Evaluate Live Capture Selective Harvest Methods For Commercial Salmon Fisheries On The Columbia River

Final Report on 2001 Field Season

BPA contract #2001-007-00
Objectives 2 and 3

Geoffrey S. Whisler
Oregon Department of Fish and Wildlife
Interjurisdictional Fisheries
Columbia River Management

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- All mesh sizes tested (3.5”, 4.5”, 5”-6” range) functioned as tangle nets for adult spring chinook
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- Data suggests that 5.5” mesh may not be the ideal size for spring chinook tangle nets
- Nets hung at a 3:1 ratio showed a significantly higher immediate mortality rate on adult spring chinook
- Ideal spring chinook tangle net would be constructed of mesh greater than 3.5” and less than 5.5” and be hung at a ratio less than 3:1.

General Comments and Conclusions

- Fishers were willing and able to learn and experiment with live capture techniques for spring chinook fisheries
- The coho-sized recovery system used is not appropriate for spring chinook. Modifications to both box size and flow rate have been developed for chinook and should be utilized in future live capture studies
- Steelhead directed research should be planned and conducted to provide information on the effects of live capture gear to this species

Introduction

Commercial salmon fisheries in the Columbia River have gone through many changes since their inception in the mid-1800s. During the last several decades, fishing opportunity, as measured by number of seasons and open days, has been reduced markedly in response to declines in salmonid abundance. In response, commercial gillnet fisheries have become increasingly selective, with fishery managers primarily utilizing avoidance techniques such as time and area restrictions to minimize impacts to at-risk stocks. Additionally, restrictions on gillnet mesh size have been used to either target or avoid certain species. Until the early 1990s these regulations were effective at reducing impacts to depressed species and maintaining limited commercial fishing opportunities on abundant stocks.

During the last ten years the majority of the naturally produced salmonid stocks returning to the Columbia River Basin have been listed under the federal Endangered Species Act (ESA). Wild spring chinook (*Oncorhynchus tshawytscha*) from the Snake River were listed as threatened in 1992; upper Columbia River wild spring chinook were listed as endangered and lower Columbia River and Willamette wild spring chinook were listed as threatened in 1999. Any of these listed stocks could be encountered in a lower Columbia River winter or spring commercial salmon fishery. The ESA impact guidelines have reduced fishing opportunity for the sake of conserving depleted stocks. In response to the listing of wild Willamette spring chinook, the Oregon Department of Fish and Wildlife (ODFW) produced a Fishery Management and Evaluation Plan (FMEP) which took effect in February 2001. The FMEP included a requirement "that all unmarked, wild fish will be required to be released in all fisheries" (ODFW 2001) which in effect required the commercial fishery to immediately adopt live capture fishing gears and methods. In recent years, federal and state funded hatcheries have begun mass-marking hatchery produced spring chinook and coho (*O. kisutch*). The excision of the adipose fin prior to release provides a visual indicator of hatchery origin returning adults. This tool allows managers to structure fisheries around the harvest of hatchery-produced salmonids because fishers can identify potential wild fish to release. Mass-marked Willamette River spring chinook began returning in 2000 as three-year-olds, and 1998 was the first year of mass-marked coho returns to the Columbia River. This program has resulted in successful mark selective sport fisheries on these species.

Current commercial fisheries on the lower Columbia River consist of highly regulated gillnet fisheries that target spring and fall chinook, coho, sockeye (*O. nerka*), white sturgeon (*Acipenser transmontanus*), eulachon smelt (*Thaleichthys pacificus*), and American shad (*Alosa sapidissima*). These gillnet fisheries have a limited capacity for live release of non-target species or stocks. The ODFW and Washington Department of Fish and Wildlife (WDFW) use time and area closures coupled with gear restrictions (primarily mesh size) to focus fisheries on harvestable stocks or species while minimizing impacts on weaker stocks. This strategy is effective when only a few weak stocks or species need protection, but when the weak stocks are relatively abundant and not separated spatially, temporally, or by size from the harvestable stocks, these fishery management tactics limit fishing opportunities. This is now the case in the lower Columbia River. Reduced abundance, in concert with ESA protection, has resulted in restrictions on commercial harvest while surpluses of hatchery-origin chinook return to hatcheries and spawning grounds throughout the region. These surpluses are undesirable because they signify the region is underutilizing fish produced to supplement fisheries and because hatchery-origin salmonids present on the spawning grounds introduce both ecological and genetic risks to wild fish (Ford and Hard 2000).

The ODFW and WDFW are committed to providing sustainable harvest of hatchery-produced salmon for commercial fisheries and managing within ESA-related impact guidelines. In spring chinook commercial fisheries, the status quo management strategy does not achieve both of these objectives, highlighting a need for new management options. The answer may come from the development of selective live capture commercial fisheries. Successful selective live capture fisheries must accomplish two things: 1) fisheries must be conducted at economically feasible levels and 2) bycatch released from the gears must survive to complete their life cycle (whether non-target salmonids or other non-target species). Live capture fishing gear and methods would provide additional harvest opportunity and reduce impacts to federally-listed stocks since bycatch can be released alive. For the lower Columbia River the definition of bycatch must be expanded to include non-target stocks of the target species, (i.e., unmarked spring chinook).

The ODFW and WDFW have implemented selective recreational coho and spring chinook fisheries, allowing anglers to keep marked hatchery fish while releasing unmarked fish. Selective measures have also been implemented into regional commercial seine and troll fisheries to allow live release of non-target salmonids (ODFW-MRP 2001; DFO 2002). Various salmon trap designs have also been tested with minimal success (DFO 2002; Vander Haegen et al. 2002). The nature of a conventional gillnet fishery has precluded any real possibility for selective live capture fisheries without significant changes. Over the past few years, tangle (or tooth) nets have been tested as a possible substitute for the gillnet. A tangle net is basically identical to a gillnet except the mesh size is smaller, which can make a substantial difference in how a fish is captured. A gillnet is designed to capture an adult salmon by the body or under the operculum while the tangle net, with its smaller sized mesh, prevents adult fish from entering the net as far, resulting in capture by facial protrusions, teeth, or the head. This method of capture appears to be more benign in that physical damage to gill structure and removal of scales and slime layer is drastically reduced. Variations such as hang ratio or the addition of strings to slacken the net are frequently used in gillnet construction to increase catch efficiency and can also be used with tangle nets. Because the design and fishing methods associated with tangle nets are very similar to gillnets, they are an attractive live capture gear for implementation into commercial fisheries.

Live capture selective commercial fishing methods are not limited to changes in net construction. Other important components of a live capture fishery include reducing drift time, reducing net length, implementing proper fish handling techniques, and use of laminar-flow recovery boxes. Shortened drift times and shorter nets result in a captured fish spending less time in the net, thereby entering the boat in relatively better physiological condition. (Ferrell et al. 2000; Gallaugher et al. 2001) Good handling practices can be employed to reduce physical damage and air exposure. Finally, a recovery box is used to resuscitate lethargic or injured fish by providing a safe and isolated environment to recover along with a constant supply of river water pumped over the fish's gills to assist with ventilation.

Various recovery box designs have been developed and tested in British Columbia, Canada since 1998. The Fraser-style laminar-flow recovery box (developed primarily by Jake Fraser with technical and analytical assistance from fisheries physiologists at Simon Fraser University (SFU)) has proved to be the most successful in reviving salmonids in a severely stressed physiological state (Farrell et al. 2001; Berry et al. 2001). This system is designed to recover fish from a weakened physiological state resulting from capture to an improved state conducive to live release. It is also designed to revive fish that show no visible signs of life at capture, and would otherwise be categorized as an immediate mortality, to a "normal" (pre-capture) physiological state. Their studies demonstrated that salmonids revived with this system had extremely high post-release survival rates (97% in 2001) (Farrell et al. 2001). Beginning in 2003, after a two-year transition period, the Fraser recovery system will be the only style allowed in Canadian live capture gillnet, tangle net, and selective troll fisheries.

Since the concept inception in 1995, several studies have examined the effectiveness of tangle nets on a variety of salmon species including chum (*O. keta*), coho, chinook, and steelhead. While these studies have been highly variable in scope and approach, they clearly show that fish released from tangle nets are in better condition than those released from gillnets and, correspondingly, immediate mortality rates of salmon caught in gillnets are higher. Reported post-release survival rates are also variable but several similar tests of small mesh gear and recovery boxes have shown rates exceeding 97% for coho after a 24-hour holding period (Fraser 1999; Farrell et al. 2000; Farrell et al. 2001). Furthermore, salmon caught in experimental tangle net fisheries in British Columbia, Canada have a significantly higher market value than those captured in conventional gillnets due to the nature of the fishery. Live capture gear and careful handling practices result in little or no bruising of the flesh and minimal scale loss, resulting in a high quality product; this methodology also lends itself to the development of live fish markets (Petrunia 1997; Blewett and Taylor 1999).

