2 and 1.7 fish per fisher-hour, respectively. Aggregate mark rates were 49% for adult Chinook and 50% for adult Coho. An additional 429 jack Chinook (175 marked) and 571 jack Coho (356 marked) were caught in 2017. The percentage of jacks in the combined Chinook and Coho catch was lower than the previous year (16% vs. 27%), but still 60% higher than it was for Chinook and Coho passing Bonneville Dam during the timeframe fished by the pound net in 2017 (10%). Catches of non-target species included 921 steelhead and 28 rainbow trout/residualized steelhead smolts (presumably differentiated by fish length) (A. Tuohy, WFC, personal communication). Approximately 0.4 steelhead were handled/encountered in the pound net trap for each marked adult salmon (Chinook and Coho combined; Table 11a). Although the ratio of steelhead to marked adult salmon was significantly lower in 2017 compared to the previous year, the steelhead catch rate (steelhead/fisher-hour) was the same in both years (1.1 steelhead/fisher-hour), even though the steelhead run was 34% lower in 2017. This suggests that improvement in the steelhead-marked adult salmon ratio was primarily due to an increase in catchability of adult salmon, rather than a reduction in steelhead encounters. In fact, the lack of change in the steelhead catch rate despite the smaller steelhead run suggests that the catchability of steelhead in the pound net may also have increased in 2017. In 2017, Coho comprised the largest percentage of the total salmonid catch (49.2%), followed by Chinook (37.4%), and steelhead (13.0%; Table 11b). The shift in species composition of the pound net catch from 2016 to 2017 is consistent with the improvement in the pound net's capability to capture Coho and Chinook. Detailed fish condition data are not yet available for 2017; however, a total of 9 salmonids (1 adult Chinook, 1 adult Coho, 1 jack Chinook, 4 jack Coho, 2 rainbow trout/residualized steelhead smolts) were recorded as immediate mortalities (Gayeski and Tuohy 2018).

In addition to the biological data from test fishing, there are also important non-biological issues to consider regarding the feasibility of the pound net to be used as an alternative gear for mark-

selective fall commercial fisheries. Construction and deployment of a pound net requires a substantial investment of money and time due to the need to drive many pilings (≥ 40) into the riverbed, and the gear's relative complexity. Capital costs associated with the pound net trap itself would include the pilings (as well as the cost to place them, and possibly reposition them), nets for all the trap components (lead, heart, pot/tunnel, and spiller), pulleys, ropes, stand pipes, and other hardware to lower and raise nets as well as open and close the tunnel door, an electric winch to lift the spiller, and an aluminum marine mammal exclusion gate. A dock (wood deck on aluminum pontoons) and perforated aluminum live well to sort fish would represent additional capital costs (WFC 2017; Gayeski and Tuohy 2018). The estimated capital investment cost for a single pound net trap utilizing 40 pilings ranges from approximately \$80,000 to \$100,000 (not including costs associated with trap assembly or set up), depending on the proximity of the site to the pile driving equipment.

Regulatory requirements for construction and deployment of a fixed gear such as the pound net are considerable, and include permits from and/or coordination with:

- US Army Corps of Engineers
- US Coast Guard
- NOAA Fisheries-NMFS
- Department of State Lands (for state-owned lands) or agreement with upland landowner

Due to the complexity of the permitting process, it is often necessary to hire a consultant to prepare the paperwork and navigate it through the proper channels. Consultant and permit fees would add to the capital investment costs mentioned above.

Socially, there is the potential for conflict with recreational anglers if the pound net is located in an area that is also popular for sport fishing, especially given the semi-permanent nature of the structure. Although the level of conflict might be minimal with one or two pound nets, it would likely increase significantly if numerous pound net sites were established in the lower Columbia. During the heyday of the Columbia River pound nets in the early 1900s, the recreational fishery in the lower river was a tiny fraction of what it is today (Craig and Hacker 1938). In addition, placement of a fixed trap requires approval by the upland landowner prior to obtaining permits, and there is no guarantee that approval would be granted for a particular site, or for a long-term period.

After three years of testing the Cathlamet pound net, use of this gear type for a large-scale mark-selective commercial fishery during the fall season in the lower Columbia River remains uncertain. Although refinements to the pound net's design and operational procedures improved target fish catch rates during the evaluation, it remains unclear whether a pound net is capable of catching enough harvestable adult salmon to make the substantial capital investment in this gear type commercially viable. The aggregate mark rates of 51% for Chinook and 53% for Coho captured in the pound net during 2016 and 2017 suggest that almost half of all adult Chinook and Coho handled in the pound net would have to be released in a mark-selective commercial fishery. In addition, a disproportionately large percentage of jacks was captured in the pound net compared to the Chinook and Coho runs at large. Based on recent evaluations of alternative gears such as the arrow net, floating fish trap, and 2013 pound net, this tends to happen when the gear has difficulty capturing and retaining adult salmon. It likely occurs when adult fish, which appear to be more bottom oriented than jacks, are escaping under the trap's nets. Although jacks can be

harvested, they contribute very little to commercial ex-vessel value due to their low weight and price-per-pound. In addition, some fish buyers do not want a large number of jacks as they are not as marketable as adult salmon.

The ratio of steelhead to marked adult salmon in the pound net catch decreased between 2016 and 2017 due to the improved catchability of Coho and Chinook in the trap, but a constant steelhead catch rate on a declining run suggested that the catchability of steelhead had also increased. The species composition of the pound net catch was heavily skewed towards steelhead and Coho in 2016, but shifted more towards Coho and Chinook in 2017 due to improvements in the trap's capability to capture and retain adult salmon. The aggregate species composition of the pound net catch for 2016 and 2017 indicated that almost half of the salmonids captured in the pound net were Coho salmon, which typically have a lower value per fish than fall Chinook ("bright" grade) due to lower weight and price-per-pound. However, if the captured Chinook are of the tule stock, which mature quickly upon river entry, the price-per-pound can be as low as 30 cents per pound (ODFW unpublished data). Tissue samples for genetic analysis were collected from a subsample of Chinook captured in the pound net in 2017, but the results of the analysis are not yet available (Gayeski and Tuohy 2018). The stock composition of the fall Chinook catch in the pound net would be another important factor in evaluating the commercial viability of the pound net; therefore, review of the results of the genetic analysis is warranted when available. It should also be noted that about 19% of the pound net catch consisted of steelhead, which cannot be retained in current Columbia River non-treaty commercial fisheries. This percentage is comparable to the historical (1889-1934) average contribution of steelhead to the commercial pound net catch of approximately 16% (Craig and Hacker 1938). The potential effects of the pound net's catch composition on the gear's commercial viability is assessed more fully later in this report (see Mainstem Commercial Fisheries—Comparative Commercial Gear Analysis).

Although immediate mortality rates for salmonids captured in the pound net were extremely low, the tendency of the pound net to capture high numbers of steelhead is a concern, especially since the gear would be fishing during a timeframe when the vast majority of ESA-listed natural-origin B-Index summer steelhead are migrating through the lower Columbia. A commercial pound net fishery consisting of numerous sites could have a significant effect on the use of available ESA impacts for steelhead since mortalities are a function of not only the mortality rate, but also the number of fish handled.

The high gear conversion cost associated with the pound net is a major concern with respect to the gear's feasibility for large-scale implementation as an economically viable alternative commercial gear. Given the large investment in time and money necessary to make a single pound net operational, it is particularly disconcerting that the gear is essentially fixed at one location. Should the initial site selected be a poor one, or if river conditions and/or salmon migratory routes change, it would be very difficult and expensive to relocate a pound net to a more productive site. Even pulling and relocating a single piling at the same site to adjust the configuration of a trap can cost approximately \$1,000 (Clearwater Solutions, personal communication). In addition, if a commercial pound net fisher decided that he/she no longer wanted to participate in the fishery, a pound net trap could be difficult to sell, particularly if the fishery is not performing to expectations. It is possible to reduce the investment cost per fisher by forming a cooperative where the costs and revenue are shared by a group of fishers. However, beyond a certain number of fishers (4 or 5?),

the marginal contribution of each additional fisher to a trap's productivity (catch per hour) would diminish, as would the trap's revenue per fisher.

Additional research is necessary to see if catch rates of harvestable adult salmon (especially high-value bright Chinook) can be improved, while simultaneously reducing the catch rate of steelhead. Given the high investment costs associated with a pound net, large catches of harvestable high-value salmon would be required in order for the gear to be economically viable. Because of high costs, potential concerns of sport fishers and landowners, and the uncertainty associated with the number of pound net sites that would be permitted by regulatory agencies, a commercial pound net fishery would likely be limited in scope. It is possible that salmon harvested in a pound net could be sold in a high-value specialty market; however, the availability of these niche markets to a potential pound net commercial fishery has not been fully explored.

A potential non-commercial use for the pound net is to utilize it as a run monitoring or research tool in the lower Columbia River. Currently, the only means to regularly monitor returning salmon and steelhead in the Columbia downstream of Bonneville Dam is via a passive integrated transponder (PIT) tag detection array (PD7) on the end of a piling row near Westport, Oregon (RM 42). Located near the Cathlamet pound net, the PD7 array has the disadvantage of only being able to monitor the return of previously PIT tagged salmon and steelhead, which comprise a fraction of the runs, and may not be representative of the various stocks. A pound net, either in the current location in the Cathlamet Channel, or perhaps one on each side of the main channel, could provide the capability to capture, enumerate, and sample/tag a representative cross-section of the various salmon and steelhead runs returning to the Columbia River, particularly those returning to tributaries downstream of Bonneville Dam. This would enable fishery managers to have more timely information on the status of these runs, which would, in turn, improve the management of lower river fisheries, as well as provide researchers with access to fish for various studies.

Tributary Weir - Fall

Native Americans used weirs to capture salmon and steelhead, as well as resident fish, in the tributaries of the Columbia River. Located in small and medium size streams, the weirs were constructed of poles hewn from trees and willow branches (Figure 12a). Spanning the stream's width, a weir formed a fence that blocked migrating fish and guided them into enclosures, or traps, where they were harvested (Oregon Historical Society 2017).

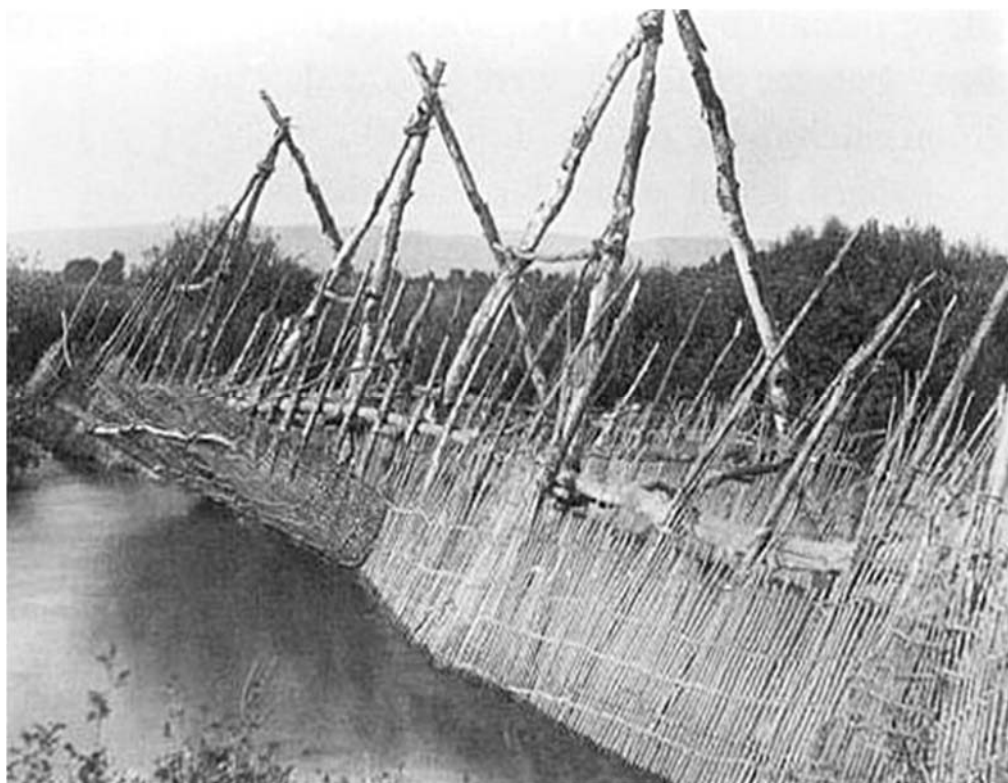


Figure 12a. Native American fish weir, circa 1901 (source: Confluence Project 2017).

In 2015, ODFW investigated the possibility of using weirs in lower Columbia River tributaries to capture and selectively harvest hatchery fall Chinook for commercial purposes. Fall Chinook were selected as the target species since they are found in several lower Columbia tributaries, with hatchery fish abundant in some. Spring Chinook typically return to larger tributaries in the mid to upper reaches of the Columbia basin.

Two modern weir designs that are suitable for operation in lower Columbia tributaries are a resistance board weir and a fixed picket weir. A resistance weir consists of a series of panels (made of evenly spaced PVC pickets) that are connected in line and hinged to a substrate rail across the width of a stream. Boards or floats attached to the underside of the downstream end of the panels provide lift and raise the panels above the water, but also allow them to move up and down as flows change and debris passes (Figure 12b). Resistance weirs work well in medium size streams with fluctuating flows and heavy debris loads (Zimmerman and Zabkar 2007). A fixed picket weir is usually constructed of evenly spaced metal pickets and does not adjust to stream flow, nor does it pass debris (Figure 12c). A fixed weir is cheaper and easier to assemble, and is

best suited for smaller streams with more consistent flows and light debris loads (Zimmerman and Zabkar 2007). Both types of weirs temporarily block upstream passage and divert migrating fish into a trap. They are usually used in fishery management and research for monitoring escapement or sampling adult salmon and steelhead. Theoretically, weirs could also be used in certain Columbia River tributaries to harvest returning hatchery salmon while allowing the release of natural-origin fish or non-target species above the weir to continue their migration.

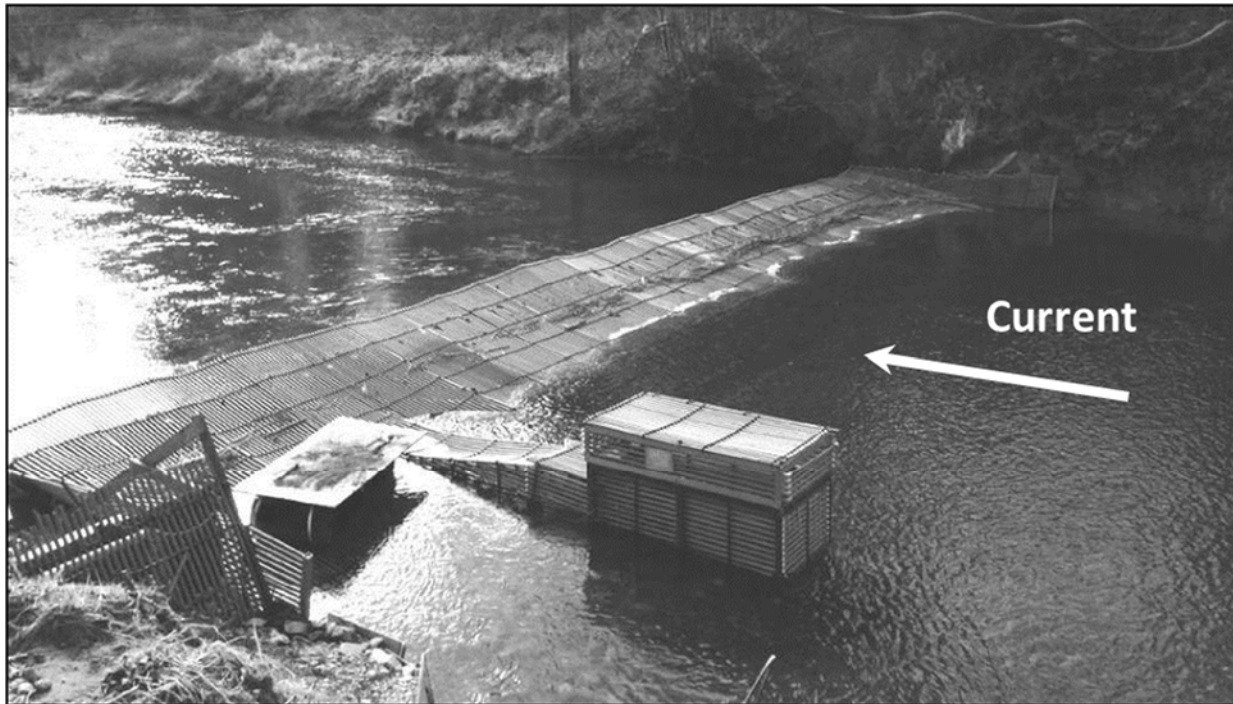


Figure 12b. Example of a resistance board weir and trap (source: Gleizes et al. 2014).



Figure 12c. Example of a fixed picket weir (source: Bureau of Reclamation 2012).

Because resistance and fixed picket weirs have been used for fisheries management and research purposes for decades and have a proven track record of successfully capturing adult salmon with minimal harm, we did not believe it was necessary to conduct field trials using these gears. Instead, we focused on modelling hypothetical weir fisheries in lower Columbia tributaries to determine whether or not the tributaries could support economically viable mark-selective commercial fisheries. We analyzed escapement data from 2013 and 2014 to identify streams that had the potential to provide sufficient numbers of returning hatchery adult fall Chinook to sustain a commercial operation. We limited our analyses to Oregon tributaries since the data were readily available to us. Based on the initial assessment, we selected Plympton Creek, the Lewis and Clark River, and the South Fork of the Klaskanine River for the modelling exercise.

The model used 2013-2014 spawning ground escapement data (and hatchery escapement data for the South Fork Klaskanine), and average fall Chinook weights and price-per-pound (by stock) specific to the year from Select Area and mainstem commercial fisheries, to estimate a theoretical annual ex-vessel value for each stream. Harvest was based on the assumption that the weirs/traps were located near the tributary mouths, and that they were capable of capturing 80% of the fall Chinook escapement in the streams (Cramer Fish Sciences, personal communication). For the South Fork Klaskanine, Select Area Bright (SAB) fall Chinook hatchery escapement goals were subtracted from the return to calculate each year's harvestable surplus. Weir-related costs (e.g. materials and fabrication, installation, and maintenance) were then subtracted from the fishery ex-vessel value to calculate a net value for the fishery. Because we were interested in seeing if a tributary weir fishery was economically viable at a very basic level, we assumed that all initial capital costs would be incurred during the weir's first year of operation, and that only operational and maintenance costs would apply in subsequent years. We did not consider financing options that would have allowed capital costs to be amortized over a period of time. The net value was our estimation of whether or not the hypothetical fishery was economically viable. It should be noted that because we used final Chinook escapements for the streams, our harvest estimates are based on the weirs fishing for the duration of the fall Chinook run. In practice, this would be highly unlikely; thus, the actual numbers of hatchery Chinook that could be harvested from the tributaries that we analyzed would be lower than our estimates. Therefore, our estimates of net value should be viewed as "best case", in which the weirs are fished for the entire season.

The presence of a hatchery on the South Fork Klaskanine greatly complicates the scenario for a commercial weir fishery. The model assumed that if the total return to the South Fork Klaskanine was sufficient to meet the hatchery broodstock goal, the goal would be satisfied through a combination of hauling fish from the weir to the hatchery, and escapement of fish past the weir to the hatchery. We used the proportion of the actual return of SABs to the hatchery and spawning grounds in 2013 and 2014 to apportion the fish escaping the weir into their respective destinations. For simplicity, and because we knew the actual return, the model set aside fish for the broodstock goal in one lump sum, allowing us to easily determine the harvestable surplus. This essentially simulated a situation where the broodstock goal was met up front, allowing a fishery to occur later on the harvestable surplus (which would not be known exactly in-season). A scenario where harvest occurs neatly after hatchery escapement needs are met is unlikely, as it is usually desirable to obtain broodstock over the breadth of the run to maintain as much genetic diversity as possible. A more realistic scenario where hatchery SABs captured at the weir would periodically need to be prioritized for hatchery broodstock throughout the season would create a high degree of

uncertainty for both the commercial fishery and the hatchery since the number of fish returning to the river is unknown.

Under a hypothetical scenario where three small to medium size Oregon tributaries were fished with two different types of weirs in 2013 and 2014, our modelling indicated that commercial weir fisheries appeared to be feasible in Plympton Creek and the South Fork Klaskanine River, but not in the Lewis and Clark River (Table 12). Although the fall Chinook return to Plympton Creek was comprised almost exclusively of relatively low value tules, large returns in both years, combined with the much lower cost of purchasing and operating a fixed picket weir, resulted in net values of approximately \$4,400 in 2013 and \$21,100 in 2014. The South Fork Klaskanine had an exceptionally strong return of high-value SAB fall Chinook in 2013, which produced an ex-vessel value of almost \$40,000 and a net value of approximately \$10,000. Even though the SAB return was much lower in 2014, resulting in a higher proportion of tule Chinook in the catch, the ex-vessel value produced that year would have been sufficient to cover the installation and maintenance costs of the weir during the second year of operation. A relatively good return of mostly bright fall Chinook to the Lewis and Clark River in 2013 would have produced an ex-vessel value of just over \$27,000 that year, but this would not have been enough to cover the initial capital cost of \$30,000 for the more expensive resistance weir. In 2014, the Chinook return in the Lewis and Clark decreased by 66%, with a higher proportion of tule Chinook in the run, resulting in a much lower ex-vessel value of approximately \$5,700. Therefore, net value in the Lewis and Clark fishery would have been negative in both years.

Table 12. Summary of hypothetical weir fisheries modelled for three Oregon tributaries of the lower Columbia River, 2013-2014.

Year	Stream	Hatchery Chinook	Percent	Ex-Vessel	Weir Type	Weir Costs ³	Net Value ⁴
		Harvested ¹	Tule ²	Value			
2013	Plympton	1,185	99%	\$19,434	Fixed Picket	\$15,000	\$4,434
	Lewis and Clark	705	9%	\$27,024	Resistance	\$30,000	(\$2,976)
	S Fk Klaskanine	990	1%	\$39,856	Resistance	\$30,000	\$9,856
	Avg	960	36%	\$28,771		\$25,000	\$3,771
2014	Plympton	2,006	100%	\$26,108	Fixed Picket	\$5,000	\$21,108
	Lewis and Clark	240	28%	\$5,722	Resistance	\$10,000	(\$4,278)
	S Fk Klaskanine	533	21%	\$13,209	Resistance	\$10,000	\$3,209
	Avg	927	50%	\$15,013		\$8,333	\$6,680

¹ Based on escapement and mark rate data from spawning ground surveys, and a weir/trap capture efficiency of 80%. Harvest of SABs in S Fk Klaskanine trap is estimated surplus above hatchery escapement goal.

² Stock composition for Plympton and Lewis and Clark from coded wire tags recovered during spawning ground surveys; stock composition for S Fk Klaskanine is estimated at weir based on spawning survey data and SAB hatchery escapement.

³ Costs in 2013 include initial fabrication as well as installation and maintenance. Costs in 2014 only include installation and maintenance.

⁴ Does not include any other costs associated with the fishery beyond the weir.

Our modelling of hypothetical tributary weir fisheries in Oregon tributaries suggested that sufficient numbers of hatchery fall Chinook could be harvested in at least *some* streams and years to make an investment in the purchase and operation of a weir worthwhile. However, fall Chinook returns and stock composition can be highly variable in individual tributaries, leading to unpredictable economic outcomes for a fishery with moderately high harvest costs (depending on weir type). Also, actual fishery results in the South Fork Klaskanine could be very different from

what was modelled due to the complexity of attempting to meet both hatchery broodstock and commercial harvest objectives. Because the model used price-per-pound data from commercial fisheries occurring in Select Area sites and the mainstem Columbia, where Chinook may be in better condition/quality than in the tributaries, the estimated fishery values could have a positive bias.

Since this was a modelling exercise, we were not able to directly evaluate the handle of non-target species, their condition at capture, or potential effects of the gear on ESA impacts. However, assuming that a commercial weir was designed and operated in a manner similar to those used in fishery management and research, we could presume that captured non-target fish would be released in an acceptable condition. Similarly, we were also not able to calculate any potential conservation benefit that might accrue due to operation of a weir and selective removal of hatchery fish before they reach spawning grounds. Weirs are currently being used extensively in lower Columbia tributaries for this purpose.

Capital investment costs for a weir fishery can be substantial, especially one using a resistance weir. In addition, there would be annual installation and maintenance costs after the initial investment. There are also several regulatory hurdles that would need to be overcome before a weir could be installed in a waterway. In Oregon, a fisher interested in installing a weir would, at a minimum, need to obtain applicable permits and certifications from the Oregon Department of State Lands (ODSL) and the Oregon Department of Environmental Quality (J. Davis, ODSL, personal communication). Furthermore, some larger tributaries such as the Cowlitz, Lewis, and Sandy rivers have significant sport fisheries that would make implementing commercial fisheries on them socially difficult. Lastly, security for a weir site would need to be considered, as the existing sites have attracted theft, snagging, and vandalism. These risks are likely higher than they would be for other fixed gears due to the proximity of roads and public access near most likely weir sites.

Based on modelling of hypothetical tributary weir fisheries, use of this gear type for a mark-selective commercial fishery targeting fall Chinook in lower Columbia River tributaries, could be possible, but would naturally be limited. Although a weir fishery might be commercially viable on a tributary like Plympton Creek due to its small size (fishable with a less expensive fixed picket weir) and larger runs of hatchery fall Chinook, in general, a commercial weir fishery would not likely be feasible in most lower Columbia tributaries. Many tributaries do not have large enough runs of hatchery fall Chinook to make them economically viable, some may not have the right combination of stream width, depth, substrate, and flow to provide a suitable weir site, and others have popular sport fisheries on them that make implementation of a commercial fishery difficult or impossible. In addition, tributaries with large hatchery fish returns usually have a hatchery located on them, or in the watershed, thereby limiting the utility of a separate weir. In the case of the South Fork Klaskanine, hatchery broodstock needs for SAB fall Chinook limit the actual number of hatchery Chinook available for commercial harvest, and this could be significant in years when returns are lower. Permits for a weir site on some streams could be difficult to obtain due to land use restrictions. Because the number of weir sites in lower Columbia tributaries would probably be very limited, commercial weir fisheries would only benefit a small number of fishers. Native Americans often fished weirs cooperatively, with family members sharing the work and harvest (Oregon Historical Society 2017). A modern commercial weir could also be fished as a

cooperative, with a group of fishers sharing the costs, work, and revenue. This would expand participation in a commercial weir fishery to a greater number of fishers, but a commercial weir targeting hatchery fall Chinook, and possibly hatchery Coho, in a lower Columbia River tributary would likely provide a very modest income to each fisher in the cooperative.

DRAFT

Columbia Gorge Fish Wheel

Fish wheels first appeared on the Columbia River around 1879, and were once a common means of commercially capturing fish. There were at least 79 stationary wheels in and out of operation around the turn of the 19th century, and they accounted for 5 to 7 percent of their period's total commercially caught salmon (Donaldson and Cramer 1971). Often, canneries owned several large wheels that operated day and night. Fish wheels, outfitted with multiple baskets, were turned by the river current, and captured migrating salmon and steelhead by scooping them out of the water as they swam into the path of the rotating wheel. The angled baskets or chutes on the wheel then slid the fish into large boxes or compartments where they were sorted by an attendant fisher. Large leads built with pilings and wooden slats guided fish towards the wheel (Figure 13a). Eventually, the length of the lead was regulated to span no more than one-third of the river's width (Donaldson and Cramer 1971). Fish wheels performed at their best when they could be located in an area where large numbers of fish were concentrated in a narrow channel (Johnson et al. 1948). Therefore, most fish wheels on the Columbia were employed in the relatively narrow Columbia River Gorge from Celilo Falls downstream to about 10 miles below present-day Bonneville Dam (Wendler 1961). The era of the fish wheel came to a close in Oregon in 1926 when a law was passed to ban their use (Washington followed suit in 1934), though this ban was later repealed in Oregon in 1965 (D. Taylor, 2008 memorandum to S. Sanders, Oregon Department of Justice, on the history of laws prohibiting fish wheels).



Figure 13a. Left, typical fish wheel used to harvest salmon in the Columbia River Gorge (source: Oregon Historical Society 2018); right, Kelly Fish Wheel, built in 1890, near McCord Creek, Oregon (source: Donaldson and Cramer 1971).

In December of 2010, ODFW was contacted by a commercial fisher interested in using a fish wheel to harvest non-native American Shad. Though known as an historical and effective means of capturing salmon in the Columbia River, this gear type had yet to be examined for its potential use in selective commercial fisheries. The fisher was willing to build the wheel in cooperation with ODFW as an opportunity for the agency to test it as an alternative commercial gear. The wheel was to be located on a past fish wheel site in the Columbia River Gorge at Ives Island, Washington (RM 142). Figure 13b shows an historic fish wheel at the proposed site on Ives Island. ODFW staff worked with the Department's legal counsel, WDFW, and NOAA Fisheries to investigate the potential of using this fixed gear for harvesting shad, and staff also researched the

“fish friendly” fish wheel designs currently used in Alaska and Canada (T. Jones, 2014 memorandum to J. North, ODFW, on a timeline of efforts to deploy a fish wheel in the Columbia River Gorge).



Figure 13b. Annotated image of the original fish wheel at the proposed Ives Island site, 1935 (source: Columbia River Gorge Commission).

ODFW issued an Experimental Gear Permit (EGP) to the fisher in January of 2012, allowing the use of a fish wheel to harvest shad. However, the EGP required that the fisher obtain any additional permits and permissions necessary to build the fish wheel, and that it be built in a specific fashion so as to minimize harm to fish. All incidental catch was to be released immediately, and only a certain number of unmarked salmonids and sturgeon could be handled; once a limit was met for any specific species, fishing would cease for the season. As part of the research on alternative commercial fishing gears, an ODFW or WDFW observer would be present during the fish wheel's operation to collect data. The fish wheel proposed by the fisher was to be fitted on a 30 ft x 60 ft metal pontoon with leads on each side to guide fish towards the wheel, akin to the layout of the site's original wheel, though of a smaller scale. Figure 13c is an example of a modern day design, which the proposed wheel would model in scale. To build the wheel, up to 10 new pilings would be needed to anchor it in place, as the site was located in an area of fast current, and the existing pilings were no longer useable. In May of 2014, ODFW sent a letter on behalf of the fisher to the Columbia River Gorge Commission to facilitate permitting of the new pilings.



Figure 13c. A modern-day experimental fish wheel, much smaller in size than its predecessors, located in the Columbia River Gorge.

Through communications with Skamania County and the Gorge Commission in the fall of 2014, it was determined that the proposed fish wheel site was within the Columbia River Gorge National Scenic Area (NSA), and because it was located in a Special Management Area, a fish wheel could only be permitted as a “natural resource enhancement”. This meant that the fisher could not build the fish wheel for commercial purposes, unless the NSA code itself was amended. Furthermore, the Gorge Commission was not accepting applications for amendments at the time. The fish wheel could still be built for research purposes, but would need a State Environment Policy Act (SEPA) checklist review and a Shorelines Permit. The NSA, SEPA, and Shorelines permitting would take approximately 12-18 months and would cost \$2,350 in application fees, with a strong likelihood that the permits would not be granted (J. Davenport, Skamania County, personal communication). Due to these permitting obstacles, and the loss of the fisher’s ability to commercially harvest shad, work towards evaluation of a fish wheel as an alternative commercial gear was discontinued.

Assessment of Alternative Gears

Summary of Gears

Based on an analysis of the evaluation results for 13 combinations of alternative gears and seasons during 2009-2017, we graded each of the alternative commercial gears with respect to the key criteria outlined at the beginning of this section to assess the feasibility of the gears for implementation in mark-selective commercial fisheries in the mainstem lower Columbia River. A comparison of the pros and cons for each gear type is displayed in Table 13 using color-coded feasibility ratings (green = *good*; yellow = *fair*; red = *poor*).

The low catch rates observed for the majority of alternative gears were due to a variety of reasons. Some gears such as the arrow net, floating fish trap, and commercial troller struggled with gear deployment issues. In some cases, like with the arrow net and floating fish trap, this may have been partly because of fishers' inexperience with the gear. In addition, most fish were probably able to elude or escape the arrow net and floating fish trap because their nets could not be consistently kept on the river bottom due to strong currents. Target fish catch rates for the pound net during the early part of its evaluation were similarly low, but refinements to the gear and operational procedures led to significant improvements in the catch rate over time. The commercial troller, designed to be fished in the open waters of the ocean, failed to catch many target fish because it was ill-suited for use in the shallow and crowded waters of the Columbia River estuary. Catch rates for modelling of summer and fall commercial hook and line fisheries, although based on those of professional fishing guides, were considered to be too low for commercially viable fisheries, where ex-vessel value is affected by the species/stock, weight, and price per pound of the fish caught. Finally, the summer beach and purse seines, as well as the Coho tangle net, targeted a specific stock with relatively low and/or variable abundance (summer Chinook and late stock Coho), which may have contributed to the lower observed catch rates for the gears.

The majority of the alternative gears scored in the low to moderate range for target species mark rate because they primarily targeted summer and fall Chinook, which typically have lower overall mark rates, compared to spring Chinook and late stock Coho (ODFW and WDFW 2014-2018a; ODFW and WDFW 2014-2018b). On the other hand, Coho tangle nets had a high target species mark rate because they targeted Coho in October when mark rates for that species are usually high. The tributary weir had high mark rates for fall Chinook due to the very high proportion of fin-clipped hatchery fish in the streams that were used for modelling of hypothetical weir fisheries, and in fact the high prevalence of hatchery fish in these areas is a primary driver in efforts seeking to increase selective removal of hatchery salmon via fisheries. The commercial troller also had high mark rates for both Chinook and Coho; however, this may have been an artifact of small sample sizes ($n = 18$ for Chinook; $n = 21$ for Coho), as mark rates in the co-occurring recreational Buoy 10 fishery were lower.

Since all of the alternative gears demonstrated a capability to release non-target fish in good to fair condition, the handle of non-target fish would be the primary factor determining the number of mortalities attributed to each gear. Beach and purse seines, in all seasons, as well as the pound net

Table 13. Feasibility of alternative fishing gears evaluated for potential implementation in lower Columbia River mainstem mark-selective commercial fisheries, 2009-2017.¹

Alternative Commercial Gear	Catch Rate of Target Species / Stock	Mark Rate of Target Species / Stock	Handle of Non-Target Species / Stock	Condition of Non-Target Catch	Potential Effect on ESA Impacts	Gear/Boat Investment Costs	Regulatory Requirements	Social Issues / Concerns	Potential for Fishery Implementation	Key Points
Beach Seine - Summer	Low	Moderate	High	Good	High	Moderate	Low	Low	Low	Low catch rate; handle of ESA-listed Sockeye likely to be prohibitively high; steelhead handle also high.
Purse Seine - Summer	Low	Moderate	High	Good	High	High	Low	Low	Low	Low catch rate; handle of ESA-listed Sockeye likely to be prohibitively high; steelhead handle also high; high gear conversion costs.
Purse/Beach Seine - Late Spring (American Shad)	Moderate-High	N/A	Moderate	Fair-Good	Moderate	High	Low	Low	Moderate	High gear conversion cost for purse seiners leads to limited participation. Shad catch was usually good for purse seine, but markets are unpredictable; insufficient data on beach seine; condition of incidental salmonids dependent on water temperature; may issue EGPs as needed to continue evaluation.
Arrow Net - Summer/Fall	Low	Moderate	High	Fair	High	Moderate	Low	Low	Low	Low catch rate; gear only fishes effectively for a short time during slack tides; high steelhead handle.
Commercial Hook and Line - Summer/Fall	Low	Moderate	Low	Good	Low	Moderate	Low	High	Low-Moderate	Catch rates, mark rates, and fall Chinook stock composition unfavorable for large-scale commercial fishery; small value-added fishery may be possible; competition with sport fishers in productive fishing areas leads to high probability of conflict.
Beach Seine - Fall	Moderate	Moderate	High	Good	High	Moderate	Low	Low	Moderate-High	High handle of ESA-listed steelhead could be a constraint; limited fisheries implemented 2014-2016.
Purse Seine - Fall	Moderate-High	Low	Moderate	Good	Moderate	High	Low	Low	Moderate-High	Low mark rates may limit Chinook harvest; moderately high handle of ESA-listed steelhead could be a constraint; high gear conversion cost; limited fisheries implemented 2014-2016.
Coho Tangle Net - Fall	Low	High	Low	Fair-Good	Moderate	Low	Low	Low	Moderate-High	Low catch rate, but some potential for decent harvest in years with strong Coho run; high mark rate; low gear conversion cost; limited fisheries implemented 2013-2015.
Floating Fish Trap - Fall	Low	Moderate	Low	Fair	Moderate	High	Moderate	Moderate	Low	Very low catch rate; floating trap design and deployment are challenging due to strong river currents; high gear conversion costs.
Commercial Troller - Fall	Low	High	Low	Good	Low	High	Low	High	Low	Very low catch rate; gear not suitable for use in riverine environment; high gear conversion costs; competition with sport fishers in productive trolling areas leads to high probability of conflict.
Pound Net - Fall	Moderate	Moderate	High	Good	High	High	High	Moderate	Low	Catch rates improved during 3-yr test fishing due to gear/operational refinements; high steelhead handle; very high gear conversion costs and regulatory restrictions may severely limit implementation; gear is non-mobile.
Tributary Weir - Fall	Moderate	High	Unknown	Good	Unknown	High	High	Moderate	Low	Although theoretically possible, weir fishery would be very small scale due to limited available harvest in tributaries; high gear conversion costs and regulatory issues; potential conflict with sport fishers.
Columbia Gorge Fish Wheel	Unknown	Unknown	Unknown	Unknown	Unknown	High	High	High	Low	Testing not conducted due to difficulty acquiring necessary permits.

¹ Feasibility ratings: Green = Good, Yellow = Fair, Red = Poor

and arrow net, had moderate to high handle of non-target fish. The summer seines handled large numbers of Sockeye, and even though their capture condition was relatively good, the sheer numbers of fish encountered could still result in significant impacts to ESA-listed Snake River Sockeye. The fall seines, pound net, and arrow net handled moderate to high numbers of steelhead, which could similarly affect impacts on ESA-listed steelhead stocks. In general, it appeared that gears designed to encircle a large area with small-mesh nets, potentially capturing a large number and variety of fish (purse and beach seines), or intercept fish migrating close to shore (pound net, arrow net, and beach seine), had a higher handle of non-target species such as Sockeye and steelhead, which typically travel in large groups (Sockeye) or closer to shore (steelhead and Sockeye). It should also be noted that a purse seine fished close to shore can encounter steelhead at a rate similar to, or sometimes higher than, a beach seine (ODFW unpublished data).

Gears that caught relatively low numbers of non-target fish included commercial hook and line, commercial troller, Coho tangle net, and the floating fish trap. These gears either used terminal tackle intended specifically for the target species (hook and line, commercial troller), or they were fished during a time when the abundance of non-target species was relatively low (Coho tangle net). The floating fish trap did not catch very many fish in general due to difficulties with gear deployment, so the low observed handle of non-target fish may not be indicative of what encounter rates might be like if the gear was deployed in a more productive manner. It is also important to remember that in a mark-selective fishery, unmarked fish of the target species are also considered to be non-target fish. Therefore, the mark rate of the target species can greatly affect the number of unmarked non-target fish handled by the gear.

Almost all of the alternative gears evaluated would require a moderate to large investment in new gear, and in several cases, a new type of boat. Some gear types, such as the pound net, fish wheel, and floating fish trap, would also require a substantial investment in support structures such as pilings or barges. The only alternative gear with a relatively low capital investment cost is the Coho tangle net, which can be fished from boats currently used by the commercial fleet, and is similar in cost to nets already in use. Although a Coho tangle net fishery also requires use of a fish recovery box, most current Columbia River commercial fishers have used them in spring Chinook tangle net fisheries.

Regulatory requirements could make it difficult to implement some of the alternative gears. Large, complex gear types, such as the fish wheel, pound net, tributary weir, and floating fish trap, that are usually fixed at a location and require significant support structures, and potentially impact public waterways, are subject to greater regulatory requirements than more conventional fishing gears such as seines, tangle nets, and hook and line. In the case of the Columbia Gorge fish wheel, regulatory hurdles were so problematic that it was impossible to even test the gear in the desired/most practicable location. It is also difficult to determine how many of the fixed gear types would be permitted by regulatory agencies. This would greatly affect the scale at which fixed gears could be adopted by commercial fishers. Finally, the application cost for permits can be significant, depending on the complexity of the regulatory process. It would have cost over \$2,000 to apply for the necessary permits for the Columbia Gorge fish wheel, with a 12-18 month processing time, and no guarantee of approval. Additional costs would be incurred if a consultant were hired to prepare and shepherd an application through the permitting process.

Although we did not collect data specifically on social concerns or issues surrounding the evaluated alternative gears, we used our professional judgement, along with the anecdotal observations of ODFW field staff during testing of several of the gears, to identify social issues and concerns that might occur during implementation of a large-scale alternative gear commercial fishery. We assumed that gears requiring extensive regulatory review and permitting would likely have social concerns proportional to the level of review and permitting. Therefore, gears such as the fish wheel, pound net, tributary weir, and floating fish trap, with moderate to high regulatory requirements, were also considered to have moderate to high levels of social concern. In addition, gears that could be fishing the same area and/or time as recreational anglers, such the commercial troll and hook and line gear types, were considered to have a high potential for social conflict.

Fishery Implementation

Based on the available data, we determined that the fall beach and purse seines, the Coho tangle net, and the shad purse seine had the best potential to be implemented in commercial fisheries. Consequently, limited mark-selective commercial fisheries using seines and tangle nets were conducted in the fall of 2014-2016 and 2013-2015, respectively. These alternative gear fisheries are described later in this report (see Alternative Gear Fisheries Implementation—Fall Seine Fishery, Coho Tangle Net Fishery). The fall seines were considered feasible for mark-selective fisheries because of moderate to moderately high catch rates of target fish, good condition of captured non-target fish, and low regulatory and social issues. Although the purse seine had high gear conversion costs, which could limit participation, the beach seine had moderate gear costs, potentially allowing greater adoption by current or new fishers. However, the moderate to high handle of steelhead in the fall seines is a concern, especially with regard to impacts on ESA-listed natural-origin B-Index summer steelhead, even with a low post-release mortality per-fish-handled.

Although the Coho tangle net had relatively low catch rates for target fish during its feasibility testing, the mark rate of Coho in October was high, so there is potential for harvest to be good in years with strong Coho returns. In addition, this gear type was considered to be a good candidate for fisheries implementation because non-target fish handle, gear conversion costs, and regulatory/social concerns were all low.

The late-spring purse seine showed some potential to catch adequate numbers of American Shad during its evaluation, and even though the high capital costs associated with purse seine boats and gear would likely restrict its use to a handful of existing purse seiners, experimental gear permits can continue to be issued to those interested in using this alternative gear for commercial shad fisheries.

Finally, although the commercial viability of the pound net remains uncertain, it has good potential to serve as a valuable monitoring and research tool that could help to improve management of fisheries in the lower Columbia River.

ALTERNATIVE GEAR POST-RELEASE MORTALITY EVALUATIONS

The primary reason for investigating alternative commercial fishing gears for the mainstem lower Columbia River is to find a gear type that is capable of not only catching fish of the target species in commercially viable numbers within mark-selective fisheries, but also minimizing the handle of non-target fish and/or releasing them in a condition conducive to lowering impacts on sensitive and ESA-listed stocks. Assessing ESA impacts in mark-selective fisheries is dependent on knowing the number of fish killed as a result of fisheries. This required an assessment of the total number retained and released by species/stock. The estimate of released fish is multiplied by a gear- and species-specific post-release mortality rate. The total mortality for the fishery is then the sum of dead harvest fish and the number of released fish that subsequently die. During the gear feasibility evaluations, we assessed the total handle of non-target fish for the various alternative gears, and gauged the general condition of fish captured in each alternative gear type. Observed condition of fish at capture and immediate mortality are related, and immediate mortality correlates with longer-term post-release mortality. However, a study specifically looking at post-release mortality *in situ* helps provide a statistically rigorous estimate of the post-release mortality rate. Therefore, between 2011 and 2017, WDFW and ODFW conducted post-release mortality evaluations for three alternative gears that were considered to have the best potential for implementation in mark-selective commercial salmon fisheries: fall purse seine, fall beach seine, and Coho tangle net. We describe methods and results for each of these evaluations, along with a study conducted in 2015 by ODFW to address questions raised in the 2013 fall seine mortality study.

Fall Seine Mortality Study

Between 2011 and 2017, WDFW used three separate study designs to evaluate post-release mortality rates for fall Chinook, Coho, and steelhead captured in fall purse and beach seines: a study design based on the Ricker-Two-Release (RTR) model, a telemetry study, and a net-pen holding study. The RTR study design used to estimate mortality rates for Chinook, Coho, and steelhead in 2011-2012, and for steelhead in 2013, had been successfully used for previous mortality work with spring Chinook tangle nets in the Columbia River (Vander Haegen et al. 2004, Ashbrook et al. 2008). This method compares the relative recovery rates of tagged fish released from treatment and control groups to estimate survival for the treatment group. The treatment groups were those captured in the gear tests, the control group consisted of fish collected at the Adult Fish Facility (AFF) at Bonneville Dam (RM 145). The following assumptions must be met for survival estimates to be valid:

1. The fate of each fish is independent of others.
2. Treatment and control fish have the same natural and handling mortality after release.
3. All fish within the treatment group have the same probability of survival and recovery.
4. Survivors from both groups have the same probability of recovery.

Due to the use of PIT arrays at mainstem dams as recovery locations, survival was partitioned into short-term (release to Bonneville Dam or Bonneville Hatchery, including immediate mortalities) and intermediate-term (Bonneville Dam to McNary Dam, including recoveries in tributaries and fisheries) components. Treatment and control group recoveries for each component were analyzed separately.

Analyses of data from the 2011 and 2012 experiments suggested that Chinook and Coho in the treatment and control groups may not have been comprised of the same mix of populations, and thus may have had different recovery probabilities at target destinations (Holowatz et al. 2014). Because of this potential violation of model assumptions, in 2013, a subsample of Chinook and Coho captured in beach and purse seines were instrumented with radio transmitters and tracked with telemetry equipment to determine their post-release behavior and survival. Control fish were presumed to be of upriver origin due to their capture at Bonneville Dam AFF. The RTR method continued to be used for steelhead in 2013 because analysis of the 2011-2012 data indicated that model assumptions appeared to be met for steelhead (Rawding et al. 2014).

Data from the 2013 radio-telemetry study suggested that the migratory behavior of seine-caught Chinook may have been altered, leading to inconclusive results regarding the origin of these fish and their short-term survival. In addition, low detection probabilities and tag loss for Coho precluded the use of telemetry data for determination of destination and short-term survival for that species.

During 2011-2013, WDFW contracted with four commercial fishers (two purse seiners and two beach seiners) each year to capture adult Chinook, Coho, and steelhead for the RTR/radio-telemetry mortality studies. Annually, 30 fishing days were allocated to each test fisher. Test fishing was conducted in Zone 5 between Rooster Rock, Oregon (RM 129) and Skamania Landing,

Washington (RM 140) from late August through late October. Purse seines ranged in length from 150 to 250 fathoms with a depth of 40 ft, and consisted of 3½-in knotted nylon mesh with a 1-in bunt. Beach seines had similar dimensions and mesh size, without the bunt. Fishing techniques were similar to those used in the feasibility evaluation, and set time (elapsed time from completion of set layout to beginning of fish sorting) was largely left to the discretion of the fisher (Holowatz et al. 2014, Rawding et al. 2014).

In 2017, two purse seiners were contracted to test fish in Zone 5 near Rooster Rock between September 14 and October 25 to capture Chinook and Coho for the net pen holding mortality study. Purse seine characteristics were similar to those in 2011-2013.

All Chinook, Coho, and steelhead captured in the seines in 2011-2013 were scanned for the presence of a passive integrated transponder (PIT) tag. Fish not already implanted with a PIT tag were tagged for the species and gear-specific treatment groups. The PIT tag code, fish condition, and other biological data were recorded prior to releasing fish back into the river. Details of fish sampling and tagging methods, as well as biological data collected, are described in Holowatz et al. (2014). Control groups of Chinook, Coho, and steelhead were collected and PIT-tagged at the Bonneville Dam AFF, transported downstream to a boat ramp near the test fishing area (RM 140), and released back into the river. The PIT Tag Information System (PTAGIS) database was queried with the tag codes from the treatment and control groups to obtain detections/recoveries at PIT tag arrays and sampling facilities throughout the Columbia Basin. Short-term recovery probabilities were determined from PIT tag detections at Bonneville Dam adult fish-ways and in the fish ladder at Bonneville Hatchery. Intermediate-term recovery probabilities were calculated using fish that had passed Bonneville Dam and were subsequently detected in the McNary Dam adult fish-ways, or in tributaries and fisheries between Bonneville and McNary dams (Rawding et al. 2014). Fish sampling procedures in 2017 were similar to those in 2011-2013, with the exception that only Chinook and Coho were PIT-tagged in 2017, and both treatment and control fish were transported after tagging/sampling to the net pen site (Cox et al. 2017). Specific methods and results for the RTR, radio-telemetry, and net pen holding studies are discussed separately.

Ricker-Two-Release Method

Short and intermediate-term, as well as cumulative survival (release to McNary Dam, including tributaries and fisheries between Bonneville and McNary dams), for Chinook, Coho, and steelhead were originally estimated using a Bayesian approach to the RTR model (Holowatz et al. 2014). Subsequently, Rawding et al. (2014) re-analyzed 2011-2013 steelhead data with the addition of the Jeffreys prior. They also re-analyzed the 2011-2012 short-term survival data for Chinook by restricting the sample groups to fish with known origins above Bonneville Dam. The proportion of fish PIT-tagged as juveniles in interior basins, subsequently captured in the treatment group and then detected at Bonneville Dam was high (89-100%); however, the proportion of treatment group fish PIT-tagged during the study that ultimately passed Bonneville Dam was substantially lower. Therefore, only fall Chinook PIT-tagged as juveniles above Bonneville Dam and captured as adults in the seines were used for the treatment group, and steelhead collected at the AFF (assumed to be of upriver origin) were used for the control group. To maximize Chinook sample sizes for the analyses, treatment groups for beach and purse seines were combined into a single “seine” treatment group, with the same short-term survival estimate applied to both gear types. This

approach was also used in 2013 as an alternative to the short-term survival estimate derived from radio-telemetry data. WDFW estimated intermediate-term survival for fall Chinook in 2011-2013 separately for beach and purse seines using a modified version of the Ricker model that adjusted for any “fall back” of fish passing Bonneville Dam. Fall back adjustments for the treatment group were based on 2013 radio-telemetry data, and adjustments for the control group were based on data from Boggs et al. (2004). Cumulative survival for fall Chinook was the product of short and intermediate-term survivals (Rawding et al. 2014). Short, intermediate, and cumulative survival estimates for Coho salmon in 2011 and 2012 were based on the Ricker model without the Jeffreys prior (Holowatz et al. 2014).

Steelhead Results

Steelhead survival estimates for 2011-2013 using the RTR model are shown in Table 14a. Steelhead survival was high for all components in all years, but survival for steelhead captured in beach seines was lower than for steelhead caught in purse seines.

Table 14a. Steelhead survival estimates (median point estimate with 95% confidence intervals) based on the Ricker-Two-Release model for fall beach and purse seines, 2011-2013. Short-term estimates include immediate gear mortalities (adapted from Rawding et al. 2014).

Year	Component	Group	<i>n</i>	Recoveries	Survival	Lower 95% CI	Upper 95% CI
2011	Short-Term	Control	458	442	--	--	--
		Beach Seine	233	218	0.97	0.93	1.00
		Purse Seine	318	302	0.99	0.95	1.00
	Intermediate-Term	Control	442	342	--	--	--
		Beach Seine	218	164	0.97	0.89	1.00
		Purse Seine	302	249	0.99	0.96	1.00
	Cumulative	Control	458	342	--	--	--
		Beach Seine	233	164	0.95	0.86	1.00
		Purse Seine	318	249	0.99	0.95	1.00
2012	Short-Term	Control	415	405	--	--	--
		Beach Seine	386	366	0.97	0.94	1.00
		Purse Seine	470	447	0.98	0.95	1.00
	Intermediate-Term	Control	405	335	--	--	--
		Beach Seine	364	299	0.98	0.93	1.00
		Purse Seine	447	378	0.99	0.96	1.00
	Cumulative	Control	415	335	--	--	--
		Beach Seine	386	299	0.97	0.90	1.00
		Purse Seine	470	378	0.99	0.94	1.00
2013	Short-Term	Control	89	82	--	--	--
		Beach Seine	350	314	0.98	0.92	1.00
		Purse Seine	265	245	0.99	0.94	1.00
	Intermediate-Term	Control	82	66	--	--	--
		Beach Seine	314	259	0.98	0.92	1.00
		Purse Seine	245	205	0.99	0.92	1.00
	Cumulative	Control	89	66	--	--	--
		Beach Seine	350	259	0.97	0.88	1.00
		Purse Seine	265	205	0.98	0.91	1.00

Chinook Results

Fall Chinook survival estimates for 2011-2013 using the RTR model are shown in Table 14b. Although short-term survival rates for PIT tagged fish were high (89-100%) because the annual sample sizes for these PIT-tagged as juveniles treatment fish were small (range 10 – 36 per year), the *U.S. v. Oregon* Technical Advisory Committee (TAC), which reviews and approves mortality rates used in lower Columbia River fisheries, was reluctant to use this analysis as the sole basis for estimating short-term survival. However, intermediate-term survival estimates based on the RTR method were thought to be valid based on sufficient sample sizes and the apparent satisfaction of method assumptions.

Table 14b. Fall Chinook survival estimates (median point estimate with 95% confidence intervals) based on the Ricker-Two-Release model for fall beach and purse seines, 2011-2013. Short-term estimates include immediate gear mortalities (adapted from Rawding et al. 2014).

Year	Component	Group	<i>n</i>	Recoveries	Survival	Lower 95% CI	Upper 95% CI
2011	Short-Term ¹	Control	458	442	--	--	--
		Seine	10	10	0.98	0.78	1.00
	Intermediate-Term	Control	899	550	--	--	--
		Beach Seine	347	200	0.96	0.87	1.00
		Purse Seine	1,050	633	0.98	0.93	1.00
	2012	Short-Term ¹	Control	415	405	--	--
Seine			24	23	0.97	0.85	1.00
Intermediate-Term		Control	985	688	--	--	--
		Beach Seine	1,582	1,064	0.97	0.92	1.00
		Purse Seine	1,203	790	0.95	0.90	1.00
2013		Short-Term ¹	Control	89	82	--	--
	Seine		36	32	0.96	0.83	1.00
	Intermediate-Term	Control	947	745	--	--	--
		Beach Seine	763	592	0.99	0.94	1.00
		Purse Seine	466	384	1.00	0.97	1.00

¹ Steelhead were used for the control group and fall Chinook tagged as juveniles above Bonneville Dam were used for the treatment group (beach and purse seine data pooled).

Coho Results

Coho survival estimates for 2011-2012 using the RTR model are shown in Table 14c. WDFW believed that short-term survival estimates for Coho were biased low due to hypothesized differences in the origin of fish in treatment and control groups, leading to unequal recovery probabilities for survivors from the two groups (Holowatz et al. 2014). Therefore, in 2013, they attempted to determine the origin of seine-caught Coho, and estimate their survival, by means of radio-telemetry.

Table 14c. Coho survival estimates (median point estimate with 95% confidence intervals) based on the Ricker-Two-Release model for fall beach and purse seines, 2011-2012. Short-term estimates include immediate gear mortalities (adapted from Holowatz et al. 2014).

Year	Component	Group	<i>n</i>	Recoveries	Survival	Lower 95% CI	Upper 95% CI
2011	Short-Term	Control	582	534	--	--	--
		Beach Seine	297	137	0.50	0.44	0.57
		Purse Seine	702	493	0.77	0.72	0.81
	Intermediate-Term	Control	526	134	--	--	--
		Beach Seine	136	33	0.86	0.64	0.99
		Purse Seine	491	123	0.91	0.77	1.00
	Cumulative	Control	582	134	--	--	--
		Beach Seine	297	33	0.50	0.34	0.69
		Purse Seine	702	123	0.77	0.62	0.94
2012	Short-Term	Control	305	281	--	--	--
		Beach Seine	480	356	0.81	0.76	0.86
		Purse Seine	548	423	0.84	0.79	0.89
	Intermediate-Term	Control	277	79	--	--	--
		Beach Seine	257	75	0.93	0.75	0.99
		Purse Seine	358	82	0.77	0.60	0.96
	Cumulative	Control	305	79	--	--	--
		Beach Seine	480	75	0.62	0.46	0.81
		Purse Seine	548	82	0.59	0.45	0.78

Radio-Telemetry Method

In 2013, WDFW contracted with the US Geological Survey (USGS) to conduct a radio-telemetry evaluation of fall Chinook and Coho captured in beach and purse seines within the previously described study area. The purpose of this investigation was to determine the post-release locations and status (alive/dead) of Chinook and Coho in the seine treatment groups. Subsamples of PIT-tagged Chinook (~800) and Coho (~400) in the treatment groups were implanted with radio transmitters and their movements monitored using a combination of fixed antenna sites and mobile tracking. The number of radio-tagged fish per species was approximately split between the two gear types.

A total of 16 fixed radio-telemetry sites extended along the Columbia River from Cascade Locks, Oregon (RM 149) to the confluence of the Washougal River (RM 120). The Cascade Locks site was used to verify passage of radio-tagged fish above Bonneville Dam, and the three Washougal sites were used to identify fish moving downstream out of the study area. Mobile tracking efforts extended as far downstream as the Willamette River mouth (RM 101), and occasionally to the Cowlitz River confluence (RM 67, Rawding et al. 2014). Mobile tracking was conducted from late August through mid-November, with the exception of a 15-day period during October 1-15 when the USGS was unable to work due to a federal government shutdown. Details regarding radio-tagging methods, as well as tracking protocols, are described in Liedtke et al. (2014). Radio-

telemetry estimates of short-term survival for fall Chinook were based on a state space Kaplan-Meier (KM) adaptation of a known fates model. Details of methods used to analyze radio-telemetry data were provided by Rawding et al. (2014).

Chinook Results

A total of 847 fall Chinook were used to estimate short-term survival using the radio-telemetry method. Eight of the fish were considered to be immediate mortalities and were not radio-tagged. Based on final detections, 52% of the 839 radio-tagged Chinook were determined to be at or above Bonneville Dam, 23% of the fish remained within the study area, and 25% moved downstream out of the study area. A total of 64 tagged fish (8%) were confirmed to have died within the study area after release, and an additional 63 fish were initially detected alive within the study area, but never detected again. The latter group was presumed to be dead, although other possibilities included tag failure or unreported harvest (Rawding et al. 2014).

Short-term survival of fall Chinook caught in beach seines was estimated to be 95% based on the radio-telemetry method (95% CI = 93%-96%). Short-term survival for Chinook caught in purse seines was also estimated to be 95%, with the same confidence interval (Rawding et al. 2014). These results were very similar to the fall Chinook short-term survival estimate (96%) derived from the modified RTR method in 2013 (Table 14b).

Cumulative survival estimates for fall Chinook captured in beach and purse seines are shown in Table 14d. For 2011 and 2012, cumulative survival was the product of RTR short (modified version) and intermediate-term survivals, and for 2013, it was the product of KM short-term survival and RTR intermediate-term survival (Rawding et al. 2014). Cumulative survival estimates for Chinook were high and similar between gear types and years. However, TAC expressed concerns about the small sample sizes associated with the modified short-term RTR survival estimates, as well as the high percentage of radio-tagged Chinook that remained downstream of Bonneville Dam since it was not consistent with the coded wire tag (CWT) based stock composition of Chinook caught in Zone 5 during historical commercial gillnet fisheries (ODFW unpublished data). Therefore, TAC recommended further investigation into the origin of Chinook captured in Zone 5 using purse and beach seines. A genetic study addressing this issue is described later in this report (Alternative Gear Post-Release Mortality Evaluations—Zone 5 Fall Chinook Stock Composition Study).

Table 14d. Cumulative survival of fall Chinook (median point estimate with 95% confidence intervals) based on Kaplan-Meier and Ricker-Two-Release models for fall beach and purse seines, 2011-2013 (adapted from Rawding et al. 2014).

Year	Gear	Survival	Lower 95% CI	Upper 95% CI
2011	Beach Seine	0.92	0.73	0.99
	Purse Seine	0.95	0.76	1.00
2012	Beach Seine	0.94	0.82	0.99
	Purse Seine	0.92	0.80	0.99
2013	Beach Seine	0.93	0.89	0.96
	Purse Seine	0.94	0.91	0.96

Coho Results

A total of 376 Coho were tagged with both a radio tag and PIT tag. Radio tag detection probabilities for Coho at the Washougal, Skamania, Bonneville tailrace, and Bonneville fish-way fixed sites were 90%, 40%, 43%, and 100%, respectively. These detection probabilities were much lower than they were for fall Chinook (99%, 88%, 90%, and 100%, respectively). In addition, 7% of Coho were confirmed to have lost their radio tags, and 6% were never detected after release. Since the low detection probabilities and tag loss violated key assumptions of the known fates model—that the fate of all fish is known—short-term survival based on radio-telemetry could not be estimated for Coho. The low detection probabilities, and lack of radio-tagged control fish, precluded estimation of RTR intermediate-term survival because of the inability to account for Coho fallback at Bonneville Dam (Rawding et al. 2014). Although no statistically valid survival estimates for Coho were generated by the 2011-2013 Fall Seine Mortality Study, based on their analyses of the data, Rawding et al. (2014) believed that short-term, intermediate-term, and cumulative survival estimates for Coho were likely somewhere between those for steelhead and Chinook.

Net Pen Holding Method

Due to inconclusive findings from the RTR and radio-telemetry studies, and confounding information garnered from Chinook PIT-tagged as juveniles, in 2017, WDFW switched to a net pen holding study design to directly observe the mortality of Chinook and Coho captured in purse seines. Chinook and Coho captured by contracted purse seiners were PIT-tagged, and temporarily held in onboard totes with circulating river water, while being transported to the net pen site near Skamania Landing, Washington (RM 140). Control fish collected at the Bonneville Dam AFF were sampled and tagged in a similar manner and transported via a tanker truck to a boat ramp near the net pen site, where they were then transferred to a boat for delivery to the net pens. Treatment and control fish were mixed together in the four net pens, each of which had dimensions of approximately 20 ft (L) x 20 ft (W) x 10 ft (D). Chinook and Coho were held at a maximum capacity of 30 fish per pen, and all fish were held for a 48-hr (short-term) period. Net pens were checked every 24 hours, and any mortalities were enumerated and PIT tag codes recorded. Species-specific post-release mortality rates for Chinook and Coho captured in purse seines were estimated relative to the control group using predicted survival probabilities from logistic regression models (Cox et al. 2017).

As of the date of this report, final results from WDFW's 2017 net pen holding mortality study for fall Chinook and Coho captured in purse seines were not available. Because of concerns regarding the mortality estimates for fall Chinook and Coho from the 2011-2013 fall seine mortality studies based on the RTR and radio-telemetry methods, TAC adjusted these mortality rates using the long-term CWT dataset from Zone 5 commercial fisheries, as well as estimates of fall Chinook spawning in the mainstem Columbia immediately downstream of Bonneville Dam, to account for the stock composition of Chinook and Coho typically observed in the study area. TAC did not adjust mortality rates for steelhead because the estimates were believed to be statistically valid. The mortality rates recommended by TAC, and approved by NOAA Fisheries, for use in the 2015-2016 mark-selective commercial fall seine fisheries are shown in Table 14e. These are the

mortality rates currently used by ODFW and WDFW for the fall seine fishery, pending any new information that may be submitted to TAC for its review.

Table 14e. Species-specific mortality rates used for beach and purse seines in the mark-selective commercial fall seine fishery, 2015-2016.

Gear	Chinook ¹	Coho ¹	Steelhead
Beach Seine	33%	38%	5%
Purse Seine	21%	29%	2%

¹ TAC-adjusted mortality rate.

DRAFT

Zone 5 Fall Chinook Stock Composition Study

The results from WDFW's 2011 and 2012 fall seine post-release mortality evaluations yielded confounding results. Chinook captured that had been PIT-tagged as juveniles in interior basins passed Bonneville Dam at a relatively high rate (89-90%) as did PIT-tagged steelhead, however, a relatively high proportion of the fall Chinook and Coho captured in purse and beach seines, and PIT-tagged as part of the study design, did not pass Bonneville Dam as expected. Based on these results, it was unclear if seine gear or study design was causing significant post-release mortality, affecting the behavior of Chinook and Coho, or if fish originating from below the study area were over-running their destination, being caught, and then exiting the study area through downstream areas as opposed to passing Bonneville Dam where they could be detected. Therefore, in 2013, a sub-sample of the Chinook ($n = 839$) and Coho ($n = 376$) caught with seine gear were fitted with radio tags to track their migration patterns and estimate short-term survival. The results of this work indicated that a significant number of radio-tagged Chinook and Coho were either remaining within the area from Bonneville Dam downstream to the Sandy and Washougal rivers, or exiting downstream of this river reach (Liedtke et al. 2014). Based on these findings, WDFW re-analyzed the radio-telemetry data, resulting in much lower proposed release mortality rates of 7% for fall Chinook caught in beach seines and 6% for Chinook captured in purse seines (Rawding et al. 2014). Mortality rates for Coho salmon could not be estimated due to known and verified violations of study design assumptions (e.g. low detection probabilities and tag loss). The revised Chinook mortality rates assumed that a significant percentage of the Chinook in the study area, which is essentially Commercial Fishing Zone 5, were from populations originating downstream of Zone 5. However, this assumption was contradictory to long-term CWT results for commercial and recreational fisheries in the study area, which have consistently shown that the vast majority of fall Chinook caught in this area are destined for areas upstream of Zone 5 (RMIS, ODFW unpublished data). As part of WDFW's re-analysis, release mortality rates for steelhead were also adjusted lower. The results of the study and proposed rates were reviewed extensively by TAC with a focus on the conflicting radio-telemetry and CWT data.

For steelhead, TAC did not think there needed to be any adjustment for lower river stock fish, and relied on the WDFW analysis for its recommendation on release mortality rates. For Chinook, because of the discrepancy between the radio-telemetry results and long-term CWT data, TAC used CWT data and estimates of the number of fish spawning naturally just downstream of Bonneville Dam to adjust the estimated release mortality rates, thereby taking into account the presence of lower river fish.

Therefore, mortality rates used for the 2014 pilot commercial seine fishery were revised beginning in 2015. The changes in the rates were, in part, from corrections to the numbers of PIT tagged fish released and recovered for the different groups of Chinook, and an updated analysis of CWT data. The revised release mortality rates (based on TAC analysis of information from studies conducted by WDFW during 2011-2013) for Chinook and Coho (Table 14e) were higher than managers expected based on low immediate mortality observed during gear feasibility evaluations in 2009-2011, and higher than modeled when developing the supporting documents for the Harvest Reform Policy.

Because of the reliance upon Bonneville Dam for detection of treatment and control groups in the RTR experiment, the largest questions surrounding interpretation of the mortality study results were: Was the study design affecting survival and if not, what proportion of Chinook and Coho present in the study area originated from below Bonneville Dam, or more specifically, downstream of Zone 5, and would therefore not be expected to be detected at Bonneville? For steelhead, available information indicated that the number of lower river stock steelhead in this area during the late summer and fall would have been expected to be zero. But for fall Chinook and Coho, there is some natural spawning that occurs in the mainstem and small tributaries within the study reach, and CWT data indicated that some lower river hatchery fish originating from tributaries downstream of the study area have been caught by fisheries in this river section. The 2013 radio-telemetry data indicated that some fish moved downstream of the study area, while some fish entered various lower river tributaries. However, it was not clear whether the fish originated from these tributaries or not. Lower river fish caught with seine gear that were not destined to reach either Bonneville Dam or Bonneville Hatchery would have biased the survival rates because they would have been counted as mortalities due to non-detection.

TAC recommended that additional data be collected from Chinook handled in mark-selective commercial seine fisheries implemented in 2015 and beyond (in Zone 5 or elsewhere), to address the question of the number, or proportion, of lower river stock fish caught with seine gear. This is important, both in terms of clarifying the data from the 2011-2013 mortality studies, and in planning future seine fisheries anywhere in the lower river. Data from Zone 5 would help TAC evaluate the stock composition of fall Chinook in Zone 5 where the 2013 radio-telemetry results did not align with historic CWT data.

In response to TAC's recommendation, ODFW contracted with one purse seine fisher and one beach seine fisher in 2015 to capture adult fall Chinook in Zone 5 for genetic and CWT sampling. The purse seine was 200 fathoms long with a depth of 45 ft. The beach seine was 130 fathoms long and 40 ft deep. Both seines were constructed of 3½-in knotted nylon webbing. Net configurations and fishing techniques were similar to those used in past research and the fall commercial seine fishery. Between August 25 and September 24, 18 fishing days were allocated to each gear type, and the number of fishing days per week was scaled approximately to weekly catch percentages observed during the 2013 USGS-WDFW radio-telemetry study and the 2013 fall commercial gillnet fishery in Zone 5. Test fishing effort was primarily concentrated in the first two weeks of September when the fall Chinook run historically peaks in Zone 5, but the entire sampling period coincided with the time frame when 98% of the Chinook from the USGS-WDFW study were radio-tagged. The test fishers made approximately four sets per day. The purse seiner fished in the vicinity of Rooster Rock State Park (RM 129-130) along both the Oregon and Washington banks. Due to an abundance of snags in the river reach, the beach seiner made all of his sets at one relatively "clean" location on the Oregon shore just upstream of Multnomah Creek (RM 136).

All adult Chinook that had not been previously sampled for DNA had an approximately ½-in triangle of tissue removed from the tip of the upper caudal fin. Samples were stored within an acid-free paper insert in an envelope which had been pre-printed with a unique sample number. In addition to the sample number, the fin-mark status was recorded for each fish. All marked Chinook were scanned with a handheld wand for the presence of a CWT. If a fish was "wand positive", the

fish was sacrificed and the snout removed for subsequent recovery of the tag at the ODFW lab in Clackamas. To compare stock origin of fall Chinook caught in seines to those caught in gillnets, we also collected DNA samples and CWTs from adult Chinook caught in the Zone 5 commercial gillnet fishery during a time frame similar to the seine test fishing period (excluding a 2-week period during September 1-14 when the gillnet fishery was closed).

During five weeks of test fishing, the purse seiner made 61 sets and the beach seiner made 73 sets. A total of 5,514 adult Chinook were captured in the seines, with 5,337 of those fish (97%) sampled for DNA (2,994 from purse and 2,343 from beach). The 177 adult Chinook that were not DNA sampled either escaped prior to sampling, were recaptures, or could not be sampled because field staff ran out of sample envelopes. Aggregate Chinook mark rates were 44% for the purse seine and 51% for the beach seine (Table 15a). Incidental salmonids included a total of 208 adult Coho and 458 steelhead. The primary non-salmonid species captured in seines were juvenile American Shad ($n = 359$) and sublegal White Sturgeon ($n = 120$).

Table 15a. Zone 5 Fall Chinook Stock Composition Study beach and purse seine test fishing summary, 2015.

Gear Type	Week	Days	Sets	Adult Chinook			Chinook			Adult Coho			Coho		Steelhead-A		Steelhead-B		Total Steelhead
				Marked	Unmarked	Mark Rate	Marked	Unmarked	Mark Rate	Marked	Unmarked	Mark Rate	Marked	Unmarked	Marked	Unmarked			
Beach Seine	35	3	14	30	36	45%	0	1	0%	9	6	1	2	18					
	36	5	21	227	229	50%	8	9	47%	43	12	3	2	60					
	37	4	15	545	327	63%	8	12	40%	10	4	10	10	34					
	38	4	15	376	465	45%	7	6	54%	26	9	8	3	46					
	39	2	8	84	176	32%	3	2	60%	4	2	0	3	9					
Subtotal	18	73	1,262	1,233	51%	26	30	46%	92	33	22	20	167						
Purse Seine	35	3	12	12	29	29%	0	2	0%	1	1	0	0	2					
	36	4	16	187	221	46%	12	24	33%	28	15	1	1	45					
	37	4	14	341	219	61%	30	25	55%	42	7	5	1	55					
	38	4	12	523	785	40%	11	7	61%	61	20	18	21	120					
	39	3	7	268	417	39%	20	21	49%	35	5	20	9	69					
Subtotal	18	61	1,331	1,671	44%	73	79	48%	167	48	44	32	291						
Seine Total		36	134	2,593	2,904	47%	99	109	48%	259	81	66	52	458					

*Table does not include any fish whose life stage, steelhead stock, or fin-mark status could not be determined.

During test fishing, 89 CWTs were collected from adult Chinook caught by the purse seine, while another 88 CWTs were collected from the beach seine catch. Raw CWT numbers were expanded using a method used for management of fall season commercial and recreational fisheries in the lower Columbia River (G. Whisler, ODFW, personal communication). Expanded CWTs indicated that 1.1% of adult Chinook caught by the beach seine in Zone 5 had originated from downstream of Zone 5. No adult Chinook caught by the purse seine had origins below Zone 5 according to the CWT data (Table 15b).

We also collected 173 CWTs from adult Chinook caught in Zone 5 during the 2015 commercial gillnet fishery. Analysis of expanded CWTs indicated that 6.3% of the Chinook caught in Zone 5 by gillnets originated from areas downstream of Zone 5 (Table 15b). CWT results for both seines and gillnets in 2015 were consistent with previous CWT analyses for gillnets, hook and line gear, and beach seines in Zone 5. A more detailed breakdown of the CWT-based stock composition of Chinook caught by the three gear types in Zone 5 during 2015 is illustrated in Figure 15a.

Table 15b. Stock composition (based on CWT analysis) of adult Chinook caught in Zone 5 by gillnet, hook-and-line, and seines, 2011-2015.

Fishery	Year	Dates	Total		Above Bonneville Dam		Below Bonneville Dam		Below Zone 5	
			Catch (raw CWT)		Catch (raw CWT)	%	Catch (raw CWT)	%	Catch (raw CWT)	%
Gillnet	2011	Aug 1 - Oct 31	14,799 (105)		12,837 (99)	86.7%	1,962 (6)	13.3%	731 (2)	4.9%
	2012	Aug 1 - Oct 31	12,132 (207)		10,244 (189)	84.4%	1,888 (18)	15.6%	736 (6)	6.1%
	2013	Aug 1 - Nov 1	33,176 (691)		29,780 (651)	89.8%	3,396 (40)	10.2%	650 (13)	2.0%
	2014	Aug 1 - Oct 31	34,801 (612)		29,507 (567)	84.8%	5,294 (45)	15.2%	2,187 (12)	6.3%
	2015	Aug 24 - Sep 23	24,995 (173)		22,636 (160)	90.5%	2,359 (13)	9.4%	1,584 (6)	6.3%
	Avg					87.2%		12.7%		5.1%
Sport ¹	2011	Aug 1 - Oct 31	4,959 (40)		4,870 (38)	98.2%	89 (2)	1.8%	(0)	0.0%
	2012	Aug 1 - Oct 31	3,542 (42)		2,893 (38)	81.7%	649 (4)	18.3%	(0)	0.0%
	2013	Aug 1 - Oct 31	5,961 (28)		5,961 (28)	100.0%	(0)	0.0%	(0)	0.0%
	2014	Aug 1 - Oct 31	6,702 (56)		6,702 (56)	100.0%	(0)	0.0%	(0)	0.0%
	2015	Aug 1 - Oct 31	10,612 (62)		9,286 (59)	87.5%	1,326 (3)	12.5%	(0)	0.0%
	Avg					93.5%		6.5%		0.0%
Seine	2014 Beach	Sep 3 - 23	832 (28)		761 (27)	91.4%	71 (1)	8.6%	(0)	0.0%
	2015 Beach TF	Aug 25 - Sep 24	2,502 (88)		2,254 (85)	90.0%	248 (3)	9.9%	27 (1)	1.1%
	2015 Purse TF	Aug 25 - Sep 24	3,012 (89)		2,947 (88)	97.8%	65 (1)	2.2%	(0)	0.0%
	Avg					93.1%		6.9%		0.4%

¹ Data from Sport Section 1 (Reed Island to Bonneville Dam).

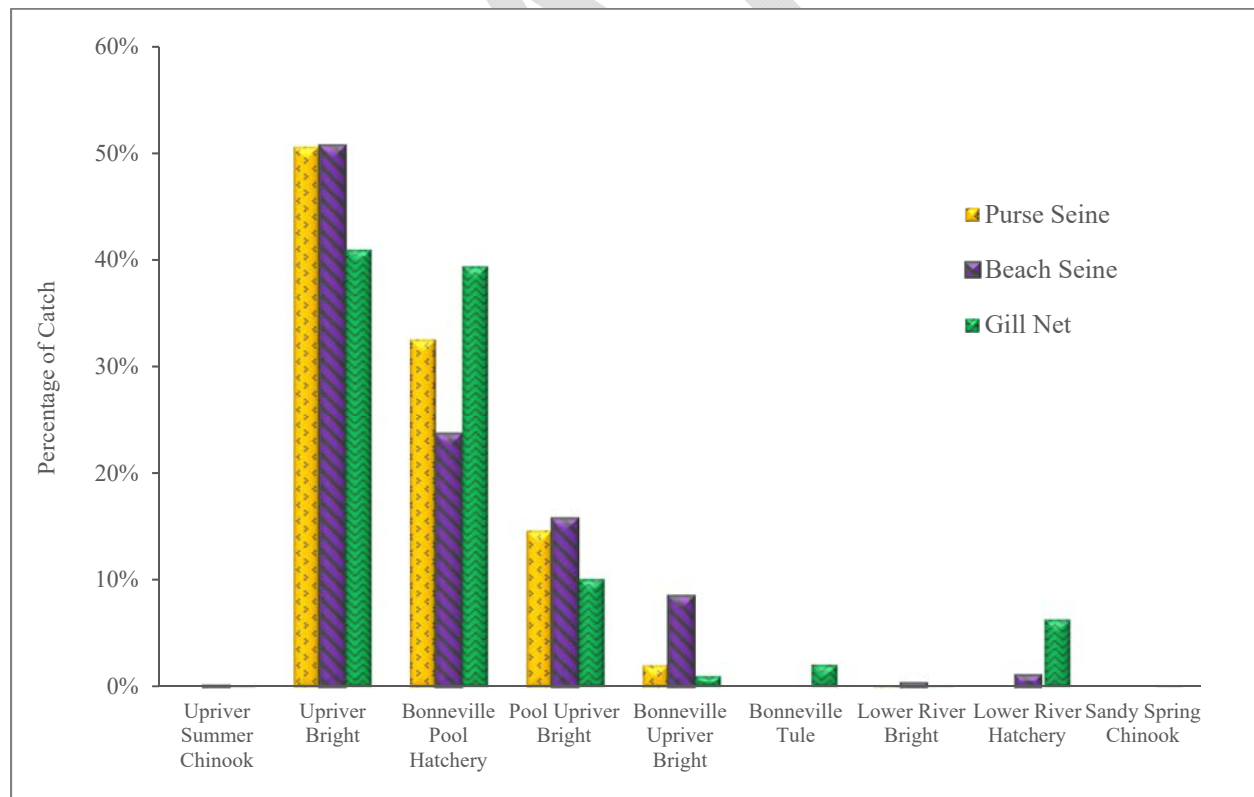


Figure 15a. Stock origin (based on CWT analysis) of adult Chinook caught in Zone 5 by gillnet, purse seine, and beach seine in August and September, 2015.

In addition to the 2,994 genetic samples collected on the purse seiner and 2,343 samples from the beach seine, another 1,242 DNA samples were collected from adult Chinook caught in Zone 5 during the commercial gillnet fishery. Based on consultations with the Columbia River Inter-Tribal Fish Commission’s (CRITFC) Hagerman Genetics Laboratory, which conducted the genetic analyses, we randomly selected a subsample of 253 DNA samples from the purse seine collection, and 200 samples each from the beach seine and gillnet collections (J. Hess, CRITFC, personal communication). For each collection, subsampling was stratified by week, with the number of weekly samples scaled to Chinook catch percentages. For the gillnet collection, we used Chinook landings from the sampled fishing periods (August 25-26, September 15-16, and September 22-23) to apportion the samples.

Results from the genetic analyses indicated that 4.1% of the Chinook captured in purse seines, 1.7% of the Chinook caught in beach seines, and 3.1% of the Chinook caught in gillnets originated from hatcheries or tributaries below Zone 5. These findings were consistent with stock composition results from both the 2015 and historical CWT analyses (Figure 15b, Table 15b). Furthermore, there was not a significant difference in genetic stock composition between Chinook caught in purse seines, beach seines, and gillnets ($p = 0.825$, Hasselman 2016). The genetic study results showed that the percentage of Zone 5 seine-caught Chinook originating from areas downstream of Zone 5 was very small ($< 5\%$). Although they do not support the assumption that a large percentage of Chinook caught in Zone 5 by purse and beach seines originate from populations below Zone 5, and therefore discount survival estimate adjustments made from the radio-telemetry data, it is still unclear what effect study design-related tagging of Chinook may have had on survival.

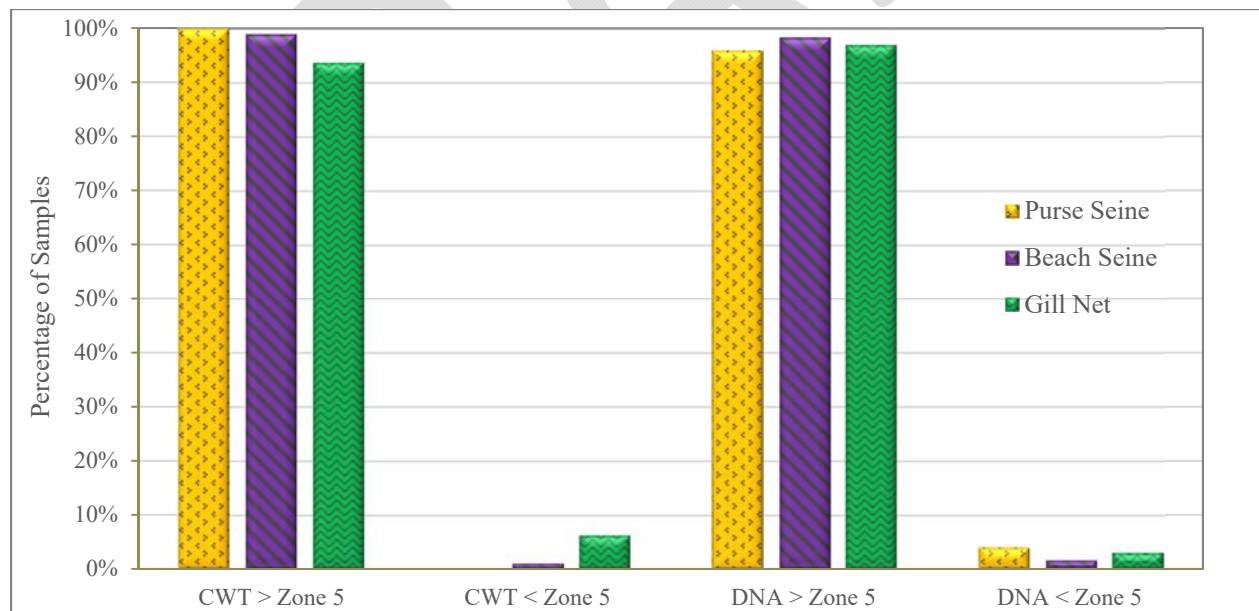


Figure 15b. Stock composition (based on CWT and DNA analysis), above and below Zone 5, of adult Chinook caught in Zone 5 by purse seine, beach seine, and gillnet in August and September, 2015.

Coho Tangle Net Mortality Study

Based on positive results from a feasibility evaluation conducted during 2009-2011, commercial tangle net fisheries targeting hatchery-origin Coho salmon were implemented in 2013-2015. This gear was identified as an alternative commercial type as part of Harvest Reform policies adopted by the Commissions in 2013. Because this fishery is operated under mark-selective regulations, an estimate of release mortality rates on ESA-listed fish is needed to monitor impacts on ESA-listed stocks. Immediate mortality rates can be obtained from direct on-board monitoring of fisheries, but post-release mortality estimates require a more in-depth investigation using specific study designs. The initial post-release mortality study for Coho tangle nets was conducted in the fall of 2013. In the interim, the 2013 pilot fishery was implemented using a placeholder release mortality rate of twice the average immediate mortality rate observed during the 2009-2011 feasibility study ($2 \times 6.8\% = 13.6\%$). This placeholder rate was increased to 30% for 2015, based on a higher immediate mortality rate observed during the 2014 full-fleet fishery.

2013-2014 Mortality Study

In 2013 and 2014, ODFW conducted a post-release mortality study using a study design based on Ricker's two-release method (Burnham et al. 1987). This method compares the recovery rate of tagged fish released from a treatment group relative to a control group to estimate survival for the treatment group. It also requires that the following assumptions be met for survival estimates to be valid:

1. The fate of each fish is independent of others.
2. Treatment and control fish have the same natural and handling mortality after release.
3. All fish within the treatment group have the same probability of survival and recovery.
4. Survivors from both groups have the same probability of recovery.

