Wild Fish Conservancy
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2016 Washington Coastal Restoration Initiative Report

Evaluation of Pound Nets as Stock-Selective Fishing Tools - Year 1

Wild Fish Conservancy

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ABSTRACT

Many wild salmonid populations of the Lower Columbia River have been listed under the Endangered Species Act due to overharvest, habitat loss, dams, and impacts from hatchery production. In an effort to reduce bycatch mortality of non-target wild stocks in commercial fisheries, increase selective harvest of hatchery-origin fishes, and minimize genetic introgression of hatchery-wild spawners, the Washington Department of Fish and Wildlife (WDFW) initiated the Commercial Selective Gear Implementation Program in 2009 and testing of various commercial gear-types in the Lower Columbia Sub-basin to provide sustainable alternatives to conventional non-selective gillnets. This prompted local fishers, the non-profit Wild Fish Conservancy (WFC), and WDFW to collaborate in testing Washington State's first commercial salmon trap in over 80 years. Based on historical blueprints of Columbia River traps and inspired by stock-selective successes in the Lummi Island reef net fishery, WFC and partners constructed an experimental pound net trap upstream of Cathlamet, WA where salmon traps were once common prior to the 1936 fixed-gear ban. Year-one test fishing targeted Fall Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*) to examine the potential of the gear in capturing commercially viable quantities of salmon while minimizing immediate mortality of captured and released fishes. Results from the 30-day test fishing period suggest that commercial salmon traps may work well as stock-selective fishing tools: during the test period, over 2,100 salmonids were captured and released with an immediate survival rate of 99.58%. Future testing in 2017 will investigate long-term and cumulative post-release survival through a tag, release, and recapture procedure.

INTRODUCTION

With the continuation of salmon and steelhead hatchery programs to augment fisheries in the Columbia River Basin, the development of stock-selective harvest tools for improved targeting of hatchery-origin fishes and the reduction of bycatch mortality is fundamental to the recovery of wild salmon and the rejuvenation of stifled commercial fishing communities (LCFRB 2004). While hatchery production can enhance short-term commercial harvest for local fishers, escapement of hatchery fishes and genetic introgression with wild salmonids has been identified as one of the leading factors contributing toward the long-term decline of wild populations (Lichatowich 1999). Furthermore, commercial use of gillnets for the harvest of hatchery salmon has inflicted detrimental rates of bycatch mortality on non-targeted stocks, hindering the recovery of wild populations and forcing premature closure of fisheries when ESA take limits have been exceeded (Beamesderfer et al. 2005). As a result, WDFW's Hatchery and Fishery Reform Policy Decision (2009) initiated the Lower Columbia River Basin's commercial selective gear implementation program to "develop and implement alternative fishing gear to maximize catch of hatchery-origin fish with minimal mortality to native salmon and steelhead" (WDFW 2009a). This was followed by WDFW's Columbia River Basin Salmon Management Policy Decision to "phase out the use of non-selective gill nets in non-tribal commercial fisheries in the mainstem Columbia River" and fully transition to use of selective harvest techniques by 2017 (WDFW 2013). However, after nearly seven years, all alternative gears assessed in the Lower Columbia have resulted in substantial rates of cumulative post-release mortality (the sum of immediate, short-term, and long-term mortality), impeding ESA recovery objectives (WDFW 2014). If hatchery production and commercial harvest are to continue in the Columbia River

Basin, a viable stock-selective harvest tool must be developed, tested, and commercially implemented to prevent the extirpation of ESA-listed wild salmonids.

Gillnets have long maintained a reputation for non-selectivity and bycatch mortality in salmon fisheries (Ricker 1976; ASFEC 1995; Buchanan et al. 2002). While mesh sizes function well to restrict catch to the salmonid family, gillnet fisheries which involve mixed stocks of salmon are greatly limited in selectivity due to the principle of geometric similarity (Hamley 1975). In prominent Northwest fisheries such as the Lower Columbia River salmon fishery, five salmonid species of both wild and hatchery origin may be involved in the fishery. Selective harvest of hatchery stocks and release of non-target wild populations is essential for meeting conservation goals. Nevertheless, for over a century, the non-selective nature of gillnets has compromised the survival of threatened fishes which often become tangled in commercial nets. Of the threatened fish that are accidently caught and released in commercial operations, cumulative mortality rates—combining immediate mortality at the point of release and long-term mortality of fish enroute to spawning grounds—commonly range from 35-70% (Buchanan et al. 2002). These low survival rates are an obstacle to effective conservation. Recovery of listed salmon species is not believed to be attainable “without substantial and innovative increases in fish survival” (Beamesderfer et al. 2005).

As bycatch issues have thwarted the survival of threatened wild spawners, management has attempted to counteract the decline of the resource through hatchery production and commercial fishing restrictions. However, these actions have inflicted unintended consequences on the genetics of depressed wild populations. For thousands of years, local salmon populations adapted to specific local conditions through evolutionary processes and enhanced their fitness within a given area of a watershed (Quinn 2005). An expanding body of research has validated that escapement and introgression of hatchery-origin fishes can reduce the success of wild salmon populations. Within only a single generation of domestication, hatchery salmonids reared from local wild broodstock and their wild offspring exhibit reduced survival and reproductive capacity (Christie at al. 2012; Christie et al. 2014). As a result of the domestication process, hybridization of hatchery and wild fish reduces the fitness of wild salmon populations (Goodman 1990; Levin et al. 2001; Christie et al. 2012; Lichatowich 2013). In response, many recommendations have been made for the reduction or elimination of hatchery supplementation (Goodman 1990; Hindar 1991; Krueger and May 1991; Hilborn 1992; Lichatowich 1999; ISAB 2003; RSRP 2004; Beamesderfer 2005). Despite evidence which indicates the detrimental genetic and ecological impacts that artificial propagation inflicts upon wild salmonid ESUs, hatchery programs are not expected to end anytime soon in the Pacific Northwest due to political pressure and treaty obligations.