Based on these results, the tangle net and recovery system concept shows promise as a selective fishing option. However, none of these studies focused on spring chinook, occurred in the Columbia River, or examined the logistics of incorporating tangle nets and associated live capture fishing techniques into a full fleet commercial fishery. A pilot project, funded by ODFW, was conducted in the spring of 2000 to determine if the use of small mesh tangle nets in the Columbia River was worthy of further investigation. The pilot study was limited to seven test fishing days between April 17 and May 18 in the lower Columbia River between river miles 17 and 25. Study design included the comparison of 3.5" and 6.75" (multifilament) mesh sizes, shorter than typical soak times[†] (43-minute average), and the use of recovery boxes. Conclusions from the pilot study were summarized in Hirose (2001):

1) Small mesh tangle net gear performed as well as conventional gill net gear in capturing spring chinook.
2) Condition of salmon at capture was better for fish captured with 3.5" mesh tangle net gear than for fish captured using conventional 6.75" gill net gear.

[†] Soak time is defined as the time elapsed between the first mesh of the net entering the water and the last mesh exiting the water; therefore, is a measure of the total time the net spent in the water. Due to natural uncertainties in fishing conditions (i.e. amount of catch, amount of debris in the water, stage of tide, snagging of gear on submerged objects, etc.) soak times can be highly variable.

3) Immediate and delayed (48-hour holding period) mortality rates can be reduced by shortening drift times and improving the onboard recovery tank design.

Based on the positive results of the 2000 ODFW pilot study, ODFW and WDFW submitted a joint project proposal (#23036) that was funded by the Bonneville Power Administration (BPA) in 2001.

Four objectives were outlined in the original funding proposal submitted and ultimately approved for funding by the Northwest Power Planning Council. The ODFW was the lead agency for the 72-hour post-release survival (objective 2) and limited entry demonstration fishery (objective 3) portions. From the high priority project proposal narrative submitted to the Bonneville Power Administration: Objective 2 was designed to evaluate the "effects of drift time on catch rate and post-release survival of adult spring chinook captured and released from a conventional gillnet and from a tangle net." Two tasks were identified: "2.1 Capture adult salmonids with drifts of 10, 20, and 30 minutes in duration; describe, tag, and hold adult spring chinook; 2.2 Summarize results and compare catch efficiency and condition at capture and release by drift time." Objective 3 compared the "catch efficiency and condition at capture of adult spring chinook salmon caught in tangle nets constructed with 3.5" or 4.5" mesh and describe by-catch." Three tasks were identified for this objective: "3.1 Select fishers to participate in experimental gear permit fishery; 3.2 Fish gears and characterize catch; 3.3 Summarize and analyze data and compare catch and condition at capture for unmarked spring chinook by gear types."

The WDFW was the lead agency on the two remaining objectives designed to evaluate longer-term survival of spring chinook released from 3.5" mesh tangle net and 8" mesh gillnet (objective 1) and investigate the feasibility of using a floating trap to selectively harvest spring chinook (objective 4). The results were reported in Vander Haegen et. al. (2002).

This study continues the work being done on the concepts of live capture selective commercial fisheries while addressing the specifics related to Columbia River spring chinook fisheries and implementation. This report summarizes activities and findings by ODFW in the spring of 2001 related to objectives 2 and 3.

Objective 2: Evaluation of Drift Time and Gear Type on Fish Condition and Post-Release Survival

Methods

Two local commercial fishers were chosen by means of a competitive bidding process and contracted to perform all fishing operations. Each fished up to two days per week for 10 total days between April 10 and May 24. One boat fished near Skamokawa, Washington (RM 33) for the entire period while the other fished near Tongue Point, Oregon (RM 18) for 4 days and Clifton, Oregon (RM 38) for the remaining 6 days (Appendix A). Both test fishers attended a workshop co-sponsored by ODFW, Department of Fisheries and Oceans Canada, and Northcoast Selective Gillnetters Association (British Columbia, Canada) prior to the test fishery. This workshop covered the concepts vital to live capture methodology, focusing on the overarching ideas and specifics of live fish handling and recovery. Proper handling techniques were emphasized during the study.

A net constructed of one shackle of conventional gillnet and one shackle of tangle net was fished at least one drift each sampling day for specified drift times[†] of 10, 20, and 30 minutes each; therefore each contracted vessel made at least three drifts per fishing day. Actual lengths of the shackles varied with abundance of spring chinook in the system but did not exceed 75 total fathoms (≈137 meters) each for a maximum net length of 150 fathoms (≈274 meters). Shorter nets were fished early when salmonid abundance was highest and lengthened as the peak of the run passed. The conventional gillnets were constructed of either 6.75” or 7” multifilament nylon mesh web and were hung at a ratio of 2:1. The tangle nets were constructed with 3.5” multifilament nylon mesh and hung in at a ratio of 3:1. The hang ratio defines how many stretched fathoms of web are hung per fathom of corkline. Neither net was slackened with strings. Alternate ends of the net were picked up first to rotate the net and ensure equal drift time for each gear type. Start and end times of both the layout and pick-up of the gear were recorded. General weather conditions, turbidity, water surface temperature, and the locations of the drift were also recorded.

All catch from each gear type was enumerated and placed into a live tank containing fresh river water. All non-salmonid bycatch was noted and released overboard. Specific biological data was collected from all salmonids including species, visual stock identification (VSI), condition at capture, physical capture method, fork length, and presence of any fin marks. Condition assessments were made according to the standard 1-5 scale described below. Any salmonid not graded a 1 or 2 was placed into a recovery box until revived to this condition level or the biologist made the determination that it would not revive in a reasonable amount of time. Each live salmonid was then tagged with a numbered anchor tag placed at the base of the dorsal fin. During the holding period, these tags functioned as unique identifiers on each salmonid allowing for an evaluation of post-release survival. After

[†] Drift time is defined as the time elapsed between the first mesh of the net entering the water and the first mesh exiting the water; therefore, is a measure of the time the net was fished before retrieval is initiated. This variable is easy to hold constant.

each drift, fish were transported via the live tank or recovery box on the fishing vessel to an anchored net pen (20'x20'x8') for a 72-hour holding period. Transportation time was less than 20 minutes. The condition at release into the net pen was recorded for each fish. At the end of the holding period all live salmonids were released and tag numbers were recorded from any mortalities.

Physical method of capture by the nets was recorded for each salmonid. The classifications used were: tangled (captured by the mouth or head anterior to the insertion of the operculum), gilled (between the insertion of the operculum and the pectoral collar), and wedged (captured by the body).

The ranking scale used to assess salmonid condition was developed over time for use in the evaluation of Canadian selective fisheries. The five-tiered scale is defined as follows: 1- lively and no bleeding; 2- lively but bleeding; 3- lethargic and no bleeding; 4- lethargic but bleeding; 5- no sign of ventilatory movements. These rankings have been correlated to physiological measures of stress (Gallaugher and Farrell 1999). An immediate mortality is defined as a fish that did not survive the capture process despite attempts at revival. Post-release survival was determined by observing the number of fish released into the net pen that were still alive after the 72-hour holding period. Overall survival is defined as the total catch minus the sum of immediate and 72-hour delayed mortality.

Laminar-flow recovery boxes were utilized to revive and recover stressed or lethargic salmonids. These aluminum boxes had two chambers for fish, each measuring 42"L x 8"W x 16"H. Fresh river water was pumped into one end of the box via a Rule® 3700 12-V submersible bilge pump hung overboard when in operation. System flow rate was approximately 24 gal/min, providing about 12 gal/min to each chamber of the box. The recovery system used in this study was based on designs developed in British Columbia for coho and steelhead (*O. mykiss*) and was the latest available at the time. Chinook size-specific modifications are currently being developed and tested in British Columbia and Oregon.

Data collected on both chinook and steelhead catch was analyzed. Catch of target and non-target salmonid stocks and species were summarized by gear and assigned drift time. Due to the fact that net length was varied relative to abundance, and the natural variation in actual soak time, a rate of catch per hour per fathom of net was calculated and multiplied by 100 to standardize catch efficiency. Catch rate values were pooled by gear type to compare differences between the tangle net and gillnet, and conversely, pooled by assigned drift time to analyze differences associated with time. Regression analyses were performed to determine the strength of correlations between drift time and catch rate and drift time and overall survival (See Appendix B for regression graphs). An F-Test (α=0.05) was performed to compare variance in catch rates between gear. Analysis of variance (ANOVA) single factor test (α=0.05) was performed on the pooled data set to evaluate differences in catch rates between drift times. Chi-square analysis tests were conducted on condition assessments to compare the frequency of fish graded as 1 and 5 at capture versus those assessed at a different level, and the frequency of immediate mortality. Survival rates were analyzed using a general linear models procedure (GLM) followed by a Tukey's studentized range test to determine pairwise differences (α=0.05).

Results

Data from two days of test fishing have been excluded from the summary and analysis due to the potential introduction of bias. On April 10, more than 30 salmonids were captured in the 10-minute drift, reducing our ability to collect accurate data, tag the fish, and hold them for transport. The decision was made to cease operations for the day and use shortened gear the next day. On May 24, the live box pump failed during transport to the net pen. The fish were released back into the river rather than subjecting them to transportation without circulating water.