Post-release survival was partitioned into short-term (release to Bonneville Dam or Bonneville Hatchery) and long-term (Bonneville Dam to final detection at a site above Bonneville Dam—e.g. Bonneville Reservoir tributaries or at The Dalles Dam and other upriver sites) components. Treatment and control group recovery rates for each component were analyzed separately.

Each year, four commercial fishers were contracted to capture adult Coho for the treatment group using tangle nets in Commercial Fishing Zone 5 (RM 129-141). Nets were 150 fathoms long and 32 ft deep, and constructed with 3¾-in (stretched measure) multifilament mesh to reflect those used in the commercial tangle net fishery. Test fishers were randomly assigned to nets "hung in" at 10, 15, or 20 percent to represent a variety of hang ratios expected to be used in the fishery. In addition, drift times were limited to 30 minutes (first cork in to last cork out) to maintain consistency with fall tangle net fishery regulations. In both years, 12 fishing days were allocated to each fisher between September 30 and October 16. Each test fisher was required to make at least six drifts per day. Test fishing was primarily conducted between the mouth of Horsetail Creek (RM 138) and navigational marker 85 (RM 139); however, in 2014, one of the boats fished further downstream near Cape Horn (RM 129-130).

All adult Coho captured in the tangle nets were scanned for the presence of a PIT tag. Any fish not already implanted with a PIT tag was tagged for the treatment group. The PIT tag code, capture method, and fish condition were recorded prior to releasing fish back into the river. A control group of adult Coho was PIT tagged at the Bonneville Dam AFF, transported downstream to a boat ramp near the test fishing area (RM 140), and released back into the river. In 2013, we used Coho tagged by WDFW as control fish for their seine mortality study, and in 2014, ODFW tagged fish at the AFF. The PTAGIS database was queried with the tag codes from the treatment and control groups to obtain detections/recaptures at PIT tag arrays and sampling facilities throughout the Columbia Basin. From mid-October through November, foot surveys were conducted once per week in nine Oregon tributaries from Rooster Rock (RM 128) to Bonneville Dam (RM 145) to recover PIT tagged fish that may have entered them to spawn. Surveys covered most of the anadromous fish habitat available in each stream.

Fishing effort and catch composition from Zone 5 tangle net test fishing in 2013 and 2014 are shown in Table 16a. In 2013, 294 adult Coho were PIT tagged for the treatment group, while 457 were tagged for the control group. For the 2014 study, 765 Coho were tagged for the treatment group and 484 for the control group.

Table 16a. Coho Mortality Study tangle net test fishing summary, 2013-2014.

Year	Dates	River Mile	Fisher-Days	Drifts	Water Temp °F		Coho		Chinook		Steelhead
					Avg	Range	Adults	Jacks	Adults	Jacks	
2013	Oct 1-15	137-140	48	288	61	58-63	353	34	153	70	60
2014	Sep 30-Oct 16	126-129, 138-139	48	314	66	64-67	1,026	34	117	150	71
Total			96	602	63	61-65	1,379	68	270	220	131

During spawning ground surveys in 2013, we found three spawned out Chinook and one Coho in a Zone 5 tributary that had been PIT tagged that year by WDFW for treatment groups in their fall seine mortality study (Table 16b, PTAGIS 2013). In the WDFW study, which had an identical study design to ours, they found larger than expected differences between the short-term recovery rates for adult Chinook and Coho in control and treatment groups. They hypothesized that at least some of this disparity might be due to differences in the origin of treatment and control fish (Holowatz et al. 2014). Fish tagged at the Bonneville Dam AFF had already shown a propensity to pass Bonneville Dam due to their capture there; however, fish tagged in the treatment gear several miles downstream of the dam may or may not be destined to pass over Bonneville. There are numerous Zone 5 tributaries below Bonneville Dam that are known to have spawning populations of Chinook and Coho (ODFW 2015b; R. Jacobsen, ODFW, personal communication). In 2014, we recovered three tagged Coho from the ODFW tangle net mortality study treatment group in two of these tributaries (Table 16b). No control fish were recovered during spawning ground surveys in either year. Zone 5 tributary recoveries of fish from the treatment groups, but not the control groups, led us to suspect that fish from the treatment and control groups likely had different inherent tendencies to pass, and therefore be detected, at Bonneville Dam. Thus, survivors from the two groups did not have an equal probability of recovery, which was a violation of one of the Ricker model's assumptions.

Table 16b. Spawning ground recoveries in Zone 5 Oregon tributaries of PIT tagged fish from post-release mortality studies, 2013-2014.

PIT Tag Code	Species	Tagging			Tagging Agency	Recovery Date	Recovery Location
		Group	Tagging Date	Tagging Location			
3DD.003BB93CEC	Chinook	Treatment	9/27/2013	Columbia R near Multnomah Cr	WDFW	10/16/2013	Tanner Cr
3DD.003BB93F8E	Chinook	Treatment	9/9/2013	Columbia R near Rooster Rock	WDFW	10/16/2013	Tanner Cr
3DD.003BB9312E	Coho	Treatment	10/1/2013	Columbia R near Rooster Rock	WDFW	11/15/2013	Tanner Cr
3DD.003BB93004	Chinook	Treatment	10/4/2013	Columbia R near Multnomah Cr	WDFW	11/19/2013	Tanner Cr
3DD.003BC503F9	Coho	Treatment	10/6/2014	Columbia R near Horsetail Cr	ODFW	11/6/2014	Multnomah Cr
3DD.003BCFBBF7	Coho	Treatment	10/13/2014	Columbia R near Horsetail Cr	ODFW	11/12/2014	Horsetail Cr
3DD.003BC50652	Coho	Treatment	10/10/2014	Columbia R near Horsetail Cr	ODFW	11/25/2014	Horsetail Cr

There were also issues with the long-term survival component of the mortality study. In both 2013 and 2014, the long-term control group had a much higher proportion of Coho returning to the Klickitat River compared to the treatment group (Table 16c). This could be related to the capture of control fish at the AFF on the Washington side of the Columbia, while treatment fish were captured near both sides of the river. This may potentially bias the recovery rate for the control group as the Klickitat River is 36 miles upstream of the long-term start point at Bonneville Dam, and recoveries could presumably be more likely for fish traveling shorter distances. The difference in recapture proportions also suggested that, like the short-term groups, treatment and control fish in the long-term groups may have been from different populations, with survivors having potentially different recovery probabilities since not all tributaries have PIT tag arrays. Because of these problems with the 2013-2014 study design, we considered an alternative design for the 2015 Coho tangle net mortality study.

Table 16c. Final detections at mainstem dams and tributaries above Bonneville Dam of PIT tagged fish from long-term control and treatment groups in the Coho Mortality Study, 2013-2014.

Tagging Group	Year	n	Detection Sites Above Bonneville Dam								
			Hood R	Klickitat R	The Dalles	Deschutes R	Umatilla R	McNary	Yakima R	≥ Priest Rapids ¹	Snake R
Control	2013	59	2%	71%	13%	2%	3%	2%	2%	2%	3%
	2014	106	1%	42%	15%	4%	1%	10%	12%	12%	3%
	Avg	83	2%	57%	14%	3%	2%	6%	7%	7%	3%
Treatment	2013	20	0%	40%	15%	15%	10%	15%	0%	0%	5%
	2014	43	5%	23%	16%	2%	0%	19%	23%	10%	2%
	Avg	32	3%	32%	16%	9%	5%	17%	12%	5%	4%

¹ Includes mainstem dams and tributaries above Priest Rapids Dam.

2015-2016 Mortality Study

An alternative to indirectly estimating survival with a mark-recapture tagging study is to directly estimate it by holding and observing treatment fish for a set period of time. Previous studies have successfully used net pen holding to evaluate the short-term survival of adult Coho salmon captured in commercial fishing gear (Farrell et al. 2001; Buchanan et al. 2002). This type of study design has also been used for survival studies involving non-salmonids such as White Sturgeon (Robichaud et al. 2006; ODFW unpublished data). Although net pen holding studies also have

their limitations and assumptions, such as the potential effects of holding on fish condition (Donaldson et al. 2011), or the assumption that gear-related mortality occurs during the holding period, ODFW elected to use this method for its 2015-2016 survival studies since assumptions related to this type of study were believed to be more easily met than those required for a mark-recapture study.

In 2015 and 2016, two commercial fishers were contracted each year to test fish with tangle nets for adult Coho near Astoria, Oregon. Nets were identical to those described for the 2013-2014 mortality study. Furthermore, each fisher used a recovery box and carried a 150-gal insulated tote plumbed for fresh river water to hold captured Coho until pen transfer. Test fishing occurred between September 30 and November 6 in 2015, and September 25 and October 22 in 2016. These sampling periods were intended to encompass the timeframe of the commercial Coho tangle net fisheries, which have typically extended from early to late October. Each fisher made six 30-minute drifts per sampling day, with 21 days allotted to each fisher in 2015, and 16 days allocated to each fisher in 2016. To ensure proximity to the net pens, fishing was conducted mainly inside the Tongue Point Select Area (Zone 71 near RM 18), but some drifts were made in the mainstem of the Columbia near Tongue Point (Zone 1; RM 18) and Rice Island (Zone 2; RM 19).

Upon capture, adult Coho had their caudal fin hole-punched and were held for transfer to a net pen. If fish were caught with a previous punch, they were released to the river to avoid double sampling. A condition assignment of “lively”, “lethargic”, or “no signs of life” was made for each fish shortly after removal from the net. Lethargic fish were allowed to spend time in the recovery box to improve their condition before net pen transfer or release, as required in the commercial fishery. Fish showing no signs of life were also placed in the recovery box and given the opportunity to recover. If they recovered to at least a lethargic level, they were transferred to a net pen. If they did not recover, they were considered an immediate mortality. Fish were usually placed in pens soon after the completion of a drift, but if there were only a few fish on board and they were in good condition, occasionally, they were held for an additional drift prior to transfer. Fish were tallied by condition category as they were transferred to the net pen. This was done to compare the proportion of fish in each condition category at capture and pen transfer, and evaluate whether transport was negatively affecting fish condition. Each fisher used a separate pen each day and these were treated as individual treatment groups. In 2015, the net pens were located at Pier 6 of the Tongue Point Job Corps Center, and at the Clatsop County Fisheries (CCF) juvenile rearing site at the Marine and Environmental Research and Training Station (MERTS), both of which were within the boundaries of the Tongue Point Select Area. In 2016, all net pens were located at MERTS. Up to 10 net pens were used to accommodate rotating treatment groups during the study, with each pen measuring 20 ft (L) x 20 ft (W) x 8 ft (D) and providing approximately 3,200 ft³ of holding space. Sturdy piping around the perimeter of each pen kept the net square and at depth. All pens were covered with bird netting to help deter predators and keep fish from jumping out. Trail cameras were set up over the pens to deter vandals and poachers, as well as to document any predators near the pens.

All treatment groups were held in net pens for a short-term duration of two days. A 2002 Canadian study used a 2-day holding period in net pens to evaluate the short-term post-release mortality of adult Coho caught in commercial fishing gear (Buchanan et al. 2002). Another reason that we chose a 2-day period for short-term holding is because it was the most common number of days

that it took short-term survivors from the treatment group to reach their target destination during the 2013-2014 mortality study (ODFW unpublished data). For the long-term mortality component of the study, each week, two of the short-term groups (one per fisher) were held for an additional six days. Although a review of the literature found no comparable survival studies that held adult salmonids for longer than two days, Jones et al. (2013) found that adult Coho salmon fitted with acoustic tags took an average of eight days to travel from the tagging site in the Columbia River estuary to lower Columbia spawning tributaries, or to Bonneville Dam. Because the stress of net pen holding can have a negative effect on the physiology of adult salmon (Donaldson et al. 2011), we were reluctant to hold fish for longer than a total of eight days. To maximize sample sizes, whenever possible, we selected treatment groups with greater numbers of fish for long-term mortality evaluation. To determine when fish died during the holding period, treatment groups were checked for mortalities at regular intervals (daily for short-term groups and every other day for long-term groups in 2015, daily for all groups in 2016). We used an underwater video camera for the intermediate checks to minimize stress on the fish in 2015. In 2016, due to the presence of river otters at the net pen site, we crowded the fish to one side of the pen to get an accurate daily count of live fish and removed mortalities as soon as possible. At the end of the holding period, live and dead fish were enumerated, and the live fish released.

We pooled data from all treatment groups, by test fisher, to calculate short and long-term survival rates for Coho caught by each fisher:

$$\hat{S} = \frac{\sum_{i=1}^n x_i}{\sum_{i=1}^n y_i}$$

Where \hat{S} is the point estimate of survival, x_i is the number of survivors in treatment group i , and y_i is the total number of fish in treatment group i . Confidence intervals were calculated using a modification of the Wilson Score method, where the variance is:

$$v(xy) = x^2v(y) + y^2v(x) - v(x)v(y)$$

and,

$$CI = \frac{\hat{p} + \frac{Z_{1-\alpha/2}^2}{2n} \pm Z_{1-\alpha/2} \sqrt{v(xy) + \frac{Z_{1-\alpha/2}^2}{4n^2}}}{1 + \frac{Z_{1-\alpha/2}^2}{n}}$$

Cumulative survival was calculated as the product of the average immediate survival rate from 2013-2015 tangle net fishery observation, and the short and long-term survival estimates from the post-release mortality study (Kaplan and Meier, 1958; Ashbrook et al. 2008).

$$S_c = S_i \cdot S_s \cdot S_l$$

We used the average (weighted) immediate survival rate from the tangle net fishery because the data were collected under actual commercial fishery conditions and the average number of fishing

vessels observed each year was 52--considerably more than in the 2015-2016 mortality study. Survival rates were converted to mortality rates using:

$$M = 1 - S$$

Tangle net test fishing effort and catch composition for 2015-2016 are summarized in Table 16d. In 2015, a total of 256 drifts were made and 378 adult Coho were caught (164 by Fisher A and 214 by Fisher B). Included in the adult Coho catch were 61 immediate gear mortalities, 3 immediate predation mortalities, and 3 recaptured fish. Furthermore, 11 fish escaped during net pen transfer, and 5 died during on board holding/transport. Therefore, a total of 295 adult Coho were placed in net pens in 2015 (138 by Fisher A and 157 by Fisher B). The mean number of fish per pen was 8 ($\approx 0.02 \text{ lb/ft}^3$), with a range of 1 to 21. In 2016, 193 drifts were made and 343 adult Coho were caught (139 by Fisher A and 204 for Fisher B). Of these, 21 were immediate gear mortalities, 2 were immediate predation mortalities, and 6 were recaptures. There were also 8 fish that escaped, 2 were not transferred to a pen due to severe predator-induced injuries, and 3 fish died during transport. The total number of adult Coho placed into net pens in 2016 was 301 (120 by Fisher A and 181 by Fisher B). The average number of fish per pen was 10 ($\approx 0.03 \text{ lb/ft}^3$), with a range of 1 to 51. In 2015 and 2016, water temperatures averaged 65 degrees at the beginning of the study period and cooled to the upper fifties towards the end, although this cooling occurred much sooner in 2016. In both years, the Coho catch peaked in mid-October during Week 42, and incidental catches of Chinook, steelhead, and Chum were low. Most Chum were caught in late October or early November, after the Coho tangle net fishery usually ends.

Table 16d. Coho Mortality Study tangle net test fishing summary, 2015-2016.

Year	Week	Dates	Fisher-Days	Average Drifts	Average Water Temp F	Coho		Chinook		Steelhead	Chum
						Adults	Jacks	Adults	Jacks		
2015	40	Sep 30 - Oct 1	4	24	65	46	24	11	9	5	0
	41	Oct 7 - Oct 11	8	49	64	22	11	1	2	0	0
	42	Oct 13 - Oct 17	9	54	62	151	107	2	0	1	3
	43	Oct 18 - Oct 24	11	69	62	85	54	0	0	0	2
	44	Oct 26 - Oct 28	3	18	60	54	40	0	0	0	2
	45	Nov 2 - Nov 6	7	42	58	20	14	0	1	0	14
Total			42	256	62	378	250	14	12	6	21
2016	39/40	Sep 25 - Sep 30	8	48	65	56	152	4	1	1	0
	41	Oct 4 - Oct 7	8	49	61	100	208	0	0	0	0
	42	Oct 12 - Oct 16	6	34	59	110	225	0	0	0	1
	43	Oct 18 - Oct 22	9	62	58	77	130	0	0	1	4
	Total			31	193	61	343	715	4	1	2

Table 16e compares the condition of treatment fish shortly after capture in the tangle net, to fish condition at the time of net pen transfer. For both fishers each year, fish condition was substantially better at pen transfer than it was at capture. From initial capture to transfer, 66% of lethargic fish in 2015 and 69% in 2016 improved to a lively condition. Therefore, rather than declining, average fish condition improved during on-board holding and transport, likely due to the fish's placement in the recovery box. We saw similar improvements in fish condition between capture and release during the 2009-2011 tangle net feasibility evaluation.

Table 16e. Adult Coho condition at capture and net pen transfer, 2015-2016.

	Condition	2015		2016	
		Capture % (n)	Transfer % (n)	Capture % (n)	Transfer % (n)
Fisher A	Lively	58% (81)	88% (122)	48% (57)	85% (102)
	Lethargic	42% (58)	12% (16)	52% (63)	14% (17)
Fisher B	Lively	53% (85)	83% (133)	50% (91)	81% (149)
	Lethargic	47% (76)	15% (24)	50% (92)	18% (32)
Total	Lively	56% (166)	85% (255)	49% (148)	84% (255)
	Lethargic	44% (134)	13% (40)	51% (155)	15% (45)

*Table does not include one treatment fish with unknown condition at transfer (2016). Transfer % does not always equal 100% because fish that died during on-board holding/transport ($n = 5$ in 2015, $n = 3$ in 2016) were not placed in pens and are not included in the transfer %; however, they are included in the capture % and in calculating recovery.

Mortality results in 2015-2016 for adult Coho held in net pens for a short-term duration are shown in Table 16f. For both years, we pooled each fisher's treatment groups to estimate their short-term mortality rates. In 2015, Fisher A had 17 treatment groups ($n = 1-21$) that we combined ($n = 113$) for a mortality estimate of 8.0%, and Fisher B had 20 treatment groups ($n = 1-21$) that we combined ($n = 152$) for a mortality estimate of 7.2%. In 2016, we pooled 14 treatment groups ($n = 2-14$) for Fisher A for a mortality estimate of 6.5% ($n = 108$), and 15 treatment groups ($n = 1-51$) for Fisher B for a mortality estimate of 9.3% ($n = 161$). Chi-square analyses did not find a significant difference between the mortality rates of the two fishers in 2015 ($\chi^2 = 0.05$, $df = 1$, $P = 0.82$) or in 2016 ($\chi^2 = 0.69$, $df = 1$, $P = 0.41$). Therefore, we concluded that the difference in mortality rates between the two test fishers was due to chance, and not hang ratio, differential fish handling, or any other characteristic of the fishers or their gear. Therefore, data from both fishers were pooled each year to generate a combined short-term mortality estimate of 7.5% (95% confidence limits 4.9% and 11.4%) in 2015 ($n = 265$) and 8.2% (95% confidence limits 5.5% and 12.1%) in 2016 ($n = 269$), or 92.5% and 91.8% survival, respectively. Most short-term mortalities (65% in 2015 and 100% in 2016) occurred within the first 24 hours after fish were transferred to the pens.

Table 16f. Short-term gear-related mortalities for adult Coho held in net pens for a 2-day period, 2015-2016.

		n ¹	Mortalities Observed			Short-Term Mortality Rate
			24-hr	48-hr	Cumulative 2-day	
2015	Fisher A	113	6	3	9	8.0%
	Fisher B	152	7	4	11	7.2%
	Total	265	13	7	20	7.5%
2016	Fisher A	108	7	0	7	6.5%
	Fisher B	161	15	0	15	9.3%
	Total	269	22	0	22	8.2%

¹ Does not include predation mortalities or catch from October 27, 2015.

Mortality results for adult Coho held in net pens for a long-term duration are shown in Table 16g. In 2015, we pooled data from three treatment groups ($n = 3-15$) for Fisher A ($n = 25$), and three treatment groups ($n = 5-18$) for Fisher B ($n = 36$), to estimate long-term mortality rates for each fisher. Long-term mortality was 4.0% for fish caught by Fisher A, and 5.6% for fish caught by Fisher B. In 2016, four treatment groups ($n = 4-11$) for Fisher A ($n = 25$) and four treatment groups

($n = 1-21$) for Fisher B ($n = 46$) were pooled for long-term mortality rates of 4.0% and 6.5%, respectively. There was no significant difference between the long-term mortality rates of the two fishers in 2015 ($\chi^2 = 0.08$, $df = 1$, $P = 0.78$) or in 2016 ($\chi^2 = 0.19$, $df = 1$, $P = 0.66$). Therefore, we pooled the data from both fishers to generate a combined long-term mortality estimate of 4.9% (95% confidence limits 1.7% and 13.5%) for 2015 ($n = 61$) and 5.6% (95% confidence limits 2.2% and 13.6%) for 2016 ($n = 71$), or 95.1% and 94.4% survival, respectively.

During the long-term part of the evaluation, most mortalities occurred late in the holding period (Table 16g). This is in sharp contrast to the results from short-term holding, where most mortalities occurred early in the holding period. This suggests that some long-term mortality could have been related to, or exacerbated by, the effects of extended net pen confinement. Because of the lack of studies where adult salmonids were held for longer than two days, it is difficult to determine exactly when confinement begins to affect fish survival. Therefore, we used all of the data from the long-term tests, and our long-term mortality estimates should be considered as conservative.

Table 16g. Long-term gear-related mortalities for adult Coho held in net-pens for six days beyond short-term (ST) holding, 2015-2016.

		n^1	Mortalities Observed ²						Cumulative 6-day	Long-Term Mortality Rate
			ST+1	ST+2	ST+3	ST+4	ST+5	ST+6		
2015	Fisher A	25	0	--	0	--	1	0	1	4.0%
	Fisher B	36	0	--	1	--	0	1	2	5.6%
	Total	61	0	--	1	--	1	1	3	4.9%
2016	Fisher A	25	0	0	0	0	1	0	1	4.0%
	Fisher B	46	0	0	0	1	0	2	3	6.5%
	Total	71	0	0	0	1	1	2	4	5.6%

¹ Does not include predation mortalities or catch from October 27, 2015.

² Mortalities checked at 1, 3, 5, and 6 days after short-term holding in 2015, and every day in 2016.

The 2015 and 2016 short-term mortality estimates of 7.5% and 8.2%, respectively, are comparable to the 2-day mortality rate of 9.7% reported in Buchanan et al. (2002). In that study, a variety of tangle nets (with a slightly larger mesh size) were used to capture adult Coho, and longer soak times (40 - 140 minutes) were examined. Therefore, it is reasonable that our mortality estimates would be slightly lower.

Combining the short and long-term survival rates from this study, with the average immediate survival rate of 87.5% from observation of the 2013-2015 Coho tangle net fisheries, yielded a cumulative survival estimate of 77.0%, or 23.0% mortality (95% confidence limits 17.7% and 28.7%) for 2015, and a survival estimate of 75.8%, or 24.2% mortality (95% confidence limits 18.8% and 29.8%) for 2016.

$$(0.875) \cdot (0.925) \cdot (0.951) = 0.770$$

Cumulative survival for 2015, and 2016:

$$(0.875) \cdot (0.918) \cdot (0.944) = 0.758$$

The average cumulative survival rate for the two years was 76.4%, or a mortality rate of 23.6%. One of the problems that we encountered during the 2015-2016 study was the presence of piscivores around the net-pens. In the first year of the study, several fish were recovered from the

pens with their heads bitten off. Since no holes were found in the net-pen mesh, we believed that marine mammals were probably grabbing the fish through the mesh. This was confirmed when one of our field staff witnessed a live fish with its head burrowed in the mesh decapitated by a marine mammal approaching from below the pen. Subsequently, all mortalities were closely examined to identify any fish that may have died from predation-related injuries. In 2016, some treatment fish were found partially consumed or bitten through their gill plates, both inside the pens and on the walkways. Photographs from trail cameras confirmed the presence of river otters on the walkways around the pens. To prevent further predation, we took additional measures to close any gaps between the bird netting and the pen mesh. For our analyses, all predation-related mortalities ($n = 9$ for short-term groups, and $n = 6$ for long-term groups in 2015; $n = 30$ for short-term groups, and $n = 14$ for long-term groups in 2016) were excluded from the treatment samples.

Another problem encountered in 2015 involved the advanced maturity of some Coho caught towards the end of the test fishing period. A long-term treatment group captured on October 27, 2015 ($n = 21$) contained fish appearing to be well advanced in their maturity, and this group experienced much higher mortality than preceding long-term groups. Buchanan et al. (2002) hypothesized that survival after capture could be negatively affected by maturity. Based on their capture location inside the Tongue Point Select Area, and their general appearance, it is likely that the October 27 fish were early stock Select Area Coho that had been in the river for some time. We suspect their advanced maturity compromised their survival in the study, especially when exposed to the stress of confinement for an extended period of time. They also did not appear to be representative of fresh late stock Coho that would typically be caught in a Zone 1-3 tangle net fishery in October. For these reasons, we excluded the October 27 group from both the short and long-term treatment samples. To reduce the potential for this problem in 2016, we started test fishing a week earlier, and ended earlier as well. Consequently, all groups of Coho captured in 2016 were of acceptable condition for the mortality evaluation.

The 2015-2016 mortality study did not control for the additional handling involved in examining Coho and transferring them to net pens. Although our mortality estimates may incorporate some degree of mortality due to this additional handling, we believe that it would be very small given the minimal amount of handling associated with the study protocol. Nevertheless, our mortality estimates should be considered to be conservative.

The results from the 2015-2016 mortality study, and proposed mortality rate of 23.6%, were reviewed by TAC in early 2018. TAC recommended that NOAA's National Marine Fisheries Service (NMFS) approve this mortality rate for use in future Coho tangle net fisheries in the lower Columbia River. NMFS concurred with TAC's recommendation in July 2018.

Pound Net Mortality Study

After two years of initial test fishing in 2013 and 2016 (Alternative Gear Feasibility Evaluations—Fall Pound Net), in 2017, WFC conducted a post-release mortality study for fall Chinook and steelhead captured in an experimental pound net near Cathlamet, Washington (RM 43). The study design was based on a Ricker-Two-Release (RTR) model used for previous mortality work with spring Chinook tangle nets (Vander Haegen et al. 2004, Ashbrook et al. 2008) and fall purse and beach seines (Alternative Gear Post-Release Mortality Evaluations—Fall Seine Mortality Study) in the Columbia River (Gayeski and Tuohy 2018). This method compares the relative recovery rates of tagged fish released from treatment and control groups to estimate survival for the treatment group. It also requires that the following assumptions be met for survival estimates to be valid:

1. The fate of each fish is independent of others.
2. Treatment and control fish have the same natural and handling mortality after release.
3. All fish within the treatment group have the same probability of survival and recovery.
4. Survivors from both groups have the same probability of recovery.

Survival was partitioned into short-term (release to Bonneville Dam, including immediate mortalities) and long-term (Bonneville Dam to McNary Dam, including recoveries in tributaries and fisheries) components. Treatment and control group recoveries for each component were analyzed separately.

The treatment group consisted of a subsample of Chinook and steelhead captured in the pound net spiller, lifted in the spiller by an electric winch, and spilled into an adjacent submerged and perforated aluminum live well. Fish for the control group were also captured in the pound net spiller, but were dip-netted while free swimming in the spiller, and placed into the live well. Fish in both groups were PIT tagged and released. WFC attempted to alternate tagging sessions dedicated to treatment and control groups throughout each fishing day; however, this was not always possible due to the difficulty of dip-netting control fish out of the spiller in low light conditions. PIT tagging procedures, biological data and samples collected from sampled fish, and analytical methods used to estimate survival are described in Gayeski and Tuohy (2018).

As of the date of this report, final results from WFC's 2017 post-release mortality study for fall Chinook and steelhead captured in an experimental pound net have not been presented to TAC for review. Preliminary findings, based on WFC's initial analysis of the data, are presented in Gayeski and Tuohy (2018).

ALTERNATIVE GEAR FISHERIES IMPLEMENTATION

During the Harvest Reform transition period, two mark-selective commercial fisheries using alternative gears were implemented in the mainstem lower Columbia River: 1) A seine fishery

primarily targeting hatchery fall Chinook, and 2) a tangle net fishery targeting hatchery Coho. Because these mark-selective alternative gear fisheries were implemented on a trial basis, ODFW and WDFW collected data during onboard observation of the fisheries to assist in evaluating their effectiveness. We describe the development and structure of these fisheries, and assess their results.

Fall Seine Fishery

Fishery Development and Regulations

WDFW and ODFW's evaluation of fall beach and purse seines from 2009 through 2012 concluded that, based on moderate to moderately high target species catch rates and relatively good capture condition of non-target fish, seines may be a viable gear for use in mark-selective fall commercial fisheries in the lower Columbia River. Use of seines for commercial harvest of salmon had been prohibited in Washington since 1935, and Oregon since 1950; however, legislation passed in Oregon in 2013 removed the prohibition in that state. The states took legislative and regulatory action to allow implementation of a commercial seine fishery on a limited basis. During 2013-2014, Department staff met with the commercial fishing industry to gather input on the design and implementation of a pilot seine fishery. At the same time, TAC developed interim post-release mortality rates for a seine fishery, based partly on research conducted by WDFW (Alternative Gear Post-Release Mortality Evaluations--Fall Seine Mortality Study, this report).

In 2014, research impacts for ESA-listed salmon and steelhead stocks were set aside for the pilot fall seine fishery. Fishery managers modelled the fishery using the available ESA impacts to estimate the number of Chinook and Coho that could be harvested, as well as the allowable handle of steelhead. Because fewer impacts were available than would normally be for a full commercial fishery, the seine fishery was conducted on a limited entry basis. Modelling results were used to determine the number of fishers that could participate in the 2014 fishery (six beach seiners and four purse seiners). Permit holders were then drawn lottery-style from a pool of applicants holding a current Columbia River commercial fishing license, with substantiated landings from either of the previous two calendar years. Individual fisher quotas (IFQ) were assigned to each permit holder based on the type of gear that they planned to fish (Table 17a). Quotas applied to kept adult Chinook and Coho, as well as released steelhead, and were intended to ensure that the fishery remained within its allowable ESA impact limits. Once the quota for any species was reached on a given permit, that permit could no longer be fished.

In 2015 and 2016, research ESA impacts were not available to prosecute the seine fishery, so sub-allocations of the commercial fall ESA allocations were reserved during the North of Falcon process, an annual process involving federal, state, tribal, and fishing industry (recreational and commercial) representatives that sets fall fishing seasons. To reduce the economic impact on the existing commercial gillnet fishery, but allow for a commercial seine fishery, 10% of the fall commercial impacts (for whatever stock was most limiting) were set aside for the 2015 and 2016 seine fisheries. As in 2014, the 2015-2016 fisheries were modelled pre-season to determine IFQs (Table 17a) and the number of available permits. Of the 10 permits available to potential fishers in 2015, three beach seine and four purse seine permits were actually purchased and fished. One

of the three beach seine permittees did not land any fish, though all of the purse seine permittees did. Permit numbers were again adjusted down in 2016 in order to increase IFQs (to encourage participation) while staying under allowable impacts in a year with a lower forecasted fall Chinook return. Four seine permits (two each for purse and beach) were issued in 2016.

Table 17a. IFQs for commercial fall seine fisheries, 2014-2016.

Year	Gear	Chinook ¹	Coho ¹	Steelhead
2014	Beach	500	250	360
	Purse	750	450	360
2015	Beach	400	150	180
	Purse	650	200	150
2016	Beach	600	400	320
	Purse	750	600	230

¹ Kept adults.

Each year, Department staff held pre-season meetings with the permit holders to discuss fishery objectives, season structures, and regulations. Detailed descriptions of the initial season structures, gear requirements, and regulations pertaining to the 2014-2016 fall seine fisheries can be found in the respective Columbia River Compact fishery notices (ODFW 2014a, 2015a, 2016a).

The 2014-2016 commercial seine fisheries were primarily mark-selective for fin-clipped hatchery fall Chinook and Coho, although on an experimental basis in 2016, fishers were allowed to retain unmarked bright stock fall Chinook on one day during the season. The identification of bright stock Chinook, based on visual characteristics, was left to the fishers, and DNA samples were collected from all harvested unmarked Chinook to evaluate the fishers' ability to differentiate between stocks. WDFW and ODFW observed all fishing trips made by permittees during the seine fisheries. This was required to closely monitor IFQs, and to collect data so that fishery managers could evaluate the seine fishery's performance.

Fishery Landings and Ex-Vessel Value

In general, the number of days fished, both in total days and in the percent of available days, by beach and purse seiners declined between 2014 and 2016. Of the 22 fishing periods set for the 2014 fall seine season, beach seining occurred on 12 days, and purse seining occurred on 15 days, between August 19 and September 24 (Table 17b). In 2015, out of an available 23 days, beach and purse seiners fished 6 and 14 days, respectively, between August 31 and September 23. The 2016 seine fishery was scheduled for 20 fishing days, but was fished on 6 days by beach seiners and 13 days by purse seiners between September 6 and September 30. In 2016, four seine fishing periods were set in late August, but the seine permit holders elected to wait until early September to begin fishing, when Chinook numbers are usually higher. The relatively large number of available fishing periods in each year gave permittees the flexibility to choose when they wanted to fish.

Table 17b. Chinook landings and ex-vessel value for the commercial fall seine fishery in the lower Columbia River, 2014-2016.

Year	Gear	Permits Fished	Days Fished	Deliveries	Chinook Landed ¹	Mark Rate	Avg Wt (lb)	Avg \$/lb	Avg \$/Fish	Ex-Vessel Value
2014	Beach	6	12	20	1,337	45%	13.1	\$1.52	\$19.93	\$26,647
	Purse	4	15	19	1,457	33%	13.5	\$1.47	\$19.74	\$28,760
	Total	10	27	39	2,794	38%	13.3	\$1.49	\$19.83	\$55,407
2015	Beach	3	6	6	681	66%	10.9	\$1.39	\$15.21	\$10,360
	Purse	4	14	19	2,312	37%	10.4	\$1.71	\$17.77	\$41,075
	Total	7	20	25	2,993	41%	10.5	\$1.63	\$17.18	\$51,434
2016	Beach	2	6	3	2	50%	8.0	\$2.81	\$22.50	\$45
	Purse	2	13	21	1,113	29%	10.6	\$2.28	\$24.12	\$26,849
	Total	4	19	24	1,115	29%	10.6	\$2.28	\$24.12	\$26,894
2014-2016 Seine Avg		7	22	29	2,301	36%	11.5	\$1.80	\$20.38	\$44,578

¹ Includes adults and jacks. For 2016, beach seine landings include 1 unmarked Chinook and purse seine landings include 292 unmarked Chinook allowed on one non-MSF day.

Total Chinook landings in the commercial seine fishery ranged from a high of 2,993 in 2015 to a low of 1,115 in 2016, with an average of 2,301 for the three years of the fishery (Table 17b). The mark rate of fall Chinook (adults and jacks) encountered in the seine fishery averaged 36%, indicating that about one-third of the Chinook caught in beach and purse seines were harvestable in the mark-selective fishery. Mark-selective fisheries are most effective when the mark rate greatly exceeds the release mortality rate, e.g., the spring Chinook recreational and commercial tangle-net fisheries. The average weight of seine-caught Chinook decreased from 13.3 lb in 2014 to approximately 10.5 lb in 2015 and 2016. Analysis of seine observation data indicated that this decrease in average Chinook weight did not appear to be the result of an increase in the jack proportion in the catch (ODFW unpublished data). It is more likely that the change in average weight of seine-caught Chinook was due to the later timing of seine fisheries in 2015 and 2016, when adult fall Chinook tend to be smaller (ODFW unpublished data). Although an increase in average price per pound from 2014 to 2016 helped to partially compensate for the reduction in average fish size, total Chinook ex-vessel value for the seine fishery still decreased from \$55,407 in 2014 to \$26,894 in 2016 as a result of lower landings. The average ex-vessel value for Chinook during 2014-2016 was \$44,578. Chinook landings and ex-vessel value for purse seines were usually much higher than they were for beach seines. In 2016, two Chinook were landed by beach seiners, with a total ex-vessel value of \$45.

Total Coho landings in the commercial seine fishery were 1,070 in 2014, but decreased to about 600 fish in 2015 and 2016, and averaged 754 during the three years of the fishery (Table 17c). The difference in annual landings likely reflected the relatively strong Coho run in 2014, and much weaker runs in 2015 and 2016. The mark rate of Coho (adults and jacks) varied widely from 32% in 2014 to 63% in 2016, averaging 46%. Therefore, on average, less than half of the Coho caught in beach and purse seines were harvestable in the mark-selective fishery. In a trend similar to Chinook, the average weight of seine-caught Coho decreased from 7.8 lb in 2014 to approximately 6.0 lb in 2015 and 2016. The later timing of the seine fishery in 2015 and 2016 would not explain this reduction in average Coho weight because, unlike Chinook, later arriving Coho tend to be larger in size due to characteristics of the late stock (ODFW unpublished data). However, in 2016, the percentage of jacks in the seine Coho catch increased sharply from 4% in 2014 and 2015 to 20% in 2016, which likely depressed the average weight that year. An increase in the average

price per pound from 2014 to 2016 helped to partially offset the decrease in average fish size, but Coho ex-vessel value still dropped from \$9,593 in 2014 to \$5,215 in 2015, and \$6,392 in 2016, as a result of lower landings. The average ex-vessel value for Coho during 2014-2016 was \$7,067. Coho landings were greater for purse seines than beach seines in all years, and ex-vessel value was usually higher for purse seines, except in 2014, when beach seines had a slightly higher ex-vessel value due to a better price per pound.

Table 17c. Coho landings and ex-vessel value for the commercial fall seine fishery in the lower Columbia River, 2014-2016.

Year	Gear	Permits Fished	Days Fished	Deliveries	Coho Landed ¹	Mark Rate	Avg Wt (lb)	Avg \$/lb	Avg \$/Fish	Ex-Vessel Value
2014	Beach	6	12	20	509	35%	7.8	\$1.22	\$9.56	\$4,864
	Purse	4	15	19	561	29%	7.7	\$1.09	\$8.43	\$4,729
	Total	10	27	39	1,070	32%	7.8	\$1.15	\$8.96	\$9,593
2015	Beach	3	6	6	58	33%	6.8	\$1.50	\$10.19	\$591
	Purse	4	14	19	529	46%	5.7	\$1.52	\$8.74	\$4,624
	Total	7	20	25	587	44%	5.8	\$1.52	\$8.88	\$5,215
2016	Beach	2	6	3	39	89%	3.6	\$1.18	\$4.22	\$165
	Purse	2	13	21	565	62%	6.3	\$1.74	\$11.02	\$6,227
	Total	4	19	24	604	63%	6.2	\$1.72	\$10.58	\$6,392
2014-2016 Seine Avg		7	22	29	754	46%	6.6	\$1.46	\$9.48	\$7,067

¹ Includes adults and jacks.

Fishery Observation

WDFW and ODFW field staff observed 100% of the fishing trips during the 2014-2016 commercial fall seine fisheries. Observers were dedicated to each vessel for the duration of its fishing day. In 2014, the seine fishery was spread across Zones 1-5; however, in 2015 and 2016, the fishery was focused on Zones 2 and 3, as well as the upper part of Zone 4, to collect additional data for those areas. Due to the need to monitor IFQs and evaluate fishery performance, emphasis during observation was placed on collecting data on catch numbers and species/stock composition, rather than detailed information on capture method or fish condition. At the end of each fishing trip, observers summarized the day's catch, and subtracted catch totals from IFQ balances at the beginning of the day. The new balances were then communicated to the permittees so that they could plan for future fishing trips.

A total of 218 beach and purse seine sets were observed in 2014, 137 in 2015, and 136 in 2016. Observed catches of adult Chinook, Coho, and steelhead for each year and gear type throughout the season are displayed in Tables 17d, 17e, and 17f. The mark rate of adult Chinook caught by both gears combined was 38% in 2014, 41% in 2015, and 30% in 2016. Mark rates for adult Chinook caught in beach seines were higher than they were for purse seines in 2014 and 2015

Table 17d. 2014 fall seine fishery observation summary by gear type and date.

Gear	Date	Zone	Vessels	Sets	Adult Chinook		Chinook	Marked Adult	Adult Coho		Coho	Marked Adult	Steelhead/Marked	
					Marked	Unmarked	Mark Rate	Chinook/Set	Marked	Unmarked	Mark Rate	Coho/Set	Adult Chinook	
Beach	8/19/2014	1	1	4	63	49	56%	15.8	5	4	56%	1.3	26	0.41
	8/21/2014	1	1	5	29	28	51%	5.8	9	11	45%	1.8	15	0.52
	8/26/2014	1	1	2	38	17	69%	19.0	40	24	63%	20.0	10	0.26
	8/28/2014	1	1	5	40	40	50%	8.0	93	56	62%	18.6	22	0.55
	9/3/2014	1	1	5	44	54	45%	8.8	84	46	65%	16.8	18	0.41
		2	1	6	2	1	67%	0.3	1	0	100%	0.2	0	0.00
		4	1	11	33	27	55%	3.0	1	9	10%	0.1	14	0.42
	9/4/2014	5	1	5	29	35	45%	5.8	1	2	33%	0.2	6	0.21
		5	1	2	8	8	50%	4.0	1	3	25%	0.5	3	0.38
	9/8/2014	2	1	7	7	9	44%	1.0	2	3	40%	0.3	0	0.00
		3	1	2	1	0	100%	0.5	0	1	0%	0.0	0	0.00
	9/9/2014	4	2	12	133	144	48%	11.1	25	80	24%	2.1	62	0.47
		5	1	5	81	100	45%	16.2	6	22	21%	1.2	15	0.19
		4	1	8	145	296	33%	18.1	50	154	25%	6.3	81	0.56
	9/10/2014	5	1	4	61	56	52%	15.3	9	23	28%	2.3	8	0.13
		4	1	9	239	287	45%	26.6	126	381	25%	14.0	113	0.47
		5	1	1	0	0	--	0.0	0	6	0%	0.0	1	--
	9/12/2014	5	1	6	147	195	43%	24.5	27	56	33%	4.5	31	0.21
	9/19/2014	3	1	3	0	0	--	0.0	0	1	0%	0.0	0	--
	9/23/2014	5	1	4	18	56	24%	4.5	5	15	25%	1.3	25	1.39
5		1	2	15	23	39%	7.5	4	6	40%	2.0	6	0.40	
Subtotal			22	108	1,133	1,425	44%	10.5	489	903	35%	4.5	456	0.40
Purse	8/21/2014	2	1	4	12	17	41%	3.0	0	0	--	0.0	3	0.25
	8/26/2014	1	1	6	20	30	40%	3.3	0	2	0%	0.0	7	0.35
	8/28/2014	1	1	5	12	16	43%	2.4	1	1	50%	0.2	4	0.33
	9/2/2014	3	1	6	40	41	49%	6.7	3	3	50%	0.5	1	0.03
	9/3/2014	2	1	3	15	34	31%	5.0	11	5	69%	3.7	11	0.73
		3	1	4	17	16	52%	4.3	1	6	14%	0.3	0	0.00
	9/4/2014	4	1	7	26	34	43%	3.7	2	7	22%	0.3	4	0.15
		3	1	4	157	235	40%	39.3	66	103	39%	16.5	9	0.06
	9/8/2014	4	1	5	182	202	47%	36.4	15	53	22%	3.0	13	0.07
		3	1	5	10	49	17%	2.0	25	33	43%	5.0	1	0.10
	9/9/2014	4	1	5	85	135	39%	17.0	26	71	27%	5.2	27	0.32
		3	1	5	90	237	28%	18.0	30	79	28%	6.0	11	0.12
	9/10/2014	4	1	5	133	203	40%	26.6	50	199	20%	10.0	40	0.30
		3	1	6	69	203	25%	11.5	26	104	20%	4.3	4	0.06
	9/11/2014	3	1	2	34	90	27%	17.0	11	52	17%	5.5	6	0.18
	9/12/2014	3	1	5	50	104	32%	10.0	12	42	22%	2.4	4	0.08
		4	1	7	115	261	31%	16.4	106	238	31%	15.1	36	0.31
	9/17/2014	4	1	10	161	343	32%	16.1	58	82	41%	5.8	44	0.27
	9/22/2014	3	1	6	50	210	19%	8.3	44	110	29%	7.3	12	0.24
	9/23/2014	3	1	4	14	64	18%	3.5	33	68	33%	8.3	3	0.21
9/24/2014	3	1	6	14	97	13%	2.3	22	61	27%	3.7	7	0.50	
Subtotal			21	110	1,306	2,621	33%	11.9	542	1,319	29%	4.9	247	0.19
Seine Fishery Total			43	218	2,439	4,046	38%	11.2	1,031	2,222	32%	4.7	703	0.29

Table 17e. 2015 fall seine fishery observation summary by gear type and date.

Gear	Date	Zone	Vessels	Sets	Adult Chinook		Chinook	Marked Adult	Adult Coho		Coho	Marked Adult	Steelhead	Steelhead/Marked
					Marked	Unmarked	Mark Rate	Chinook/Set	Marked	Unmarked	Mark Rate	Coho/Set		Adult Chinook
Beach	9/2/2015	4	1	9	44	30	59%	4.9	5	33	13%	0.6	41	0.93
	9/3/2015	4	1	5	48	17	74%	9.6	12	20	38%	2.4	17	0.35
	9/8/2015	4	1	5	78	36	68%	15.6	4	15	21%	0.8	17	0.22
	9/9/2015	4	1	8	218	122	64%	27.3	14	18	44%	1.8	63	0.29
	9/10/2015	4	1	10	102	71	59%	10.2	7	23	23%	0.7	47	0.46
	9/11/2015	4	1	9	82	44	65%	9.1	13	10	57%	1.4	36	0.44
	Subtotal			6	46	572	320	64%	12.4	55	119	32%	1.2	221
Purse	8/31/2015	2	1	4	25	20	56%	6.3	4	3	57%	1.0	3	0.12
	9/1/2015	2	2	7	5	15	25%	0.7	1	0	100%	0.1	1	0.20
	9/2/2015	2	2	9	110	85	56%	12.2	5	5	50%	0.6	11	0.10
	9/3/2015	2	2	8	39	47	45%	4.9	8	17	32%	1.0	2	0.05
	9/8/2015	2	1	5	246	281	47%	49.2	14	15	48%	2.8	27	0.11
	9/9/2015	2	1	2	6	11	35%	3.0	0	0	--	0.0	2	0.33
	9/11/2015	2	2	9	278	380	42%	30.9	21	23	48%	2.3	32	0.12
	9/14/2015	2	2	8	311	427	42%	38.9	21	24	47%	2.6	13	0.04
	9/15/2015	2	3	9	202	317	39%	22.4	20	35	36%	2.2	18	0.09
	9/16/2015	2	1	4	138	225	38%	34.5	26	30	46%	6.5	9	0.07
	9/17/2015	2	1	2	134	297	31%	67.0	40	56	42%	20.0	18	0.13
	9/21/2015	2	2	10	315	651	33%	31.5	148	143	51%	14.8	51	0.16
	9/22/2015	2	1	4	75	181	29%	18.8	60	46	57%	15.0	24	0.32
	9/23/2015	2	2	10	307	665	32%	30.7	141	206	41%	14.1	45	0.15
Subtotal			23	91	2,191	3,602	38%	24.1	509	603	46%	5.6	256	0.12
Seine Fishery Total			29	137	2,763	3,922	41%	20.2	564	722	44%	4.1	477	0.17

Table 17f. 2016 fall seine fishery observation summary by gear type and date.

Gear	Date	Zone	Vessels	Sets	Adult Chinook		Chinook	Marked Adult	Adult Coho		Coho	Marked Adult	Steelhead	Steelhead/Marked
					Marked	Unmarked	Mark Rate	Chinook/Set	Marked	Unmarked	Mark Rate	Coho/Set		Adult Chinook
Beach	9/12/2016	2	1	3	0	0	--	0.0	0	0	--	0.0	0	--
	9/13/2016	3	1	2	0	0	--	0.0	0	0	--	0.0	0	--
	9/14/2016	2	1	3	0	1	0%	0.0	1	0	100%	0.3	0	--
	9/15/2016	3	1	3	0	0	--	0.0	0	0	--	0.0	0	--
	9/19/2016	2	1	4	0	0	--	0.0	8	2	80%	2.0	0	--
	9/26/2016	2	1	3	0	0	--	0.0	4	0	100%	1.3	2	--
Subtotal			6	18	0	1	0%	0.0	13	2	87%	0.7	2	--
Purse	9/6/2016	3	1	2	22	50	31%	11.0	10	5	67%	5.0	1	0.05
	9/7/2016	3	2	16	156	275	36%	9.8	53	49	52%	3.3	12	0.08
	9/8/2016	3	2	11	154	329	32%	14.0	106	54	66%	9.6	45	0.29
	9/9/2016	3	2	8	92	161	36%	11.5	53	37	59%	6.6	30	0.33
	9/12/2016	3	2	14	78	209	27%	5.6	43	35	55%	3.1	56	0.72
	9/13/2016	3	2	13	129	349	27%	9.9	36	24	60%	2.8	63	0.49
	9/14/2016	3	1	7	22	81	21%	3.1	10	7	59%	1.4	14	0.64
	9/15/2016	3	2	11	40	96	29%	3.6	19	18	51%	1.7	15	0.38
	9/21/2016	3	2	10	16	76	17%	1.6	22	20	52%	2.2	10	0.63
	9/26/2016	3	1	5	4	13	24%	0.8	27	9	75%	5.4	9	2.25
	9/28/2016	3	1	5	4	34	11%	0.8	13	3	81%	2.6	11	2.75
	9/29/2016	3	2	12	11	33	25%	0.9	69	17	80%	5.8	28	2.55
	9/30/2016	3	1	4	0	4	0%	0.0	8	3	73%	2.0	1	--
Subtotal			21	118	728	1,710	30%	6.2	469	281	63%	4.0	295	0.41
Seine Fishery Total			27	136	728	1,711	30%	5.4	482	283	63%	3.5	297	0.41

¹ One unmarked adult Chinook kept by a beach seiner on September 14, and 272 unmarked adult Chinook kept by purse seiners on September 7 when retention of unmarked bright stock Chinook was allowed.

(44% vs. 33% and 64% vs. 38%, respectively). The Chinook mark rate for beach seines in 2016 was 0%, but only 1 (unmarked) adult Chinook was caught. During the 2009-2012 fall beach and

purse seine feasibility evaluations, Chinook mark rates were similarly higher for beach seines (Tables 6 and 7). Anecdotal observations by ODFW staff and commercial fishers suggest that tule fall Chinook, which are typically marked at a higher rate than bright stock Chinook, may travel closer to shore, and therefore be more vulnerable to capture in beach seines, resulting in the higher observed Chinook mark rates for that gear. The catch rate of marked adult Chinook, for both gears combined, was 11.2 fish per set in 2014, 20.2 fish per set in 2015, and 5.4 fish per set in 2016. Chinook catch rates tended to peak in early to mid-September, and were higher for purse seines than beach seines in all years. On average, 78% of the purse seine catch of marked adult Chinook occurred during the first two weeks of September, and 99% of the beach seine catch occurred during that timeframe (Figures 17a and 17b).

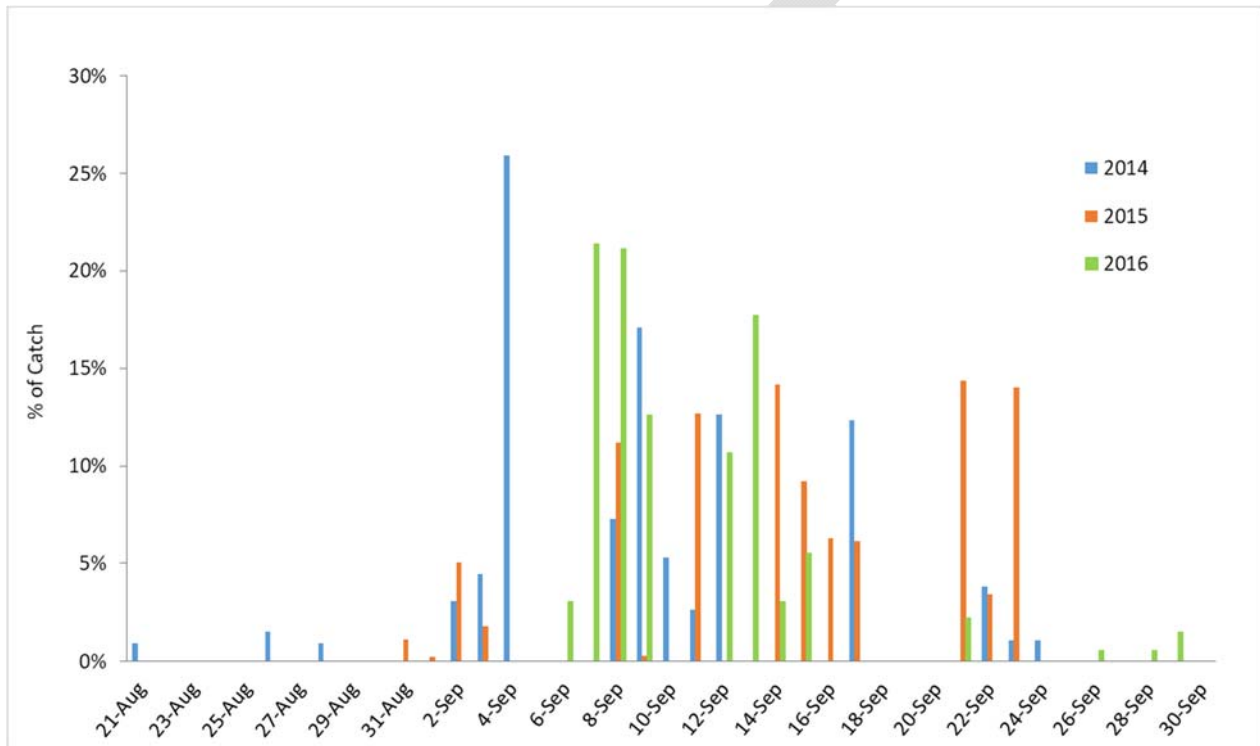


Figure 17a. Percentage of the total marked adult Chinook catch by date in the 2014-2016 commercial purse seine fisheries.

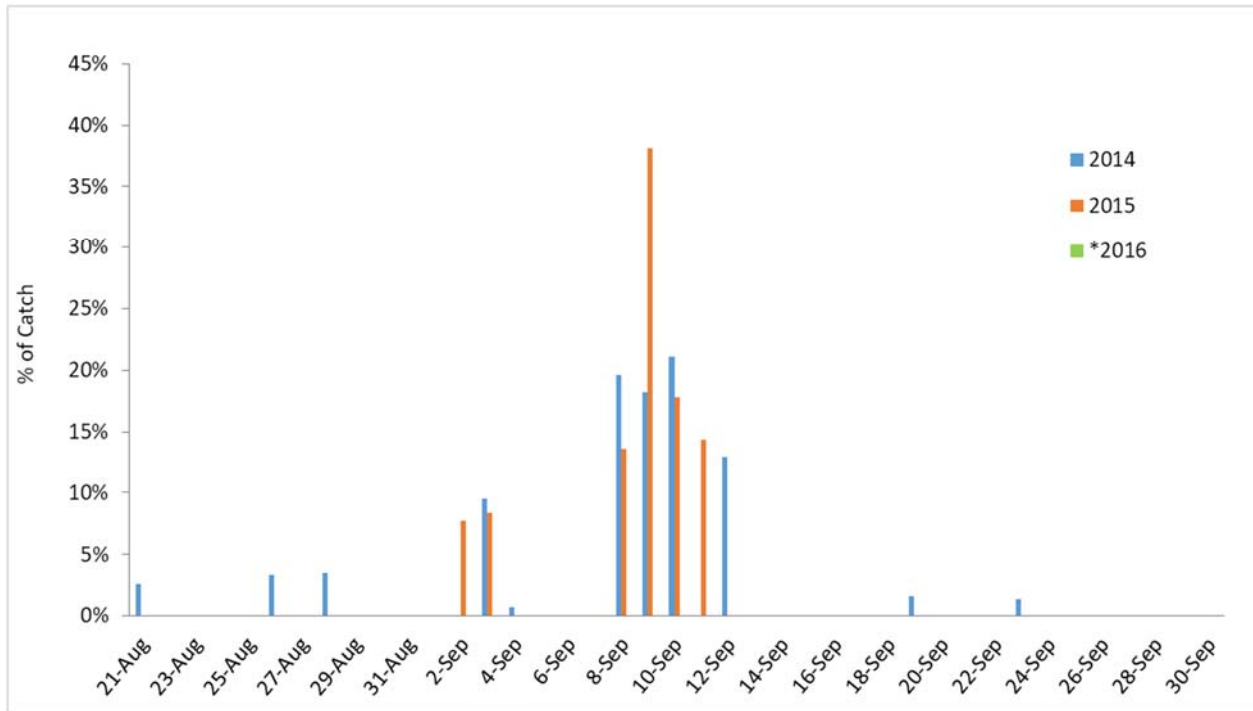


Figure 17b. Percentage of the total marked adult Chinook catch by date in the 2014-2016 commercial beach seine fisheries. *No marked adult Chinook were caught by beach seines in 2016.

The mark rate of adult Coho caught by both gears combined was low in 2014 and 2015 (32% and 44%, respectively), but was substantially higher in 2016 (63%). The Coho mark rate was higher for beach seines than it was for purse seines in two out of the three years. The catch rate of marked adult Coho, for both gears combined, was 4.7 fish per set in 2014, 4.1 fish per set in 2015, and 3.5 fish per set in 2016. Coho catch rates usually peaked in early September, although in 2015, Coho catch rates in purse seines were much higher in late September. In all years, catch rates for Coho were higher in purse seines than in beach seines.

The ratio of steelhead to marked adult Chinook, for both gears combined, was 0.29 in 2014, 0.17 in 2015, and 0.41 in 2016. The ratio was higher for beach seines than purse seines in 2014 and 2015 (0.40 vs. 0.19 and 0.39 vs. 0.12, respectively); the ratio for beach seines was not calculated in 2016 since no marked adult Chinook were caught. Anecdotal observations indicate that steelhead often travel relatively close to shore; therefore, they may be more vulnerable to capture in beach seines. The steelhead to marked adult Chinook ratio for purse seines was substantially higher in 2016 compared to the previous two years (0.40 observed vs. 0.30 expected in Harvest Reform modelling), and could have been due to lower Chinook catches in 2016. However, observations by ODFW staff during purse seine test fishing indicate that when purse seines are fished close to shore like a beach seine, they too can encounter high numbers of steelhead.

During the 2014-2016 fall seine fisheries, individual permit holders fished an average of five days and made 25 sets per season (Table 17g). The typical crew size for both beach and purse seiners was four fishers. The average permit holder caught 282 marked and 461 unmarked adult Chinook, attaining 48% of his/her Chinook quota. Approximately 24% of the permittees caught 90% or more of their Chinook quota, and one-third of the permittees caught less than 5% of their quota. Seine permittees also caught an average of 99 marked and 154 unmarked adult Coho, fulfilling

Table 17g. Fall seine fishery observation summary by year and permit, 2014-2016.

Year	Permit	Gear	Zone	Dates	Days			Adult Chinook		Marked Adult	% of Chinook	Adult Coho		Marked Adult	% of Coho	% of Steelhead	
					Fished	Crew	Sets	Marked	Unmarked	Chinook/Set	Quota	Caught	Marked	Unmarked	Coho/Set	Quota	Caught
2014	2014001	Beach	1	Aug 19 ,21, 26, 28, Sep 3	5	4	21	214	188	10.2	43%	231	141	11.0	92%	91	25%
	2014002	Beach	2	Sep 3,8	2	5	13	9	10	0.7	2%	3	3	0.2	1%	0	0%
	2014003	Beach	3	Sep 8,19	2	5	5	1	0	0.2	0%	0	2	0.0	0%	0	0%
	2014004	Beach	4	Sep 8-10	3	4	23	476	672	20.7	95%	196	597	8.5	78%	248	69%
	2014005	Beach	4	Sep 3,8	2	4	17	74	82	4.4	15%	6	27	0.4	2%	22	6%
	2014006	Beach	5	Sep 3, 4, 8-10, 12 ,19, 23	8	3	29	359	473	12.4	72%	53	133	1.8	21%	95	26%
	2014007	Purse	1	Aug 26,28	2	4	11	32	46	2.9	4%	1	3	0.1	0%	11	3%
	2014008	Purse	2	Aug 21, Sep 3	2	4	7	27	51	3.9	4%	11	5	1.6	2%	14	4%
	2014009	Purse	3	Sep 2-4, 8-12, 22-24	11	5	53	545	1,346	10.3	73%	273	661	5.2	61%	58	16%
	2014010	Purse	4	Sep 3, 4, 8, 9, 12, 17	6	4	39	702	1,178	18.0	94%	257	650	6.6	57%	164	46%
Avg					4	4	22	244	405	8.4	40%	103	222	3.5	32%	70	20%
2015	2015001	Beach	4	Sep 2, 9, 10	3	3	27	364	223	13.5	91%	26	74	1.0	17%	151	84%
	2015002	Beach	4	Sep 3, 8, 11	3	4	19	208	97	10.9	52%	29	45	1.5	19%	70	39%
	2015003	Beach	4	N/A ¹	N/A ¹	N/A ¹	N/A ¹	0	0	0.0	0%	0	0	0.0	0%	0	0%
	2015007	Purse	2	Aug 31-Sep 3, Sep 8-9, 11, 14-15	9	4	36	645	793	17.9	99%	50	60	1.4	25%	61	41%
	2015008	Purse	2	Sep 11, 14-15, 17	4	3	14	650	973	46.4	100%	82	108	5.9	41%	60	40%
	2015009	Purse	2	Sep 15-16, 21-23	5	4	20	498	981	24.9	77%	188	241	9.4	94%	74	49%
	2015010	Purse	2	Sep 1-3, 21, 23	5	3	21	398	855	19.0	61%	189	194	9.0	95%	61	41%
Avg					5	4	23	395	560	18.9	69%	81	103	4.0	42%	68	42%
2016	2016001	Beach	2-3	Sep 12-13, 15	3	4	8	0	0	0.0	0%	0	0	0.0	0%	0	0%
	2016002	Beach	2	Sep 14, 19, 26	3	4	10	0	1	0.0	0%	13	2	1.3	3%	2	1%
	2016003	Purse	3	Sep 6-9, 12-13, 15, 21, 26, 29	10	4	53	368	786	6.9	64%	296	156	5.6	49%	188	82%
	2016004	Purse	3	Sep 7-9, 12-15, 21, 28-30	11	4	65	360	924	5.5	69%	173	125	2.7	29%	107	47%
Avg					7	4	34	182	428	3.1	33%	121	71	2.4	20%	74	32%
2014-2016 Seine Fishery Average					5	4	25	282	461	10.9	48%	99	154	3.5	33%	70	29%

¹ The three beach seiners fished together as a cooperative, but no fish were landed on this permit.

33% of their Coho quota. The average seine permittee handled 70 steelhead, which accounted for 29% of the steelhead quota.

Immediate mortalities of unmarked Chinook and Coho, as well as all steelhead, released from beach and purse seines during the 2014-2016 fall seine fisheries were negligible (Table 17h), and were similar to those observed during the 2009-2012 feasibility evaluations.

Table 17h. Immediate mortalities of unmarked Chinook and Coho, and all steelhead, caught in beach and purse seines during the 2014-2016 fall seine fisheries.

Year	Gear	Species	Life Stage			Adult Mortality Rate
			Adult	Jack	Unknown	
2014	Beach	Chinook	4	1	1	0.3%
		Coho	0	0	0	0.0%
		Steelhead	2	0	0	0.4%
	Purse	Chinook	0	7	0	0.0%
		Coho	0	1	1	0.0%
		Steelhead	0	0	0	0.0%
	Total	Chinook	4	8	1	0.1%
		Coho	0	1	1	0.0%
		Steelhead	2	0	0	0.3%
2015	Beach	Chinook	0	0	0	0.0%
		Coho	0	0	0	0.0%
		Steelhead	0	0	0	0.0%
	Purse	Chinook	10	14	0	0.3%
		Coho	5	3	0	0.8%
		Steelhead	0	0	0	0.0%
	Total	Chinook	10	14	0	0.3%
		Coho	5	3	0	0.7%
		Steelhead	0	0	0	0.0%
2016	Beach	Chinook	0	0	0	0.0%
		Coho	0	0	0	0.0%
		Steelhead	0	0	0	0.0%
	Purse	Chinook	2	7	0	0.1%
		Coho	0	1	0	0.0%
		Steelhead	0	0	0	0.0%
	Total	Chinook	2	7	0	0.1%
		Coho	0	1	0	0.0%
		Steelhead	0	0	0	0.0%

ESA Impacts

Impact Analysis

In 2014, ESA impacts set aside for research fisheries were used for the pilot fall seine fishery, and the 2015 and 2016 seine fisheries used ESA impacts sub-allocated from the fall commercial allocation. Table 17i shows the number of adult fall Chinook that were harvested by beach and purse seines compared to impacts and mortalities of ESA-listed LCR tule Chinook and natural-origin B-Index summer steelhead in the 2014-2016 fall seine fisheries. Overall, purse seines used more LCR tule impacts than beach seines, but were also able to harvest more adult Chinook per LCR tule mortality due to higher Chinook catch rates. Total use of natural-origin B-Index steelhead impacts was similar between the gears; however, because of lower encounter rates purse seines were able use their ESA impacts much more efficiently, harvesting almost five times more adult Chinook per natural-origin B mortality than beach seines.

Table 17i. Harvest of adult fall Chinook relative to natural-origin LCR tule Chinook and natural-origin B-Index steelhead impacts and mortalities during the 2014-2016 commercial fall seine fisheries.

Gear	Year	Adult Chinook Harvest ¹	Wild LCR Tule Chinook			Wild B-Index Steelhead		
			LCR Impacts	LCR Mortalities	Harvest Per Mortality	Wild B Impacts	Wild B Mortalities	Harvest Per Mortality
Beach	2014	1,133	0.082%	20.5	55	0.028%	3.8	298
	2015	572	0.004%	1.3	440	0.010%	0.6	953
	2016	1	0.000%	0.0	--	0.000%	0.0	--
	Total	1,706	0.086%	21.8	78	0.038%	4.4	388
Purse	2014	1,306	0.067%	16.7	78	0.008%	1.1	1,232
	2015	2,191	0.044%	14.7	149	0.020%	1.2	1,889
	2016	1,000	0.041%	9.8	103	0.007%	0.2	4,140
	Total	4,497	0.152%	41.1	109	0.035%	2.5	1,827

¹ Includes 1 unmarked CHF for beach and 272 unmarked CHF for purse in 2016.

Fall Chinook Visual Stock Identification

Since ESA impacts for LCR tule fall Chinook could limit a full fleet commercial fall seine fishery in the lower Columbia, one way to potentially increase economic benefits for the seine fishery would be to selectively release natural-origin tule Chinook caught in purse and beach seines, while allowing the retention of marked hatchery tules, as well as both marked and unmarked bright stock Chinook. For this effort to be successful, commercial fishers would have to be able to accurately identify Chinook stocks based on visual stock identification (VSI) techniques. In 2014, ODFW evaluated the ability of commercial fishers to identify fall Chinook stocks (brights and tules) using visual characteristics on the fish. For comparison, we also assessed the VSI accuracy of experienced ODFW and WDFW commercial fisheries samplers. During observation of the 2014 fall seine fishery, fishers were required to make a “stock call” on all kept adult Chinook. They were to identify the stock of the fish while it was still alive, and as soon as possible after it was removed from the gear, based on their own expertise and experience. No training was provided to the fishers in VSI techniques, and no assistance was given to them in the field. Their stock calls

were recorded by ODFW and WDFW observers, and all fish identified as tules had the upper lobe of the caudal fin hole-punched for later identification at fish processing facilities.

When Chinook from the seine fishery were landed, Department samplers collected biological data, including CWTs, from a subsample of the fish. They also made their own stock calls, and examined fish for caudal fin punches. The presence or absence of a fin punch indicated the fisher's stock call, which allowed us to make comparisons with stock information from CWTs. We also compared the stock calls of the Department samplers to the fish's actual stock identification. We did this separately for brights and tules to assess the fishers' and samplers' VSI accuracy for each stock, and also combined the results to determine how accurately fall Chinook, overall, could be identified by stock.

VSI accuracy scores for commercial seine fishers and Department samplers, by gear type, are shown in Table 17j. For purse seines, fishers were able to accurately identify fall Chinook stocks 92.0% of the time, while for beach seines, fishers were able to correctly identify stocks 76.6% of the time. This overall success rate appears to be related to the higher proportion of bright stock fish in the river at this time as both purse and beach seine fishers were better at identifying brights than tules (95.5% vs. 68.2%, and 85.7% vs. 34.8%, respectively). (Figure 17c). For purse seine fishers, VSI accuracy declined slightly moving upriver, while it increased substantially for beach seine fishers. Zone 4 was the only commercial fishing zone fished by both purse and beach seines in 2014, and purse seiners there had higher VSI accuracy for both stocks, as well as Chinook in general.

Table 17j. VSI accuracy (by stock and all fall Chinook) of commercial seine fishers and ODFW/WDFW samplers with respect to coded wire tagged fall Chinook harvested in the 2014 commercial fall seine fishery.

Gear	Stock Identifier	Zone	Bright		Tule		Fall Chinook		% Tule in Sample
			<i>n</i> ¹	Accuracy	<i>n</i> ¹	Accuracy	<i>n</i> ¹	Accuracy	
Purse Seine	Fisher	3	45	95.6%	7	71.4%	52	92.3%	13.5%
		4	109	95.4%	15	66.7%	124	91.9%	12.1%
		Total	154	95.5%	22	68.2%	176	92.0%	12.5%
	Sampler	3	43	97.7%	8	87.5%	51	96.1%	15.7%
		4	106	96.2%	17	76.5%	123	93.5%	13.8%
		Total	149	96.6%	25	80.0%	174	94.2%	14.4%
Beach Seine	Fisher	1	22	63.7%	8	0.0%	30	46.7%	26.7%
		4	60	90.0%	8	25.0%	68	82.4%	11.8%
		5	23	95.7%	7	85.7%	30	93.3%	23.3%
		Total	105	85.7%	23	34.8%	128	76.6%	18.0%
	Sampler	1	16	68.8%	10	50.0%	26	61.5%	38.5%
		4	58	93.1%	8	50.0%	66	87.9%	12.1%
		5	22	100.0%	7	100.0%	29	100.0%	24.1%
		Total	96	90.7%	25	64.0%	121	85.2%	20.7%

¹ Sample sizes for fishers and samplers are not always the same due to gaps in the respective data sets.

For fish caught in purse seines, Department samplers were able to accurately identify fall Chinook stocks 94.2% of the time, and 85.2% of the time for Chinook caught in beach seines. Like the

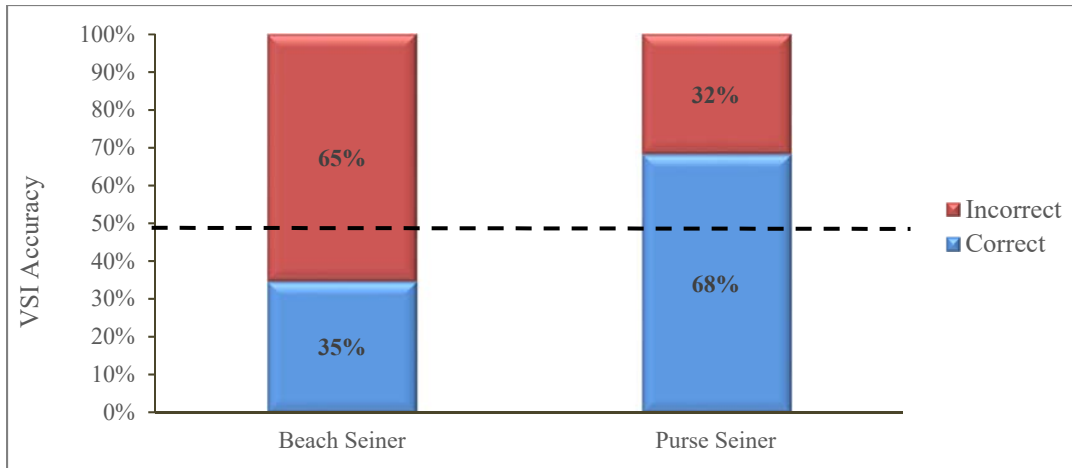


Figure 17c. Accuracy of VSI calls made by beach and purse seine fishers on known tule Chinook caught during the 2014 fall seine fishery.

commercial fishers, Department samplers were better at identifying brights than tules, for both purse seine and beach seine caught fish (96.6% vs. 80.0%, and 90.7% vs. 64.0%, respectively). VSI accuracy trends moving upriver were also similar to those of the commercial fishers--decreasing for purse seine caught fish, and increasing for beach seine caught fish. Department samplers also identified purse seine caught fish more accurately than beach seine caught fish in Zone 4.

The VSI results indicated that tule Chinook were more frequently misidentified than bright stock Chinook. Tules may be more difficult to identify because they can exhibit intermediate phenotypic characteristics, whereas bright Chinook typically do not (C. Rodriguez and D. Volenec, ODFW, personal communication). This is particularly true in Zone 1, where tule Chinook arriving from the ocean are less mature, and can have bright silver coloration and a streamlined appearance, similar to bright Chinook (Figure 17d).



Figure 17d. Example of a “bright” tule Chinook (above) and an upriver bright Chinook (below) caught in the Columbia River estuary.



Figure 17e. Example of a maturing tule Chinook caught in the lower Columbia River.

As tules move upriver and continue to mature, they begin to exhibit characteristics more typical of the stock, and therefore, become easier to identify (McIsaac and Quinn 1988, Figure 17e). This could explain the significant increase in VSI accuracy for beach seine caught tules moving upriver from Zone 1 to Zone 5 (Table 17j). If tules really were more difficult to identify by stock, then having a higher percentage of tules in the sample would presumably depress VSI accuracy for Chinook in general. We evaluated this hypothesis by seeing if there was a negative association between the percentage of tules in the overall Chinook sample, and the VSI accuracy for all Chinook in the sample. Using data for both commercial fishers and Department samplers, we found a moderate negative association between the percentage of tules in the sample and VSI accuracy for fall Chinook ($R^2 = 0.45$), suggesting that stock identification may, in part, be less accurate when tules comprise a higher percentage of the catch (Figure 17f).

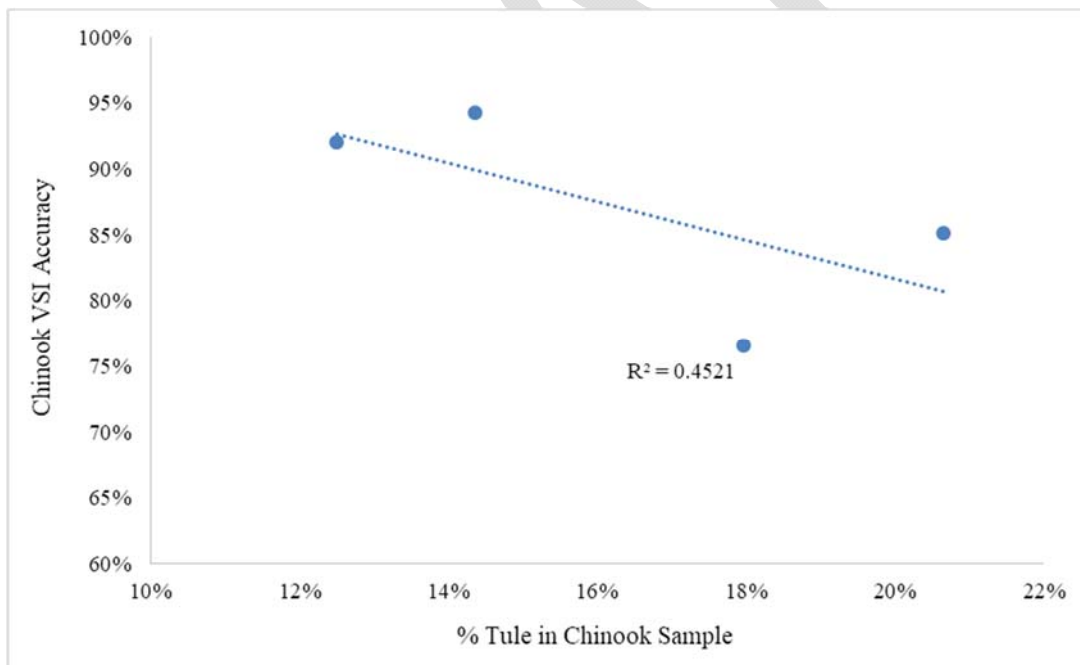


Figure 17f. Relationship between the percentage of tules in the sample and accuracy of VSI determinations for fall Chinook, 2014 fall seine fishery.

Chinook caught in purse seines were more accurately identified by stock than those caught in beach seines, by both commercial fishers and Department samplers. This is likely due to the lower percentage of tules in the purse seine catch compared to the beach seine (average of 13.5% for purse seine and 19.4% for beach seine).

For all gear types and zones, Department samplers had higher VSI accuracy scores compared to the commercial fishers. One of the likely reasons for this is that the commercial fishers made their stock calls on live fish, while the Department samplers made their stock calls on dead fish. Anecdotal observations by Department staff strongly suggest that phenotypic characteristics, especially for tule Chinook, become more pronounced after the fish's death. This would make it more accurate for Department samplers to differentiate between the two Chinook stocks when observed at commercial fish buying stations. Also, observations by Department staff on purse and beach seine vessels indicated that the commercial fishers appeared to often base their stock calls on how they thought the fish would be graded by fish buyers. Because the fishers are paid vastly different prices by the buyer for "bright" and "tule" fall Chinook due to differences in meat color and quality, they have likely become accustomed to looking at Chinook based on fish quality rather than biological characteristics. In contrast, Department samplers have been trained to make their stock calls based on visual cues characteristic of biological stocks. Thus, a "bright" tule Chinook may be called a bright by a commercial fisher due to its silvery coloration and relatively immature status, while an experienced Department sampler would likely focus on other characteristics (e.g. spotting on the dorsal surface or caudal fin, or development of the dorsal ridge) that would more accurately identify the fish as a tule.

Providing VSI training to commercial seine fishers would likely improve their stock identification skills, and over time, the VSI accuracy of fishers completing a training workshop might approach those of the Department samplers. However, it is important to remember that market forces would likely continue to apply pressure on this front, and even trained and highly experienced Department samplers had difficulty identifying fall Chinook in the lower reaches of the Columbia, where LCR tule Chinook are more prevalent in the catch. Our analysis of the 2014 data suggested that a high percentage of tules in the catch could negatively affect VSI accuracy. Difficulty in accurately identifying tule Chinook in the lower fishing zones, where LCR tule impacts are likely to be highest, combined with existing market forces could lead to "bright" natural-origin tules being retained in the fishery, causing actual ESA impacts to be higher than expected.

Economics

An important aspect of any commercial fishery, including one using alternative gears, is the net economic return of the fishery. A key aspect of viability is whether the value derived from the fishery is more than enough to compensate for the costs of participating in the fishery, so that the fishery can provide a source of meaningful income to the fisher. We examined the net economic return of the fall seine fishery by comparing actual landings and ex-vessel values for 2014-2016 to estimated costs associated with using purse and beach seines to commercially harvest salmon in the lower Columbia River. Annual harvest costs for the seine fishery were calculated using capital, annual, and daily operating costs from Table 3 of the 2013 Fiscal and Economic Impact Statement that was used to predict the economic impacts of the Harvest Reform Policy (FIS; ODFW 2013c; Table 17k). However, it is very difficult to determine the actual costs associated with a given commercial fishery; therefore, the net economic returns that we have calculated should probably be viewed as close approximations. It should also be noted that gear-specific harvest costs from the 2013 FIS are in 2013 dollars, so they may not be comparable to costs in different years. Nevertheless, because harvest-related costs have been applied to all commercial

fisheries in this report in a standardized manner, the results of the analyses are still useful for comparing relative economic returns in different Columbia River commercial fisheries.

Table 17k. Estimated costs associated with commercial fishing gears used in the lower Columbia River (adapted from ODFW 2013c).

Cost Type	Item	Gear Type		
		Gillnet/Tangle Net	Beach Seine	Purse Seine
Capital	Main vessel	\$25,000	\$25,000	\$125,000
	Skiff	\$0	\$10,000	\$20,000
	Net	\$4,000	\$10,000	\$15,000
	Rigging	\$5,000	\$8,000	\$30,000
Annual	Liability Insurance	\$0	\$2,000	\$2,000
	Net Repair ~10-Day Season	\$667	\$1,667	\$2,500
	Net Repair ~20-Day Season	\$1,333	\$3,333	\$5,000
Daily	Crew	\$0	\$750	\$1,050
	Fuel	\$150	\$200	\$350

Our seine economic analysis focused on fishers new to purse and beach seining (i.e. the vast majority of current gillnet fishers), who would have to purchase all of the necessary boats and gear to participate in the fishery. Therefore, for purse seines, capital costs included a main vessel, skiff, net, and rigging. Beach seine capital costs included all of the same except for a main vessel. We assumed that a beach seiner had a current gillnet vessel with sufficient power to fish a seine. Although prospective seine fishers could probably finance the purchase of boats and gear in a variety of ways, for simplicity, we represented all capital costs as the total annual cost of repayments on an amortized Small Business Administration (SBA) loan that was available to all fishers (Table 17l).

Table 17l. Amortized capital costs used for economic viability analysis of the fall seine fishery.

	Total Capital Costs ¹	SBA Loan Terms	Monthly Payment	Annual SBA Loan Cost
Beach Seine	\$28,000	5-yr loan @ 6.75% (Oct 2016)	\$551	\$6,612
Purse Seine	\$190,000	10-yr loan @ 6.25% (Oct 2016)	\$2,100	\$25,200

¹ Assumes beach seiners can use their existing gillnet boat as their main vessel for seining.

Annual costs for beach and purse seiners included insurance (to cover the liability of fishing with a crew of 3-5 people) and net repair costs from the 2013 FIS. Daily operating costs included boat fuel and crew pay. In the 2013 FIS, crew pay is presented as a daily total wage based on crew sizes of 2-3 persons for beach seines and 3-4 persons for purse seine operations (not including the skipper/permit holder).

Capital and annual costs were applied to the number of vessels participating in the seine fishery, while daily operating costs were applied to both the number of vessels and days fished. Capital, annual, and daily operating costs were summed to provide an estimate of the total annual fishery harvest cost. Total fishery cost was then subtracted from total ex-vessel value to determine the net

economic return to the seine fishery. To allow for comparison with other fisheries with different participation levels, the net fishery return was divided by the number of seine permittees to provide an estimated net annual return per fisher.

The results of our analysis are shown in Table 17m. Total fishery harvest costs for both beach and purse seines combined ranged from \$89,329 in 2015 to \$231,274 in 2014. The net economic return to the seine fishery ranged from -\$166,275 in 2014 to -\$32,680 in 2015. Net return per seine permittee ranged from -\$20,793 in 2016 to -\$4,669 in 2015, and averaged -\$14,030 for the three years of the seine fishery. Although landings and ex-vessel values were higher for purse seines than beach seines in all years, the cost of fishing with purse seines was also much higher; therefore, net losses for the purse seine fishery were larger than they were for the beach seine fishery. The beach seine fishery was able to reduce its losses considerably in 2015 when the three beach seine permittees fished as a cooperative, using only one main vessel and crew. This helped to keep costs to a minimum.

Table 17m. Comparison of landings and ex-vessel value to estimated harvest costs for the 2014-2016 commercial fall seine fisheries.

Year	Gear	Avg Days		Salmon Landed ²	Total Ex-Vessel Value	Costs				Net Fishery Return	Net Return/Permittee
		Fished	Vessels ¹			Capital ³	Annual	Daily	Total		
2014	Beach	4	6	1,846	\$31,511	\$39,672	\$22,002	\$22,800	\$84,474	(\$52,963)	(\$8,827)
	Purse	5	4	2,018	\$33,488	\$100,800	\$18,000	\$28,000	\$146,800	(\$113,312)	(\$28,328)
	Total	9	10	3,864	\$64,999	\$140,472	\$40,002	\$50,800	\$231,274	(\$166,275)	(\$16,627)
2015	Beach	3	1	739	\$10,951	\$6,612	\$3,667	\$2,850	\$13,129	(\$2,179)	(\$726)
	Purse	6	2	2,841	\$45,698	\$50,400	\$9,000	\$16,800	\$76,200	(\$30,502)	(\$7,625)
	Total	9	3	3,580	\$56,649	\$57,012	\$12,667	\$19,650	\$89,329	(\$32,680)	(\$4,669)
2016	Beach	3	2	41	\$210	\$13,224	\$7,334	\$5,700	\$26,258	(\$26,048)	(\$13,024)
	Purse	11	2	1,678	\$33,077	\$50,400	\$9,000	\$30,800	\$90,200	(\$57,123)	(\$28,562)
	Total	14	4	1,719	\$33,286	\$63,624	\$16,334	\$36,500	\$116,458	(\$83,172)	(\$20,793)
2014-2016 Avg		11	6	3,054	\$51,645	\$87,036	\$23,001	\$35,650	\$145,687	(\$94,042)	(\$14,030)

¹ In 2015, the three beach seine permittees fished as a cooperative using one vessel and crew, and the four purse seine permits were fished on two vessels.