Alternative Commercial Gear Testing

With the continuation of hatchery programs on the Columbia River, selective harvest of hatchery salmon and the reduction of cumulative post-release bycatch mortality have been identified as avenues toward wild salmon recovery and rejuvenation of stifled commercial fishing communities (LCFRB 2004). Initiation of funding for alternative selective harvest strategies began in 2004 in the Columbia River. Six gear types were suggested for testing by the Washington Fish and Wildlife Commission: beach seines, purse seines, pound nets, fishwheels, reef nets, and tangle nets. All methods demonstrated the potential to improve survival of ESA-listed species by enabling respiration, reducing scale loss, minimizing gill impairment, and decreasing physiological impacts (Ashbrook et al. 2007; Vander Haegen et al. 2004; Rayton et al. 2010; WDFW 2013). While the prospects of reef nets and fish wheels were dismissed due to insufficient flow conditions of the river, testing of tangle nets, beach seines, and purse seines occurred in the Lower Columbia Sub-Basin from 2009 through 2013 (WDFW 2014). Adopting a new policy prioritizing recreational fishing and promoting the development of alternative selective gear-types, the Washington Fish and Wildlife Commission is striving to phase-out the use of gillnets in the mainstem Columbia by 2017 (WDFW 2013). Initiating the transition to alternative gear-types, purse and beach seines received commercial implementation in 2014.

While improvements in immediate survival (survival from capture to release) and cumulative survival (survival from release to distant detection points at dams, hatcheries, and spawning grounds) have been documented from recent testing efforts, alternative gears such as tangle nets, beach seines, and purse seines—even when operated with extreme caution—have resulted in cumulative post-release mortality rates detrimental to wild salmonid recovery objectives (WDFW 2014). Through various testing efforts, tangle nets exhibited *immediate* mortality rates as high as 20%; WDFW detected no statistical difference between post-release cumulative survival rates of conventional gillnets and tangle nets (Ashbrook et al. 2007). Cumulative mortality results were recently released by WDFW (2014) for experimental beach and purse seine evaluations in the Lower Columbia River (Table 1). Although both gear-types outperformed tangle nets, exhibiting immediate mortality rates less than 1%, beach and purse seines produced cumulative post-release mortality rates ranging from 10-50% and 22-41% respectively for Chinook and coho species (WDFW 2014). Conventional gillnets commonly result in cumulative post-release mortality rates between 35-70% (Buchanan et al. 2002). Further investigations into purse seine, beach seine, and tanglenet post-release mortality are currently underway to reassess the accuracy of WDFW's results.

Table 1. Cumulative post-release release mortality in 2011 and 2012 for beach and purse seines tested in the Lower Columbia River test fishery (WDFW 2014, Tables 10, 11, and 20).

Fall Bright Chinook

Treatment	2011 Cumulative Mortality	2012 Cumulative Mortality
Beach Seine	44% (n=748)	25% (n=2623)
Purse Seine	22% (n=1643)	26% (n=2173)

Tule Chinook

Treatment	2011 Cumulative Mortality	2012 Cumulative Mortality
Beach Seine	31% (n=143)	10% (n=459)
Purse Seine	36% (n=408)	30% (n=359)

Coho

Treatment	2011 Cumulative Mortality	2012 Cumulative Mortality
Beach Seine	50% (n=297)	38% (n=480)
Purse Seine	23% (n=702)	41% (n=548)

As recently as 2015, all attempts to develop selective harvest tools have failed to solve the problem; bycatch mortality has not been substantially reduced in the Lower Columbia River. Furthermore, risks associated with hatchery production remain high in the Columbia Basin. In response to recent test results, it has been suggested that different alternative commercial gears—which capture salmonids efficiently while minimizing handling, mucous, and scale loss—should be developed and implemented as soon as possible to protect the Lower Columbia's 13 ESA-listed salmonid stocks (Donaldson et al. 2012). Status-quo hatchery and harvest practices cannot be maintained if ESA-recovery objectives are intended to be achieved (Lichatowich 2013).

Pound Net Technology

Attention has recently been drawn toward the potential of pound nets as selective harvest tools for salmon fisheries. First utilized on the Columbia River for commercial efforts in the late-19th century, pound nets (commonly known as fish traps) became one of the most prominent gears deployed in the Pacific Northwest (Wilcox 1902; Johnson et al. 1948). While greatly outnumbered by gillnetting fleets by a ratio of nearly five to one, pound net harvests on the Columbia River accounted for approximately one third of total salmonid catch. Compared to the efficiency of gillnets, catch per license issued on the lower Columbia River remained 150% greater for that of pound net operators functioning with relatively less gear surface area (Johnson et al. 1948). In Puget Sound and Alaska, pound nets were often responsible for the majority of total catch (Wilcox 1902; Mackovjak 2013). A single trap could harvest up to 1.2 million salmon in a season (Mackovjak 2013). Various accounts note that the gear type was the most efficient tool developed for the harvest of salmon and produced a product of superior quality (Wilcox 1902; Higgs et al. 1982; Radke 2002; Mackovjak 2013). Ultimately, it was the great efficiency of the pound net that led to the fixed gear ban of 1934, terminating use of pound nets in Washington State waters for over eighty years (Higgs et al. 1982).