A total of 162 drifts were made over the test period, equally divided between tangle net and gillnet gear and evenly distributed among the three designated drift times. A total of 80 spring chinook were captured, comprised of 73 adults and 7 jacks. A jack is defined as a precocious returning salmon with a fork length measurement of less than 61 cm. Forty-one adult spring chinook and 7 jacks were captured with the tangle net and 32 adults and 0 jacks with the gillnet. Sixteen adults were captured in the 10-minute drifts, 26 in the 20-minute drifts, and 31 in the 30-minute drifts. Additionally, a total of 22 steelhead were captured, 21 in the tangle net and 1 in the gillnet. Of these, seven were in 10-minute drifts, six in 20-minute drifts, and nine in 30 minute drifts.

Actual soak times were approximately 11 minutes longer than the assigned drift times. Specifically, the 10-minute drifts resulted in a mean soak time of 21 minutes, 20-minute drifts averaged 31 minute soak time, and the 30-minute drifts resulted in a soak time of 42 minutes.

Spring Chinook

Gear Efficiency

The standardized mean catch rates (adult chinook/hour/fathom) were similar by gear, 1.49 for the tangle net compared with 1.40 for the conventional gillnet. Standardized catch rate for ten-minute drifts (adult chinook/hour/fathom) averaged 1.66, 20-minute drifts averaged 1.26, and 30-minute drifts averaged 1.41. Differences were not significant for either variable (gear type: df=78, P=0.44; drift time: df=157, P=0.86). Tangle net catch rates did trend downward (R^2=0.92) as drift time increased (Table 2.1). Catch rates with the gillnet indicated an upward trend associated with drift time but the correlation was weak (R^2=0.11).

Only drifts for which soak time could be calculated (both start and end times recorded) were used in the analysis of catch efficiency. Any catch not associated with a soak time would not be reflected in the catch rate.

Table 2.1. Catch rate by gear type and drift time of adult spring chinook captured in the lower Columbia River between April 10 – May 24, 2001.

Drift Time	10 min		20 min		30 min	
	Tangle Net	Gillnet	Tangle Net	Gillnet	Tangle Net	Gillnet
Chinook Caught	10	6	13	10	18	12
Catch/hr/fthm	1.93	1.46	1.39	1.17	1.22	1.61

Condition at Capture

The difference between the number of tangle net- and gillnet-caught adult spring chinook graded in condition 1 at capture was significant (df=1, *P*=0.05). Of all adult spring chinook captured in tangle nets, 83% were graded as condition 1 at capture compared with 63% of those captured with the gillnets. Immediate mortality of adult spring chinook was 7% for those caught in the tangle net and 13% for those caught in the gillnet.

Adult spring chinook in condition 1 at capture comprised 88% of the catch in 10-minute drifts, 69% in 20-minute drifts and 71% in 30-minute drifts. A chi-square analysis did not detect a significant difference in the frequency of capture condition 1 as a result of varying the drift time (df=2, *P*=0.37).

Although the frequency of adult spring chinook assessed in a condition other than 1 at capture appears to increase with drift time (Table 2.2), sample sizes are too small to test this observation statistically.

Table 2.2. Condition at capture (including immediate mortality) by gear type and drift time of adult spring chinook captured in the lower Columbia River between April 10 – May 24, 2001.

	10 min				20 min				30 min			
Condition	Tangle Net		Gillnet		Tangle Net		Gillnet		Tangle Net		Gillnet	
1	10	100%	4	67%	10	77%	8	62%	14	78%	8	62%
2	0	0%	2	33%	3	23%	2	15%	0	0%	2	15%
3	0	0%	0	0%	0	0%	2	15%	0	0%	1	8%
4	0	0%	0	0%	0	0%	0	0%	1	6%	0	0%
5	0	0%	0	0%	0	0%	1	8%	3	17%	2	15%
Immediate Mortality	0	0%	0	0%	0	0%	2	15%	3	17%	2	15%

Physical Capture Method

Adult spring chinook captured in the tangle net were observed to be tangled (captured by the head or face) 98% of the time (Figure 2.1). One fish, or 2% of the catch, was caught by the body (wedged); most likely this was due to a broken mesh while none were gilled by the 3.5” tangle net mesh. The gillnet resulted in a very different physical capture method profile for adult spring chinook with 78% gilled, 13% wedged, and 9% tangled.

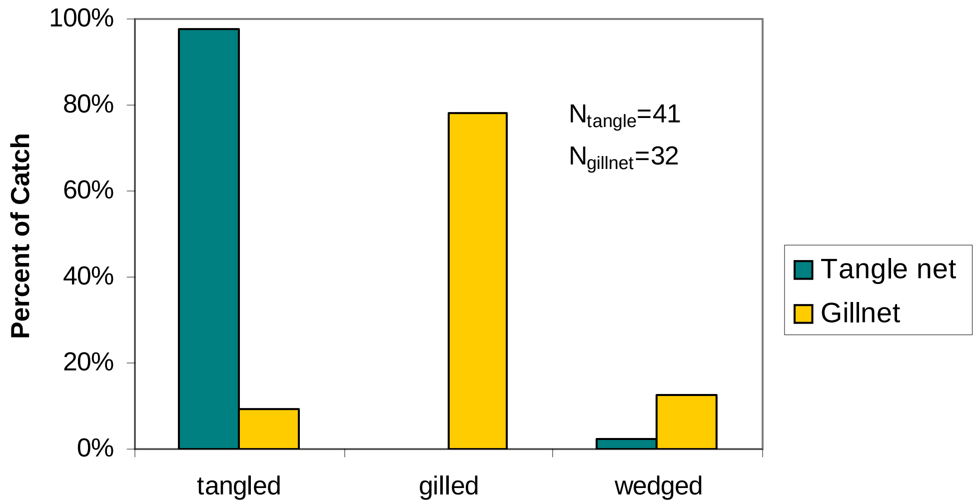

Figure 2.1. Physical method of capture by gear type for adult spring chinook captured in the lower Columbia River between April 10 - May 24, 2001.

Post-release (72-hour) and Overall Survival

Of adult spring chinook caught with the tangle net and released alive into the net pens, 97% survived the first 72 hours after capture compared to 93% survival of gillnet-caught fish. The only delayed mortality was observed from the groups of fish captured in 20-minute drifts (88% survival).

Differences in overall survival by gear or drift time were not found to be significant (gear: $P>0.05$; time: $P>0.05$). The overall survival for both gears trended downward as drift time increased. Overall survival of adult spring chinook was 100% for 10-minute drifts with both gears, 92% and 69% in 20-minute drifts with tangle net and gillnet respectively, and 83% and 85% for tangle net and gillnet drifts of 30 minutes (Table 2.3). The tangle net data demonstrated a strong correlation between drift time and survival (R^2=0.99) while the gillnet did not (R^2=0.23). By gear, overall survival was 90% for tangle net-caught adult spring chinook and 81% for those captured with the gillnet.

Table 2.3. Post-release (72-hour) and overall survival rates by gear type and drift time of adult spring chinook captured in the lower Columbia River between April 10 – May 24, 2001.

Drift Time	10 min		20 min		30 min	
	Tangle Net	Gillnet	Tangle Net	Gillnet	Tangle Net	Gillnet
Chinook Held	10	6	13	11	15	11
72-hr Survival	10	6	12	9	15	11
Survival Rate	100%	100%	92%	82%	100%	100%
Overall Survival Rate	100%	100%	92%	69%	83%	85%

Steelhead

Gear Efficiency

The difference in steelhead catch rates between the two gear types were found to be statistically significant (df=78, $P<0.05$). The standardized mean catch rate (steelhead/hour/fathom) was 0.72 for the tangle net and 0.05 for the conventional gillnet.

Since only one steelhead was captured in the gillnet, only data from the tangle net was analyzed for differences in drift time. No significant differences in catch rates between drift times were found (df=77, $P=0.30$). Catch rates (steelhead/hour/fathom) averaged 1.22 for 10-minute drifts, 0.50 for 20-minute drifts, and 0.49 for 30-minute drifts (Table 2.4).

Table 2.4. Catch rate by gear type and drift time of steelhead captured in the lower Columbia River between April 10 – May 24, 2001.

Drift Time	10 min		20 min		30 min	
	Tangle Net	Gillnet	Tangle Net	Gillnet	Tangle Net	Gillnet
Steelhead Caught	6	1	6	0	9	0
Catch/hr/fthm	1.22	0.16	0.50	--	0.49	--

Condition at Capture

Of steelhead caught in the tangle net, 75% were graded in condition 1 at capture as was the only steelhead caught in the gillnet. Four of the 21 steelhead (19%) captured with the tangle net were immediate mortalities.

Sixty seven percent (67%) of steelhead captured in the 10 minute drifts were assessed to be in condition 1 at capture as were 83% from 20 minute drifts and 78% of those from 30 minute drifts (Table 2.5). Sample sizes were too small to detect significant differences in condition at capture by drift time for steelhead captured in the tangle net.

Table 2.5. Condition at capture (including immediate mortality) by gear type and drift time of steelhead captured in the lower Columbia River between April 10 – May 24, 2001.