² Includes Chinook and Coho (adults and jacks).

³ Annual amortized loan cost for boats, net, and rigging. Assumes beach seiners do not need to purchase a new main vessel.

Our analysis indicated that the economic viability of the 2014-2016 fall seine fisheries would have been extremely poor if all fishers had been responsible for covering not only their annual and daily operating costs, but their start-up capital costs as well. The combination of low catches/ex-vessel value and high costs would have led to significant economic losses, for both the fishery as a whole, and individual fishers.

We acknowledge that the large average economic losses estimated in our analysis do not apply to the fishers who actually participated in the 2014-2016 seine fisheries. Based on post-season surveys, we know that some beach and purse seine permittees were able to make modest profits during the 2014-2016 fisheries (see 2014-2016 Seine Fisher Post-Season Surveys), and that actual economic outcomes were highly variable among participants, depending on their level of experience, skill, and the actual costs they incurred. Some purse seiners participating in the fall seine fishery already had their main vessels, skiffs, nets, and rigging from other commercial or contract test fisheries. Some beach seiners also had nets and rigging from previous contract test

fishing. Therefore, their costs were substantially lower compared to someone new to seining. Nevertheless, it is important to account for the capital costs that would be incurred by potential new seine fishery participants.

Some seine permittees were able to limit their costs by partnering with fishers that already had the boats and gear, as well as the expertise and experience, to participate in the fishery. Nevertheless, it is noteworthy that, even if capital costs were completely excluded from the analysis, the seine fishery would have still had negative returns in two out of the three years.

2014-2016 Seine Fisher Post-Season Surveys

To get feedback on the 2014-2016 fall seine fisheries, WDFW conducted phone and mail surveys of the fishery participants. In 2014, all ten of the permit holders/fishers (plus an additional fisher who partnered with a permittee) responded to the survey. In 2015 and 2016, about half of the fishery participants responded to the surveys. Three of the four respondents in 2015 also fished in the 2014 fishery, either as a primary fisher or crew member. Survey questions were similar between years, and sought to gather participants' general impressions of the seine fishery, perceived advantages and disadvantages of the seine gear relative to traditional gillnets, thoughts on the economic viability of the seine fishery, and suggestions for fishery improvement.

Summaries of fisher responses to the survey questions are outlined in Tables 17n, 17o, and 17p. The majority of participants had a negative overall impression of the seine fishery, primarily citing the non-retention of abundant unmarked Upriver Brights (URBs) and high costs associated with the fishery. Several fishers said that they would not participate in future seine fisheries. Nevertheless, among those who participated in multiple years, there was a general feeling that the 2015 fishery was an improvement over the 2014 pilot fishery, mostly due to increased flexibility in when and where they could fish.

Fishery participants believed that the primary advantages of the seine gear were the relatively good condition/low mortality of released fish, higher quality of seine-caught fish, and the potential to catch a lot of fish at certain times and places. Perceived disadvantages of the seine gear included high start-up and operational costs, greater difficulty/complexity in effectively fishing the gear, and the need to fish very specific sites in order to be successful (especially for beach seines). One fisher stated that the cost of purchasing a purse seine boat, skiff, and net/gear was prohibitively high for potential new entrants to the fishery. Several participants also mentioned the high labor costs associated with needing 3-5 crew members to fish the seine gear. Insurance costs were also high because of larger crew sizes.

Most survey respondents did not believe that a commercial seine fishery was economically viable because of a combination of high costs and limited retention (marked fish only) of high value URBs. Less than one-third of the respondents were able to make a profit in the 2014-2016 seine fisheries. Respondents overwhelmingly said that allowing retention of unmarked URBs was the key to improving the economic return of the seine fishery. One fisher believed that there were some untapped markets for high-quality seine-caught fish, and that this could lead to increased ex-vessel value for the fishery.

Overall, the majority of survey respondents appeared to be dissatisfied with their seine fishery experience, primarily due to issues related to economic return. Although costs associated with fishing seines are high, most felt that allowing retention of unmarked Chinook, particularly the abundant high-value URBs, would help offset some of the costs, and potentially allow a greater percentage of the fishers to make a profit. However, from a fisheries management standpoint, allowing the retention of unmarked URBs poses a dilemma because, although harvest of unmarked URBs would certainly enhance the value of the fishery, commercial seine fishers may not be able to accurately identify tule fall Chinook (see Fall Chinook Visual Stock Identification section). Their difficulty in correctly identifying “bright” tule Chinook in the lower fishing zones (where tules are most prevalent in the catch), could lead to higher than expected impacts on natural-origin LCR tules, which would limit the overall net return to the fishery.

Table 17n. Summary of post-season surveys conducted with fishers ($n = 11$) participating in the 2014 commercial fall seine fishery.

Question	Summary of Responses	Comments
1 What were your general impressions of this fall’s pilot commercial seine fishery?	Generally negative. Inability to keep unmarked URBs made it tough economically.	A couple of fishers that did relatively well were more positive about the fishery.
2 What advantages do you think that this gear has over traditional methods?	Condition of released fish seemed good. Potential to catch a lot of fish at certain times.	Several fishers cited no advantage to the gear or could not think of any.
3 What disadvantages do you think that this gear has over traditional methods?	Large crew size; high costs; difficult to fish effectively/steep learning curve; relative lack of mobility compared to gillnets (especially for beach seiners).	
4 Do you think a viable commercial fishery could be developed using this gear?	Most did not think so. Having to release so many unmarked Brights made it economically difficult. High operational cost was another factor.	One fisher that did relatively well thought it could definitely be viable with high fish numbers, but inability to keep unmarked URBs hurt.
5 If not, what do you think it would take for this to become a viable commercial fishing gear?	Almost unanimous on being able to keep all Chinook. More flexibility in where they could fish was also mentioned by a couple of fishers.	Even with retention of all Chinook, one fisher questioned whether the fishery would be profitable given high operating costs.
6 What improvements would you make for out-years, if you were to make any?	Allow retention of all Chinook; more flexibility in when and where they could fish; improved infrastructure for seine fishery to more efficiently get fish to market; increased efforts to garner public support for fishery.	One fisher brought up the possibility of fishing at night to improve catch rates.
7 How did your one-time costs (nets, insurance, etc.) compare to your operating costs (fuel, labor, maintenance, etc.)?	One-time costs such as boats, nets, and insurance were high. Labor costs were also high due to the need for 3-4 person crews. Fuel and maintenance costs were relatively low.	
8 Was the 2014 seine fishery profitable for you?	Only three fishers appeared to make a profit, but not much. High operating costs cut into gross receipts.	Several fishers also mentioned the lost opportunity cost of not participating in more lucrative fisheries.
9 Are there other considerations (especially economic) that you think we should know about?	Some fishers mentioned providing some kind of financial assistance for equipment if the fishery is going to continue long-term.	

Table 17o. Summary of post-season surveys conducted with fishers ($n = 4$) participating in the 2015 commercial fall seine fishery.

Question	Summary of Responses	Comments
1 What were your general impressions of the 2015 commercial seine fishery?	Fishers were split 50/50 on their impressions of the fishery. One felt that it was better than 2014 because there was more flexibility on where and when they could fish.	
2 What advantages do you think that this gear has over traditional methods?	Probably lower mortality rate on released fish; higher quality of iced and bled seine-caught fish--potential for increased ex-vessel value if markets can be developed	
3 What disadvantages do you think that this gear has over traditional methods?	Large crew size; high costs; difficult to fish effectively/steep learning curve	
4 Do you think a viable commercial fishery can continue to be developed using this gear?	Fishers were split 50/50 on whether the fishery could be commercially viable; a carefully structured and planned fishery might be viable.	
5 What do you think is required for this fishery to become viable?	Allow retention of all fall Chinook (particularly unmarked URBs); reassess mortality rates; possibly fish for high value spring Chinook.	One fisher said that entry into the fishery for new participants is cost prohibitive.
6 In 2015, how did any one time costs (nets, insurance, etc.) compare to operating costs (fuel labor, maintenance, etc.)?	At least two of the fishers participated in the 2014 seine fishery, so they already had the boats and gear. Labor costs were significant. Fuel and maintenance costs were relatively low.	
7 Was the 2015 seine fishery profitable for you overall?	Half of the interviewed fishers were able to make a profit.	One fisher requested more advance notice before fishery implementation so that marketing plans could be developed, and preparations made.
8 Are there other economic considerations we should be aware of?	There are some potentially untapped markets that could be developed.	
9 If you also participated in the 2014 seine fishery, how did the 2015 fishery compare for you in terms of fishery design or economic difference?	One fisher felt that there was more flexibility in 2015 regarding when they could fish.	One fisher stated that it was an interesting experience, but would not participate again because it was unprofitable; another fisher believed that a market for high-quality seine-caught fish could be developed.
10 What suggestions do you have to improve this fishery in the future?	Allow retention of all fall Chinook (particularly unmarked URBs); reassess mortality rates; possibly fish for high value spring and summer Chinook; meet with potential fishers to design a profitable fishery.	

Table 17p. Summary of post-season surveys conducted with fishers ($n = 2$) participating in the 2016 commercial fall seine fishery.

Question	Summary of Responses	Comments
1 What were your general impressions of the 2016 commercial seine fishery?	Both respondents had difficulty catching salmon quota.	One fisher had problems with defective equipment.
2 What advantages do you think that this gear has over traditional methods?	Less harmful to released non-target fish.	
3 What disadvantages do you think that this gear has over traditional methods?	Requires more labor, and catch is highly dependent on fishing site selected (especially for beach seine).	
4 Do you think a viable commercial fishery can continue to be developed using this gear? If not, what do you think is required for this fishery to become viable?	One fisher thought the seine fishery uses too much of the ESA impacts compared to the number of fish harvested. He also thought it would severely reduce the size of the commercial fleet. Another fisher wanted more flexibility to target the right tides.	
5 How did any one time costs (nets, insurance, etc.) compare to operating costs (fuel, labor, maintenance, etc.)?	One beach seiner paid \$3,500 for his net, and about \$100 in fuel per trip. He paid his crew based on a percentage of the catch.	
6 Was the 2016 seine fishery profitable for you overall?	No. One fisher spent nearly \$5,000 for gear, but made less than \$300.	
7 Are there other economic considerations we should be aware of?	One beach seiner had to bring a second boat for the sole purpose of transporting the Department observers to the seining site (did not need it for seining). He felt that the Departments should provide transportation for their observers to the site.	
8 Did you experience any social issues or negative interaction with other boaters while participating in this fishery?	One of the two respondents said sport anglers were angry with them for "catching all the marked fish". The other respondent fished in an area not heavily used by sport fishers.	
9 Do you think this gear type could be operated at night?	No.	
10 If you also participated in the 2015 seine fishery, how did the 2016 fishery compare for you in terms of fishery design or economic factors?	Not applicable.	
11 What suggestions do you have to improve this fishery in the future?	One respondent suggested having more fishing periods per week so that they could fish when the tides were right. The other respondent didn't think the seine fishery should be continued.	

Assessment of the Fall Seine Fishery

Because the 2014-2016 commercial fall seine fisheries were implemented on a limited entry basis, with allowable harvest capped by IFQs for each permit holder, these fisheries were a microcosm of what a full fleet seine fishery on the lower Columbia River might be like. Nevertheless, they provided an important opportunity to collect data on seine fishery characteristics and economics, within the scope of a real-world commercial setting. This allowed us to make an initial assessment of the fall seine fishery for this report.

Beach Seine

The combined catch rate of marked adult Chinook and Coho was fair for beach seines, averaging 9.8 marked adult salmon per set during the 2014-2016 seine fisheries, but the catch rate during the most recent fishery in 2016 was 0.7 marked adult salmon per set, with a total beach seine ex-vessel value of \$210. Also, catch rates of individual beach seiners varied considerably (Table 17g); 18% of beach seiners were able to attain 90% or more of their Chinook quota, while 45% caught less than 5% of the quota. Under a full fleet fishery scenario, beach seine catch rates would likely be lower than observed in 2014-2016 because some fishers would likely be forced to fish less productive locations, and a larger fleet of seiners could increase the competition for hatchery salmon, particularly in years with smaller runs.

One advantage of the beach seine, relative to the purse seine, was the higher mark rate for adult fall Chinook observed during the 2014-2016 fisheries. This would allow proportionally more beach seine-caught Chinook to be harvested in a mark-selective fishery. The higher beach seine mark rate for Chinook may have been associated with a greater propensity to capture mass-marked tule Chinook, which appear to travel in the shallower water normally fished by beach seines. However, a downside to catching more tules is their much lower ex-vessel price, compared to brights (Table 22t). In 2015, when the beach seine mark rate for Chinook was over 60%, the proportion of tules in the catch was likely high, which could have contributed to the low average price per pound for Chinook received by beach seiners that year (Table 17b).

Another advantage of the beach seine over the purse seine, was its lower fishery participation cost, especially with regard to capital costs. Gillnet fishers with vessels of sufficient power would probably be able to use their current gillnet boat to conduct beach seining operations, reducing start-up costs significantly. On average, beach seiners had negative economic returns during 2014-2016 (Table 17m), but their losses were much smaller than those of purse seiners.

Beach seines had a relatively low number of immediate mortalities of non-target fish (unmarked Chinook and Coho, as well as all steelhead), and immediate mortality rates were well below 1% in all years. However, steelhead encounter rate ratios in beach seines were relatively high (0.40 and 0.39 steelhead per marked adult Chinook in 2014 and 2015, respectively; encounter rate ratio could not be calculated in 2016 due to lack of Chinook; Table 17f), and this could limit Chinook harvest in a full fleet seine fishery where the number of allowable natural-origin B-Index steelhead impacts would be very limited. During 2014-2016, beach seines harvested low numbers of adult Chinook per LCR tule or natural-origin B-Index steelhead mortality, averaging 78 adult Chinook per LCR tule mortality and 388 adult Chinook per natural-origin B-Index steelhead mortality.

Lastly, observations by Department field staff indicated that the abundance of snags in nearshore waters was a major impediment to successful beach seining operations. This was one of the reasons why beach seiners did so poorly in 2016, averaging 1 adult salmon per set. For a site to be fishable, beach seiners would need to put additional time and resources into clearing out snags prior to the start of the seine fishery.

Purse Seine

The combined catch rate of marked adult Chinook and Coho was almost twice as high for purse seines as beach seines, averaging 18.9 fish per set during the 2014-2016 seine fisheries. Like the beach seiners, catch rates of individual purse seiners varied considerably (Table 17g), and 30% of purse seiners caught 90% or more of their Chinook quota, while 20% caught less than 5% of the quota. Under a full fleet fishery scenario, purse seine catch rates might be lower than observed in 2014-2016 because some fishers will likely be forced to fish less productive locations. Compared to beach seiners, purse seiners have a little more flexibility in where they can fish, and they may even be able to take turns fishing through a productive drift. Nevertheless, a larger fleet of seiners could increase the competition for hatchery salmon, particularly in years with smaller runs.

As with beach seines, observed mortalities of non-target adult salmon and steelhead released from purse seines were low, with immediate mortality rates below 1% in all years. One advantage of purse seines, relative to beach seines, was a lower steelhead encounter rate. The steelhead-to-marked adult Chinook ratio for purse seines averaged 0.24 during 2014-2016. A lower steelhead encounter rate could allow purse seines to harvest more Chinook before steelhead impacts became limiting. In 2016, the steelhead-to-marked adult Chinook ratio was unusually high (0.41) in purse seines, and it is unclear whether this was because of lower Chinook catches, or if the purse seiners were fishing shallower waters that year. Observations by ODFW staff during seine test fishing indicate that when purse seines are fished very close to shore in a manner similar to beach seines, steelhead catch rates can approach, or even surpass, that of beach seines (ODFW unpublished data). In a full fleet fishery scenario, it would be difficult to regulate how closely purse seiners fish to shore. Therefore, the lower steelhead encounter rates for purse seines observed in 2014 and 2015 (Tables 17d and 17e) could increase if purse seiners were to change the way they deploy their gear when target fish are more abundant in nearshore waters. Nevertheless, during the 2014-2016 seine fisheries, purse seines were able to harvest more adult Chinook per LCR tule mortality than beach seines (109 vs. 78), as well as more adult Chinook per natural-origin B-Index steelhead mortality (1,827 vs. 388).

The primary disadvantage of the purse seine is the initial cost of entering the fishery associated with this type of gear. Our analysis (Table 17m) comparing the estimated costs incurred by new purse seiners with ex-vessel values from the 2014-2016 commercial fall seine fisheries indicated that they would have sustained significant economic losses in every year. In the 2015 post-season survey conducted by WDFW (2014-2016 Seine Fisher Post-Season Surveys, this report), one of the purse seine participants commented that high capital costs were “definite stumbling blocks to entering this fishery”. In addition to high start-up costs, recurring annual and daily operating costs were estimated to be higher for purse seines than beach seines (on a per boat basis), and much higher than estimated costs associated with gillnets or tangle nets (Table 17k). One possible way to lower costs would be for purse seine permit holders to fish cooperatively, as the three beach

seine permittees did in 2015. Also, funding may be available to help defray a portion of the capital costs, allowing for limited expansion of the fishery under a “full fleet” scenario.

The low mark rate for adult fall Chinook is an additional challenge for purse seines. The aggregate adult Chinook mark rate for purse seines in the 2014-2016 fisheries was 35%, requiring almost two-thirds of the adult Chinook captured in purse seines to be released in the mark-selective fisheries. Many of these released Chinook were high value URBs, which had an average mark rate of 20% during 2014-2016 (ODFW unpublished data).

Conclusion

The low observed immediate mortality rate of non-target fish released during 2014-2016 was a positive characteristic of the seine fishery. The catch rate of targeted hatchery adult Chinook, although better for purse seines than beach seines, was moderate overall, resulting in a modest average ex-vessel value of \$44,578 for the fishery, and \$6,368 per participating vessel. Since the 2014-2016 seine fisheries operated during some of the largest fall Chinook runs observed in many years, fisheries in years with smaller runs would likely have lower average landings and ex-vessel value. The low mark rates observed for fall Chinook caught in the seine fishery contributed to the relatively low landings and ex-vessel value. In their post-season survey responses, many seine fishers commented on their inability to retain high value unmarked URB Chinook in the mark-selective fishery, and how this detracted from the fishery’s value and economic viability. However, alternative gears were primarily intended to harvest hatchery salmon while allowing the release of weak or ESA-listed stocks such as natural-origin LCR tule Chinook. One potential way to allow retention of unmarked bright Chinook in the seine fishery would be to have fishers identify unmarked tule Chinook in the catch, and release them. This is dependent on the fisher being able to accurately identify tule Chinook, and the 2014 fall Chinook VSI evaluation indicated that they currently do not have the ability to do this. In addition, fishers would need to willingly release retainable fish for this to be effective. During the 2016 seine fishery, retention of unmarked Chinook was allowed on one day for each gear type to see if fishers could selectively harvest unmarked URB Chinook, while releasing all unmarked tule Chinook. Although WDFW collected DNA samples from all unmarked Chinook harvested in the 2016 seine fishery to evaluate the fishers’ VSI abilities, as of the date of this report, no results were available. Another potential way of allowing the harvest of unmarked brights is to implement a non-mark-selective seine fishery that is restricted to Zones 4 and 5, where encounters with tules are less frequent. However, this scenario does not provide for the efficient use of the limited ESA impacts allocated to the commercial fishery, and is discussed in greater detail later in this report (see Mainstem Commercial Fisheries—Comparative Commercial Gear Analysis).

Although the 2014-2016 seine fisheries were limited in scope due to the ESA impacts that were available during those years, if a greater share of impacts were allocated to the seine fishery, it is unlikely that fishery landings and ex-vessel values would have increased proportionately since most seine fishers did not approach fulfillment of their quotas (Tables 17a and 17g). Furthermore, effort levels in the seine fisheries were modest, with purse seiners fishing on an average of 65% of the available fishing periods, and beach seiners fishing on 37% of the available fishing periods. Also, in 2015, half of the available beach seine permits were purchased and fished. Given these

characteristics of the 2014-2016 seine fisheries, increasing the available ESA impacts, quotas, permits, and expanding seasons, would not proportionately improve the net return for fishers.

High costs, both capital and operating, were another major problem for the fall seine fishery. Our economic analysis of the 2014-2016 seine fisheries, which compared actual ex-vessel values to estimated fishery participation costs for new purse and beach seine fishers, indicated that the low value of the seine fishery, combined with its high costs, would have resulted in negative net returns for both gear types in all years. Even if capital costs were not considered in the analysis, the seine fishery, on average, would have had net economic losses in 2 out of the 3 years. Although some fishers who previously possessed suitable gear and vessels (purse) were able to make modest profits in the seine fishery, the vast majority of participants did not believe that the seine fishery was economically viable, and high costs were cited as a major factor.

Even though observed immediate mortality rates were low for the 2014-2016 seine fisheries, the number of mortalities associated with a fishery is a function of both mortality rate (immediate and post-release) and handle. Because of this, the relatively high handle of steelhead by both beach and purse seines will still lead to a significant number of steelhead mortalities in a full-scale commercial seine fishery (see Mainstem Commercial Fisheries—Comparative Commercial Gear Analysis). In addition, the low landings observed during 2014-2016 made the seine fishery relatively inefficient with respect to its ESA impact usage. Because the harvest of adult Chinook per natural-origin B-Index steelhead mortality has been relatively poor for seines, no fall seine fishery took place in 2017, when natural-origin B-Index steelhead impacts were severely limited. There were also no plans to have a fall seine fishery in 2018 due to continued low B-Index steelhead numbers, as well as the limited available harvest of Snake River Wild (SRW) fall Chinook, which are also ESA-listed.

Tables C4 and C5 of the Harvest Reform Policy provided estimates of what could be expected from a mark-selective commercial fall seine fishery during 2013-2017 in terms of harvest and ex-vessel value (ODFW 2012), based on assumptions and information available at that time. For a number of reasons, with the exception of the number of open fishing days, the seine fisheries prosecuted so far have not met those expectations (Table 17q).

Table 17q. Comparison of assumptions for the fall seine fishery presented in Tables C4 and C5 of the Harvest Reform Policy to actual fishery results during 2013-2017.

Category	Reform Assumptions (C4/C5)						Actual Results					
	2013	2014	2015	2016	2017	Avg	2013 ¹	2014	2015	2016	2017 ¹	Avg
# Beach Permits	12	12	12	12	12	12	0	6	3	2	0	2
# Purse Permits	8	8	8	8	8	8	0	4	4	2	0	2
Open Fishing Days	11	11	11	11	11	11	0	22	23	14	0	12
Beach Marked Adult CHF Landed	6,065	6,065	6,065	14,866	14,866	9,585	0	1,133	572	0	0	341
Beach Marked Adult COH Landed	2,824	2,824	2,824	6,754	6,754	4,396	0	489	55	13	0	111
Purse Marked Adult CHF Landed	5,129	5,129	5,129	12,573	12,573	8,107	0	1,306	2,191	728	0	845
Purse Marked Adult COH Landed	3,186	3,186	3,186	7,620	7,620	4,960	0	542	509	469	0	304
Seine CHF Ex-Vessel Value	\$190,851	\$190,851	\$190,851	\$467,868	\$467,868	\$301,658	\$0	\$55,407	\$51,434	\$26,894	\$0	\$26,747
Seine COH Ex-Vessel Value	\$73,562	\$73,562	\$73,562	\$175,901	\$175,901	\$114,497	\$0	\$9,593	\$5,215	\$6,392	\$0	\$4,240

¹ No fall seine fishery occurred.

Because of the inherently high costs associated with participation in a seine fishery, and limited harvest potential, it is unlikely that seines could be broadly adopted by current Columbia River commercial fishers with the expectation of a reasonable return on investment. Therefore, a seine fishery would probably be most economically viable for the small number of fishers who already have the boats, nets, and gear to participate in the fishery. A limited number of fishers could partner with these experienced seiners, forming small cooperatives to share the expenses and revenue like the three beach seine permittees did in 2015. A mark-selective seine fishery may be most appropriate on a small scale, targeting concentrations of hatchery fall Chinook near the mouths of lower Columbia River tributaries, such as the Cowlitz or Lewis rivers, to provide conservation benefits in terms of reductions in the percentage of hatchery origin spawners (pHOS). During the fall season, popular sport fisheries also occur at these tributary mouths, creating the potential for conflict between the two fisheries. In addition, summer steelhead tend to congregate at the cooler tributary mouths during August and September, seeking relief from the warm waters of the Columbia. This could potentially pose problems for a gear type that is prone to capturing steelhead along with targeted Chinook and Coho. These issues would need to be addressed prior to fishery implementation.

Coho Tangle Net Fishery

Fishery Development and Regulations

ODFW's evaluation of tangle nets during 2009-2011 concluded that, based on the gear's low handle of non-target fish and low gear conversion cost, as well as the potential for moderately high harvest in strong Coho years, tangle nets may be a viable gear for mark-selective commercial Coho fisheries in the lower Columbia River. Development of the Coho tangle net fishery was relatively straightforward, as a similar live-capture fishery using tangle nets for spring Chinook has been implemented in the lower mainstem Columbia since 2001 (ODFW and WDFW 2002). TAC developed interim post-release mortality rates for a pilot Coho tangle net fishery based on average immediate mortality rates observed during the 2009-2011 feasibility evaluation, pending final results of the Coho Tangle Net Mortality Study (this report).

In 2013, fishery managers modelled the Coho tangle net fishery, along with other late fall non-treaty commercial fisheries, in order to estimate pre-season impacts to ESA-listed Lower Columbia Natural (LCN) Coho and natural-origin B-Index summer steelhead. The 2013 pilot Coho tangle net fishery was implemented in Zones 1-3 with regulations largely based on findings from the feasibility evaluation (e.g. a 3¾-in maximum mesh size restriction, 30-minute maximum soak time, mandatory use of recovery boxes, etc.). In addition, all fishers planning to participate in the tangle net fishery were required to complete a workshop conducted by ODFW staff in live capture techniques. Tangle net fisheries targeting fin-clipped hatchery Coho in Zones 1-3 were also conducted in 2014 and 2015. Detailed descriptions of the initial season structures, gear requirements, and regulations pertaining to the 2013-2015 Coho tangle net fisheries can be found in the respective Columbia River Compact fishery notices (ODFW 2013a, 2014c, 2015d). In all three years, ODFW and WDFW staff observed vessels participating in the fishery in order to collect data so that fishery managers could evaluate the performance of the tangle net fishery.

Fishery Landings and Ex-Vessel Value

The 2013 Coho tangle net fishery occurred on eight days between October 2 and October 15, the 2014 fishery on nine days between October 1 and October 21, and the 2015 fishery on three days between October 1 and October 7; only 2014 was extended beyond the initial season structure. That year, five fishing periods were initially set at the pre-season Compact, and four periods were added later when it became apparent that the late Coho run was larger than expected.

Coho and Chinook landings and ex-vessel values for the 2013-2015 late fall tangle net fisheries are shown in Tables 18a and 18b, respectively. Coho landings varied widely between years, from a low of 993 in 2015 to a high of 18,234 in 2014, and roughly corresponded to the Coho run sizes in those years (FPC 2015). Coho mark rates were high in all years, averaging 76% overall, and allowed a large proportion of the Coho catch to be retained. The average weight of Coho was similar in 2013 and 2014, but was noticeably lower in 2015. Average price per pound also differed among years, although this is not uncommon due to changes in market conditions from year to year (D. Case, ODFW, personal communication). The ex-vessel value of Coho landed in the tangle net fishery varied significantly, during the three years of the fishery (Table 18a).

Although late stock hatchery Coho were the primary target of the tangle net fishery, fall Chinook (hatchery and natural-origin) were an important component of the total fishery harvest. Chinook landings for the tangle net fishery were stable during 2013-2015, and were almost double that of Coho in 2015, comprising 82% of the total ex-vessel value that year.

Table 18a. Coho landings and ex-vessel value for the commercial Coho tangle net fishery, 2013-2015.

Year	Days		Coho Landed ¹	Mark Rate	Avg Wt (lb)	Avg \$/lb	Avg Value/Fish	Total Ex-Vessel Value
	Fished	Deliveries						
2013	8	174	4,831	77%	6.1	\$1.87	\$11.44	\$55,251
2014	9	242	18,234	83%	6.3	\$1.20	\$7.54	\$137,556
2015	3	102	993	67%	5.7	\$1.65	\$9.36	\$9,299
Avg	7	173	8,019	76%	6.0	\$1.57	\$9.45	\$67,369

¹ Includes hatchery adults and jacks.

Table 18b. Chinook landings and ex-vessel value for the commercial Coho tangle net fishery, 2013-2015.

Year	Days		Chinook Landed ¹	Avg Wt (lb)	Avg \$/lb	Avg Value/Fish	Total Ex-Vessel Value
	Fished	Deliveries					
2013	8	174	1,862	8.5	\$1.94	\$16.56	\$30,834
2014	9	242	1,988	7.3	\$1.74	\$12.66	\$25,176
2015	3	102	1,893	10.1	\$2.10	\$21.30	\$40,325
Avg	7	173	1,914	8.7	\$1.93	\$16.84	\$32,112

¹ Includes hatchery and wild adults and jacks.

Fishery Observation

On each day of the 2013-2015 Coho tangle net fisheries, ODFW and WDFW field staff observed a sample of the fishery participants. Some observers were assigned to a vessel for the duration of the fishing day (“dedicated” observation type), while others were dropped off on various fishing vessels by a Department boat for shorter term observation (“boat to boat” observation type). Boat to boat observation was possible for the Coho tangle net fishery because it occurred during daylight hours, and at a relatively low boat density, which allowed for safer navigation through the fishing area and transfer of observers from one boat to the other. Commercial Coho fisheries typically occur during daylight hours because Coho do not appear to avoid gillnets and tangle nets as readily during the day, compared to Chinook. Use of dual observation types allowed for some in-depth observation, while also ensuring an adequate sample size and a representative sample across the fleet. Distribution of observation effort across Zones 1-3 was approximately scaled to the proportion of historical Coho landings in each zone. Due to the need to track fishery performance and ESA impacts, emphasis during observation was placed on collecting data on catch numbers and species/stock composition, rather than detailed information on capture method or fish condition.

The results from observation of the 2013-2015 Coho tangle net fisheries are displayed in Table 18c. Primarily targeting late stock hatchery Coho, tangle net fisheries commenced on, or shortly after, October 1, and fishing periods occurred one to four times per week. The total number of fishing vessels observed in a given year ranged from 31 to 62, with an average of 52. On average,

about 30% of the participating vessels (using deliveries as a surrogate) were observed annually. The number of observed marked adult Coho ranged from 57 in 2015 to 1,254 in 2014, with an average of 9% of the marked adult Coho landed in the tangle net fishery observed on the water.

Table 18c. Coho tangle net fishery observation summary, 2013-2015.

Year	Dates	Days Fished	Water Temp °F		Observed		Adult Coho ¹		Adult Coho Mark Rate	Marked Adult Coho/Drift	Catch Sample Rate	Adult			Steelhead /Marked Adult Coho	Adult Coho Immediate Mortality Rate ²
			Avg	Range	Boats	Drifts	Marked	Unmarked				Chinook	Steelhead	Chum		
2013	Oct 2-3,7-10,14-15	8	61	57 - 67	62	357	693	204	77%	1.9	14%	283	17	2	0.02	6.9%
2014	Oct 1-2,6-8,13-14,20-21	9	65	58 - 70	64	262	1,254	266	83%	4.8	7%	78	20	5	0.02	14.5%
2015	Oct 1,5,7	3	64	57 - 65	31	109	57	28	67%	0.5	7%	142	18	0	0.32	13.3%
Avg		7	63	58 - 67	52	243	668	166	76%	2.4	9%	168	18	2	0.12	12.5%

¹ Coho catch does not include fish of unknown fin-mark status.

² 2014 mortality rate includes a subsample of 245 kept Coho evaluated for condition upon entering the boat; 2013-2015 average mortality rate is weighted by sample size.

The mark rate of adult Coho was relatively high, ranging from 67% to 83%, with an average of 76%. Catch rates of marked adult Coho varied widely from 0.5 fish per drift in 2015, to 4.8 fish per drift in 2014. Catch rates were slightly higher than observed during the 2009-2011 feasibility evaluation (see Table 8a), and appeared to be strongly correlated ($R^2 = 0.96$) with the relative abundance of late stock hatchery Coho during 2013-2015 (Figure 18a).

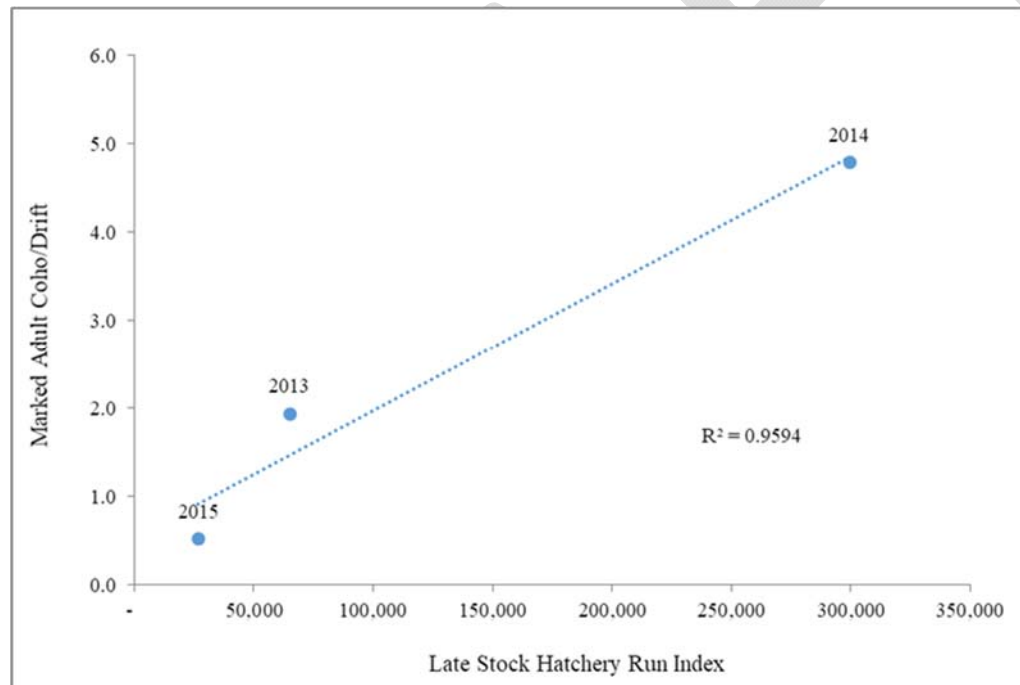


Figure 18a. Relationship between relative abundance of late stock hatchery Coho and catch rate of hatchery adult Coho in fall tangle net fisheries, 2013-2015. The late stock hatchery run index consists of year-specific mark rates observed in the 2013-2015 tangle net fisheries applied to the respective estimated run sizes for late stock Coho.

Incidental catches of steelhead and Chum were modest, likely due to the timing of the tangle net fisheries in October, when abundances for these species are low. Steelhead to marked adult Coho ratios were 0.02 in 2013 and 2014, but increased significantly to 0.32 in 2015 (Table 18c). The

primary reason for this was the very low Coho catch in 2015, but post-season data analysis also suggested that one observer may have incorrectly identified some fish as steelhead.

Immediate mortality rates for adult Coho caught in tangle net gear ranged from 6.9% in 2013 to 14.5% in 2014, with a weighted average of 12.5%. Analysis of water temperatures and mortality rates observed during the Coho tangle net fisheries strongly suggested that mortality rates increased as water temperature increased ($R^2 = 0.95$; Figure 18b). Other studies have also documented the negative effects of warm water temperatures on mortality rates of adult Pacific salmon (Martins et al. 2012, Raby et al. 2015).

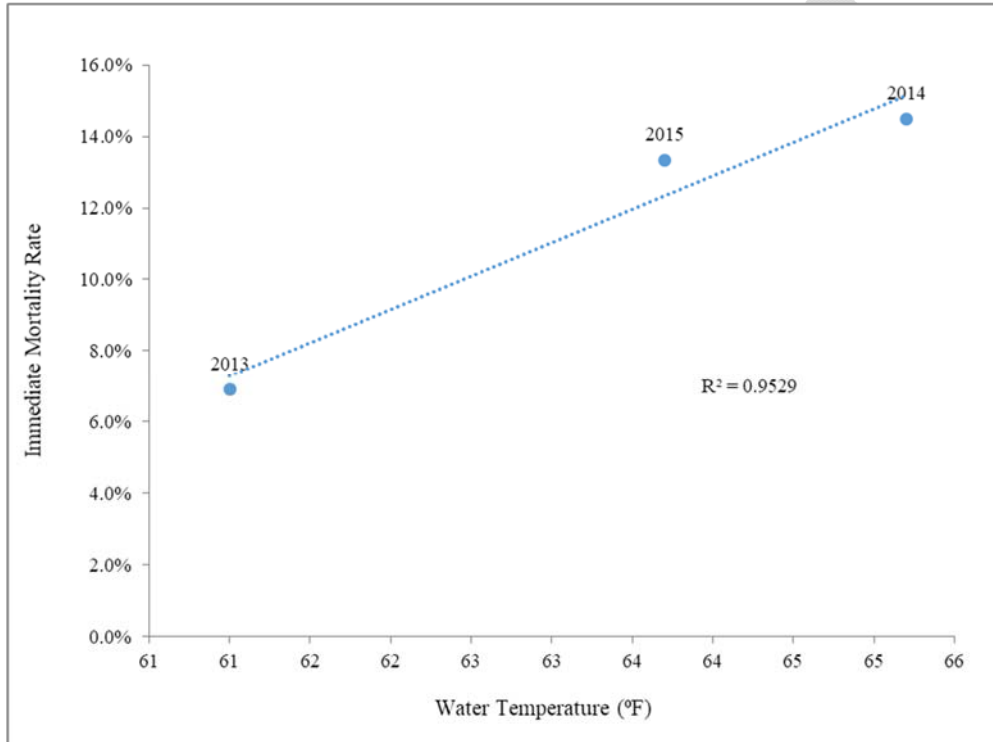


Figure 18b. Relationship between average water temperature and immediate mortality rate of adult Coho observed during fall tangle net fisheries, 2013-2015.

ESA Impacts

Impact Analysis

Table 18d shows the number of hatchery adult Coho that were harvested compared to mortalities of ESA-listed LCN Coho and natural-origin B-Index summer steelhead during the 2013-2015 Coho tangle net fisheries. Harvest efficiency, in terms of adult Coho harvested per mortality, was highly variable, with 2014 having the highest efficiencies at 99 Coho harvested per LCN mortality, and 2,179 Coho harvested per natural-origin B-Index steelhead mortality. This is likely due to the exceptionally strong Coho run in 2014. It should be noted that natural-origin B-Index steelhead mortalities in 2015 could have been overestimated due to possible misidentification of fish by one of the fishery observers. Nevertheless, because the Coho tangle net fishery occurs in October, even if few steelhead are encountered, the proportion that are B-Index steelhead is high. Therefore,

impacts to natural-origin B-Index steelhead may limit the ability to prosecute this fishery in some years.

Table 18d. Harvest of hatchery adult Coho relative to LCN Coho and natural-origin B-Index summer steelhead mortalities during the Coho tangle net fishery, 2013-2015.

Year	Adult Coho Harvest ¹	LCN Coho		Wild B-Index Steelhead	
		LCN Mortalities	Harvest Per Mortality	Wild B Mortalities	Harvest Per Mortality
2013	3,441	65	53	2	1,696
2014	16,321	164	99	7	2,179
2015	820	47	17	5	182
Avg	6,861	92	75	5	1,466

¹ Harvest of adult Coho estimated by applying adult proportion from fishery observation to total Coho landings.

Economics

Any commercial fishery, including those using alternative gears, needs to have positive enough net-returns to provide a reasonable income to the fisher, and offer an incentive to participate in the fishery. We examined the economic returns of the Coho tangle net fishery by comparing actual landings and ex-vessel values from the 2013-2015 fisheries to estimated costs associated with using tangle nets to commercially harvest salmon in the lower Columbia River (Table 17k). Estimated costs were taken from the 2013 Fiscal and Economic Impact Statement that was used to predict the economic impacts of the Harvest Reform Policy (ODFW 2013c).

For the purpose of this analysis, we estimated the average number of vessels participating in each year's Coho tangle net fishery by dividing the total annual deliveries for the fishery by the number of Coho tangle net fishing periods. In doing so, we assumed that all participating vessels delivered fish, which we believed was likely for most fishers in this fishery, given conversations with participating fishers. With respect to harvest costs, we assumed that the only capital cost incurred by tangle net fishery participants was the cost of the tangle net, since existing gillnet boats and rigging could easily be used. As fishery participation increased in 2014 and 2015, we assumed that all fishers participating in previous years continued to participate in the tangle net fishery, and we only applied capital costs to the new participants. Because post-season feedback from the tangle net fishery participants indicated that the tangle nets were relatively fragile and easily damaged, we applied the higher \$1,333 per year net repair cost to each fisher's annual cost.

The results of our analysis are shown in Table 18e. Coho tangle net fishery landings and ex-vessel value were highly variable, with 2014 being, by far, the best year. On the other hand, fishery participation costs were highest in the first year of the fishery, when all participants had to purchase a tangle net. After that, total fishery costs decreased each year. Net economic returns were negative in two out of the three years of the tangle net fishery, and were lowest in 2013, when ex-vessel value was modest and harvest cost was high. In fact, in 2013, capital costs alone were higher than the total ex-vessel value for that year's fishery. On average, each fisher would have lost almost \$2,600 in 2013. Even though total harvest costs were lowest in 2015, the poor Coho return that year led to a substantial net loss for the fishery. In 2014, a large Coho return resulted in a high ex-vessel value for the tangle net fishery, and this helped to provide an average net gain

of about \$2,600 per fisher. However, over the three years of the Coho tangle net fishery, fishers would have averaged a net loss of \$366.

Table 18e. Comparison of landings and ex-vessel value to estimated harvest costs for the 2013-2015 Coho tangle net fisheries.

Year	Days Fished	Avg # of Vessels ¹	Salmon Landed ²	Total Ex-Vessel Value	Costs				Net Fishery Return	Net Return/Vessel
					Capital ³	Annual	Daily	Total		
2013	8	22	6,693	\$86,085	\$87,000	\$28,993	\$26,100	\$142,093	(\$56,008)	(\$2,575)
2014	9	27	20,222	\$162,732	\$20,000	\$35,843	\$36,300	\$92,143	\$70,589	\$2,625
2015	3	34	2,886	\$49,624	\$28,000	\$45,322	\$15,300	\$88,622	(\$38,998)	(\$1,147)
Avg	7	28	9,934	\$99,480	\$45,000	\$36,719	\$25,900	\$107,619	(\$8,139)	(\$366)

¹ Average number of vessels fishing during the season. Approximated using average number of deliveries per day.

² Includes Chinook and Coho (adults and jacks).

³ Capital costs in 2014 and 2015 were only applied to the "new" participating vessels (5 in 2014 and 7 in 2015) since we assumed that each year's vessels continued to participate in subsequent years.

Even with relatively low harvest costs compared to other alternative gear fisheries, such as the fall seine fishery (Table 17m), the Coho tangle net fishery was only able show a positive net return in one of three years. In our analysis, the tangle net fishery had positive returns when Coho returns and landings were large. As Columbia River Coho returns can be erratic (ODFW and WDFW 2016), this could make it difficult for the Coho tangle net fishery to be economically viable on a consistent basis; traditional Coho gillnets seasons would likely be similarly affected. Therefore, this fishery may be most applicable in years when late stock Coho returns are relatively strong.

As with our economic analysis of the fall seine fishery, our approach to assessing the economic value of the Coho tangle net fishery necessarily took a very broad view. Actual economic outcomes for individual fishers in each year were likely mixed, depending on how many days they actually fished and how well they did. Nevertheless, we believe that this analysis provides a good representation of how landings and ex-vessel values derived from the Coho tangle net fishery compare to the costs associated with harvesting those fish. It also demonstrates how even relatively minor increases in costs to a fishery can determine whether or not net economic returns are positive or negative in a given year.

Assessment of the Coho Tangle Net Fishery

The Coho tangle net fishery was implemented as one of an array of fall commercial fisheries occurring in the mainstem lower Columbia River during 2013-2015. Therefore, the ESA impacts available to the fishery were limited, with the number of fishing periods ranging from 3 to 9 per year. Nevertheless, they provided an important opportunity to collect data on Coho tangle net fishery characteristics and economics, within the scope of a real-world commercial setting. This allowed us to make an initial assessment of the Coho tangle net fishery for this report.

The primary advantage of the tangle net compared to other alternative gears is its relatively low fishery implementation cost. Since current Columbia River gillnet fishers can use their existing vessels and gear to fish the tangle net, and most fishers already have fish recovery boxes used in mark-selective spring Chinook tangle net fisheries, the only real capital cost is the Coho tangle net

itself. A comparison of the deliveries per period (an index of the number of vessels participating in a commercial fishery) for Coho-directed tangle net and 6-in gillnet fisheries occurring in 2013-2015 suggested that a majority of fishers participating in late fall Coho fisheries used both tangle nets and gillnets. In addition, annual and daily operating costs for a tangle net fishery are relatively low, being essentially the same as they are for gillnet fisheries. That said, according to our economic analysis, tangle net fishers would have lost money in 2 out of 3 years because of poor Coho landings in 2013 and 2015 (Table 18e). Therefore, even with its relatively low costs, the economic viability of the Coho tangle net fishery appears to be very sensitive to fluctuations in Coho returns. The lower value per fish for Coho, compared to Chinook (Table 22s), may also make Coho fisheries more economically marginal.

A positive aspect of the tangle net fishery was the high mark rate of Coho caught in the fishery. Mark rates averaged 76% during 2013-2015, allowing a high percentage of the Coho captured in tangle nets to be harvested and potentially reducing the number of hatchery fish that wind up on spawning grounds. This also helped to keep the handle of unmarked Coho, and therefore impacts to ESA-listed LCN Coho, at a low level. The observed immediate mortality rate for Coho appeared to be positively associated with water temperatures during the fishery, and averaged 12.5% for the three years. Combining this average immediate mortality rate with the post-release mortality rate from the 2015-2016 Coho tangle net mortality study (see Alternative Gear Post-Release Mortality Evaluations—Coho Tangle Net Mortality Study) yielded a total mortality rate of 23.6%, which was reviewed by TAC, and approved by NMFS, in 2018 for use in future Coho tangle net fisheries. Because mortality rates can be affected by water temperature, this should be taken into consideration when planning the timing of fall tangle net fisheries.

The catch rate of marked adult Coho during the 2013-2015 tangle net fisheries was slightly better than it was during the 2009-2011 feasibility evaluation, but it was still relatively low, averaging 2.4 fish per drift. Including adult fall Chinook (hatchery and natural-origin) in the catch rate improved it slightly to an average of 3.2 kept salmon per drift. Although this catch rate is still somewhat low, because of short (30-minute) soak times and the ability to almost immediately redeploy the net at the conclusion of a drift, tangle net fishers can generate a high number of drifts during a 12-hr fishing period, helping to maintain daily catches at an acceptable level. However, this high level of effort can also equate to higher operating and opportunity costs in terms of fuel and the fisher's time.

The number of adult hatchery Coho harvested per LCN Coho or natural-origin B-Index steelhead mortality was highly variable from year to year, and appeared to largely depend on Coho landings and the strength of the run. Therefore, harvest efficiency, in terms of ESA impacts, could be either good or poor for this fishery in a given year. Although high numbers of steelhead were not encountered during the 2013-2015 tangle net fisheries, impacts for natural-origin B-Index steelhead can still accumulate quickly in this fishery because the steelhead stock composition during the timeframe of the fishery is heavily skewed towards B-Index steelhead.

Conclusion

Tables C4 and C5 of the Harvest Reform Policy provided estimates of what could be expected from a mark-selective commercial Coho tangle net fishery during 2013-2017 in terms of harvest

and ex-vessel value (ODFW 2012). Like the fall seine fishery, the Coho tangle net fishery fell short of meeting expectations (Table 18f). Nevertheless, the Coho tangle net may be a viable alternative gear for late-fall mainstem commercial fisheries due to low costs, high target fish mark rates, low handle of non-target fish, and relatively low release mortality rate.

Table 18f. Comparison of assumptions for the Coho tangle net fishery presented in Tables C4 and C5 of the Harvest Reform Policy to actual fishery results during 2013-2017.

Category	Reform Assumptions (C4/C5)						Actual Results					
	2013	2014	2015	2016	2017	Avg	2013	2014	2015	2016 ¹	2017 ¹	Avg
# Participating Boats	60	60	60	60	60	60	22	27	34	0	0	17
Open Fishing Days	8	8	8	8	8	8	8	9	3	0	0	4
Marked Adult Coho Landed	20,160	20,160	20,160	20,160	20,160	20,160	4,831	18,234	993	0	0	4,812
Coho Ex-Vessel Value	\$246,713	\$246,713	\$246,713	\$246,713	\$246,713	\$246,713	\$55,251	\$137,556	\$9,299	\$0	\$0	\$40,421

¹ No Coho tangle net fishery occurred.

CURRENT SELECT AREA FISHERIES

The current Select Area Fisheries Enhancement (SAFE) project began as the Select Area Fisheries *Evaluation* project in 1993 after the Northwest Power and Conservation Council recommended the identification and development of terminal fishing sites in the lower Columbia River to allow commercial harvest of hatchery salmon, while minimizing the incidental harvest of weak stocks (North et al. 2006). The project, funded by the Bonneville Power Administration (BPA), evaluated potential sites based on a variety of criteria, such as fishable area, depth, catch of target and non-target fish, water quality parameters (e.g. temperature, dissolved oxygen, etc.), and the presence/absence of unique water sources (for juvenile imprinting and adult homing) and infrastructure. Together, these criteria were used to identify sites that had the capability to rear/acclimate, imprint, and release hatchery salmon smolts, and to prosecute commercial fisheries that could efficiently harvest returning adults, with limited impacts to ESA-listed stocks (Hirose et al. 1996).

Based on the results of the evaluation and available funding, new terminal/off-channel fishing sites were selected for development at Tongue Point (OR), Blind Slough (OR), Deep River (WA), and Steamboat Slough (WA). In addition, the established Youngs Bay (OR) terminal fisheries area was designated for expansion. The Tongue Point site was eventually expanded to include South Channel, and the Blind Slough site was expanded to include Knappa Slough. The Steamboat Slough site was discontinued after five years of Coho releases because returning adults were primarily being recovered at Elochoman Hatchery, rather than holding within the Steamboat Slough fishery area (North et al. 2006). Therefore, there are currently four Select Area sites supporting fisheries in the lower Columbia River (Figure 19a). Management and operation of the SAFE project is a cooperative effort between ODFW, WDFW, Clatsop County Fisheries (CCF, formerly the Clatsop Economic Development Council (CEDC) Fisheries Project), and BPA. As of FY2017, most of the funding for the Select Areas comes from the state of Oregon (47%), followed by BPA (31%), and NOAA Fisheries (19%). The remaining 3% comes from the state of Washington, Clatsop County, and a voluntary assessment on commercial fishery landings.

Each Select Area site contains a net-pen complex where juvenile hatchery salmon are reared and/or acclimated until they are ready for release (Figure 19b). Individual pen dimensions are generally 20 ft long x 20 ft wide x 8 ft deep, offering approximately 3,200 ft³ of available rearing space per pen. The number of pens per site varies, ranging from 15 at Blind Slough to 70 at Youngs Bay. Depending on the species and stock, fish may be held in the pens for as little as two weeks for acclimation, or reared over-winter. Multiple hatcheries in Oregon and Washington provide production for the Select Area sites, several of which release smolts directly into the sites. A complete list of hatcheries contributing to Select Area production in recent years is provided by Duff et al. 2013. The primary species and stocks released into the Select Areas are spring Chinook, Coho, LRH tule fall Chinook, and Select Area Bright (SAB) fall Chinook (derived from Rogue River fall Chinook stock). The Rogue stock was chosen because of its excellent flesh quality, ocean migration patterns, and broad run timing. Because this stock turns south upon ocean entry, it could contribute to Oregon coastal fisheries, as well as Select Area fisheries (Duff et al. 2013). Due to the stock's out of basin nature, all SABs receive a left ventral (LV) fin-clip prior to release for easy identification as adults.

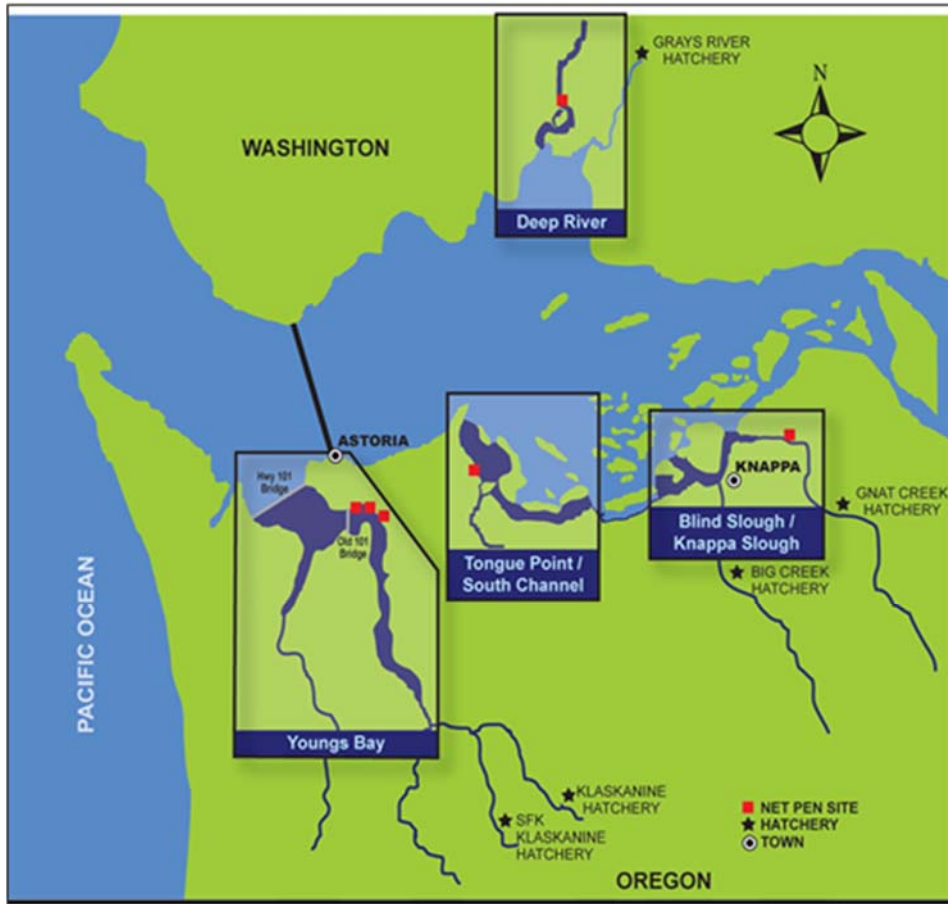


Figure 19a. Select Area fishing sites in the lower Columbia River.



Figure 19b. Youngs Bay net pens located near the City of Astoria Yacht Club boat launch, Astoria, Oregon.

Smolt Releases

Past Releases

Coho salmon smolts have been released in Youngs Bay by CCF since 1977, and in the other three Select Area sites since 1995. Spring Chinook were first released from Youngs Bay in 1989, Tongue Point and Blind Slough in 1996, and Deep River in 1998. SAB fall Chinook originated from Rogue River egg transfers in the early 1980s, and have been released exclusively from Youngs Bay facilities since 1998. SAB production is maintained through a self-sustaining broodstock program at South Fork Klaskanine Hatchery (North et al. 2006). Tule fall Chinook have been released from Big Creek Hatchery since the 1940s, but more recent releases began at Deep River in 2009, and Klaskanine Hatchery in 2010 (Duff et al. 2013). Total releases of spring Chinook, SAB and tule fall Chinook, and Coho into the current Select Areas for the 1996-2015 brood years are shown in Figure 19c. During this time period, releases of tule Chinook and Coho averaged 6.1 million and 4.0 million, respectively, while releases of spring Chinook and SABs averaged 1.4 million and 1.2 million, respectively. More detailed release information, by specific release location, for the 2000-2015 brood years is presented in Table 19a.

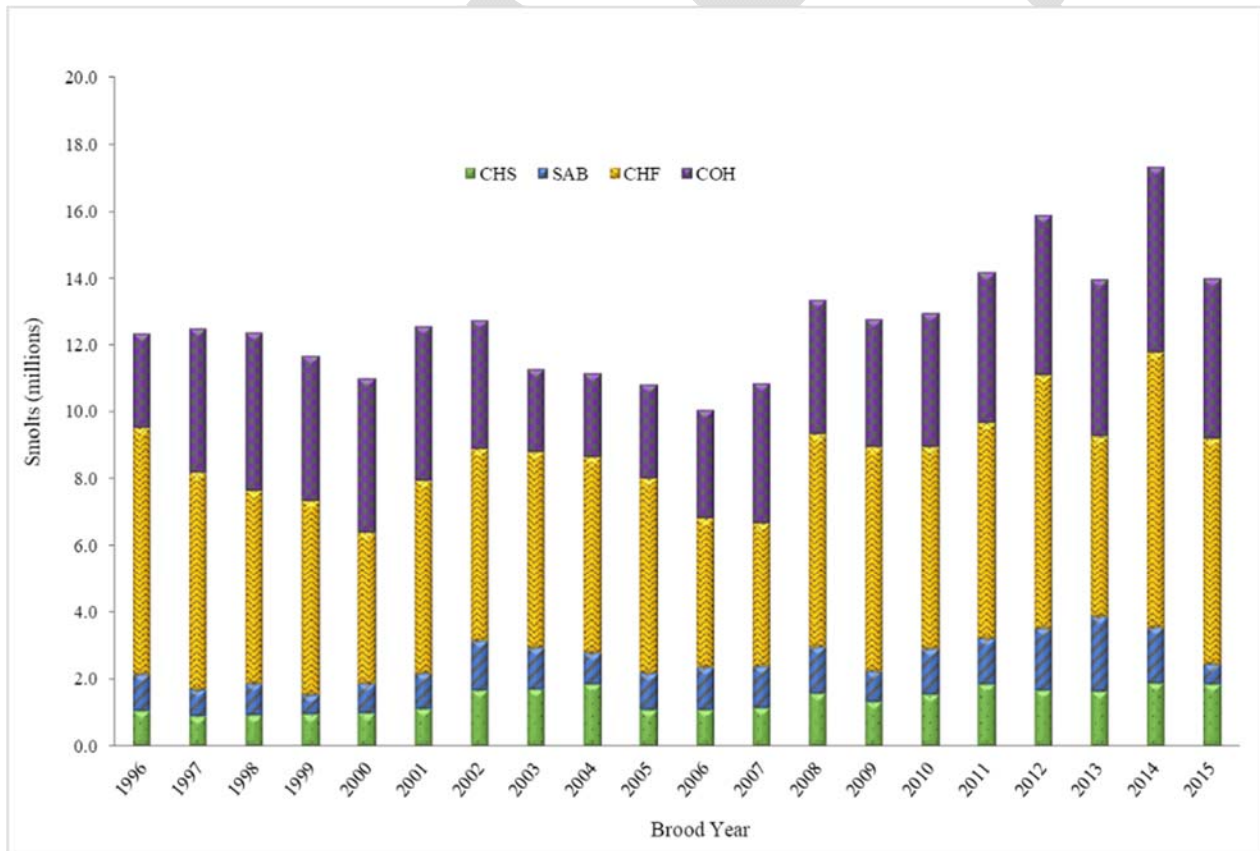


Figure 19c. Total releases of spring Chinook (CHS), Select Area Bright fall Chinook (SAB), tule fall Chinook (CHF), and Coho (COH) salmon smolts into the Select Areas for the 1996-2015 brood years.

Table 19a. Summary of smolt releases from Select Area-related facilities for the 2000-2015 brood years.

Brood Year	Species/ Stock ¹	Youngs Bay			Blind Slough			Tongue Point	Deep River		Other	Select Area Total
		South Fork Klaskanine Hatchery	Klaskanine Hatchery	Youngs Bay Net Pens	Big Creek Hatchery	Blind Slough Net Pens	Gnat Creek Hatchery	Tongue Point Net Pens	Deep River Net Pens	Grays River Hatchery	Steamboat Slough Net Pens	
2000	CHS	—	—	478,062	—	390,908	—	—	95,940	—	—	964,910
	SAB	—	669,913	205,145	—	—	—	—	—	—	—	875,058
	CHF	—	—	—	4,537,448	—	—	—	—	—	—	4,537,448
	COH	583,248	—	1,688,696	540,898	343,842	—	667,758	354,557	154,107	273,108	4,606,214
2001	CHS	—	—	451,623	—	426,309	—	57,797	141,904	—	—	1,077,633
	SAB	—	620,527	467,056	—	—	—	—	—	—	—	1,087,583
	CHF	—	—	—	5,765,933	—	—	—	—	—	—	5,765,933
	COH	641,555	—	1,686,711	537,085	316,804	—	675,712	366,435	153,000	239,635	4,616,937
2002	CHS	639,446	—	455,825	—	408,495	—	48,056	97,318	—	—	1,649,140
	SAB	—	702,218	780,314	—	—	—	—	—	—	—	1,482,532
	CHF	—	—	—	5,764,833	—	—	—	—	—	—	5,764,833
	COH	131,185	—	1,470,914	516,942	298,748	—	697,522	357,200	157,000	204,600	3,834,111
2003	CHS	458,659	—	457,994	—	433,044	—	53,299	254,471	—	—	1,657,467
	SAB	53,963	681,155	519,676	—	—	—	—	—	—	—	1,254,794
	CHF	—	—	—	5,887,836	—	—	—	—	—	—	5,887,836
	COH	—	—	1,146,068	506,172	309,527	—	202,727	144,900	146,000	—	2,455,394
2004	CHS	566,030	—	391,843	—	451,388	—	82,565	336,300	—	—	1,828,126
	SAB	45,247	735,066	161,237	—	—	—	—	—	—	—	941,550
	CHF	—	—	—	5,865,175	—	—	—	—	—	—	5,865,175
	COH	—	—	1,125,609	527,631	305,573	—	194,442	201,300	156,302	—	2,510,857
2005	CHS	—	—	417,662	—	272,226	—	104,149	263,600	—	—	1,057,637
	SAB	628,888	—	476,497	—	—	—	—	—	—	—	1,105,385
	CHF	—	—	—	5,850,219	—	—	—	—	—	—	5,850,219
	COH	—	—	1,157,746	529,697	304,558	—	174,547	449,200	157,500	—	2,773,248
2006	CHS	—	—	543,803	—	312,962	—	79,343	121,500	—	—	1,057,608
	SAB	708,412	—	564,641	—	—	—	—	—	—	—	1,273,053
	CHF	—	—	—	4,467,016	—	—	—	—	—	—	4,467,016
	COH	278,944	232,455	768,960	559,717	310,133	—	597,754	368,000	132,188	—	3,248,151
2007	CHS	—	—	457,161	—	280,437	—	103,060	279,811	—	—	1,120,469
	SAB	674,181	—	574,020	—	—	—	—	—	—	—	1,248,201
	CHF	—	—	—	4,286,153	—	—	—	—	—	—	4,286,153
	COH	370,796	609,400	1,014,141	540,169	300,036	—	477,830	706,150	158,000	—	4,176,522
2008	CHS	—	—	804,665	—	265,832	—	101,700	363,000	—	—	1,535,197
	SAB	714,118	—	702,659	—	—	—	—	—	—	—	1,416,777
	CHF	—	—	—	5,666,218	—	—	—	700,000	—	—	6,366,218
	COH	347,494	561,968	783,092	516,206	417,506	—	483,412	747,000	153,000	—	4,009,678
2009	CHS	—	—	702,609	—	253,503	—	100,557	234,000	—	—	1,290,669
	SAB	685,056	—	229,105	—	—	—	—	—	—	—	914,161
	CHF	—	2,093,575	—	3,948,579	—	—	—	700,000	—	—	6,742,154
	COH	368,980	392,314	796,443	538,402	388,505	—	479,365	692,000	155,000	—	3,811,009
2010	CHS	—	—	612,330	—	258,923	—	253,002	405,000	—	—	1,529,255
	SAB	672,829	—	684,030	—	—	—	—	—	—	—	1,356,859
	CHF	—	1,932,616	—	3,255,120	—	—	—	862,000	—	—	6,049,736
	COH	390,610	489,060	757,474	532,082	372,265	—	491,330	800,000	163,000	—	3,995,821
2011	CHS	—	—	601,862	—	326,490	99,190	481,617	320,000	—	—	1,829,159
	SAB	704,594	—	653,452	—	—	—	—	—	—	—	1,358,046
	CHF	—	1,954,732	—	3,614,747	—	—	—	893,000	—	—	6,462,479
	COH	386,668	607,824	769,971	571,616	586,277	—	849,381	600,000	165,000	—	4,536,737
2012	CHS	—	—	631,337	—	370,858	150,834	493,595	—	—	—	1,646,624
	SAB	680,806	481,663	687,801	—	—	—	—	—	—	—	1,850,270
	CHF	—	1,986,471	—	2,956,068	—	—	—	2,620,000	—	—	7,562,539
	COH	336,856	732,994	774,533	537,811	623,649	—	928,589	725,000	155,000	—	4,814,432
2013	CHS	—	—	560,520	—	437,583	142,959	465,420	—	—	—	1,606,482
	SAB	697,554	822,825	706,974	—	—	—	—	—	—	—	2,227,353
	CHF	—	1,644,974	—	2,837,901	—	—	—	930,000	—	—	5,412,875
	COH	260,289	903,119	684,306	537,661	569,921	—	935,023	654,000	165,000	—	4,709,319
2014	CHS	—	275,973	627,857	—	128,700	380,848	437,585	—	—	—	1,850,963
	SAB	672,387	525,600	472,678	—	—	—	—	—	—	—	1,670,665
	CHF	—	4,118,792	—	3,120,715	—	—	—	975,000	—	—	8,214,507
	COH	209,923	1,552,458	766,193	568,328	574,243	—	842,341	920,000	156,000	—	5,589,486
2015	CHS	—	—	910,343	—	116,114	379,653	399,621	—	—	—	1,805,731
	SAB	160,487	461,441	—	—	—	—	—	—	—	—	621,928
	CHF	—	2,802,981	—	3,090,605	—	—	—	875,000	—	—	6,768,586
	COH	209,745	1,487,362	550,062	536,144	349,156	—	747,057	855,000	53,000	—	4,787,526

¹ CHS =Spring Chinook, SAB =Select Area Bright Fall Chinook, CHF =Tule Fall Chinook, COH =Coho.

Current and Future Releases

One of the Harvest Reform Policy objectives is to enhance the economic benefits of off-channel commercial fisheries by “providing additional hatchery fish for release in off-channel areas by shifting production, and where possible, providing new production (OAR 635-500-6705(7)(a)).” Although not specified in rule, the Oregon Fish and Wildlife Commission (OFWC) provided further guidance related to the numbers and stocks of hatchery fish that were to be released in off-channel areas. Enhanced hatchery releases associated with Columbia River fisheries reform are described below, including some projected releases for 2018 and 2019. It should be noted that a comprehensive review of Mitchell Act-funded hatchery programs by NOAA Fisheries in 2016 has affected planned releases of Coho, as well as SAB and tule fall Chinook, in the Select Areas. These reductions, and potential approaches to mitigate them, were presented to the OFWC for their consideration during adaptive management decisions for the post-transition (2017+) period.

- a) Spring Chinook: Oregon initiated an increase in releases of 250,000 smolts per year in 2010, based on Commission direction in 2008. An additional 500,000 annual Oregon increase was initiated in 2013 as part of the Harvest Reform transition period. WDFW discontinued releases of 350,000 spring Chinook into Deep River in 2014, as planned in the reform package, due to poor survival and negligible contribution of these fish to Select Area fisheries, but initiated target production of 250,000 spring Chinook annually for release into Cathlamet Channel beginning in 2014. Further Oregon increases of 250,000 beginning in 2017 brought the total additional release goal to 1.25 million and a cumulative goal of 2.2 million by 2017. The March 2017 OFWC decision supported the staff recommendation to release an additional 1.5 million spring Chinook in Oregon Select Area sites (500,000 from Gnat Creek Hatchery, 390,000 as backfill for Mitchell Act Coho cuts, 250,000 to a new or existing Select Area site, and 360,000 additional to supplement commercial economics), bringing the total release goal to 3.7 million by 2019.
- b) Coho: Oregon initiated an increase in releases of 120,000 smolts per year in 2010, based on Commission direction in 2008. An additional 600,000 Oregon increase was implemented in 2013 as part of the transition period. WDFW was also to initiate additional production of 200,000 Coho in 2013. Further Oregon increases of 1.0 million were scheduled to begin in 2017 to bring the total additional release goal to 1.92 million with a cumulative goal of 6.09 million by 2017. However, due to federally mandated hatchery reforms and Mitchell Act cuts, the goal beginning in 2017 was reduced to 5,255,100.
- c) SAB fall Chinook: Oregon planned to increase SAB fall Chinook production by 500,000 beginning in 2013 as part of the transition period. Further increases of 250,000 were scheduled to begin in 2017 to bring the total to a cumulative goal of 2.2 million in 2017; however, due to Mitchell Act cuts, the goal beginning in 2017 was reduced to 1.0 million, and this program may be eliminated due to concerns over adverse interactions with ESA-listed fall Chinook stocks.

The Harvest Reform Policy did not specify changes to planned releases of tule fall Chinook from lower river hatcheries. These releases will also be affected by proposed actions associated with the 2016 Mitchell Act review.

As of the time of this writing, regional discussions are underway regarding the potential use of additional production from hatchery programs to support recovery of ESA-listed Southern Resident killer whales. The outcome of these discussions could lead to increased funding for production in various hatchery programs in the Columbia Basin, including Select Area programs.

Average Select Area releases to date have been at or above target in some years, but well below goals in other years (Table 19b). For 2013-2019 (through 2018 for SAB fall Chinook), average actual/projected releases of spring Chinook, Coho, and SAB fall Chinook have been 86%, 98%, and 69% of their respective targets. However, as a result of changes to Mitchell Act-funded production, 2017 and 2018 production goals for Coho and SAB fall Chinook were significantly reduced relative to the original goals for those years (footnote *e*, Table 19b), while spring Chinook goals have been increased.

Experimental releases of spring Chinook into Cathlamet Channel during 2014-2018, as part of WDFW's efforts to develop a new Select Area site, were 200,000, 141,000, 108,000, 120,000, and 260,000, respectively. Disease issues prevented meeting the 250,000 release goal at this site in every year except 2018. Fish released into Cathlamet Channel are not included in totals shown in Table 19b because no commercial fishery has been established there to harvest any returning adults. Adult returns from the 2014 and 2015 releases were expected in 2016 and 2017, and some fish were recovered in existing Select Area sites and lower Columbia recreational fisheries; however, no fish were recovered in Cathlamet Channel test fisheries, despite nearly 100% of the released fish having coded wire tags (RMIS). Due to these poor returns, WDFW plans to switch releases of spring Chinook (approximately 200,000) back to Deep River in 2019.

Table 19b. Summary of Select Area production goals and actual/planned releases prior to, and during, implementation of the Harvest Reform Policy.

Species/Stock	Period	Release Year	Total	Total	% of Goal	First Adult Return Year
			Release Goal	Actual/Planned Release		
Spring Chinook	Pre-Transition	2010 ^a	1,550,000	1,535,200	99%	2012
		2011 ^a	1,550,000	1,290,700	83%	2013
		2012 ^a	1,550,000	1,529,300	99%	2014
	Transition	2013	2,050,000	1,829,200	89%	2015
		2014 ^{bc}	1,950,000	1,646,600	84%	2016
		2015 ^{bc}	1,950,000	1,606,300	82%	2017
		2016 ^{bc}	1,950,000	1,850,800	95%	2018
	Post-Transition	2017 ^{bc}	2,200,000	1,805,700	82%	2019
		2018 ^{bc}	2,200,000	2,135,100	97%	2020
2019 ^b		3,700,000	2,547,403	69%	2021	
Coho	Pre-Transition	2010 ^a	4,290,000	4,009,700	93%	2011
		2011 ^a	4,290,000	3,811,000	89%	2012
		2012 ^a	4,290,000	3,995,800	93%	2013
	Transition	2013	5,090,000	4,536,700	89%	2014
		2014	5,090,000	4,814,400	95%	2015
		2015 ^d	5,090,000	4,709,300	93%	2016
		2016 ^d	5,090,000	5,589,500	110%	2017
	Post-Transition	2017 ^e	5,255,100	4,787,500	91%	2018
		2018 ^e	5,255,100	5,720,000	109%	2019
2019 ^e		5,255,100	5,118,203	97%	2020	
SAB Fall Chinook	Transition	2013	1,950,000	1,850,300	95%	2015
		2014	1,950,000	2,227,400	114%	2016
		2015	1,950,000	1,670,700	86%	2017
		2016	1,950,000	621,900	32%	2018
	Post-Transition	2017 ^e	1,000,000	599,500	60%	2019
		2018 ^e	1,000,000	300,500	30%	2020

^a Includes 250,000 spring Chinook and 120,000 Coho additional production specified as part of 2008 OFWC Allocation Policies.

^b 350,000 spring Chinook from WDFW (Deep River) were discontinued between 2014 and 2018; beginning in 2019, releases include 200,000 planned for Deep River.

^c Does not include releases of 200,000, 141,000, 108,000, 120,000, and 260,000 spring Chinook from Cathlamet Channel during 2014-2018 which did/will not contribute directly to a Select Area fishery.

^d 200,000 Coho from WDFW scheduled for release beginning in 2015 were discontinued due to budget cuts.

^e Beginning in 2017, Coho and SAB fall Chinook production goals reflect Mitchell Act cuts. Prior to the cuts, Coho production was planned to increase to 6.09 million in 2017 and SAB production was planned as 2.2 million.

Fishery Seasons, Landings, and Ex-Vessel Value

Select Area Seasons

Winter/Spring/Summer

Select Area commercial fisheries for spring Chinook began in Youngs Bay in 1992, Tongue Point/South Channel and Blind Slough/Knappa Slough in 1998, and Deep River in 2003. Initially, spring Chinook seasons occurred from late April through early June. As spring Chinook releases increased, winter seasons (late February through March) were added in Youngs Bay and Blind Slough, and a summer season (mid-June through July) was added in Youngs Bay, to harvest as many of the returning adults as possible. The Youngs Bay summer season also provided an opportunity to harvest early returning SAB fall Chinook. Spring Chinook seasons in the Tongue Point/South Channel area have been more limited due to the presence of upriver spring Chinook in some years. Successful modifications to season structures and fishery boundaries have enabled some experimentation with additional winter seasons in recent years. Winter seasons were added in Deep River in 2006 (ODFW and WDFW 2014-2018b). In recent years, spring Chinook seasons have been expanded further to provide fishers additional opportunity to harvest early and late returning SAFE stock spring Chinook. These season expansions are discussed later in this report (see Expansion of Existing Select Area Seasons).

Fall

Select Area fall commercial fisheries began in Youngs Bay in 1962, and have taken place in Tongue Point/South Channel, Blind Slough/Knappa Slough, and Deep River since 1996. The fall fisheries primarily target hatchery Coho returning to net pen sites, and typically occur from late August or early September through October. In Youngs Bay, fishing periods also occur throughout August to harvest SAB and tule fall Chinook returning to facilities in the area. In addition, Big Creek Hatchery tules are targeted in Blind Slough/Knappa Slough, and tules released from the Deep River net pens are harvested in that area (ODFW and WDFW 2016).

Select Area Deliveries and Landings

The number of deliveries made by Select Area commercial fishers during various seasons from 2010 through 2017 are shown in Table 19c. The number of deliveries serves as an index of commercial fishing effort, as a delivery usually equates to a trip made by a fisher on a given day. With the exception of the 2014 spring season, total deliveries during each season were relatively stable from year to year. The unusually low number of deliveries during the 2014 spring season corresponded with much lower than expected harvest of spring Chinook that year. Although some enhancements have occurred in the Select Areas during implementation of the Harvest Reform Policy (e.g. increased smolt production, some expanded seasons), the median number of Select Area deliveries (all seasons combined) during the post-Harvest Reform years (2013-2017) has remained very similar to what it was during the most recent pre-Reform years (2010-2012). This suggests that there has not been a large influx of fishers to the Select Areas or significant increase in the number of trips made by fishers since implementation of the Policy. Although decreases in

some adult returns may explain part of this, it is also possible that the current Select Areas have a limited capacity to accommodate additional fishers.

Table 19c. Commercial deliveries by Select Area season and site, 2010-2017.

	Winter/Spring					Summer				Fall					Select Area Total
	Youngs Bay	Tongue Point ¹	Blind Slough ²	Deep River	W/Sp Total	Youngs Bay	Tongue Point ^{1,3}	Blind Slough ^{2,3}	Summer Total	Youngs Bay	Tongue Point ¹	Blind Slough ²	Deep River	Fall Total	
2010	1,152	62	342	68	1,624	192	--	--	192	1,166	227	375	350	2,118	3,934
2011	973	102	262	32	1,369	250	--	--	250	1,445	241	243	346	2,275	3,894
2012	1,151	82	254	11	1,498	301	--	--	301	994	204	208	271	1,677	3,476
2013	1,042	113	224	35	1,414	380	--	--	380	1,246	338	187	662	2,433	4,227
2014	596	32	143	31	802	371	--	--	371	1,373	543	421	449	2,786	3,959
2015	964	122	256	54	1,396	304	--	--	304	935	373	173	431	1,912	3,612
2016	830	139	347	43	1,359	245	--	--	245	831	283	187	352	1,653	3,257
2017	1,162	202	310	11	1,685	347	114	121	582	927	344	193	406	1,870	3,902
2010-2012 Median					1,498				250					2,118	3,894
2013-2017 Median					1,396				371					1,912	3,902

¹ Tongue Point and South Channel.

² Blind Slough and Knappa Slough.

³ Prior to 2017, spring Chinook fisheries in Tongue Point/South Channel and Blind Slough/Knappa Slough that were extended into the summer timeframe were included under the spring season.

Although Washington fishers account for just under 50% of the commercial fishers licensed to fish the Columbia River (ODFW unpublished data), they represent only 25% of those fishing in the Select Areas (Table 19d). Therefore, it does not appear that Washington commercial fishers, no longer able to fish in mainstem spring and summer fisheries, are moving into off-channel fisheries. As previously mentioned, this could be due to a lack of space in the existing Select Area sites, which are mostly in Oregon state waters and predominantly used by Oregon fishers, and/or the additional costs and time associated with purchasing an Oregon license and transporting a boat to and from the Oregon Select Area sites on a regular basis.

Commercial harvest of Chinook and Coho (including non-SAFE stocks) in the Select Areas during 2010-2017 is displayed in Table 19e. Select Area salmon landings prior to 2010 can be found in Duff et al. 2013, and on the ODFW website. Total spring Chinook harvest during the winter/spring seasons varied significantly from a high of 23,920 in 2010 to a low of 2,801 in 2014. Chinook harvest during the summer season occurs primarily in Youngs Bay, and is mostly comprised of late returning spring

Table 19d. Commercial fishers participating in Select Area fisheries, by state, 2013-2017.

	Oregon	Washington	Total	% Washington
2013	125	43	168	26%
2014	114	43	157	27%
2015	107	43	150	29%
2016	116	30	146	21%
2017	129	42	171	25%
Avg	118	40	158	25%

Table 19e. Commercial salmon landings by Select Area season (species/stock) and site, 2010-2017.

	Winter/Spring (spring Chinook)					Summer (spring/SAB Chinook)				Fall (SAB/tule Chinook)					Fall (Coho)				Select Area Total	
	Youngs Bay	Tongue Point ¹	Blind Slough ²	Deep River	W/Sp Total	Youngs Bay	Tongue Point ^{1,3}	Blind Slough ^{2,3}	Summer Total	Youngs Bay	Tongue Point ¹	Blind Slough ²	Deep River	CHF Total	Youngs Bay	Tongue Point ¹	Blind Slough ²	Deep River		COH Total
2010	19,779	727	2,999	415	23,920	972	--	--	972	8,048	1,402	10,205	1,011	20,666	27,564	6,734	5,201	19,260	58,759	104,317
2011	6,929	656	1,611	100	9,296	1,822	--	--	1,822	12,339	2,527	5,768	2,295	22,929	26,538	6,504	1,388	15,083	49,513	83,560
2012	6,328	503	961	44	7,836	2,260	--	--	2,260	16,197	2,466	3,366	1,691	23,720	5,986	3,902	1,534	3,932	15,354	49,170
2013	4,626	374	936	124	6,060	2,022	--	--	2,022	14,360	5,828	2,362	1,592	24,142	14,254	14,165	3,882	10,002	42,303	74,527
2014	2,197	72	467	65	2,801	1,842	--	--	1,842	11,830	5,460	4,666	2,161	24,117	65,937	50,752	24,620	27,188	168,497	197,257
2015	7,308	1,262	3,117	204	11,891	1,779	--	--	1,779	6,765	3,614	3,405	4,303	18,087	11,463	9,721	1,698	4,519	27,401	59,158
2016	4,858	1,106	2,617	79	8,660	1,836	--	--	1,836	6,398	2,007	2,027	1,999	12,431	15,784	11,284	1,493	6,162	34,723	57,650
2017	7,976	2,034	2,100	21	12,131	2,822	1,483	1,161	5,466	6,277	2,251	1,636	1,870	12,034	13,603	12,534	2,460	9,382	37,979	67,610
2010-2012 Median					9,296				1,822					22,929					49,513	83,560
2013-2017 Median					8,660				1,842					18,087					37,979	67,610

¹ Tongue Point and South Channel.

² Blind Slough and Knappa Slough.

³ Prior to 2017, spring Chinook fisheries in Tongue Point/South Channel and Blind Slough/Knappa Slough that were extended into the summer timeframe were included under the spring season.

Chinook. In addition, a small number of early returning SAB fall Chinook and incidental upriver summer Chinook are harvested during the Youngs Bay summer season (Table 19f). Despite a strong return of spring Chinook to the Select Areas during the 2010 winter/spring season, summer landings in Youngs Bay were relatively low in 2010, with 972 Chinook landed. Since 2011, Youngs Bay summer landings have been stable, averaging a little over 2,000 Chinook per year. Spring seasons in Tongue Point/South Channel and Blind Slough/Knappa Slough have recently been expanded into the summer timeframe, and although these expanded spring seasons were classified as “summer” seasons beginning in 2017, harvest consists of late arriving Select Area spring Chinook. The unusually late run timing of spring Chinook in 2017 likely explains the relatively high summer season landings for Youngs Bay, Tongue Point/South Channel, and Blind Slough/Knappa Slough that year. Preliminary landings for the 2018 summer season were approximately 2,100 Chinook.

Table 19f. Stock composition of Chinook harvested in Select Areas during the winter, spring, and summer seasons, 2002-2017.

	Select Area Stock					
	Spring Chinook	SAB Fall Chinook ¹	Lower River Spring Chinook	Upriver Spring Chinook	Upriver Summer Chinook ¹	Coastal Spring Chinook
2002	69.4%	4.4%	20.6%	4.8%	0.5%	0.3%
2003	76.1%	1.4%	15.9%	5.1%	0.8%	0.6%
2004	87.6%	2.5%	7.7%	1.9%	0.4%	0.0%
2005	89.4%	2.4%	7.5%	0.6%	0.1%	0.0%
2006	92.4%	0.8%	5.1%	1.6%	0.1%	0.0%
2007	92.3%	1.3%	5.6%	0.7%	0.1%	0.0%
2008	69.0%	19.4%	4.8%	5.3%	1.5%	0.0%
2009	68.0%	17.2%	10.4%	3.7%	0.7%	0.0%
2010	84.9%	1.7%	7.2%	6.1%	0.1%	0.0%
2011	76.8%	9.6%	10.6%	2.7%	0.3%	0.0%
2012	84.4%	4.4%	7.8%	3.3%	0.0%	0.0%
2013	62.8%	17.3%	16.5%	3.2%	0.1%	0.0%
2014	48.2%	29.5%	15.7%	5.6%	1.0%	0.0%
2015	81.4%	0.5%	11.2%	5.9%	1.1%	0.0%
2016	82.8%	2.5%	10.4%	3.3%	0.9%	0.0%
2017	87.5%	0.1%	9.5%	2.7%	0.3%	0.0%
Avg	78.3%	7.2%	10.4%	3.5%	0.5%	0.1%

¹ Some SAB fall Chinook and upriver summer Chinook are harvested during the Select Area summer season (July 16-31).

Fall Chinook harvest in the Select Areas has generally declined since 2013. Much of this is due to reduced returns of SAB fall Chinook to Youngs Bay in recent years, but harvest of tule fall Chinook in Youngs Bay and other Select Area fisheries has also decreased. In 2015, 2016, and 2017, the fall season in Youngs Bay was modified to increase the escapement of SAB fall Chinook needed for broodstock. It is noteworthy that, although the mainstem Columbia saw a record run of fall Chinook in 2015, fall Chinook harvest in the Select Areas in 2015 was the third lowest during the 2010-2017 period.