Pound net technology is a zero carbon commercial strategy with the potential for efficient hatchery harvest and significant reductions in bycatch mortality (LCFRB 2004). Consisting of a series of pilings and attached web fences that extend from the high water mark to the river or estuary bottom, fish traps passively funnel returning adult salmon from the shoreline "lead"—positioned perpendicular to shore—to a large maze of walls and compartments (Figure 1). Since migrating salmon tend to forge ahead and rarely choose to turn backward, salmon move steadily through a trap's strategically designed inner-compartments. The first of these compartments, the "heart", is positioned at the outside end of the lead and is V-shaped, with the apex pointing upstream. Fish are naturally guided by the shape of the heart and their desire to move upstream through the apex of the V-shaped compartment to what is known as the "tunnel". The tunnel is conical in shape with a wide entrance and a very narrow outlet; it guides fish further upstream to the "pot" and tends to prevent most fish from returning backward to the heart. Once in the "pot"—a rectangular compartment that can be blocked at both the upstream and downstream ends—salmon are effectively entrapped. The pot acts as a holding pen for fish that are removed from the containment "spiller". Like the pot, the spiller is rectangular in shape and enables fish to swim freely until removal upon harvest or release (Cobb 1921; Higgs et al. 1982; Mackovjak 2013).

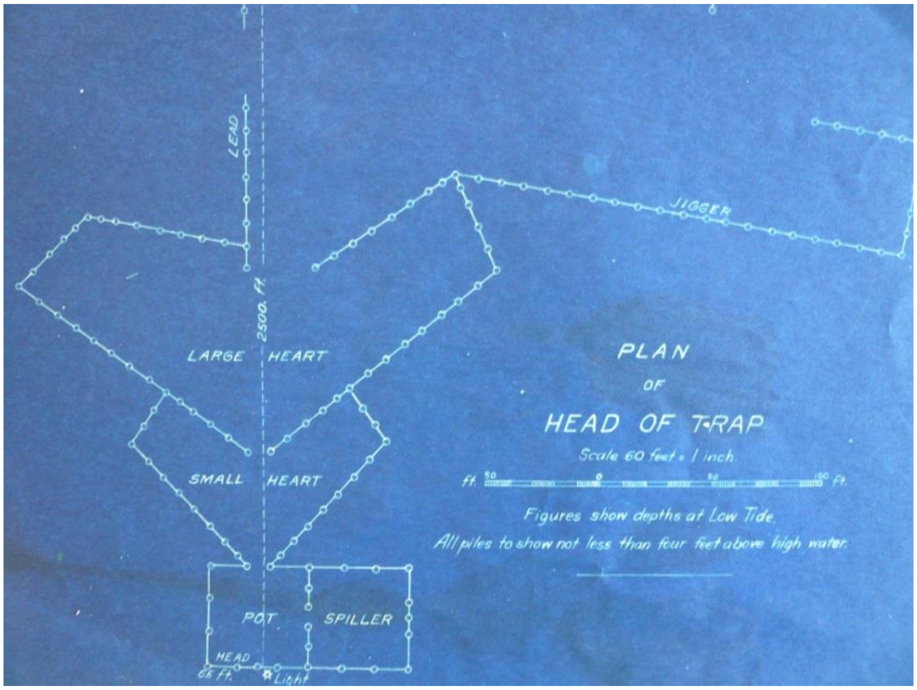

Figure 1. Historical design of a pound net trap located in SE Alaska.

The conservation benefits of the pound net design come from the method in which fish are entrapped. Salmon that enter the trap spiller are captured from neither tangling of teeth nor the operculum, reducing physical injury and many physiological issues arising from conventional gillnets and tangle nets. Additionally, the large dimensions of the spiller allow fish to swim in relative comfort with continuously circulating water prior to removal which may act to reduce stress and scale loss, further enhancing survival rates of non-targeted species relative to beach and purse seines. Through this method, all trapped fish can be safely sorted allowing for the harvest of targeted hatchery-origin fish and release of ESA-listed wild salmonids. With the potential for reduced physical injury rates, handling, exhaustion, air exposure, and stress of non-targeted salmonids, recommendations have been made for the testing of pound net technology by fishermen, NGOs, and the state government (LCRFB 2004; WDFW 2009; Arnold 2011; WFC 2013).

In collaboration with the Washington Department of Fish and Wildlife (WDFW) and local commercial fishers, Wild Fish Conservancy constructed and tested a full-scale pound net fish trap three miles upstream of Cathlamet, WA on the Columbia River. Specifically, objectives were to quantitatively evaluate the effectiveness of pound nets in capturing salmon, targeting hatchery reared Fall Chinook (both Bright and Tule) and coho, and reducing immediate bycatch mortality of ESA-listed wild fishes in the Lower Columbia Sub-Basin. Methods of the study mirrored previous strategies of alternative gear testing on the Columbia River. Procedures developed by the Colville Tribes and utilized by WDFW for experimental seine and tangle net operations were followed to maintain consistency for comparison of results between studies (Ashbrook 2007; WDFW 2014). Similar to previous alternative gear tests, year-1 of this study intended to achieve three major goals:

1) Learn how to use pound nets in the lower Columbia River and identify any modifications that can improve gear effectiveness.
2) Determine the effectiveness of the harvest method in capturing fish relative to previously tested alternative gears.
3) Evaluate the ability of pound nets to selectively harvest hatchery fish and release wild fish through the identification of immediate survival rate and capture/release conditions.