	10 min				20 min				30 min			
Condition	Tangle Net		Gillnet		Tangle Net		Gillnet		Tangle Net		Gillnet	
1	3	60%	1	100%	5	83%	0	--	7	78%	0	--
2	0	0%	0	0%	0	0%	0	--	0	0%	0	--
3	1	20%	0	0%	0	0%	0	--	0	0%	0	--
4	0	0%	0	0%	0	0%	0	--	0	0%	0	--
5	1	20%	0	0%	1	17%	0	--	2	22%	0	--
Immediate Mortality	1	20%	0	0%	1	17%	0	--	2	22%	0	--

Physical Capture Method

The 3.5" mesh functioned as a tangle net for steelhead with 90% captured by the face or head. One steelhead (5%) was wedged, and one was gilled by the tangle net. The one gillnet-captured steelhead was gilled.

Post-release (72-hour) and Overall Survival

Of tangle net-caught steelhead released alive into the net pens, 82% survived through the first 72 hours after capture. The single steelhead captured with the gillnet survived through the 72-hour holding period.

Table 2.6. Post-release (72-hour) and overall survival rates by gear type and drift time of steelhead captured in the lower Columbia River between April 10 – May 24, 2001.

Drift Time	10 min		20 min		30 min	
	Tangle Net	Gillnet	Tangle Net	Gillnet	Tangle Net	Gillnet
Steelhead Held	5	1	5	0	7	0
72-hr Survival	5	1	4	--	5	--
Survival Rate	100%	100%	80%	--	71%	--
Overall Survival Rate	83%	100%	67%	--	56%	--

Differences in the overall survival of steelhead related to drift time were not significant for tangle net caught fish (P>0.05). Overall survival was 83%, 67%, and 56% for tangle net drifts of 10, 20, 30 minutes, respectively (Table 2.6). This downward trend was highly correlated to drift time (R^2=0.99). Seven of the 21 steelhead captured in the tangle net died within 72 hours, resulting in a 33% overall mortality rate.

Discussion

This study demonstrated the benefit of a small mesh tangle net over a conventional gillnet as a selective live capture commercial fishing tool. This became evident when comparing initial condition of adult spring chinook, physical method of capture, and post-release survival. The 3.5" mesh clearly functioned as a tangle net on adult spring chinook, with the majority of the catch characterized as tangled. Similarly, the 6.75" and 7.0" mesh proved to function as a gillnet, the majority were gilled and a significant portion of the remainder were wedged. The tangle net showed significant improvement in the frequency of adult spring chinook captured in condition 1. It also had about half of the immediate mortality rate of the gillnet, although the instance of immediate mortality in both gears was too small for the chi-square test to detect a significant difference. Survival during the 72-hour holding period was similar for the two gears but the tangle net showed a slightly higher survival rate. Overall survival was also greater for the tangle net caught spring chinook.

Mesh size was not shown to have any statistically significant effect on overall catch rate of adult spring chinook. No significant differences in catch efficiency were observed associated with the drift time, however, some interesting distinctions were found between the two gears as drift times increased. While the gillnet appeared to be slightly more effective as drift time increased, the tangle net showed a strong negative correlation between catch rate and drift time. This suggests the 3.5” mesh used in the tangle net may have been too small to effectively hold adult spring chinook in the net beyond a short period of time. Further investigations into mesh sizes that could balance efficiency with post-release survival are recommended.

Longer drift times did appear to have a negative effect on the overall survival of adult spring chinook. While no significant difference was found between the frequency of fish in condition 1 at capture, both gears showed declining survival rates as drift time increased. An interesting note is that the tangle net showed a strong correlation between drift time and overall survival while the gillnet did not. Since the gillnet demonstrated a lower overall survival, this suggests that the harmful effects of gillnet capture may not be offset significantly by shortening drift time.

Steelhead stocks protected under the ESA may be encountered as bycatch in a lower Columbia River spring chinook commercial fishery making information pertaining to steelhead and potential live capture fishing gear crucial. This particular research, however, focused on the effects to spring chinook captured with small mesh tangle nets and conventional sized gillnets and relationships to drift time. The time frame of this study was characterized by a low abundance of steelhead, resulting in sample sizes too small for many statistical conclusions. The only finding was that the 6.75” and 7.0” mesh captured a significantly lower number of steelhead than the 3.5” mesh. The 3.5” mesh tangle net appeared to have mixed results regarding steelhead condition and survival. The majority of steelhead captured in this net were in condition 1 and 90% were classified as tangled. However, this net configuration also had a fairly high immediate and post-release mortality rate on steelhead. It is also difficult to draw any conclusions related to drift times. No significant differences in catch rates were detected between the drift times and no discernable pattern appeared regarding the percentage of steelhead graded in condition 1 at capture. A strong inverse correlation between overall survival and drift time did appear, indicating that this may be an important variable in steelhead survival.

The relative effectiveness of the tangle net demonstrated that this gear could be conducive to an economically feasible fishery although the 3.5” mesh size specifically proved to have limitations. Although a mesh size designed to gill spring chinook (6.75” and 7.0”) clearly is not appropriate for a live capture fishery on that species, the utility of a mesh large enough to avoid capturing steelhead may be useful in a species-selective fishery. The drift times used appear to work for the concept of live capture but a threshold where immediate mortality increased significantly was not identified. Considering the trend for spring chinook and steelhead survival to drop with increased drift time, caution should be used if longer times are allowed in an actual fishery.

Additional Recommendations

A 72-hour holding period can provide a measure of variable-specific post-release survival of bycatch, longer-term estimates are costly and extremely difficult to obtain in a system as complex as the Columbia River. Therefore, I recommend that future research investigate correlations between condition profiles (including immediate mortality) and a defined long-term survival period. Quantifying this correlation would give fishery managers greater confidence when using data collected by a fishery observation program to estimate impacts to ESA-listed stocks

It became apparent during the data analysis that modifications should be made to the current recovery system prior to implementation in a selective live capture fishery. None of the spring chinook graded at condition 5 at capture were actually revived. This indicates a major flaw in the specific variation of recovery system used in this study, probably stemming from an inadequate flow rate. This shortcoming was also observed in objective 3 and is discussed extensively in that discussion section.

Designing and conducting a steelhead specific study to evaluate effects related to live capture tangle net gear in the lower Columbia River is also recommended. This type of information is crucial to the overall evaluation of the appropriateness of implementing tangle net gear into fishery management strategies. Due to the difficulty in obtaining sufficient sample sizes of this species when research is focused on spring chinook, seperate research should be conducted closer to the peak of winter steelhead abundance in the lower Columbia River.

Objective 3. Evaluation of Selected Gear Variables within a Limited Entry Demonstration Fishery

Methods

Early in 2001, all licensed lower Columbia River gillnetters received a letter from the Oregon and Washington departments of Fish and Wildlife (ODFW and WDFW) soliciting interest in a limited entry experimental tangle net fishery. The responses generated a pool of 48 interested fishers from which twenty participants were randomly selected. This study was designed to simulate a fishery; the fishers sold adipose fin-marked chinook as compensation while releasing all steelhead, unmarked chinook, and other bycatch.

The Columbia River Compact set seasons between April 23 and May 18, 2001 and adopted regulations specific to this demonstration fishery at the April 20, 2001 hearing. Specific locations, dates, and other miscellaneous restrictions were included in a special "Permit to Use Experimental Tangle Net Gear to Live Capture Spring Chinook" issued to each participant by ODFW (Appendix C). Drift time, measured from the time the first mesh of web entered the water to the time the first mesh exited during the pick, was initially limited to 30 minutes but reduced pre-season to 20 minutes as a conservation measure. Individual daily catch limits of 181 chinook handled were in place to ensure that the fishery did not exceed preset ESA impact levels.

Each participating fisher attended a training workshop co-sponsored by ODFW, Department of Fisheries and Oceans Canada, and Northcoast Selective Gillnetters Association (British Columbia, Canada) prior to the experimental fishery. This workshop covered the fundamental concepts of live capture, focusing on the overarching ideas and specifics of live fish handling and recovery.

All boats had a recovery box system onboard to revive salmonids prior to release. These systems varied from fisher to fisher but were based on a standardized design in development for use in selective salmon fisheries in British Columbia. Required dimensions were identical to those described in Objective 2. While recovery boxes could be constructed from any appropriate material, the majority were plywood and a few were made of aluminum. Pumps used for recovery systems included 12-V electric bilge pumps and built-in mechanical washdown pumps. Specific flow rates were not mandated by the Columbia River Compact or recorded during the fishery.

The non-treaty commercial fishing area between the mouth of the Columbia River and Bonneville Dam was divided into four distinct geographical regions (Appendix A); with one region fished per day. The fleet was evenly divided between these four areas, and boats fished their assigned area for the duration of the study. All boats fished one day per week over the four-week period. Each boat was allowed to fish a maximum of 10 hours, which would equate to roughly one half of a tidal phase (e.g. low slack to high slack) when taking into account natural variation in tidal timing. Specific times and places within these parameters were up to the discretion of the fisher. An ODFW or WDFW observer was onboard each vessel during all fishing activities to monitor activities, assist with handling and recovery of the catch, record data, and educate the fishers on aspects of live capture techniques.