Select Area Coho harvest fluctuated widely during 2010-2017, from a low of 15,354 in 2012 to a record high of 168,497 in 2014, and back down to 27,401 in 2015. Although Coho landings since 2015 have been somewhat stable at around 33,000 fish per year, Coho fisheries are often “boom or bust” in nature, even in recreational fisheries (Table 21d). Some researchers have hypothesized that differences in ocean distribution and migratory characteristics may affect how different

salmon species respond to changing ocean conditions (Hill et al. 2003). Even though Select Area Coho releases have trended upward since the 2003 brood year (Table 19a), adult returns and harvest have not grown proportionally (Figure 19d). Large inter-annual fluctuations in Coho returns can make fisheries relying on this species more unpredictable, and poses a risk for Select Area fisheries where Coho can often comprise the majority of the year's commercial harvest (Figure 19e).

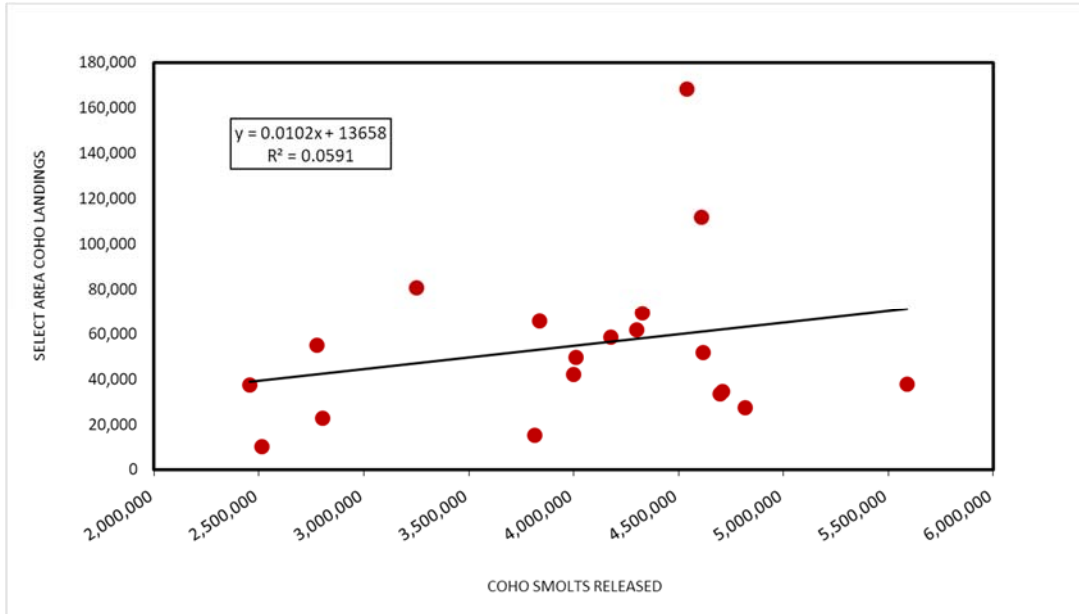


Figure 19d. Annual Coho releases and corresponding adult harvest in Select Area commercial fisheries, 1999-2017. Releases adjusted to return year.

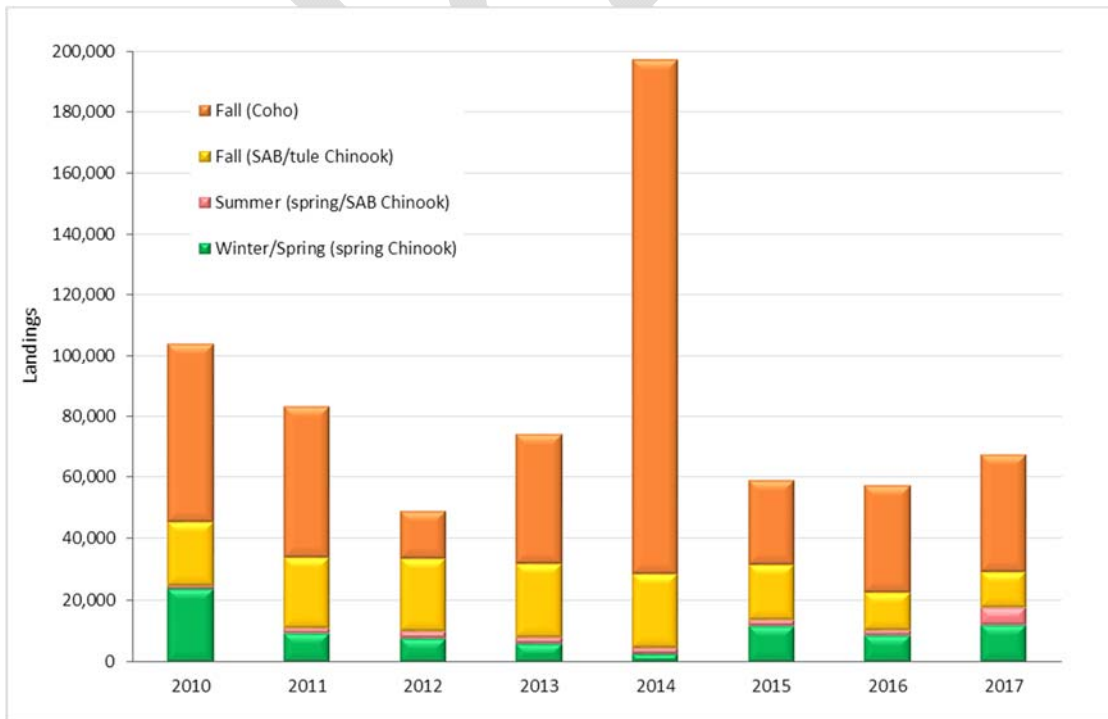


Figure 19e. Annual commercial salmon landings, by season (species/stock), in Select Areas, 2010-2017.

Examination of median harvest pre- and post-Harvest Reform indicated that median harvest was lower during the post-Reform years for all Select Area seasons, except for the summer season, where harvest was similar between the two periods (Table 19e). This suggests that, although smolt releases in the current Select Areas were enhanced due to the Harvest Reform Policy, other factors, such as poor ocean survival, likely had a stronger influence on adult returns and subsequent harvest in the Select Areas.

Prior to implementation of the Harvest Reform Policy, Department staff projected future Select Area harvest based on modelled increases in smolt releases proposed by the Policy. Table 19g compares actual Select Area harvest for 2013-2017 to the expected harvest numbers. Select Area harvest of SAFE stock adult spring Chinook was lower than expected in 3 out of 5 years since implementation of the policy, and ranged from 35% of expected harvest in 2014 to 152% of expected harvest in 2017. The SAB fall Chinook return was exceptionally strong in 2013, resulting in a SAB harvest that was 3.5 times greater than expected. Since 2013, SAB returns have decreased at a steady rate, culminating in a 2017 SAB harvest that was half of what was projected for that year. Partly because of declining SAB runs, the harvest of all fall Chinook in the Select Areas (including non-SAB stocks) also failed to meet expectations in recent years, dropping from 130% of expected in 2013 and 2014 to 60% of expected in 2017. With the exception of 2014, when Coho returned to both the Select Areas and mainstem Columbia in unusually high numbers, Select Area Coho harvest failed to meet expectations during the post-Reform period. In recent years, Coho harvest has averaged less than half of what was expected. Overall, salmon harvest in the Select Areas during implementation of the Harvest Reform Policy met expectations about half of the time, even though it was assumed that Select Area commercial harvest would increase steadily due to the enhanced releases proposed by the Policy. Changes in ocean productivity and salmon survival rates are difficult to predict, and their effects can sometimes offset increased production and expected gains in adult harvest.

Table 19g. Expected and actual Select Area salmon harvest, 2013-2017.

Return Year	Spring Chinook ¹			SAB Fall Chinook ²			All Fall Chinook ³			Coho ⁴		
	Expected ⁵	Actual	% of Expected	Expected ⁵	Actual	% of Expected	Expected ⁵	Actual	% of Expected	Expected ⁵	Actual	% of Expected
2013	6,234	5,042	81%	4,350	15,288	351%	18,528	24,142	130%	58,380	40,344	69%
2014	6,250	2,164	35%	4,350	9,761	224%	18,528	24,117	130%	69,580	160,696	231%
2015	8,805	11,055	126%	4,995	6,798	136%	19,173	18,087	94%	69,580	26,132	38%
2016	9,951	8,605	86%	5,775	4,140	72%	19,953	12,431	62%	69,580	33,115	48%
2017	10,000	15,210	152%	5,850	2,858	49%	20,028	12,034	60%	69,580	36,221	52%

¹ SAFE stock adult spring Chinook.

² Adult SAB fall Chinook.

³ Expected includes a base number of non-SAB fall Chinook (14,178). Includes adults and jacks.

⁴ SAFE stock adult and jack Coho.

⁵ Expected harvest from Table C4 of Management Strategies for Columbia River Recreational and Commercial Fisheries: 2013 and Beyond (ODFW 2012). Based on modelling prior to implementation of the Harvest Reform Policy.

Harvest rates of Select Area stock spring Chinook, Coho, and SAB fall Chinook were also modelled prior to implementation of the Harvest Reform Policy, and are compared to actual harvest rates in the Select Areas during 2013-2017 in Table 19h. Harvest rates for SAB fall Chinook were initially higher than expected, largely due to better than anticipated survival for adults returning in 2013-2015, but overall, there has been a steady decline in SAB harvest and harvest rates during the post-Harvest Reform period (Table 19g, Table 19h). Harvest rates for Select Area stock spring Chinook fluctuated during 2013-2017, meeting expectations in 2015 and 2017 when returns to Oregon Select Area sites were strong. Coho harvest rates met expectations

in 2014, when a record number of Coho returned to the Select Areas, but were well below expectations in the remaining years.

Table 19h. Expected and actual harvest rates for Select Area stock salmon, 2013-2017.

Species/Stock ¹	Expected Harvest Rate	Actual Harvest Rate				
	2013-2017	2013	2014	2015	2016	2017
Spring Chinook	0.50%	0.36%	0.15%	0.66%	0.47%	0.85%
Coho	1.40%	0.79%	3.34%	0.55%	0.59%	0.76%
SAB Fall Chinook	0.30%	1.35%	0.72%	0.42%	0.20%	0.15%

¹ Select Area stock only.

Select Area Ex-vessel Value

Commercial ex-vessel values for Select Area salmon fisheries (including non-SAFE stocks) during 2010-2017 are shown in Table 19i. Ex-vessel values prior to 2010 can be found in Duff et al. 2013. Total annual ex-vessel value ranged from \$1.3 million in 2012 to \$2.6 million in 2010. Ex-vessel values for each season/species/stock varied considerably among years, primarily due to fluctuations in adult returns and harvest, although inter-annual differences in average fish weights and prices can also have a significant effect on ex-vessel value. For example, during 2010-2017, the average weight of spring Chinook caught during the winter/spring season varied from 10.9 to 14.1 pounds, while the average price per pound ranged from \$4.90 to \$8.69. Because of these changes in fish weights and prices from year to year, it is difficult to directly compare ex-vessel value between different periods, or between modelled and actual values. Coho usually represented the largest share of total annual landings in the Select Areas (Figure 19e); however, spring Chinook accounted for the largest share of total annual ex-vessel value (Figure 19f). This is because of the larger size of Chinook compared to Coho, and the much higher price per pound garnered by spring Chinook. Overall, spring Chinook accounted for nearly half of the Select Areas' ex-vessel value, with only a small portion coming from the summer season. The ex-vessel value derived from Harvest Reform-related increases in smolt production accounted for 1% to 18% of total annual ex-vessel value for the Select Areas between 2013 and 2017 (Figure 19g). The contribution of these enhanced releases to total ex-vessel value has leveled off in recent years, potentially due to the effects of changing ocean conditions.

Table 19i. Commercial ex-vessel value by season (species/stock) for the Select Areas, 2010-2017.

	Winter/Spring (spring Chinook)	Summer (spring/SAB Chinook)	Fall (SAB/tule Chinook)	Fall (Coho)	Select Area Total
2010	\$1,375,948	\$45,993	\$418,353	\$786,258	\$2,626,552
2011	\$749,169	\$87,220	\$621,791	\$755,059	\$2,213,239
2012	\$572,902	\$115,603	\$441,429	\$173,493	\$1,303,427
2013	\$606,985	\$140,296	\$779,085	\$569,780	\$2,096,146
2014	\$252,750	\$101,146	\$497,362	\$1,622,922	\$2,474,179
2015	\$852,197	\$72,849	\$378,842	\$297,190	\$1,601,077
2016	\$813,797	\$112,743	\$301,281	\$428,588	\$1,656,409
2017	\$1,154,915	\$308,828	\$323,253	\$581,649	\$2,368,645

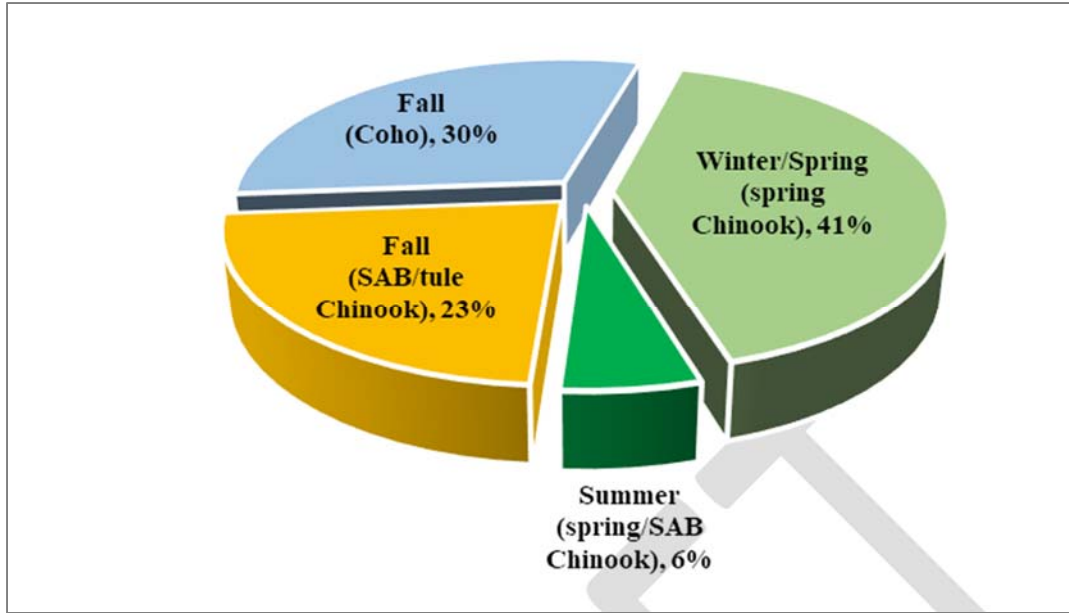


Figure 19f. Median contribution of seasonal fisheries to total annual Select Area ex-vessel value, 2010-2017.

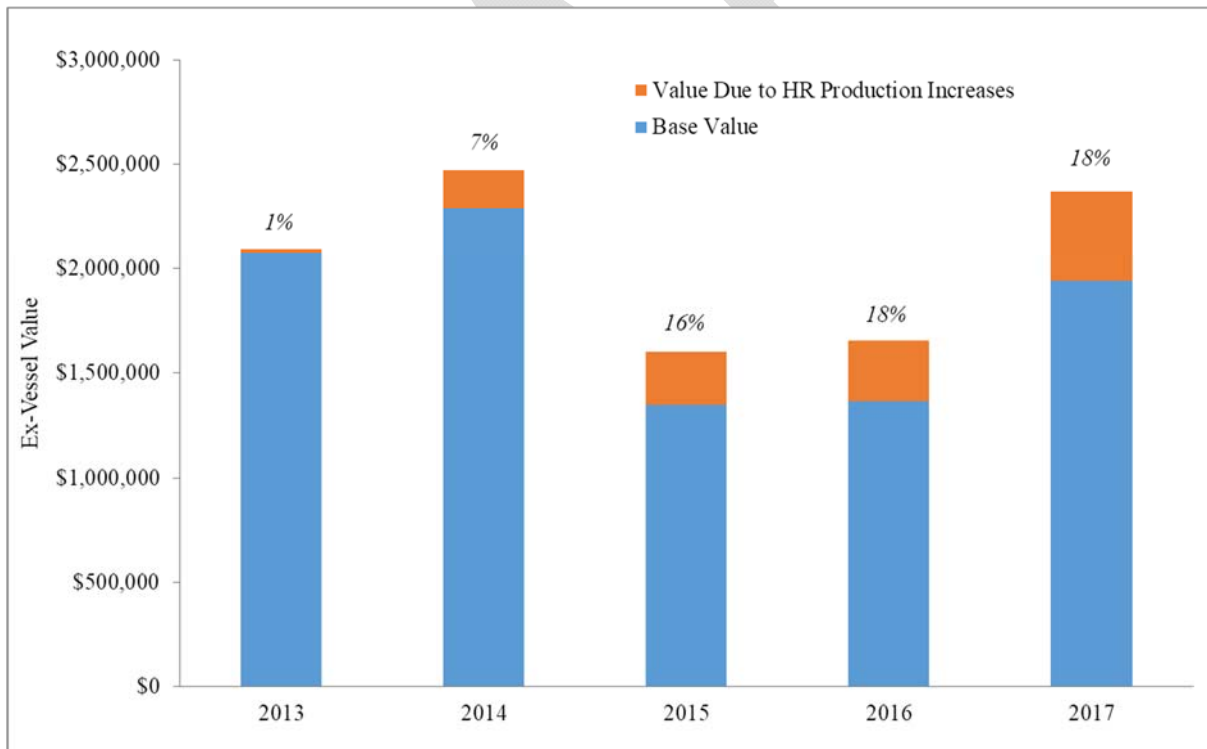


Figure 19g. Total annual ex-vessel value for the Select Areas partitioned into base value and value due to enhanced smolt releases from the Harvest Reform Policy, 2013-2017. Percentages in italics indicate the percent of total value attributed to Harvest Reform-related changes in releases.

ESA Impacts

From 2008-2016, the Select Areas were annually allocated a fixed 0.150% in ESA impacts for upriver spring Chinook to prosecute spring Chinook fisheries. Beginning in 2017, Select Area fisheries are allocated the full 20% non-treaty commercial upriver spring Chinook impact allocation and are no longer subjected to run size buffering limits. Table 19j shows the impacts used by each of the Select Area sites during 2010-2017, as well as how the total impacts used compares to the amount allocated to the Select Areas. To some degree, impact use by site corresponds with landings, as Youngs Bay has both the highest spring Chinook landings and impact usage, while Deep River has the lowest landings and impact usage (Table 19e, Table 19j). However, landings do not appear to correspond with impact use for Tongue Point/South Channel and Blind Slough/Knappa Slough. Although Blind Slough typically has a higher harvest of spring Chinook than Tongue Point (Table 19e), the latter usually uses more ESA impacts. This is likely related to Tongue Point's closer proximity to the main Columbia River channel, and the greater likelihood for upriver spring Chinook to be pushed into the area under certain river conditions, such as high flow.

During 2010-2016, when the fishery was restricted to a fixed 0.150% allocation, combined Select Area fisheries used more than the allocated ESA impacts in 5 out of the 7 years. In 2017, despite a higher allocation of impacts for Select Area fisheries of 0.300%, the fishery used 0.400% impact. When this occurs, fishery managers generally have to use impacts allocated to other fisheries (usually mainstem commercial) to allow the Select Area fisheries to continue. The tendency for the current Select Area fisheries to exceed their allotted ESA impacts in some years would make it difficult to expand opportunities in existing or new sites. The impact requirements for expanded and new Select Area sites are addressed later in this report (Expanded and New Select Area Evaluations).

Table 19j. Upriver spring Chinook impacts used by Select Area sites, 2010-2017.

	Youngs Bay	Tongue Point/ South Channel	Blind Slough/ Knappa Slough	Deep River	Total SAFE Impacts Used	Total SAFE Impacts Allocated	% of Allocated
2010	0.416%	0.024%	0.022%	0.010%	0.471%	0.150%	314%
2011	0.078%	0.036%	0.018%	0.005%	0.138%	0.150%	92%
2012	0.144%	0.013%	0.002%	0.003%	0.162%	0.150%	108%
2013	0.175%	0.026%	0.007%	0.004%	0.211%	0.150%	141%
2014	0.085%	0.002%	0.017%	0.003%	0.107%	0.150%	71%
2015	0.218%	0.045%	0.009%	0.006%	0.278%	0.150%	186%
2016	0.122%	0.046%	0.016%	0.000%	0.185%	0.150%	123%
2017	0.319%	0.066%	0.014%	0.002%	0.400%	0.300%	133%
Avg	0.195%	0.032%	0.013%	0.004%	0.244%	0.169%	145%

Economics

We examined the economic performance of current Select Area commercial fisheries by comparing actual landings and ex-vessel values for 2013-2017 to estimated costs associated with using gillnets to commercially harvest salmon in the Select Areas. As mentioned earlier in this report, it is difficult to determine the actual costs associated with any given commercial fishery, and the harvest-related costs taken from the 2013 FIS are in 2013 dollars (Table 17k); therefore, the net economic returns that we have calculated, are best viewed as close approximations. Nevertheless, because harvest-related costs have been applied to all commercial fisheries in this report in a standardized manner, the results of the analyses are still useful for comparing relative economic returns in different Columbia River commercial fisheries.

To estimate the average number of vessels/fishers participating in each Select Area fishery, we used deliveries as a surrogate for participating vessels, and divided the total number of deliveries made during the season by the number of open fishing days with at least one delivery. This assumes that each vessel participating in a fishing period makes one delivery, which is not necessarily the case during certain times of the season. Therefore, adjustments to deliveries were made when we deemed they were necessary and possible. We defined a fishing day as a single fishing period in a Select Area site, ranging in duration from 4 to 24 hours. Based on past information, we assumed that most vessels participating in Select Area gillnet fisheries had one fisher onboard. Therefore, crew pay and liability insurance costs did not apply to these fisheries (Table 17k). As fishers participating in Select Area gillnet fisheries already had the necessary boats, nets, and rigging, we did not include any capital costs, but we did include recurring annual and daily operating costs based on the number of vessels participating in each fishery. We assumed that fishers would have to replace half of their large mesh (≥ 7 -in) and small mesh (≤ 6 -in) gillnets each year due to damage from snags and sea lions, at an annual cost of approximately \$1,250 per net (S. Garber, Englund Marine and Industrial Supply, personal communication). These partial net replacement costs were applied to the winter/spring and fall fisheries since these were the seasons when most damage was expected to occur. A lower annual net repair cost of \$667 was applied to the shorter summer fishery to account for damage incurred during that season. Furthermore, fuel costs of \$150 per day were applied to each participating vessel (Table 17k).

Select Area Winter/Spring Fishery

In Select Area commercial fisheries, the number of deliveries made for a given fishing period is an approximation of the number of fishing vessels/fishers that participated during the period. During the winter season (mid-February through March), spring Chinook abundance is relatively low and not all fishers may catch fish and make a delivery. Therefore, the number of deliveries during winter periods can underestimate the number of participating fishers. In 2014, ODFW conducted vessel counts at viewpoints, and in the air by helicopter, in Youngs Bay during the winter/spring season. The counts were done at set times during the day on a select number of days. We compared daily peak vessel counts to corresponding deliveries for the same day to calculate expansion factors for February (1.72 vessels/delivery) and March (1.23 vessels/delivery) that would enable us to convert the number of deliveries for these months to an estimate of the number of participating vessels. Because we believed that these relationships held true for early season

spring Chinook fisheries in general, we applied the expansion factors to winter deliveries for all the Select Area sites. In addition, any “0” delivery for a fishing period late in the spring season when Chinook abundance is once again low, was counted as 1 vessel since anecdotal information suggested that some fishing effort was likely to have occurred.

The results of our economic analysis for the Select Area winter/spring fishery are shown in Table 19k. Average net return per vessel varied considerably among sites and was usually higher in Youngs Bay and Blind Slough/Knappa Slough, and lower in Deep River. Although net return per vessel was negative for Deep River in 2014, 2016, and 2017, and for Tongue Point/South Channel in 2014, this does not suggest that fishers in those areas all suffered economic losses, since individual fishers can vary greatly in their landings and actual operating costs. However, the negative values do indicate that economic conditions during the winter/spring season were not favorable for these sites in those years.

Table 19k. Comparison of landings and ex-vessel value to estimated harvest costs for the 2013-2017 Select Area winter/spring fisheries.

Year	Site	Days Fished	Avg # of Vessels ¹	Chinook Landed ²	Total Ex-Vessel Value	Costs			Net Fishery Return	Net Return/Vessel
						Annual	Daily	Total		
2013	Youngs Bay	47	23	4,626	\$453,686	\$29,103	\$162,515	\$191,617	\$262,068	\$11,369
	Tongue Point/South Channel	24	5	374	\$41,161	\$6,493	\$18,516	\$25,009	\$16,152	\$3,140
	Blind Slough/Knappa Slough	32	8	936	\$95,957	\$9,632	\$36,621	\$46,253	\$49,704	\$6,515
	Deep River	32	2	124	\$16,182	\$2,231	\$8,481	\$10,712	\$5,470	\$3,096
	Total	135	38	6,060	\$606,985	\$47,459	\$226,133	\$273,591	\$333,394	\$8,869
2014	Youngs Bay	49	13	2,197	\$184,367	\$16,505	\$96,090	\$112,595	\$71,772	\$5,490
	Tongue Point/South Channel	25	2	72	\$10,067	\$2,778	\$8,250	\$11,028	(\$961)	(\$437)
	Blind Slough/Knappa Slough	32	5	467	\$50,166	\$6,630	\$25,208	\$31,838	\$18,328	\$3,490
	Deep River	32	2	65	\$8,150	\$2,285	\$8,688	\$10,973	(\$2,824)	(\$1,560)
	Total	138	22	2,801	\$252,750	\$28,198	\$138,236	\$166,433	\$86,316	\$3,865
2015	Youngs Bay	43	24	7,308	\$528,569	\$30,061	\$153,581	\$183,642	\$344,927	\$14,486
	Tongue Point/South Channel	24	6	1,262	\$87,322	\$7,158	\$20,412	\$27,570	\$59,752	\$10,538
	Blind Slough/Knappa Slough	34	8	3,117	\$213,805	\$10,282	\$41,535	\$51,817	\$161,988	\$19,890
	Deep River	30	2	204	\$22,500	\$3,033	\$10,811	\$13,843	\$8,657	\$3,603
	Total	131	40	11,891	\$852,197	\$50,535	\$226,338	\$276,873	\$575,324	\$14,373
2016	Youngs Bay	49	19	4,858	\$500,839	\$23,778	\$138,432	\$162,210	\$338,629	\$17,979
	Tongue Point/South Channel	33	5	1,106	\$91,183	\$6,139	\$24,069	\$30,208	\$60,975	\$12,540
	Blind Slough/Knappa Slough	44	9	2,617	\$212,196	\$10,794	\$56,426	\$67,219	\$144,977	\$16,958
	Deep River	35	2	79	\$9,579	\$2,670	\$11,105	\$13,775	(\$4,196)	(\$1,984)
	Total	161	34	8,660	\$813,797	\$43,381	\$230,031	\$273,412	\$540,385	\$15,727
2017	Youngs Bay	57	21	7,976	\$750,566	\$26,616	\$180,254	\$206,870	\$543,696	\$25,789
	Tongue Point/South Channel	27	8	2,034	\$201,368	\$10,416	\$33,414	\$43,830	\$157,538	\$19,095
	Blind Slough/Knappa Slough	42	8	2,100	\$199,515	\$10,038	\$50,090	\$60,127	\$139,388	\$17,531
	Deep River	25	1	21	\$3,466	\$1,746	\$5,186	\$6,931	(\$3,466)	(\$2,506)
	Total	151	39	12,131	\$1,154,915	\$48,816	\$268,943	\$317,759	\$837,156	\$21,651

¹ Average number of vessels fishing during the season. Approximated using adjusted average number of deliveries per day.

² Includes adults and jacks.

Select Area Summer Fishery

Select Area summer fisheries primarily harvest late arriving SAFE stock spring Chinook, as well as some early SAB fall Chinook in Youngs Bay. Analysis of landings and deliveries during the summer season suggested that the number of deliveries was probably a sufficient surrogate for the

number of vessels/fishers participating in the summer fishery; therefore, no adjustments were made to summer daily deliveries as we had done for the winter/spring fishery.

The results of our summer fishery analysis are presented in Table 19l. Average net return per vessel for the summer fishery was positive in all years, and was substantially higher in 2016 and 2017. The unusually late spring Chinook run in 2017 likely contributed to the strong economic showing during that year’s summer fishery. It should be noted that the expanded portion of the spring seasons in Tongue Point/South Channel and Blind Slough/Knappa Slough were re-categorized as “summer” seasons in 2017; therefore, economic returns for this period prior to 2017 were included in the winter/spring season.

Table 19l. Comparison of landings and ex-vessel value to estimated harvest costs for the 2013-2017 Select Area summer fisheries.

Year	Site	Days Fished	Avg # of Vessels ¹	Chinook Landed ²	Total Ex-Vessel Value	Costs			Net Fishery Return	Net Return/Vessel
						Annual	Daily	Total		
2013	Youngs Bay	12	32	2,022	\$140,296	\$21,122	\$57,000	\$78,122	\$62,174	\$1,963
2014	Youngs Bay	21	18	1,842	\$101,146	\$11,784	\$55,650	\$67,434	\$33,712	\$1,908
2015	Youngs Bay	21	14	1,779	\$72,849	\$9,656	\$45,600	\$55,256	\$17,593	\$1,215
2016	Youngs Bay	21	12	1,836	\$112,743	\$7,782	\$36,750	\$44,532	\$68,211	\$5,847
2017	Youngs Bay	17	20	2,822	\$169,053	\$13,615	\$52,050	\$65,665	\$103,388	\$5,065
	Tongue Point/South Channel	12	10	1,483	\$74,838	\$6,337	\$17,100	\$23,437	\$51,402	\$5,411
	Blind Slough/Knappa Slough	12	10	1,161	\$64,937	\$6,726	\$18,150	\$24,876	\$40,061	\$3,973
Total		41	40	5,466	\$308,828	\$26,677	\$87,300	\$113,977	\$194,851	\$4,872

¹ Average number of vessels fishing during the season. Approximated using average number of deliveries per day.

² Includes adults and jacks.

Select Area Fall Fishery

The fall season in the Select Areas offers the opportunity to harvest Coho, as well as SAB (Youngs Bay) and tule fall Chinook. Therefore, our analysis of economic viability for the fall fishery used the combined landings and ex-vessel values for all fall salmon. Analysis of landings and deliveries during the fall season suggested that the number of daily deliveries late in the season (mid-late October) may underrepresent the number of vessels participating in late season fishing periods due to the low abundance of SAFE stock fall Chinook and Coho at that time. However, since we did not have vessel counts to compare to delivery numbers late in the fall season to formulate an expansion factor for deliveries, we used unadjusted deliveries as an approximation of the number of vessels participating in the fishery.

The results of our fall fishery analysis are displayed in Table 19m. Average net return per vessel varied among sites during the fall season, with economic returns generally higher in the Tongue Point/South Channel and Youngs Bay sites and lower in the Blind Slough/Knappa Slough and Deep River sites. The record Coho return to the Select Areas in 2014 was responsible for the strong economic performance that year in all sites. The lower economic returns in 2015-2017 reflect reduced returns of all fall SAFE stocks, particularly SAB fall Chinook.

Table 19m. Comparison of landings and ex-vessel value to estimated harvest costs for the 2013-2017 Select Area fall fisheries.

Year	Site	Days Fished	Avg # of Vessels ¹	Salmon Landed ²	Total Ex-Vessel Value	Costs			Net Fishery Return	Net Return/Vessel
						Annual	Daily	Total		
2013	Youngs Bay	55	23	28,614	\$740,788	\$28,601	\$186,900	\$215,501	\$525,287	\$23,187
	Tongue Point/South Channel	29	12	19,993	\$347,502	\$14,715	\$50,700	\$65,415	\$282,087	\$24,203
	Blind Slough/Knappa Slough	34	6	6,244	\$98,031	\$6,944	\$28,050	\$34,994	\$63,037	\$11,461
	Deep River	29	23	11,594	\$162,544	\$28,820	\$99,300	\$128,120	\$34,424	\$1,508
	Total	147	63	66,445	\$1,348,865	\$79,080	\$364,950	\$444,030	\$904,836	\$14,446
2014	Youngs Bay	58	24	77,767	\$966,149	\$29,886	\$205,950	\$235,836	\$730,313	\$30,851
	Tongue Point/South Channel	41	13	56,212	\$598,456	\$16,720	\$81,450	\$98,170	\$500,286	\$37,775
	Blind Slough/Knappa Slough	46	9	29,286	\$294,861	\$11,555	\$63,150	\$74,705	\$220,156	\$24,055
	Deep River	36	12	29,349	\$260,818	\$15,746	\$67,350	\$83,096	\$177,721	\$14,249
	Total	181	59	192,614	\$2,120,284	\$73,908	\$417,900	\$491,808	\$1,628,476	\$27,818
2015	Youngs Bay	69	14	18,228	\$274,744	\$17,108	\$140,250	\$157,358	\$117,386	\$8,663
	Tongue Point/South Channel	42	9	13,335	\$183,037	\$11,212	\$55,950	\$67,162	\$115,875	\$13,048
	Blind Slough/Knappa Slough	43	4	5,103	\$83,786	\$5,079	\$25,950	\$31,029	\$52,756	\$13,113
	Deep River	36	12	8,822	\$134,465	\$15,115	\$64,650	\$79,765	\$54,700	\$4,569
	Total	190	38	45,488	\$676,032	\$48,514	\$286,800	\$335,314	\$340,718	\$8,867
2016	Youngs Bay	51	16	22,182	\$363,842	\$20,571	\$124,650	\$145,221	\$218,621	\$13,417
	Tongue Point/South Channel	33	9	13,291	\$177,141	\$10,827	\$42,450	\$53,277	\$123,864	\$14,444
	Blind Slough/Knappa Slough	35	5	3,520	\$66,962	\$6,745	\$28,050	\$34,795	\$32,167	\$6,020
	Deep River	43	8	8,161	\$121,924	\$10,335	\$52,800	\$63,135	\$58,789	\$7,182
	Total	162	38	47,154	\$729,869	\$48,478	\$247,950	\$296,428	\$433,441	\$11,288
2017	Youngs Bay	57	16	19,880	\$382,650	\$20,532	\$139,050	\$159,582	\$223,068	\$13,716
	Tongue Point/South Channel	28	12	14,785	\$256,488	\$15,511	\$51,600	\$67,111	\$189,377	\$15,414
	Blind Slough/Knappa Slough	31	6	4,096	\$74,563	\$7,860	\$28,950	\$36,810	\$37,753	\$6,064
	Deep River	35	12	11,252	\$191,202	\$14,645	\$60,900	\$75,545	\$115,657	\$9,970
	Total	151	46	50,013	\$904,902	\$58,548	\$280,500	\$339,048	\$565,854	\$12,202

¹ Average number of vessels fishing during the season. Approximated using average number of deliveries per day.

² Includes Chinook and Coho (adults and jacks).

Economics Summary

Median net return per vessel for all Select Area sites combined during 2013-2017 was \$14,373 in the winter/spring fishery, \$1,963 in the summer fishery, and \$12,202 in the fall fishery. This does not imply that the typical Select Area fisher earned approximately \$28,000 per year because these figures are for all sites combined, and most Select Area fishers only fish one, or two sites at most. However, it does indicate that the winter/spring fishery provided the highest economic return during the year, likely due to the high value of spring Chinook. Although many more salmon are harvested during the fall season, their value per fish (particularly for tule fall Chinook) is lower than in the spring, and fall harvest costs are slightly higher due to a longer season. Nevertheless, the fall fishery provided a significant contribution to the economic performance of the Select Areas. Although the summer season is relatively short, and landings are modest, the Select Area summer fishery provides an important economic “bridge” between the larger spring and fall fisheries. The variation in net return per vessel among sites, and between seasons and years, illustrates the importance of providing a variety of fishery opportunities, in case one or two fisheries perform poorly in a given year. Our analyses indicated that Select Area commercial gillnet fisheries, overall, provide a net positive economic return because of the variety of fishery opportunities, i.e., salmon stocks and fishing seasons, which help to buffer against downturns in any one season, as well as the relatively low costs associated with salmon harvest using gillnets. The potential loss of SAB fall Chinook production in Youngs Bay due to NOAA Fisheries’

concerns over straying would negatively impact the Select Area summer and fall fisheries, and reduce the diversity of fishing opportunities in the Select Areas.

Youngs Bay Closure Zone

The Youngs Bay Closure Zone (YBCZ), also known as Control Zone, is an area at the mouth of Youngs Bay that is closed to recreational fishing during August 1 to September 15. It was established in 2014 by the OFWC as a result of Harvest Reform-related legislation (Senate Bill 830) passed by the 2013 Oregon Legislature. The closure is intended to increase the number of hatchery salmon (SAB fall Chinook and Coho) returning to the Youngs Bay Select Area by reducing the number of fish intercepted by recreational anglers.

The YBCZ includes waters north of the Hwy 101 Bridge to a line projected from the east end of the seawall at the Warrenton Fiber log yard, northeasterly through four green navigational buoys, to the Astoria-Megler Bridge abutment adjacent to, and north, of the ship channel. The control zone is bordered on the upstream end (heading up the Columbia) by the center of the Astoria-Megler Bridge (Figure 19h).

The YBCZ encompasses approximately 4.7 mi², which constitutes about 4% of the fishable area available to the popular Buoy 10 recreational fishery. The Buoy 10 fishery extends from August 1 into the month of October; however, most of the angling effort occurs in August and early September.



Figure 19h. Aerial view of the Youngs Bay Closure Zone area.

We attempted to assess the effectiveness of the YBCZ in meeting its objective of reducing recreational harvest of SAB fall Chinook by analyzing recreational and commercial harvest, as well as harvest shares for this stock. SAB harvest was based on analysis of CWT data from the respective fisheries.

Harvest shares of adult SAB fall Chinook for the Buoy 10 sport and Youngs Bay commercial fisheries have fluctuated over the last 18 years, but the Buoy 10 share of the SAB harvest has trended upward since 2009 (Figure 19i). This increase in the Buoy 10 harvest share does not appear to be positively associated with the strength of the SAB return. On the contrary, there may be some tendency for the Buoy 10 harvest share to be higher in years when the SAB return is lower. In the four years just prior to implementation of the YBCZ (2010-2013), the Buoy 10 share of the SAB harvest averaged 21%, while in the four years since implementation of the YBCZ, it has doubled to an average of 42% (Table 19n). Between these two periods, the average SAB return decreased, but average angler effort in the Buoy 10 fishery increased substantially. Figure 19j shows a moderately strong positive relationship ($R^2 = 0.44$) between Buoy 10 angler effort and the Buoy 10 share of SAB harvest during 2000-2017.

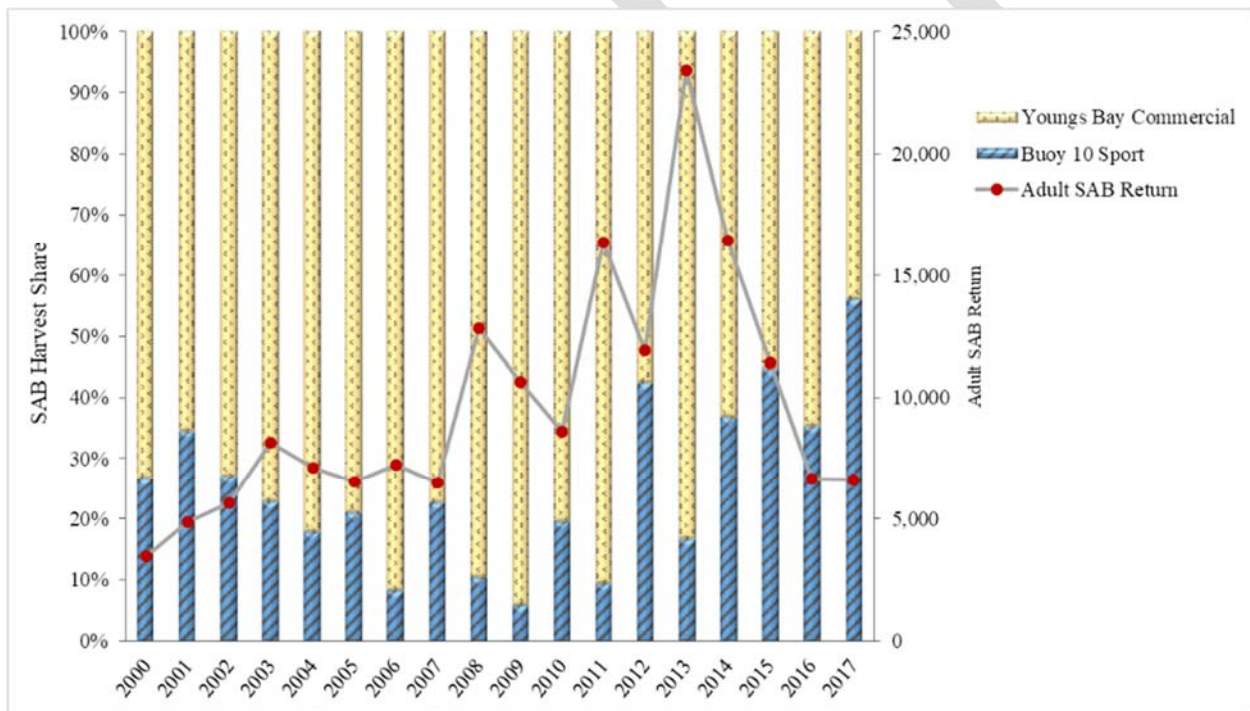


Figure 19i. Harvest shares of adult SAB fall Chinook for the Youngs Bay Select Area commercial fishery and the Buoy 10 sport fishery, 2000-2017.

Overall, it is difficult to accurately assess the effectiveness of the YBCZ. Although the Buoy 10 SAB harvest and harvest share actually increased after implementation of the closure area in 2014, this may have been due to other confounding factors. From 2014-2017, there was a significant increase in angler effort in the Buoy 10 fishery, and in recent years, anglers accustomed to the large Chinook returns in 2014 and 2015 have been fishing in greater numbers during the first half of August, when SABs are more abundant in the fishery area. These changes in the dynamics of the Buoy 10 fishery may have overwhelmed any reduction in SAB harvest that might have been

attributed to the YBCZ. However, it is also possible that the YBCZ may have tempered what could have been an even greater increase in the Buoy 10 share of the SAB harvest had the closure area not existed.

Table 19n. Harvest and harvest shares of adult SAB fall Chinook for the Buoy 10 sport fishery and Youngs Bay Select Area commercial fishery, 2000-2017.

Year	Adult SAB Return	Buoy 10 Angler Trips	SAB Harvest		SAB Harvest Share	
			Buoy 10 Sport	Youngs Bay Commercial	Buoy 10 Sport	Youngs Bay Commercial
2000	3,472	72,518	428	1,181	27%	73%
2001	4,862	125,829	850	1,624	34%	66%
2002	5,681	84,434	694	1,873	27%	73%
2003	8,134	88,827	1,004	3,391	23%	77%
2004	7,097	68,818	465	2,137	18%	82%
2005	6,551	55,183	769	2,884	21%	79%
2006	7,232	40,608	238	2,638	8%	92%
2007	6,493	36,064	932	3,180	23%	77%
2008	12,854	32,467	836	7,192	10%	90%
2009	10,629	72,803	334	5,399	6%	94%
2010	8,617	52,300	901	3,730	19%	81%
2011	16,358	49,409	996	9,623	9%	91%
2012	11,935	65,070	3,728	5,085	42%	58%
2013	23,393	65,767	2,320	11,591	17%	83%
2014	16,462	107,522	3,893	6,697	37%	63%
2015	11,440	108,213	3,527	4,376	45%	55%
2016	6,676	94,950	1,498	2,758	35%	65%
2017	6,617	93,547	2,957	2,328	56%	44%
2010-2013 Avg	15,076	58,137	1,986	7,507	21%	79%
2014-2017 Avg	10,299	101,058	2,969	4,040	42%	58%

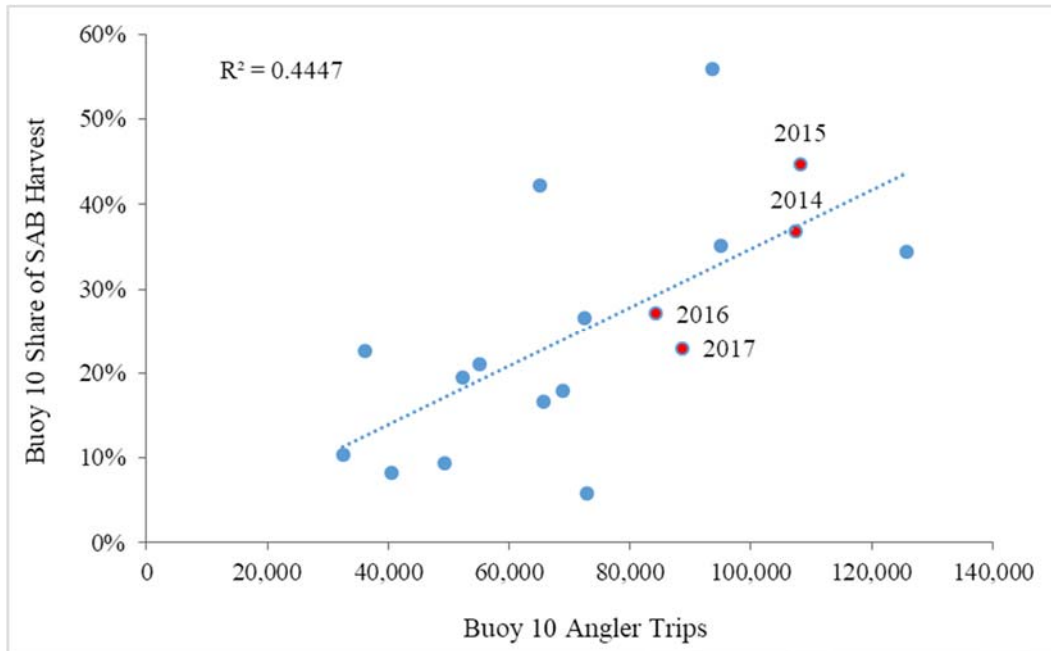


Figure 19j. Relationship between angler effort in the Buoy 10 fishery and the Buoy 10 share of the adult SAB fall Chinook harvest, 2000-2017 (2014-2017 data points labeled to indicate years when YBCZ was in effect).

Select Area Recreational Fisheries

Although we have focused on commercial fisheries in the Select Areas, which is the reason why they were created, recreational fishing is allowed in most of the Select Area sites. Beginning in 1998, a year-round recreational season was opened for Chinook and adipose fin-clipped Coho in Youngs Bay, Tongue Point, and Blind Slough. Similar seasons were adopted for South Channel and Knappa Slough in 1999 and for Deep River in 2000. In 2003, regulations were adopted to allow year-round angling for adipose fin-clipped steelhead in all Oregon Select Areas sites. To maintain consistency with mainstem recreational spring Chinook fisheries, mark-selective regulations were permanently adopted for Select Area recreational spring Chinook fisheries effective January 1, 2004. Also in 2004, classification of Tongue Point and South Channel as Select Area recreational fishing sites was rescinded due to discontinuation of production-level spring Chinook releases, and because these areas were already open to angling concurrent with the mainstem Columbia River. Impacts to non-local Chinook and steelhead (including natural-origin fish) are expected to be minimal since the majority of recreational fishing effort is concentrated in upper tidewater areas or in the tributaries.

Most recreational fishing in the Select Areas occurs for spring Chinook. Recreational harvest is estimated from catch record cards (also referred to as “punch cards”), which are turned in voluntarily by anglers. The reported catch is expanded by a reporting rate to estimate total recreational harvest. Catch record card data are not available for at least one year post-fishery, so preliminary estimates are made for the current year by correlating trends in previous year estimates, Select Area commercial landings, and spring Chinook run-size information. Recreational harvest of spring Chinook in the Select Areas during 1998-2017 is illustrated in

Figure 19k. In most years, spring Chinook harvest has been less than 1,000 fish; however, in years with strong returns, such as 2010, 2015, and 2017, harvest can be considerably higher. Effort and harvest in Select Area recreational fisheries has increased in recent years as returns of adult spring Chinook and productive fishing opportunities have increased. The percentage of the recreational spring Chinook harvest (mainstem and off-channel recreational fisheries downstream of Bonneville Dam) attributed to Select Area recreational fisheries increased from an average of 5% during the 2010-2012 pre-Reform period to 7% during the 2013-2017 post-Reform period. In addition, recreational fisheries accounted for an average of 7% of the Select Area winter/spring season Chinook harvest in 2010-2012 and 10% in 2013-2017. With planned increases in Select Area spring Chinook production, per the Harvest Reform Policy, recreational harvest in the Select Areas could increase in the future, particularly if the fishery becomes more popular, and if enhanced production translates into increased adult returns. Some recreational fishing also occurs in the Select Areas during the fall, with harvest averaging approximately 750 Chinook and 350 Coho annually in Oregon Select Area sites.

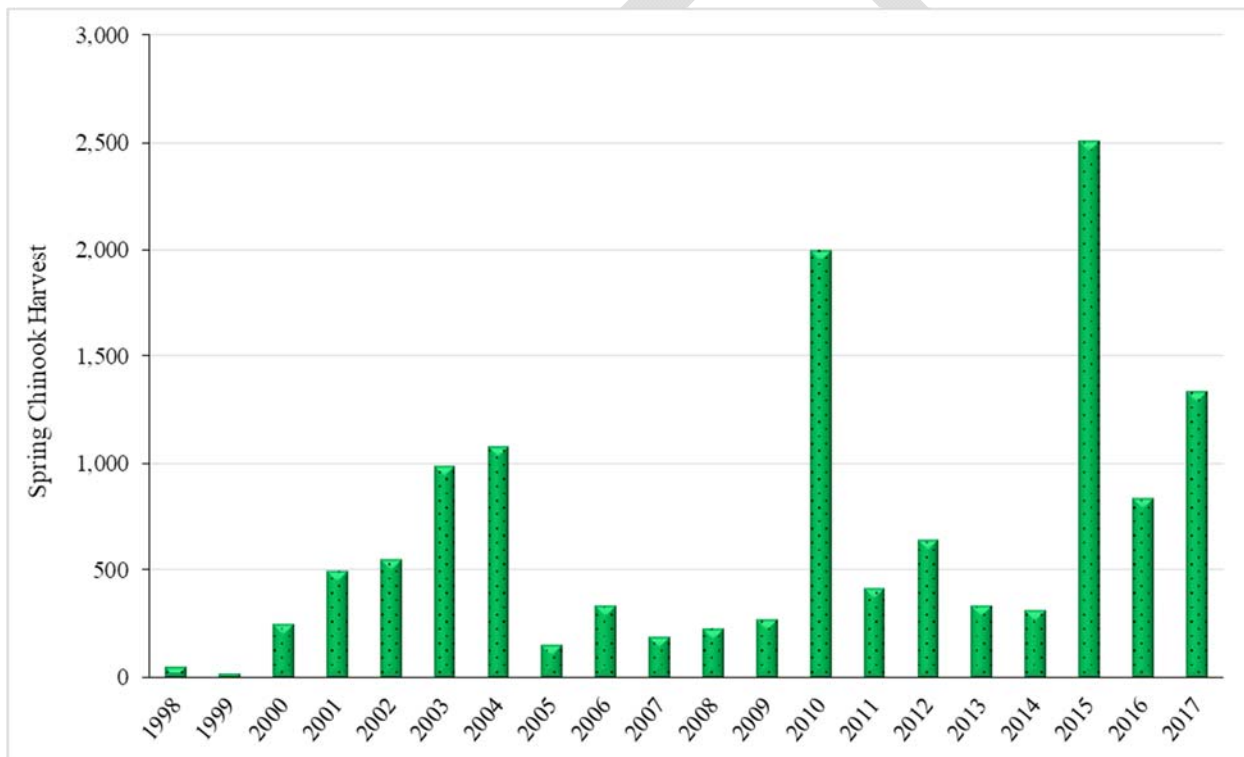


Figure 19k. Recreational harvest of spring Chinook in the Select Areas, 1998-2017.

EXPANDED AND NEW SELECT AREA EVALUATIONS

The Commission’s rules relative to the Harvest Reform Policy stated that “department staff shall manage fisheries consistent with the guiding principles” (OAR 635-500-6710), including enhancement of the economic benefits of off-channel commercial fisheries by “expanding existing seasons and boundaries in off-channel areas and/or establishing new off-channel areas, allowing increased harvest in areas where the likelihood of impacting ESA-listed stocks is lower than the mainstem. (OAR 635-500-6705(7)(b)).” To comply with these rules, ODFW investigated the feasibility of expanding existing seasons and boundaries in current Select Areas, as well as developing new Select Area sites. Expanded seasons and boundaries at existing sites would provide additional fishing time and area, respectively, and would be focused on adult returns from existing releases. In contrast, a new Select Area site would provide harvest opportunity for new releases from the site.

Expansion of Existing Select Area Seasons

Because of the duration of existing fishing seasons in current Select Areas, opportunities to expand the normal season structure are limited to the winter timeframe in Tongue Point/South Channel (TP/SC) and Knappa Slough (KS), and the summer timeframe in Youngs Bay (YB), Tongue Point/South Channel, and Blind Slough/Knappa Slough (BS/KS). Expanded winter seasons have been implemented in TP/SC and KS since 2013. During 2013-2017, new winter seasons added an average of 24 commercial fishing periods, 31 deliveries, and 78 landed spring Chinook annually for both sites combined (Table 20a). Spring Chinook abundance is generally low during the winter timeframe, thus participation and harvest to date have been limited. Although winter season landings account for less than 1% of the combined landings during the winter, spring, and summer seasons for all Select Area sites, fish prices are highest in the winter since these early fish are the first Columbia River spring Chinook of the year available to the market. In addition, spring Chinook average weights during the winter season are higher than in the spring, probably due to the earlier run timing of larger age-5 spring Chinook (ODFW unpublished data).

Table 20a. Summary of expanded seasons in off-channel winter fisheries, 2013-2017. Includes year, date range of fisheries, number of fishing periods added, deliveries, Chinook landed, and percentage of the total winter-spring-summer season landings for all Select Area sites combined.

Site	Year	Date Range	Periods	Deliveries	Chinook	% of Total
Tongue Point/ South Channel	2013	Feb 11-Mar 12	9	23	70	0.9%
	2014	Feb 10-Mar 14	10	17	33	0.7%
	2015	Feb 9-Mar 13	10	26	70	0.5%
	2016	Feb 8-Mar 11	10	41	109	1.0%
	2017	Feb 6-Mar 30	13	38	82	0.5%
			Average	10	29	73
Knappa Slough ^a	2013	Feb 11-Mar 12	9	2	6	0.1%
	2014	Feb 10-Mar 14	10	2	4	0.1%
	2015	Feb 9-Mar 20	12	3	10	0.1%
	2016	Feb 8-Mar 18	17	3	3	0.1%
	2017	Feb 6-Mar 31	20	0	0	0.0%
			Average	14	2	5

^a Some landings for Knappa Slough may have been reported as Blind Slough.

Use of ESA impacts for upriver spring Chinook during the winter season can be significant, accounting for 9% to 36% of the impacts used annually in the Select Areas during 2013-2017, with an average of 27% (Table 20b). This impact usage is relatively high, considering that 19% of winter-spring ex-vessel value is accrued during the winter season (Table 20c). Despite a higher price per pound and average weight for spring Chinook in winter fisheries, an analysis of ex-vessel value per upriver spring Chinook impact indicated that impact usage is far less efficient during the winter season compared to the spring season (Table 20d).

Table 20b. Upriver spring Chinook impacts used during winter and spring seasons in all Select Area sites combined, 2013-2017.

	Impacts (%)			% of Total Accrued During Winter
	Winter	Spring	Total	
2013	0.020	0.191	0.211	9%
2014	0.029	0.078	0.107	27%
2015	0.084	0.194	0.278	30%
2016	0.067	0.118	0.185	36%
2017	0.114	0.286	0.400	29%
Avg	0.063	0.173	0.236	27%

Table 20c. Winter and spring fishery ex-vessel values for all Select Area sites combined, 2013-2017.

	Ex-Vessel Value			% of Total Accrued During Winter
	Winter	Spring	Total	
2013	\$102,134	\$505,001	\$607,135	17%
2014	\$86,953	\$165,792	\$252,745	34%
2015	\$118,198	\$720,358	\$838,556	14%
2016	\$216,195	\$541,231	\$757,426	29%
2017	\$180,283	\$974,797	\$1,155,080	16%
Avg	\$140,752	\$581,436	\$722,188	19%

Table 20d. Ex-vessel value derived per upriver spring Chinook impact used during winter and spring seasons in all Select Area sites combined, 2013-2017.

	Ex-Vessel Value Per Impact	
	Winter	Spring
2013	\$42,270	\$72,019
2014	\$17,033	\$21,544
2015	\$18,775	\$24,521
2016	\$39,547	\$69,535
2017	\$34,070	\$474,806
Avg	\$30,339	\$132,485

Summer seasons have occurred in Youngs Bay for many years, but starting in 2014, 5-7 fishing periods per year have been added to the early part of the existing summer season to provide additional harvest opportunity for late arriving Select Area spring Chinook (Table 20e). For similar reasons, spring seasons in Blind Slough/Knappa Slough and Tongue Point/South Channel were extended into the summer timeframe beginning in 2015 and 2016, respectively. For BS/KS and TP/SC combined, an average of 20 fishing periods, 147 deliveries, and 1,711 landed spring Chinook have been added annually during the summer timeframe. The landings from these

additional fishing periods have accounted for approximately 12% of the combined landings during the winter, spring, and summer seasons for all Select Area sites.

Table 20e. Summary of expanded seasons in off-channel spring-summer fisheries, 2014-2017.^a Includes year, date range of fisheries, number of fishing periods added, deliveries, Chinook landed, and percentage of the total winter-spring-summer season catch for all Select Area sites combined.

Site	Year	Date Range	Periods	Deliveries	Chinook	% of Total
Youngs Bay ^b	2014	Jun 16-Jul 8	7	--	--	--
	2015	Jun 16-Jul 7	6	--	--	--
	2016	Jun 16-Jul 7	6	--	--	--
	2017	Jun 19-Jul 6	5	--	--	--
	Average			6	--	--
Blind Slough/ Knappa Slough	2015 ^c	Jun 16-Jul 3	5	23	336	2.5%
	2016	Jun 16-Jul 19	10	75	858	8.2%
	2017	Jun 19-Jul 28	12	121	1,161	6.6%
	Average			9	73	785
Tongue Point/ South Channel	2016	Jun 16-Jul 19	10	34	369	3.5%
	2017	Jun 19-Jul 28	12	114	1,483	8.4%
	Average			11	74	926

^a Prior to 2017, fishing periods added between June 16 and July 30 in Blind Slough/Knappa Slough and Tongue Point/South were considered as extensions of the spring season. Beginning in 2017, they were categorized as “summer” seasons.

^b Because landings for Youngs Bay summer fishing periods planned pre-season and added in-season are combined, landings specific to the additional fishing periods are not available.

^c The first two periods were for both Blind Slough and Knappa Slough; last three periods were for Knappa Slough only.

Assessment of Expanded Select Area Seasons

Winter season participation and harvest to date have been limited, which is not unexpected for fisheries in this timeframe because, even with increased releases from Harvest Reform, spring Chinook abundance is typically low early in the year. For many fishers, fish abundance is too low in February and early March to justify the cost and effort of participating in these early commercial fisheries. During 2013-2017, landings from the expanded (early) part of the winter season accounted for an average of 0.8% of all spring Chinook landed in the Select Areas. Furthermore, winter fisheries in general used a disproportionately high share of the impacts for upriver spring Chinook (27%), relative to the contribution they made to total spring Chinook ex-vessel value (19%), and spring fisheries derived, on average, over four times as much value from each upriver impact compared to winter fisheries. Prices and average fish weights are higher in the winter; however, the trade-offs are lower fish abundance and less efficient use of limited ESA impacts. Although the expansion of time in the winter season is attractive to some fishers due to the opportunity to catch high-value fish, fishery managers will continue to assess whether ESA impacts used for expanded winter fisheries are in the overall best interest of Select Area commercial fisheries.

Participation and harvest in the portion of the spring season expanded into the summer timeframe was greater than in the expanded winter season. Landings from the spring expansion during 2013-2017 accounted for an average of 11.7% of the total spring Chinook harvest for the Select Areas. The expanded spring seasons in BS/KS and TP/SC, and fisheries in YB during the summer

timeframe, primarily harvest late arriving Select Area stock spring Chinook, with very few upriver summer Chinook and early SAB fall Chinook landed (Table 19f). Prices for spring Chinook arriving at the tail end of the run are usually lower than they are during the winter and spring seasons due to a lower level of quality and market conditions (D. Case, ODFW, personal communication). In addition, there is some uncertainty regarding the benefit that an expanded spring Chinook season has in an area such as Youngs Bay, where there is already an active summer fishery. Would most of the spring Chinook caught in the expanded (early) part of the Youngs Bay summer season simply be caught later during the regular summer fishery? Nevertheless, it is clear that new “summer” seasons in BS/KS and TP/SC do provide opportunities to harvest additional spring Chinook, and these expanded spring seasons will likely continue for the foreseeable future.

Expansion of Existing Select Area Boundaries

With the planned transition of gillnets into off-channel fishing areas per the Harvest Reform Policy, it was believed that expanding existing Select Area site boundaries might help to accommodate a greater number of commercial fishers in these areas. Although this strategy would primarily benefit Oregon fishers since most of the existing sites are on the Oregon side of the Columbia, expanding the area of existing sites would be the most expedient way of providing fishing opportunity for additional fishers. Therefore, from 2011 through 2015, ODFW evaluated the feasibility of expanding boundaries at current Select Area sites.

Candidate Site Selection

Based on the professional judgement of fishery managers, the following areas were identified as candidates for evaluation: Outer Youngs Bay (OYB), Lower Prairie Channel (LPC), Grant Slough (GSL), and Upper Prairie Channel (UPC) (Figure 20a). These areas were selected for investigation because they were adjacent to and continuous with current Select Areas, had clearly definable boundaries, and were presumed to have lower abundances of ESA-listed stocks than the mainstem Columbia. The primary focus was on expanding the fishable area of existing sites, and not on providing additional catch through increased production in the expanded areas.

Adult Test Fishing Evaluation

To determine the extent to which ESA-listed stocks used the potential expansion areas, ODFW contracted with commercial fishers to test fish in the four candidate sites. ODFW field staff on board test fishing vessels collected data on the abundance and stock composition of salmonids in the areas, and gathered relevant biological data and samples from captured fish. Test fishing was conducted in GSL and UPC during 2011-2015, LPC during 2012-2015, and OYB in 2013-2015 (Table 20f). Test fishing occurred in the spring and/or fall seasons in GSL, UPC, and LPC, and in the spring, summer, and fall seasons in OYB, with not all seasons being sampled each year at a given site. In addition, the existing off-channel fishing area in Inner Youngs Bay (IYB) was also periodically test fished in the spring and/or summer of 2013-2015 to provide an established reference point in terms of spring Chinook catch characteristics.

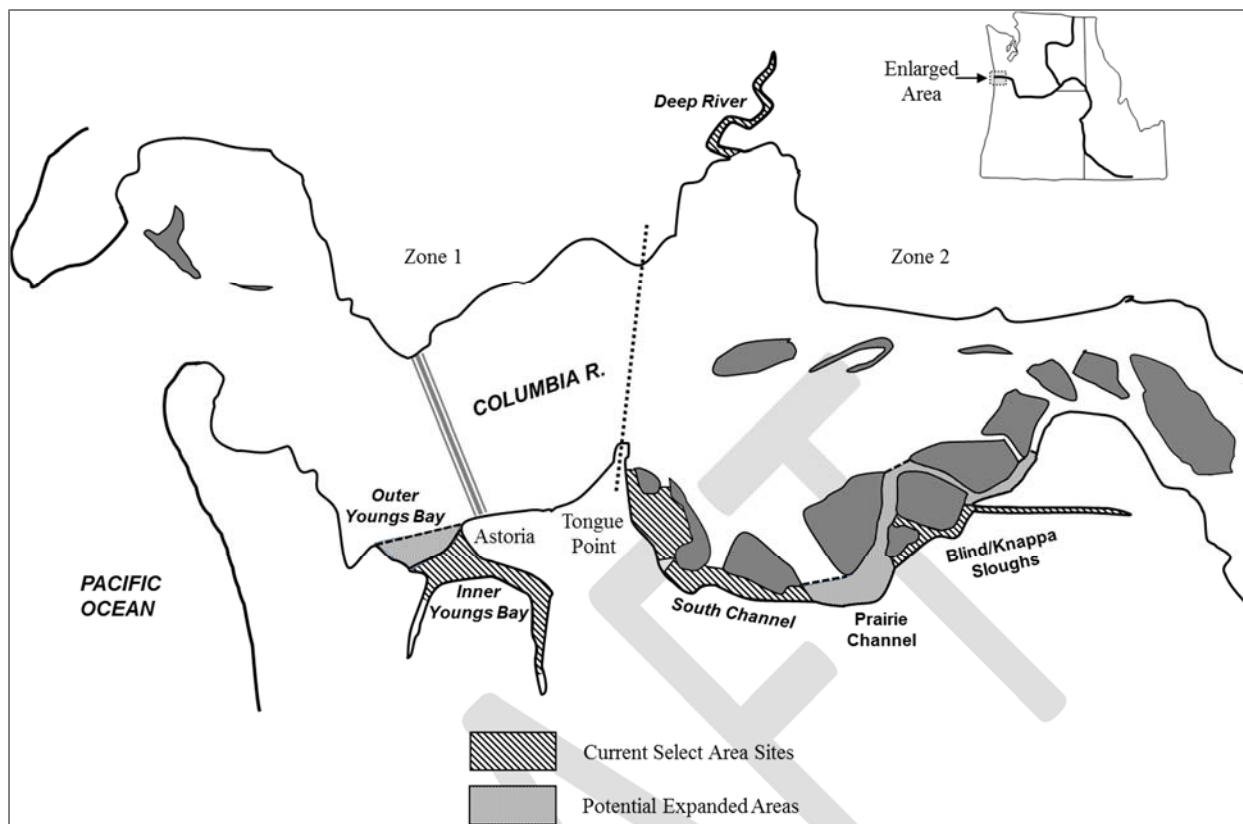


Figure 20a. Current Select Area fishing sites in the lower Columbia River and areas evaluated for potential site expansion.

Contracted test fishers used gillnet/tangle net mesh sizes that varied by season and location to minimize mortality while still maintaining catch efficiency (Table 20f). Nets were a minimum length of 150 fathoms, with depths ranging from 30 to 40 feet (with stringers).

Table 20f. Test fishing dates and gear specifications for evaluation of potential expanded Select Area boundaries.

Location	Year	Season(s)	Dates	Mesh Size (inches) ^a
Outer Youngs Bay (OYB)	2013	Spring/Summer; Fall	3/12 - 7/31; 8/30 - 10/10	5.1/7.5; 5.5
	2014	Spring/Summer; Fall	3/4 - 7/31; 8/4 - 10/10	5.25/7.0; 5.4-7.0
	2015	Spring/Summer; Fall	3/2 - 7/30; 8/6 - 10/8	5.0-5.25/7.0-7.25; 5.5-7.0
Inner Youngs Bay (IYB)	2013	Spring/Summer	3/12 - 7/31	5.1/7.5
	2014	Spring	3/4 - 5/15	5.25
	2015	Spring	3/10 - 5/11	5.0
Lower Prairie Channel (LPC)	2012	Fall	8/30 - 9/27	5.5-6.0
	2013	Spring; Fall	3/12 - 6/13; 8/30 - 10/7	4.25; 5.5
	2014	Spring; Fall	3/5 - 6/9; 8/26 - 10/5	5.0; 5.5-6.0
	2015	Spring	3/4 - 6/11	4.25-5.25
Grant Slough (GSL)	2011	Fall	8/28 - 10/12	5.5-6.5
	2012	Fall	8/30 - 10/1	5.0-5.6
	2013	Fall	8/31 - 10/7	5.5-6.0
	2014	Spring	3/5 - 6/9	5.0
	2015	Spring	3/4 - 6/11	5.25

Upper Prairie Channel (UPC)	2011	Fall	8/30 - 10/10	5.5
	2012	Fall	8/30 - 9/27	5.4
	2013	Spring; Fall	3/12 - 6/13; 8/30 - 9/26	5.0; 5.25-6.0
	2014	Spring	3/5 - 6/9	5.0
	2015	Spring	3/4 - 6/8	5.25

^a Net dimensions indicate stretch measure.

Additional weights and anchors were attached directly to the lead line when necessary. Contractors performed between one and four net sets/drifts per day in each study area, with a maximum set duration of 45 minutes. Set times were occasionally reduced to ensure healthy capture condition of fish when water temperatures were elevated and/or sea lions were present in the vicinity of the fishing vessel.

ODFW field staff recorded the following data for each test fishing drift: drift location description and GPS coordinates, gear specifications, layout/pickup start and end times, as well as the minimum and maximum depths observed during the drift. Environmental data included: water temperature, tide height at Tongue Point, Oregon, weather conditions, and Secchi depth. Biological data such as species, life stage, fin-mark status, VSI-based stock (if applicable), and capture condition were recorded for all captured salmonids. During the spring season, a DNA sample was collected from the upper lobe of the caudal fin on all Chinook to determine the stock origin of each fish. Photos of each Chinook were also taken to verify stock assignments made in the field based on VSI characteristics. After sampling, salmonids were revived, as needed, in recovery boxes and released back into the river. All salmonid mortalities were scanned for the presence of a CWT in the fish's snout. If a CWT was detected, the snout was retained and the tag was extracted and read at the ODFW lab in Clackamas to determine the hatchery of origin.

Test Fishing Results

Spring

Between 2013 and 2015, test fishing was performed from early March to mid-June (late July for OYB and IYB) to collect data during the breadth of the Select Area spring Chinook return; however, only data that was collected during the "standard season" timeframe was used for evaluation of the expanded Select Area sites since that would be the time when Select Area commercial spring Chinook fisheries would actually take place (Table 20g). A standard Select Area spring season includes statistical weeks 7 to 12 and 16 to 24 for YB, and weeks 7 to 12 and 17 to 24 for TP/SC and BS/KS. Among the sites that were evaluated for area expansion, the average catch rate of adult Chinook was highest in LPC (0.88 fish/drift) and lowest in OYB (0.19 fish/drift). Chinook mark rates were similar among all the expansion sites (range: 82-88%), and were slightly lower than in the IYB reference site. The percentage of upriver spring Chinook in the catch was highest in LPC (41%) and UPC (34%), and lowest in OYB (14%). Compared to the IYB reference site, average upriver spring Chinook percentages were between 5 and 14 times greater in the expansion sites. Depending upon the catch rate and number of boats fishing in an area, a higher percentage of upriver spring Chinook in the landings could lead to a rapid accumulation of ESA impacts, and potential curtailment of fisheries in all the Select Area sites. Using catch rates for upriver spring Chinook from standard season test fishing during 2013-2015 and catch data from existing Select Area commercial fisheries, we developed average expected

upriver impact estimates for hypothetical expanded Select Area fisheries. This analysis will be discussed later in this section. Steelhead catch rates were higher in LPC (0.26 fish/drift) and UPC (0.19 fish/drift) (Table 20g).

Table 20g. Select Area boundary expansion evaluation test fishing summary for the standard spring season, 2013-2015.^a Shaded values are averages.

Site	Year	Effort			Adult Chinook				Steelhead			
		# Fishers	Fisher Days ^a	Drifts	Catch	Mark Rate	Chinook/Drift	% Upriver Chinook	Catch	Mark Rate	Steelhead/Drift	Chinook/Steelhead
Outer Youngs Bay (OYB)	2013	1	19	40	7	86%	0.18	14%	3	100%	0.08	2.3
	2014	1	20	44	5	75%	0.11	20%	2	0%	0.05	2.5
	2015	2	39	117	33	93%	0.28	9%	8	63%	0.07	4.1
	Total/Avg.	4	78	201	45	85%	0.19	14%	13	54%	0.06	3.0
Lower Prairie Channel (LPC)	2013	1	22	70	56	80%	0.80	34%	19	74%	0.27	2.9
	2014	1	20	60	80	86%	1.33	55%	25	48%	0.42	3.2
	2015	1	29	29	15	80%	0.52	33%	3	67%	0.10	5.0
	Total/Avg.	3	71	159	151	82%	0.88	41%	47	63%	0.26	3.7
Grant Slough (GSL)	2014	1	20	20	0	--	--	--	2	50%	0.10	0.0
	2015	2	56	56	17	88%	0.30	29%	4	75%	0.07	4.3
	Total/Avg.	3	76	76	17	88%	0.30	29%	6	63%	0.09	2.1
Upper Prairie Channel (UPC)	2013	1	23	43	9	78%	0.21	11%	10	80%	0.23	0.9
	2014	1	20	20	6	100%	0.30	67%	6	67%	0.30	1.0
	2015	1	27	27	21	86%	0.78	24%	1	100%	0.04	21.0
	Total/Avg.	3	70	90	36	88%	0.43	34%	17	82%	0.19	7.6

^a Standard spring season includes weeks 7-12 and 16-24 for YB, and weeks 7-12 and 17-24 for TP/SC and BS/KS.

Fall

Between 2011 and 2015, all of the expansion sites test fished during the fall season were sampled for three years, although not all sites were sampled concurrently. Similar to the spring test fishing results, the average catch rate for adult Chinook was highest in LPC (2.83 fish/drift), and was approximately 2-3 times higher than in the other expansion sites (Table 20h). Chinook mark rates ranged from a low of 49% in LPC to a high of 72% in GSL. The percentage of unmarked tules in the Chinook catch was highest in UPC (5.3%) and LPC (3.5%), and the percentage of non-local brights was highest in LPC (70%). Average catch rates for adult Coho were highest in OYB (1.80 fish/drift) and LPC (1.78 fish/drift), and lowest in UPC (0.28 fish/drift). Coho mark rates varied from 76% in LPC and UPC to 88% in OYB. Steelhead catch rates in LPC (0.24 fish/drift) were 3-8 times higher than in the other expansion sites.

Table 20h. Select Area boundary expansion evaluation test fishing summary for the fall season, 2011-2015. Shaded values are averages.

Site	Year	Effort			Adult Chinook						Adult Coho				Steelhead			
		# Fishers	Fisher Days	Drifts	Catch	Mark Rate	Chinook/Drift	% Unmarked Tule	% SAB	% Non-Local Brights	Catch	Mark Rate	Coho/Drift	Unmarked Coho/Drift	Catch	Mark Rate	Steelhead/Drift	Chinook/Steelhead
Outer Youngs Bay (OYB)	2011	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	2012	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	2013	1	14	29	18	50%	0.62	0%	22%	61%	32	75%	1.10	0.28	3	100%	0.10	6.00
	2014	2	40	80	106	82%	1.33	4%	59%	25%	304	93%	3.80	0.28	12	75%	0.15	8.83
	2015	1	22	47	27	81%	0.57	0%	30%	41%	23	96%	0.49	0.02	1	100%	0.02	27.00
	Total	4	76	156	151	71%	0.84	1.3%	37%	42%	359	88%	1.80	0.19	16	92%	0.09	13.94
Lower Prairie Channel (LPC)	2011	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	2012	1	12	34	50	56%	1.47	6%	2%	64%	21	76%	0.62	0.15	6	83%	0.18	8.33
	2013	1	12	32	135	46%	4.22	0%	7%	85%	76	74%	2.38	0.63	8	38%	0.25	16.88
	2014	1	18	54	151	46%	2.80	5%	5%	62%	126	79%	2.33	0.50	16	69%	0.30	9.44
	2015	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	3	42	120	336	49%	2.83	3.5%	5%	70%	223	76%	1.78	0.42	30	63%	0.24	11.55
Grant Slough (GSL)	2011	1	10	21	15	80%	0.71	0%	0%	27%	5	60%	0.24	0.10	0	--	0.00	--
	2012	1	12	26	10	70%	0.38	0%	40%	50%	4	100%	0.15	0.00	1	100%	0.04	10.00
	2013	1	11	20	36	67%	1.80	6%	31%	47%	29	90%	1.45	0.15	1	100%	0.05	36.00
	2014	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	2015	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	3	33	67	61	72%	0.97	1.9%	24%	41%	38	83%	0.61	0.08	2	100%	0.03	23.00
Upper Prairie Channel (UPC)	2011	1	10	19	15	60%	0.79	7%	7%	47%	5	60%	0.26	0.11	0	--	0.00	--
	2012	1	12	24	20	75%	0.83	0%	0%	65%	3	67%	0.13	0.04	2	100%	0.08	10.00
	2013	1	10	18	22	64%	1.22	9%	14%	50%	8	100%	0.44	0.00	1	0%	0.06	22.00
	2014	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	2015	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	3	32	61	57	66%	0.95	5.3%	7%	54%	16	76%	0.28	0.05	3	50%	0.05	16.00

Assessment of Potential Expanded Select Area Boundaries

Outer Youngs Bay

Spring

The upriver spring Chinook impact estimate for a hypothetical OYB fishery indicated that this site could theoretically be accommodated within the impacts available to Select Area fisheries during a standard spring season (Table 20i); however, use of this area would create a tenuous situation for managing ESA impacts because of its proximity to the mainstem Columbia River migration corridor. Anecdotal observations by fishers suggest that high river flows and strong winds can sometimes “push” non-local spring Chinook into off-channel areas, potentially causing catches of upriver spring Chinook to increase. Thus, implementing Select Area commercial fisheries close to the mainstem Columbia can be risky in terms of ESA impacts, especially during the spring season when high flows are common. Therefore, OYB may not be a suitable candidate for spring season implementation.

Table 20i. Expected usage of upriver spring Chinook impacts in Select Area fisheries during the standard spring season if commercial fisheries were implemented in expanded areas. The maximum impacts allowed in a standard spring season for all Select Area sites combined (pre-season) is 0.380%.

Expected Standard Season Impacts¹	
Current Select Areas	
Youngs Bay	0.223%
Tongue Point	0.034%
Blind/Knappa Sloughs	0.016%
Deep River	--
Subtotal	0.273%
Expanded Select Areas	
Outer Youngs Bay	0.033%
Lower Prairie Channel	2.019%
Grant Slough	0.026%
Upper Prairie Channel	0.284%
Subtotal	2.361%

¹ Standard season impact estimates utilize Youngs Bay season structure (weeks 7 to 12 and 16 to 24) for Youngs Bay and Outer Youngs Bay and a Tongue Point season structure (weeks 7 to 12 and 17 to 24) for all other sites.

Fall

OYB has some potential as an expanded area site during the fall season. Catch rates of fall Chinook and steelhead were modest, as were the percentages of unmarked tules and non-local brights in the Chinook catch. The percentage of SABs in the Chinook catch and the catch rate of

Coho were both high, likely reflecting the capture of fish returning to the established Youngs Bay Select Area. Although implementing off-channel fisheries close to the mainstem always poses some risk of intercepting non-local stocks, the risk may be lower in the fall due to reduced river flows at that time of the year and cooler water temperatures in the mainstem relative to Youngs Bay. The primary benefit of this site would be increased fishing area rather than increased catch since a significant portion of the fish would likely be destined for harvest in the existing Youngs Bay fishery area.

Lower Prairie Channel

Spring

Upriver spring Chinook impact analysis indicated that LPC could not be accommodated within the impacts available to spring Select Area fisheries (Table 20i). If implemented, LPC would use three times more impacts than all the other Select Area sites combined, both current and potential expanded areas. The high catch rates for Chinook and steelhead during spring test fishing, as well as the elevated percentage of upriver spring Chinook in the catch, indicated that LPC is commonly used in the spring as a “dip-in” area by non-local stocks traveling up the Columbia.

Fall

During fall test fishing, the catch rates of Chinook, unmarked Coho, and steelhead were all highest in LPC. In addition, the percentages of unmarked tules and non-local brights in the Chinook catch were also high. These results indicated that, similar to the spring, LPC is also used heavily in the fall by non-local stocks. Implementation of a fall Select Area fishery in LPC could have impacts on a variety of ESA-listed stocks, including LCR tule and Snake River Wild fall Chinook, natural-origin B-Index summer steelhead, and LCN Coho. Therefore, LPC would not be a good candidate for fall fishery implementation.

Grant Slough

Spring

Based on our impact analysis, GSL could be accommodated within the ESA impacts available to spring Select Area fisheries. The upriver spring Chinook impacts estimated for this area would be roughly mid-way between those estimated for the current Select Area sites of Tongue Point and Blind Slough/Knappa Slough during a standard spring season, and were the lowest estimated for any of the expansion sites (Table 20i). Although GSL is not likely to accumulate a significant number of upriver spring Chinook impacts, the fishable area is small and shallow, and would not accommodate many additional fishers.

Fall

Test fishing results indicated that the presence of non-Select Area stocks was likely low in GSL during the fall season. The Chinook catch rate in GSL was similar to UPC and OYB, but the percentages of unmarked tules and non-local brights in the Chinook catch were relatively low.

The relatively high percentage of SABs in the Chinook catch indicated that SABs from Youngs Bay were straying into GSL, but the reason for this was unknown. Catch rates of unmarked Coho and steelhead in GSL were low. Although the fall test fishing results for GSL appear to be favorable in terms of impacts on non-local stocks, the small fishable area limits benefits to fishers, and the low overall catch rates for Chinook and Coho indicate that harvest would also be limited.

Upper Prairie Channel

Spring

According to our impact analysis, UPC could not be accommodated within the ESA impacts available to spring Select Area fisheries. If UPC were implemented as a Select Area fishery, the impacts used by the Select Areas would total 0.557%, which is about 40% higher than the 0.380% currently allowed pre-season (Table 20i). UPC's impact usage would also be greater than all the other current Select Area sites combined. Steelhead catch rates were also relatively high in UPC during spring test fishing. For these reasons, UPC would not be a good candidate for a spring Select Area fishery.

Fall

Catch rates of unmarked Coho and steelhead in UPC were relatively low, suggesting that natural-origin Coho and steelhead may not use the area to a significant degree. However, the high percentages of unmarked tules and non-local brights in the Chinook catch indicated that the presence of non-local Chinook stocks in UPC was likely substantial. For this reason, UPC may not be a suitable candidate for fall fishery implementation.

Development of New Select Area Fisheries

In addition to evaluating the feasibility of expanding existing Select Area seasons and site boundaries, ODFW also investigated the possibility of establishing one or more new Select Area sites that could provide additional smolt production and harvest opportunity for returning adults. Although ODFW, WDFW, and CEDC (now CCF) had previously completed an exhaustive review and evaluation of potential lower Columbia River off-channel commercial fishing sites in the early 1990s (Hirose et al. 1996), which led to the establishment of the current Select Areas, it was believed that a "fresh look" might uncover a site that was either overlooked during the initial evaluation, or whose characteristics or circumstances had changed since the 1990s. In this section, we summarize the selection process for candidate sites, test fishing conducted to assess potential impacts on non-local stocks, an evaluation of each candidate site's capability to rear/acclimate juvenile salmon, estimated costs to develop a new Select Area site, and the ex-vessel value expected to be generated by a new Select Area site.

Candidate Site Selection

In early 2014, a panel of biologists and fishery managers from ODFW’s Columbia River Management program was assembled to identify off-channel areas of the Columbia River below Bonneville Dam that might have the potential to support economically viable commercial fisheries, while allowing Select Area fisheries overall to remain within the ESA impacts allocated to them. The sites that were identified for initial consideration are presented in Table 20j. Based on their knowledge, experience, and familiarity with the current Select Area fisheries program, the panel also developed a set of site attributes important to the development of a Select Area site (Table 20k), which were scored for each site listed in Table 20j. Individual site scores were summed and the total score used to rank the sites.

Table 20j. Off-channel areas in the Columbia River below Bonneville Dam considered for evaluation as a potential new Select Area site.

• Bachelor Island Slough	• Cowlitz River	• Martin Slough
• Baker Bay	• Dibblee Slough	• Multnomah Channel
• Bradbury Slough	• Elochoman Slough	• Pierce Island
• Camas Slough	• Fisher Island	• Sandy Island Slough
• Carrols Channel	• Grays Bay	• Skipanon Waterway
• Cathlamet Channel	• Hayden Island	• Steamboat Slough
• Clifton Channel	• Knappa Slough	• Svensen
• Coal Creek Slough	• Lake River	• Wallace Island
• Coffee Pot Island	• Lewis River	• Westport Slough
• Columbia River Gorge	• Lower Willamette River	

Table 20k. Site attributes used to rank off-channel areas.

• Capacity (i.e. fishable area)	• Definable boundary
• Potential for harvest of non-local stocks	• Enforceable boundary
• Potential for juvenile rearing/acclimation	• Terminal or Side Channel
• Potential for adult homing	• Presence of dock/infrastructure
• Potential for negative residential interaction	• Fisher access
• Potential for negative navigational interaction	

The panel reviewed the highest ranked areas and initially selected three sites for in-depth evaluation beginning in 2014. The sites included two Oregon locations, Clifton Channel (CLC) and Westport Slough (WPS), and one site located in Washington, Coal Creek Slough (CCS) (Figure 20b). Bradbury Slough (BBS), another Oregon site, was added to the evaluation program in 2015 because it provided the opportunity to investigate a second relatively large site. In addition, WDFW carried out their own evaluation of Cathlamet Channel (Figure 20b) as a potential new Select Area site, with adult test fishing conducted during 2013-2018, and experimental releases of juvenile spring Chinook occurring in 2014-2018. Releases into Cathlamet Channel are planned to be discontinued after 2018 due to poor adult returns. For this section of the report, we will primarily focus on ODFW’s evaluation of potential new Select Area sites.