Results of the experiment demonstrate that pound nets can effectively harvest an equal or greater number of salmonids with similar immediate survivorship of released fishes relative to previously tested alternative gears (WDFW 2011; WDFW 2014). Ultimately, development and completion of year-2 testing is required to determine if the gear can substantially improve cumulative survivorship of released fishes for the benefit of local fishing communities and the recovery of ESA-listed wild fish populations.

METHODS

Pound Net Project Site

The project site is located approximately three miles southeast of Cathlamet, WA (Wahkiakum County) off Ocean Beach Highway in nearshore waters of the Cathlamet Channel—a side-channel of the Lower Columbia River (Lower Columbia Sub-Basin) positioned NE of Puget Island (Figure 2). Coordinates for the trap are 46.172089 N lat. / 123.338656 W long. This location is near, but outside the main navigation channel of the Columbia River and is used by commercial and recreational fishers at various times of the year. The geomorphology of the river bed at the site location is suitable for pound net development. With a sand bar situated along the right bank in a SW (downstream) to NE (upstream) position, maximum depth of 7 meters, sand substrate, low water velocity (from orientation near a point bar), and low turbulence, the project site was successfully utilized by fish trappers of the 19th and 20th centuries and is locally known to have relatively high salmonid migration densities.

Figure 2. 2016 project site. The existing trap location was utilized historically and is outside the main navigation channel of the Columbia River.

Pound Net Design

The pound net trap consisted of 40 untreated wood pilings, mesh webbing, cork line, auxiliary lines, a tunnel door, pulleys, and a live-well. Pound nets are used to concentrate and entrap fish in a containment spiller formed by webbing that extends from the high-water line to the river bottom, preventing escape and enabling selective harvest and release of non-targeted species.

The design of the pound net model was based upon the historical blueprints of traps that operated in the lower Columbia River, Puget Sound, and Southeast Alaska (Figures 3). Modifications to materials and operations were made based upon successes in selective reef net and alternative purse seine fisheries (WDFW 2014). The trap lead consisted of 16 pilings, extending approximately 280 ft. into the Cathlamet Channel at an angle perpendicular to the right-bank. The lead pilings functioned to hang highly visible, black nylon mesh (3.25'') attached approximately 3 ft. above the high-water line. The mesh of the lead extended to the river bottom (maximum depth 25 ft.). The heart of the trap utilized 12 untreated wood pilings at the end of the outer lead piling and formed a V-shape with the apex pointing upstream. The maximum length and width of the heart chamber were 75 ft. and 70 ft. respectively. The apex of the heart narrowed upstream to 6 ft. All mesh black nylon webbing of the heart (3.25'') similarly extended from 3 ft. above the high-water line to the river bottom (maximum depth 25 ft.). The spiller tunnel was designed of 2.5'' knotless mesh webbing; it protruded 8 ft. upstream to the successive compartment. The tunnel was opened or closed via ropes and pulleys. The spiller consisted of 10 untreated wood pilings and a combination of 2.5'' knotless black nylon mesh (bottom) and 3.25'' knotted mesh (top) extending from 3 ft. above the high water line to the river bottom. The spiller had a 2.5'' knotless mesh bottom that could be lifted with ropes, pulleys, and a mechanical winch. The mesh size of the spiller bottom was smaller than the remainder of the trap to reduce potential entanglement and injury to captured fishes. The live-well, positioned at the spiller edge of the sorting deck enabled hauled fish to swim in relative comfort prior to documentation and release.

Figure 3. The 2016 pound net trap located in the Cathlamet Channel of Wahkiakum County, WA. Photo taken looking north.