All catch was enumerated by species and selected biological data such as VSI, fork length, and presence of fin marks was recorded from released fish. Condition at capture was assessed for all salmonids to be released using the standard grading scale described previously. Salmonids graded 1 or 2 were released directly overboard; while those graded 3-5 were placed into the recovery box until either revived or the observer determined that further recovery was not possible. Any dead, unmarked chinook were sampled for coded-wire tags (CWTs) and donated to local charities. All other bycatch was recorded and released immediately.

Biological sampling of the sold catch occurred at buying stations as it would for any lower Columbia River non-treaty commercial fishery. The sampling is crucial for in-season fishery management and post-season fishery evaluation because it provides information needed for run reconstruction purposes, including the determination of stock composition for the kept catch. Data collected includes average weights, fork lengths, scale samples, and recovery of fin marks and CWTs.

Catch efficiency was calculated as the number of fish caught per hour standardized to 75 fathoms of net. Chinook catch rates include adults only while steelhead catch rates include all age classes. Length frequencies and catch rates were analyzed with an analysis of variance (ANOVA) single factor test (α=0.05). Chi-square tests (α=0.05) were performed to compare frequencies of salmonids graded as either 1 or 5 at capture, and those graded 5 at release (immediate mortality) by gear type. Regression analyses were used to determine correlation between mesh size and condition at capture and mesh size and immediate mortality (See Appendix B for regression graphs). Differences in condition profiles at capture and release for adult spring chinook and steelhead were compared using chi-square tests (α=0.05). Data for all gear types were pooled by species for the recovery box analysis. Scale samples were analyzed to determine composition of spring chinook catch by age class. Coded-wire tag data was used to reconstruct the stock composition of the chinook catch.

This study was originally designed to gather data regarding the effects of two mesh sizes on condition at capture and catch efficiency in a controlled fishery setting. Compromises between the states late in the planning phase introduced two additional variables: hang ratio and the use of stringers to slacken the net. On May 7, halfway through the study season, a third mesh size range was added.

3.5” v 4.5” Mesh Size

All twenty boats fished 150 fathoms (≈274 meters) of net constructed of one 75-fathom (≈137 meters) shackle each of 3.5” and 4.5” mesh. All of the 3.5” mesh and most of 4.5” mesh was constructed with multifilament nylon webbing (three of nets used 4.5” monofilament nylon webbing). Results are not stratified by twine type because that variable was not a focus of this study. Two variations of tangle nets were employed. The first net variation had the web hung in at a ratio of 3:1 (meaning three stretch fathoms of web per fathom of corkline) and was left unslackened. The other variant was hung at a ratio of 2:1 (also known as hanging a net “even”) and slackened vertically using stringers. Each boat was assigned one of the two styles to fish for the duration of the study. Gear assignments were spread evenly throughout the four geographically defined study areas and the test fleet.

5”–6” Mesh Size

As the study progressed, the opportunity arose to expand the scope of the gear under examination. Industry proposed that gear constructed with web of a mesh size between 5” and 6” be incorporated into the study in addition to the gear currently in use. Managers evaluated the progress of the study to date and concluded that encounter and impact rates to listed stocks were minimal, therefore expansion of the study/fishery was reasonable. As a result, each participating fisher was given the opportunity to fish one additional day per week with nets of their choosing, up to 150 fathoms (≈274 meters) long, with the mesh size restricted to 5” minimum and 6”maximum. Drift time restrictions were relaxed to a maximum of 45 minutes although the participating fishers by now realized the necessity of short soak times in live capture fisheries and voluntarily kept drift times under half an hour.

All of the data collected during this portion of the study was the same as described above (3.5” v 4.5” portion) with one addition: physical method of capture. The classification of physical method of capture was described in the methods section for objective 2.

Results

Data from the first week of the four-week fishery is not included in this summary or analysis. We had not received all of the materials from the manufacturer necessary to construct the test nets by the scheduled start date of April 23, therefore we were unable to conduct the study as designed until the following week, beginning May 1.

During the 5”-6” mesh evaluation, the majority of drifts (63%) were fished with nets constructed of mesh sizes between 5” and 5.5” (inclusive), 17% used 5.63”, and exact mesh size was not recorded on 21% of drifts although they fell within the required range.

Soak times, measured as the time elapsed from the first mesh to enter the water to the last mesh removed, for 150 fathoms of net averaged 47 minutes in the 3.5” v 4.5” portion (range: 17 minutes to 2 hours 31 minutes). Soak time in the 5”-6” portion averaged 52 minutes for 150 fathoms of net (range: 16 minutes to 2 hours 38 minutes).

Catch

For the three weeks of data used in the analysis (May 1 – May 18, 2001), 582 drifts captured 638 adipose-marked spring chinook (including 186 jacks), 412 unmarked spring chinook (including 84 jacks), and 160 steelhead in the 3.5" v 4.5" mesh comparison (Table 3.1). The additional 5"-6" mesh evaluation, conducted from May 7 – May 18, 2001, captured 449 adipose-marked spring chinook (including 123 jacks), 264 unmarked spring chinook (including 63 jacks), and 88 steelhead in 151 drifts (Table 3.1).

Marked chinook averaged 62% of the chinook catch for all gears over the course of the season. Mark rates were similar for all gear types since all gears were fished concurrently.

Table 3.1. Gear specific summary for spring chinook and steelhead captured in the lower Columbia River, May 2001.

Gear				Catch						
				Spring Chinook						Steelhead
Mesh Size	Fathoms	Hang Ratio[a]	Drifts	Adult			Jack			
				Marked	Unmarked	Total	Marked	Unmarked	Total	Total
3.5"	75	3:1	175	101	61	162	37	22	59	53
3.5"	75	2:1 S	117	69	52	121	25	7	32	26
4.5"	75	3:1	175	151	121	272	61	31	92	46
4.5"	75	2:1 S	115	131	94	225	63	24	87	35
5-6" [b]	150	Various	151	326	201	527	123	63	185	88

[a] "S" Indicates net was slackened
[b] May 7-18, 2001

Length frequency

The average fork length of released spring chinook was similar for all gears. The mean fork length of adult spring chinook caught with both 3.5" and 4.5" mesh hung in 3:1 was 76 cm. The same mesh sizes hung even and slackened caught fish with mean fork lengths of 78 cm and 77 cm respectively. Adult spring chinook captured in the 5"-6" mesh averaged 76 cm in fork length. Mean fork length was not significantly different between each unique gear style (df=533, *P*=0.14) or between mesh size only (df=533, *P*=0.78).

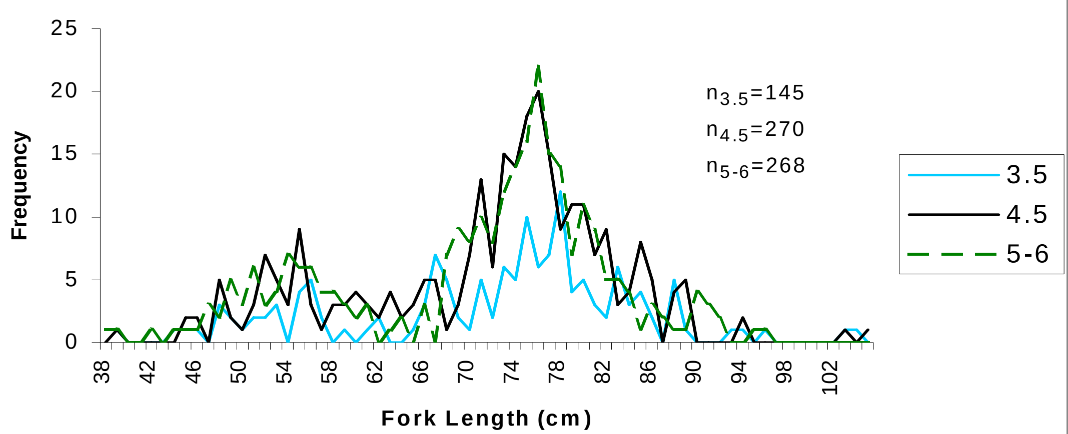

Figure 3.1. Mesh-specific length frequencies of spring chinook captured in the lower Columbia River, May 2001.

Gear Efficiency

Table 3.2. Gear specific catch rates of adult spring chinook and steelhead captured in the lower Columbia River, May 2001.

Gear		Mean Catch Rate	
Mesh Size	Hang Ratio[a]	Adult Spring Chinook	Steelhead
3.5"	3:1	1.43	0.48
3.5"	2:1 S	1.67	0.36
4.5"	3:1	2.17	0.38
4.5"	2:1 S	2.65	0.36
5-6"[b]	Various	2.16	0.39

[a] "S" Indicates net was slackened
[b] May 7-18, 2001

Standardized catch rates of spring chinook ranged from 1.4 to 2.6 fish per drift (Table 3.2). Catch rates with 3.5" mesh were significantly lower than both 4.5" and 5"-6" gear (Table 3.3). Chinook catch rates with 4.5" and 5"-6" were not significantly different from each other. The data suggests that nets hung at a 2:1 ratio and slackened had higher catch rates of adult spring chinook, however, no significant differences in chinook catch rates were found to be associated with hang ratio, whether within a particular mesh size or pooled.