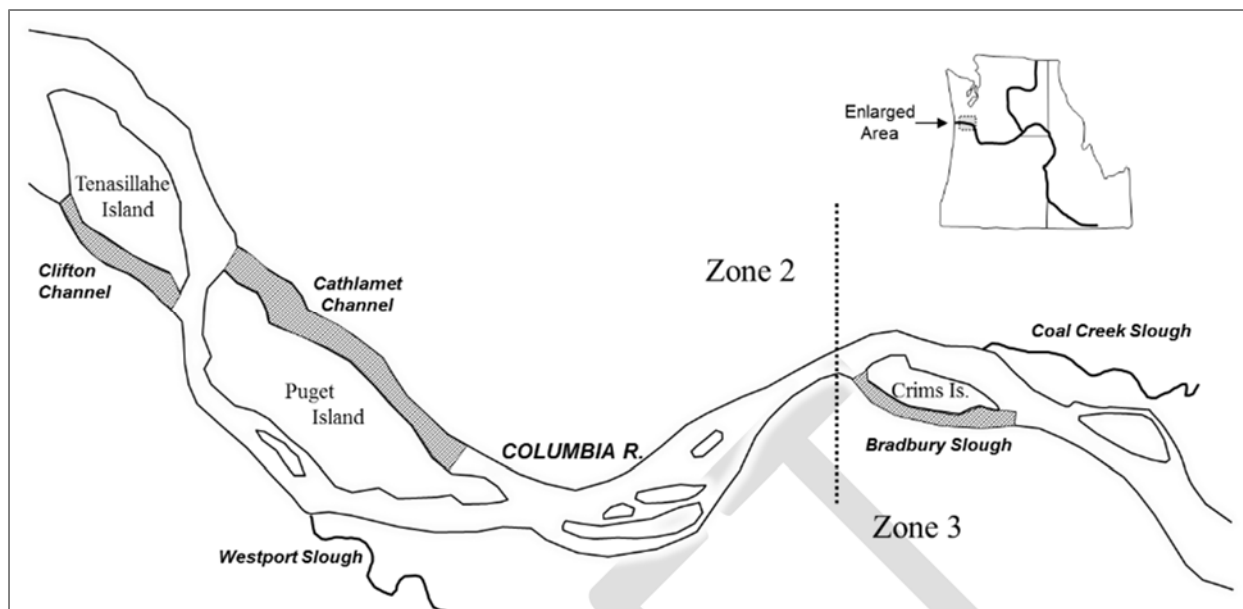


Figure 20b. Potential new Select Area sites evaluated in the lower Columbia River.

Adult Test Fishing Evaluation

ODFW contracted with commercial fishers to conduct spring and/or fall test fishing for adult salmonids in CLC in 2014-2015, WPS in 2014-2016, BBS in 2015-2016, and CCS in 2014-2015 to assess each site's potential for impacting non-local/ESA-listed stocks. Test fishing dates and gillnet/tangle net mesh sizes used by contracted fishers are presented in Table 201. In general, test fishing protocols used during the new site evaluation were similar to those used during the expanded area evaluation, with the exception that drift times up to 1 hour were permitted in terminal areas such as WPS and CCS, if conditions allowed.

Table 201. New Select Area evaluation test fishing dates and gear summary, 2014-2016.

Location	Year	Season(s)	Dates	Mesh Size (inches) ^a
Clifton Channel (CLC)	2014	Spring; Fall	3/31 - 6/11; 9/14 - 10/26	4.25; 5.5/5.75
	2015	Spring; Fall	3/9 - 6/6; 9/13 - 10/30	4.25; 5.5
Westport Slough (WPS)	2014	Spring; Fall	3/26 - 6/10; 9/9 - 10/31	5.0/5.5; 5.25/5.5
	2015	Spring	3/10 - 6/11	5.25-5.5
	2016	Spring	3/9 - 6/8	5.5
Bradbury Slough (BBS)	2015	Spring; Fall	3/9 - 6/9; 9/3 - 10/28	4.25/5.5; 5.5
	2016	Spring	3/23 - 6/10	4.25
Coal Creek Slough (CCS)	2014	Spring; Fall	3/27 - 6/13; 9/8 - 10/30	5.5
	2015	Spring; Fall	3/9 - 6/11; 9/2 - 10/29	5.5

^a Gear specifications are stretch mesh measure.

Test Fishing Results

Spring

Similar to the expanded area evaluation, we focused our spring test fishing analyses on data collected in the potential new sites during the standard spring season (weeks 7-12 and 17-24), when Select Area spring commercial fisheries would most likely occur. Spring test fishing results (Table 20m) indicated that average adult Chinook catch rates were higher in side channel areas such as CLC (0.76 fish/drift) and BBS (0.57 fish/drift), compared to terminal areas like WPS (0.43 fish/drift) and CCS (0.03 fish/drift). Average upriver spring Chinook percentages were also much higher in side channel sites (42% and 29% in CLC and BBS, respectively vs. 1% and 0% in WPS and CCS, respectively), as were steelhead catch rates (0.29 and 0.34 fish per drift in CLC and BBS, respectively vs. 0.14 and 0.06 fish/drift in WPS and CCS, respectively). Chinook mark rates were relatively high in all areas, and were highest in Westport Slough (99%).

The higher catch rates of Chinook and steelhead, as well as the higher upriver spring Chinook percentages, in the side channel areas is not surprising given that these areas are often used as secondary migration corridors by returning adult salmonids. Anecdotal observations by commercial fishers and ODFW staff suggest that the degree to which side channels are used for upstream migration during the spring may depend, at least partly, on factors such as river flow and run size.

Table 20m. New Select Area evaluation test fishing summary for the standard spring season, 2014-2016.^a Shaded values are averages.

Site	Year	Effort			Adult Chinook				Adult Steelhead			
		# Fishers	Fisher Days ^a	Drifts	Catch	Mark Rate	Chinook/Drift	% Upriver	Catch	Mark Rate	Steelhead/Drift	Chinook/Steelhead
Clifton Channel (CLC)	2014	2	37	148	92	83%	0.62	37%	38	76%	0.26	2.42
	2015	1	26	109	98	79%	0.90	48%	35	63%	0.32	2.80
	Total/Ave.	3	63	257	190	81%	0.76	42%	73	70%	0.29	2.61
Westport Slough (WPS)	2014	2	32	126	6	100%	0.05	0%	9	44%	0.07	0.67
	2015	1	22	88	64	100%	0.73	3%	26	23%	0.30	2.46
	2016	1	22	88	45	96%	0.51	0%	4	0%	0.05	11.25
Total/Ave.	4	76	302	115	99%	0.43	1%	39	23%	0.14	4.79	
Bradbury Slough (BBS)	2015	2	42	171	64	88%	0.37	39%	42	48%	0.25	1.52
	2016	1	19	75	58	81%	0.77	19%	32	91%	0.43	1.81
	Total/Ave.	2	42	171	64	84%	0.57	29%	42	69%	0.34	1.67
Coal Ck. Slough (CCS)	2014	1	16	64	0	--	0.00	--	0	--	0.00	--
	2015	1	20	80	4	75%	0.05	0%	9	67%	0.11	0.44
	Total/Ave.	2	36	144	4	75%	0.03	0%	9	67%	0.06	0.44

^a Standard spring season for Select Areas includes weeks 7-12 and 17-24.

Fall

Fall test fishing results (Table 20n) indicated that average adult Chinook catch rates were relatively high in CLC (0.79 fish/drift), WPS (0.95 fish/drift), and BBS (0.94 fish/drift), and much lower in CCS (0.18 fish/drift). The percentage of unmarked tules in the Chinook catch was higher in the terminal areas (11.0% in WPS and CCS) compared to side channel areas (1.6% and 5.9% in CLC and BBS, respectively), as was the mark rate for Chinook (88% and 89% in WPS and CCS, respectively vs. 42% and 65% in CLC and BBS, respectively). The percentage of non-local brights in the Chinook catch was higher in the side channel areas (76% and 57% in CLC and BBS,

respectively vs. 6% and 4% in WPS and CCS, respectively), as was the catch rate of steelhead (0.12 and 0.17 fish/drift in CLC and BBS, respectively vs. 0.00 and 0.04 fish/drift in WPS and CCS, respectively). The percentage of SABs in the Chinook catch was very low in all of the potential new sites. The catch rate of unmarked adult Coho was highest in WPS (0.35 fish/drift) and lowest in BBS (0.04 fish/drift).

Similar to the results for spring test fishing, the fall test fishing data suggest that upriver stocks such as non-local bright fall Chinook and late summer steelhead tend to be encountered more frequently in side channel areas compared to terminal areas. Side channels such as CLC and BBS can be important secondary migration corridors in the fall, as well as spring. In contrast, the high percentage of unmarked tules in the terminal areas suggests that nearby tributaries such as Plympton Creek (WPS) and Coal Creek (CCS) are used by natural spawning populations of tule Chinook, and the high mark rate for Chinook in general indicates that hatchery tules, which are typically marked at a very high rate, are also found in the terminal areas. Plympton Creek, in particular, is known to have significant numbers of spawning tule Chinook, of both natural and hatchery origin (ODFW unpublished data). The high catch rate of unmarked adult Coho in WPS suggests that test fishers there likely encountered natural-origin Coho from the small tributaries within WPS and/or the nearby Clatskanie River, a key component of the LCN Coho ESU. For this reason, and because of the high encounter rate of unmarked tule Chinook, WPS was not test fished in the fall of 2015.

Table 20n. New Select Area evaluation test fishing summary for the fall season, 2014-2015.^a Shaded values are averages.

Site	Year	Effort			Adult Chinook						Adult Coho				Adult Steelhead					
		# Fishers	Fisher Days ^a	Drifts	Catch	Mark Rate	Chinook/ Drift	% Unmarked Tule	% SAB	% Non-Local Bright	Catch	Mark Rate	Coho/ Drift	Un-marked Coho/ Drift	Catch	Mark Rate	Steelhead /Drift	% Wild A	% Wild B	Chinook/ Steelhead
Clifton Channel (CLC)	2014	1	20	82	71	41%	0.87	1%	1%	73%	174	85%	2.12	0.32	9	67%	0.11	22%	11%	7.89
	2015	1	20	78	55	44%	0.71	2%	0%	78%	29	83%	0.37	0.06	10	90%	0.13	0%	10%	5.50
	Total/Ave	2	40	160	126	42%	0.79	1.6%	1%	76%	203	84%	1.25	0.19	19	78%	0.12	11%	11%	6.69
Westport Slough (WPS)	2014	2	38	152	144	88%	0.95	11%	1%	6%	138	62%	0.91	0.35	0	--	0.00	--	--	--
	2015	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total/Ave	2	38	152	144	88%	0.95	11%	1%	6%	138	62%	0.91	0.35	0	0%	0.00	--	--	--
Bradbury Slough (BBS)	2014	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	2015	1	18	72	68	66%	0.94	6%	0%	57%	10	70%	0.14	0.04	12	42%	0.17	42%	17%	5.67
	Total/Ave	1	18	72	68	65%	0.94	5.9%	0%	57%	10	70%	0.14	0.04	12	42%	0.17	--	--	5.67
Coal Ck. Slough (CCS)	2014	1	22	88	15	93%	0.17	7%	0%	0%	32	44%	0.36	0.20	2	100%	0.02	0%	0%	7.50
	2015	1	18	72	13	85%	0.18	15%	0%	8%	9	22%	0.13	0.10	4	75%	0.06	25%	0%	3.25
	Total/Ave	2	40	160	28	89%	0.18	11.0%	0%	4%	41	33%	0.24	0.15	6	88%	0.04	13%	0%	5.38

^a Fall test fishing in WPS was discontinued in 2015 due to concerns regarding potential encounters with ESA-listed LCR tule Chinook and LCN Coho. Bradbury Slough was added as a candidate site in 2015.

Test Fishing Assessment

Based on the results of adult test fishing, CLC and BBS do not appear to have good potential for implementation as Select Area fisheries during either the spring or fall seasons. As side channel sites, they had the highest encounter rates for upriver stocks of spring and fall Chinook, as well as steelhead. Analysis of expected upriver spring Chinook impacts for the potential new Select Area sites indicated that neither CLC nor BBS could be accommodated within the ESA impacts allocated to the Select Areas during a standard spring season (Table 20o). During the fall season, fisheries in CLC and BBS would likely have impacts on ESA-listed upriver stocks such as SRW fall Chinook and natural-origin B-Index summer steelhead.

Table 20o. Expected usage of upriver spring Chinook impacts in Select Area fisheries during the standard spring season if commercial fisheries were implemented in new off-channel areas. The maximum impacts allowed in a standard spring season for all Select Area sites combined is 0.400%.

Expected Standard Season Impacts¹	
Current Select Areas	
Youngs Bay	0.223%
Tongue Point	0.034%
Blind/Knappa Sloughs	0.016%
Deep River	--
Subtotal	0.273%
New Select Areas	
Clifton Channel	1.035%
Bradbury Slough	0.241%
Westport Slough	0.013%
Coal Creek Slough	0.000%
Cathlamet Channel ²	1.508%
Subtotal	2.797%

¹ Standard season impact estimates utilize Youngs Bay season structure (weeks 7 to 12 and 16 to 24) for Youngs Bay and Outer Youngs Bay and a Tongue Point season structure (weeks 7 to 12 and 17 to 24) for all other sites.

² Lower and middle sections only.

The terminal area sites of WPS and CCS had much lower encounter rates for upriver stocks of spring and fall Chinook, as well as steelhead, since they do not serve as potential routes for fish migrating up the Columbia. Thus, upriver spring Chinook impact analyses indicated that commercial fisheries at both sites could be accommodated within the allowable impacts for the Select Areas, even on a concurrent basis (Table 20o). However, in the fall, WPS had high encounter rates for unmarked tule Chinook and unmarked Coho, which could have consequences in terms of impacts to ESA-listed LCR tule Chinook and LCN Coho. While test fishing results suggest that WPS could be a viable candidate for spring Select Area fisheries, this area would be a poor choice for fall fisheries implementation. Therefore, CCS was the only candidate site that had favorable test fishing results during both the spring and fall seasons. Due to the low test fishing

catch of adult salmonids in general, a commercial fishery in CCS would likely have a low probability of impacting ESA-listed stocks of salmon and steelhead.

Juvenile Rearing/Acclimation Evaluation

In recent years, almost 80% of spring Chinook and 60% of Coho released into the current Select Areas were reared and/or acclimated in net pens within the sites (ODFW unpublished data). Therefore, a potential Select Area site's capability to provide this important function is a key factor in its evaluation. Although some Coho rear over winter in Select Area net pens before being released the following spring, most juvenile salmon destined for release from the net pens are reared at hatcheries, then transferred to the net pens for approximately two weeks of acclimation prior to release. Successful acclimation is critical since it is during this period that smolts imprint on the chemistry of the water in which they are being held. If the timing of acclimation, relative to the fishes' physiology, is off, or if the chemistry of the holding water is not "unique" enough for them to imprint on and accurately home to as adults, significant straying can occur, resulting in lost harvest opportunities in the Select Areas, as well as potential negative interactions with non-local stocks in natural spawning areas.

ODFW staff identified the following requirements as crucial to a site's capability to rear and/or acclimate and release juvenile salmon:

- infrastructure for anchoring/accessing net pens (e.g. dock, pilings, gangway)
- permission from the upland landowner to use the infrastructure
- minimum low tide depth of 10 ft at the potential net pen location
- adequate water quality for fish health and survival
- a unique water source with sufficient discharge to successfully imprint juveniles and facilitate adult homing to the site

Infrastructure Inventory and Depth Investigation

ODFW field staff surveyed each candidate site to inventory any intact infrastructure (e.g. docks, pilings, etc.) that could potentially serve as an anchoring and access point for net pens. Three potential net pen locations were identified in both Bradbury Slough (BBS-1, BBS-2, and BBS-3) and Coal Creek Slough (CCS-1, CCS-2, and CCS-3), and four such locations were identified in Westport Slough (WPS-1, WPS-2, WPS-3, and WPS-4). Monthly depth readings (minimum depth at low tide) were taken at each of the potential net pen locations to ensure that the desired minimum depth of 10 ft was met during fish rearing/acclimation periods. A 10 ft depth helps to ensure a 2 ft clearance between the bottom of the net pen and the river substrate, as well as adequate flushing of fish waste and feed associated with rearing activities (an Oregon Department of Environmental Quality requirement). Figure 20c displays monthly depth readings at the sites from June 2015 to July 2016. Each candidate site had one potential net pen location which did not meet the minimum depth requirement during the primary fish acclimation period of March-April.

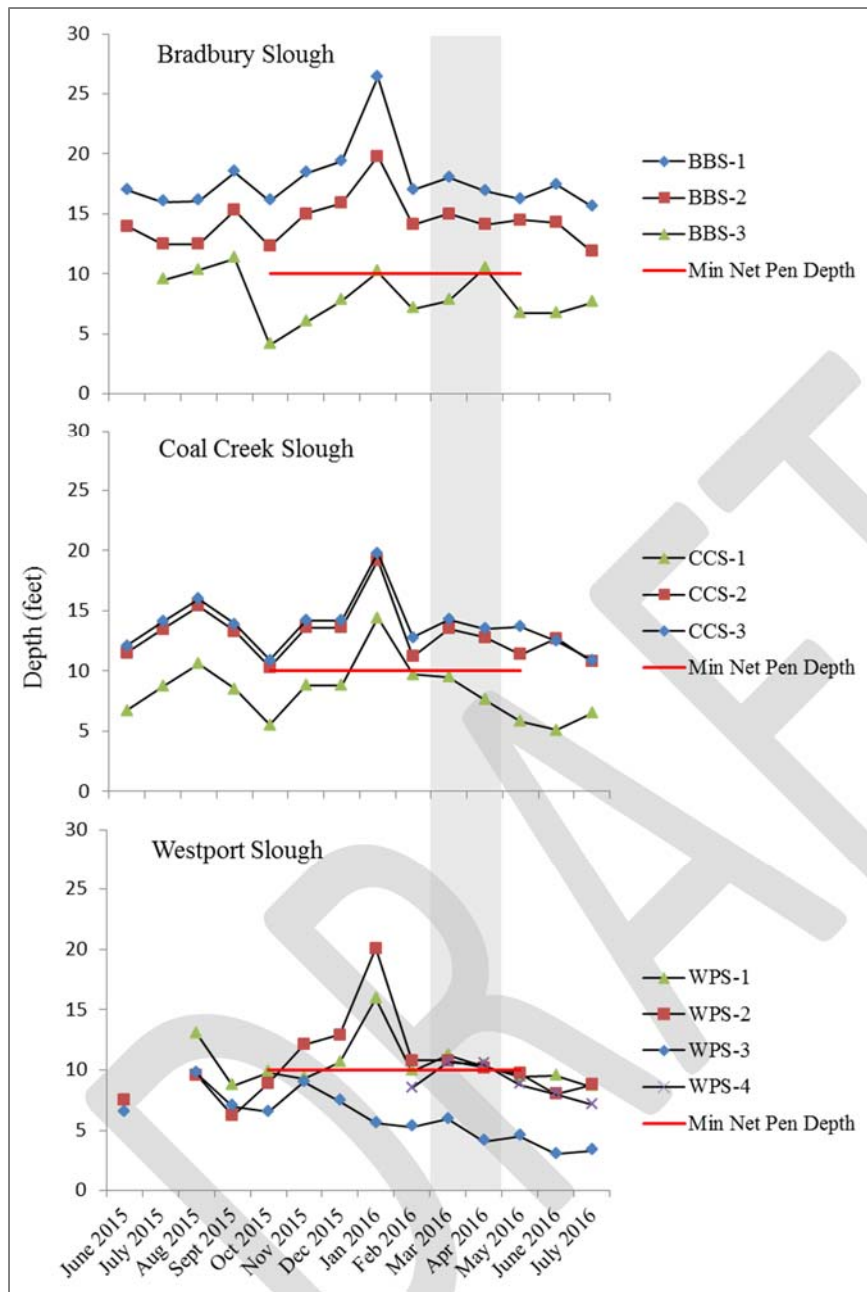


Figure 20c. Minimum monthly low tide depths at potential net pen locations in new Select Area candidate sites, 2015-2016. Shaded area represents primary months for acclimation.

For potential acclimation sites where initial depth criteria were met, we attempted to contact property owners to discuss the possibility of accessing and using their docks or pilings. When we were able to contact the landowner, we: a) provided them with information about the evaluation and potential future net pen rearing projects/fisheries in areas adjacent to their property, b) gauged their receptiveness to and interest in forming partnerships with ODFW to accomplish project objectives, and c) attempted to secure tentative verbal agreements for permission to access and use their infrastructure for net pen acclimation. We identified one landowner each in Westport, Bradbury, and Coal Creek sloughs who was receptive to our efforts and provided tentative permission to access their property.

Water Quality

Beginning in January 2016, ODFW field staff collected monthly water quality data to assess each candidate site's capability to support juvenile and adult salmon health and survival. Measurements were recorded once or twice per month from several mid-channel reference points located throughout the area. The number of water quality waypoints varied from five in BBS and CLC, to eight in WPS, and nine in CCS, due to differences in site morphology. At each reference point, several water quality parameters were measured using a Hanna 9828 multi-parameter meter. Prior to each sampling, the probe and meter were calibrated to ensure accurate measurements. The main parameters of interest from a fish rearing and adult return perspective were water temperature and dissolved oxygen (mg/L). Additional parameters recorded included: pH, conductivity, total dissolved solids, specific gravity, salinity, and atmospheric pressure.

Average monthly water temperature in the candidate sites was highest in July or August (Table 20p). Water temperatures tended to be slightly higher in the terminal sites than in side channel locations, likely due to reduced circulation of river water in the former. The highest water temperatures were observed in CCS during the month of August. Water temperatures in the candidate sites during March-May, when juvenile acclimation primarily takes place, were similar to those measured in the existing Select Area sites in 2015 and 2016. However, the terminal candidate sites were 1-2 degrees warmer than the existing sites during the month of May. Even with these somewhat elevated temperatures during the later part of the acclimation period, water temperatures in the candidate sites met the recommended conditions for juvenile rearing identified by the U.S. Environmental Protection Agency (USEPA 2003). Dissolved oxygen (DO) levels in the candidate sites were lowest in June or July (Table 20p). The lowest DO levels were recorded in CCS during July. Although we did not have DO readings from the existing Select Area sites for comparison, all of the DO levels recorded in the candidate sites during March-May exceeded the minimum 1-day DO criteria of 6.5 mg/L established by the Washington Department of Ecology (WADOE) for salmonid rearing and migration (WAC 173-201A-200).

Table 20p. Average monthly water temperatures and dissolved oxygen levels for new Select Area candidate sites, 2015-2016. Shaded area represents primary months for acclimation.

Parameter	Year	Month	Candidate Site				
			Clifton	Westport	Bradbury	Coal Creek	
Water Temperature (°C)	2015	January	5.9	6.6	—	8.1	
		February	6.7	8.6	6.8	8.0	
		March	6.5	8.4	9.1	8.1	
		April	9.9	11.6	9.8	12.1	
		May	13.9	16.6	13.6	16.0	
		June	19.4	20.9	19.3	21.8	
		July	22.6	—	22.6	23.3	
		August	22.1	23.2	21.5	23.5	
		September	18.2	17.3	18.3	19.4	
		October	17.3	16.9	17.4	16.9	
		November	11.7	9.5	12.8	12.0	
		December	—	6.6	7.6	8.0	
	2016	January	4.6	5.7	4.5	4.2	
		February	6.8	8.4	6.6	8.0	
		March	8.0	9.7	8.1	9.6	
		April	13.1	14.6	11.9	13.4	
		May	15.2	17.1	14.9	16.1	
		June	18.4	21.7	17.6	18.6	
		July	19.5	20.8	19.8	20.7	
		Dissolved Oxygen (mg/L)	2015	January	11.9	9.5	—
	February			10.9	8.6	11.7	8.9
	March			12.0	10.1	10.7	10.6
	April			12.3	10.5	11.9	9.0
	May			10.8	9.2	10.6	8.7
June	9.5			7.1	9.1	7.7	
July	7.9			—	7.7	6.6	
August	9.5			8.6	8.9	8.5	
September	9.2			8.5	9.5	8.0	
October	9.0			8.3	9.7	7.1	
November	9.8			8.7	8.9	7.4	
December	—			9.6	12.4	8.7	
2016	January		12.0	10.2	12.0	9.0	
	February		13.0	10.0	12.0	10.0	
	March		14.0	9.3	13.7	9.9	
	April		12.0	9.1	12.6	11.0	
	May		10.9	8.5	12.7	8.9	
	June		12.1	8.4	9.4	7.2	
	July		10.2	8.3	9.8	8.2	

Juvenile Imprinting/Adult Homing Potential

The imprinting and homing potential of each candidate site was evaluated by measuring the stream discharge of tributary streams flowing directly into or upstream of the area. The streams were chosen based on their potential to serve as an imprinting water source for smolts during the acclimation process, and also as a homing water source for returning adults. We did not measure amino acid concentrations directly, which research suggests are primarily responsible for cuing the homing response in adult salmonids (Shoji et al. 2003). Rather, we used stream discharge as a simplified and cost effective indicator of homing potential. The streams that were selected for discharge measurement were Hunt Creek (CLC), Plympton Creek (WPS), Green Creek (BBS), and Coal Creek (CCS). Beginning in July 2015, stream discharge was measured 1-2 times per month using a Hach FH950 handheld flow meter with top-setting wading rod, and following USGS Midpoint methodology. In months when stream flow fell below the detection limit of the meter, we made qualitative assessments to characterize discharge.

With few exceptions, average monthly discharge was greatest in Coal Creek, followed by Plympton Creek, Hunt Creek, and Green Creek (Figure 20d). During the months of September and October, when adult Coho typically return to the lower Columbia River, tributary discharges

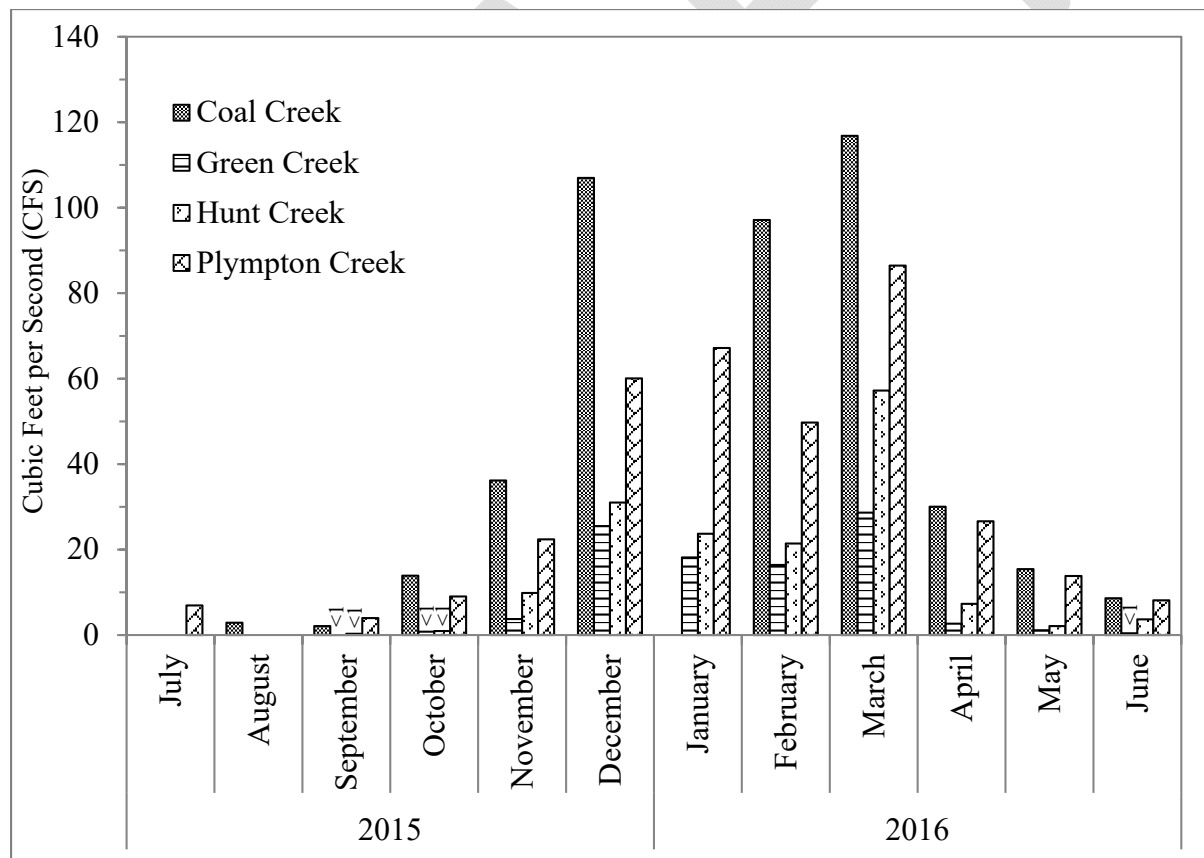


Figure 20d. Average monthly discharge (cubic feet per second) for potential homing tributaries in new Select Area candidate sites, 2015-2016. Coal Creek not sampled in July 2015 and January 2016, Green Creek not sampled in July-August 2015, Hunt Creek not sampled in July-August 2015, and Plympton Creek not sampled in August 2015.

were highest in the terminal sites (Coal Creek and Westport sloughs) and lowest in the side channel sites (Clifton Channel and Bradbury Slough), suggesting that adult Coho could have greater difficulty homing to the latter locations. Although discharge in Plympton Creek appeared to be adequate, the Clatskanie River is located immediately upstream of Westport Slough, and during the winter and spring, some flow from the Clatskanie can reach the slough via an old channel. Therefore, juvenile imprinting in Westport Slough could be confounded at times by multiple water sources. Tributary discharge was greatest at all candidate sites during the month of March, but dropped off sharply in April and May. This is a concern since smolts acclimating later in the spring may not have sufficient tributary flows for proper imprinting.

Previous attempts to acclimate juvenile Coho in a side channel area of the lower Columbia (Steamboat Slough) resulted in good survival, but the adults did not home back to the release site. Instead, there was significant straying to the nearby Elochoman River (North et al. 2006). Due to its limited discharge, the unique chemistry of Steamboat Slough's intended imprinting tributary, Skamokawa Creek, was likely overwhelmed by flows from the much larger Elochoman River just upstream of the acclimation area.

The importance of the proximity of the net pens to a unique water source with sufficient discharge for juvenile imprinting has also been demonstrated in other Select Area sites. When net pens were initially installed in the Tongue Point Select Area, they were located nearly 2 miles downstream from the intended imprinting water source (John Day River, Clatsop Co.), and adult stray rates at the time averaged 22.1%. After the Tongue Point net pens were moved upstream to within approximately 0.65 miles of the John Day River, adult stray rates decreased to 8.9% (Duff et al. 2013).

Juvenile Rearing/Acclimation Assessment

Table 20q summarizes findings from the evaluation of juvenile rearing/acclimation potential for new Select Area candidate sites. None of the sites had favorable (green) ratings in all of the categories, and most had one or two unfavorable (red) ratings, some of which were "deal breakers". The intended imprinting tributaries in Clifton Channel and Bradbury Slough were found to have inadequate discharge during the primary acclimation months; therefore, these areas have a low probability of successfully acclimating juvenile salmon. Lessons learned from the former Select Area site in Steamboat Slough suggest that fish released from Clifton Channel and Bradbury Slough would have a high likelihood of straying. Despite favorable ratings in some of the other categories, the lack of a reliable imprinting/homing tributary precludes the use of these sites for acclimation of juvenile salmon.

Westport Slough and Coal Creek Slough also had some issues with their imprinting/homing potential that deserve caution. Both areas had intended imprinting tributaries with low discharge in April and May, which could prove inadequate for smolts acclimating in the late spring. In addition, imprinting of smolts in Westport Slough could be complicated by intermittent influxes of Clatskanie River water into the acclimation area. However, if these concerns turn out to be unfounded, then at least one location in each of these areas may have the potential to support the acclimation and release of juvenile salmon. Site #4 in Westport Slough, an existing marina, has the desired infrastructure, and the landowner has given tentative permission to use it, but there is

currently no dock space available for net pens. Although the minimum depth at this site is marginal, water quality appears to be adequate during most of the year. Site #2 in Coal Creek Slough is another potential acclimation site. Although the site currently only has pilings with no dock or gangway, the landowner has given tentative permission to access the property, and was interested in a potential agreement that would add a dock and gangway to the existing pilings. Other factors such as depth and water quality were also favorable for this site. Therefore, out of the 11 individual locations assessed for juvenile rearing/acclimation, 2 may have a reasonable potential to serve as rearing/acclimation sites.

Table 20q. Summary of the juvenile rearing/acclimation evaluation for new Select Area candidate sites.

	Site #	Existing Infrastructure	Adequate Depth	Access Permission	Adequate Water Quality	Imprinting/Homing Potential
Clifton Channel	#1	Yes, but dock in very poor condition. Existing lease in place.	Yes	No	Yes	Tributary discharge likely inadequate, significant potential for straying.
Westport Slough	#1	No, lacking dock and gangway.	Borderline	Unknown	OK, but elevated summer temps may affect early returning fall salmon.	Questionable, intermittent connection to Clatskanie River, tributary discharge low in late spring.
	#2	No, lacking dock and gangway. Additional pilings needed in deeper water.	Borderline	Unknown	OK, but elevated summer temps may affect early returning fall salmon.	Questionable, intermittent connection to Clatskanie River, tributary discharge low in late spring.
	#3	No, insufficient number and placement of pilings. Pilings needed in deeper water.	Insufficient depth during acclimation period.	Unknown	OK, but elevated summer temps may affect early returning fall salmon.	Questionable, intermittent connection to Clatskanie River, tributary discharge low in late spring.
	#4	Yes, but dock space is currently unavailable.	Borderline	Access tentative, subject to completion of proposed marina expansion.	OK, but elevated summer temps may affect early returning fall salmon.	Questionable, intermittent connection to Clatskanie River, tributary discharge low in late spring.
Coal Creek Slough	#1	Yes	Insufficient depth during acclimation period.	No, landowner concerns regarding length of commitment and constrained personal use.	OK, but elevated summer temps may affect early returning fall salmon.	Questionable, tributary discharge low in late spring.
	#2	No, lacking dock and gangway.	Yes	Yes, contingent upon details of any planned Select Area project.	OK, but elevated summer temps may affect early returning fall salmon.	Questionable, tributary discharge low in late spring.
	#3	No, lacking dock and gangway.	Yes	Unknown	OK, but elevated summer temps may affect early returning fall salmon.	Questionable, tributary discharge low in late spring.
Bradbury Slough	#1	Yes	Yes	Tentative	Yes	Tributary discharge likely inadequate, significant potential for straying.
	#2	Yes, but dock in very poor condition.	Yes	Unknown	Yes	Tributary discharge likely inadequate, significant potential for straying.
	#3	No, lacking gangway and structurally sound pilings.	Insufficient depth during acclimation period.	Unknown	Yes	Tributary discharge likely inadequate, significant potential for straying.

Estimated New Select Area Site Development Costs

To get a rough idea of the approximate cost to develop an acclimation site in a new Select Area, we estimated costs for the two areas, Westport Slough and Coal Creek Slough, that were determined to have some potential to acclimate juvenile salmon. Development costs included infrastructure (dock, pilings, gangway), net pens and netting, fish transport, and fish marking/tagging. Fish transport costs were based on round-trip distances from the likely source

hatchery to the acclimation site, and a transportation rate that included labor and fuel. Expected annual smolt releases for each site were approximated using Select Area release goals and the estimated capacity for the site given a relatively fixed acclimation window. Tagging costs included labor and the cost of the tags. To simplify the process, we did not include personnel costs associated with fish husbandry, facility maintenance, and project administration, or any costs related to fish feed, permits, or landowner lease agreements.

Total site development costs were approximately \$222,000-\$243,000 for each site, and were about \$20,000 higher for Coal Creek Slough due to a greater number of fish to be tagged (Table 20r). Roughly 23-30% of the total estimated costs in Table 20r represent recurring annual costs.

Table 20r. Estimated costs associated with development of juvenile acclimation facilities for potential new Select Area sites in Westport Slough and Coal Creek Slough.

Westport Slough

Dock:	8' x 100' dock with 60 ft. gangway	\$ 75,000
Pilings:	4 pilings (materials, install, and mobilization)	\$ 16,000
Pens:	One 4-pen unit with decking	\$ 74,500
Nets:	Four nets and bird covers	\$ 5,500
Fish Transport:	Spring Chinook: 362 miles @ \$2.25/mile (10 loads)	\$ 8,145
Fish Tagging (CWT):	Spring Chinook: 250,000 @ \$0.17/fish	\$ 42,500
	Total:	\$221,645

Assumptions:

- Spring Chinook originating from Marion Forks Hatchery
- 100% marking/tagging initially to evaluate site performance
- Releases of Coho are not planned due to potential for fall fishery impacts on ESA-listed LCR tule fall chinook and LCN Coho
- Dock and piling costs could be reduced if a planned expansion (timeline unknown) of the existing marina is successfully completed and ODFW is granted permission to access and use the infrastructure

Coal Creek Slough

Dock:	8' x 100' dock with 60 ft. gangway	\$ 75,000
Pilings:	4 pilings (materials, install, and mobilization)	\$ 16,000
Pens:	One 4-pen unit with decking	\$ 74,500
Nets:	Four nets and bird covers	\$ 5,500
Fish Transport:	Spring Chinook: 100 miles @ \$2.25/mile (8 loads)	\$ 1,800
	Coho: 100 miles @ \$2.25/mile (8 loads)	\$ 1,800
Fish Tagging (CWT):	Spring Chinook: 200,000 @ \$0.17/fish	\$ 34,000
	Coho: 200,000 @ \$0.17/fish	\$ 34,000
	Total:	\$242,600

Assumptions:

- Fish originate from a WDFW hatchery located 50 miles from Coal Creek and transport/tagging costs are equal to those for ODFW
- 100% marking/tagging initially to evaluate site performance
- Piling costs could be eliminated if agreement is reached with owner of existing pilings

Estimated Ex-Vessel Value of Potential New Select Areas

Using expected smolt releases for Westport Slough (spring Chinook) and Coal Creek Slough (spring Chinook and Coho), along with 2013-2016 average harvest rates and 2013-2017 average fish values for spring Chinook and Coho in the current Select Areas, we calculated the expected

ex-vessel value for hypothetical commercial fisheries in Westport Slough and Coal Creek Slough. For this exercise, the ex-vessel value was specific to the released cohort, and only represented the value of fish originating from Westport Slough and Coal Creek Slough, and did not include any harvest of fish from other Select Area sites or non-local stocks.

The total estimated ex-vessel value for Coal Creek Slough was approximately \$103,000 and was 20% higher than the value for Westport Slough (Table 20s). The difference in ex-vessel value was primarily due to the greater numbers of fish that would be released from Coal Creek Slough since Westport Slough would not release Coho because of concerns regarding a fall fishery in that area. Having a fall fishery in Coal Creek Slough not only increases the total ex-vessel value of the site, and uses the site more efficiently, but also provides an economic buffer should the spring Chinook fishery be poor in a given year. As previously mentioned, our calculated ex-vessel values do not include harvest of fish originating from outside the respective sites, and since Westport Slough and Coal Creek Slough are small terminal sites, it is unlikely that many fish from other areas would be harvested.

Table 20s. Estimated ex-vessel values for hypothetical commercial fisheries in potential new Select Areas.

Site	Spring Chinook Smolts Released	Coho Smolts Released	Spring Chinook Harvested	Coho Harvested	Spring Chinook Ex-Vessel Value	Coho Ex-Vessel Value	Total Ex-Vessel Value
Westport Slough	250,000	0	1,023	0	\$85,902	\$0	\$85,902
Coal Creek Slough	200,000	200,000	818	2,783	\$68,722	\$34,291	\$103,013

Assessment of Potential New Select Areas

An overall assessment of potential new Select Area sites based on the adult test fishing and juvenile rearing/acclimation evaluations is presented in Table 20t. Clifton Channel and Bradbury Slough are not viable sites for a new Select Area due to unfavorable findings in both the adult test fishing and juvenile acclimation evaluations. Although some concerns remain regarding the reliability of water sources for juvenile imprinting and adult homing in Westport Slough and Coal Creek Slough, these sites provide the only viable off-channel locations for establishing a new Select Area. However, because of the potential for a fall fishery in Westport Slough to encounter relatively large numbers of natural-origin tule fall Chinook and Coho, only a spring fishery could be implemented there. We summarize our assessment of each candidate site below.

Clifton Channel

Test fishing results showed that Clifton Channel had relatively high encounter rates of upriver Chinook and steelhead during both the spring and fall, which would likely lead to significant impacts on ESA-listed stocks. In addition, an analysis of expected upriver spring Chinook impacts for Clifton Channel indicated that impacts there would push the Select Areas over the total impact limit allocated to them. Stream discharge data collected during the juvenile acclimation evaluation suggested that Clifton Channel's intended imprinting/homing tributary, Hunt Creek, did not have sufficient discharge during the spring acclimation season to provide a reliable source of imprinting water for smolts. This would likely lead to substantial straying of fish released from the site. For these reasons, Clifton Channel was eliminated from consideration as a new Select Area site.

Table 20t. Overall assessment of new Select Area candidate sites following adult test fishing and juvenile rearing/acclimation evaluations.

Candidate Site	Adult Test Fishing Evaluation	Juvenile Rearing/Acclimation Evaluation
Clifton Channel	High encounter rates of upriver stocks; high potential to impact ESA-listed stocks in spring and fall; expected upriver spring Chinook impacts exceed allowed impacts	No reliable water source for juvenile imprinting and adult homing; high potential for straying
Westport Slough	SPRING: Low encounter rates of upriver stocks; low potential to impact ESA-listed stocks in spring; expected upriver spring Chinook impacts fit within allowed impacts FALL: High encounter rates of unmarked tule Chinook and unmarked Coho; high potential to impact wild LCR tule Chinook and LCN Coho	Marginal water source for juvenile imprinting and adult homing (low tributary flow in late spring/intermittent connection to Clatskanie River); moderate potential for straying; one site with infrastructure and tentative access permission
Bradbury Slough	High encounter rates of upriver stocks; high potential to impact ESA-listed stocks in spring and fall; expected upriver spring Chinook impacts exceed allowed impacts	No reliable water source for juvenile imprinting and adult homing; high potential for straying
Coal Creek Slough	Low encounter rates of non-local stocks; low potential to impact ESA-listed stocks in spring and fall; expected upriver spring Chinook impacts fit within allowed impacts	Marginal water source for juvenile imprinting and adult homing (low tributary flow in late spring); moderate potential for straying; one site with tentative access permission but no dock

Westport Slough

Test fishing results showed that Westport Slough had relatively low encounter rates of upriver Chinook and steelhead during both the spring and fall, but high encounter rates of unmarked tule Chinook and Coho in the fall, which could lead to significant impacts on ESA-listed LCR tule Chinook and LCN Coho. An analysis of expected upriver spring Chinook impacts for Westport Slough indicated that impacts there would fit within the total impact limit allocated to the Select Areas. Furthermore, stream discharge data collected during the juvenile acclimation evaluation suggested that Westport Slough's intended imprinting/homing tributary, Plympton Creek, likely had sufficient discharge during the early part of the spring acclimation season to provide a reliable source of imprinting water for smolts; however, Plympton Creek's discharge decreased sharply in late spring, and acclimation in Westport Slough may be further complicated by intermittent flows received from the nearby Clatskanie River through an old channel. These factors could lead to increased straying of fish released from the site. Although Westport Slough might be considered a viable new Select Area site for the spring season, there are still some issues/concerns remaining. First, permission to access the privately-owned infrastructure needed for an acclimation site is very tentative since the landowner has indicated that final permission would be contingent upon the details of any proposed new Select Area project. In addition, Westport Slough is a relatively small and narrow site, with an estimated fishable area of just under 0.20 mi². This already small area may be further reduced because Plympton Creek is located in the lower one-third of the fishable area, and is likely to draw most of the returning adults to the lower section. Therefore, fisher

participation may be low, thus limiting the economic benefit to the commercial fleet. Finally, ODFW staff working on the reintroduction of Chum in lower Columbia River tributaries have expressed concerns regarding the possible establishment of a Select Area fish acclimation facility and commercial fishery in Westport Slough due to its proximity to the Clatskanie River, a principal reintroduction site for Chum in Oregon. Before a new Select Area site can be developed in Westport Slough, these concerns would need to be addressed.

Bradbury Slough

Test fishing results showed that Bradbury Slough had relatively high encounter rates of upriver Chinook and steelhead during both the spring and fall seasons, which would likely lead to significant impacts on ESA-listed stocks. In addition, an analysis of expected upriver spring Chinook impacts for Bradbury Slough indicated that impacts there would push the Select Areas over the total impact limit allocated to them. Stream discharge data collected during the juvenile acclimation evaluation suggested that Bradbury Slough's intended imprinting/homing tributary, Green Creek, did not have sufficient discharge during the spring acclimation season to provide a reliable source of imprinting water for smolts. This would likely lead to substantial straying of fish released from the site. For these reasons, Bradbury Slough was eliminated from consideration as a new Select Area site.

Coal Creek Slough

Test fishing results showed that Coal Creek Slough generally had very low encounter rates for adult salmonids during both the spring and fall. Therefore, a fishery would have a low potential for impacting ESA-listed stocks. An analysis of expected upriver spring Chinook impacts for Coal Creek Slough indicated a fishery at this site would easily fit within the total impact limit allocated to the Select Areas. Stream discharge data collected during the juvenile acclimation evaluation showed that Coal Creek Slough's intended imprinting/homing tributary, Coal Creek, had the highest average monthly discharge among the candidate site tributaries. However, like the other tributaries, its discharge decreased sharply in late spring, which could reduce imprinting reliability for smolts at that time. Although Coal Creek Slough might be considered a viable new Select Area site for both the spring and fall seasons, there are still some issues/concerns remaining. First, permission to access the privately-owned infrastructure needed for an acclimation site is very tentative since the landowner has indicated that final permission would be contingent upon the details of any proposed new Select Area project. In addition, Coal Creek Slough is a relatively small and narrow site, with an estimated fishable area of approximately 0.25 mi². The limited capacity for fishers at this site would restrict economic benefit to a very small part of the commercial fleet. Also, high August temperatures recorded in Coal Creek Slough could inhibit early returning adult salmon from entering the site (USEPA 2003).

RECREATIONAL FISHERIES

Recreational fisheries in the mainstem Columbia River target a variety of species, such as spring, summer, and fall runs of Chinook, Coho and Sockeye, winter and summer runs of steelhead, and White Sturgeon. Shad and Walleye fishing are also popular at certain times of the year. Because the Harvest Reform Policy primarily addresses recreational salmon fisheries downstream from Bonneville Dam, our discussion of Columbia River recreational fisheries for this report will focus on these aspects.

Anglers fishing for salmon and steelhead in the lower Columbia River participate in four distinct seasonal fisheries: spring, summer, fall-mainstem, and fall-Buoy 10 fisheries. The “spring” season extends from January through June 15, the “summer” season from June 16 through July, and the “fall” season from August through December (though few anglers fish from November through mid-February). The spring fishery generally targets spring Chinook (when retention is open), the summer fishery primarily targets summer Chinook (when retention is open), and the fall fisheries target fall Chinook and Coho. Steelhead are targeted to varying degrees in all three seasons, but primarily during June-August, or when salmon abundance is low or retention is closed. Several reports provide detailed background and historical information on the lower Columbia River recreational fisheries (Watts 2009; ODFW and WDFW 2014-2018a; ODFW and WDFW 2014-2018b).

Recreational Effort

The primary measure of recreational fishery effort is an angler trip, where an angler fishes for a variable amount of time on a particular day. The trip may be made either locally or at a destination. The number of angler trips is important to the recreational fishery because economic value (in terms of purchased tackle, bait, gas, food, lodging, guided trips, etc.) is associated with them. Unlike commercial fisheries, economic value in recreational fisheries is not entirely dependent on fishing success, although angler effort often corresponds with catch rates. Angler trips expended for the main lower Columbia River recreational fisheries from 1993 through 2017 are shown in Table 21a. Between 1993 and 2000, total annual angler effort was relatively low, and effort was skewed heavily towards the fall fisheries. This was primarily due to depressed runs of salmon and steelhead during the 1990s, especially spring and summer Chinook. As runs improved in the early 2000s and mark-selective regulations provided opportunities to fish for hatchery spring and summer Chinook, angler effort increased significantly and became more balanced between spring/summer and fall fisheries. Total salmonid angler trips for the lower Columbia River recreational fishery have closely corresponded with the total run size of Chinook and Coho (Figure 21a). Figure 21b shows a strong positive logarithmic relationship between total salmon (Chinook and Coho) returns and total salmonid angler trips for the lower Columbia fishery ($R^2 = 0.83$), with the increase in angler effort tapering off at large returns.

Table 21a. Salmonid angler trips for the lower Columbia River recreational fisheries, by season/fishery, 1993-2017.

Year	Spring	Summer	Fall-Mainstem	Fall-Buoy 10	Total
1993	48,286	25,379	50,011	75,774	199,450
1994	39,035	18,268	27,678	9,253	94,234
1995	3,616	15,640	50,165	25,186	94,607
1996	4,288	19,371	55,437	18,034	97,130
1997	5,495	21,037	64,477	55,725	146,734
1998	9,021	16,217	65,884	41,042	132,164
1999	6,892	22,705	70,673	49,568	149,838
2000	16,039	28,038	80,759	72,518	197,354
2001	177,642	32,312	97,253	125,829	433,036
2002	180,127	54,839	110,796	84,434	430,196
2003	166,640	46,943	113,330	88,827	415,740
2004	161,992	41,850	87,414	68,818	360,074
2005	124,695	38,505	86,594	55,183	304,977
2006	86,835	43,802	89,287	40,608	260,532
2007	83,010	39,768	79,793	36,064	238,635
2008	102,972	51,288	80,772	32,467	267,499
2009	146,402	63,213	117,975	72,803	400,393
2010	186,132	70,661	114,285	52,300	423,378
2011	154,895	75,818	147,343	49,409	427,465
2012	127,919	80,733	128,831	65,070	402,553
2013	109,655	52,037	141,481	65,767	368,940
2014	145,642	53,661	143,946	107,522	450,771
2015	151,173	50,555	131,374	108,213	441,315
2016	126,826	58,067	133,300	94,950	413,143
2017	63,303	41,595	114,721	93,547	313,166

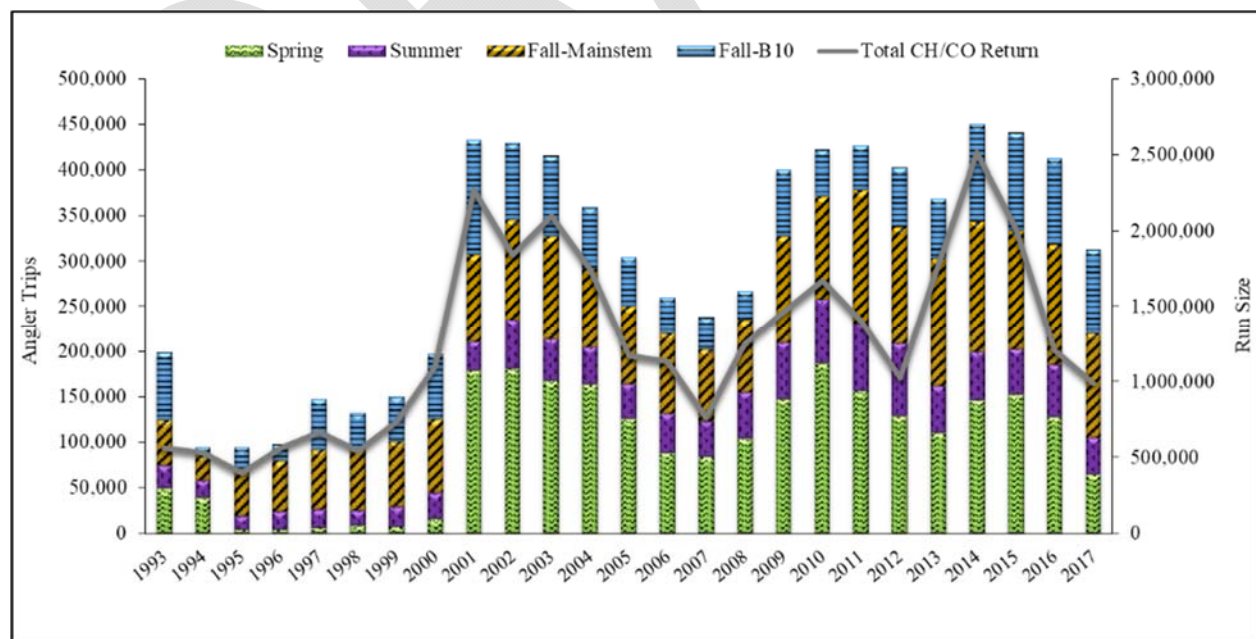


Figure 21a. Salmonid angler trips by season/fishery for the lower Columbia River recreational fisheries and total Chinook and Coho returns to the Columbia River, 1993-2017.

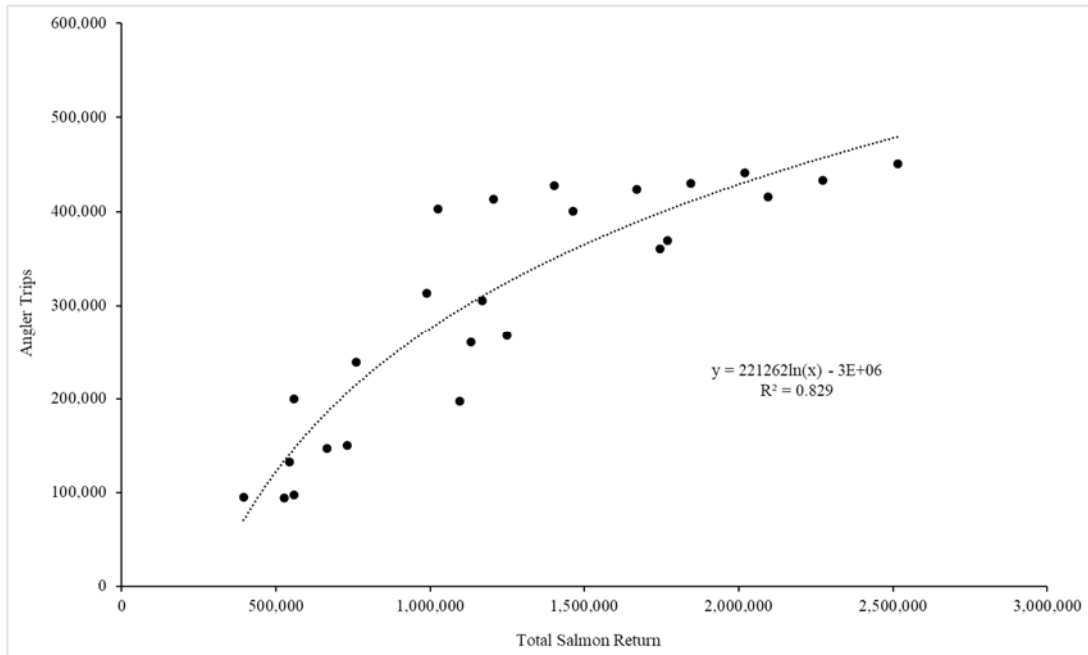


Figure 21b. Relationship between total salmon return and salmonid angler effort in the lower Columbia River recreational fishery, 1993-2017.

Spring Chinook fisheries in the lower Columbia were very limited throughout the 1990s because of low run sizes and the ESA-listing of upriver spring Chinook stocks. Spring angler effort increased significantly beginning in 2001, as run sizes increased and mark-selective fisheries for hatchery spring Chinook were implemented. Effort peaked in 2010 with a strong spring Chinook return, and after another strong run in 2015, spring Chinook returns have decreased the last two years, with angler effort following suit. Spring angler effort in 2017 was the lowest since 2000, and was likely the product of both a relatively low return and poor fishing conditions due to high, turbid river flows during much of the season. Figure 21c shows generally good correspondence between spring Chinook run sizes and angler effort in the spring fishery over a 25-year period.

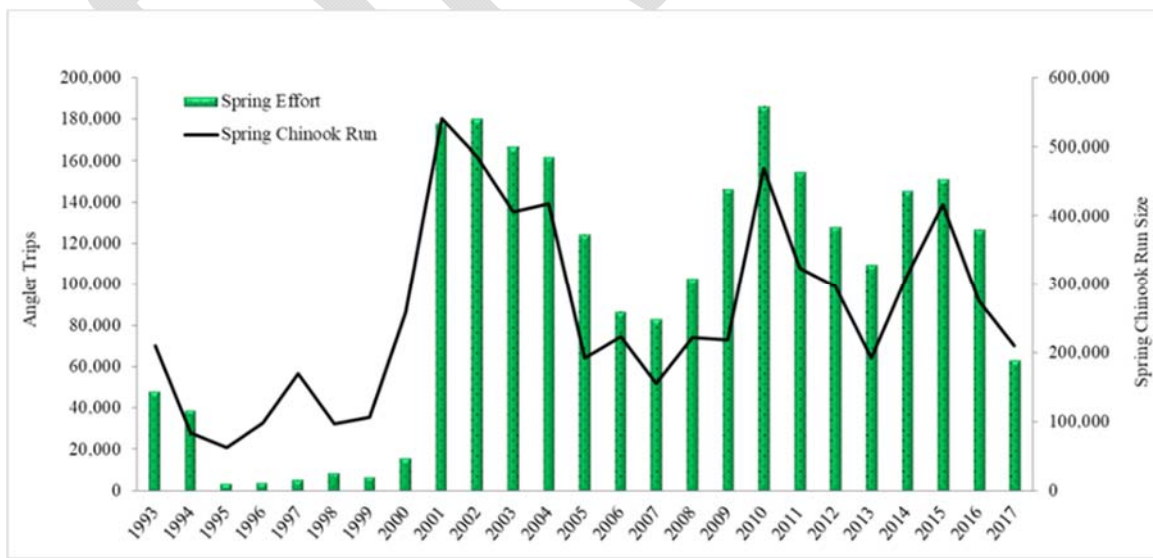


Figure 21c. Salmonid angler effort for the lower Columbia River recreational spring fishery, and total spring Chinook run size, 1993-2017.

The summer Chinook fishery in the lower Columbia River was closed from 1974 through 2001, primarily due to low run sizes of upriver summer Chinook, but also because of ESA-listed Snake River spring/summer Chinook, which were managed with non-ESA listed upriver summer Chinook until 2005 (ODFW and WDFW 2014-2018b). Therefore, the relatively low summer effort from 1993 through 2001 reflects angler trips for steelhead only. Beginning in 2002, with the resumption of summer Chinook fisheries, there was a corresponding increase in angling effort (Figure 21d). After peaking at nearly 81,000 angler trips in 2012, summer season effort has leveled off at around 50,000 trips annually, despite relatively strong summer Chinook returns during 2014-2016.

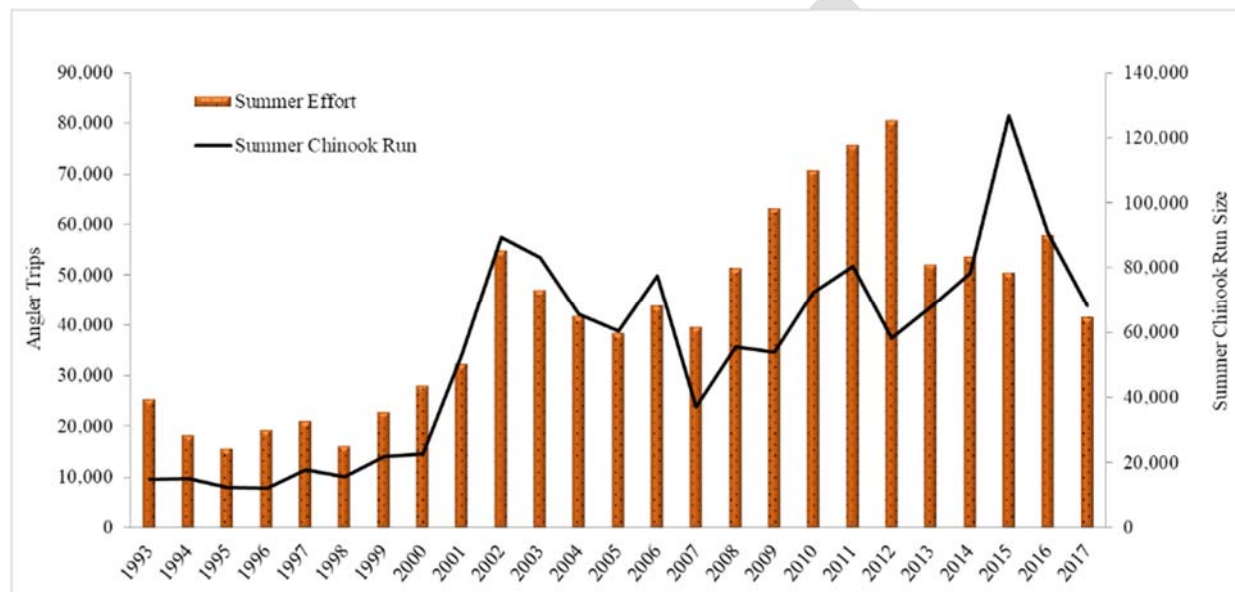


Figure 21d. Salmonid angler effort for the lower Columbia River recreational summer fishery, and summer Chinook run size, 1993-2017.

Catch rates (kept adults/angler trip) for summer Chinook are generally lower than they are for spring and fall Chinook (ODFW unpublished data), and this may dampen angler effort even when returns are good. The summer Chinook fishery is usually mark-selective, and the 50-55% mark rates typically seen in this fishery partly explain the lower catch rates for kept fish. Catch rates also decline steadily during the season as summer Chinook pass through the lower Columbia, and water temperatures increase. In addition, summer Chinook angling effort is limited by the relatively short season, lasting anywhere from two to six weeks. A lesser reason why summer season angler effort may not always correspond well with summer Chinook run size is because summer salmonid effort includes a subset of anglers who may target species other than Chinook, such as steelhead or Sockeye, and circumstances related to these other species (e.g. low run size or retention closures) may affect the effort level of those anglers. Salmonid anglers are not asked to specify a target species during creel interviews on the lower Columbia (Watts 2009); therefore, the relative contribution to total summer salmonid effort by anglers targeting different species is difficult to determine.

Similar to the spring and summer seasons, total angler effort during the fall has been generally higher since 2001. This coincides with increased returns of fall Chinook and Coho beginning in

the early 2000s (Figure 21e). There are two components to the lower Columbia River recreational fall fishery: 1) The “Buoy 10” fishery, which takes place in the estuary between navigational marker 10 and a line running from Tongue Point, Oregon to Rocky Point, Washington, and 2) The “mainstem” fishery, which occurs upstream of the Tongue Point-Rocky Point line to Bonneville Dam. The proportion of total fall angler effort attributed to each of these components varies from year to year, depending on fishing conditions, catch rates, and season lengths in the respective areas. Excellent catch rates in the estuary for Coho in 2001, 2003, and 2009, and Chinook during 2014-2017, contributed to relatively high angler effort for the Buoy 10 fishery in those years. Even with reduced fall Chinook returns in 2016 and 2017, catch rates remained high in the Buoy 10 fishery, and continued to draw anglers to that fishery.

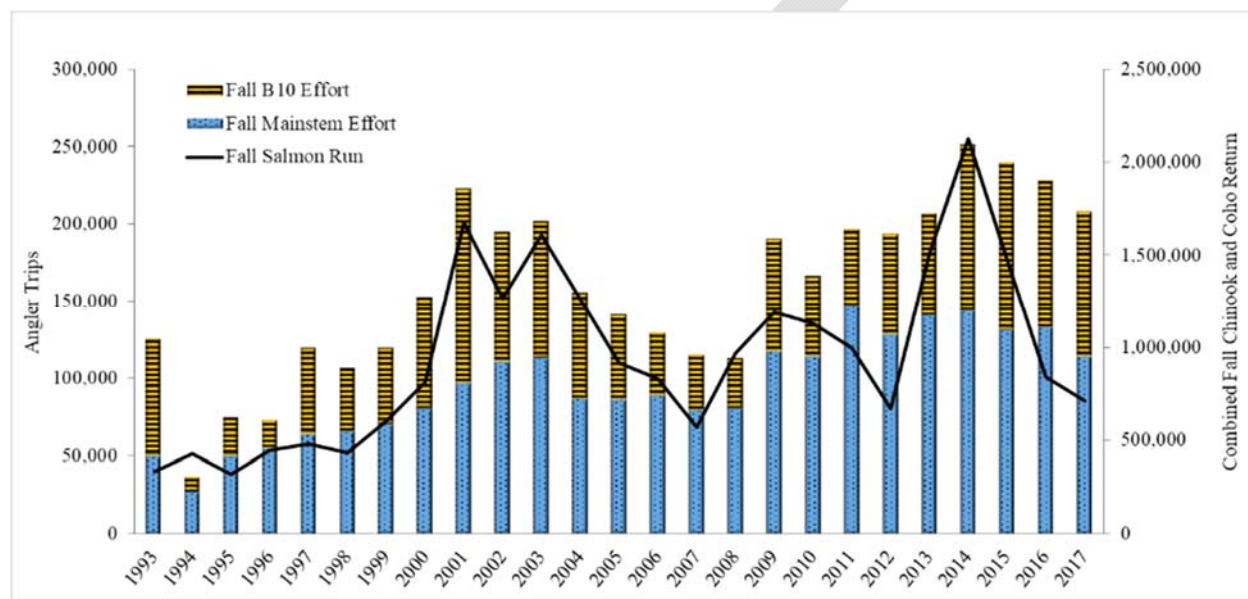


Figure 21e. Salmonid angler effort for the lower Columbia River recreational fall fisheries, and combined returns of fall Chinook and Coho, 1993-2017.

Angler effort in the fall mainstem fishery has declined since 2014, but it has decreased much more slowly than salmon returns during that time. One possible explanation for this is that anglers fishing the mainstem, particularly in the area between Warrior Rock/Lewis River and Bonneville Dam, have been using new fishing techniques and tackle to fish more effectively in areas and during times (e.g. flood tides) that have not typically been productive in the past. This expansion in fishing effectiveness is offsetting some of the negative effects of lower salmon returns, and helps to maintain angling effort at higher than expected levels.

In recent years, the implementation of mark-selective regulations for fall Chinook during part of the Buoy 10 (2013-2016) and mainstem (2012-2017, downstream of Warrior Rock/Lewis River) seasons has been used to conserve LCR tule impacts, so that these fisheries have a greater likelihood of achieving the season objectives (August 1-Labor Day for Buoy 10, August 1-September 14 for mainstem) outlined in the Harvest Reform Policy. Although angler effort typically drops when mark-selective regulations for fall Chinook are implemented (due to relatively low mark rates for desirable URB fall Chinook), anglers have also responded by planning their trips around mark-selective days or moving to an area that remains non-mark-selective for Chinook.

Expected vs. Actual Fishing Seasons and Angler Effort

Prior to implementation of the Harvest Reform policy, ODFW staff modelled the expected number of open fishing days for Chinook salmon, as well as angler trips, for each season of the lower Columbia River recreational fishery during the post-Reform period. We compared assumptions from Tables C1-C3 of the Management Strategies (ODFW 2012) to actual open fishing days and angler trips for 2013-2017. Analysis of post-season results for 2013-2017 indicated that the actual average number of open fishing days for the lower Columbia recreational fisheries usually met, or exceeded, expectations (Table 21b). The one season that fell well short of expectations was the post-update spring Chinook season, where an average of 58% of the expected open fishing days actually occurred. Although this season takes place after the initial run size update, there is often a large degree of uncertainty regarding the in-season run size due to variable environmental conditions, which can greatly affect the timing of the run, and therefore fishery managers' ability to make accurate predictions. Along with this run size uncertainty, there is also a need to ensure that recreational fisheries upstream of Bonneville Dam are not adversely affected by outcomes for the recreational fishery downstream of Bonneville. For example, if the lower river fishery exceeds its allocated share of ESA impacts or harvestable upriver spring Chinook, it could result in reduced opportunity for the upper river fishery. Therefore, fishery managers must be conservative in their management of the lower river fishery, even after the initial run update. Lastly, seeking to maximize open fishing days in April (pre-update) in the lower river, when catch rates are typically high and the catch is comprised primarily of upriver stocks, can reduce balances of allocated ESA impacts and harvestable upriver spring Chinook to the point where the expectation of a full 37 days of post-update fishing opportunity in the lower river cannot be met.

Table 21b. Expected and actual open fishing days for Chinook salmon in the lower Columbia River recreational fisheries, 2013-2017.

Chinook Season	Reform Assumptions (Tables C1-C3) ¹						Actual ¹						Actual/ Expected Avg	Actual/ Expected Run
	2013	2014	2015	2016	2017	Avg	2013	2014	2015	2016	2017	Avg		
Spring (Pre-Update) ²	44	44	44	44	45	44	40	45	43	39	50	43	98%	86%
Spring (Post-Update) ³	37	37	37	37	37	37	22	32	31	23	0	22	58%	86%
Summer ⁴	18	18	26	26	46	27	15	40	46	46	40	37	140%	121%
Buoy 10 ⁵	34	34	34	34	34	34	50	32	28	61	35	41	121%	204%
Mainstem (Below Lewis) ⁶	45	45	45	45	45	45	45	45	45	45	45	45	100%	204%
Mainstem (Above Lewis) ⁷	92	92	92	92	92	92	92	92	92	82	92	90	98%	204%

¹ Open fishing days were expected to be consecutive; however, actual open days were not always consecutive due to the need for in-season management.

² March 1-May 9; assumes run update occurs on May 10.

³ May 10-June 15.

⁴ June 16-July 31.

⁵ Expected open days based on August 1-September 3 (average date for Labor Day). Actual open days include any days open for Chinook retention August 1-September 30. In 2014, the fishery still met the Labor Day objective as Labor Day fell on September 1 that year. For Buoy 10, the Policy does not distinguish between open days that are Chinook MSF or non-MSF.

⁶ August 1-September 14, including one week of Chinook MSF September 8-14.

⁷ August 1-October 31.

With respect to angler effort, average annual angler trips in the summer and fall recreational fisheries downstream of Bonneville Dam exceeded expectations for their respective seasons (Table 21c). This generally corresponds with how the actual summer and fall Chinook runs compared to the run sizes used in pre-Reform modelling, although not to the same degree. Average annual angler trips in the spring fishery were 68% of the expected average number of trips, and did not

meet expectations in any of the post-Reform years, despite relatively good spring Chinook returns in 2014-2016 and allocation increases for recreational fisheries from 65% in 2013 to 80% in 2017. One partial explanation for this is that pre-Reform modelling of spring angler trips was based on an expected annual total of 81 open fishing days between March 1 and June 15. Although the pre-update season has largely provided its expected level of fishing opportunity, the post-update season has not, and this could have contributed to the shortfall in angler trips. Another possible reason for the lower than expected angler trips is that spring fishing conditions in some years (e.g. 2014 and 2017) were challenging due to high, turbid river flows, and this could have discouraged angler effort to some degree.

Table 21c. Expected and actual salmonid angler trips in the lower Columbia River recreational fisheries, 2013-2017.

Season	Reform Assumptions (Tables C1-C3)						Actual						Actual/ Expected Avg	Actual/ Expected Run
	2013	2014	2015	2016	2017	Avg	2013	2014	2015	2016	2017	Avg		
Spring	175,376	175,376	175,376	175,376	180,453	176,391	109,655	145,642	151,173	126,826	63,303	119,320	68%	86%
Summer	33,746	33,746	45,047	45,047	70,000	45,517	52,037	53,661	50,555	58,067	41,595	51,183	112%	121%
Fall	175,000	175,000	175,000	175,000	175,000	175,000	207,248	251,468	239,587	228,250	208,268	226,964	130%	204%

Recreational Catch

Numbers of adult salmon and steelhead harvested in the various lower Columbia River recreational fisheries from 1999 through 2017 are displayed in Table 21d. Figure 21f shows that, as with angler effort, there was also a positive logarithmic relationship between the total return of Chinook and Coho to the Columbia River and the harvest of these species in recreational fisheries downstream of Bonneville Dam ($R^2 = 0.64$). However, the strength of the relationship was not as great for catch as it was for effort. Often, there are factors other than run size that can have a significant effect on an angler's ability to catch fish--such as river conditions (e.g. flow, turbidity, and temperature), angler skill/experience, innovations in angling methods/tackle, and whether the fish are "biting".

Table 21d. Kept catch of adult salmon and steelhead in the lower Columbia River recreational fisheries, 1999-2017.

Year	Spring	Summer	Summer	Sockeye	Fall-Mainstem		Fall-Buoy 10		Total
	Chinook	Chinook	Steelhead		Chinook	Coho	Chinook	Coho	
1999	0	0	7,090	0	8,652	1,276	9,850	8,960	35,828
2000	322	0	9,834	22	7,620	1,620	6,085	21,478	46,981
2001	25,711	0	11,412	114	9,355	3,068	12,709	132,035	194,404
2002	20,936	1,352	11,860	13	21,182	3,011	19,438	6,205	83,997
2003	16,892	1,854	9,557	0	26,195	1,145	16,316	54,440	126,399
2004	23,740	1,119	8,741	6	17,719	1,273	16,016	15,169	83,783
2005	11,315	1,571	7,396	0	18,256	586	9,287	6,878	55,289
2006	6,985	4,924	10,076	0	13,398	1,173	1,710	3,683	41,949
2007	6,476	2,214	10,650	0	8,089	881	3,776	8,356	40,442
2008	20,040	2,051	9,103	494	10,675	2,248	8,349	8,573	61,533
2009	16,923	2,256	16,927	900	14,711	3,989	5,941	48,127	109,774
2010	29,247	2,539	18,324	218	17,326	1,584	6,807	7,980	84,025
2011	11,694	5,160	24,973	1,427	28,169	1,667	10,919	7,614	91,623
2012	13,332	2,897	19,972	3,948	22,438	884	18,550	7,385	89,406
2013	6,950	1,832	12,749	502	31,879	951	22,594	7,620	85,077
2014	15,728	1,980	15,445	938	26,336	5,761	26,788	57,744	150,720
2015	19,586	5,928	9,515	958	41,525	995	36,422	36,859	151,788
2016	12,666	3,080	8,255	744	25,133	1,317	17,780	9,181	78,156
2017	9,047	3,516	1,679	264	26,138	3,114	28,398	18,834	90,990

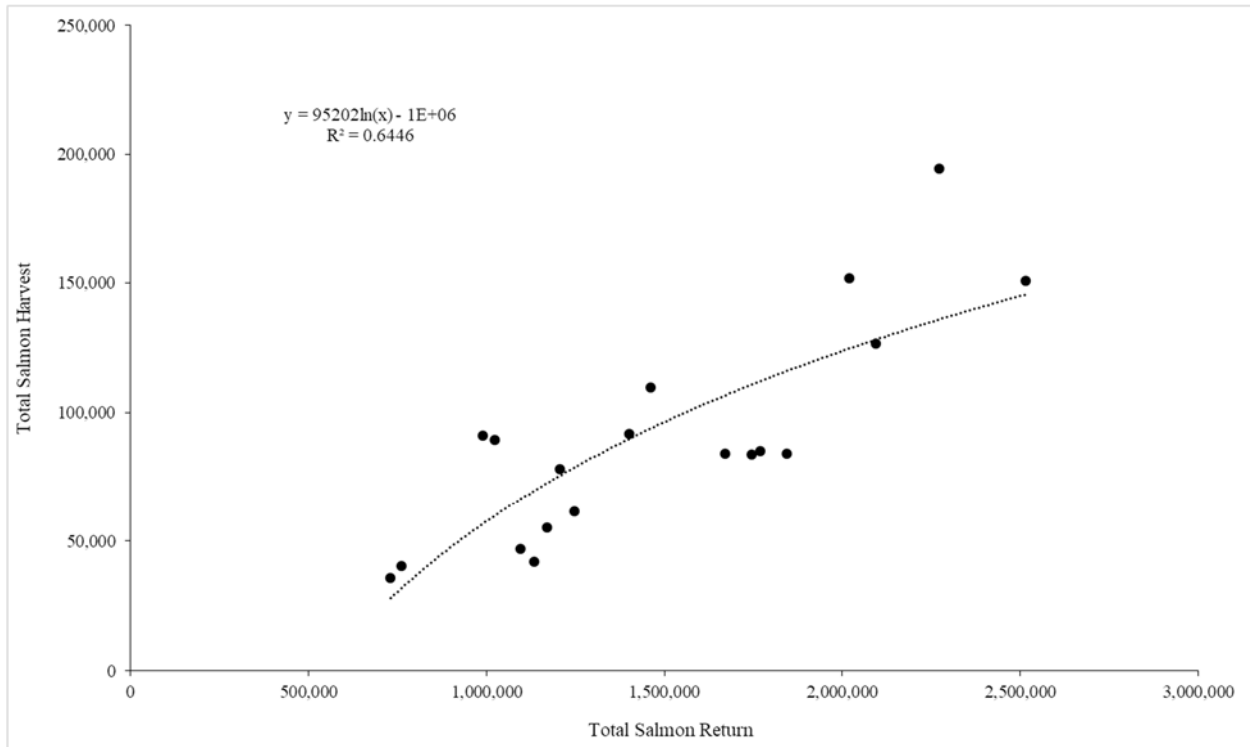


Figure 21f. Relationship between total salmon return and salmon harvest in the lower Columbia River recreational fishery, 1999-2017.

On average, approximately 68% of the annual Chinook salmon harvest occurred in the fall mainstem and Buoy 10 fisheries, although spring Chinook harvest was significant in strong run years, and in years when spring fishing conditions were very favorable. Annual summer Chinook harvest was modest, ranging from approximately 1,000-6,000 fish per year. Summer steelhead catches ranged from a high of 24,973 in 2011 to a low of 1,679 in 2017. The unusually low steelhead harvest in 2017 was the result of a poor summer steelhead return and the special regulations that were implemented to reduce harvest (e.g. August retention closure, reduced daily bag limit). Coho harvest was highly variable from year to year, primarily reflecting large fluctuations in run size. However, with most Coho harvest occurring in the Buoy 10 fishery, in some years (e.g. 2015), good fishing conditions/high effort in the estuary can lead to a high Coho catch, even in poor return years. Sockeye fisheries were very limited prior to 2008 due to the ESA-listing of the Snake River population, and overall low returns. Even with large Sockeye returns during 2008-2016, harvest remained relatively modest, as anecdotal observations indicate that most anglers would rather target summer Chinook and steelhead during the summer season. This is likely due to the small size of Columbia River Sockeye, which average around 4 pounds. Overall, inter-annual variations in Chinook and Coho harvest generally coincided with the strength of the respective runs (Figures 21g, 21h, and 21i), although the pattern was not as clear for summer Chinook.

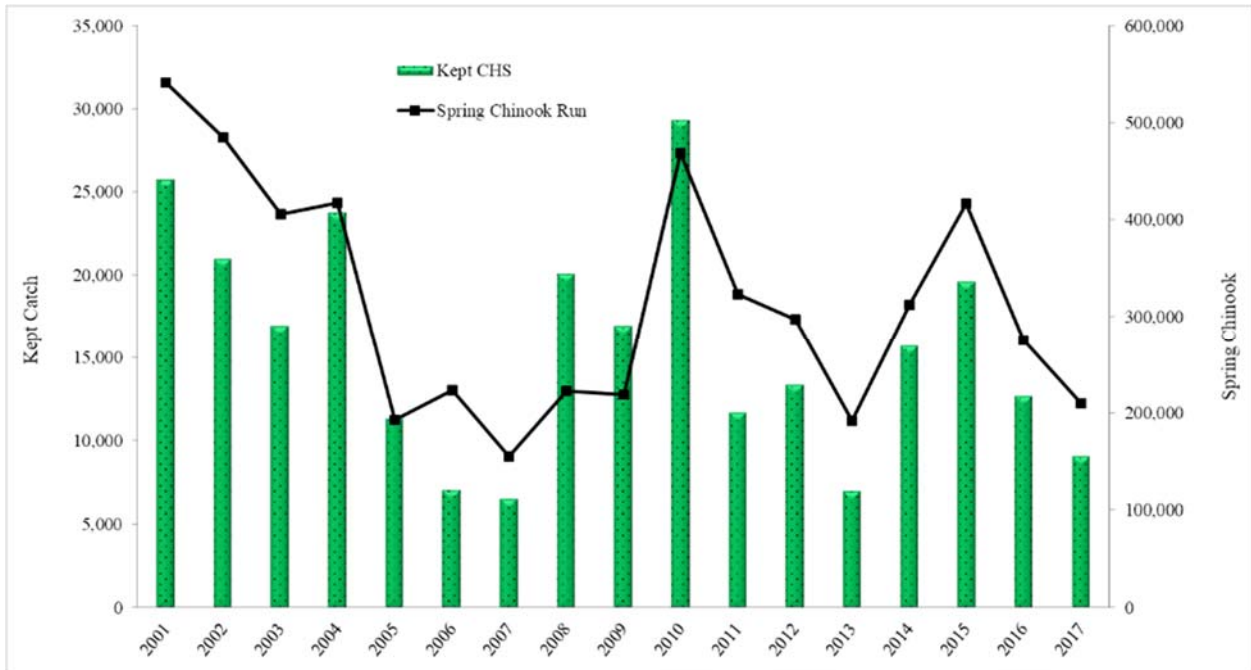


Figure 21g. Kept catch of adult spring Chinook in the lower Columbia River recreational spring fishery, and spring Chinook run size, 2001-2017.

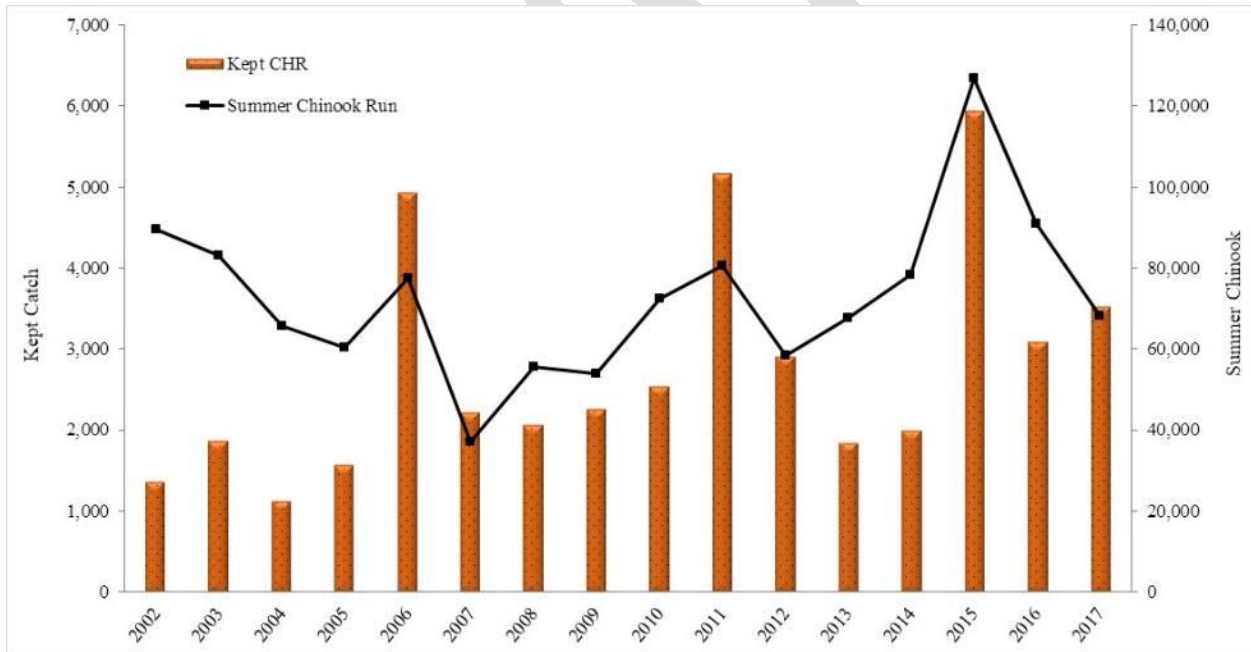


Figure 21h. Kept catch of adult summer Chinook in the lower Columbia River recreational summer fishery, and summer Chinook run size, 2002-2017.