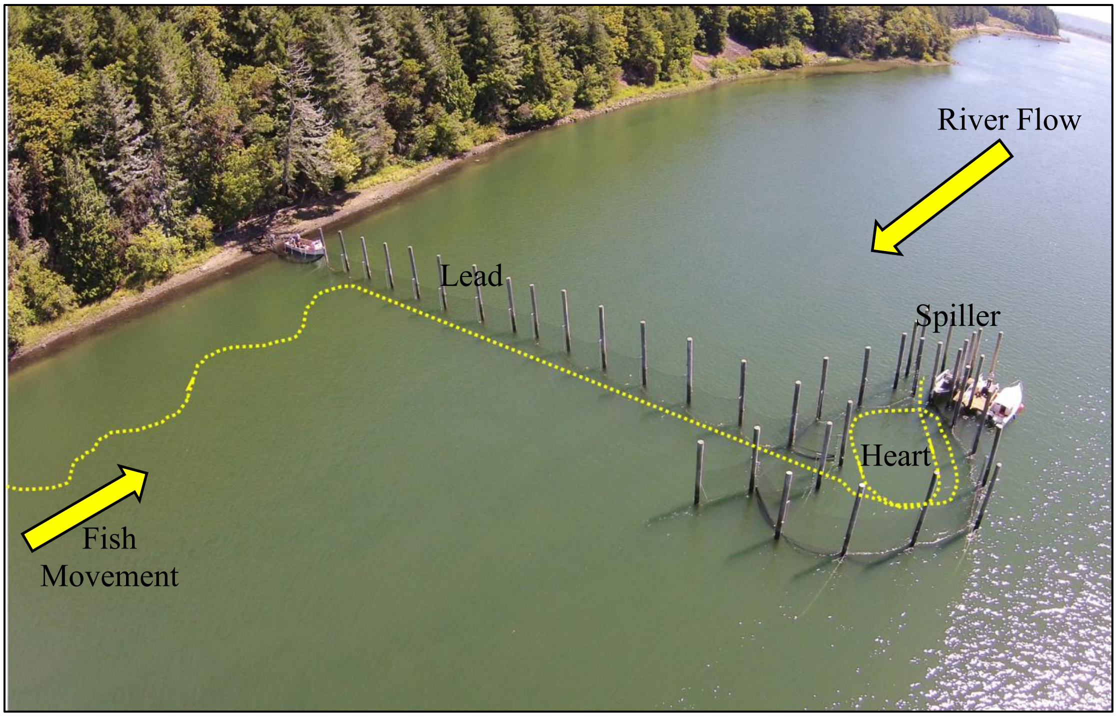

Figure 4. 2016 pound net trap viewed from above. Photo taken looking northeast.

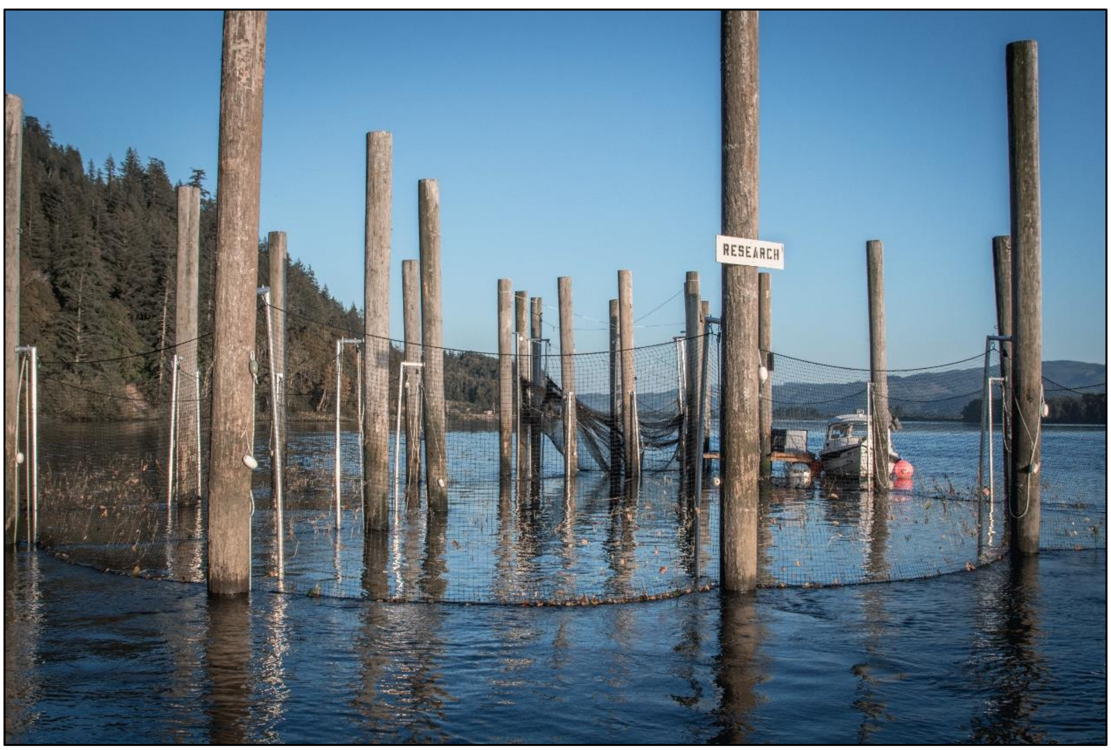

Figure 5. 2016 pound net heart (photo taken looking upstream).