Steelhead catch rates appear to be similar for all gears with no significant differences existing between mesh size or hang ratio (Table 3.3).

Table 3.3. Results of statistical tests of significance on catch rates associated with mesh size and hang ratio for adult spring chinook and steelhead captured in the lower Columbia River, May 2001. **Bold type** indicates significance.

	Comparison					
			Mesh			Hang Ratio
	3.5" 3:1v 2:1 S[a]	4.5" 3:1v 2:1 S[a]	3.5" v 4.5"	3.5" v 5"-6"	4.5" v 5"-6"	3:1 v 2:1 S[a]
Spring Chinook	df=279 *P*=0.35	df=271 *P*=0.17	df=551 ***P*<0.05**	df=429 ***P*<0.05**	df=421 *P*=0.44	df=551 *P*=0.10
Steelhead	df=272 *P*=0.35	df=271 *P*=0.87	df=544 *P*=0.46	df=422 *P*=0.65	df=421 *P*=0.82	df=544 *P*=0.41

[a] "S" Indicates net was slackened

Condition at Capture

The 3.5" and 4.5" pooled mesh sizes had a similar percentage of the adult spring chinook catch assessed in condition 1 at capture, 78% and 77% respectively. The 5"-6" mesh had 62% of the adult spring chinook catch in condition 1 at capture (Table 3.4). There was no significant difference in the frequency of conditions 1 and 5 at capture with a 3.5" and 4.5" mesh size yet the 4.5" mesh had a significantly higher occurrence of immediate mortality. The 5"-6" mesh had a significantly lower frequency of adult spring chinook in condition 1 at capture and significantly higher rates of condition 5 at capture and immediate mortality when compared to the 3.5" mesh. The 5"-6" mesh also captured significantly fewer adult spring chinook in condition 1 than the 4.5" mesh; differences in the frequency of capture condition 5 and immediate mortality were not significant between these mesh sizes. See Table 3.6 for *P* values from chi-square tests.

Adult spring chinook immediate mortality rates appeared to be positively correlated with increasing mesh size (R^2=0.96). Less than 1% of spring chinook captured with 3.5" mesh were immediate mortalities compared with 5% with 4.5" mesh and 7% with 5"-6" mesh.

The hang ratio used to construct the tangle net did not have a significant effect on the frequency of chinook graded either as a 1 or 5. Immediate mortality associated with a 3:1 hang ratio was significantly greater than the 2:1S nets (Table 3.6). Hang ratios of 3:1 resulted in 75% of the catch assessed in condition 1 at capture and a 6% immediate mortality rate. Nets hung at 2:1S captured 80% of the spring chinook in condition 1 and resulted in an immediate mortality of <1%.

Table 3.4. Gear specific condition at capture assessments, including immediate mortality, for unmarked adult spring chinook captured in the lower Columbia River, May 2001.

	Mesh Size									
	3.5"				4.5"				5"-6"	
	Hang Ratio[a]									
	3:1		2:1 S		3:1		2:1 S		various	
Condition	N	%	N	%	N	%	N	%	N	%
1	50	76%	41	82%	100	75%	66	80%	133	62%
2	0	0%	0	0%	1	1%	3	4%	4	2%
3	14	21%	6	12%	21	16%	11	13%	57	27%
4	1	2%	1	2%	1	1%	0	0%	1	0%
5	1	2%	2	4%	10	8%	3	4%	19	9%
Immediate Mortality	1	2%	0	0%	10	8%	1	1%	16	7%

[a] "S" Indicates net was slackened

The frequency of steelhead in capture condition 1 or 5, or an immediate mortality was not significantly different between 3.5" or 4.5" mesh. The frequency of steelhead in condition 1 at capture in 5"-6" mesh was significantly lower than the 3.5" mesh, however no difference was found between the frequency of capture condition 5 or immediate mortality for these mesh sizes. The frequency of condition 1 or 5 at capture and immediate mortality was not different for 4.5" and 5"-6" mesh sizes. See Table 3.6 for *P* values from chi-square tests.

Percentages of steelhead in condition 1 at capture tended to decrease as mesh size increased (R^2=0.99) and immediate mortality rates increased with mesh size (R^2=0.95). The 3.5" mesh had 70% condition 1 at capture and a 12% immediate mortality rate. The 4.5" mesh captured 55% of steelhead in condition 1 with an immediate mortality of 17%. The 5"-6" mesh had 35% in condition 1 and a 28% immediate mortality rate (Table 3.5).

Table 3.5. Gear specific condition at capture assessments, including immediate mortality, for steelhead captured in the lower Columbia River, May 2001.

	Mesh Size									
	3.5”				4.5”				5”-6”	
	Hang Ratio[a]									
	3:1		2:1 S		3:1		2:1 S		various	
Condition	N	%	N	%	N	%	N	%	N	%
1	24	71%	11	69%	16	52%	19	58%	10	35%
2	0	0%	0	0%	2	7%	0	0%	3	10%
3	7	21%	1	6%	5	16%	6	18%	7	24%
4	0	0%	0	0%	0	0%	2	6%	2	7%
5	3	9%	4	25%	8	26%	6	18%	7	24%
Immediate Mortality	2	6%	4	25%	5	16%	6	18%	8	28%

[a] “S” Indicates net was slackened

There was no significant difference in the frequency of condition 1 or 5 at capture or immediate mortality associated with hang ratio for steelhead. The frequency of steelhead in condition 1 at capture or an immediate mortality was similar among hang ratios with 3:1 showing 62% and 11%, respectively and 2:1S with 61% and 20%.

Table 3.6. *P* values from chi-square tests performed to ascertain significant differences in condition at capture and immediate mortality by gear variable for adipose-marked spring chinook and steelhead captured in the lower Columbia River, May 2001. **Bold type** indicates significant difference.

		Comparison			
	Condition	3.5” v 4.5”	3.5” v 5”-6”	4.5” v 5”-6”	3:1 v 2:1 S[a] (3.5” & 4.5”)
Spring Chinook	1	*P*=0.74	***P*<0.01**	***P*<0.01**	*P*=0.28
	5	*P*=0.16	***P*=0.03**	*P*=0.26	*P*=0.46
	Immed. Mort.	***P*=0.05**	***P*<0.01**	*P*=0.31	***P*=0.02**
Steelhead	1	*P*=0.10	***P*<0.01**	*P*=0.07	*P*=0.97
	5	*P*=0.28	*P*=0.26	*P*=0.81	*P*=0.63
	Immed. Mort.	*P*=0.44	*P*=0.08	*P*=0.25	*P*=0.15

[a] “S” Indicates net was slackened

Physical Capture Method (5”-6” mesh)

The 5”-6” mesh size range captured 80% of adult spring chinook by tangling, 7% by gilling, and 13% by wedging (Figure 3.2). Of tangled adult spring chinook, 67% were assessed to be in condition 1 at capture as were 76% of wedged fish. The highest percentage of gilled adult spring chinook (46%) were in condition 3. Twenty three percent (23%) of steelhead were tangled, 42% gilled, and 35% wedged (Figure 3.2). All of the tangled steelhead and 43% of those wedged were in condition 1 at capture, 50% of those caught by gilling were in condition 5.

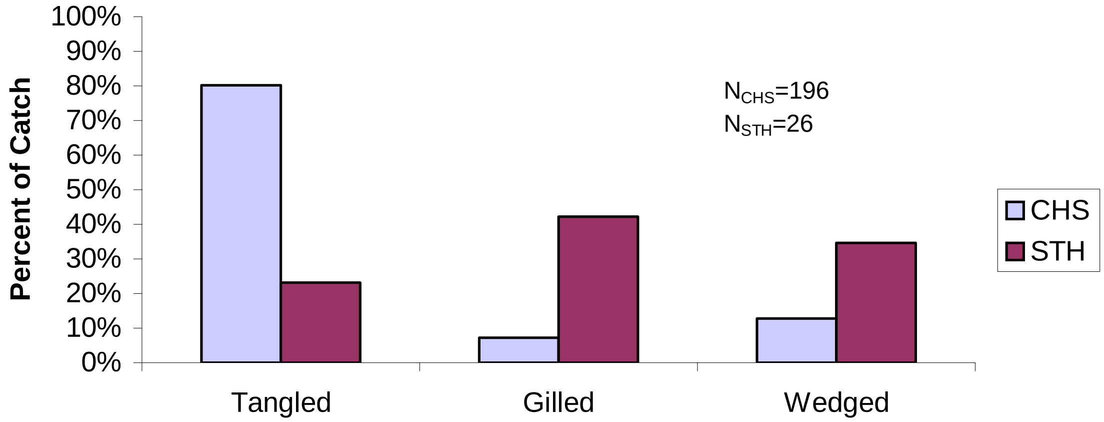

Figure 3.2. Physical method of capture for adult spring chinook (CHS) and steelhead (STH) caught in 5"-6" mesh nets in the lower Columbia River, May 2001.

Effectiveness of Recovery Box System

Adult spring chinook in condition 1 increased from 70% to 89% and condition 1 steelhead rose from 56% to 78% with the use of the recovery system (Figures 3.3 and 3.4). Those in condition 3 at capture showed the greatest improvement. Twenty percent (20%) of condition 5 adult spring chinook were revived, as were 11% of condition 5 steelhead.