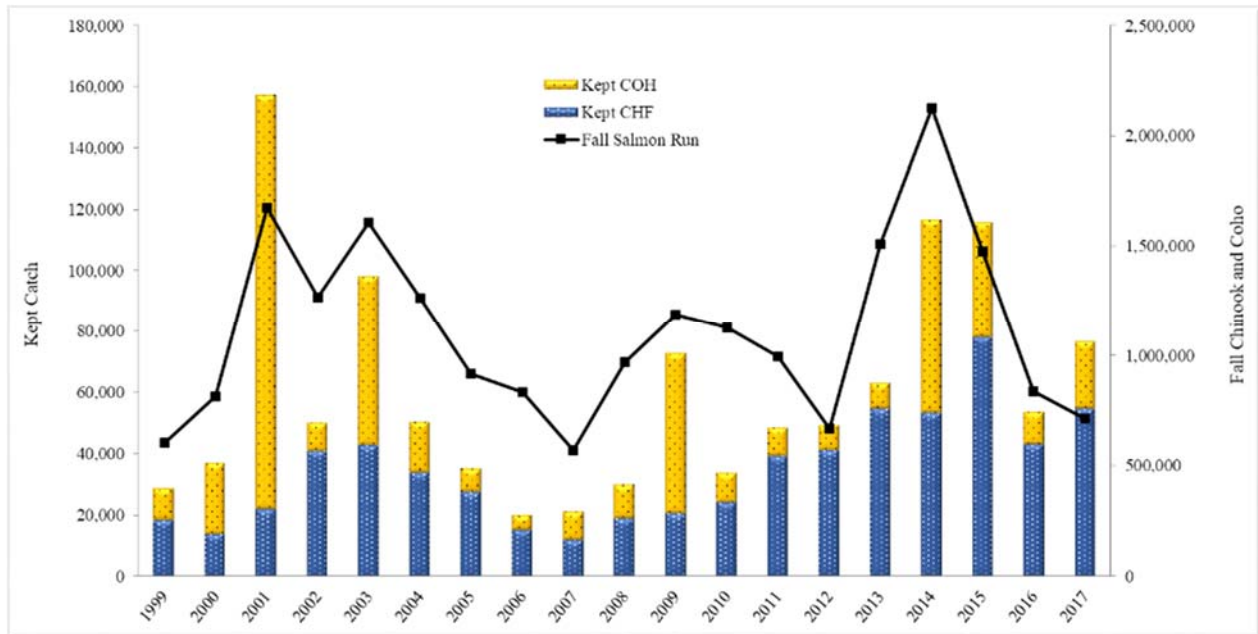


Figure 21i. Kept catch of adult fall Chinook and Coho in the lower Columbia River recreational fall fisheries, and combined run size of fall Chinook and Coho, 1999-2017.

Expected vs. Actual Chinook Harvest

Prior to implementation of the Harvest Reform policy, ODFW staff modelled the expected harvest of adult Chinook for each season of the lower Columbia River recreational fishery during the post-Reform period. We compared assumptions from Tables C1-C3 of the Management Strategies (ODFW 2012) to actual Chinook harvest during 2013-2017. Analysis of post-season results for 2013-2017 indicated that, with the exception of the spring fishery, actual average annual adult Chinook harvest exceeded expectations (Table 21e), likely due to larger than expected run sizes. The results were similar to those for expected vs. actual angler trips, and it is likely that the same factors (e.g. difficult spring fishing conditions in some years) contributed to the spring Chinook harvest falling below expectations.

Table 21e. Expected and actual kept catch of adult Chinook in the lower Columbia River recreational fisheries, 2013-2017.

Season	Reform Assumptions (Tables C1-C3)						Actual						Actual/ Expected Avg	Actual/ Expected Run
	2013	2014	2015	2016	2017	Avg	2013	2014	2015	2016	2017	Avg		
Spring	17,701	17,701	17,701	17,701	18,442	17,849	6,950	15,728	19,586	12,666	9,047	12,795	72%	86%
Summer	2,604	2,604	3,142	3,142	3,772	3,053	1,832	1,980	5,928	3,080	3,516	3,267	107%	121%
Fall	33,800	33,800	33,800	33,800	33,800	33,800	54,473	53,124	77,947	42,913	54,536	56,599	167%	204%

ESA Impacts/Catch Balancing

Lower Columbia Spring Chinook Fishery

The spring Chinook fishery in the Columbia River is managed to remain within the allowed impacts to ESA-listed upriver spring Chinook. Since 2010, non-treaty fisheries must also remain

within their allowed “catch balance” of upriver spring Chinook (kept fish plus release mortalities) relative to treaty fisheries per the 2008-2017 *U.S. v. Oregon* Management Agreement (ODFW and WDFW 2011). Commercial and recreational fisheries are each allocated a share of the allowable non-treaty ESA impacts and catch balances for upriver spring Chinook.

Table 21f compares ESA impacts and catch balances assigned to the lower Columbia River recreational spring Chinook fishery, with what was actually used during the 2001-2017 seasons. Inter-annual variation in allowable ESA impacts and catch balances primarily reflect fluctuations in upriver spring Chinook run sizes; however, changes in allocation shares between commercial and recreational fisheries since implementation of the Harvest Reform Policy in 2013 have also affected the impacts/catch balance available to the recreational fishery. Before the catch balancing provision was implemented in 2010, the recreational fishery was limited by ESA impacts, and the allowable impacts were exceeded in some years. Since 2010, the catch balance has become the greater limiting factor for the spring recreational fishery (average usage of 95% vs. 75% for impacts). With more conservative management in recent years due to both catch balancing and the use of the pre-update buffer, the recreational fishery has remained within its guidelines in most years.

Table 21f. Upriver spring Chinook ESA impacts and catch balances for the lower Columbia River recreational spring Chinook fishery, 2001-2017.

Year	Impacts Allowed ¹	Impacts Used	% Impacts Used	Catch Balance Allowed ²	Catch Balance Used	% Catch Balance Used
2001	0.80%	0.84%	105%	-	-	-
2002	1.02%	0.93%	92%	-	-	-
2003	1.11%	0.77%	69%	-	-	-
2004	0.80%	1.14%	143%	-	-	-
2005	0.79%	0.80%	101%	-	-	-
2006	0.86%	0.45%	53%	-	-	-
2007	0.86%	0.57%	67%	-	-	-
2008	0.87%	1.25%	144%	-	-	-
2009	0.93%	1.05%	113%	-	-	-
2010	0.83%	0.84%	102%	16,996	23,535	138%
2011	0.90%	0.54%	60%	12,647	9,505	75%
2012	0.85%	0.63%	75%	12,666	10,428	82%
2013	0.77%	0.61%	79%	6,168	5,343	87%
2014	1.05%	0.79%	76%	15,682	13,572	87%
2015	1.16%	0.69%	59%	19,316	15,689	81%
2016	1.00%	0.71%	71%	10,791	10,167	94%
2017	0.90%	0.68%	76%	6,334	7,198	114%
2010-17 Avg	0.93%	0.69%	75%	12,575	11,930	95%

¹ 2001-2003 include impacts allowed for the recreational fishery above Bonneville Dam.

² Catch balancing provision first implemented in 2010.

Lower Columbia Fall Chinook Fisheries

In most years, the primary limiting factor for the fall Buoy 10 and mainstem recreational fisheries is the allowable impact to ESA-listed natural-origin Lower Columbia River (LCR) tule fall Chinook; however, in some years, ESA impacts to Snake River wild fall Chinook and steelhead may also be constraints. Because of the low numbers of wild LCR tules, a more abundant indicator stock, Lower River Hatchery (LRH) tules, is used as a surrogate for calculating fishery impacts and establishing protective measures in fisheries. LCR tule impacts are allocated between the commercial and recreational fisheries, and the recreational share is further sub-allocated to the Buoy 10 and mainstem fisheries.

Table 21g compares ESA impacts for LCR tule Chinook allocated to the Buoy 10 and lower mainstem recreational fisheries, with what was actually used during the 2008-2017 seasons. Inter-annual variation in allowable ESA impacts primarily reflect fluctuations in LCR tule run sizes; however, changes in allocation shares between commercial and recreational fisheries since implementation of the Harvest Reform Policy in 2013 have also affected the impacts available to the recreational fishery. During 2013-2017, the Buoy 10 fishery has exceeded its allowed guideline in 3 out of 5 years, and has used an average of 103% of its allocation. In contrast, the mainstem fishery did not exceed its LCR tule impact guideline in any year since 2012, and has used an average of 61% of its allocation.

Table 21g. LCR tule fall Chinook ESA impacts for the lower Columbia River recreational fall Chinook fisheries, 2008-2017.

Year	Buoy 10			Mainstem			Total Fall		
	Impacts Allowed	Impacts Used	% Impacts Used	Impacts Allowed	Impacts Used	% Impacts Used	Impacts Allowed	Impacts Used	% Impacts Used
2008	2.03%	2.34%	115%	2.25%	1.26%	56%	4.28%	3.60%	84%
2009	2.59%	2.19%	85%	2.06%	1.49%	72%	4.65%	3.68%	79%
2010	2.40%	1.24%	52%	1.75%	2.27%	130%	4.15%	3.51%	85%
2011	1.92%	1.12%	58%	1.55%	3.78%	244%	3.47%	4.90%	141%
2012	2.16%	5.16%	239%	2.69%	3.34%	124%	4.85%	8.50%	175%
2013	3.16%	3.70%	117%	2.34%	1.78%	76%	5.50%	5.48%	100%
2014	3.54%	4.70%	133%	2.03%	0.54%	27%	5.57%	5.24%	94%
2015	4.12%	3.91%	95%	1.97%	0.60%	30%	6.09%	4.51%	74%
2016	6.52%	3.95%	61%	1.33%	1.18%	89%	7.85%	5.13%	65%
2017 ¹	4.76%	5.25%	110%	1.51%	1.28%	85%	6.27%	6.53%	104%
2013-2017 Avg	4.42%	4.30%	103%	1.84%	1.08%	61%	6.26%	5.38%	87%

¹ Preliminary.

With the growing popularity of the Buoy 10 fishery in recent years, a greater share of the recreational fall ESA impacts have shifted to that fishery. Between 2012 and 2017, the Buoy 10 share of assigned impacts increased from 45% to 76%, and its share of the used impacts increased from 61% to 80% (Figure 21j). In 2016 and 2017, preseason and actual impact usage have been more well aligned, likely reflecting increased stability in those years when compared to 2013-2015, when very large fall Chinook returns drove dramatically increased angler effort and catch.

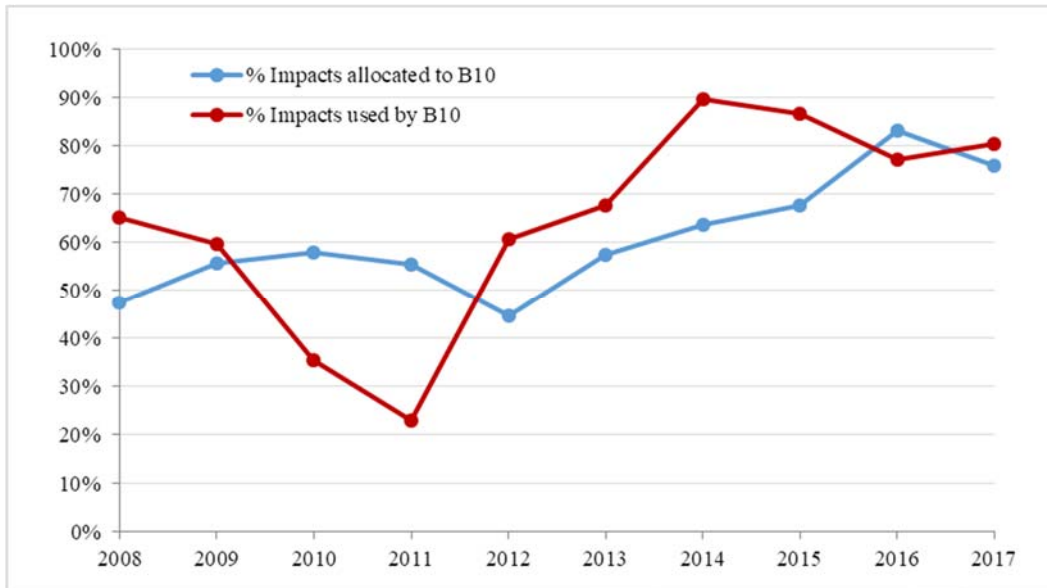


Figure 21j. Percentage of recreational fall LCR tulle impacts allocated to, and used, by the Buoy 10 fishery, 2008-2017.

In addition to increased angler effort, another possible reason for the expanded use of LCR tulle impacts by the Buoy 10 fishery is an apparent change in the demographics of the fishery during recent years. Since 2012, the percentage of the total angler trips and kept salmon catch in the Buoy 10 fishery attributed to guides and their clients has grown disproportionately to about 23% of the trips and 33% of the catch in 2017 (Figure 21k). Increased concentration of the catch within an angler subgroup with higher than average catch rates and higher than average effort (in terms of rods per boat, days fished per season) may be one reason why managing the Buoy 10 fishery within allowable ESA impacts to a fixed target date of Labor Day has become more challenging in recent years.

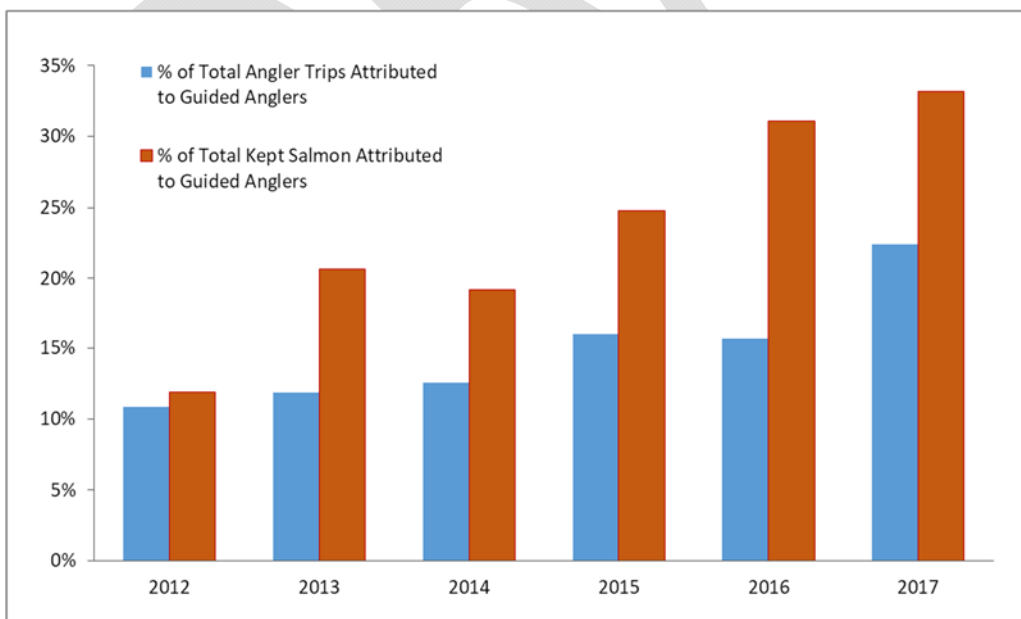


Figure 21k. Percentage of total angler trips and kept Chinook and Coho in the Buoy 10 fishery attributed to guided anglers, 2012-2017.

Effect of Harvest Reform Allocation Changes on the Recreational Fishery

As part of the Harvest Reform process, the Oregon Commission adopted the following policy objective in rule (635-500-6705): “(5) For steelhead, salmon and sturgeon, prioritize recreational fisheries in the mainstem and commercial fisheries in off-channel areas of the lower Columbia River. Toward this end: a) Assign mainstem recreational fisheries a sufficient share of ESA-impacts and harvestable surplus to enhance current fishing opportunity and economic benefit. b) Assign commercial fisheries a sufficient share of the ESA-impacts and harvestable surplus to effectively harvest fish in off-channel areas and harvest surplus fish with selective techniques in the mainstem Columbia River” (emphasis added).

This policy objective includes a phased shift in allocation from non-tribal commercial fisheries to recreational fisheries in 2013 and beyond per OAR 635-500-6715 through OAR 635-500-6750. Table 21h shows updated recreational and commercial allocations and policies for 2017+ adopted by the Washington and Oregon commissions in January and March of 2017, respectively.

Table 21h. Summary of impact sharing as defined in Harvest Reform rules/policy. Shares are listed as recreational/commercial.

Species/Stock	Transition Period				Long-term
	2013	2014	2015	2016	2017+
Spring Chinook	65/35	70/30			80/20 ^a
Summer Chinook (<Priest Rapids)	60/40		70/30		80/20 ^b
Sockeye ^c	70/30				80/20
LCR Fall Chinook ^d	≤70/≥30				≤70/≥30 ^e
SRW Fall Chinook ^f	≤70/≥30				≤70/≥30 ^e
LCN Coho ^g	Priority to Select Area and mainstem Chinook commercial fisheries				Priority to Select Area, mainstem Chinook, and hatchery Coho commercial fisheries
Chum	No retention. Share sufficient to implement Select Area and mainstem commercial fisheries targeting other species.				
White Sturgeon	80/20 (when retention allowed)				

^a Oregon policy allows post-run update mainstem commercial fishery using tangle nets if impacts remain available above what is needed for Select Areas; Washington policy requires any spring mainstem commercial fishery to use alternative gears other than tangle net.

^b By policy, any mainstem commercial summer Chinook fishery must use alternative gears.

^c Commercial share for incidental harvest in Chinook-directed fisheries.

^d Lower Columbia River natural-origin tule fall Chinook (LCR).

^e Oregon policy allocation is ≤70/≥30 (with no more than 2% of 30% applied to alternative gear types) and Washington policy allocation is ≤75/≥25 through 2018, and ≤80/≥20 thereafter. Washington policy has a sunset provision for Zone 4-5 gillnet fishery after 2018, while Oregon policy has no sunset provision.

^f Snake River Wild fall Chinook (SRW).

^g Lower Columbia River natural-origin Coho (LCN).

Several different approaches could be used to evaluate the potential effects of Harvest Reform-related allocation changes on the recreational fishery. During development of the Policy, “angler trips” was the primary metric used to evaluate the effects of potential policy choices on recreational

fisheries. Given this, one approach is to directly compare angler trips for the “post-Reform” years (2013-2017) to a baseline of the most recent “pre-Reform” years (e.g. 2010-2012) to see if angler effort increased. This approach would assume that any observed difference in average angler effort between the two periods was due to the allocation change, and not to other factors.

When we examined angler effort for the lower Columbia spring Chinook fishery, we found that the average number of angler trips actually decreased by 23.7% during the post-Reform period, relative to the pre-Reform baseline period (Table 21i). Because it does not make sense that an increase in the recreational allocation, theoretically allowing more fish to be caught, would lead to a lower level of angler effort, there must be other factors affecting angler effort. Table 21i shows that the average spring Chinook return also decreased by 22.5% between pre-Reform and post-Reform periods. As previously mentioned, spring angler effort corresponds closely with spring

Table 21i. Comparison of average angler effort and run size between pre-Reform (2010-2012) and post-Reform (2013-2017) periods for the lower Columbia River spring Chinook fishery.¹

Year	Angler Trips	Spring Chinook Run Size
2001	177,642	541,068
2002	180,127	485,109
2003	166,640	405,908
2004	161,992	417,510
2005	124,695	192,847
2006	86,835	223,575
2007	83,010	155,506
2008	102,972	222,555
2009	146,402	219,063
2010	186,132	468,798
2011	154,895	323,122
2012	127,919	297,089
2010-2012 Pre-Reform Avg	156,315	363,003
2013	109,655	191,978
2014	145,642	311,987
2015	151,173	416,733
2016	126,826	275,689
2017	63,303	210,191
2013-2017 Post-Reform Avg	119,320	281,316
% Change Between Periods	-23.7%	-22.5%

¹ The 2001-2009 angler trips and run sizes shown for reference.

Chinook run size (Figure 21c), and studies have found that perceived/actual fish abundance (i.e. run size) and catch rates can greatly affect the level of angler effort at a particular time (The Research Group 2015). Therefore, due to the probable confounding effects of run size and other non-allocation related factors (e.g. river conditions, catch rates, etc.) on angler effort, we concluded that a direct comparison between pre-Reform and post-Reform angler trips could not be used to accurately assess the potential effects of an allocation shift. Even our comparisons of expected (modelled) and actual open fishing days, angler trips, and Chinook harvest (Tables 21b, 21c, and

21e) reported earlier are likely confounded by factors outside of the Harvest Reform Policy, such as differences between average run sizes used in the models and actual returns.

An alternative approach to evaluating the effect of allocation changes on angler trips uses a model that begins with an observed fishery year, and then simulates the changes that would be expected to have occurred with different allocations. A year and season-specific model using actual fishery data would allow a comparison of outputs (e.g. open fishing days and angler trips) at pre- and post-Reform allocations, while holding all other variables (e.g. run size, catch rate, river conditions, etc.) constant. Therefore, any difference in fishing days or angler trips would be solely due to a change in the allocation. Because this modelling approach could isolate the effects of allocation change, we used year-specific Columbia River fishery management models for spring, summer, and fall Chinook recreational fisheries to evaluate the potential effects of Harvest Reform-related allocation changes.

Since we already knew the actual season structures and results for the various recreational fisheries at post-Reform allocations, we used “reverse” modelling to see if simulating the fisheries at *lower* pre-Reform allocations would result in *less* fishing opportunity (i.e. fewer open fishing days and angler trips). If it did, then we could logically conclude that the opposite was also true—that *higher* post-Reform allocations for the recreational fishery had resulted in *more* fishing opportunity, relative to the pre-Reform allocation. If the simulation did not result in any change in fishing opportunity, then we concluded that the allocation shift had no effect.

To simplify modelling, we focused our analyses on mainstem recreational fisheries downstream of Bonneville Dam during the 2013-2017 post-Harvest Reform period. We used the three years immediately preceding Reform (2010-2012) to calculate an average pre-Reform allocation for each fishery. This allowed us to make a comparison that was close in time, as well as use a pre-Reform period of relatively stable allocations. Using years prior to 2010 would have introduced potentially confounding factors due to the less stable allocations characterizing those years. Because each lower Columbia River recreational season and fishery has its own unique characteristics and management considerations, specific methods and results are discussed separately below.

Lower Columbia Spring Chinook Fishery

For spring Chinook fisheries modelling, we used the average 2010-2012 allocation of 60% recreational and 40% commercial (post-run update; not including unallocated ESA impacts) as our pre-Reform allocation. Since the recreational spring Chinook fishery is usually limited by the allowable catch balance rather than ESA impacts (Table 21f), we focused on modelling the catch balances. Because the spring Chinook fishery is modelled by fishery managers at specific decision points during the season (usually when the run size is updated), we adopted the same stepwise approach for our modelling exercise. This takes into account that *what* information fishery managers have, and *when* they have it, can greatly affect in-season management decisions regarding season structure and fishing opportunity. For the spring fishery, we ran a year-specific model at four decision points (pre-run update, first run update, second run update, and third run update), at both pre- and post-Reform allocations, for 2013 through 2017. At each decision point, we used a catch balance model to determine the catch balance available to the recreational fishery

at the estimated upriver spring Chinook run size and designated allocation. We used post-season reports to identify the fishery management objective (e.g. fishery extension on specific dates) and decision for each modelling point (ODFW and WDFW 2014-2018b).

We first ran the fishery model with the post-Reform catch balance limits to verify that a management objective, for example, to extend the April fishery by two days on April 11 and 12, would be met without exceeding the catch balance, and that the modelled catch accurately reflected the in-season estimate at the decision point. We then re-ran the model using the pre-Reform catch balance to see if the objective could still be met at the lower allowed catch. If it could, then we concluded that the allocation change had no effect on season structure/fishing opportunity at the decision point. If the fishery objective could not be met at the pre-Reform catch balance, then we began to subtract fishing days until the modeled catch no longer exceeded the allowed catch balance number. In the example above, if the season could not be extended on April 11 and 12 without exceeding the pre-Reform catch balance, then we would start by eliminating the first date, April 11. If the modelled fishery still exceeded the catch balance, then we would eliminate April 12 as well, resulting in the “loss” of both fishing days. The number of lost fishing days in this reverse modelling exercise was then re-interpreted as the number of days *gained* from the allocation increase. We used actual in-season estimates of angler trips, for the specific dates gained, to quantify the increase in fishing opportunity in terms of angler trips. We repeated these steps for each of the decision points, and summed the number of fishing days and angler trips gained during the spring season for each year.

Modelling results for the 2013-2017 recreational spring Chinook fisheries below Bonneville Dam are shown in Table 21j. For 2013, no additional fishing days or angler trips were gained because there was very little change in the fishery allocation that year. The allocation for the recreational fishery was supposed to increase to 65% in 2013, but 5% was never allocated due to a legal stay order. Therefore, the 2013 post-Reform fishery was modelled with a 60% recreational and 35% commercial allocation, and about 200 fish were added to the recreational catch balance. This was not enough to make a difference in management decisions at any of the in-season decision points.

In 2014, the recreational allocation increased to 70%, and although no fishing days or trips were gained prior to the run update, the allocation increase did result in some gains post-run update. After the first run update on May 5, the management objective was to extend the fishery to include May 9 and 10. At the post-Reform catch balance, this objective could be met; however, at the lower pre-Reform catch balance, the fishery could only be opened on May 10. Therefore, the May 9 fishing day, and its 3,221 angler trips, were “lost” at the pre-Reform allocation. After the second run update on May 12, at the post-Reform catch balance, fishery managers were able to further extend the season from May 15 through June 15. At the pre-Reform catch balance, managers would have had to wait until May 19 to begin the second extension. Therefore, the May 15-18 fishing days, and their 7,567 total angler trips, would have been lost at the pre-Reform allocation. These modelling results were re-interpreted as a total *gain* of five additional fishing days and 10,788 angler trips for the 2014 recreational spring Chinook fishery due to the allocation increase from Harvest Reform. Note that the number of angler trips gained per day varied considerably, depending on when the fishing day was added. The single fishing day added on May 5 was worth approximately 3,200 angler trips, while the four fishing days added on May 12 were worth about

1,900 angler trips per day. This is because the number of daily angler trips during the spring season typically decreases rapidly after the first week of May (ODFW unpublished data).

Table 21j. Evaluation of allocation changes for the lower Columbia River recreational spring Chinook fishery, 2013-2017.

		2013	2014	2015	2016	2017
Pre-Run Update ¹	Date	3-Apr	3-Apr	8-Apr	7-Apr	26-Mar & 12-Apr
	Buffered Upriver CHS Run Size	98,980	158,900	162,750	132,160	160,400
	Pre-Reform Available Catch Balance	4,750	9,205	9,357	6,830	6,809
	Post-Reform Available Catch Balance	4,934	10,157	10,318	7,515	6,905
	Fishing Days Gained	0	0	1	1	0
	Angler Trips Gained	0	0	6,293	6,497	0
First Run Update	Date	13-May	5-May	29-Apr	10-May	15-May
	Estimated Upriver CHS Run Size	107,500	185,000	220,000	188,800	83,000
	Pre-Reform Available Catch Balance	5,610	9,660	12,503	9,629	4,064
	Post-Reform Available Catch Balance	5,868	10,945	14,155	10,877	4,256
	Fishing Days Gained	0	1	0	0	0
	Angler Trips Gained	0	3,221	0	0	0
Second Run Update	Date	20-May	12-May	4-May	18-May	25-May
	Estimated Upriver CHS Run Size	107,500	224,000	241,000	180,000	108,000
	Pre-Reform Available Catch Balance	5,610	12,816	13,696	9,145	5,517
	Post-Reform Available Catch Balance	5,868	14,523	15,506	10,326	5,778
	Fishing Days Gained	0	4	1	0	0
	Angler Trips Gained	0	7,567	4,028	0	0
Third Run Update	Date	28-May	19-May	11-May	24-May	30-May
	Estimated Upriver CHS Run Size	107,500	224,000	250,000	180,000	118,000
	Pre-Reform Available Catch Balance	5,610	12,816	14,208	9,145	6,878
	Post-Reform Available Catch Balance	5,868	14,523	16,086	10,326	7,185
	Fishing Days Gained	0	0	0	0	0
	Angler Trips Gained	0	0	0	0	0
Season Total	Fishing Days Gained	0	5	2	1	0
	Angler Trips Gained	0	10,788	10,321	6,497	0
	Pre-Reform Total Angler Trips	109,655	134,854	140,852	120,329	63,303
	% Gain in Angler Trips	0.0%	8.0%	7.3%	5.4%	0.0%

¹ Catch balances prior to a run update are based on a buffered run size (70% of pre-season estimate). Per the Harvest Reform Policy, beginning in 2017, the buffer only applied to the recreational fishery catch balance since a pre-run update mainstem commercial fishery was no longer permitted.

Modelling results for the 2015 spring season were similar to 2014 in terms of total angler trips gained due to Harvest Reform (Table 21j). Although only two fishing days were added to the 2015 season, each day was worth approximately 4,000-6,000 angler trips because of the timing of the additions, as well as the overall increase in angler effort during 2015. On April 3, prior to a run update, fishery managers extended the season to include April 11 and April 16 at the post-Reform catch balance, but would have only been able to extend it April 11 at the pre-Reform catch balance. Because the April 16 fishing day was added post-Reform at a peak time in the season, it was worth over 6,000 angler trips. After the second run update on May 4, fishery managers extended the season to include May 9, and then May 16 through June 15, at the post-Reform catch balance. At the pre-Reform catch balance, they would not have been able to add May 9. Therefore, the May 9 fishing day, gained due to reform, added an estimated 4,028 trips to the 2015 fishery.

In 2016, the pre-update fishery ended on April 8 at the post-Reform allocation. When the season was modelled using the lower pre-Reform catch balance, the April 8 fishing day and its 6,497 angler trips could not be accommodated. Therefore, in 2016, the allocation increase helped the pre-update fishery gain one additional fishing day and 6,497 trips. Post-run update, the 2016 fishery was extended to include May 13-15, May 20-22, May 27-30, and June 3-June 15. Modelling the post-update fishery at the three run updates in May with the pre-Reform allocation led to no change in any of the fishing periods; therefore, we concluded that the allocation shift had no effect on the 2016 post-update spring fishery.

The 2017 pre-update fishery was scheduled to close on April 7; however, high turbid river flows in March resulted in poor fishing conditions and much lower than expected effort and catch. Therefore, on March 26, the fishery was easily extended to include April 7-10 at both the pre- and post-Reform guidelines. With river conditions and catch rates still relatively poor in early April, on April 12, the pre-update fishery was again extended at both pre- and post-Reform guidelines for April 13-17 and April 20-23. Angler effort and catch rates increased substantially during the April 20-23 fishing period, resulting in a total of 7,196 upriver spring Chinook mortalities (kept and released), which exceeded the pre-update catch balance guideline of 6,905 fish (post-Reform allocation). Thus, the upriver catch also exceeded the lower pre-Reform guideline of 6,809 fish (Table 21j). At the first run update on May 15, the upriver run was downgraded substantially to 83,000 fish, resulting in a much lower catch balance guideline at both pre- and post-Reform allocations. At subsequent run updates on May 25 and May 30, the run was upgraded slightly, but the recreational fishery catch still exceeded the guidelines. Because the actual catch was larger than the post-Reform (and pre-Reform) guidelines at all of the management decision points in May, no further extensions were made to the 2017 spring season, and no fishing days or angler trips were gained due to reform.

For the 2013-2017 lower Columbia spring Chinook fisheries, Harvest Reform-related allocation changes led to increases in fishing opportunity in 3 out of the 5 years. The annual percent gain in angler trips ranged from 0.0% in 2013 and 2017 to 8.0% in 2014. Although we modelled the spring fisheries through the third run update each year, in actuality, no management decisions in 2013-2017 were necessary after the second update. Furthermore, by late May, angler effort and catch were too low for changes in the catch balance guideline to be a factor in management of the fishery.

Lower Columbia Summer Chinook Fishery

Management of the summer Chinook fishery differs from that of the spring Chinook fishery because upper Columbia summer Chinook are not listed under the ESA, and there are no catch balancing provisions to take into consideration. The allowable harvest of summer Chinook (kept fish plus release mortalities) for the lower Columbia recreational fishery is determined by the non-treaty commercial-recreational fisheries allocation below Priest Rapids Dam, as well as sharing provisions within the recreational fishery. For summer Chinook fisheries modelling, we used the 2010-2012 joint Commission guidance allocation of 50% recreational and 50% commercial as our pre-Reform allocation. Prior to 2002, the recreational summer Chinook fishery had been closed since 1974. The length of the recreational summer Chinook season can vary greatly, and in some years, it can be as short as two weeks. Therefore, in-season management is often limited to one or

two decision points in late June or early July, when run updates become available. In addition, the various fishery components don't often fully use their catch guideline, so there can be more flexibility in how seasons are managed since unused balances can sometimes be moved from one fishery component to another, if needed.

In recent years, the recreational summer Chinook fishery has primarily been mark-selective, but there is the potential of implementing non-mark-selective regulations. Using this management tool can affect season structure and fishing opportunity; however, there are opposing opinions on the merit of mark-selective vs. non-mark-selective regulations for recreational summer Chinook fisheries. Attempting to incorporate non-mark-selective regulations into the decision-making process for our summer Chinook modelling exercise would greatly increase the number and complexity of potential outcomes, and could mask possible effects of an allocation change. Therefore, we decided not to consider non-mark-selective regulation options in our modelling of the summer Chinook fishery.

We modelled the summer fishery at three points during the season (first run update, second run update, and third run update). Although no management decisions were necessary at the second or third updates for the 2013-2017 summer Chinook fisheries, we thought it prudent to model at multiple points during the season to see if the fishery would have been constrained at some point during the season by a lower pre-Reform catch guideline. Because the summer Chinook fishery model does not provide daily estimates of angler effort and catch, at each run update, we compared the cumulative in-season harvest estimate to the pre-Reform catch guideline to determine if the fishery was operating within limits at the pre-Reform allocation. A positive guideline balance indicated that the fishery would not have been constrained by a lower pre-Reform guideline, and that the allocation change did not affect the season structure or fishing opportunity.

Modelling results for the 2013-2017 recreational summer Chinook fisheries below Bonneville Dam are shown in Table 21k. In 2013, the summer Chinook season was initially set for two weeks from June 16 through June 30. Catches were higher than expected, and when the run size was downgraded from the pre-season estimate of 73,500 to 60,000 at the first update on July 1, the fishery was not extended. Because actual harvest exceeded both the pre- and post-Reform guidelines, and the season would have closed on June 30 under either guideline, the allocation change had no effect on the 2013 fishery.

The 2014 summer Chinook season was set pre-season through June 30; however, catches were less than expected in June, so the fishery was extended July 3-6 at a state hearing on July 1. After the run was upgraded from a pre-season estimate of 67,500 to 74,000 at the first update on July 7, fishery managers extended the season again from July 11 through the end of July. As the run continued to be upgraded through the season, the catch guideline also increased, and catches remained moderate enough that they did not exceed the guideline, even at the pre-Reform allocation. Therefore, the allocation change had no effect on the outcome of the 2014 summer Chinook season.

Table 21k. Evaluation of allocation changes for the lower Columbia River recreational summer Chinook fishery, 2013-2017.

		2013	2014	2015	2016	2017
First Run Update	Date	1-Jul	7-Jul	29-Jun	5-Jul	5-Jul
	Estimated CHR Run Size	60,000	74,000	85,000	91,000	74,100
	Pre-Reform Guideline	1,665	2,472	3,106	3,558	2,467
	Post-Reform Guideline	1,816	3,063	4,348	4,981	3,946
	Cumulative Harvest	1,996	2,296	1,770	2,335	2,777
	Pre-Reform Guideline Balance	-331	176	1,336	1,223	-310
	Fishing Days Gained	0	0	0	0	25
	Angler Trips Gained	0	0	0	0	5,594
Second Run Update	Date	N/A	14-Jul	6-Jul	11-Jul	N/A
	Estimated CHR Run Size	--	77,000	100,000	91,000	--
	Pre-Reform Guideline	--	2,674	4,195	3,558	--
	Post-Reform Guideline	--	3,349	5,873	4,981	--
	Cumulative Harvest	--	2,343	2,887	2,835	--
	Pre-Reform Guideline Balance	--	331	1,307	722	--
	Fishing Days Gained	0	0	0	0	0
	Angler Trips Gained	0	0	0	0	0
Third Run Update	Date	N/A	21-Jul	13-Jul	18-Jul	N/A
	Estimated CHR Run Size	--	78,000	108,000	91,000	--
	Pre-Reform Guideline	--	2,740	4,641	3,558	--
	Post-Reform Guideline	--	3,443	6,498	4,981	--
	Cumulative Harvest	--	2,390	3,861	2,948	--
	Pre-Reform Guideline Balance	--	350	780	610	--
	Fishing Days Gained	0	0	0	0	0
	Angler Trips Gained	0	0	0	0	0
Season Total	Fishing Days Gained	0	0	0	0	25
	CHR Angler Trips Gained	0	0	0	0	5,594
	Pre-Reform CHR Angler Trips ¹	26,019	26,831	25,278	29,034	15,204
	% Gain in CHR Angler Trips	0.0%	0.0%	0.0%	0.0%	36.8%

¹ Assumes that 50% of the total summer season effort is comprised of angler trips targeting summer Chinook.

The 2015 summer Chinook season was originally set through July 6, but on June 29, the run was upgraded from a pre-season estimate of 73,000 to 85,000 fish, and with catches up to that point less than expected, managers extended the season through the end of July. Although catch rates increased in July, the run size and catch guideline increased as well, so even at the pre-Reform guideline, the fishery was able to stay within its limits. Therefore, the allocation change had no effect on fishing opportunity in 2015, as the season would have continued through the end of July at either allocation.

In 2016, the summer Chinook fishery was planned from June 16 through July 31, and although the run was slightly downgraded from the pre-season forecast of 93,300 to 91,000 in-season, the fishery was prosecuted as planned. Catch rates in the 2016 fishery were modest, and even at the lower pre-Reform harvest guideline, cumulative catches were well under the guideline at each in-season run update. Thus, the 2016 summer Chinook fishery would have had a full season at either allocation.

The 2017 summer Chinook season was originally planned to go through the end of July; however, higher than expected catch rates and mark rates during the first two weeks of the season resulted in a rapid accumulation of catch, and managers closed the fishery at the end of June. On July 5,

TAC upgraded the run from a pre-season forecast of 63,100 to 74,100. The cumulative harvest through June 30 was 2,777 adult summer Chinook, which was under the post-Reform guideline of 3,946 at the updated run size. Therefore, managers re-opened the summer Chinook fishery from July 7 through July 31. But, at the pre-Reform guideline of 2,467 fish, the cumulative catch would have exceeded the guideline, and the fishery would not have been re-opened. Thus, due to the higher post-Reform guideline, the 2017 summer Chinook fishery was able to gain 25 days of fishing in the later part of the season.

Quantifying the gain in angler trips targeting summer Chinook (per the Policy) was more challenging because during the summer season, some anglers target steelhead even when Chinook retention is open. Since information on targeted species is not collected from salmonid anglers during creel surveys, we estimated the proportion of summer season anglers targeting summer Chinook by comparing effort data for consecutive periods that were open and closed to Chinook retention. Initially, we planned to use effort data from the 2017 summer fishery to do this; however, the poor steelhead return in 2017 and the special regulations that were in place to reduce steelhead harvest that year (e.g. one fish daily bag limit) resulted in much lower than usual angling effort for steelhead during the Chinook closure in early July. This would have caused our estimated proportion of Chinook anglers in a mixed summer Chinook-steelhead fishery to be biased high. Therefore, we used data from the 2018 summer fishery, where steelhead effort during the Chinook closure in early July was more typical, to estimate the proportion of Chinook anglers in a mixed fishery.

In addition, because summer Chinook abundance rapidly decreases and steelhead abundance increases in the lower Columbia during the month of July (Figures 21l and 21m), it is highly likely that the proportion of anglers targeting Chinook in July also decreases as anglers switch from less abundant Chinook to more abundant steelhead. We used ratios of summer Chinook to steelhead passing Bonneville Dam during specific periods (June 25-July 8, 2018 and July 7-31, 2017) to adjust the Chinook angler proportion from the early season 2018 period to the late season 2017 period, when the additional angler trips were gained. Since anecdotal information from summer season anglers also suggested that some anglers preferred to target Chinook even when abundance was low, we scaled up the late July proportion by 50% to account for this. Our analysis indicated that an estimated 5,594 summer Chinook angler trips were gained during July 7-31, 2017 due to the allocation change from Harvest Reform; an increase of approximately 37% from the estimated 15,204 angler trips that would have targeted summer Chinook in 2017 at the pre-Reform allocation.

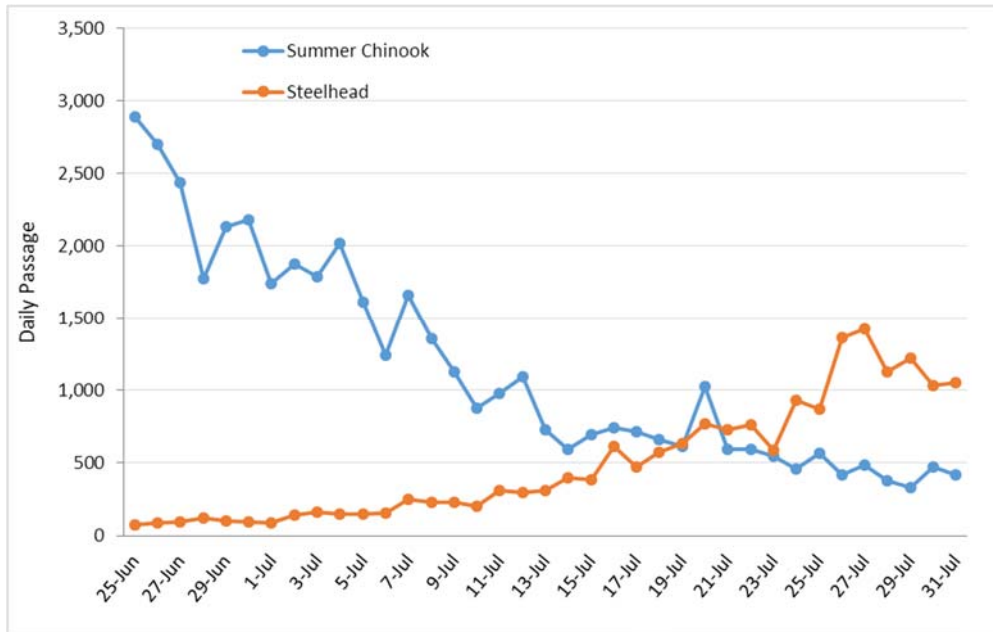


Figure 21i. Daily passage of adult summer Chinook and steelhead at Bonneville Dam, June 25-July 31, 2017.

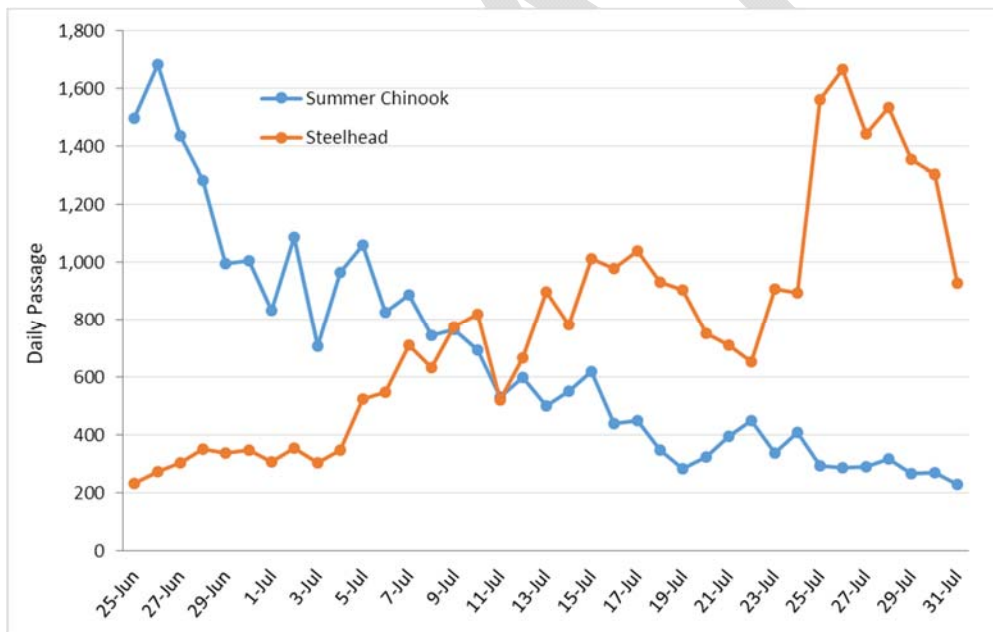


Figure 21m. Daily passage of adult summer Chinook and steelhead at Bonneville Dam, June 25-July 31, 2018.

Modelling of the 2013-2017 lower Columbia recreational summer Chinook fisheries at pre- and post-Reform catch guidelines indicated that the allocation increases from Harvest Reform had no effect on season structure or fishing opportunity in 4 out of the 5 years. This was unexpected because this fishery had routinely closed early due to attainment of catch limits in years prior to 2013, even when MSF regulations were in place. In 2013-2016, actual harvest was either over the allowed guideline at both pre- and post-Reform allocations (2013), or it was under the guideline

at both allocations (2014-2016). However, in 2017, the summer Chinook harvest prior to the first run update in early July was unusually high, exceeding the pre-Reform guideline, but not the post-Reform guideline. This allowed the post-Reform fishery to re-open for 25 days in July, with an additional 5,594 summer Chinook angler trips, whereas this would not have been possible at the pre-Reform allocation.

Lower Columbia Fall Chinook Fishery

The recreational fall Chinook fisheries that occur in the Buoy 10 area, and in the mainstem Columbia from Tongue Point/Rocky Point upstream to Bonneville Dam, are usually limited by the allowable impacts to ESA-listed natural-origin LCR tule fall Chinook. As previously mentioned, LRH tules are used as a surrogate for the natural-origin stock in fishery management models. The allowable harvest of fall Chinook (kept fish plus release mortalities) is determined by the non-treaty commercial-recreational fisheries allocation, as well as sharing provisions within the recreational fishery for the Buoy 10 and mainstem fisheries. For fall Chinook fisheries modelling, we used the average 2010-2012 allocation of 59% recreational and 41% commercial as our pre-Reform allocation. The Buoy 10 and mainstem sport fisheries are primarily non-mark-selective for fall Chinook; however, in recent years, fishery managers have relied on Chinook MSF regulations for part of the season to manage both fisheries within ESA limits to their Chinook season objective dates. For the mainstem fishery, Chinook MSF regulations have only been applied to the area from Tongue Point/Rocky Point to the mouth of the Lewis River, where most LRH tule impacts are accrued, and include a Commission-mandated Chinook MSF during September 8-14. The fall recreational fishery above the Lewis River has a low impact on natural-origin LCR tule Chinook, and was therefore excluded from this analysis. Large increases in fall angler effort and Chinook catch in the last several years have been the primary reason for the need to use Chinook MSF regulations in the Buoy 10 and mainstem fisheries below the Lewis (Tables 21a and 21d).

Because the Chinook MSF tool has become an instrumental part of managing fall recreational fisheries, and because angler effort and catch have tended to respond to its use, we used a slightly different approach for modelling the fall Chinook fisheries. Instead of simulating the fisheries at pre- and post-Reform catch guidelines and comparing the results at discrete decision points during the season, as we did for spring and summer Chinook fisheries, we modelled how the difference between pre- and post-Reform allowable LRH impacts could be made up by using MSF regulations. Each MSF day of fishing uses fewer impacts than a non-MSF day because, under MSF regulations, unmarked fish are released, and so only a portion of them become mortalities. For example, if 0.28% impacts are used for each non-MSF day, and 0.11% is used for each MSF day, the difference between the two, 0.17%, would be the daily impact “savings” of converting a fishing day from non-MSF to MSF regulations. Our modelling objective for the fall fisheries was to determine, for each year and fishery, how many non-MSF days would have to be converted to MSF in order to make up the impact difference between pre- and post-Reform allocations. We stopped converting days when we were within 5% of the target impact level because that level was within the tolerance for uncertainty that would have led to setting another day. The new MSF days were added immediately prior to any MSF days that were implemented in-season or planned pre-season. Since analysis of daily fishing effort for the Buoy 10 fishery indicated that angler effort usually decreased when Chinook MSF regulations were implemented, we used this information to

estimate what angler effort on a non-MSF day would have been if the day was fished under MSF regulations. The difference between the higher non-MSF angler trips and the lower MSF angler trips, for each converted day, was considered to be the number of angler trips “lost” due to the implementation of MSF regulations. We then summed the lost trips for the new MSF days to calculate a season total. We had to use a slightly different approach to estimate lost angler trips for the mainstem fishery because in-season catch and effort estimates are made on a weekly rather than daily basis. To calculate average daily effort for the mainstem fishery, we divided the weekly effort estimate by 7 days. We then used the decrease in average daily effort between non-MSF and MSF periods to estimate the number of lost angler trips for each converted fishing day. As with the spring and summer Chinook fisheries, our analysis of the fall Chinook fishery was a reverse modelling exercise, so the “lost” days and trips were re-interpreted as non-MSF days and angler trips *gained* due to allocation increases from Harvest Reform.

Modelling results for the 2013-2017 recreational fall Chinook fisheries below Bonneville Dam are shown in Table 211. Our analysis indicated that the Buoy 10 fishery gained an average of 3 non-MSF days and 1,296 angler trips per year due to allocation increases from Harvest Reform during 2013-2017. Gains varied significantly between years, and circumstances unique to each year likely affected how much each year’s fishery benefitted from Harvest Reform, or if it benefitted at all. For example, the 2013 and 2014 Buoy 10 fisheries were very similar in the number of non-MSF days gained, but there was a big difference in the number of angler trips gained. The primary reason for this is that angler effort in 2013 and 2014 responded very differently to the implementation of Chinook MSF regulations.

Table 211. Evaluation of allocation changes for lower Columbia River recreational fall Chinook fisheries, 2013-2017.

		2013	2014	2015	2016	2017
Buoy 10	Pre-Reform Allowable LRH Impacts	2.71%	2.98%	3.47%	5.51%	4.09%
	Post-Reform Allowable LRH Impacts	3.16%	3.54%	4.12%	6.52%	4.76%
	Change in LRH Impacts	0.45%	0.56%	0.65%	1.01%	0.67%
	Non-MSF Days Gained	5	6	2	0	0
	Angler Trips Gained	4,560	1,015	907	0	0
	Pre-Reform Total Angler Trips	61,207	106,507	107,306	94,950	93,547
	% Gain in Angler Trips	7.5%	1.0%	0.8%	0.0%	0.0%
Mainstem (Below Lewis R)	Pre-Reform Allowable LRH Impacts	2.00%	1.71%	1.66%	1.12%	1.30%
	Post-Reform Allowable LRH Impacts	2.34%	2.03%	1.97%	1.33%	1.51%
	Change in LRH Impacts	0.34%	0.32%	0.31%	0.21%	0.21%
	Non-MSF Days Gained	3	6	5	0	0
	Angler Trips Gained	2,470	2,265	10,402	0	0
	Pre-Reform Total Angler Trips	139,011	141,681	120,972	133,300	114,721
	% Gain in Angler Trips	1.8%	1.6%	8.6%	0.0%	0.0%
Fall Recreational	Pre-Reform Allowable LRH Impacts	4.71%	4.70%	5.13%	6.63%	5.39%
Total	Post-Reform Allowable LRH Impacts	5.50%	5.57%	6.09%	7.85%	6.27%
	Change in LRH Impacts	0.79%	0.87%	0.96%	1.22%	0.88%
	Non-MSF Days Gained	8	12	7	0	0
	Angler Trips Gained	7,030	3,280	11,309	0	0
	Pre-Reform Total Angler Trips	200,218	248,188	228,278	228,250	208,268
	% Gain in Angler Trips	3.5%	1.3%	5.0%	0.0%	0.0%

In 2013, there was a sharp decrease in effort when MSF regulations were implemented on August 23 due to higher than expected catches of LRH Chinook. This was the first time that MSF regulations were applied to Chinook in the Buoy 10 fishery, and this, coupled with the perception that a “keeper” Chinook might be difficult to catch due to relatively low mark rates for fall Chinook, may have caused some anglers to cancel their trips, even though weather conditions and overall catch rates were good at the time. Because of this large drop in effort with the regulation change, we estimated that Chinook MSF regulations under a *pre-Reform* allocation would have cost the 2013 fishery a high number of angler trips per day. Therefore, a relatively large number of trips were gained at the *post-Reform* allocation in 2013.

In contrast, there was not much of a decrease in angler effort when the 2014 Buoy 10 fishery switched to Chinook MSF regulations. A few things might explain this: 1) The MSF days were planned pre-season, so there was plenty of notice and anglers were expecting it, 2) the MSF regulations were implemented over Labor Day Weekend, when many anglers may have had a holiday trip planned, regardless of whether the Chinook fishery was mark-selective or not, and 3) the Coho run was relatively strong, so there was still a good chance of harvesting salmon. Therefore, in 2014, MSF days at a *pre-Reform* allocation would not have cost the fishery much in terms of lost angler trips. Hence, the relatively low number of trips gained at the *post-Reform* allocation.

Similarly, in 2015, the two additional non-MSF days fell on a Saturday and Sunday, which typically have high levels of effort regardless of whether MSF regulations are in place or not. This was particularly the case as the regulation change occurred during the third weekend in August—the usual peak weekend for the Buoy 10 fishery (ODFW unpublished data). Therefore, the allocation change, and subsequent change in MSF regulations, would not have added a high number of angler trips to the 2015 Buoy 10 fishery.

In 2016, due to restrictions on ocean fisheries, there were plenty of LRH tule impacts available for in-river fisheries, and the Buoy 10 fishery would not have been limited by these ESA impacts at either the pre- or post-Reform allocations. On the other hand, available pre-season ESA impacts for URB/SRW fall Chinook were a constraint for all fall fisheries, and the 2016 Buoy 10 season began with several planned Chinook MSF days. The fishery met its Labor Day objective for Chinook retention (with Chinook MSF regulations removed for the Sunday and Monday of Labor Day Weekend), and was extended through the end of September, with Chinook MSF regulations in place during September 15-30. With respect to in-season management, the 2016 Buoy 10 fishery would have still met its Labor Day objective even at the lower pre-Reform allocation for URB/SRW Chinook; therefore, the allocation increase due to the Policy did not affect the Buoy 10 season structure.

The 2017 Buoy 10 fishery was not constrained in-season by LRH tule impacts (at either pre- or post-Reform allocations) due to a surplus of available impacts from ocean fisheries, and no Chinook MSF regulations were necessary to get the fishery to its Labor Day objective. Similarly, the fishery remained within its in-season impact guideline for URB/SRW Chinook through the Labor Day objective, and would have done so at either allocation. Although post-season analysis of CWT data indicated that the Buoy 10 fishery exceeded its allocated impacts for LRH tule Chinook, the allocation changes from Harvest Reform did not affect in-season management of the 2017 Buoy 10 fishery or attainment of its Labor Day objective.

A couple of things are worth noting about our modelling results for the 2013-2017 Buoy 10 fisheries, and how they relate to actual fishery outcomes. First, the number of angler trips gained each year due to allocation increases from Harvest Reform comprised a relatively small percentage of the total number of angler trips for the fishery, averaging 1.8% (range 0.0% to 7.5%). Considering that angler effort in the Buoy 10 fishery has increased significantly in the last few years, this suggests that other factors, such as strong Chinook returns and high catch rates, likely had a greater effect on the number of angler trips expended in this fishery, compared to the allocation shift. In addition, the Buoy 10 fishery exceeded its allowable LRH impacts in 3 out of the 5 years that were modelled (Table 21g)--even at the higher post-Reform allocations. Adding angler effort to a fishery that is already struggling to remain within its impact guideline, may make managing the Buoy 10 fishery to its Labor Day objective even more difficult.

The interaction between allocation changes, establishment of season date objectives, the available “management tools”, and fishery performance is complex but bears some discussion because it leads to some results that may not be immediately intuitive. The Harvest Reform Policy simultaneously established an increased allocation *and* a set of season date objectives for fall recreational fisheries. Initial modelling conducted prior to adoption of the Policy indicated that the season date goals for the Buoy 10 fishery could be achieved without the use of MSF (i.e.,

seasons were modelled as non-MSF). However, likely due to large increases in fall Chinook returns beginning in 2013, angler effort and catch after adoption of the Policy began to increase significantly from those expectations, to the point that season objectives were not achievable with non-MSF approaches. Managers have several tools available to extend recreational seasons while remaining within catch or ESA limits; these include, but are not limited to daily bag limits, closed periods, closed areas, and MSF. The Buoy 10 fishery has operated with a one Chinook daily bag limit for more than 10 years, so that tool is already in effect. The Buoy 10 fishing area is relatively small and does not lend itself to subdivision into closed areas; although the implementation of the YBCZ did close a portion of this fishing area, additional closures do not appear feasible. The season objectives for Buoy 10 imply an every-day season from August 1 through Labor Day, limiting the use of closed periods as a tool. These factors illustrate why a shift to MSF has become the primary tool for managers to stretch the Buoy 10 season to meet date objectives. If a season date objective did not exist, a management choice could be to run the fishery as non-MSF until ESA impact limits were reached, and then close the fishery. Under that scenario, the aforementioned modelling would have been conducted as a simpler “open/closed” day exercise (like modelling of spring and summer Chinook fisheries). We cannot estimate what the effect on estimated overall trips would have been for this scenario compared to what was observed, but it is possible that the estimated total trips would be less due to closed days. Because there is an observed decline between angler trips occurring on non-MSF and MSF days, such an exercise would likely result in a larger estimated *proportional* change between pre- and post-Reform allocation effects, even if estimates of absolute angler trips were reduced overall. The approach taken in our modelling reflects the suite of management objectives and tools as they were used during the period observed.

For the fall mainstem recreational fishery below the Lewis River, our modelling indicated that the fishery gained an average of 3 non-MSF days and 3,027 angler trips per year during 2013-2017 due to allocation increases from Harvest Reform. However, the 2015 mainstem fishery presented some potentially confounding circumstances during the modelling process. In sharp contrast to 2014, angler effort in the area between Tongue Point and the Lewis River dropped off dramatically when Chinook MSF regulations were implemented in 2015. As a result, our model suggested that a change from MSF to non-MSF regulations would have provided a substantial gain in angler trips in 2015. Further analysis of angler effort in the 2015 mainstem fishery revealed that there appeared to be a substantial shift in angler effort from the MSF Tongue Point-Lewis River area to the non-MSF Lewis River-Bonneville Dam area after Chinook MSF regulations were implemented on September 8. During the week of September 8-14, effort in the Lewis River-Bonneville Dam area increased by 43%, and went from comprising 26% of mainstem sport effort to 60% after the regulation change took place below the Lewis River. The likely reason for this effort shift is that catch rates in the Lewis River-Bonneville Dam area were high in 2015, thereby leaving many anglers with little incentive to fish the mark-selective area below the mouth of the Lewis, where kept Chinook catch rates were much lower. So, even though our modelling results for the 2015 mainstem fishery might suggest that there was a large gain in angler trips resulting from Harvest Reform-related allocation changes, it is highly likely that much of the increase was actually in the area unaffected by MSF regulations, and was not related to the allocation change.

Like the Buoy 10 fishery, LRH tule impacts were not a factor for the 2016 mainstem recreational fishery, and instead, the fishery was limited by allowable impacts for URB/SRW fall Chinook.

The mainstem fishery from Tongue Point to the Lewis River met its September 14 objective for Chinook retention (Chinook MSF during September 10-14 per Policy), and the Chinook MSF for this area was extended through the end of September. The fishery from the Lewis River to Bonneville Dam fell just short of its October 31 Chinook retention objective when both the Buoy 10 and mainstem fisheries closed on October 22 due to a downgrade in the URB/SRW run. However, because the combined URB/SRW impacts for recreational and commercial fisheries would have exceeded the total guideline at both pre- and post-Reform allocations, the mainstem recreational season would not have been any different at the pre-Reform allocation.

Due to a surplus of available LRH tulle impacts from ocean fisheries, the 2017 mainstem recreational fishery was not limited by LRH Chinook. In addition, the 2017 fall mainstem commercial fishery was constrained by very limited impacts for natural-origin B-Index summer steelhead, thereby making available in-season additional URB/SRW impacts for the mainstem recreational fishery. As a result, the 2017 mainstem recreational fishery, which met all Chinook retention objective dates, would not have been affected in-season by its pre- or post-Reform allocation. Although post-season analysis of CWT data indicated that the mainstem recreational fishery exceeded its allocation of URB/SRW impacts due to higher than expected catch rates in the Lewis River-Bonneville Dam area, this information was not available in-season, and could not be used to make modifications to the season structure.

Our modelling indicated that the Buoy 10 and mainstem fall recreational fisheries gained a combined annual average of 5 non-MSF days and 4,324 angler trips from Harvest Reform-related allocation increases during 2013-2017. The gain in trips represented an average increase in angler effort of 2.0% per year from pre-Reform levels for fall recreational fisheries downstream of Bonneville Dam. These results are similar to those for the spring recreational fishery in terms of the average number of angler trips gained annually; however, the number of angler trips gained per day was much higher for the spring fishery. This is because, when modelling the spring fishery (which has been 100% MSF since 2001), we were working with days that were either “open” or “closed” to salmon fishing; therefore, a fishing day gained in the spring season brought with it the full angler effort for the day, compared to 0 trips for a closed day. With the fall fishery, we were modelling a change that increased only a portion of a day’s effort (from MSF to non-MSF level). As described earlier, the modelled changes to MSF regulations in the fall fisheries proved to be difficult to interpret because angler effort did not always respond in a consistent manner. Modelling of the fall Chinook recreational fisheries is more complicated than it is for the spring and summer Chinook fisheries because of the use of Chinook MSF regulations during only a part of the season, and because of the need to meet “hard” objective dates for Chinook retention (per Policy). In addition, several options exist for fall fishing in the lower Columbia, further adding to the complexity. For example, if anglers do not wish to fish in the Buoy 10 fishery because of Chinook MSF regulations there, they can simply go fish above Tongue Point, where the Chinook fishery may be non-mark selective. When the fishery between Tongue Point and the Lewis River switches to Chinook MSF regulations, can move to the non-MSF above the Lewis River. Although we attempted to model changes in angler effort resulting solely from the Harvest Reform allocation shifts, we believe that, for the fall fisheries, other unrelated factors may have caused many of the observed inconsistencies in effort response. Therefore, modelled gains in angler trips for the fall recreational fisheries should be interpreted cautiously.

Summary

Table 21m summarizes gains in fishing days and angler trips for each season resulting from Harvest Reform-related allocation increases for the lower Columbia River recreational fishery. Allocation-related gains in fishing opportunity for a given season did not occur in all years, and only happened in one year for the summer Chinook fishery. In several years for the summer Chinook fishery, the actual recreational catch was either above or below *both* the pre- and post-Reform guidelines, and so the season structure would have been the same under either guideline. For the fall Chinook fishery, surplus impacts for LRH tule Chinook were available from ocean fisheries in 2016 and 2017; therefore, the attainment of fall recreational fishery objectives were not affected in-season by allowable impacts for that stock at the pre- or post-Reform allocation. In addition, pre- and post-Reform allocation of impacts for URB/SRW Chinook, although a constraint in 2016 and 2017, would not have had different effects on in-season management decisions or attainment of Chinook season objectives for either the Buoy 10 or mainstem fisheries in those years.

Table 21m. Summary of gains in fishing days and angler trips due to Harvest Reform-related allocation increases for the lower Columbia River recreational Chinook fisheries, by year and season/fishery, 2013-2017.

		Gains Due To Reform	2013	2014	2015	2016	2017
Spring Chinook	Fishing Days		0	5	2	1	0
	Angler Trips		0	10,788	10,321	6,497	0
Summer Chinook	Fishing Days		0	0	0	0	25
	CHR Angler Trips		0	0	0	0	5,594
Fall Chinook	Buoy 10	Non-MSF Days	5	6	2	0	0
		Angler Trips	4,560	1,015	907	0	0
	Mainstem (Below Lewis R)	Non-MSF Days	3	6	5	0	0
		Angler Trips	2,470	2,265	10,402	0	0
	Fall Total	Non-MSF Days	8	12	7	0	0
		Angler Trips	7,030	3,280	11,309	0	0
All Seasons Total	Fishing Days		8	17	9	1	25
	Angler Trips		7,030	14,069	21,630	6,497	5,594
	% Gain in Angler Trips		2.1%	3.4%	5.5%	1.7%	2.0%

For all seasons combined, the annual gain in fishing days ranged from 1 in 2016 to 25 in 2017, and the annual gain in angler trips varied widely from 5,594 in 2017 to 21,630 in 2015. Modelling results indicated that even though the allocation share for the recreational fishery increased in all seasons between 2013 and 2017, this did not translate into a proportional increase in open fishing days or angler trips because changing the allocation did not always affect season structures. The overall increase in angler trips from pre-Reform levels averaged around 3% per year. Figure 21n presents the angler trips for each season during 2013-2017 at both pre- and post-Reform allocations, and illustrates the relatively minor effect of allocation changes on the number of angler trips made in a given season. Other factors such as run size and catch rates likely had a far greater effect on the magnitude of angler effort within a particular year.

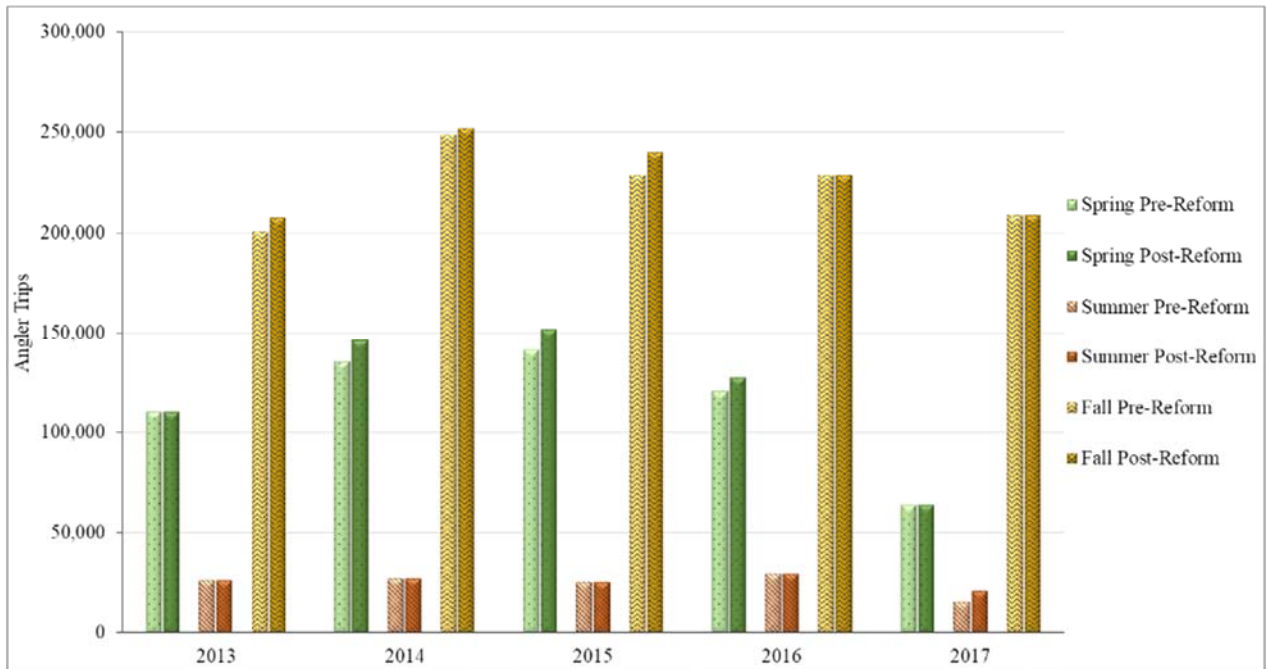


Figure 21n. Changes in seasonal angler effort due to Harvest Reform-related allocation increases for the 2013–2017 lower Columbia River recreational fisheries. There was no change in the 2013 spring season recreational allocation due to a stay order.

The percentage gains in angler trips due to the Policy were less than what was expected prior to Policy implementation (Table 21n). During the first five years of the Policy, the total annual Chinook-targeted trips were expected to increase by an average of 13.3% per year, compared to the 2.9% average gain that actually occurred. Actual percentage gains were closer to expected for the spring Chinook fishery (4.1% actual vs. 6.7% expected), but were furthest apart for the summer Chinook fishery (7.4% actual vs. 82.1% expected).

Table 21n. Comparison of expected and actual percentage gain in angler trips due to Harvest Reform-related allocation increases for the lower Columbia River recreational fishery, 2013-2017.

Fishery	Transition Period						Long-Term >		Average			
	2013		2014		2015		2016		2017		Expected	Actual
	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual
Spring Chinook ¹	6.1%	0.0%	6.1%	8.0%	6.1%	7.3%	6.1%	5.4%	9.1%	0.0%	6.7%	4.1%
Summer Chinook	35.0%	0.0%	35.0%	0.0%	80.2%	0.0%	80.2%	0.0%	180.0%	36.8%	82.1%	7.4%
Fall Chinook	9.4%	3.5%	9.4%	1.3%	9.4%	5.0%	9.4%	0.0%	9.4%	0.0%	9.4%	2.0%
Total	9.6%	2.1%	9.6%	3.4%	12.9%	5.5%	12.9%	1.7%	21.4%	2.0%	13.3%	2.9%

¹ Includes pre- and post-run update trips.

MAINSTEM COMMERCIAL FISHERIES

Since 1957, mainstem non-treaty commercial fisheries in the Columbia River have been restricted to Commercial Fishing Zones 1-5 (river mouth upstream to Beacon Rock), and treaty commercial fisheries to Zone 6 (Bonneville Dam to McNary Dam; Figure 1). Commercial gillnet fisheries in Zones 1-5 have historically harvested salmon and sturgeon during distinct seasons, ranging from winter (January-March) and spring (April-June 15), to summer (June 16-July), early fall (August), and late fall (September-October). Retention of White Sturgeon was prohibited downstream of Bonneville Dam during 2014-2016, but limited retention was allowed beginning in 2017. Because retention of Chum salmon is currently prohibited, and Sockeye and Pink salmon comprise a very small percentage of the commercial harvest, our discussion of the mainstem commercial fishery will focus on Chinook and Coho, which have been the primary species harvested in non-treaty commercial fisheries during the Harvest Reform period.

Mainstem gillnet fisheries in the lower Columbia have traditionally been managed using mesh size, area, and season/time restrictions to allow harvest of hatchery and healthy natural-origin salmon stocks, while minimizing impacts to weak stocks. For example, to reduce catch of upriver spring Chinook, no commercial salmon fishing was allowed upstream of Kelley Point at the Willamette River mouth during winter salmon seasons from 1975 through 2007. Subsequent to the prohibition of steelhead sales in 1975 (for non-treaty commercial fisheries), the minimum mesh size for the spring season was increased to 8-inch to reduce steelhead handle. This mesh size remained in effect for mainstem spring fisheries until the introduction of small-mesh tangle nets and live-capture techniques in 2002 (ODFW and WDFW 2014-2018b). Recent mainstem winter/spring commercial fisheries in Zones 1-5 have been constrained by a decreasing commercial sub-allocation of allowable ESA impacts for upriver spring Chinook, as well as catch balancing provisions per *U.S. v. Oregon*. The current 20% commercial share of the non-treaty upriver spring Chinook allocation is primarily used to prosecute Select Area winter and spring commercial fisheries.

Because upriver summer Chinook are not listed under the ESA, mainstem non-treaty summer commercial fisheries are managed according to harvest sharing guidelines with treaty and recreational fisheries. Fisheries from 2005-2016 in Zones 1-5 were non-mark-selective for summer Chinook. Commission guidance adopted in 2017 requires the use of gear other than gillnets for this fishery. Based on the results of gear evaluations (see Alternative Gear Feasibility Evaluations), no suitable alternative gear has been identified to access the commercial share of summer Chinook in a mainstem fishery.

Since 1992, fall season commercial fisheries below Bonneville Dam have been reduced in response to ESA listings of some stocks of fall salmon and summer steelhead. During 1995-1998, extremely low Coho abundance curtailed nearly all commercial fishing opportunities during the late fall period. During 1997-2001, early fall fisheries consisted primarily of short fishing periods targeting sturgeon. As fall salmon runs improved after 2001, August fisheries expanded in time and area, with increased emphasis placed on targeting Chinook. Until recently, early fall seasons have included the first half of August in Zones 1-5 and the last half of August in Zones 4-5 (Warrior Rock upstream to Beacon Rock). Since 2013, the early fall season has occurred in Zones 4-5 with

9-inch gillnets due to increasingly restrictive ESA constraints; reduced allocation guidelines for LCR tule Chinook put a higher focus on this approach. Late fall target Chinook seasons using 8-inch gillnets typically occur from mid/late September through the end of October within Zones 4-5, depending on the availability of impacts for ESA-listed stocks. Beginning in 2014, beach and purse seines have been used in some years on a limited basis to conduct mark-selective commercial fisheries for fall Chinook and Coho in a variety of fishing zones within the lower Columbia River (see Alternative Gear Fisheries Implementation--Fall Seine Fishery). Prior to 2006, the majority of the late fall season targeted Coho in Zones 1-3 (below the mouth of the Lewis River) with 6-inch gillnets. Since 2006, the ESA listing of LCN Coho has reduced Coho fishing opportunity considerably. Beginning in 2013, mark-selective Coho fisheries have been implemented in some years in Zones 1-3 using tangle net gear and live-capture regulations to allow commercial access to harvestable hatchery-origin Coho, while remaining within allowable ESA impact limits (see Alternative Gear Fisheries Implementation--Coho Tangle Net Fishery).

Fishery Seasons, Landings, and Ex-Vessel Value

Mainstem Commercial Seasons

The number of non-treaty commercial fishing periods by season, fishery, and year are presented in Table 22a. Winter seasons occurred through 2013 and generally targeted White Sturgeon early in the year when ex-vessel values were high. Spring season fisheries occurred through 2016 using both large-mesh gillnets and tangle nets to access the commercial allocation of upriver and Willamette hatchery spring Chinook. Commission guidance in 2017 reduced the commercial allocation of upriver spring Chinook impacts to 20% of the non-treaty share, with an expectation that available impacts would be used for prosecution of Select Area commercial fisheries. This change has resulted in no mainstem spring commercial fishery since 2016. Summer season fisheries targeting Chinook were initiated in 2005 after being closed since 1965 (below Bonneville Dam), with an average of 4 fishing periods (range 1-13) occurring annually through 2016. Beginning in 2017, Commission guidance reduced the commercial summer Chinook allocation to 20% of the harvestable fish available downstream of Priest Rapids Dam, and required the use of non-gillnet gear. Since no alternative gear that satisfies conservation and net-positive economic return needs has been developed, a mainstem summer commercial fishery has not occurred since 2016. Sockeye-directed fisheries have occurred infrequently since 2003. Fall drift net fisheries rely heavily on time, area, and gear (TAG) restrictions to maximize harvest within available ESA-impact limitations. Fisheries are often designed to target either Chinook or Coho, with the latter generally occurring in the lower Zones 1-3, and primarily during October in recent years. During 2013-2016, Chinook-directed fisheries generally occurred in Zones 4-5, in order to maximize commercial fishery performance given highly constrained ESA limits and reduced commercial impact allocations. Since 2017, fall mainstem Chinook-directed fisheries have been restricted to Zones 4-5 by Policy.

Beginning in 2013, Coho tangle nets were implemented as a new commercial gear type, followed by beach and purse seines in 2014. Coho tangle net fisheries were not prosecuted in 2016 due to a late-season URB Chinook run downgrade, which curtailed all fishing. None of the new gear

types were used in 2017 due to limitations on natural-origin B-Index steelhead, and in 2018 due to the limited SRW impact rate (8.25%), which was exceeded in-season due to a run downsize, preventing any late fall commercial opportunity.

The number of open fishing periods is affected by annual stock-specific returns, which complicates any attempt to isolate the effects of allocation changes through time. Since 2003, there has been a general trend of fewer non-treaty commercial fishing periods, with exceptions resulting from the large Chinook returns in 2013-2015 and the large Coho return in 2014, which allowed for more opportunity in those years.

Table 22a. Open fishing periods by season and gear type for non-treaty commercial fisheries in the mainstem lower Columbia River, 2003-2018.

Year	Winter		Summer				Fall				Beach Seine ¹	Purse Seine ¹	Drift Net	Sum
	Gill Net	Gill Net	Tangle Net	Chinook Gill Net	Sockeye Gill Net	Zone 1/2-5 Gill Net	Zone 3/4-5 Gill Net	Coho Gill Net	Tangle Net ¹					
2003	4	2	1	0	0	22	9	7	0	0	0	0	45	
2004	5	6	3	0	2	18	7	4	0	0	0	0	45	
2005	7	5	2	6	0	12	17	6	0	0	0	0	55	
2006	10	11	0	13	0	11	5	3	0	0	0	0	53	
2007	9	3	1	2	0	15	7	8	0	0	0	0	45	
2008	11	0	3	3	1	8	20	3	0	0	0	0	49	
2009	8	0	3	3	0	7	16	4	0	0	0	0	41	
2010	5	0	2	2	0	7	8	3	0	0	0	0	27	
2011	4	2	2	2	0	4	12	2	0	0	0	0	28	
2012	3	0	2	1	0	12	11	1	0	0	0	0	30	
2013	3	2	2	2	0	2	27	5	8	0	0	0	51	
2014	0	3	2	5	0	0	28	13	9	22	22	22	104	
2015	0	3	5	3	0	1	14	2	3	23	23	23	77	
2016	0	3	3	2	0	0	13	0	0	20	20	20	61	
2017	0	0	0	0	0	0	7	0	0	0	0	0	7	
2018	0	0	0	0	0	0	4	0	0	0	0	0	4	

¹ Coho tangle net fisheries were first implemented in 2013. Seine fisheries were initially implemented in 2014 but utilized research impacts which would not normally be available for commercial fisheries.

Mainstem Commercial Deliveries and Landings

The number of individual deliveries made by commercial fishers during each management season from 2003 through 2018 are shown in Table 22b. The number of deliveries serves as an index of commercial fishing effort, which is affected by annual variations in run size, number of active fishers, fishery timing, and the allocation of available ESA-impacts. Since fish abundances vary widely within a season, deliveries can sometimes be more reflective of opportunity than success; however, a comparison of total annual mainstem salmon landings and deliveries since 2003 indicates a general relationship between annual deliveries and harvest, with 2018 being the lowest level for both since 2003 (Figure 22a). Cumulative deliveries during the winter/spring seasons were somewhat stable during 2007-2016, following a 2004 peak when the run size and commercial allocation were both relatively high. Cumulative summer season deliveries have generally declined over time since the Chinook season was reopened in 2005. Although fall Chinook returns reached record levels in 2013-2015, deliveries were higher during 2003-2004 when the Chinook returns were strong and the commercial allocation was considerably higher, allowing for more fishing time. Total annual deliveries were noticeably lower in 2017 and 2018 when mainstem opportunity was limited to mainstem fall Chinook-directed fisheries. Although commercial

allocations have decreased in recent years, the reduction in average cumulative annual deliveries (all seasons combined) during the post-Harvest Reform years (2013-2018), compared to the most recent pre-Reform years (2010-2012) was only 14%.

Table 22b. Number of deliveries in mainstem non-treaty commercial drift-net fisheries by management season, 2003-2018.

Year	Winter/Spring	Summer	Fall	Total
2003	441	0	3,387	3,828
2004	1,328	38	3,247	4,613
2005	859	444	2,223	3,526
2006	863	548	1,813	3,224
2007	550	175	1,842	2,567
2008	256	215	1,649	2,120
2009	436	292	1,668	2,396
2010	488	252	1,646	2,386
2011	536	238	1,651	2,425
2012	349	120	1,389	1,858
2013	307	154	1,993	2,454
2014	353	172	2,457	2,982
2015	537	136	1,612	2,285
2016	390	145	1,271	1,806
2017	0	0	732	732
2018	0	0	288	288
2010-12	458	203	1,562	2,223
2013-18	265	101	1,392	1,758

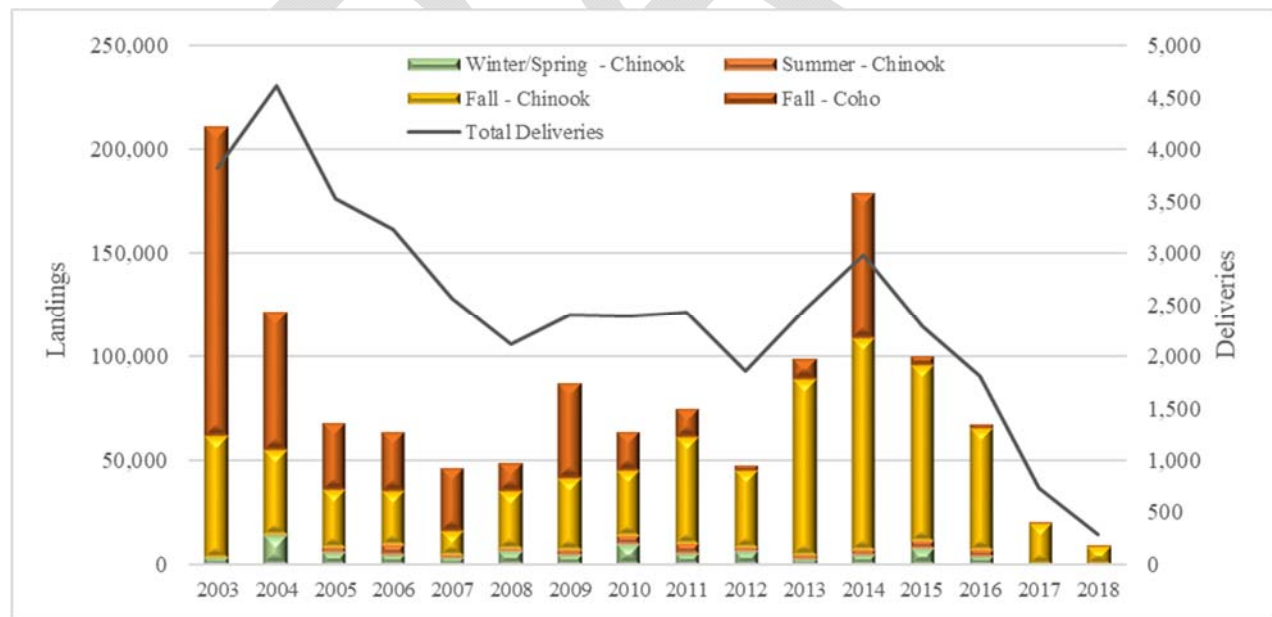


Figure 22a. Total annual salmon landings and deliveries in non-treaty mainstem commercial fisheries, 2003-2018.

The seasonal harvest of Chinook and Coho in non-treaty mainstem commercial fisheries below Bonneville Dam since 2003 is shown in Table 22c. The table includes harvest from all commercial

gear types, except for the 2014 fall seine fishery harvest, which is excluded since the pilot fishery was prosecuted with ESA impacts reserved for research, rather than from commercial impact allocations. Average mainstem harvest during the 2013-2018 post-Harvest Reform period was considerably lower for spring and summer Chinook compared to the 3-year period (2010-2012) just prior to reform. However, average harvest of fall Chinook was considerably higher during the post-Reform period as a result of strong fall Chinook runs in 2013-2015. The high Coho return in 2014 kept the average Coho harvest higher in the post-Reform period than the 2010-2013 base period (ODFW and WDFW 2014-2018a).

Table 22c. Non-treaty commercial harvest of Chinook and Coho from the mainstem lower Columbia River, 2003-2018.

Year	Winter/Spring - Chinook	Summer - Chinook	Fall - Chinook	Fall - Coho	Total Salmon ^{1,2}	Total Deliveries
2003	3,175	0	58,428	149,766	211,369	3,828
2004	13,581	186	41,057	66,522	121,346	4,613
2005	5,364	2,787	27,536	32,368	68,055	3,526
2006	4,389	4,819	26,011	28,372	63,591	3,224
2007	2,950	1,122	12,150	30,193	46,415	2,567
2008	5,952	1,370	28,052	13,107	48,481	2,120
2009	4,168	2,371	34,980	45,241	86,760	2,396
2010	9,041	4,684	31,141	18,920	63,786	2,386
2011	4,539	5,010	51,419	13,482	74,450	2,425
2012	6,118	1,692	36,871	2,615	47,296	1,858
2013	2,213	1,868	84,906	9,766	98,753	2,454
2014	4,074	2,743	101,762	70,531	179,110	2,982
2015	7,231	3,944	84,238	4,479	99,892	2,285
2016	3,613	2,990	59,055	1,269	66,927	1,806
2017	0	0	19,398	931	20,329	732
2018	0	0	8,320	380	8,700	288
All	4,776	2,224	44,083	30,496	81,579	2,468
2010-12	6,566	3,795	39,810	11,672	61,844	2,223
2013-18	2,855	1,924	59,613	14,559	78,952	1,758

¹ Catch for all mainstem gears, except 2013 seine harvest which ran on research impacts.

² Includes adults and jacks.

Non-treaty commercial harvest of Chinook and Coho, by stock and gear type/fishery, is presented in Table 22d. Total landings generally correspond with total annual returns, as shown in Figure 22b, but comparisons are confounded by ESA-impact allocation shifts, which have decreased over time, as well as other significant fishery changes that have occurred. Harvests of spring and summer Chinook during 2013-2018 were 47% and 49% of their respective harvests during 2010-2012. The reduced harvest of Chinook and Coho in the Zone 1-5 fall gillnet fisheries over time is the result of a decreasing allowed exploitation rate for natural-origin LCR tule Chinook, combined with a decreasing commercial allocation. These constraints resulted in more efficient harvest with fewer impacts on LCR tule Chinook if the fall gillnet fishery was moved to Zones 4-5. In turn, the proportion of Chinook and Coho harvested in Zone 4-5 gillnet fisheries has increased over time. Harvest in Coho-directed mainstem gillnet fisheries has also declined over time due to reductions in the allowable ESA impacts for LCN Coho. For most of the longer-term fisheries, average mainstem harvest was lower during 2013-2018, compared to the 2010-2012 base period prior to implementation of Harvest Reform allocation shifts. The total harvest of fall Chinook in

directed fisheries during 2013-2018 was nearly 70% higher than the average harvest during 2010-2012 due to the record fall Chinook returns in 2013-2015.