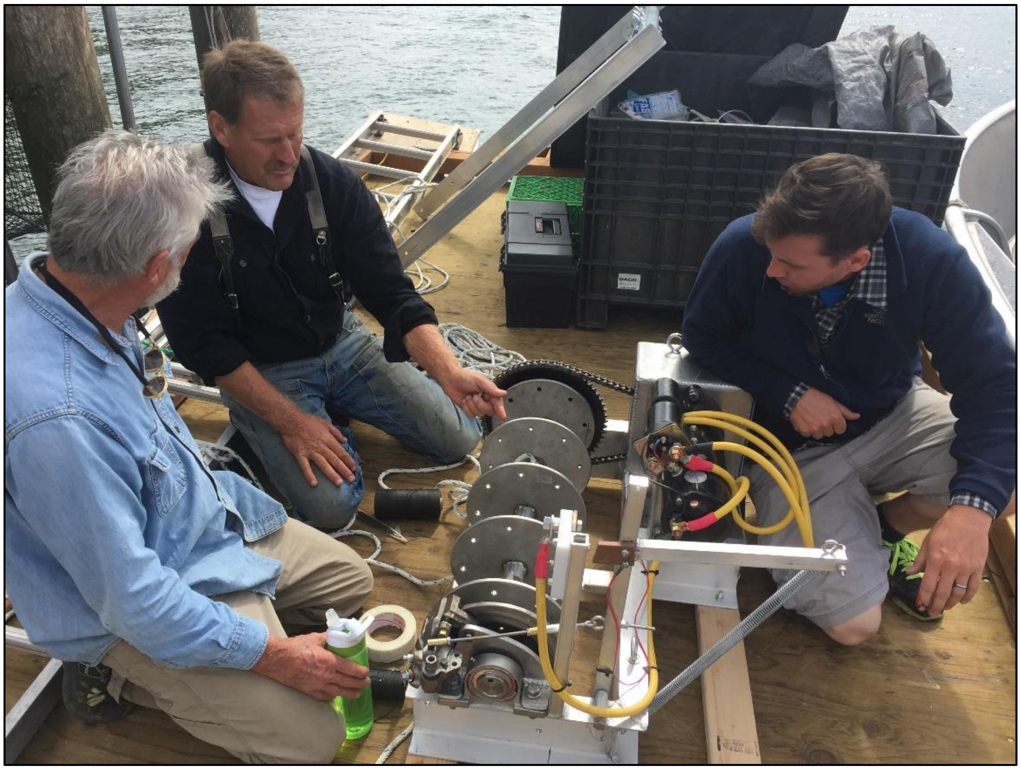

Figure 6. Installing the electric winch to lift the spiller bottom.

Figure 7. Salmon captured in the pound net trap spiller. The tunnel orifice (left) is open to fish passage.

Figure 8. WFC and local fishermen lifting the pound net trap spiller by hand prior to installation of the electric winch. All work could be performed from the live-well dock (Photo courtesy of Ann Stephenson and WDFW).

Collaborating with WDFW, Blair Peterson and WFC initiated test fishing on August 25th, 2016. The gear was fished for a total of 30 days, ending on September 29th, 2016. This period represented the peak of Fall Chinook upriver migration in the Lower Columbia Sub-basin (Healey 1991). Fall Chinook (both brights and tules) and coho salmon were the target species of the evaluation.

Testing proceeded in the following manner. At least four individuals were present on site, including lead fisherman Blair Peterson, one WDFW observer, and two trained WFC employees. Mr. Peterson and WFC staff were primarily involved in the deployment and retrieval of the gear, the capture and handling of fishes, and positioning of the work vessel. The WDFW observer was solely responsible for recording data. Prior to deployment of the gear, observers recorded the following information: the date, beginning set time, set number, participants involved, tidal conditions, weather, water conditions, and presence of marine mammals (Ashbrook et al. 2007). The spiller remained lifted out of the water with the tunnel closed prior to initiation of the soak period, defined as the period in which the spiller was deployed to the river bottom and the tunnel door opened to fish passage.

When all participants were prepared, the trap spiller was deployed by releasing lines and disengaging the electric winch brake. The tunnel door was opened by tightening the harness pulley line to enable the capture of fish. Observers noted the beginning set time. The door remained open to fish passage until the desired soak period had ended or the capacity of the spiller had been reached. All observers closely analyzed the water column to ensure overcrowding was not occurring. Once the desired soak period has ended, the tunnel door was closed by releasing the tunnel harness line, preventing further entry or escape. An observer noted the end set time. The bottom of the spiller was then carefully lifted by hand or utilizing an electric winch (installed 8/27/2016) to lift and concentrate captured fishes toward the spiller door (positioned adjacent to the live-well of the sorting deck). Once the fish were spilled into the live well, they were individually removed, counted, identified for species type, stock, origin (presence of adipose fin clip), and capture status (free swimming, entangled in the gear) (WDFW 2014). With all catch data processed, the fish were released from the live-well back into the river. Bodies of deceased fish were assessed for the cause of death and donated to local food banks (Ashbrook et al. 2007). After all specimens were processed and released, additional sets were initiated throughout the 12-hour test fishing day.

The relative success of pound nets in effectively capturing salmon with high release survivorship was evaluated by comparison of data to results of previous alternative gear pilot studies conducted in 2009 (Table 2). A gear must first demonstrate “adequate promise to warrant additional [year-2] testing” (involving a comprehensive quantitative evaluation of cumulative mortality) [WDFW 2010]. According to WDFW (2010), “adequate promise” is demonstrated if 1) fish captured are in excellent condition; and 2) few immediate mortalities are observed.

Table 2. 2009 Lower Columbia River alternative gear evaluation pilot study results (WDFW 2010).

Gear	# of Test Fishing Days	Coho	Chinook	Steelhead	Immediate Mortality
Purse Seine	15	397	213	54	0%
Beach Seine	11	112	49	17	0%

Total salmon catch and immediate survival (survival from capture to release) were compared to previous test results of beach and purse seines in 2009 (Table 2). Immediate survival was determined from the following:

$$\hat{S}_I = \frac{T}{n}$$

where

n = total number of fish captured with the pound net,

T = number of fish released from the pound net that survived.

RESULTS

The pound net trap was fished for a total of 30 days from August 25th through September 29th, 2016. A total of 2,144 salmonids were captured throughout the study. 2,135 salmonids (99.58% of catch) were released in a vigorous and lively condition from the trap. 9 coho jacks were killed (7 of hatchery origin; 2 wild), resulting in a mortality rate of 0.42%. All jack mortalities were caused by gilling or wedging in the upper spiller mesh (3.25''). The majority of fish caught were steelhead (816), followed by coho salmon (787), and Fall Chinook salmon (534). Two sockeye (*Oncorhynchus nerka*) and five chum salmon (*Oncorhynchus keta*) were captured in late August and late September respectively, in addition to one shad (*Alosa sapidissima*) and a largemouth bass (*Micropterus salmoides*).

Mean daily catch was 71 salmonids with a max catch of 208 on September 12th and a minimum catch of 7 on August 25th and September 29th. Catch increased dramatically after September 4th when issues were resolved with the trap lead and heart in which sections of the mesh were not fully descended to the river bottom.