The frequencies of adult spring chinook and steelhead assessed at conditions 1 and 2 at capture and post-application of the recovery box were evaluated for significant differences. Both species showed a statistically significant increase in the frequency of individuals at these condition levels with use of the recovery box (CHS P<0.001; STH P<0.001). The number of adult spring chinook and steelhead ranked in condition 5 did not significantly change after application of the recovery box system (CHS P=0.30; STH P=0.65).

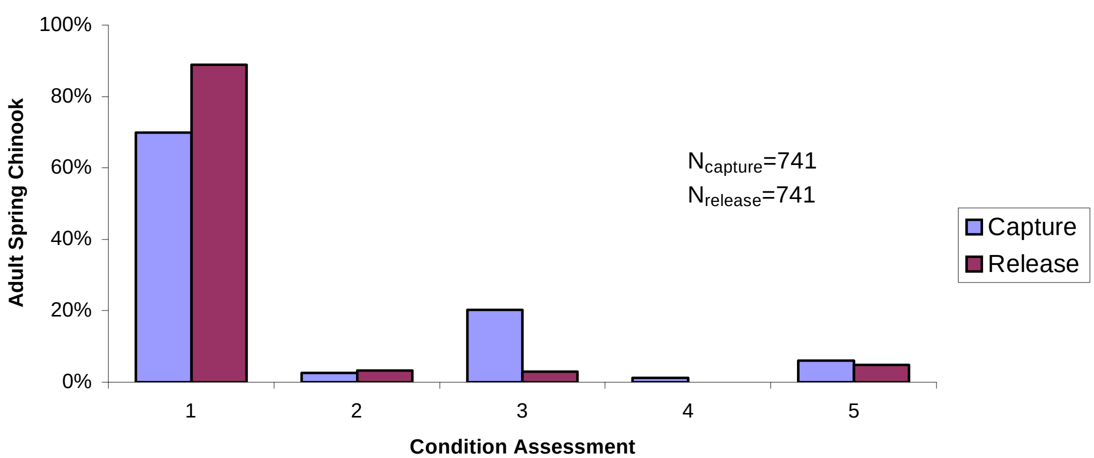

Figure 3.3. Comparison of condition at capture and condition at release after application of the recovery box system on adult spring chinook caught in the lower Columbia River, May 2001.

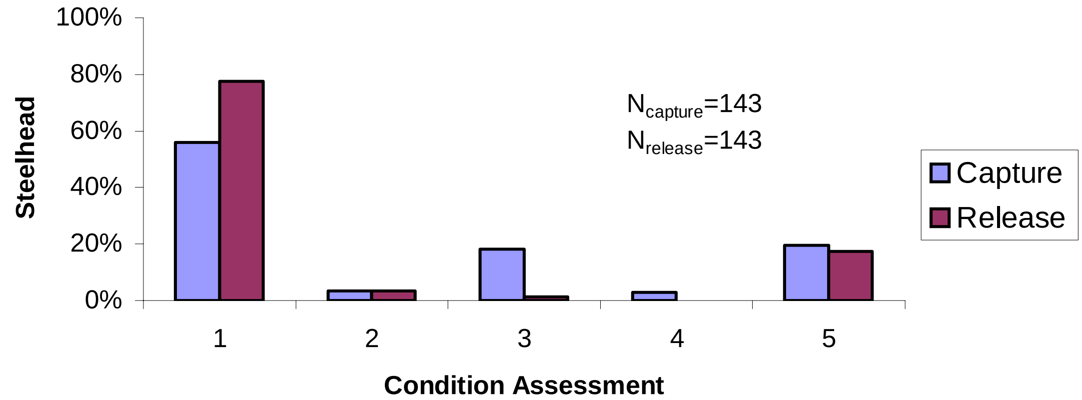

Figure 3.4. Comparison of condition at capture and condition at release after application of the recovery box system on steelhead caught in the lower Columbia River, May 2001.

Sold Catch

Sampling of sold catch at fish buying stations by ODFW and WDFW employees provided details on the age structure and stock composition of spring chinook encountered in the fishery. Scale analysis coupled with coded-wire tag (CWT) data indicate that the sold catch was comprised of 0.3% age 2_2, 28.9% age 3_2, 67.4% age 4_2, and 3.4% age 5_2 spring chinook (Gilbert and Rich age notation).

Coded-wire tag analysis showed the catch was made up of 29% lower river stocks (Willamette River, releases from Select Area fishery programs, and other tributaries below Bonneville Dam) and 71% upriver stocks (tributaries above Bonneville Dam).

Mean fork length of adult spring chinook released during the fishery and those sampled from the sold catch was identical at 76 cm (Figure 3.5).

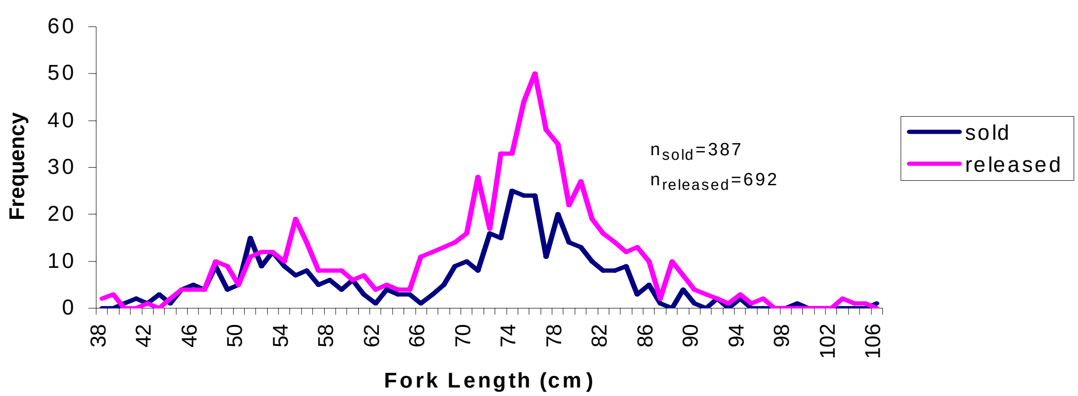

Figure 3.5. Length frequencies of spring chinook sold and released in lower Columbia River limited entry permit fishery, May 2001.

Discussion

This study achieved two goals of the evaluation of commercial live capture selective salmon fisheries in the lower Columbia River. It provided data giving direction to the development and analysis of live capture gear and techniques and allowed fishers, fishery managers, and researchers real world experience in the implementation of these ideas into a stock-selective commercial salmon fishery.

This study was designed to provide information on spring chinook relative to capture in tangle nets, therefore it was conducted during the period of spring chinook abundance. While some steelhead were captured in this study, it took place in a time frame of relatively low steelhead abundance. Although the effects of live capture tangle nets on steelhead bycatch is critical in the overall evaluation, this study by design encountered small sample sizes of steelhead (<65 steelhead per mesh size) and is unable to definitively answer all of the relevant questions regarding this species. Information collected from captured steelhead is summarized and presented but it is recommended that a study focusing on steelhead be conducted to provide statistically sound conclusions on refined iterations of mesh sizes.

All of the mesh sizes evaluated appear to meet the basic goals of live capture gear for spring chinook although some important distinctions were found, narrowing the range in which the most appropriate mesh size may be found. In all mesh sizes the majority of adult spring chinook were captured in condition 1, ranging from 62% for 5”-6” mesh to 78% in the 3.5”. Additionally, immediate mortality rates appear to be at manageable levels (from <1% with 3.5” to 7% with 5”-6”). Generally, the frequency of condition 1 at capture tended to decrease as mesh size increased; similarly, a correlation was found between an increase in mesh size and an increase in the immediate mortality of adult spring chinook.

The 3.5” and 4.5” mesh sizes appear to have similar physical effects on adult spring chinook, indicated by condition at capture assessments. The majority of fish captured were in condition 1 and the difference in condition 5 at capture was not found to be significant. The 3.5” mesh nets had significantly lower immediate mortality on adult spring chinook since a higher percentage of these fish were able to recover in the recovery system. This difference may be influenced by the high incidence of immediate mortality in the 4.5” mesh caused by the hang ratio as discussed later in this section.

The 3.5” and 4.5” mesh sizes also had similar effects on captured steelhead. While fewer steelhead captured in the 4.5” mesh were graded in condition 1 at capture, no significant differences were found between the frequency of fish assessed in condition 1, condition 5, or immediate mortality.

The analyses show that mesh sizes in the 5”-6” range functioned as a tangle net on adult spring chinook with 80% classified as tangled. Fish that were observed as tangled or wedged were mostly in condition 1 at capture. Analysis of condition at capture and immediate mortality data indicate that this mesh range is at the top end of what could be considered appropriate live capture gear for adult spring chinook. Significantly fewer adult spring chinook captured in this mesh were graded in condition 1 at capture compared to fish captured in both 3.5” and 4.5” mesh. The 5”-6” mesh range also resulted in a significantly greater frequency of capture condition 5 and immediate mortality when compared to the 3.5” mesh but not the 4.5” mesh.