Table 22d. Non-treaty commercial harvest of Chinook and Coho, by stock and gear type/fishery, from the mainstem lower Columbia River, 2003-2018.

Year	Spring Chinook		Summer Chinook	Fall Chinook						Coho					
	Gill Net	Tangle Net	Gill Net	Zone 1/2-5		Coho Gill Net	Coho			Zone 1/2-5		Coho Gill Net	Coho		
				Gill Net	Gill Net		Tangle Net ¹	Beach Seine ¹	Purse Seine ¹	Gill Net	Gill Net		Tangle Net ¹	Beach Seine ¹	Purse Seine ¹
2003	541	2,634	0	26,396	25,224	6,808	--	--	--	82,337	13,335	54,094	--	--	--
2004	3,621	9,960	186	22,931	8,224	9,902	--	--	--	39,623	340	26,559	--	--	--
2005	1,697	3,667	2,787	8,406	12,282	6,848	--	--	--	847	7,050	24,471	--	--	--
2006	4,389	0	4,819	15,504	7,075	3,432	--	--	--	4,222	1,178	22,972	--	--	--
2007	658	2,292	1,122	3,835	4,822	3,493	--	--	--	820	536	28,837	--	--	--
2008	14	5,938	1,370	12,823	15,090	139	--	--	--	3,912	4,753	4,442	--	--	--
2009	18	4,150	2,371	28,271	5,677	1,032	--	--	--	1,847	2,861	40,533	--	--	--
2010	75	8,966	4,684	10,949	19,538	654	--	--	--	6,374	1,339	11,207	--	--	--
2011	2,518	2,021	5,010	15,019	35,748	652	--	--	--	5,316	5,517	2,649	--	--	--
2012	7	6,111	1,692	6,220	30,505	146	--	--	--	838	889	888	--	--	--
2013	937	1,276	1,868	3,926	78,549	569	1,862	--	--	598	2,385	1,952	4,831	--	--
2014	1,624	2,450	2,743	0	94,962	2,018	1,988	1,337	1,457	0	7,360	43,867	18,234	509	561
2015	2,881	4,350	3,944	2,466	74,603	2,283	1,893	681	2,312	60	597	2,242	993	58	529
2016	1,219	2,394	2,990	0	57,940	0	0	2	1,113	0	665	0	0	39	565
2017	0	0	0	0	19,398	0	0	0	0	0	931	0	0	0	0
2018	0	0	0	0	8,320	0	0	0	0	0	380	0	0	0	0
2010-12	867	5,699	3,795	10,729	28,597	484	na	na	na	4,176	2,582	4,915	na	na	na
2013-18	1,110	1,745	1,924	1,065	55,629	812	957	404	976	110	2,053	8,010	4,010	121	331

¹ Coho tangle net and seine fisheries first implemented in 2013 and 2014, respectively but the 2014 seine fishery used research impacts so values are not included

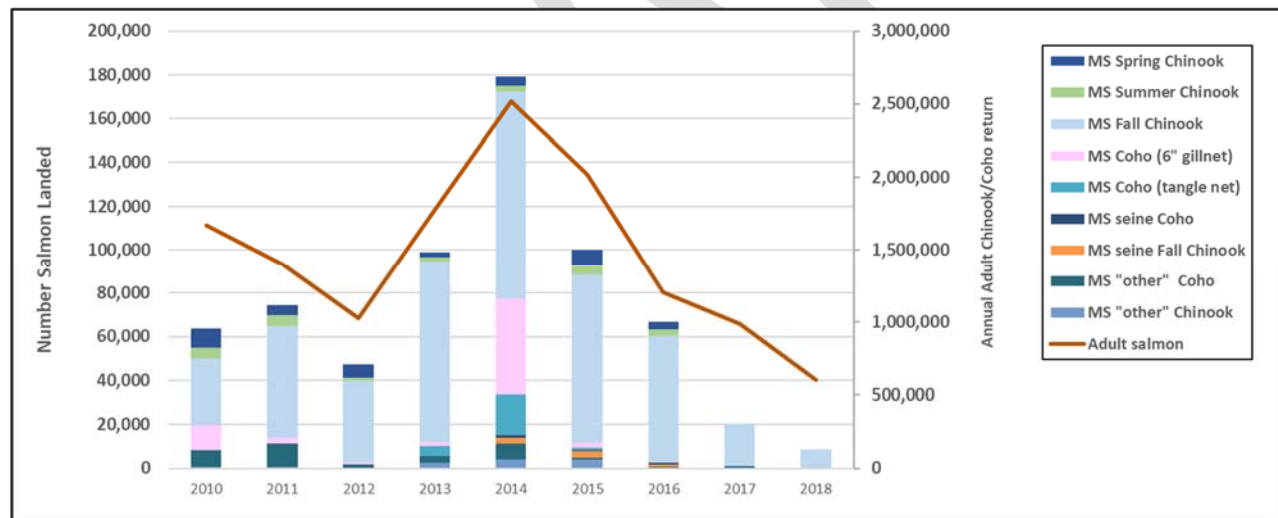


Figure 22b. Number of Chinook and Coho landed in non-treaty mainstem (MS) commercial salmon fisheries in the lower Columbia River compared to total adult Chinook and Coho returns, 2010-2018.

Mainstem Commercial Ex-Vessel Value

Ex-vessel prices for Chinook and Coho landed in mainstem non-treaty commercial fisheries during 2010-2018 varied, but generally increased over time (Table 22e). Consistent with historic patterns, Spring Chinook realized the highest average dockside price/pound at \$6.92, followed by summer Chinook at \$4.05, fall Chinook at \$2.22, and Coho at \$1.68. The highest ex-vessel prices occurred

in the most recent year(s) of harvest when price per pound averaged \$8.65 for spring Chinook (2016), \$5.55 for summer Chinook (2016), \$2.91 for fall Chinook (2018), and \$1.97 for Coho (2017). This pattern of recent significant price increases for salmon beginning in 2016 has occurred throughout the West Coast salmon fisheries (Seafood Source March 21, 2017; Anchorage Daily News, July 15, 2017).

Table 22e Average annual dockside ex-vessel prices for Chinook and Coho in mainstem non-treaty commercial fisheries, 2010-2018.

Stock/Species	2010	2011	2012	2013	2014	2015	2016	2017	2018
Spring Chinook	\$6.18	\$6.06	\$6.89	\$7.39	\$6.67	\$6.61	\$8.65	--	--
Summer Chinook	\$3.29	\$3.05	\$4.56	\$4.69	\$3.85	\$3.37	\$5.55	--	--
Fall Chinook	\$1.86	\$1.88	\$1.93	\$2.10	\$1.58	\$2.03	\$2.81	\$2.90	\$2.91
Coho	\$1.46	\$1.62	\$1.72	\$1.84	\$1.24	\$1.69	\$1.72	\$1.97	\$1.86

The combined annual ex-vessel value for Chinook and Coho landed in mainstem non-treaty commercial salmon fisheries during 2010-2018 are shown in Table 22f. Total annual ex-vessel value ranged from a high of approximately \$3.7 million in 2014 to a low of about \$0.4 million in 2018, with an average of \$2.5 million. Ex-vessel values for each season/species varied considerably among years, primarily due to fluctuations in landings, although average fish weights and prices also vary and have an effect on fishery value. In all years, fall Chinook comprised the largest portion of the mainstem ex-vessel value, with significantly higher values observed in 2013-2016 when adult returns and/or dockside prices were high. Annual combined ex-vessel values for mainstem commercial fisheries were somewhat related to combined adult returns (Figure 22c). In most years, spring Chinook were the second most valuable stock, averaging \$0.45 million annually during the 2010-2016 timeframe. Summer Chinook and Coho both had an average annual ex-vessel value of approximately \$0.2 million during 2010-2016. Coho values have varied widely from year to year, and have steadily declined since the recent peak ex-vessel value realized in 2014.

Table 22f. Total annual ex-vessel value of Chinook and Coho, by season, for mainstem non-treaty commercial fisheries, 2010-2018.

Season (Species)	2010	2011	2012	2013	2014	2015	2016	2017	2018
Winter/Spring (Chinook)	\$708,884	\$390,421	\$544,229	\$202,405	\$322,675	\$580,660	\$415,641	\$0	\$0
Summer (Chinook)	\$264,278	\$265,913	\$125,608	\$144,962	\$172,266	\$206,307	\$275,108	\$0	\$0
Fall (Chinook)	\$1,147,888	\$1,712,144	\$1,297,647	\$2,809,170	\$2,581,244	\$2,652,441	\$2,816,361	\$908,770	\$373,219
Fall (Coho)	\$308,538	\$209,748	\$37,154	\$129,137	\$617,084	\$47,583	\$16,520	\$13,535	\$5,235
Total	\$2,429,588	\$2,578,226	\$2,004,637	\$3,285,675	\$3,693,268	\$3,486,991	\$3,523,631	\$922,305	\$378,454

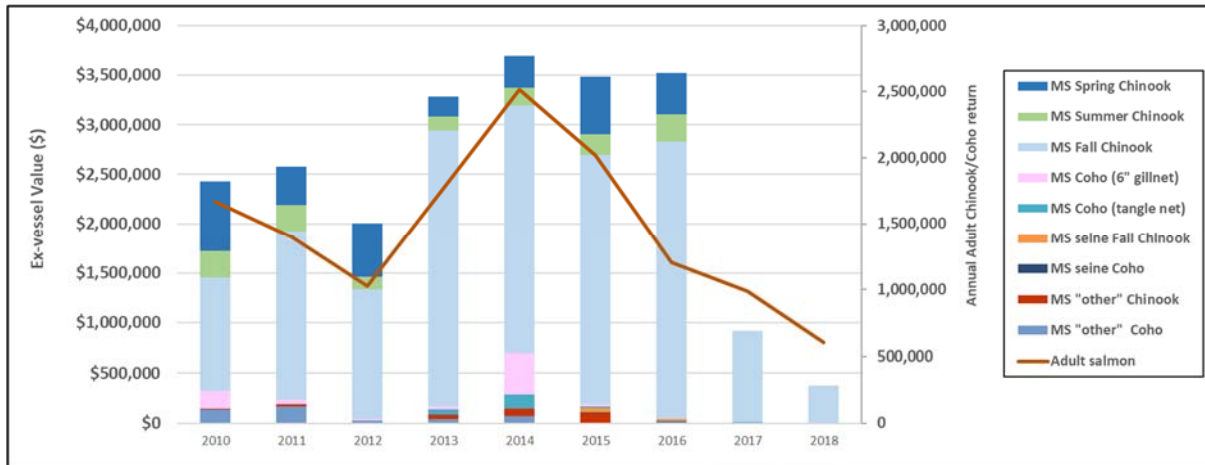


Figure 22c. Annual ex-vessel value of non-treaty mainstem (MS) commercial salmon fisheries in the lower Columbia River compared to total adult Chinook and Coho returns, 2010-2018.

Since at least 2010, the fall mainstem gillnet fishery has comprised the largest component of combined mainstem non-treaty commercial fisheries, averaging \$1.8 million in ex-vessel value per year, and 77% of the annual combined Chinook and Coho value (Tables 22g and 22h). The mainstem spring Chinook fishery has averaged 13% of the annual combined ex-vessel value, with the summer Chinook fishery representing 6%. The fall small-mesh (6-inch) Coho-directed gillnet fishery represented 12% of the total annual ex-vessel value in 2014 when Coho and Chinook abundances were high, but averaged 3% during the entire 2010-2018 period. The fall tangle net and fall seine fisheries averaged 3 and 1%, respectively, of the combined annual mainstem ex-vessel value in the years in which they were used.

Table 22g. Total annual ex-vessel value, by season and gear type, for mainstem non-treaty commercial fisheries, 2010-2018.

Season (Species)	Gear	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
Winter/Spring (Chinook)	Gill/Tangle net	\$708,884	\$390,421	\$544,229	\$202,405	\$322,675	\$580,660	\$415,641	\$0	\$0	\$351,657
Summer (Chinook)	Gillnet	\$264,278	\$265,913	\$125,608	\$144,962	\$172,266	\$206,307	\$275,108	\$0	\$0	\$161,605
	Large mesh gillnet	\$1,268,500	\$1,860,281	\$1,315,818	\$2,812,736	\$2,575,129	\$2,515,140	\$2,799,595	\$922,305	\$378,454	\$1,827,551
	Small mesh gillnet	\$187,926	\$61,611	\$18,983	\$39,486	\$460,466	\$78,612	\$0	\$0	\$0	\$94,120
Fall (Chinook/Coho)	Tangle net	\$0	\$0	\$0	\$86,085	\$162,732	\$49,624	\$0	\$0	\$0	\$33,160
	Seine	\$0	\$0	\$0	\$0	\$0	\$56,649	\$33,286	\$0	\$0	\$9,993
Total		\$2,429,588	\$2,578,226	\$2,004,637	\$3,285,675	\$3,693,268	\$3,486,991	\$3,523,631	\$922,305	\$378,454	\$2,478,086

Table 22h. Total annual proportion of annual ex-vessel value, by season and gear type, for mainstem non-treaty commercial fisheries, 2010-2018.

Season (Species)	Gear	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
Winter/Spring (Chinook)	Gill/Tangle net	29%	15%	27%	6%	9%	17%	12%	0%	0%	13%
Summer (Chinook)	Gillnet	11%	10%	6%	4%	5%	6%	8%	0%	0%	6%
	Large mesh gillnet	52%	72%	66%	86%	70%	72%	79%	100%	100%	77%
	Small mesh gillnet	8%	2%	1%	1%	12%	2%	0%	0%	0%	3%
Fall (Chinook/Coho)	Tangle net	0%	0%	0%	3%	4%	1%	0%	0%	0%	0.9%
	Seine	0%	0%	0%	0%	0%	2%	1%	0%	0%	0.3%
Total		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

As anticipated, the proportion of the average annual mainstem commercial ex-vessel value attributed to each season and gear type changed significantly between the Harvest Reform pre-transition (2010-2012), transition (2013-2016), and post-transition (2017-2018) periods. The proportion of the total annual value generated by the mainstem spring Chinook fishery dropped from 24% to 11% to 0% (Table 22i). The pattern for summer Chinook was similar, decreasing

from 9% of the annual value during the pre-transition period to 0% in the post-transition period. Small-mesh fall gillnets also dropped from 4% of the annual mainstem value during 2010-2012 to 0% in the post-transition period when they could not be used. With alternative gears contributing little to the annual mainstem commercial value, the large-mesh fall gillnet fishery contribution increased from an average of 63% of the annual mainstem value during the pre-transition period, to 77% during the transition period, to 100% in 2017-2018, when no other non-treaty commercial gear types were fished for salmon in the mainstem Columbia.

Table 22i. Average proportion of total ex-vessel value, by season and gear type, for mainstem non-treaty commercial fisheries during pre-transition (2010-2012), transition (2013-2016), and post-transition (2017-2018) periods.

Season (Species)	Gear	Pre-Transition	Transition	Post
		2010 - 2012	2013 - 2016	2017-2018
Winter/Spring (Chinook)	Gill/Tangle net	24%	11%	0%
Summer (Chinook)	Gillnet	9%	6%	0%
	Large mesh gillnet	63%	77%	100%
Fall (Chinook/Coho)	Small mesh gillnet	4%	4%	0%
	Tangle net	0%	2%	0%
	Seine	0%	1%	0%
Total		100%	100%	100%

ESA Impacts/Catch Balancing

Winter/Spring Season Fisheries

Since 2010, the allocation of non-treaty upriver spring Chinook impacts available for commercial fisheries has declined as a result of multiple policy reviews and rule modifications (Figure 22d). The commercial share was 47% in 2010, 37% during 2011-2013, 30% in 2014-2016, and 20% in 2017-2018. The commercial allocation has been used to prosecute mainstem and Select Area commercial fisheries, with an annual allocation of 0.15% reserved for managing Select Area fisheries. Since 2017, the presumptive path assumes commercial ESA impacts will be predominately used to maximize Select Area commercial fisheries. Table 22j compares the upriver spring Chinook impacts used by non-treaty commercial fisheries to the amount available post-season. Aside from 2015 and 2016, when unused recreational ESA impacts were shifted to commercial fisheries per the policy, mainstem commercial fisheries generally remained within, or close to the available allocation. Table 22k provides a similar comparison based on upriver spring Chinook mortalities, which can be more constraining when mark-selective fisheries are considered. In this case, mainstem non-treaty commercial fisheries remained within the available allocation in every year, whereas Select Area fisheries exceeded the reserved sub-allocation in most (66%) years.

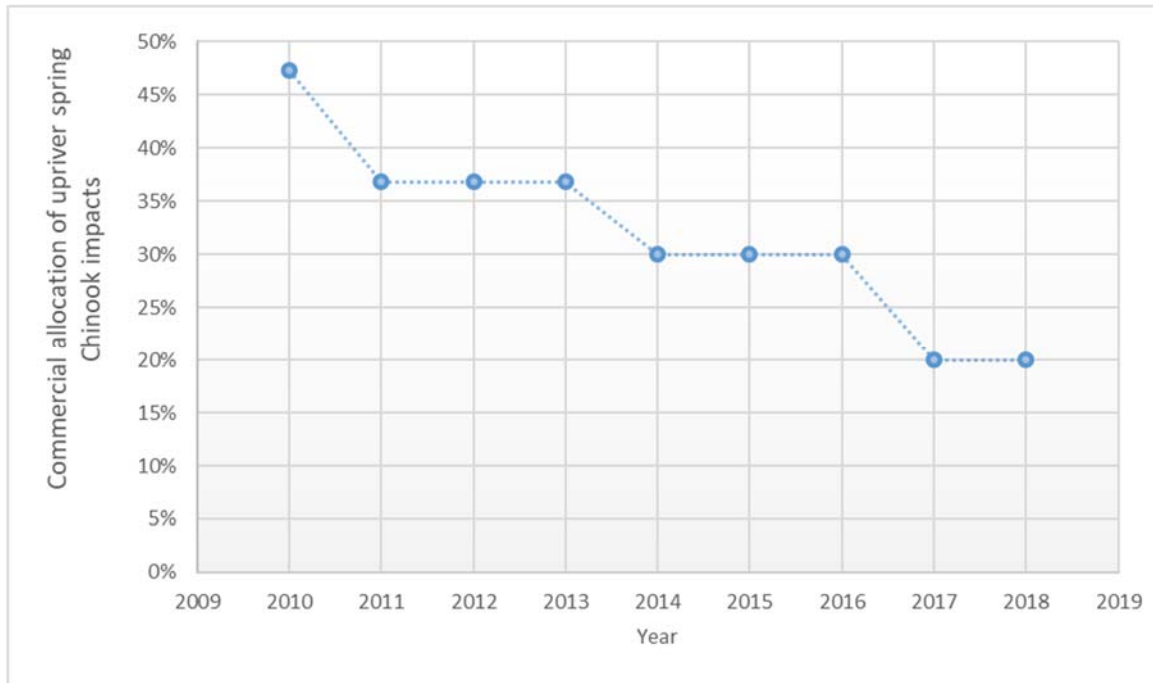


Figure 22d. Percent of non-treaty upriver spring Chinook ESA impacts allocated to commercial fisheries, 2010-2018.

Table 21j. Upriver spring Chinook harvest-related ESA impact rates in Columbia River commercial fisheries, 2010-2018.

Year	Post-season Allowed			Post-season Used			Post-Season %		
	SAFE	Mainstem	Sum	SAFE	Mainstem	Sum	SAFE	Mainstem	Sum
2010	0.150%	0.840%	0.990%	0.471%	0.406%	0.877%	314%	48%	89%
2011	0.150%	0.550%	0.700%	0.138%	0.559%	0.697%	92%	102%	100%
2012	0.150%	0.510%	0.660%	0.162%	0.365%	0.527%	108%	72%	80%
2013	0.150%	0.445%	0.595%	0.210%	0.427%	0.637%	140%	96%	107%
2014	0.150%	0.450%	0.600%	0.107%	0.509%	0.616%	71%	113%	103%
2015 ^a	0.150%	0.510%	0.660%	0.278%	0.745%	1.023%	185%	146%	155%
2016 ^a	0.150%	0.420%	0.570%	0.185%	0.571%	0.756%	123%	136%	133%
2017	0.300%	0.000%	0.300%	0.400%	0.000%	0.400%	133%	0%	133%
2018	0.266%	0.074%	0.340%	0.265%	0.000%	0.265%	100%	0%	78%
2010-12	0.150%	0.633%	0.783%	0.257%	0.443%	0.700%	171%	74%	89%
2013-16	0.150%	0.456%	0.606%	0.195%	0.563%	0.758%	130%	123%	124%
2017-18	0.283%	0.037%	0.320%	0.333%	0.000%	0.333%	116%	0%	106%

^a Adaptive management was utilized in 2015 and 2016 once sport objectives were projected to be met, resulting in additional spring Chinook harvest.

Table 22k. Upriver spring Chinook harvest-related mortalities in Columbia River commercial fisheries, 2010-2018.

Year	Post-season Allowed			Post-season Used			Post-Season %		
	SAFE	Mainstem	Sum	SAFE	Mainstem	Sum	SAFE	Mainstem	Sum
2010	473	12057	12530	1486	7591	9077	314%	63%	72%
2011	333	6492	6825	304	3511	3815	91%	54%	56%
2012	305	4454	4759	329	4276	4605	108%	96%	97%
2013	185	2439	2624	259	1498	1757	140%	61%	67%
2014	364	4547	4911	257	3364	3621	71%	74%	74%
2015 ^a	433	5942	6375	804	5724	6528	186%	96%	102%
2016 ^a	282	3053	3335	331	2954	3285	117%	97%	99%
2017	347	0	347	463	0	463	133%	0%	133%
2018	310	270	580	309	0	309	100%	0%	53%
2010-12	370	7668	8038	706	5126	5832	171%	71%	75%
2013-16	316	3995	4311	413	3385	3798	128%	82%	85%
2017-18	329	135	464	386	0	386	117%	0%	93%

^a Adaptive management was utilized in 2015 and 2016 once sport objectives were projected to be met, resulting in additional spring Chinook harvest.

Summer Chinook

Similar to upriver spring Chinook impacts and catch balance guidelines, the commercial allocation of upper Columbia River summer Chinook available for harvest downstream of Priest Rapids Dam (PRD) has steadily declined since 2012 as a result of policy modifications (Figure 22e). From 2005, when commercial fisheries targeting summer Chinook were reinstated, through 2012, non-treaty commercial fisheries were typically allocated 50% of the harvest available for non-treaty fisheries below PRD. Subsequent allocations were 45% in 2013, 40% in 2014, 30% in 2015 and 2016, and 20% in 2017 and 2018. The associated harvest has fluctuated as a result of varying run sizes, which can confound the effects of allocation reductions. For instance, summer season landings in 2015 exceeded 4,000 Chinook, even at a reduced 30% commercial allocation because the adult return was a recent record (Table 22i). In addition, landings in 2016 were inflated when unused recreational impacts were used to provide additional non-treaty commercial harvest, per the policy. Non-treaty commercial fisheries averaged 108% of post-season allocations during 2010-2016, often the result of run downgrades, which reduced the available allocation after the fisheries were mostly completed. Since 2017, non-treaty commercial harvest of summer Chinook has been limited to incidental catches in Select Area fisheries since Harvest Reform policy modifications prohibited the use of gillnets for mainstem non-treaty commercial summer Chinook fisheries, and required alternative gear types have not been identified. In 2017 and 2018 non-treaty commercial harvest of upper Columbia River summer Chinook in Select Areas were 5% and 34% of the post-season commercial guideline, respectively.

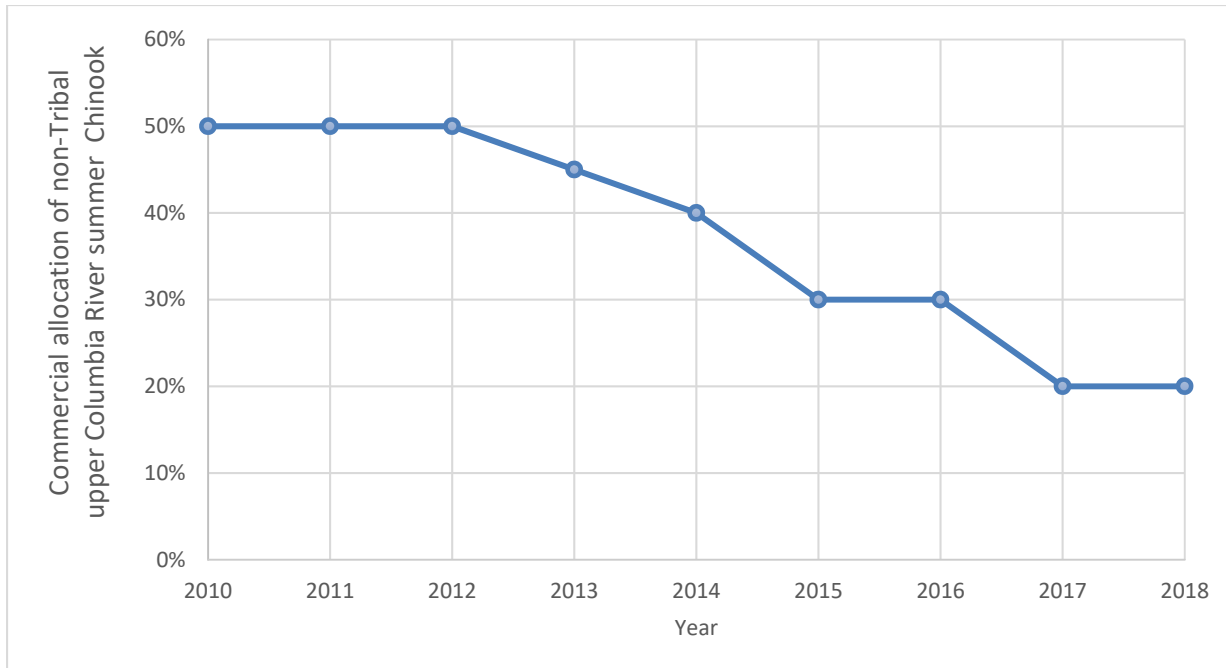


Figure 22e. Percent of upper Columbia River summer Chinook available for harvest in fisheries downstream of Priest Rapids Dam allocated to non-tribal commercial fisheries, 2010-2018.

Table 22i. Upper Columbia summer Chinook harvest in Columbia River non-treaty commercial fisheries, 2010-2018.

Year	Allocation		Actual Harvest ^a	Percent of Allocation	
	Preseason	Postseason		Preseason	Postseason
2010	5,600	3,864	4,740	85%	123%
2011	5,675	4,579	5,004	88%	109%
2012	4,629	1,559	1,715	37%	110%
2013	2,585	2,145	1,987	77%	93%
2014	1,893	2,601	2,788	147%	107%
2015	1,646	4,219	4,043	246%	96%
2016 ^b	2,633	2,513	3,050	116%	121%
2017	781	906	47	6%	5%
2018 ^c	708	71	24	3%	34%
2010-12	5,301	3,334	3,820	72%	115%
2013-16	2,189	2,870	2,967	136%	103%
2017-18	745	489	36	5%	7%

^a Includes harvest in mainstem and Select Area fisheries

^b Unused recreational allocation was shifted to commercial fisheries once sport objectives were projected to be met (per policy), resulting in additional summer Chinook harvest.

Fall Chinook

Snake River and lower Columbia River natural-origin fall Chinook were ESA-listed in 1992 and 1999, respectively. Since then, fall Chinook harvest, and even access to Coho in some years, has often been driven by the available allocation of one of these two stocks. However, allowed ESA impacts for LCN Coho and natural origin upriver summer steelhead can also constrain access to fall Chinook. For LCR natural Chinook, the maximum allowed exploitation rate applies to the combined ocean and in-river fisheries, which have been set annually since 2012 based on the combined LRH run size. In addition, sharing of allowed in-river ESA impacts between recreational and commercial fisheries has varied, depending on negotiations at North of Falcon meetings (prior to 2012) and allocations set by the Commissions (2013 and beyond). The allowed impact rate for SRW Chinook (URB fall Chinook are the surrogate) only applies to in-river fisheries, but the rate varies, depending on the total URB run, which can change in-season.

In combination, these issues can create significant annual variance in the commercial pre- and post-season allocations. Even with these issues, the average actual allocation for LCR natural Chinook used in non-treaty commercial fisheries (41%) was generally similar to preseason expectations (44%) during the 2010-2012 pre-Reform base period. Policy-mandated allocation shifts resulted in a reduced average commercial preseason allocation of 30% during the 2013-2016 transition period, with an actual used allocation of 35% (Figure 22f). For 2017, commercial fisheries only used 14% of the LCR natural Chinook impacts, compared to a preseason expectation of 31%, due to limited fishing time resulting from a low return of natural-origin B-Index steelhead. The commercial preseason rate for 2018 of 27% is less than the 30% minimum required under OFWC rules because SRW fall Chinook impacts are more constraining, which limits access to the LCR natural Chinook impacts.

For SRW fall Chinook, the pre- and post-season commercial allocations didn't change as dramatically between the base and transition periods. In fact, the average commercial SRW allocation used during the transition period (54%) actually exceeded the average rate during the base period of 48% (Figure 22g). This is likely a result of the record upriver Chinook returns during 2013-2015 that provided additional commercial opportunity after recreational season objectives were projected to be met. For 2017, commercial fisheries used 27% of the SRW Chinook impacts, compared to a preseason expectation of 36%, due to unexpectedly low Chinook catches and the very low return of natural-origin B-Index steelhead, which constrained fishing opportunity in September. For 2018, the combined non-treaty preseason ESA limit for SRW Chinook was 8.25%, much lower than the recent 15% ESA limit, due to reduced run size. As a result, SRW impacts were the primary constraint for all non-treaty fall fisheries. Recreational fisheries were not able to achieve their season objectives even with an impact allocation of 70% of SRW impacts, and 57% of the available LCR tule impacts. Unused LCR tule impacts were available for the commercial fishery, but commercial fisheries were not able to access those impacts without exceeding 30% allocation for SRW.

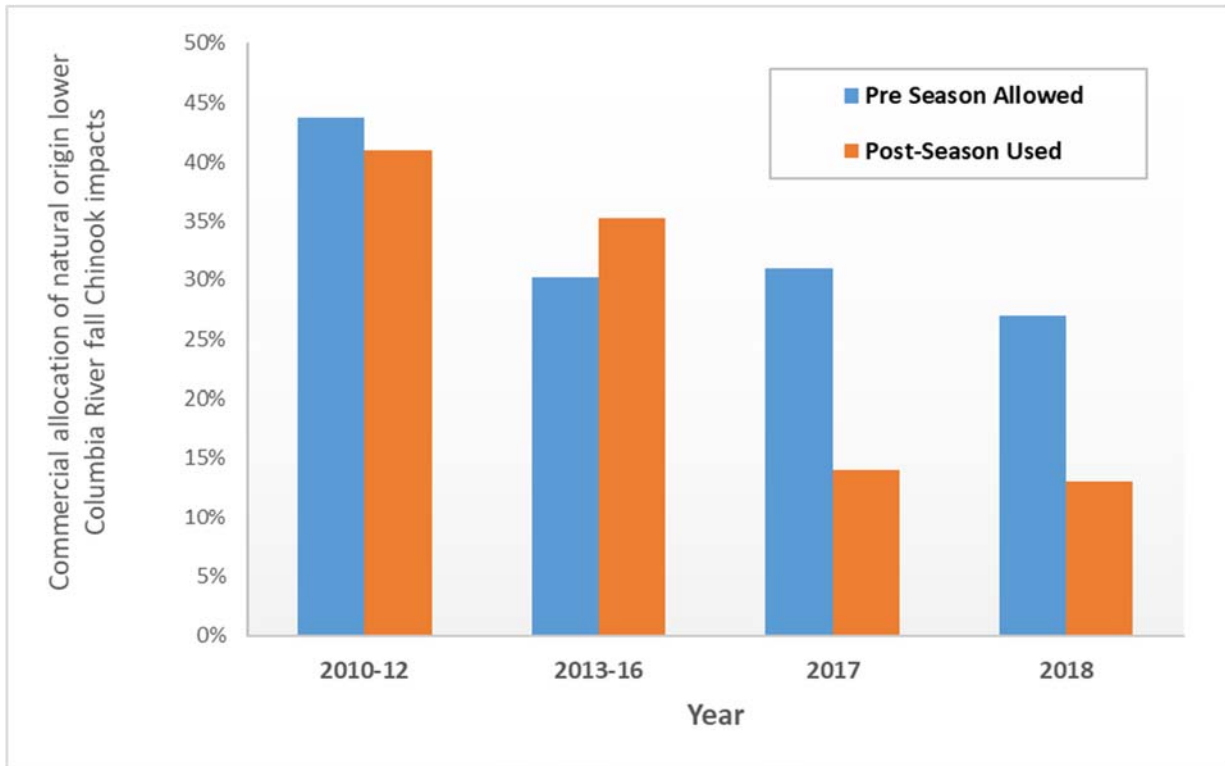


Figure 22f. Average non-treaty commercial allocation of freshwater ESA impacts for natural-origin lower Columbia River fall Chinook, 2010-2012, 2013-2016, 2017, and 2018 (preliminary).

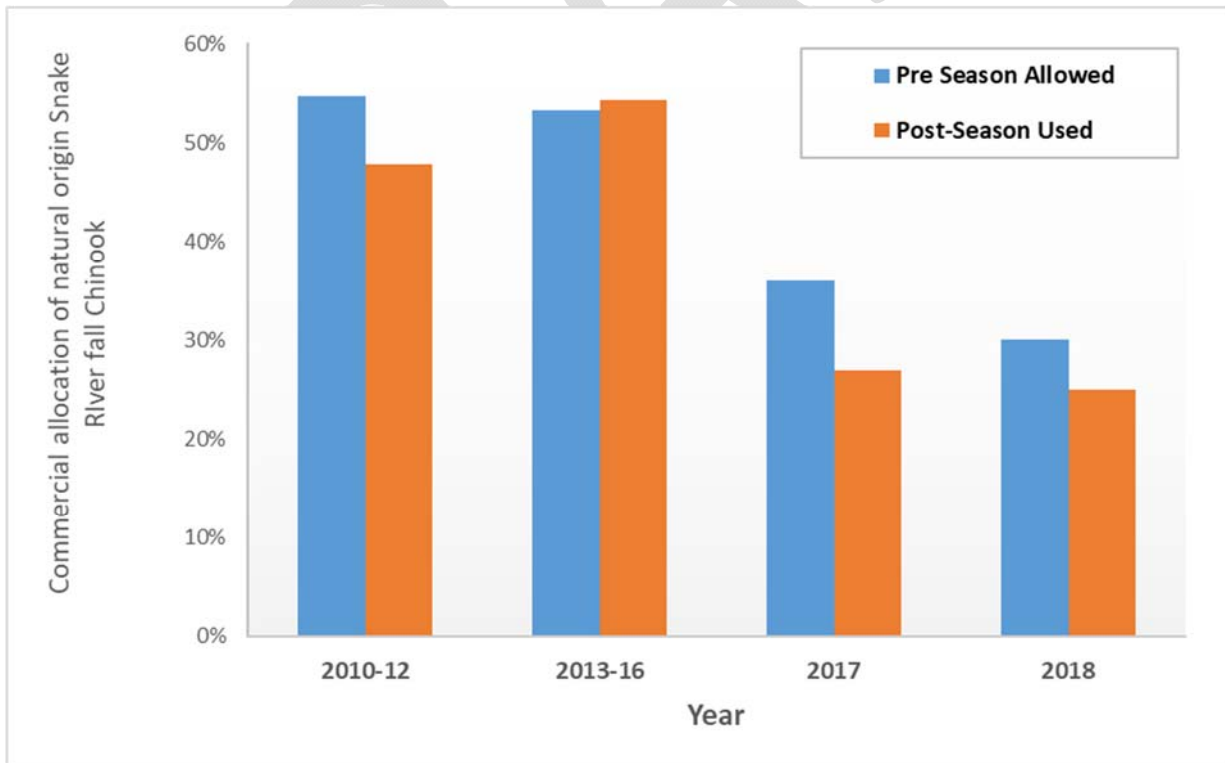


Figure 22g. Average non-treaty commercial allocation of freshwater ESA impacts for natural-origin Snake River fall Chinook, 2010-2012, 2013-2016, 2017, and 2018 (preliminary).

Coho

As with other stocks, the proportion of LCN Coho impacts used in non-treaty commercial fisheries has generally declined since 2010. Although preseason allocations averaged between 70-80% during 2010-2017, the average percent of the in-river ESA impacts used in commercial fisheries declined from an average of 78% in 2010-2012, to 55% during 2013-2016, to 32% in 2017 (Figure 22h). Reasons for the reduced impact usage include fishing constraints imposed by other stocks (SRW Chinook in 2016 and B-Index steelhead in 2017). The 2018 preseason expectation for commercial fisheries to use 40% of the in-river natural origin Coho impacts is a result of 2017 Policy changes that prohibited higher impact Coho-directed gillnet fisheries.

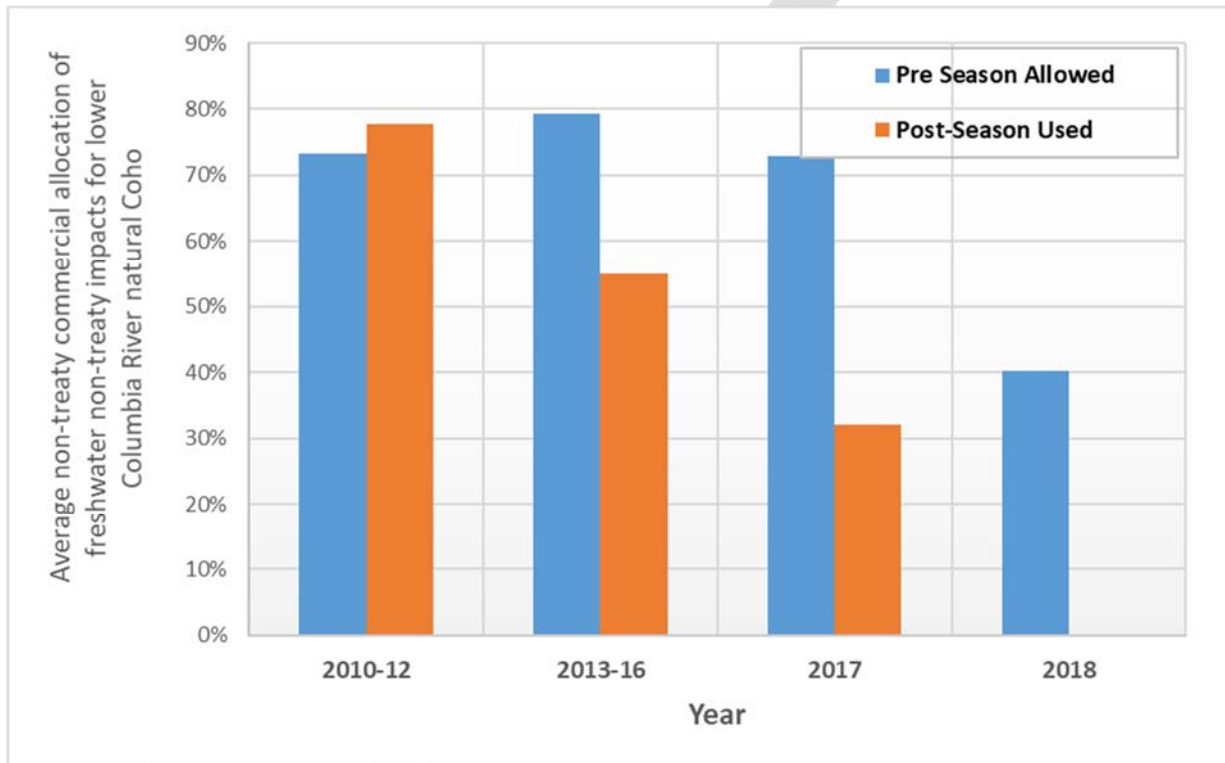


Figure 22h. Average non-treaty commercial allocation of freshwater ESA impacts for natural-origin lower Columbia River Coho, 2010-2012, 2013-2016, 2017, and 2018.

Economics

In conjunction with our economic analyses of the alternative gear commercial fisheries (fall seine fishery and Coho tangle net fishery) and current Select Area fisheries, we also examined the economic performance of the mainstem commercial fisheries during the post-Harvest Reform years by comparing actual landings and ex-vessel values to estimated costs associated with using gillnets (tangle nets for early spring Chinook) to commercially harvest salmon in the mainstem lower Columbia River. As mentioned earlier in this report, it is difficult to determine the actual costs associated with any given commercial fishery, and the harvest-related costs taken from the

2013 FIS are in 2013 dollars (Table 17k); therefore, the net economic returns that we have calculated are best viewed as close approximations. Nevertheless, because harvest-related costs have been applied to all commercial fisheries in this report in a standardized manner, the results of the analyses are still useful for comparing relative economic returns in different Columbia River commercial fisheries.

To estimate the average number of vessels/fishers participating in each mainstem fishery, we used deliveries as a surrogate for participating vessels, and divided the total number of deliveries made during the season by the number of open fishing days with at least one delivery. This assumes that each vessel participating in a fishing period makes one delivery, which is not necessarily the case during certain times of the season. Therefore, adjustments to deliveries were made when we deemed they were necessary and possible. We defined a fishing day as a single fishing period, ranging in duration from 6 to 14 hours. Based on information from past on-board fisheries observations, we again assumed that most vessels participating in mainstem gillnet fisheries had one fisher onboard and that crew pay and liability insurance costs did not apply to these fisheries (Table 17k). As fishers participating in mainstem gillnet fisheries already had the necessary boats, nets, and rigging, we did not include any capital costs, but we did include recurring annual and daily operating costs based on the average number of vessels participating in each fishery. We assumed that fishers participating in the shorter spring Chinook, summer Chinook, and Coho 6-inch gillnet fisheries would incur lower net repair costs (\$667/year), compared to the repair costs for the longer fall Zone 4-5 season (\$1,333/year). Furthermore, fuel costs of \$150 per day were applied to each participating vessel (Table 17k).

Mainstem Spring Fishery

Since a spring mainstem commercial fishery did not occur in 2017 or 2018, our economic analysis of this fishery is limited to the transition period of 2013 through 2016. We assumed that all fishers participating in the fisheries caught at least one fish and made a delivery. Therefore, we used the average number of deliveries per fishing day as an approximation of the average number of vessels/fishers participating in the fishery.

The results of our economic analysis for the spring mainstem commercial fishery are shown in Table 22m. Average net return per vessel ranged from \$1,450 in 2013 to \$6,783 in 2015, when the spring Chinook return was strong. Fishery participation declined slightly during the 4-year period, and estimated harvest costs were moderate. This resulted in an average net return per vessel of \$4,054 for about 6 fishing periods. Although the average net return per vessel in the Select Area winter/spring fishery (all sites combined) during 2013-2016 was more than twice as high as in the mainstem (Table 19k), mainstem openers tended to be relatively few days per season, whereas the Select Area seasons were much longer. On a per-fishing-period basis, the average spring mainstem net return per vessel was \$661, compared to \$75 in Select Area fisheries. This suggests that more total value can be produced during a Select Area spring Chinook season, but that it takes much longer to generate.

Table 22m. Comparison of landings and ex-vessel value to estimated harvest costs for the 2013-2016 spring mainstem commercial tangle net/gillnet fisheries.

Year	Days Fished	Avg# of Vessels ¹	Chinook Landed ²	Total Ex-Vessel Value	Costs			Net Fishery Return	Net Return/Vessel
					Annual	Daily	Total		
2013	4	75	2,213	\$202,405	\$49,692	\$44,700	\$94,392	\$108,013	\$1,450
2014	5	71	4,074	\$322,675	\$47,090	\$52,950	\$100,040	\$222,634	\$3,153
2015	8	67	7,231	\$580,660	\$44,772	\$80,550	\$125,322	\$455,338	\$6,783
2016	6	65	3,613	\$415,641	\$43,355	\$58,500	\$101,855	\$313,786	\$4,827
Avg	6	69	4,283	\$380,345	\$46,227	\$59,175	\$105,402	\$274,943	\$4,054

¹ Average number of vessels fishing during the season. Approximated using average number of deliveries per day.

² Includes adults and jacks.

Mainstem Summer Fishery

Because a summer mainstem commercial fishery did not occur in 2017 due to the lack of a suitable alternative gear (as required by Policy), our analysis of this fishery during the post-Reform period was restricted to the transition period 2013-2016. Chinook abundance during the summer season is generally good, so we assumed that all fishers participating in these fisheries caught at least one fish and made a delivery. Thus, we used the average number of deliveries per fishing day as an approximation of the average number of vessels/fishers participating in the fishery.

The results of the summer mainstem commercial fishery analysis are presented in Table 22n. Average net return per vessel varied from \$916 in 2013 to \$3,591 in 2014. Fishery participation fluctuated during the 4-year period, averaging 57 participants per year, and estimated harvest costs were modest due to the very short seasons. This resulted in an average net return per vessel of \$2,685 for about 3 fishing periods. Although the average net return per vessel in the Select Area summer fishery during 2013-2016 was very similar to the mainstem (Table 19i), the Select Area summer seasons were approximately six times longer. On a per-fishing-period basis, the average summer mainstem net return per vessel was \$930, compared to \$118 in the Select Areas.

Table 22n. Comparison of landings and ex-vessel value to estimated harvest costs for the 2013-2016 summer mainstem commercial gillnet fisheries.

Year	Days Fished	Avg# of Vessels ¹	Chinook Landed ²	Total Ex-Vessel Value	Costs			Net Fishery Return	Net Return/Vessel
					Annual	Daily	Total		
2013	2	77	1,868	\$144,962	\$51,359	\$23,100	\$74,459	\$70,503	\$916
2014	5	34	2,743	\$172,266	\$22,945	\$25,800	\$48,745	\$123,521	\$3,591
2015	3	45	3,944	\$206,307	\$30,237	\$20,400	\$50,637	\$155,670	\$3,434
2016	2	73	2,990	\$275,108	\$48,691	\$21,900	\$70,591	\$204,517	\$2,802
Avg	3	57	2,886	\$199,661	\$38,308	\$22,800	\$61,108	\$138,553	\$2,685

¹ Average number of vessels fishing during the season. Approximated using average number of deliveries per day.

² Includes adults and jacks.

Fall Zone 4-5 Fishery

Our economic analysis of the post-Reform fall Zone 4-5 commercial fishery included 2013-2017 since this fishery did occur in 2017. Although the fishery primarily targets fall Chinook, some

Coho are also included in the harvest. Chinook and Coho abundance during the timeframe of the Zone 4-5 fishery (mid-late August, mid-late September, occasionally October) is generally good, so we assumed that all fishers participating in this fishery caught at least one fish and made a delivery. In fact, catches can be high enough at certain times that smaller boats sometimes make multiple deliveries to a tender during a fishing period. Analysis of fish ticket data from the 2017 Zone 4-5 fishery indicated that the number of unique vessels making a delivery was approximately 90% of the number of deliveries made for a given fishing period (D. Case, ODFW, personal communication). We assumed that this percentage was similar in recent years for the Zone 4-5 fishery, so we applied it to the average number of deliveries per fishing day for each year, and used the adjusted value as an approximation of the average number of vessels/fishers participating in the fishery.

The results of our analysis of the fall Zone 4-5 fishery are displayed in Table 22o. Average net return per vessel varied from \$7,527 in 2017 to \$51,221 in 2014. The unusually low net return per vessel from lower than expected landings in 2017 was primarily due to the late timing of the fall Chinook run, and the very limited ESA impacts for natural-origin B-Index steelhead that were available to the fishery. Fishery participation fluctuated during the 5-year period, averaging 72 participants per year, and was similar to the mainstem spring fishery. Although the average harvest cost was higher for the Zone 4-5 fishery compared to the spring and summer season fisheries, mostly because of a longer average season, landings and ex-vessel value for the fishery were substantially higher. This resulted in an average net return per vessel of \$32,207 for about 18 fishing periods. For comparison, the average net return per vessel for Select Area fall season fisheries during 2013-2017 was approximately \$15,000 (Table 19m). On a per-fishing-period basis, the average Zone 4-5 fishery net return per vessel was \$1,711, compared to \$90 for the Select Area fall fishery.

Table 22o. Comparison of landings and ex-vessel value to estimated harvest costs for the 2013-2017 fall Zone 4-5 commercial gillnet fisheries.

Year	Days Fished	Avg # of Vessels ¹	Salmon Landed ²	Total Ex-Vessel Value	Costs			Net Fishery Return	Net Return/Vessel
					Annual	Daily	Total		
2013	27	51	80,934	\$2,711,853	\$68,282	\$207,459	\$275,741	\$2,436,112	\$47,558
2014	31	45	102,322	\$2,575,129	\$60,007	\$209,328	\$269,335	\$2,305,794	\$51,221
2015	14	83	75,200	\$2,441,263	\$111,180	\$175,152	\$286,332	\$2,154,931	\$25,837
2016	13	87	58,605	\$2,799,595	\$115,990	\$169,679	\$285,669	\$2,513,926	\$28,891
2017	7	93	20,329	\$922,305	\$124,060	\$97,722	\$221,782	\$700,523	\$7,527
Avg	18	72	67,478	\$2,290,029	\$95,904	\$171,868	\$267,772	\$2,022,257	\$32,207

¹ Average number of vessels fishing during the season. Approximated using average number of deliveries per day and a conversion factor from analysis of 2017 Zone 4-5 fishery fish tickets.

² Includes Chinook and Coho (adults and jacks).

Coho 6-inch Gillnet Fishery

The analysis of the post-Reform Coho-directed 6-inch gillnet fishery in the mainstem Columbia only included 2013-2015. In 2016, there were not enough URB/SRW fall Chinook impacts available to prosecute the fishery. In 2017, B-index steelhead impact limits prevented any directed Coho fishery from occurring, and regulations required use of tangle net only in this fishery, by Policy, in 2017. Although the fishery targets Coho in October, some Chinook are also harvested,

and in years with strong Chinook returns (e.g. 2015), the landings can be significant (2,283 Chinook vs. 2,242 Coho). Coho and Chinook abundance during the timeframe of the fishery is sufficient enough that we assumed that all fishers participating in the fishery caught at least one fish and made a delivery. Therefore, we used the average number of deliveries per fishing day as an approximation of the average number of vessels/fishers participating in the fishery.

The results of our economic analysis for the Coho 6-inch gillnet fishery are presented in Table 22p. Average net return per vessel ranged from a low of -\$46 in 2013 to a high of \$6,635 in 2014. The solid net return per vessel in 2014 was largely the result of a very strong Coho run that year, and the poor Coho returns in 2013 and 2015 were primarily responsible for the low net return per vessel in those years. In fact, if a substantial number of Chinook had not been landed in 2015, the net return per vessel would have likely been negative that year. Fishery participation increased during the 3-year period, but the average number of participating vessels/fishers in the Coho 6-inch gillnet fishery was lower than it was for the other mainstem fisheries. Average fishery harvest costs were moderate, and although the average net return per vessel for 2013-2015 was a respectable \$2,257 for about 7 fishing periods, this was buoyed by the exceptionally strong fishery performance in 2014.

Table 22p. Comparison of landings and ex-vessel value to estimated harvest costs for the 2013-2015 Coho-directed 6-inch commercial gillnet fisheries.

Year	Days Fished	Avg # of Vessels ¹	Salmon Landed ²	Total Ex-Vessel Value	Costs			Net Fishery Return	Net Return/Vessel
					Annual	Daily	Total		
2013	5	29	2,521	\$39,486	\$19,210	\$21,600	\$40,810	(\$1,324)	(\$46)
2014	13	50	45,885	\$460,466	\$33,196	\$97,050	\$130,246	\$330,220	\$6,635
2015	2	69	4,525	\$78,612	\$45,690	\$20,550	\$66,240	\$12,372	\$181
Avg	7	49	17,644	\$192,855	\$32,698	\$46,400	\$79,098	\$113,756	\$2,257

¹ Average number of vessels fishing during the season. Approximated using average number of deliveries per day.

² Includes Chinook and Coho (adults and jacks).

Economics Summary

Net return per vessel, an important indicator of economic viability and fishery performance, was strongly positive in most years for the mainstem commercial fisheries, with the exception of the Coho 6-inch gillnet fishery. This fishery had the greatest variation in annual net returns due to large fluctuations in the Coho run. Annual economic returns in the other mainstem fisheries were much more stable, with the fall Zone 4-5 fishery clearly the most productive fishery for the largest number of fishers. The net return per vessel-period for the Zone 4-5 fishery of \$1,711 was far higher than any other commercial fishery in the mainstem or Select Areas.

The mainstem spring and summer seasons were short, but provided substantial economic returns in a brief period of time. Net return per vessel-period was \$661 for the mainstem spring fishery and \$930 for the summer fishery, much higher than for their counterpart fisheries in the Select Areas, which intentionally have more protracted seasons. Therefore, even short spring and summer seasons in the mainstem can produce significant economic value for participating fishers. For all mainstem commercial gillnet fisheries, the combined average net return per vessel during 2013-2017 was \$41,203.

The variation in net return per vessel between mainstem and Select Area fisheries, and among years, illustrates the importance of providing a diverse array of fishery opportunities, in case one or two fisheries perform poorly in a given year. Our analyses indicated that mainstem commercial gillnet fisheries, overall, can contribute to the economic stability of commercial fisheries because of the diversity and abundance of salmon stocks that are available for harvest throughout the year, as well as the relatively low costs associated with salmon harvest using gillnets. However, the reduction in the number of mainstem commercial fisheries in recent years diminishes the diversity of fisheries available, and will likely inject increased variability into future economic returns.

Comparative Commercial Gear Analysis

One of the primary assumptions of the Harvest Reform Policy is that alternative gears could replace conventional gillnets in mainstem non-treaty commercial fisheries, while providing additional conservation benefits because they were considered to be “selective” and gillnets were not. This would make alternative gears suitable for mark-selective fisheries, allowing the increased harvest of fin-clipped hatchery salmon, while more safely releasing non-fin-clipped salmon. Furthermore, prior to the adaptive management that the Commission took in March of 2017, alternative gear fisheries in the fall season were originally expected to generate commercial harvests and ex-vessel values equal to a comparable fall gillnet fishery (Tables C4 and C5 of the Management Guidelines, ODFW 2012). To assess the current capability of alternative gears to replace gillnets in mainstem fall commercial fisheries, we conducted a comparative analysis of the fall Zone 4-5 gillnet fishery and the fall seine fishery with respect to a variety of fishery metrics important to the economic performance of a commercial fishery. In addition, we discuss the important concept of “selectivity”—its definition, how it is used in fisheries management, and its application to the Harvest Reform Policy.

Comparison of the Zone 4-5 Gillnet Fishery to Beach and Purse Seine Fisheries in the Fall Season

In our analysis, we used data from the 2014-2017 Zone 4-5 fisheries and 2014-2016 beach and purse seine fisheries. Given that the Cathlamet pound net was operated in a commercial setting in only one year (2018), it is not included in this comparison. Since a previous analysis of fish ticket data from the 2017 Zone 4-5 fishery indicated that the number of unique vessels making a delivery was approximately 90% of the number of deliveries made for a given fishing period (due to multiple deliveries during a period by some vessels; D. Case, ODFW, personal communication), we applied this percentage to the average number of deliveries per fishing day for each year of the Zone 4-5 fishery to estimate the average number of vessels participating in the fishery (see preceding Economics section). Based on information from on-board observation of gillnet/tangle net fisheries, we assumed that most vessels participating in the Zone 4-5 fishery had one fisher onboard. In addition, analysis of data from on-board observation of the 2017 Zone 4-5 fishery indicated that, on average, participating vessels fished for approximately 58% of the 9 or 10 hours allotted for each fishing period (ODFW unpublished data). This percentage was similar in other observation data sets for the fishery; therefore, we applied it to period hours in 2014-2016 to get a more accurate estimate of the actual hours fished by vessels in the Zone 4-5 fishery. Since the 2014-2016 fall seine fisheries were conducted with 100% on-board observation, we used the

observation data to determine the number of participating vessels, the number of days and hours fished, as well as the number of fishers per vessel.

Target Fish Catch and Ex-Vessel Value

Although the Zone 4-5 fishery was a full retention fishery for fall Chinook and Coho, while the seine fishery was mark-selective for hatchery salmon, it is still useful to compare their relative landings and ex-vessel values from the viewpoint of examining their fishery characteristics. As expected, total annual harvest, ex-vessel value, and value per fisher-day in the Zone 4-5 fishery were all far greater than in the seine fisheries (Table 22q). This is partly explained by the low mark rates for Chinook and Coho observed in the seine fishery catch (Tables 11a, 17b, and 17c). Mark selective fisheries are their most efficient in situations with high mark rates and low post-release mortality rates. A low mark rate in a mark-selective commercial fishery limits the harvestable number of captured salmon, ultimately resulting in lower ex-vessel values for the fishery, and higher handle of unmarked fish. The main reason that mark rates are low for fall Chinook is that, in most years, healthy (unmarked) natural-origin URB stocks comprise a substantial portion of the fall Chinook run (ODFW and WDFW 2014-2018a). In addition, mark rates for early stock Coho in August and September are relatively low due to a large proportion of unmarked Coho returning to hatcheries and tributaries above Bonneville Dam. The low mark rates observed for salmon captured in the fall seines contrast with higher mark rates observed in spring mark-selective fisheries, as well as October Coho tangle net fisheries (Table 22r). Adult Chinook and Coho harvest in the 2014-2016 fall seine fisheries was also capped by IFQs and available permits due to the limited number of ESA impacts available to the fishery (Table 17a). Given these constraints, it is unclear what the fishery response would have been to more liberalized regulations, however, most seine fishers did not come close to fulfilling their quotas (Table 17g).

Ex-vessel values in the seine fisheries were also impacted, compared to gillnet fisheries, by differences in the species, size, and stock composition of the catches in the respective gears. These differences in catch composition resulted in a lower value per salmon landed in the seine fishery, compared to the gillnet fishery (Table 22q), and are discussed in detail later in this section.

Table 22q. Salmon harvest, ex-vessel value, value per fisher-day, and value per salmon landed in large-mesh gillnet and seine fall commercial fisheries in the mainstem lower Columbia River, 2014-2016.

Year	Fishery	Days Fished	Fishers ¹	Harvest ²		Total Ex-Vessel Value ³	Value/ Fisher-Day	Value/ Salmon
				Chinook	Coho			
2014	Zone 4-5 Gillnet ⁴	18	70	89,747	6,152	\$2,426,031	\$1,936	\$25
	Purse Seine	21	17	1,457	561	\$33,488	\$94	\$17
	Beach Seine	22	25	1,337	509	\$31,511	\$57	\$17
2015	Zone 4-5 Gillnet	14	83	74,603	597	\$2,441,263	\$2,101	\$32
	Purse Seine	23	14	2,312	529	\$45,698	\$142	\$16
	Beach Seine	6	7	681	58	\$10,951	\$261	\$15
2016	Zone 4-5 Gillnet	13	87	57,940	665	\$2,799,595	\$2,469	\$48
	Purse Seine	21	8	821	565	\$26,033	\$155	\$19
	Beach Seine	6	8	1	39	\$187	\$4	\$5

¹ Average number of fishers participating in Zone 4-5 fishery based on average deliveries per fishing period, adjusted for multiple deliveries during a period by individual vessels. Assumes one fisher per gillnet vessel. Number of fishers participating in seine fisheries based on post-season surveys of permit holders.

² Includes adults and jacks. Does not include 292 unmarked Chinook harvested by purse seines and 1 unmarked Chinook harvested by a beach seine in 2016.

³ Does not include \$7,044 for unmarked Chinook harvested by purse seines and \$23 for an unmarked Chinook harvested by a beach seine in 2016.

⁴ Does not include large-mesh gillnet fishing periods in October to maintain similarity to August-September seine fisheries.

Table 22r. Mark rate of Chinook and Coho in mark-selective lower Columbia River fisheries and test fishing of the Cathlamet pound net, 2014-2017.

	Chinook					Coho			
	Spring Sport	Spring Tangle Net	Fall Beach	Fall Purse	Fall CPN ¹	Fall Beach	Fall Purse	Fall CPN ¹	Fall Tangle Net
2014	70%	77%	45%	33%	--	35%	29%	--	83%
2015	79%	74%	66%	37%	--	33%	46%	--	67%
2016	77%	79%	50%	29%	56%	89%	62%	73%	--
2017	91%	--	--	--	48%	--	--	52%	--
Avg	79%	77%	54%	33%	52%	52%	46%	63%	75%

¹ Based on test fishing.

We also examined catch rates for the Zone 4-5 fishery and the fall seine fisheries in a variety of ways, including adult Chinook per unit effort (standardized to a fisher-hour for all gears), adult salmon per unit effort, and harvestable pounds of salmon per unit effort. By any measure, the Zone 4-5 gillnet fishery had the highest catch rate in every year, with all three gears operated in 2016 (Figures 22i, 22j, and 22k). From an economic standpoint, the catch rate in terms of harvestable pounds of salmon is one of the more important metrics since a commercial fisher is paid for the pounds landed (although price per pound can vary considerably among species/stocks). Like total harvest and ex-vessel value, catch rates for the seine fisheries were adversely affected by low mark rates and the composition of the catches.

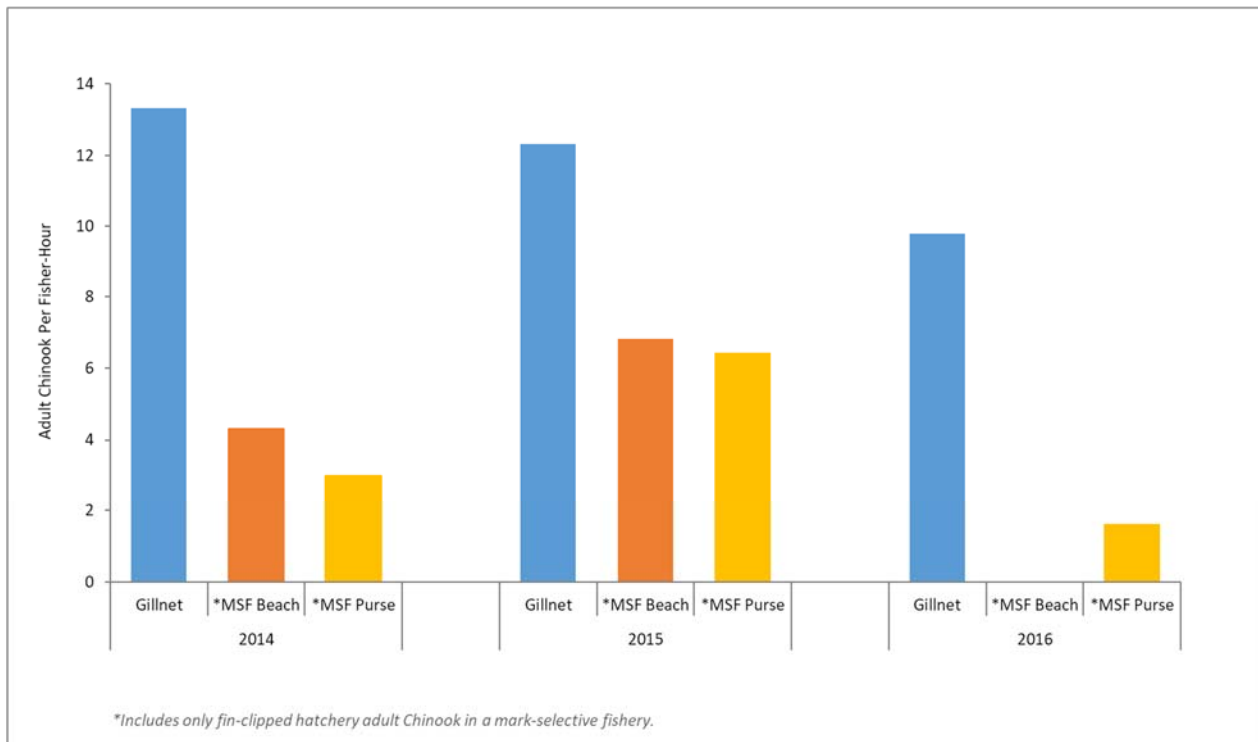


Figure 22i. Catch rates of harvestable adult Chinook in the 2014-2016 Zone 4-5 gillnet (non-MSF) and fall seine (MSF) fisheries.

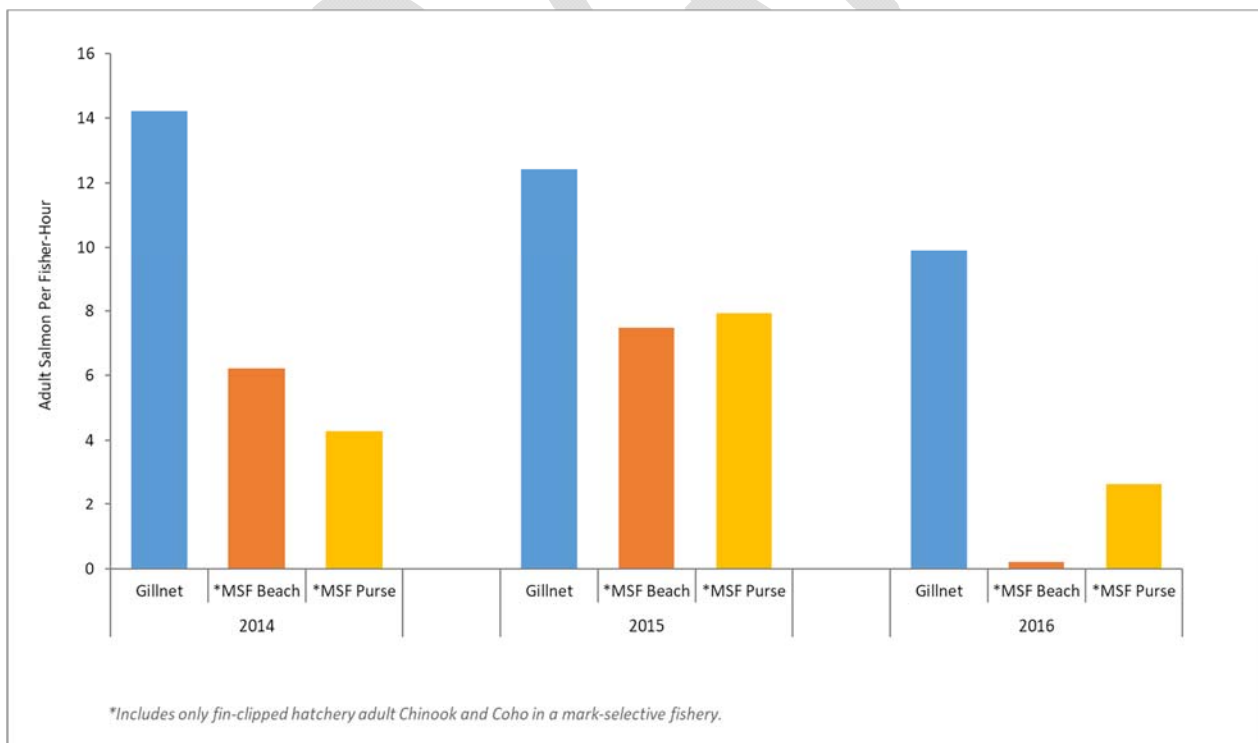


Figure 22j. Catch rates of harvestable adult salmon in the 2014-2016 Zone 4-5 gillnet (non-MSF) and fall seine (MSF) fisheries.

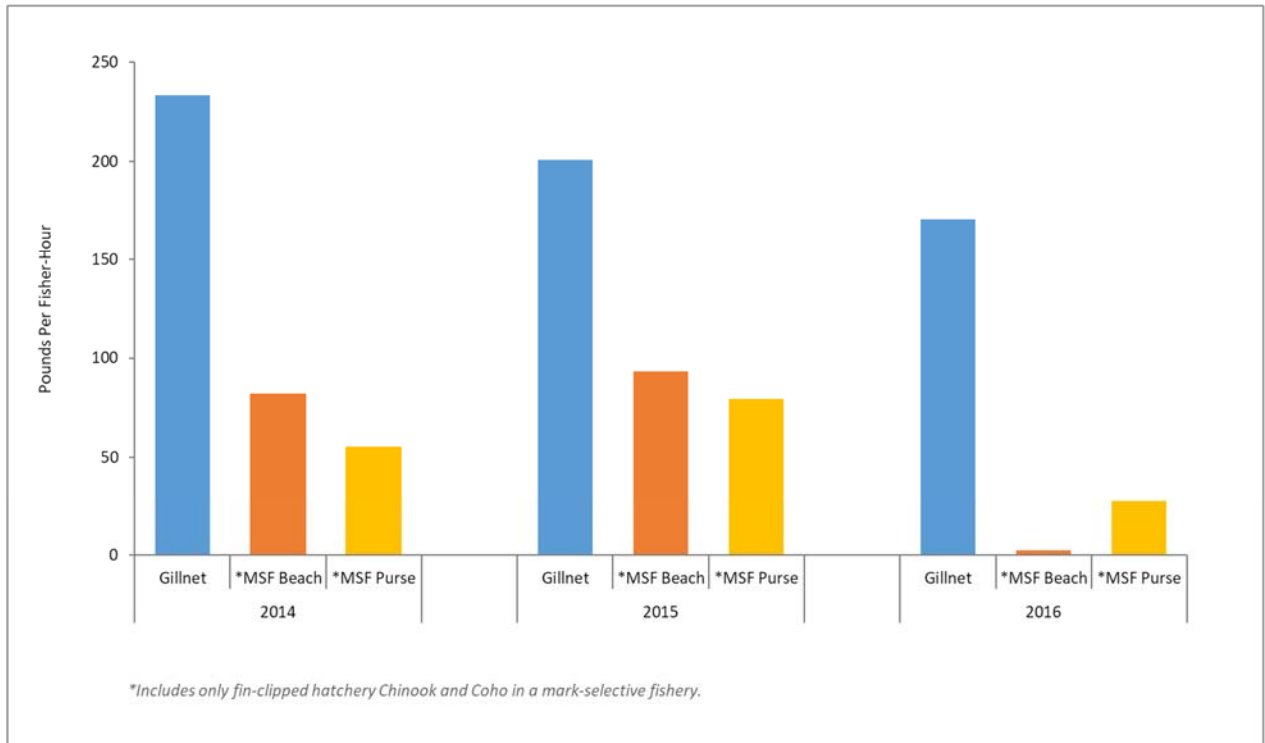


Figure 22k. Harvestable pounds of salmon per unit effort in the 2014-2016 Zone 4-5 gillnet (non-MSF) and fall seine (MSF) fisheries.

Catch Composition

Not all salmonids caught in a commercial fishery have equal economic value, and sometimes they have no commercial value when harvest is prohibited, as is the case with Chum or steelhead in Columbia River non-treaty commercial fisheries. As previously mentioned, the ex-vessel values of the fall seine fishery were much lower than in the Zone 4-5 gillnet fishery, partly because of differences in the catch composition of the gears. Figure 22l shows that, while Chinook were the predominant salmonid species caught in large-mesh gillnets (≥ 9 -inch or ≥ 8 -inch, depending on season) used in the Zone 4-5 fishery, Coho and steelhead comprised a significant percentage of the seine catches. The species composition of the catch is an important determinant of economic value in a fall commercial fishery because Chinook (tules and brights combined) garner a higher price per pound compared to Coho, especially in recent years, and they are also much larger fish. As a result, the ex-vessel value per fish can be 2-3 times higher for Chinook than Coho (Table 22s).

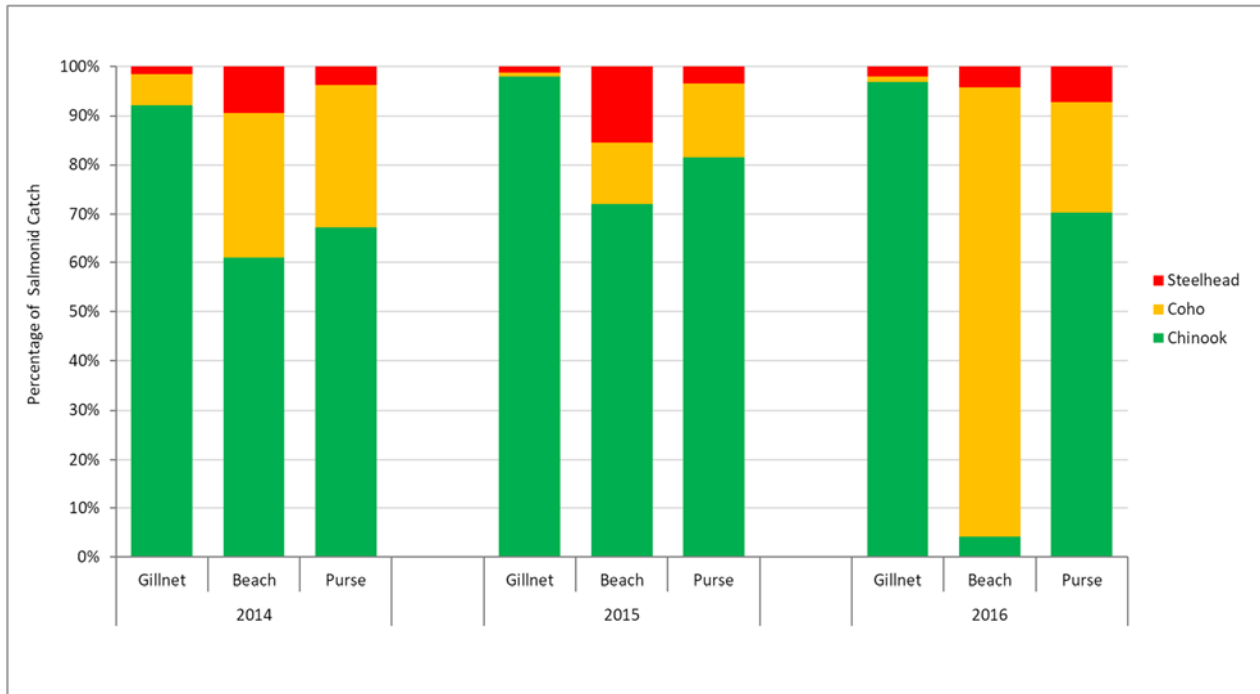


Figure 221. Species composition of the salmonid catch in the 2014-2016 Zone 4-5 gillnet and fall seine fisheries.

On average, steelhead comprised about 2% of the gillnet catch in the Zone 4-5 fishery, and 7% of the beach and purse seine catches. Therefore, in addition to having a high proportion of fish with reduced values, a substantial portion of the catch in seines consisted of salmonids with no economic value. The high handle of steelhead in seines also has important ramifications in terms of the capability of these gears to use limited natural-origin B-index summer steelhead impacts in the most effective and efficient manner for the prosecution of fall commercial fisheries.

Table 22s. Average weight, dockside price-per-pound, and value per fish in the 2014-2016 Zone 4-5 gillnet and fall seine fisheries.

Year	Fishery	Chinook ¹			Coho		
		Avg Wt	\$/lb	\$/Fish	Avg Wt	\$/lb	\$/Fish
2014	Zone 4-5 Gillnet	16.8	\$1.57	\$26	8.5	\$1.13	\$10
	Purse Seine	13.5	\$1.47	\$20	7.7	\$1.09	\$8
	Beach Seine	13.1	\$1.52	\$20	7.8	\$1.22	\$10
2015	Zone 4-5 Gillnet	16.1	\$2.03	\$33	6.5	\$1.55	\$10
	Purse Seine	10.4	\$1.71	\$18	5.7	\$1.52	\$9
	Beach Seine	10.9	\$1.39	\$15	6.8	\$1.50	\$10
2016	Zone 4-5 Gillnet	17.1	\$2.81	\$48	8.0	\$1.89	\$15
	Purse Seine	10.6	\$2.28	\$24	6.3	\$1.74	\$11
	Beach Seine	8.0	\$2.81	\$23	3.6	\$1.18	\$4

¹ Average weight and dockside price-per-pound for bright and tule Chinook combined.

In addition to disparities in the species composition of the catch for the Zone 4-5 and fall seine fisheries, there were also significant differences in the percentage of jacks in the catch (Figure 22m). The percentage of jacks was consistently very low in the gillnet fishery, averaging 1% between 2014 and 2016. In contrast, the percentage of jacks in the beach and purse seine catches was much higher, ranging from 5% to 68%, with an average of 20%. Nearshore gears such as the beach seine may have a greater probability of capturing and retaining jacks. Possible reasons for this include jacks travelling closer to shore than adults and/or higher in the water column (less likely than adults to escape under the net). Economically, the percentage of jacks in the harvestable catch is important because jacks are much smaller than adults, and provide little contribution to the total pounds landed. Also, a commercial fisher usually receives a lower price-per-pound for jacks because they are not as marketable as adults (D. Case, ODFW, personal communication). Therefore, if a fisher catches a lot of jacks, both the value per fish and the total value of the landings would be much lower than for a fisher who catches mostly adult salmon. In addition, some fish buyers may not purchase jacks, or limit the number they buy, due to the reduced marketability of the product.

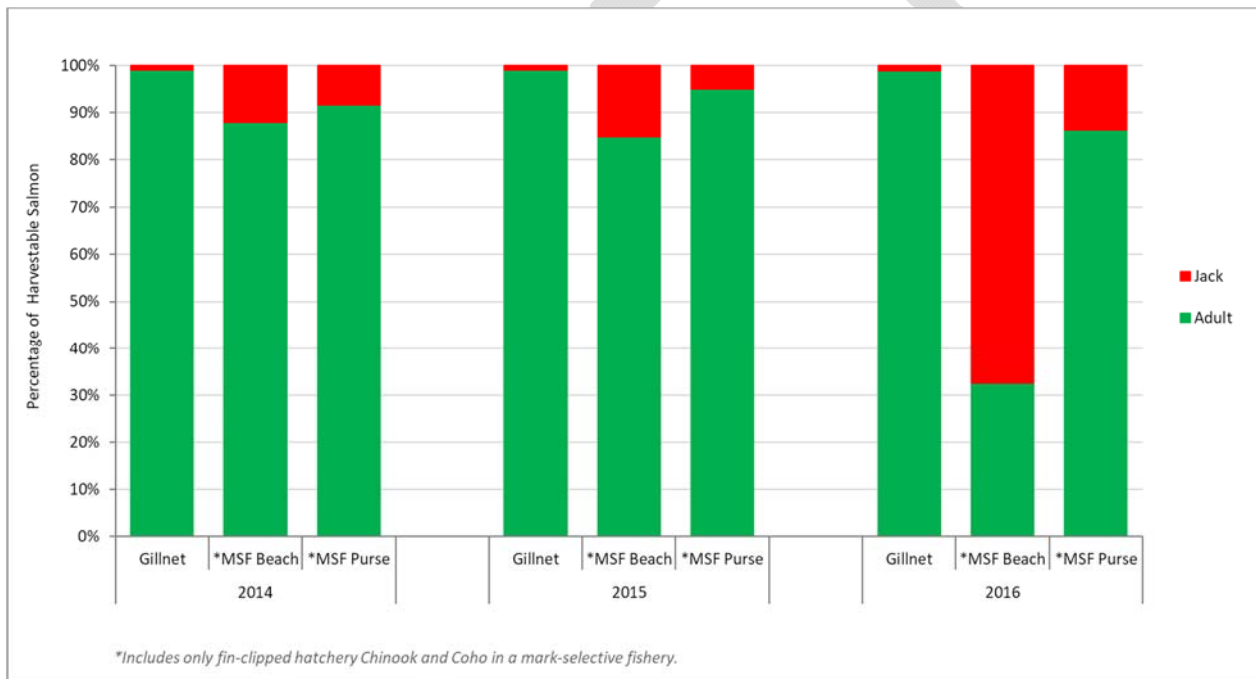


Figure 22m. Adult-jack percentages in the harvestable salmon catch in the 2014-2016 Zone 4-5 gillnet (non-MSF) and fall seine (MSF) fisheries.

The stock composition of the Chinook catch can also affect the ex-vessel value of a fall commercial fishery. Fishers receive a much lower price per pound for “tule” Chinook compared to “bright” Chinook due to the inferior market quality of the former. During 2014-2017, the average price per pound for brights was about five times higher than tules (Table 22t). Therefore, a fishery harvesting the same number of Chinook as another fishery, but with a higher proportion of tules, would realize a lower ex-vessel value. Table 22u shows the percentage of landed pounds of Chinook graded as “bright” and “tule” by fish buyers during the 2014-2016 Zone 4-5 gillnet and fall seine fisheries. On average, the percentage of landed pounds graded as tule was lowest in the gillnet fishery, followed by the purse seine and beach seine fisheries. The percentages are not

directly comparable between the gillnet and seine fisheries because the gillnet fishery took place in Zones 4-5 where tule Chinook are less frequently encountered, while the seine fisheries occurred in Zones 1-5. Nevertheless, beach seine-caught Chinook were more likely to be graded as tules than purse seine-caught Chinook, which appears to substantiate patterns observed for these gear types (see Fall Beach Seine, Fall Purse Seine, and Fall Seine Fishery sections).

Table 22t. Average dockside price per pound received by commercial fishers for “bright” and “tule” fall Chinook in the Zone 4-5 gillnet fishery, 2014-2017.

	Bright	Tule
2014	\$1.79	\$0.55
2015	\$2.41	\$0.50
2016	\$3.25	\$0.63
2017	\$3.24	\$0.59
Avg	\$2.67	\$0.57

Table 22u. Percentage of landed pounds of fall Chinook graded as “bright” or “tule” by fish buyers during the 2014-2016 Zone 4-5 and fall seine fisheries.

Year	Fishery	Bright	Tule
2014	Zone 4-5 Gillnet	79%	21%
	Beach Seine	63%	37%
	Purse Seine	66%	34%
2015	Zone 4-5 Gillnet	79%	21%
	Beach Seine	38%	62%
	Purse Seine	75%	25%
2016	Zone 4-5 Gillnet	93%	7%
	Beach Seine ¹	100%	0%
	Purse Seine	93%	7%
Average	Zone 4-5 Gillnet	83%	17%
	Beach Seine	67%	33%
	Purse Seine	78%	22%

¹ Only two Chinook were landed in the 2016 beach seine fishery.

Non-Target Catch

The principle species of interest with respect to non-target catch in fall commercial fisheries is steelhead, especially since low returns of ESA-listed natural-origin B-index summer steelhead in recent years have placed constraints on these fisheries. ESA-listed natural-origin A-index steelhead have not been a primary constraint in recent years, but impacts to this stock also have the potential to constrain fisheries. We examined two measures of steelhead encounter rate in the Zone 4-5 and fall seine fisheries: the steelhead catch rate (steelhead/fisher-hour) and the ratio of steelhead to harvestable adult Chinook. Steelhead catch rates were lowest in the Zone 4-5 gillnet fishery in all years (Figure 22n). Although the steelhead catch rate was very low for the beach seine fishery in 2016, fishing effort was extremely limited that year, excluding it from comparison in 2016. Overall, steelhead catch rates were higher for the beach seine, a nearshore gear, which

is consistent with data from previous testing of various alternative gears (see Alternative Gear Feasibility Evaluations). Steelhead tend to travel in shallower water than Chinook, and gears that are set close to shore appear to have a higher likelihood of encountering them.

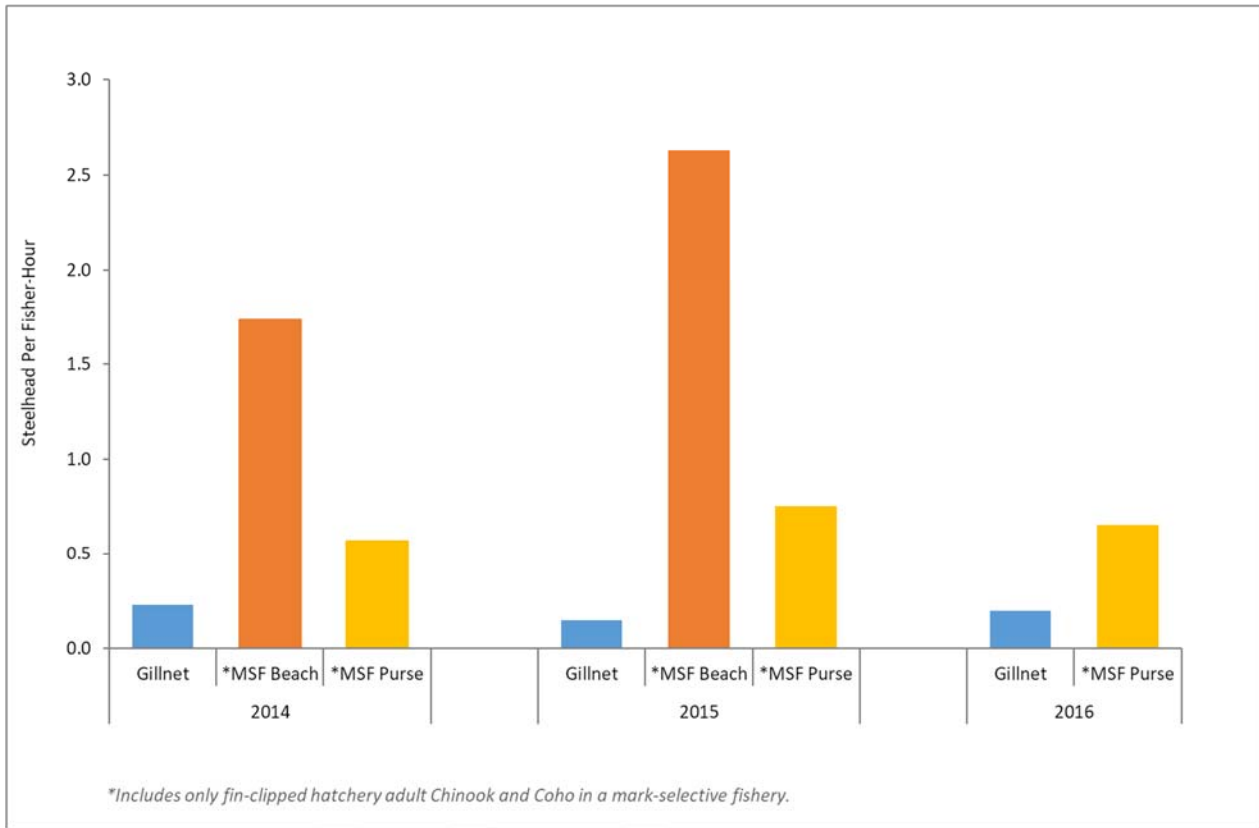


Figure 22n. Steelhead handled per fisher-hour in the 2014-2016 Zone 4-5 gillnet and fall seine fisheries (excluding 2016 beach seine).