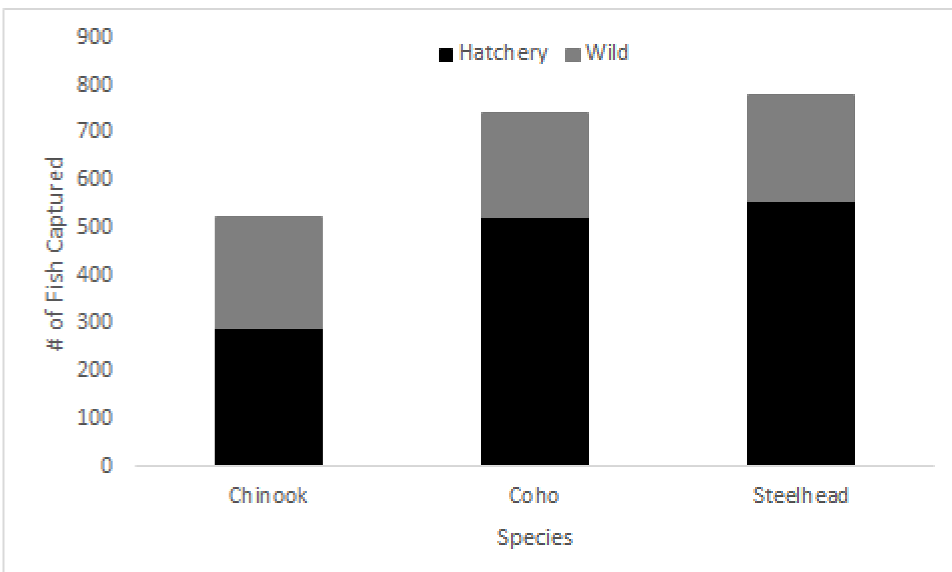

Figure 9. Total catch by species and origin (hatchery vs. wild). Catch composition was dominated by steelhead trout and coho salmon.

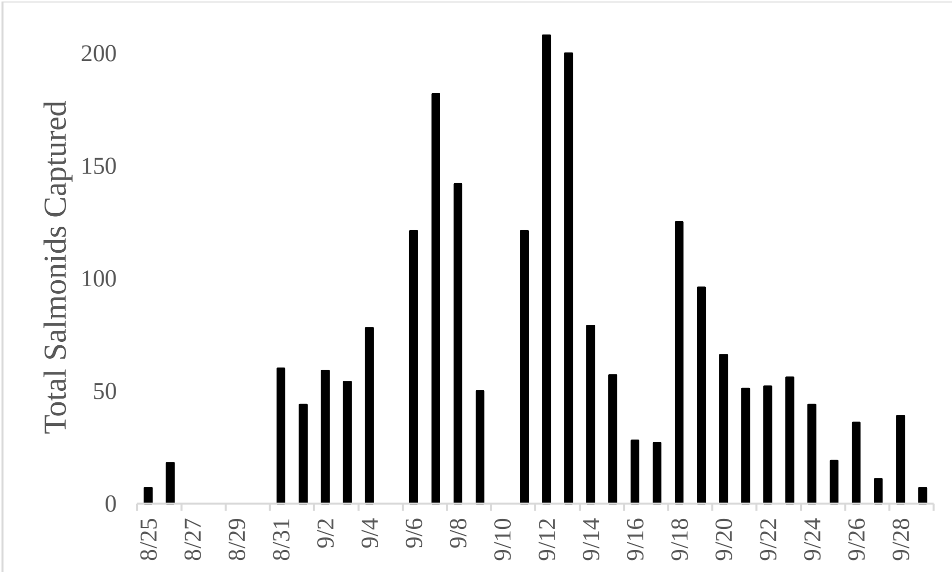

Figure 10. Salmonid catch totals throughout the 30-day test fishing period. Catch increased dramatically after issues with the trap heart and lead were resolved (September 4th). Catch peaked on September 12th. The trap was not fished from August 27th-30th, and on September 10th.

Soak period, defined as the length of time in which the tunnel door remained open to fish passage per set, ranged from 0.5 to 7.5 hours with a mean of 2.1 hours (SD = 1.1 hours). The mean length of time between sets in a day was 10 minutes with a minimum of 5 minutes (SD = 5 minutes).

The presence of marine mammals was noted at various times throughout the study. The number of marine mammals increased in late September. In response, a marine mammal barrier (a 7 ft. aluminum bar positioned vertically) was installed on the tunnel orifice. Prior to installation of the marine mammal barrier, two seals entered the spiller and were released unharmed by lowering the spiller mesh.

DISCUSSION

Capturing 2,144 salmonids in the 30-day test fishing period and demonstrating a 99.58% immediate survival rate, it is evident that pound net fish traps are effective in capturing commercially viable quantities of salmon in a lively and vigorous condition. Relative to year-1 results of 2009 purse and beach seine testing in the Lower Columbia River (Table 2), the experimental trap captured a greater total quantity of fish and a greater daily mean of the target species (Chinook and coho salmon), operating with only 57% of the 2009 August-October run-size (Fish Passage Center 2016). Although 9 coho jacks were killed throughout the duration of the study, this result is low impact relative to conventional harvest methods.