The ratio of steelhead to harvestable adult Chinook in a gear’s catch is another measure of encounter rate that puts the gear’s handle of steelhead into context in terms of the catch of the primary target fish. The Zone 4-5 gillnet fishery consistently had the lowest steelhead to Chinook ratio from 2014 through 2016 (Figure 22o). For the number of harvestable adult Chinook that they captured, beach and purse seines handled a high number of steelhead.

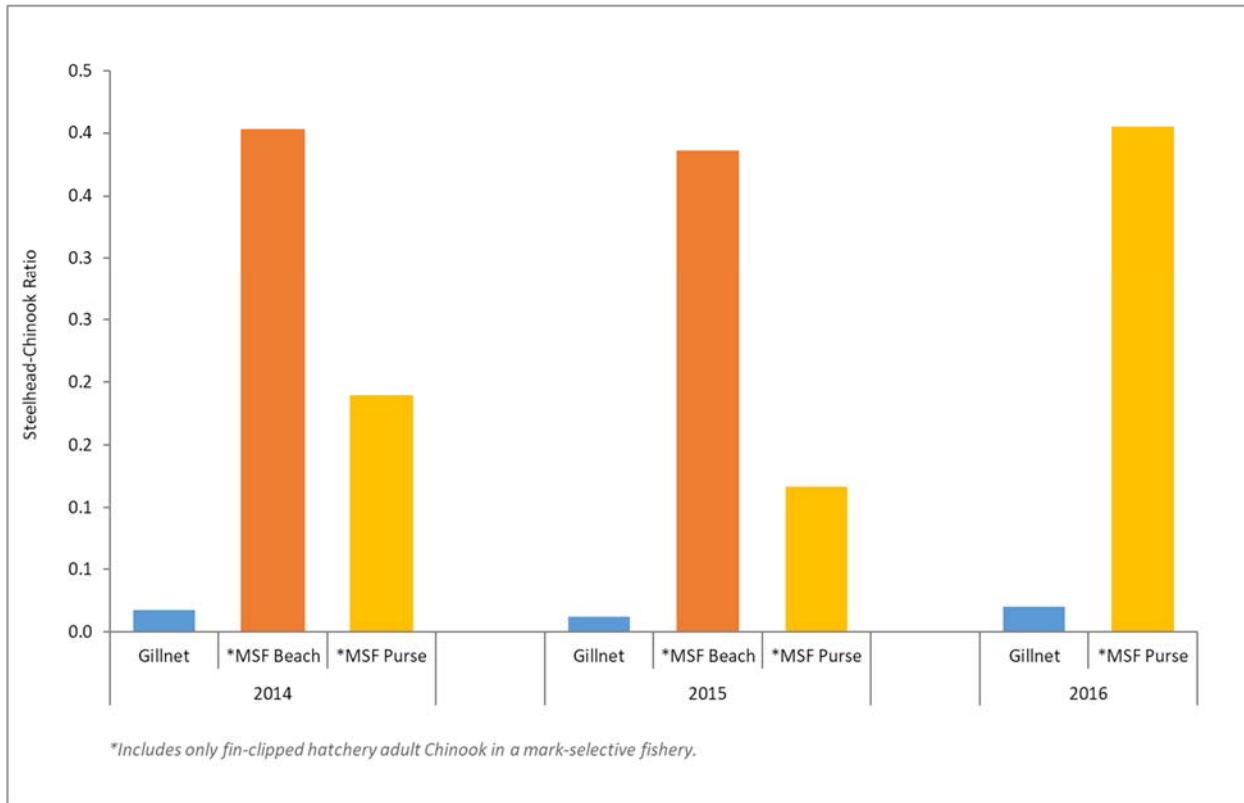


Figure 22o. Ratio of steelhead to harvestable adult Chinook in the 2014-2016 Zone 4-5 gillnet (non-MSF) and fall seine (MSF) fisheries (excluding 2016 beach seine).

Summary

From the position of impacts on ESA-listed natural-origin B-Index steelhead, the high encounter rates of steelhead in fall beach and purse seines are a concern. As might be expected, steelhead encounter rates were highest for beach seines, which fish close to shore where steelhead tend to travel. During the first few years of the post-Harvest Reform period, the primary constraint on fall commercial fisheries was the allowable ESA impacts for LCR tule Chinook. However, in 2017, a very low steelhead return severely constrained the fall commercial fishery, and no fall seine fishery was implemented because steelhead to harvestable adult Chinook ratios for the fishery in 2014-2016 suggested that an economically meaningful seine fishery would not be possible in 2017. It is likely that future fall commercial fisheries in the mainstem Columbia River will face similar challenges with regard to impacts for ESA-listed steelhead stocks. Therefore, the alternative gears under consideration for potential full-scale fisheries implementation should also be considered on their capability to use the limited steelhead impacts in a manner that optimizes economic value when compared to the current Zone 4-5 gillnet fishery.

Our analysis of landings, ex-vessel value, value per fisher-day, and value per salmon landed for the Zone 4-5 gillnet and fall seine fisheries indicated that mark-selective commercial fisheries using alternative gears would not be able to replace the harvest and economic value generated by mainstem gillnet fisheries during the fall season. Mark rates, which are important for any mark-selective fishery, were too low for fall Chinook, and Coho in August and September, to allow

enough fish to be harvested. Fall Chinook mark rates are also a double-edged sword in a mark-selective fishery because low mark rates reduce the proportion of the Chinook catch that can be harvested, but high mark rates indicate that the catch probably consists of a high proportion of low value tute Chinook. Especially disadvantageous for fall mark-selective fisheries, from an economic standpoint, is the inability to harvest usually abundant and high value unmarked URB fall Chinook. Several participants in the 2014-2016 fall seine fisheries believed that harvesting unmarked URBs was the only way for the seine fishery to become economically viable (see Fall Seine Fishery section in Alternative Gear Fisheries Implementation). However, due to the species and stock composition of their catches, using alternative gears in full retention commercial fisheries in the fall season could have negative consequences in terms of impacts to ESA-listed stocks. These specific issues will be discussed later in this section.

The catch composition of the fall seines was an important reason why ex-vessel values were low. While a very high percentage of salmonids caught in the Zone 4-5 gillnet fishery were higher value Chinook, much of the catch in the seine fisheries consisted of lower value Coho, and steelhead, which have no commercial value. Of the Chinook that were captured in seines, a higher proportion appeared to be low value tules, particularly for beach seines, compared to the gillnet fishery. Finally, almost all of the salmon catch in the gillnet fishery was comprised of adults, but a significant proportion of the catch in the seine fishery consisted of low value jacks.

Selectivity in Fisheries Management

Within the context of managing various commercial and recreational fisheries, the concept of “selectivity” can have different meanings to different interest groups, fisheries managers, and policy makers. Without a common definition, it is difficult to compare the selectivity of different fishing gears. In the late 1990s, Fisheries and Oceans Canada (DFO), recognizing the need for not just salmon fisheries, but all Pacific fisheries, to be conducted in a selective manner to maximize the harvest of target species/stocks, while reducing impacts on non-target species/stocks, defined selective fishing as “the ability to avoid known, non-target species and stocks or, if encountered, to release them alive and unharmed” (DFO 1999). This definition of selectivity recognizes that there are multiple ways to reduce impacts on non-target species and stocks while conducting fisheries.

The idea of avoiding non-target species/stocks in mixed stock fisheries has been used in the management of both commercial and recreational fisheries in the Columbia River for decades. Time, area, and/or gear (TAG) regulations are generally the first tool fishery managers use in recreational and commercial fisheries to optimize the harvest of target fish. For instance, fishery seasons can be crafted around the main migration period of the species/stock to be avoided, or the fishery may be restricted to an area where encounters with the stock are infrequent, or gear that targets certain sized fish may be mandated. Table 22v lists examples of past and current TAG-selective fisheries in the lower Columbia River.

Table 22v. TAG-selective fisheries in the lower Columbia River.

Regulations/Management Action Taken	
Commercial	<ul style="list-style-type: none"> - Off-channel (Select Area) fisheries established to avoid encounters with ESA-listed stocks in the mainstem Columbia. - Select Area fishery closures during peak upriver spring Chinook migration period (most of April). - Mesh size in summer mainstem gillnet fishery restricted to \geq 8-inch to avoid steelhead and Sockeye. - Fall mainstem gillnet fishery restricted to Zones 4-5 to avoid ESA-listed LCR tule Chinook during main migration period. Mesh size restricted to \geq 9-inch or \geq 8-inch, depending on season, to avoid steelhead.
Recreational	<ul style="list-style-type: none"> - In 1990s, spring recreational fishery restricted to downstream of I-5 Bridge, and fishery closed after March 31, to avoid encounters with ESA-listed upriver spring Chinook during main migration period. - Spring recreational fishery restricted to upstream of Hayden Island Powerlines after April 4, 2008 due to weak return of Willamette spring Chinook. - Fall mainstem recreational fishery closed to Chinook retention below Lewis River starting in mid-September to avoid encountering ESA-listed LCR tule Chinook. - Delayed opening of summer steelhead season in some years to avoid encounters with upriver spring Chinook

While TAG methods can be useful in avoiding a species or stock, avoidance of wild and hatchery components of the same species and/or stock requires a different approach. Implementation of mark-selective fisheries began decades ago in the Northwest with recreational steelhead fisheries, and the use of this tool in managing seasons has expanded over time. Mark-selective fisheries are based on the premise that gears with relatively low release mortality rates can be used to harvest abundant fin-clipped hatchery fish, while releasing non-fin-clipped fish with minimal mortalities. An important assumption of mark-selective fisheries is that mark rates of target fish are high enough to produce economically viable harvest in commercial fisheries, as well as kept fish catch rates sufficient to preserve angler satisfaction in recreational fisheries (Hoffmann and Pattillo 2008). Several recreational fisheries in the mainstem Columbia have been managed as mark-selective for many years, while commercial mark-selective fisheries began in the early 2000s with the use of small-mesh tangle nets for spring Chinook, and later included mark-selective fisheries targeting fall Chinook and Coho with seines and tangle nets, respectively (Table 22w). It should be noted that neither TAG-selective nor mark-selective fisheries are perfectly selective, in that not all non-target fish can be avoided in TAG-selective fisheries, and not all fish released from mark-selective fisheries survive.

Table 22w. Mark-selective fisheries in the lower Columbia River.

Mark Selective Fishery	
Commercial	- Spring tangle net - Coho tangle net - Fall beach and purse seine
Recreational	- Spring Chinook - Summer Chinook (usually) - Steelhead - Coho - Fall Chinook (as needed to achieve season objectives)

Because different gear types can use various forms of selectivity to accomplish the same fishery objective of maximizing the harvest (and value) of target fish while minimizing mortalities of non-target fish, it is useful to compare the economic value generated per ESA impact/mortality for several commercial gears. We analyzed the Zone 4-5 gillnet fishery and fall seine fishery in terms of ex-vessel value produced per natural-origin B-Index steelhead mortality since this stock is the most likely to constrain fall mainstem Chinook-directed commercial fisheries. The 2016 beach seine fishery was very limited and did not have any natural-origin B-Index steelhead mortalities; therefore, no ratio could be calculated and it was not included in that year's comparison. The gillnet fishery consistently produced a much higher ex-vessel value for each natural-origin B-Index steelhead mortality during 2014-2016, compared to the seines (Figure 22p). Furthermore, the Zone 4-5 fishery accomplished this while remaining within its allotted ESA impacts for steelhead, due to the management of the fishery using TAG regulations.

Another way to examine the relative efficiency of the alternative gears in terms of their use of steelhead impacts is to determine the number of steelhead mortalities that would occur if the gears were fished to the point of reaching the highest observed economic value in each year, which in this case, would be the ex-vessel value for the Zone 4-5 gillnet fishery. Therefore, based on the ex-vessel value per natural-origin B-Index steelhead mortality data illustrated in Figure 22p, we calculated the number of natural-origin B-Index steelhead mortalities that would accrue to each gear, in each year, when the value of the fishery equaled that of the gillnet fishery. Table 22x shows that if the alternative gears were fished to the point where their fishery ex-vessel values were the same as the gillnet fishery, they would accrue far more natural-origin B-Index steelhead mortalities than the gillnet fishery, using currently assumed release mortality rates.

These comparisons highlight the lower efficiency of the alternative gears in terms of their capability to maximize the harvest/value of target fish while minimizing impacts to non-target fish such as steelhead. It also underscores the importance of both variables in the mortality equation: mortality rate and non-target fish handle. Gears with potentially lower mortality rates for steelhead, such as the fall seines, can still have a significant impact on ESA-listed steelhead because their handle of these fish is high.

As discussed earlier, much of the low ex-vessel value of the alternative gear fisheries was due to the composition of their catches, which consisted of lower proportions of high-value target fish compared to the gillnet catch. To equal the value of the gillnet fishery, the mark-selective alternative gear fisheries would have had to fish for much longer, with a substantial increase in the

handle of steelhead. In reality, the alternative gear fisheries would have been closed long before their accrued steelhead mortalities reached the levels shown in Table 22x. Assuming they were not constrained by other stocks such as LCR or SRW Chinook, the fisheries would have ended upon reaching their impact limit for natural-origin B-Index steelhead. As a result, they would not have been able to equal the ex-vessel value of the Zone 4-5 gillnet fishery.

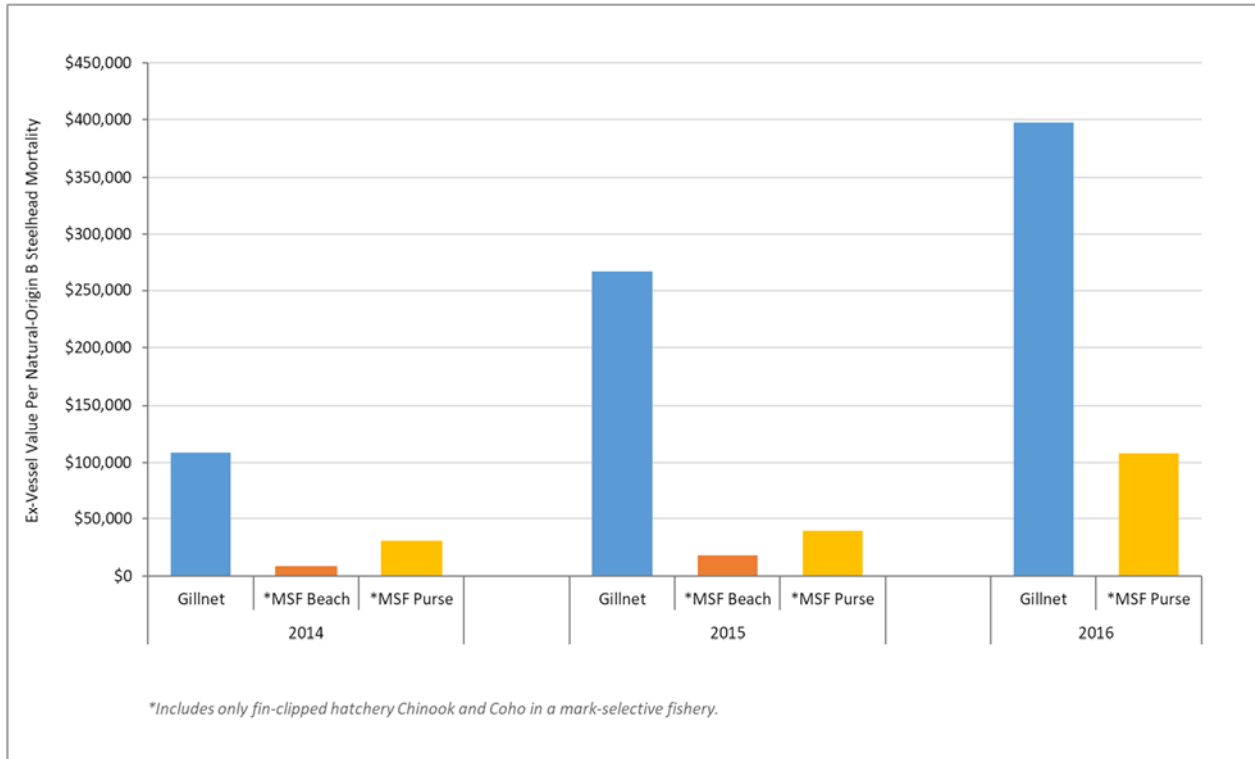


Figure 22p. Ex-vessel value per natural-origin B-Index steelhead mortality in the 2014-2016 Zone 4-5 gillnet (non-MSF) and fall seine (MSF) fisheries (excludes 2016 beach seine). Steelhead mortalities were calculated using gear-specific release mortality rates available as of the date of this report.

Table 22x. Number of natural-origin B-Index steelhead mortalities accrued by each seine fishery if all ex-vessel values were equal to that of the Zone 4-5 gillnet fishery, 2014-2016.

	2014	2015	2016
Zone 4-5 Gillnet	22.3	9.2	7.0
Beach Seine	292.6	133.8	N/C ¹
Purse Seine	79.7	62.0	26.0

¹ Not calculated due to extremely small sample size.

As previously mentioned, some participants in the 2014-2016 fall seine fisheries advocated for the retention of high-value, and usually abundant, unmarked URB Chinook to help increase the ex-vessel value of the seine fishery. However, a full retention seine fishery downstream of the Lewis River would be problematic because seines tend to capture a higher proportion of Coho and tule Chinook (Figure 22i and Table 22u), which would lead to higher impacts on ESA-listed LCN Coho and LCR Chinook and much reduced fishing opportunity as a result. A partial mark-selective

seine fishery that allowed the retention of unmarked bright Chinook, but required the release of unmarked tule Chinook might provide another alternative, however, because of the inability of commercial seine fishers to accurately identify tule Chinook using visual characteristics this option is very uncertain (see Fall Seine Fishery section), . The only remaining option to allow the harvest of unmarked bright Chinook, while minimizing impacts to LCR Chinook and LCN Coho, would be a non-MSF seine fishery in Zones 4-5, where encounters with LCR tule and LCN coho are less frequent. While we examined this approach, it is inconsistent with efforts to date to increase the use of mark-selective approaches in the commercial fishery.

We compared the ex-vessel value per mortality (using both unmarked B-Index steelhead and LCR Chinook) for a hypothetical non-mark-selective seine fishery in Zones 4-5 to the Zone 4-5 gillnet fishery . This scenario, which should greatly increase the economic potential for the seine fishery by adding in valuable unmarked URB catch with low LCN tule impacts, would allow us to assess whether this type of alternative gear could replace the economic value of the existing Zone 4-5 gillnet fishery, given the ESA impacts allocated to the commercial fishery. We used data for the fisheries from 2014 and 2015, and only included beach and purse seine data from Zones 4 and 5 (no seine fishery in Zone 4 or 5 in 2016). Because seine fishery data for Zone 5 were limited, we supplemented it with seine test fishing data from the 2015 Zone 5 Fall Chinook Stock Composition Study (see Alternative Gear Post-Release Mortality Evaluations). We also weighted the seine data by zone, according to the typical distribution of effort and catch in the Zone 4-5 fishery, to reduce any biases in the data with respect to the catch of steelhead and LCR tule Chinook. Our analysis was restricted to the harvest and ex-vessel value of adult Chinook since that is the primary target fish in a Zone 4-5 commercial fishery. Since unmarked adult Chinook released in the 2014-2015 mark-selective seine fisheries were incorporated into the kept catch of the hypothetical full retention seine fishery, and these unmarked Chinook would have likely consisted of a higher proportion of brights (due to a much lower mark rate than tules), we adjusted the value of seine-caught Chinook upward to account for this.

Figure 22q shows that the average adult Chinook ex-vessel value per unmarked B-Index steelhead mortality in the Zone 4-5 gillnet fishery was 65% higher than in a non-mark-selective Zone 4-5 purse seine fishery, and over 1,000% higher than in a comparable beach seine fishery. In addition, the average ex-vessel value produced per LCR Chinook mortality in the gillnet fishery was 48% higher than in the purse seine fishery, and 121% higher than in the beach seine fishery.

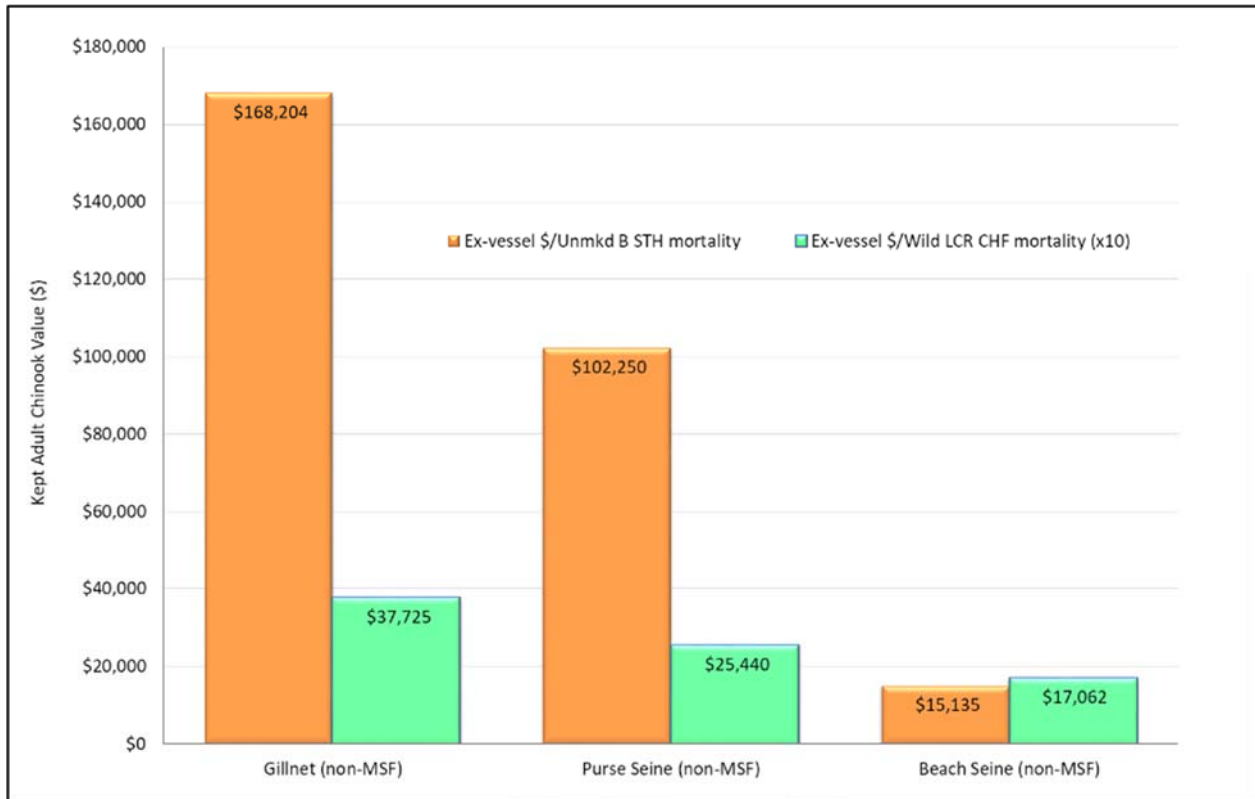


Figure 22q. Comparison of kept adult Chinook ex-vessel value per unmarked B-Index steelhead and LCR Chinook mortality for gillnet, purse seine, and beach seine gear types in a non-mark-selective Zone 4-5 commercial fishery. The ex-vessel value per LCR Chinook mortality for each fishery was multiplied by 10 so that values for both stocks could be displayed on the same scale. Steelhead mortalities were calculated using gear-specific release mortality rates available as of the date of this report.

HARVEST REFORM POLICY EFFECTS ON COMMERCIAL FISHERY ECONOMICS

Preceding development of the Harvest Reform Policy, ODFW staff modelled the expected harvest and ex-vessel value of Chinook and Coho salmon for each lower Columbia River mainstem and Select Area commercial fishery or stock to inform the expected outcome of policy actions and allocation shifts. These results were presented in Tables C4 and C5 of Appendix C within “Management Strategies for Columbia River Recreational and Commercial Fisheries 2013 and Beyond” (ODFW 2012). In these tables, “current” fishery landings (C4) and ex-vessel values (C5) for each fishery and species were calculated based on recent-year average harvest for mainstem fisheries, and average releases and harvest rates for Select Area fisheries. Out-year projections were developed based on the “presumptive path” for each fishery moving forward through the Transition (2013-2016) and Long-Term (2017-2021) periods, as outlined in the Management Strategies. For mainstem fisheries, out-year projections declined concurrent with planned commercial allocation reductions, while Select Area values generally increased with planned production increases. The combined annual commercial ex-vessel values were compared to the “current” ex-vessel value to describe how the commercial fishery value would be affected by Policy changes. Although based on recent-year average run sizes, fishery performance, and proposed reductions to commercial allocations, the out-year estimates were not intended to predict actual annual fishery performance since salmon returns, average weights, and dockside values vary annually. Rather, the process was intended to provide a relative analysis to describe the change from different policy choices under consideration by the Commissions. The annual predicted percentage difference in ex-vessel values were presented in Table C5: +6% in 2013, +7% in 2014, +9% in 2015, +19% in 2016, +5% in 2017, +10% in 2018, +11% in 2019, +12% in 2020, and +12% in 2021.

The values presented in Tables C4 and C5 also did not include non-target catch and values (Coho in Chinook-directed fisheries and Chinook in Coho fisheries) in mainstem fisheries, and non-Select Area origin catch and value in Select Area fisheries. In addition, the 2014 seine fisheries were prosecuted on research ESA impacts, which wasn’t anticipated in Harvest Reform modelling. Since the value of this combined additional catch averaged approximately \$241,691 (range \$152,400-\$306,400) during 2013-2018, actual ex-vessel values need to be standardized to include only target stocks landed in each fishery, if actual landings and values are compared with those provided in Tables C4 and C5. Considering these caveats, a comparison of assumed and adjusted actual harvest estimates for 2013-2018 are provided in Table 23a.

The average mainstem harvest of spring Chinook during 2013-2018 exceeded original policy expectations (128%) even though the average run size was 81% of the assumed return. This was partially due to use of unused recreational impacts per policy in 2015 and 2016, which provided additional spring Chinook for commercial harvest. Average harvest of summer Chinook also exceeded expectations (141%), but the average run size was larger than assumed (111%), and additional commercial harvest was provided using unused recreational impacts in 2016 per policy. For fall Chinook gillnet fisheries, the average harvest was 215% of expectations, but the run size averaged 180% of the modeled run sizes, which explains the significantly larger than expected catches.

Table 23a. Expected and actual non-treaty commercial harvest of Chinook and Coho, 2013-2018.

	Gear	Stock	Reform Assumptions (Table C4) ^a							Adjusted Actual Harvest ^{bc}							Actual/ Assumed Harvest	Actual/ Assumed Run
			2013	2014	2015	2016	2017 ^d	2018	Avg	2013	2014	2015	2016	2017	2018	Avg		
Mainstem	Tangle/Gill net	Spring Chinook ^e	3,739	2,714	2,714	2,714	0	0	1,980	1,915	3,514	6,460	3,315	0	0	2,534	128%	81%
	Gillnet	Summer Chinook ^f	2,548	2,264	1,698	1,698	0	0	1,368	1,868	2,743	3,944	2,990	0	0	1,924	141%	111%
	Gillnet (Zone 4-5/2S)	Fall Chinook	40,504	40,504	40,504	36,650	0	0	26,360	82,475	94,962	77,069	57,940	19,398	8,320	56,694	215%	180%
	Gillnet	Coho	22,099	22,099	22,099	21,375	0	0	14,612	1,952	43,867	2,242	0	0	380	8,074	55%	100%
	TBD (Zone 4-5/2S)	Fall Chinook	0	0	0	0	36,650	36,650	12,217	0	0	0	0	0	0	0	0%	180%
	Purse/Beach Seine	Fall Chinook	11,194	11,194	11,194	27,441	27,441	27,441	19,318	0	2,439	2,763	728	0	0	988	5%	180%
	Purse/Beach Seine	Coho	6,010	6,010	6,010	14,374	14,374	14,374	10,192	0	1,031	564	482	0	0	346	3%	100%
	Tangle-net	Coho	20,160	20,160	20,160	20,160	20,160	20,160	20,160	3,441	16,321	820	0	0	0	3,430	17%	100%
Select Area	Gillnet	Spring Chinook	6,234	6,250	8,805	9,951	10,000	10,000	8,540	5,042	2,164	11,055	8,605	15,210	9,987	8,677	102%	na
	Gillnet	Fall Chinook	18,528	18,528	19,173	19,953	20,028	20,028	19,373	24,142	24,117	18,087	12,431	12,034	6,699	16,252	84%	na
	Gillnet	Coho	58,380	69,580	69,580	69,580	69,580	83,580	70,047	40,344	160,696	26,132	33,115	36,221	11,606	51,352	73%	na
Total			106,254	104,945	104,379	124,412	98,625	98,625	106,207	91,651	164,877	93,862	65,455	19,398	8,700	73,991	70%	128%
^a Adults only																		
^b Values for summer Chinook, gillnet fall Chinook, and gillnet Coho include jacks, so values inflated when compared to Table C4 which only included adults																		
^c Actual landings adjusted to match assumptions used in Table C4. For mainstem fisheries, does not include Chinook landed in Coho-directed fisheries or Coho in Chinook-directed fisheries. For Select Area fisheries, does not include non-Select Area origin spring Chinook and Coho.																		
^d Some mainstem non-treaty commercial harvest projections were re-calculated in 2017 based on new assumptions and/or allocations which replaced expectations originally presented in Table C4. However, due to non-concurrence between some elements of the OR/WA policies, it is difficult to present revised expectations, so original expectations from Table C4 are presented here.																		
^e In 2015 and 2016, unused allocation was transferred from sport to commercial fisheries once sport objectives were projected to be met, resulting in additional spring Chinook harvest																		
^f In 2016, unused allocation was transferred from sport to commercial fisheries once sport objectives were projected to be met, resulting in additional summer Chinook harvest																		

Coho landings for gillnet and tangle net fisheries both fell short of expectations (55% and 17%, respectively) even though the average run size matched the assumed return. Average harvest of Chinook and Coho in seine fisheries were 5% and 3% of expectations, likely resulting from multiple factors, including lack of full implementation, low mark rates, inexperience with the gear for some fishers, IFQs, and unanticipated high steelhead handle. The combined Chinook and Coho harvest in 2013-2017 mainstem commercial fisheries averaged 73,991 fish, or 70% of the expected average harvest of approximately 106,200 adults in combined mainstem and Select Area commercial fisheries, even though the actual combined return for these species was 128% of expected.

Table 23b compares expected ex-vessel values for Chinook and Coho landed in mainstem and Select Area non-treaty commercial fisheries with actual fishery values adjusted for the same catch components used in Harvest Reform modelling. During 2013-2016, the actual ex-vessel value of combined non-treaty commercial fisheries exceeded modelled expectations by an average of \$0.94 M annually, and 22% for the period. However, most of this difference resulted from the record fall Chinook returns in 2013-2015, which yielded much higher values than contemplated during Reform modelling. Due to smaller adult returns, reduced allocations, and lack of new replacement fisheries, the adjusted actual ex-vessel values in 2017 of \$3.05 M and 2018 of \$2.0 M were 75% and 47% of the modelled values of \$4.05 M and \$4.23 M, respectively (Figure 23a).

Table 23b. Comparison of Harvest Reform modeled commercial fishery ex-vessel values from Table C4 with comparable actual ex-vessel values, 2013-2018.

Fishery	Target Stock	2013			2014			2015			2016			2017			2018										
		Current	%	C5 Modeled	Adjusted Actual Value ¹	%	C5 Modeled	Adjusted Actual Value ¹	%	C5 Modeled	Adjusted Actual Value ¹	%	C5 Modeled	Adjusted Actual Value ¹	%	C5 Modeled	Adjusted Actual Value ¹	%									
Mainstem Gillnet	Spring Chinook	\$ 395,911	10%	\$287,059	7%	\$ 202,405	4%	\$205,272	5%	\$ 322,675	6%	\$205,272	5%	\$ 580,660	12%	\$205,272	4%	\$ 415,641	8%	\$0	0%	\$ -	0%	\$ -	0%		
	Summer Chinook	\$ 151,719	4%	\$136,552	3%	\$ 144,962	3%	\$121,332	3%	\$ 172,266	3%	\$90,999	2%	\$ 206,307	4%	\$90,999	2%	\$ 275,108	6%	\$0	0%	\$ -	0%	\$ -	0%		
	Z4-5 Fall Chinook	\$ 1,272,247	33%	\$958,790	24%	\$2,767,880	54%	\$958,790	23%	\$ 2,504,803	43%	\$958,790	23%	\$2,508,461	52%	\$772,926	17%	\$2,789,466	56%	\$0	0%	\$ 908,770	30%	\$0	0%	\$ 373,219	19%
	2S Gillnet Fall Chinook	\$ 222,745	6%	\$309,341	8%	\$0	0%	\$309,341	8%	\$ -	0%	\$309,341	7%	\$ -	0%	\$353,526	8%	\$ -	0%	\$0	0%	\$ -	0%	\$0	0%	\$ -	0%
	Coho	\$ 316,682	8%	\$270,442	7%	\$ 29,030	1%	\$270,442	7%	\$ 409,201	7%	\$270,442	6%	\$ 26,391	1%	\$261,582	6%	\$ -	0%	\$0	0%	\$ -	0%	\$0	0%	\$ -	0%
Mainstem Tangle net	Coho	NA	0%	\$246,713	6%	\$ 55,251	1%	\$246,713	6%	\$ 137,556	2%	\$246,713	6%	\$ 9,299	0%	\$246,713	5%	\$ -	0%	\$246,713	6%	\$0	0%	\$246,713	6%	\$0	0%
Mainstem (Gear TBD)	Z4-5 Fall Chinook	NA	0%	\$0	0%	\$ -	0%	\$0	0%	\$ -	0%	\$0	0%	\$ -	0%	\$0	0%	\$ -	0%	\$772,926	19%	\$0	0%	\$772,926	18%	\$0	0%
Mainstem (Gear TBD)	Area 2S Fall Chinook	NA	0%	\$0	0%	\$ -	0%	\$0	0%	\$ -	0%	\$0	0%	\$ -	0%	\$0	0%	\$ -	0%	\$353,526	9%	\$0	0%	\$353,526	8%	\$0	0%
Mainstem	Fall Chinook	NA	0%	\$190,851	5%	\$0	0%	\$190,851	5%	research ²	0%	\$190,851	5%	\$ 51,434	1%	\$467,868	10%	\$26,894	1%	\$467,868	12%	\$0	0%	\$467,868	11%	\$0	0%
Seine	Coho	NA	0%	\$73,562	2%	\$0	0%	\$73,562	2%	research ²	0%	\$73,562	2%	\$ 5,215	0%	\$175,901	4%	\$ 6,392	0%	\$175,901	4%	\$0	0%	\$175,901	4%	\$0	0%
	Mainstem SUM	\$ 2,359,304	61%	\$2,473,310	61%	\$3,199,529	63%	\$2,376,303	58%	\$3,546,501	61%	\$2,345,970	56%	\$3,387,767	71%	\$2,574,787	56%	\$3,513,502	71%	\$2,016,934	50%	\$908,770	30%	\$2,016,934	48%	\$373,219	19%
Select Area	Spring Chinook	\$ 316,415	8%	\$394,493	10%	\$594,348	12%	\$395,519	10%	\$269,366	5%	\$503,300	12%	\$748,136	16%	\$605,566	13%	\$ 759,559	15%	\$631,805	16%	\$1,265,263	41%	\$632,830	15%	\$ 1,257,244	63%
	Fall Chinook	\$ 436,943	11%	\$436,943	11%	\$ 779,085	15%	\$436,943	11%	\$ 497,362	8%	\$457,237	11%	\$ 378,842	8%	\$481,779	11%	\$ 301,281	6%	\$484,139	12%	\$ 323,253	11%	\$484,139	11%	\$ 200,179	10%
	Coho	\$ 743,337	19%	\$765,362	19%	\$543,399	11%	\$912,194	22%	\$1,547,781	26%	\$912,194	22%	\$283,430	6%	\$912,194	20%	\$ 408,745	8%	\$912,194	23%	\$ 554,719	18%	\$1,095,734	26%	\$ 165,373	8%
	Select Area SUM	\$ 1,496,695	39%	\$1,596,798	39%	\$1,916,832	37%	\$1,744,656	42%	\$2,314,508	39%	\$1,872,731	44%	\$1,410,408	29%	\$1,999,539	44%	\$1,469,585	29%	\$2,028,138	50%	\$2,143,235	70%	\$2,212,703	52%	\$1,622,796	81%
Total	\$ 3,855,999	100%	\$4,070,108	100%	\$5,116,361	100%	\$4,120,959	100%	\$5,861,010	100%	\$4,218,701	100%	\$4,798,175	100%	\$4,574,326	100%	\$4,983,087	100%	\$4,045,072	100%	\$3,052,005	100%	\$4,229,637	100%	\$1,996,015	100%	

¹ To allow for direct comparison with C5 modeled values, actual ex-vessel commercial values were adjusted to match C4/5 assumptions which did not include value of: COH landed in CHF fisheries, CHF landed in COH fisheries, or non-local CHS or COH landed in SAFE fisheries. 2013-17 actual fishery values reduced by an average of \$269,091 (preliminary) to facilitate a direct comparison with C5 modeled values.

² 2014 seine fisheries operated under research impacts, so value not included since commercial impacts and fishery values were not decreased proportionately to amount used in seine fishery

Note: Earnings results that exceeded model predictions shown in GREEN, results that fell short of model predictions shown in RED.

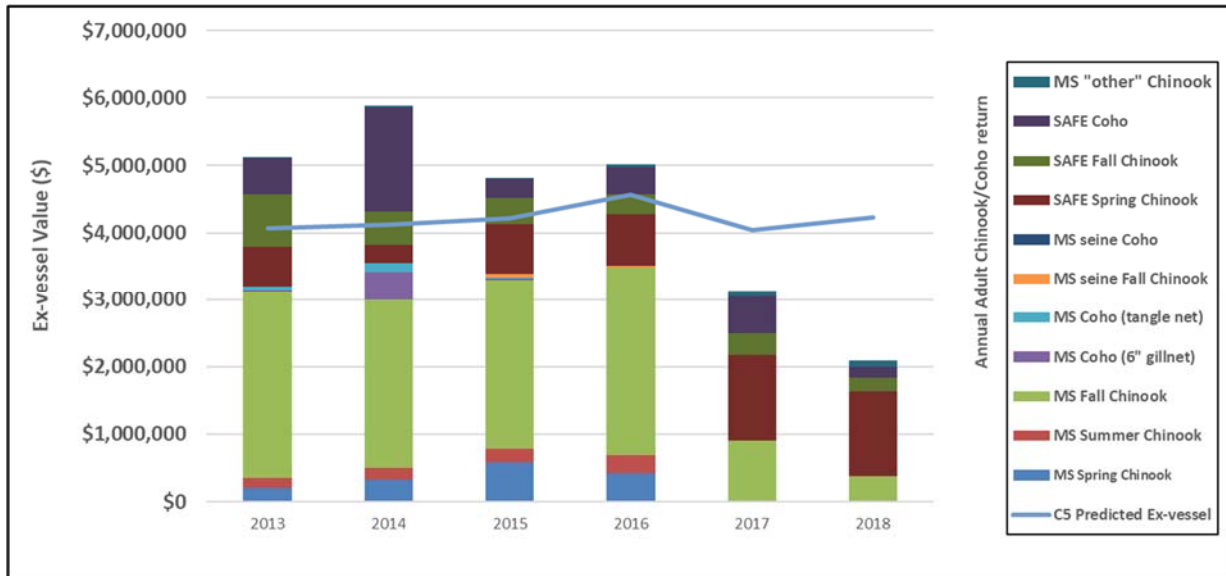


Figure 23a. Adjusted annual ex-vessel value of non-treaty mainstem (MS) and Select Area (SA) commercial salmon fisheries compared to expected values presented in Table C5, 2013-2018.

The proportion of the total annual ex-vessel value accrued in mainstem non-treaty commercial fisheries generally met, or exceeded, expectations for mainstem Chinook fisheries (spring, summer, and fall Zone 4-5). The proportion of the combined annual ex-vessel value accrued in the Coho gillnet, Coho tangle net, and mainstem seine fisheries did not meet expectations, with one exception (2014 Coho gillnet). Three anticipated fisheries (Area 2S gillnet, Zone 4-5 gear TBD, and Area 2S gear TBD) did not occur during the 2013-2018 period, and therefore did not meet expectations. For Select Area fisheries, the contribution percentage met or exceeded expectations in five of six years for spring Chinook, but only one of six years for fall Chinook and Coho.

A comparison of total non-treaty commercial landings and the combined adult returns of Chinook and Coho to the Columbia River highlights the significant effect of run size on fishery results, even in light of changing allocations and other sources of variance (Figure 23b). A similar comparison of annual ex-vessel value in non-treaty commercial fisheries and the combined Chinook and Coho run size (Figure 23c) shows a similar trend, although not as apparent. During the 2010-2018 period, total commercial ex-vessel value was positively correlated with the total Chinook and Coho run size ($R^2 = 0.79$) even though commercial ESA allocations declined progressively during the 2013-2018 timeframe (Figure 23d).

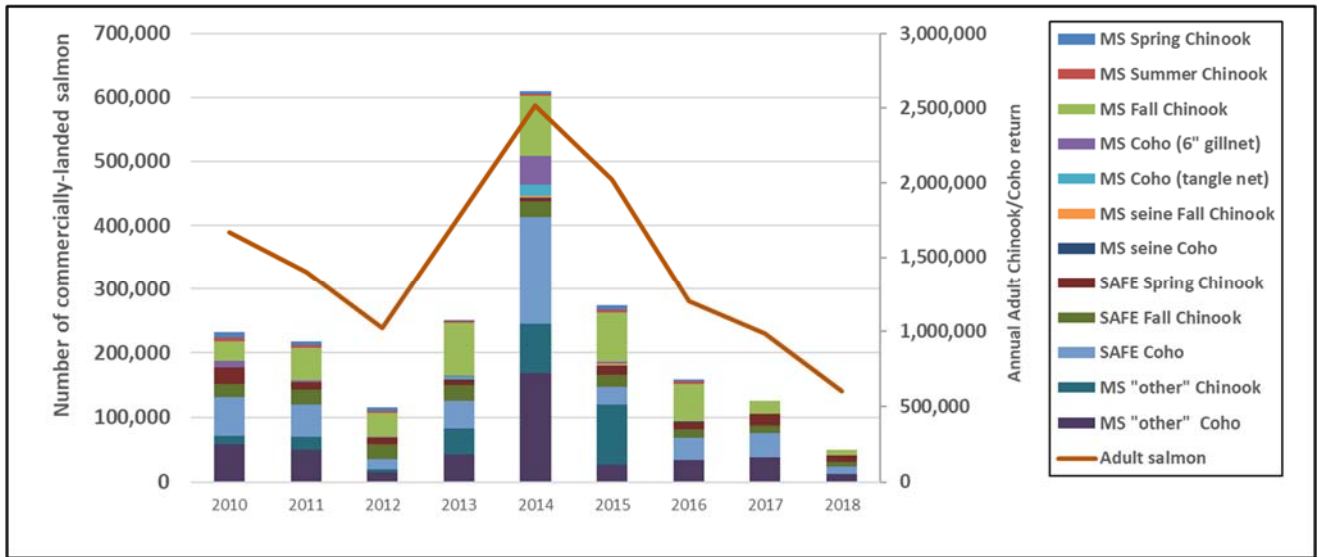


Figure 23b. Number of Chinook and Coho landed in non-treaty commercial fisheries in the lower Columbia River, and annual adult returns, 2010-2018.

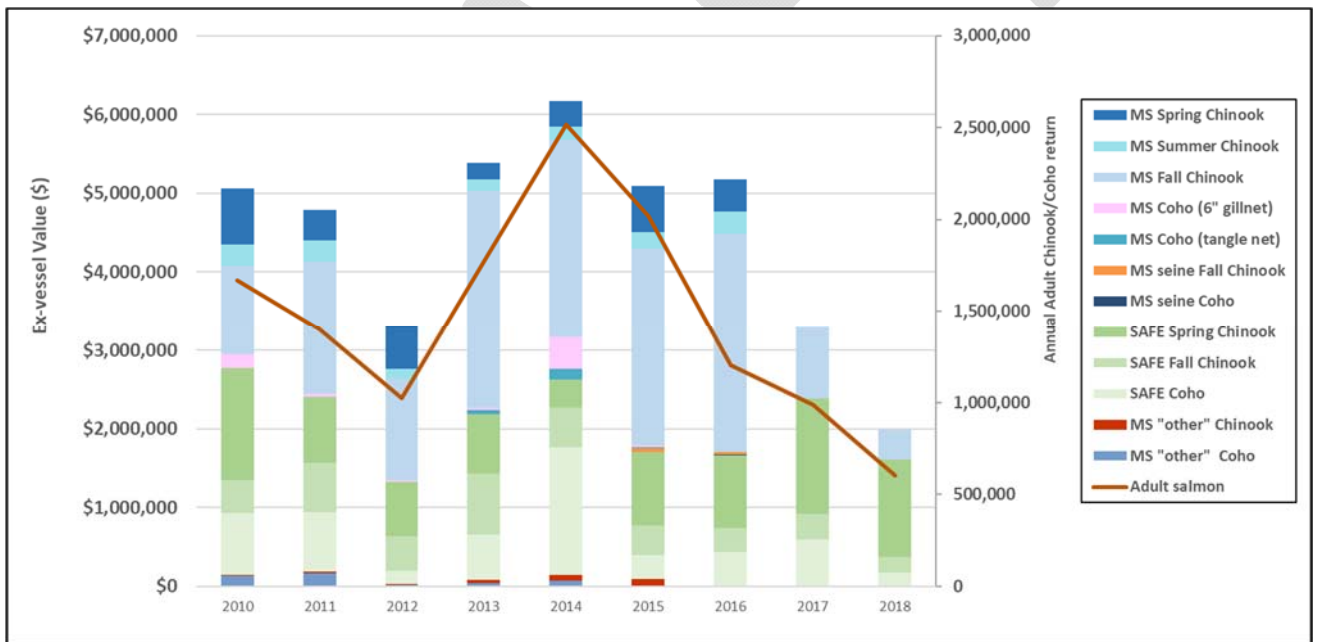


Figure 23c. Annual ex-vessel value of Chinook and Coho landed in non-treaty commercial fisheries in the lower Columbia River, and annual adult returns, 2010-2018.

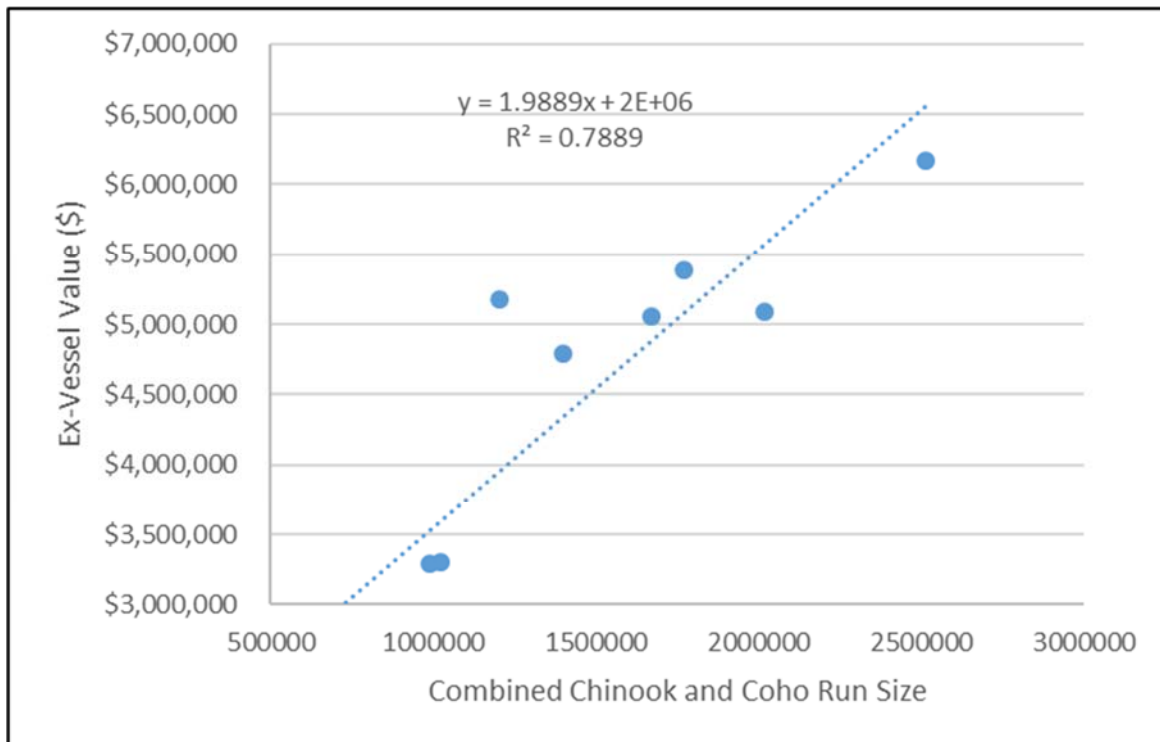


Figure 23d. Relationship between annual ex-vessel value of Chinook and Coho landed in non-treaty commercial fisheries in the lower Columbia River and annual adult returns, 2010-2018.

Because this relationship between landings and run size is so strong, it is difficult to isolate the effects of policy changes during the post-Reform period without standardizing for run size. To address this, actual annual commercial ex-vessel values realized by each fishery during 2013-2018 fisheries were calculated (Table 23c). These actual observed values were then adjusted based on average Select Area smolt releases and average ESA-impact allocations available to mainstem commercial fisheries during the three-year base period (2010-2012) preceding implementation of the Harvest Reform transition period in 2013. For mainstem commercial fisheries, this process involved re-calculating annual season-specific fishery values based on higher average ESA impacts that would have been available prior to implementation of Harvest Reform allocation shifts, while considering actual harvest potential and other limitations. We also used a “what was known when” approach, which required re-running actual in-season models (adjusted for the assumptions above) at key decision points for each run and year. Key decision points were associated with in-season *U.S. v. Oregon* TAC run updates for upriver spring Chinook, upper Columbia River summer Chinook, URB fall Chinook, Coho, and upriver steelhead, which occur throughout the year. This approach provided specific detail on how many Chinook and/or Coho would likely have been landed in each fishery given the information available at the time and the pre-Reform assumptions outlined above.

Table 23c. Actual ex-vessel value of non-treaty commercial fisheries in the lower Columbia River, 2013-2018.

Fishery	Target Stock	2013	2014	2015	2016	2017	2018	Average \$
Mainstem Gillnet	Spring Chinook	\$ 202,405	\$ 322,675	\$ 580,660	\$ 415,641	\$ -	\$ -	\$ 253,563
	Summer Chinook	\$ 144,962	\$ 172,266	\$ 206,307	\$ 275,108	\$ -	\$ -	\$ 133,107
	Z4-5 Fall Chinook	\$ 2,812,736	\$ 2,575,129	\$ 2,515,140	\$ 2,799,595	\$ 922,305	\$ 378,454	\$ 2,000,560
	2S Gillnet Fall Chinook	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
	Coho	\$ 39,486	\$ 460,466	\$ 78,612	\$ -	\$ -	\$ -	\$ 96,427
Select Area Gillnet	Spring Chinook	\$ 747,281	\$ 353,896	\$ 925,104	\$ 926,477	\$ 1,463,829	\$ 1,396,359	\$ 968,824
	Fall Chinook	\$ 779,085	\$ 497,362	\$ 378,842	\$ 301,281	\$ 323,253	\$ 200,179	\$ 413,334
	Coho	\$ 569,780	\$ 1,622,922	\$ 297,190	\$ 428,588	\$ 581,649	\$ 173,401	\$ 612,255
MS Z4-5 (gear TBD)	Fall Chinook	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Mainstem 2S (gear TBD)	Fall Chinook	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Mainstem Seine	Fall Chinook	\$ -	\$ -	\$ 51,434	\$ 26,894	\$ -	\$ -	\$ 13,055
	Coho	\$ -	\$ -	\$ 5,215	\$ 6,392	\$ -	\$ -	\$ 1,935
Mainstem Tangle net	Coho	\$ 86,085	\$ 162,732	\$ 49,624	\$ -	\$ -	\$ -	\$ 49,740
SUM		\$ 5,381,820	\$ 6,167,447	\$ 5,088,127	\$ 5,179,976	\$ 3,291,036	\$ 2,148,393	\$ 4,542,800

For spring Chinook, observed values were increased, assuming the 2010-2012 average commercial upriver spring Chinook allocation of 40% (minus actual ESA impacts used in Select Area fisheries) would have been available for mainstem fisheries during 2013-2018. These additional ESA impacts were distributed between tangle net (70%) and large-mesh (30%) gear, as they were used in 2010-2012. For each year, modelling was conducted to determine whether ESA impacts or upriver catch balancing limits would be more constraining given the adjusted allocation. Observed values for 2013-2016 fisheries were then scaled up proportionate to the increase in available upriver spring Chinook impacts or catch balancing limits, whichever was most constraining. In addition, sequential inseason spring Chinook models were reviewed for each year to ensure the expected use of the impacts would have been appropriate inseason. Since mainstem spring Chinook fisheries did not occur in 2017 and 2018, expected ex-vessel values were generated based on modelling potential catch and value rather than expanding observed values. For these years, expected price per pound was generated based on Select Area fishery ex-vessel values during the expected mainstem fishery timeframe (late March-mid April) and average weights from past mainstem fisheries. With the higher overall allocation providing for enhanced tangle net fisheries in a pre-Reform setting, the expected value for 2013-2018 mainstem spring Chinook fisheries, assuming Harvest Reform allocation changes had not occurred, were higher than actually observed in all years. These adjustments resulted in an estimated average annual ex-vessel value for non-treaty mainstem spring Chinook fisheries of \$487,115, or \$233,552 more than the actual average value. This reflects an economic loss since the potential was not realized due to Harvest Reform allocation shifts (Tables 23d and 23e).

For summer Chinook, 2013-2014 and 2016 observed commercial values (which resulted from post-Reform allocations of 30%-45%) were increased based on the 2010-2012 average pre-Reform commercial allocation of 50% of the available harvest for fisheries downstream of Priest Rapids Dam. Since the approximate final run size was available by early July in these years, it was assumed the commercial fishery could readily access these additional fish prior to the end of the summer management period (July 31). In 2015, the run size (and associated allocation) continued to increase throughout the season, so an allocation based on the final run size was not appropriate because the commercial fleet would not have been able to access 100% of the allocation before the end of the summer management period. Therefore, the 2015 analysis was based on the July 13 in-season run size estimate of 108,000 summer Chinook. Since mainstem summer Chinook fisheries did not occur in 2017 and 2018, expected ex-vessel values were generated based on

modelling potential expected catch and value rather than expanding observed values, similar to the spring Chinook exercise described above. These adjustments resulted in an estimated average expected annual value of \$248,598, or a \$115,491 loss in ex-vessel value due to Reform allocation shifts (Tables 23d and 23e).

Estimating the potential ex-vessel value of 2013-2018 fall mainstem commercial fisheries under pre-Reform conditions was a more complicated process because multiple ESA limits (lower Columbia River Chinook/Coho, Snake River natural-origin Chinook, and A/B-Index natural-origin steelhead) apply to these fisheries and can limit potential harvest. In addition, the commercial allocation of these ESA-stocks are shared among the different non-treaty commercial fisheries, creating an interplay between harvest potential in the various fall season fisheries. Assumptions incorporated into fall season modelling included:

- The 2010-2012 average commercial allocation share for LCR natural fall Chinook of 40.7% would be available instead of the post-Reform average of 29.8%.
- Seine and Coho tangle net fisheries would not have occurred.
- ESA impacts used in seine and Coho tangle net fisheries would be available for gillnet fisheries, since they would not have been in place in a pre-Reform setting.
- Chinook and Coho-directed gillnet fisheries would still be prosecuted as they occurred, albeit with additional ESA impacts available under a pre-Reform setting.
- The distribution of Chinook ESA impacts would be apportioned among non-treaty commercial fisheries in a manner similar to 2010-2012.
- These fisheries could only expand a) within available ESA impacts, and/or b) within reasonable harvest potential by season and month.
 - Natural-origin steelhead ESA impact sub-allocations reserved for commercial fisheries in pre-season modelling remained in place.
 - Maximum Chinook harvest potential was capped at 55,000 for Early Fall (August) fisheries, 6,000 for October fisheries, and was not capped for fisheries occurring in September.
- Price per pound and average fish weight would not have changed from what was actually observed in each fishery.

These adjustments resulted in an estimated average annual ex-vessel value for 2013-2018 fall mainstem Chinook-directed commercial fisheries of \$2,363,775, or a \$363,215 average annual loss in revenue due to Reform allocation shifts (Tables 23d and 23e). If these Chinook-directed fisheries had expanded as the modelling indicates, more Coho (including LCN Coho) would have also been harvested in Chinook-directed gillnet fisheries, resulting in fewer available LCN Coho impacts for Coho-directed gillnet fisheries. However, impacts associated with implementation of new Coho-directed tangle net and seine fisheries would have been available as described in the above assumptions. The combined shifting of ESA impacts indicates that Coho-directed gillnet fisheries would have realized an average annual value of \$110,991, or \$14,563 more per year in a pre-Reform scenario (Tables 23d and 23e).

Our modelling analyses did identify instances where the actual value of certain mainstem commercial fisheries likely would not have changed, even if additional Chinook ESA impacts were available under pre-Harvest Reform assumptions. In both cases, natural circumstances curtailed

additional commercial opportunity, which likely overwhelmed the effects of Policy changes. This occurred in the fall of 2016 and 2017, when significant run downgrades to URB fall Chinook and natural-origin B-Index steelhead, respectively, limited fisheries. In 2016, a 25% run downgrade to the URB fall Chinook run (including SRW) in late September was significant enough that, even if the commercial fishery had 40% of the ESA impacts (pre-Reform base allocation for SRW), the late-fall season fisheries would have been prosecuted, as they actually occurred, with no lost opportunity since SRW impacts would have been reached at the conclusion of the late-fall Zone 4-5 fishery. This situation prevented the implementation of additional late-fall Zone 4-5 Chinook-directed fisheries and the prosecution of the Coho-directed tangle net fishery. It is possible that under increased pre-Reform allocations, additional commercial fishing time may have occurred in the 2016 early fall (August) fishery, but our assumption was that any additional impacts would have been applied to the late fall fishery since the August fishery was fully prosecuted. A similar situation occurred in 2017 due to a very low natural-origin B-Index steelhead run forecast, which was eventually downgraded further in early October. Under pre-Reform assumptions, the commercial fishery would have had additional Chinook ESA impacts with which to prosecute fisheries, but the available natural-origin B-Index steelhead impacts were used in the fisheries that had occurred, which prevented implementation of additional fisheries. This resulted in no expected change from what actually occurred in the commercial fishery since Harvest Reform allocation shifts did not apply to steelhead ESA impacts.

Because fewer smolts were being released in Select Area fisheries during the 2010-2012 base period prior to implementation of the Harvest Reform Policy, the expected ex-vessel value of these fisheries for all species and years was equal to, or less than, what actually occurred. To estimate these values, actual landings resulting from Select Area production were adjusted relative to the age-specific contribution of increased smolt releases from the Policy. Since survival information specific to the additional Policy-directed production will not be available for some time, all releases (by stock) were assumed to contribute to adult returns proportionate to their release proportions (same annual survival rate). Landings and ex-vessel value of non-local catch was not adjusted since these fish would have been harvested regardless of how many fish were released from Select Area sites. For Select Area spring Chinook (2013-2018), these adjustments resulted in an average expected value of \$807,025, for an average gain of \$161,799 due to implementation of Reform policies (Tables 23d and 23e). The average annual gain during 2015-2018 was \$234,156, when an increasing percentage of the returning adults originated from Harvest Reform releases.

For SAB fall Chinook, there were no changes in fishery value until 2015 since adult returns from increased Reform production had not yet occurred. In addition, adult returns of this stock have under-performed recently, and releases have been below pre-reform goals in some years due to lack of broodstock. Therefore, the average annual ex-vessel gain due to increased SAB fall Chinook production for 2013-2018 was \$20,960 (Table 23e). Since production changes for tule fall Chinook were not associated with the Harvest Reform Policy, no economic changes were expected or modelled for this stock. For Select Area Coho, adult returns resulting from Reform-related production increases began in 2014, resulting in an average expected ex-vessel value during 2013-2018 of \$538,586, for an average annual gain of \$73,669 (Tables 23d and 23e).

Implementation of fall seine fisheries did not progress as rapidly or to the extent anticipated in the Harvest Reform process. A seine fishery did not occur in 2013 and the 2014 fishery operated under research ESA impacts; therefore, the ex-vessel value for that fishery (\$64,999) was not considered in this analysis because the value of other fisheries would have been reduced if impacts for the seine fishery had been subtracted from the commercial sub-allocation. The 2015 and 2016 seine fisheries produced ex-vessel values of \$56,649 and \$33,286, respectively (Tables 23c and 23e). Seine fisheries did not occur in 2017, in part due to steelhead ESA impact limitations. The available impacts were instead used in the Zone 4-5 gillnet fishery, which extracts a higher ex-vessel value per steelhead impact. The average annual gain for combined purse and beach seine fisheries during 2013-2018 (not including the 2014 research seine fishery) was \$14,989 (Table 23e).

A Coho tangle net fishery occurred each fall during 2013-2015 due to implementation of the Harvest Reform Policy. However, the planned 2016 tangle net fishery did not occur because of a significant URB fall Chinook run downgrade, which prevented any additional mainstem non-treaty commercial fishing that year. In 2017, the run downgrade for natural-origin B-Index steelhead prevented adoption of a Coho tangle net fishery. For 2013-2018, the annual gain in ex-vessel value from Coho-directed tangle net fisheries averaged \$49,740 (range \$0-\$162,732; Table 23e).

Table 23d. Expected ex-vessel value of non-treaty commercial fisheries in the lower Columbia River, 2013-2018.

Fishery	Target Stock	2013	2014	2015	2016	2017	2018	Average
Mainstem Gillnet	Spring Chinook	\$ 262,673	\$ 550,820	\$ 777,035	\$ 567,787	\$ 302,776	\$ 461,599	\$ 487,115
	Summer Chinook	\$ 192,223	\$ 204,169	\$ 289,034	\$ 385,105	\$ 222,122	\$ 198,936	\$ 248,598
	Z4-5 Fall Chinook	\$ 3,475,916	\$ 2,868,149	\$ 3,547,915	\$ 2,799,595	\$ 922,305	\$ 568,768	\$ 2,363,775
	2S Gillnet Fall Chinook	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
	Coho	\$ 28,742	\$ 534,392	\$ 102,809	\$ -	\$ -	\$ -	\$ 110,991
Select Area Gillnet	Spring Chinook	\$ 730,514	\$ 336,492	\$ 737,727	\$ 752,921	\$ 1,222,604	\$ 1,061,892	\$ 807,025
	Fall Chinook	\$ 779,085	\$ 497,362	\$ 359,097	\$ 240,414	\$ 283,192	\$ 195,089	\$ 392,373
	Coho	\$ 569,780	\$ 1,456,864	\$ 252,187	\$ 371,363	\$ 432,626	\$ 148,696	\$ 538,586
MS Z4-5 (gear TBD)	Fall Chinook	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Mainstem 2S (gear TBD)	Fall Chinook	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Mainstem Seine	Fall Chinook	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
	Coho	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Mainstem Tangle net	Coho	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
SUM		\$ 6,038,933	\$ 6,448,248	\$ 6,065,804	\$ 5,117,186	\$ 3,385,625	\$ 2,634,979	\$ 4,948,463

Table 23e. Expected change in ex-vessel value of non-treaty commercial fisheries in the lower Columbia River resulting from Harvest Reform allocation shifts and Select Area production changes, 2013-2018.

Fishery	Target Stock	2013	2014	2015	2016	2017	2018	Average
Mainstem Gillnet	Spring Chinook	\$ (60,269)	\$ (228,145)	\$ (196,374)	\$ (152,146)	\$ (302,776)	\$ (461,599)	\$ (233,552)
	Summer Chinook	\$ (47,260)	\$ (31,903)	\$ (82,727)	\$ (109,997)	\$ (222,122)	\$ (198,936)	\$ (115,491)
	Z4-5 Fall Chinook	\$ (663,179)	\$ (293,020)	\$ (1,032,775)	\$ -	\$ -	\$ (190,314)	\$ (363,215)
	2S Gillnet Fall Chinook	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
	Coho	\$ 10,744	\$ (73,926)	\$ (24,197)	\$ -	\$ -	\$ -	\$ (14,563)
Select Area Gillnet	Spring Chinook	\$ 16,766	\$ 17,404	\$ 187,376	\$ 173,556	\$ 241,224	\$ 334,467	\$ 161,799
	Fall Chinook	\$ -	\$ -	\$ 19,745	\$ 60,866	\$ 40,061	\$ 5,090	\$ 20,960
	Coho	\$ -	\$ 166,058	\$ 45,003	\$ 57,226	\$ 149,023	\$ 24,705	\$ 73,669
MS Z4-5 (gear TBD)	Fall Chinook	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Mainstem 2S (gear TBD)	Fall Chinook	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Mainstem Seine	Fall Chinook	\$ -	\$ -	\$ 51,434	\$ 26,894	\$ -	\$ -	\$ 13,055
	Coho	\$ -	\$ -	\$ 5,215	\$ 6,392	\$ -	\$ -	\$ 1,935
Mainstem Tangle net	Coho	\$ 86,085	\$ 162,732	\$ 49,624	\$ -	\$ -	\$ -	\$ 49,740
SUM		\$ (657,113)	\$ (280,801)	\$ (977,677)	\$ 62,790	\$ (94,589)	\$ (486,586)	\$ (405,663)

Based on modelling, the combined effects of the Harvest Reform Policy resulted in a net loss in the total annual commercial ex-vessel value of \$657,113 in 2013, \$280,801 in 2014, \$977,677 in 2015, a gain of \$62,790 in 2016, a loss of \$94,589 in 2017, and a loss of \$486,586 for 2018, compared to expected values under pre-Reform (2010-2012) allocations and Select Area releases (Table 23e). For 2013-2018, these deltas represent -11%, -4%, -16%, +1%, -3%, and -18% of the expected values (Figure 23e). The average annual loss was \$405,663, or -8% from what would have been expected to occur if the Policy had not been implemented.

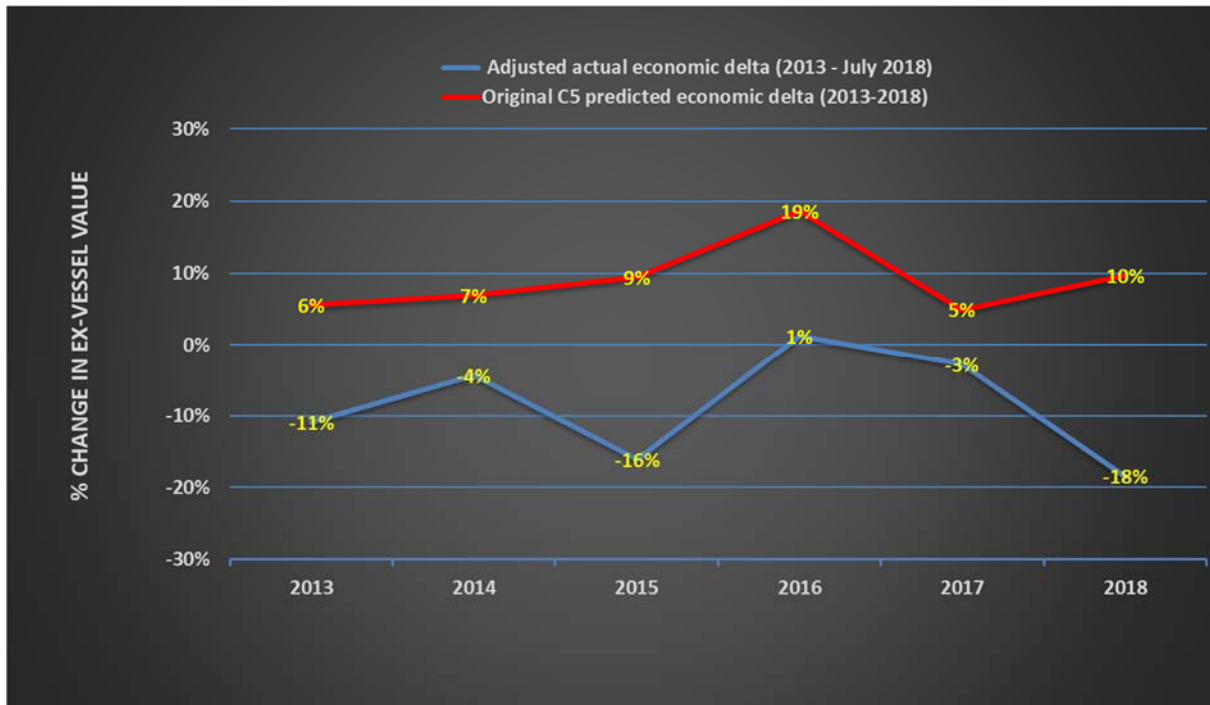


Figure 23e. Comparison of predicted and actual percent change in annual ex-vessel value for non-treaty commercial fisheries in the lower Columbia River, post-Harvest Reform, 2013-2018. Adjusted actual is the difference between actual ex-vessel and the expected value of those same fisheries under policies and Select Area releases in effect during 2010-2012.

KEY FINDINGS

The Harvest Reform Policy initiated in 2013 sought to re-configure and re-prioritize non-treaty fisheries in the Columbia River by making changes in three main areas: 1) promoting the orderly transition of commercial gillnet fisheries from the mainstem into off-channel areas (i.e. Select Area fishing sites) by increasing hatchery smolt production in the existing areas, expanding existing season structure and boundaries associated with current Select Area fisheries, and establishing new Select Area fisheries, 2) replacing use of gillnets in mainstem fisheries with alternative gears, and 3) prioritizing recreational fisheries in the mainstem Columbia by shifting allocation shares of ESA impacts and harvestable surpluses from commercial to recreational fisheries. During the first 5+ years of Policy implementation, some objectives have been met in each of these areas; however, several assumptions and expectations have not been realized, leading to differences between expected and observed performance in many areas. The following summarizes key findings to date with respect to the three main approaches to implementing the Harvest Reform Policy. The post-Reform period is defined as 2013 and subsequent years.

Select Areas

- Policy goals for increased hatchery smolt releases into existing Oregon Select Area sites have largely been achieved for Coho and spring Chinook (except projected 2019 releases for spring Chinook). Production goals for SAB fall Chinook have not been met. Poor adult returns, and subsequent escapement to the hatcheries, in recent years has led to an average of 46% of the release goal for SABs being achieved in 2016 and 2017, and 30% of the goal projected to be met in 2018. Furthermore, and unrelated to Harvest Reform, releases of this high-value stock may be discontinued in the near future due to NMFS's concerns with SAB stray rates.
- Reform-mandated hatchery smolt releases into Washington Select Area sites have generally met expectations for Coho; Washington spring Chinook enhancements have, to date, fallen far short of expectations. After five years, experimental releases of spring Chinook into the potential new Cathlamet Channel Select Area site were discontinued due to extremely poor adult returns. To date, spring Chinook releases in Washington Select Area sites (Deep River and Cathlamet Channel) have not contributed to meaningful commercial harvest.
- Average adult returns to Oregon Select Area sites have mostly met harvest expectations for spring Chinook (landings have exceeded expected harvest in 2 of the last 3 years), but have fallen short for Coho and SAB fall Chinook. The observed discontinuity between releases and adult returns for Coho indicates that increased releases of smolts do not necessarily translate into proportionally greater adult returns (and harvest) from year to year due to the significant effect of variable survival rates.
- The contribution of adult fish resulting from Reform-related hatchery releases to total annual Select Area ex-vessel value averaged 12% during the post-Reform years, because most of the value in Select Area commercial fisheries is being derived from base production.
- In general, no significant change in off-channel commercial fishing effort was observed after Policy implementation, suggesting that there was not a large influx of fishers into off-

channel fisheries as Select Area production was enhanced and mainstem gillnet fisheries were reduced. Individual daily landings in Select Area fisheries are relatively low, so these fisheries are more conducive to local-area fishers who can fish the best tides daily with low overhead expenses. Non-local fishers with higher transportation costs may not benefit as much from Select Area fisheries since they may not choose to repeatedly travel to the sites with the hope of making a profitable catch. In addition, the existing Select Area sites may be approaching capacity in terms of available fishing space.

- The use of available upriver spring Chinook ESA impacts in the current Select Area sites has exceeded the sub-allocation in 6 out of the last 8 years, including 2017 when the allocation was higher. This makes expansion of boundaries for the existing Select Area sites problematic.
- Expanded time during the winter and spring/summer seasons has been implemented for some existing Select Area fisheries, providing opportunities for fishers to harvest high-value early spring Chinook during the winter season, and access to late arriving spring Chinook.
- Evaluations conducted to assess the feasibility of establishing new Select Area sites concluded that many of the potential new sites could not be accommodated within the upriver spring Chinook ESA impact limits currently allocated to non-treaty commercial fisheries. The candidate sites with relatively low potential for impacting upriver spring Chinook--Westport Slough (OR) and Coal Creek Slough (WA)—are small sites offering limited fishing area, and have logistical issues that need to be addressed prior to implementation. Westport Slough also had problems related to juvenile acclimation that could lead to straying of returning adults, and was not feasible for fall season implementation because of a high potential for impacting ESA-listed LCR tule fall Chinook and LCN Coho. Therefore, no new Select Area sites have been implemented to date. Coal Creek Slough is similar in size to Blind Slough and Deep River and if its logistical issues can be addressed, it may provide a second off-channel fishery for a limited number of Washington commercial fishers.
- Although extremely valuable, Select Area fisheries alone cannot provide sufficient economic buoyancy for the commercial fishing industry. Volatility in Coho returns (also observed in mainstem fisheries) has led to large (and uncontrollable) fluctuations in landings and ex-vessel value; this is problematic because Coho often comprise the majority of the annual Select Area harvest. Economic stability improves by having fisheries that are diversified across several stocks, both Select Area and mainstem, and are capable of benefitting a broad spectrum of commercial fishers.

Alternative Gears

- Many alternative commercial gears have been assessed in the lower Columbia River during almost two decades of testing and evaluation, beginning well before implementation of the Harvest Reform Policy. However, it has been difficult to identify a gear that can provide conservation benefits while producing an economic value on par with gillnet fisheries. Since the Cathlamet Pound Net only functioned in a commercial capacity in 2018, a comparative analysis for that gear is not included.
- One positive aspect of the gears tested is that non-retained fish can be released in relatively good condition. However, the handle of steelhead, Sockeye, and unmarked (including

wild) Chinook and Coho in alternative gears has been high. Since fishing-induced mortality is the joint product of handle and release mortality rate, each component is critically important in determining the magnitude of mortalities caused by a fishery. Therefore, gear types that handle a large number of non-target/retainable fish may not be viable, even at a low mortality rate due to ESA constraints.

- Of the gears tested for initial feasibility, target fish catch rates were highest in fall season purse seines. Most of the other alternative gears evaluated had relatively low catch rates due to difficulties in effectively deploying the gear. Also, Chinook captured during the summer and fall seasons exhibited low fin-mark rates. Mark rates for fall Chinook are a double-edged sword in mark-selective commercial fisheries because low mark rates mean a high proportion of Chinook need to be released (i.e. lower value of marketable catch given a fixed amount of effort), while high mark rates are indicative of a high proportion of low-value tulle Chinook in the catch.
- Mark-selective commercial fall seine fisheries were conducted for three years (2014-2016). Landings and ex-vessel value in the seine fishery were modest, with the majority of the Chinook and Coho quotas allotted to the seine fishery going unharvested due to low catch rates of marked adults. The low landings and value, combined with the relatively high capital and operating costs for seines (particularly purse seines), resulted in the seine fishery not being economically viable for most participants. On average, the fall seine fishery contributed 1% of the total annual value for mainstem commercial fisheries during 2014-2016.
- A mark-selective Coho tangle net fishery was implemented between 2013 and 2015. This fishery was similar to other commercial and recreational Coho fisheries in that catches were highly correlated with abundance. When returns were strong (2014), the fishery appeared to be economically viable, but when returns were low (2013 and 2015), the fishery exhibited poor economic returns, even though the Coho tangle net had the lowest capital and operating costs, and lowest barrier to participation, of any alternative gear. The Coho tangle net fishery accounted for an average of 2% of the total annual mainstem ex-vessel value during 2013-2015. Nevertheless, because of its low handle of non-target fish, relatively low mortality rate, low cost, and moderately high participation in 2013-2015 fisheries, it could be a suitable alternative to small-mesh gillnets for Coho-directed fisheries.
- With the exception of open fishing days for the seine fishery, alternative gear fisheries did not meet the expectations in Tables C4 and C5 (from “Management Strategies for Columbia River Recreational and Commercial Fisheries: 2013 and Beyond”; ODFW 2012).
- An analysis of the current capability of alternative gears (purse and beach seines) to effectively replace the use of gillnets in fall mainstem non-treaty commercial fisheries indicated that:
 - Catch rates of target fish, total harvest, ex-vessel value, and value per fisher-day for alternative gears were lower than for gillnets.
 - The catch composition in alternative gears was less favorable economically, compared to gillnets.
 - Much higher percentage of tulle Chinook and Coho (lower value) and steelhead (no economic value and conservation concern) in the catch.

- Much higher percentage of jacks (low value); lower average weight for adult fish.
 - Shore-oriented gears (e.g. beach seine) are more likely to capture tule fall Chinook (lower value) and steelhead, which travel close to shore.
 - There are multiple approaches to “selectivity” in fisheries management (Time/Area/Gear regulated, or TAG-selective fisheries, and mark-selective fisheries). Both types of selectivity have been used for management of Columbia River commercial and recreational fisheries for many years.
 - A comparison between mark-selective alternative gears and Zone 4-5 gillnets indicated that:
 - Alternative gears generated significantly lower ex-vessel value per natural-origin B-Index steelhead mortality compared to contemporary gillnet fisheries, meaning their use does not leverage allowed impacts to ESA-listed steelhead into harvest of target fish as effectively.
 - A hypothetical non-mark-selective seine fishery in Zones 4-5, which would maximize Chinook harvest potential for seines (and limit LCR tule impacts), could still not generate greater ex-vessel value per unmarked B-Index steelhead mortality, or LCR tule mortality, than the existing gillnet fishery because of the high proportion of steelhead and tule Chinook in the catch.
- Alternative gears alone are not likely able to replace the economic value of the fall large-mesh gillnet fishery, while remaining within the ESA impacts allocated to the commercial fishery. Economic viability of a large-scale fall season mark-selective commercial fishery in the mainstem would be difficult to achieve given the relatively low mark rates for fall Chinook and early stock Coho, the catch composition in alternative gears, as well as the high capital and operating costs associated with most alternative gears. Because of these fishery characteristics, high cost alternative gears such as purse seines, are less likely to be broadly adopted by current or new Columbia River commercial fishers. Although it may be possible to sell alternative gear-caught fish in high-value specialty markets, these niche markets have not yet been fully developed or explored, and a large-scale, high-volume fishery may not have the same potential to obtain premium prices. Therefore, alternative gears may be most appropriate for small-scale mark-selective fisheries, where the participants are primarily fishers who already have the boats and/or gear to participate in the fisheries. These fisheries could be used to lower hatchery-wild fish ratios in specific locations (e.g. tributary mouths) to provide conservation benefits, while contributing to commercial fishery economics.
 - Consistent with these findings, in 2017 the OFWC implemented adaptive management measures to alter the Oregon policy to allow for continued use of fall gillnets in Zones 4-5.
 - The 2017 Oregon policy also adopted the use of tangle nets as alternative gear for harvest of Coho in Zones 1-3.
 - The 2017 Oregon policy also set aside a small portion of the commercial allocation to support potential use of alternative gears in the fall.
- One alternative gear with a post-release mortality rate comparable to recreational fisheries, and with a proven track record of being economically viable, is the spring Chinook tangle net. Despite being broadly adopted by Columbia River commercial fishers and used in

successful mark-selective commercial fisheries for almost two decades, current Washington policy does not allow for mainstem non-treaty commercial spring Chinook fisheries beginning in 2017. Oregon policy allows a mainstem spring season tangle net fishery only after an in-season run size update (typically May), if sufficient upriver spring Chinook impacts are projected to remain after full prosecution of Select Area spring commercial fisheries. As was discussed when the OFWC made this decision, this is likely to occur infrequently.

Allocation Shifts

- As part of the prioritization of recreational fisheries in the mainstem Columbia, the recreational allocation of ESA impacts and harvestable summer Chinook increased from 2010-2012 pre-Reform averages of 60% for spring Chinook, 50% for summer Chinook, and 59% for fall Chinook. The initial policy established 2017+ allocations of 80% for spring Chinook, 80% for summer Chinook, and 80% for fall Chinook. The OFWC used adaptive management in their 2017 policy review to change the long-term allocation for fall recreational fisheries to $\leq 70\%$ - equivalent to that during the 2013-2016 transition period.
- The shifting of allocation shares from the commercial to recreational fisheries resulted in an average annual gain in angler trips of 3% for the recreational fishery during 2013-2017. This suggested that the number of angler trips made annually during the post-Reform years though primarily affected by factors unrelated to the allocation shift (e.g. run sizes, fishing conditions, catch rates, etc.), was positively impacted by reform policies.
- Allocation changes did not always affect the season structure of recreational fisheries because fishery harvest and effort in a particular season were not necessarily constrained by allocation guidelines. Therefore, gains in angler trips due to the Policy were not proportional to changes in the allocation, and did not provide the expected level of benefits for the recreational fishery.

Conclusion

As a result of implementation of the Harvest Reform Policy, the commercial allocations have been significantly reduced, and use of gillnets has been eliminated from mainstem spring and summer commercial fisheries. In addition, current Washington policy eliminates the use of tangle nets in the spring and gillnets in fall season mainstem commercial fisheries after 2018. Mark-selective commercial fisheries conducted during the transition period using some of the most promising alternative gears did not meet expectations, indicating that the lost economic value of mainstem gillnet fisheries is unlikely to be replaceable by alternative gears alone.

In addition to increasing production in existing SAFE areas, the Harvest Reform Policy assumed that expanded and new Select Area sites would provide additional off-channel fishing area and economic value for commercial fishers. Multi-year evaluations have identified one small candidate site with potential for new spring and fall fishery implementation and a second small site suitable for a spring fishery only. Enhanced Select Area hatchery production is assumed to translate into proportional increases in adult returns and harvest within any given year. However,

due to annual variation in survival, increased production cannot guarantee that future returns will always be higher (e.g. plus 10% production and minus 50% survival equals lower total return).

As was discussed in 2017 OFWC hearings, analysis of all of these aspects of the Harvest Reform Policy concluded that commercial ex-vessel values under the Policy were less than what would have been produced without the Policy. The average annual economic loss to the commercial fishery between 2013 and 2018 was -\$405,663. This equates to an 8% average loss for the commercial fishery, compared to the 9% average gain expected as a result of original Policy implementation, and the 3% actual gain in angler trips for the recreational fishery from allocation shifts. Although gains in ex-vessel value during the post-Reform period were realized from increased Select Area production and the limited contribution of alternative gear fisheries, they were not enough to make up for the economic value lost in mainstem fisheries due to allocation reductions and the phasing out of gillnet use in spring and summer fisheries.

Based on analyses of these results for the 2013-2016 transition period, the OFWC enacted adaptive management changes to adjust the policy. Changes included (but are not limited to): increased production of Select Area spring Chinook to offset reductions from Mitchell Act Program changes (Fall Chinook and Coho) and to provide additional commercial ex-vessel values; holding commercial mainstem fall Chinook allocations at the $\geq 30\%$ impact level from the transition period instead of enacting the planned $\geq 20\%$ allocation initially adopted; and continued allowance of gillnets in the mainstem for fall Chinook fisheries. These increases in Select Area production have been implemented but, as anticipated, will not result in increased harvest until adults begin returning; thus, they have been unable to contribute to adult returns and ex-vessel value yet.

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