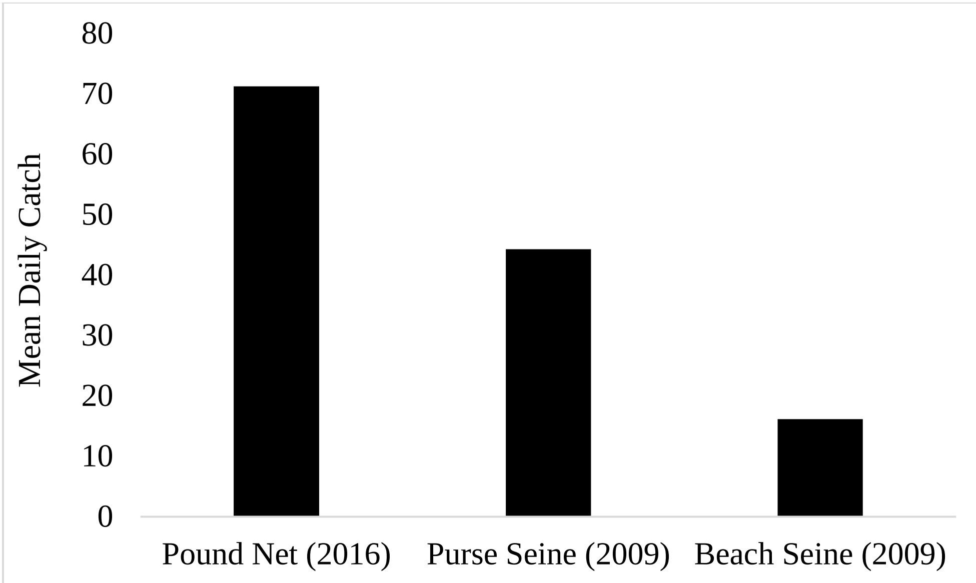

Figure 11. The 2016 pound net exhibited greater mean daily catch of both salmonids and the target species relative to Year-1 testing of beach and purse seines in 2009, operating with 57% of the 2009 August-October run size.

Future trap modifications may greatly improve catch efficiency, reduce jack mortality, and further minimize handling. Extending the trap lead and jigger would result in greater total catch and likely a higher ratio of Chinook relative to coho and steelhead. Having more lead mesh in deeper waters would likely entrap species that tend to migrate at greater depths and improve total capture. Catch can further be increased through installation of a mesh door at the upstream exit of the heart. The existing trap design enables fish to escape from the heart when the spiller compartment is lifted, reducing overall catch efficiency. Although the spiller was lifted and redeployed rapidly to minimize escapement from the heart and maximize catch efficiency, an upstream heart door would prevent all escapement between sets. Furthermore, by utilizing stainless steel cable in place of aluminum to guide the lifting and lowering of the spiller, the time between sets (mean = 10 minutes; min = 5 minutes) could be reduced substantially.

An aluminum gate with a series of vertical bars can be installed at the heart entrance to eliminate the potential of marine mammals entering the trap heart. Successfully deterring marine mammals from the spiller with the simple attachment of a vertical aluminum bar on the tunnel orifice indicates that a similar strategy can be employed at the heart entrance. Although marine mammals were not a significant nuisance to fishing operations in 2016, future testing efforts occurring at different times of the year could encounter a greater number of mammals; this possibility could hinder testing efforts if not resolved.

Reducing the mesh size of the entire spiller compartment from 3.25’’ to 2.5’’ would minimize the potential of wedging, improving survivorship of jacks drastically. Observing the location of wedging within the spiller, all mortalities occurred in the upper region of spiller compartment where mesh size was 3.25’’ relative to the spiller bottom (2.5’’ mesh). Furthermore, long-term survival would likely improve from any reduction in handling. By installing a small exit tunnel from the spiller to the live-well dock, the spiller would rarely need to be lifted, reducing mesh contact and enabling complete passive capture and release.

Installing gear modifications and utilizing a tag and recapture procedure, long-term and cumulative survival will be analyzed in future testing efforts. Employing Ricker's two release method and a traditional Jolly-Seber survival analysis, results of the experiment will indicate whether pound nets can effectively harvest an equal or greater number of salmonids with equal or improved cumulative survivorship of released fishes relative to previously tested alternative gears. Only through a more comprehensive and quantitative year-2 tagging study can pound net traps be successfully compared to existing gear-types.

If 2017 pound net testing proves effective in targeting hatchery salmon with minimal long-term and cumulative post-release mortality of non-targeted species, the commercial implementation of the gear will have far reaching benefits to ESA-listed wild fishes and local fishing communities. Currently, gillnets, purse seines, and beach seines are demonstrating high rates of cumulative post-release bycatch mortality (WDFW 2014). Enhancing the efficiency of hatchery harvest through the development of an effective stock-selective commercial gear, wild fishes would benefit from reduced competition on the spawning grounds and less severe levels of hatchery genetic introgression. In doing so, the productivity and genetic diversity of ESA-listed wild populations would be improved—critical components of their resiliency to variable climate conditions (Chilcote et al. 2011; Christie et al. 2014). Furthermore, increasing the selectivity of commercial fishing efforts and the survivorship of released fishes in the Columbia Basin would increase wild adult escapement and reduce rates of pre-spawn mortality. By meeting ESA recovery objectives and enhancing hatchery harvest efficiency, commercial and tribal fishing opportunities will be optimized, sustainable fisheries developed, and community resiliency may ultimately be improved for the long-term benefit of future generations. The rejuvenation of regional fisheries will initiate a ripple effect through local economies, improving the vitality of commercial fishing related businesses and maintaining the viability of working waterfront communities.

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