The 5”-6” mesh range did not function as a tangle net on steelhead, evidenced by the observation of 77% of steelhead either gilled or wedged. Differences between this mesh range and the 3.5” mesh were found for steelhead condition at capture. The 5”-6” range showed a significantly lower frequency of steelhead in condition 1 at capture but the differences in frequency of condition 5 at capture and immediate mortality were not found to be significant. No significant differences were found in the capture condition profile or immediate mortality rate between this mesh range and the 4.5” mesh.

Differences in adult spring chinook catch rates between the mesh sizes were documented. While the 4.5” and 5”-6” range were similar, the 3.5” mesh was significantly less efficient. This indicates that a mesh size this small would not meet the goal of an economically feasible fishery. Steelhead catch rates were essentially static for all mesh sizes evaluated.

It appears that an appropriate mesh size for use in the construction of tangle nets would be larger than 3.5” and smaller than 5.5” (the majority of the mesh used in the 5”-6” range was 5.5”). The ideal mesh size must be small enough to function as a tangle net yet is efficient enough for an economically feasible commercial fishery. Mesh sizes on the smaller end of this range may also increase the risk of mouth clamping and subsequent asphyxiation of captured salmonids.

The two methods of hanging the gear did not result in significant differences in efficiency for either spring chinook or steelhead. Hang ratio did not have a significant effect on the steelhead condition at capture profile or the immediate mortality rate. The 3:1 hang ratio was found to have a significantly higher immediate mortality rate on spring chinook. Comments from observers and fishers attribute this to excessive tangling of fish in the net, since the increased amount of web allows multiple meshes to become wrapped around the snout, holding the mouth shut and suffocating the fish. This net configuration, common in the Fraser River but not used in Columbia River gillnet fisheries, was evaluated to determine its utility within a Columbia River tangle net fishery. Typical Columbia River hang ratios do not appear to result in this type of excessive tangling; therefore, we recommend that hang ratios this high not be used in future live capture fisheries. It may be beneficial to design additional experiments to gain information on fish condition, post-release survival, and efficiency related to commonplace Columbia River hang ratios.

Use of the recovery system and assessment of fish condition are fundamentally different introductions into the realm of Columbia River commercial fisheries. Fishers and researchers alike learned how to implement and use this tool over the course of the study. Fishers readily adopted the concept, experimenting with various ways of outfitting their vessels with the system to balance ease-of-use with safety concerns, and began the process of learning to determine condition of fish throughout the recovery period. The two-chambered recovery box was appropriate for the relatively low volume of bycatch encountered which is characteristic of winter and spring Columbia River salmon fisheries.

Results from the evaluation of this particular recovery system variation are mixed. The laminar-flow Fraser recovery box system is designed to recover fish from a lethargic state and revive those which appear to be dead. The specific system used in this study was loosely based on Jake Fraser's design and did significantly improve condition profiles of both adult spring chinook and steelhead, primarily by recovering lethargic fish to a lively state. However, the system was not able to improve the condition of those assessed in condition 5 at capture. These results do not reflect the success Mr. Fraser and SFU demonstrated in their studies, which demonstrated a successful revival rate of 91-94% (Fraser 1999); in this demonstration fishery only 20% of spring chinook and 11% of steelhead were revived. The system used in the Canadian studies was designed for and tested on coho; apparently the modified system used in our study did not function as well on spring chinook and steelhead. This may be due to insufficient inflow of water, inadequate box dimensions, or a combination of the two factors. Appropriate flow rates to revive coho were developed in similar water temperatures common in the lower Columbia in early spring (12-16˚C/54-61˚F). It was determined that a flow rate of 0.6 l/sec (9.4 gal/min) at these temperatures was most effective at recovering coho (average weight 10.0 lbs.) (Farrell et al. 2001). Upon consultation with Dr. Anthony Farrell at Simon Fraser University, it was determined that double this flow would be needed to revive spring chinook with an average weight 14-18 pounds (pers. comm. 2001). The short recovery boxes used in this study did not allow room for spring chinook to swim in place to work out metabolic waste build up, which is an essential part of the recovery process and a designed function of the Fraser-style recovery box. I recommend that future recovery systems rectify these inadequacies by taking into account the best information currently available and move towards a system appropriate for the intended usage. A further recommendation is for this portion of the selective live capture fishery methodology continue to be evaluated as improvements are made. It is imperative that the recovery box function as effectively as possible, especially considering the high steelhead mortality rates observed in this study, to ensure a successful live capture fishery.

Overall, fishers demonstrated that they were able to successfully adopt, on a limited and controlled basis, the fundamentally different techniques of live capture into a lower Columbia River spring commercial chinook fishery. The gears tested provide valuable data to guide future implementation of live capture into commercial spring chinook fisheries. Mesh greater than 3.5" and less than 5.5" are worthy of further investigation for use in live capture tangle nets to balance catch efficiency of target stocks with condition and survival of released spring chinook and steelhead. Managers and researchers saw the value in using the demonstration fishery idea as a research tool. Large sample sizes are relatively easy to obtain and conclusions can be drawn from a real world scenario. Limitations exist on the types of research that can be done in this setting but we recommend that the feasibility of measuring post-release survival of salmonid bycatch during a demonstration fishery be investigated.

Acknowledgements

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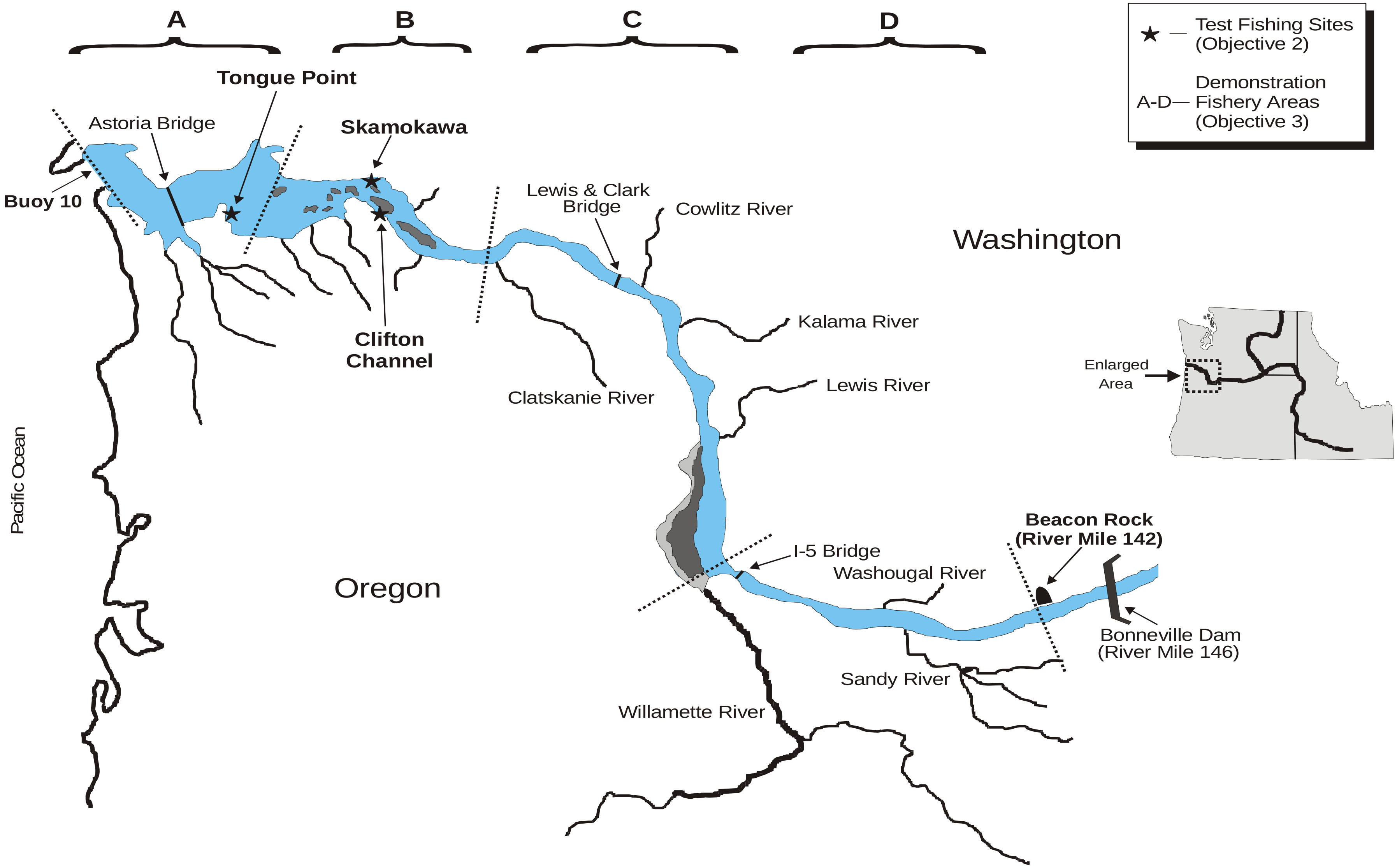
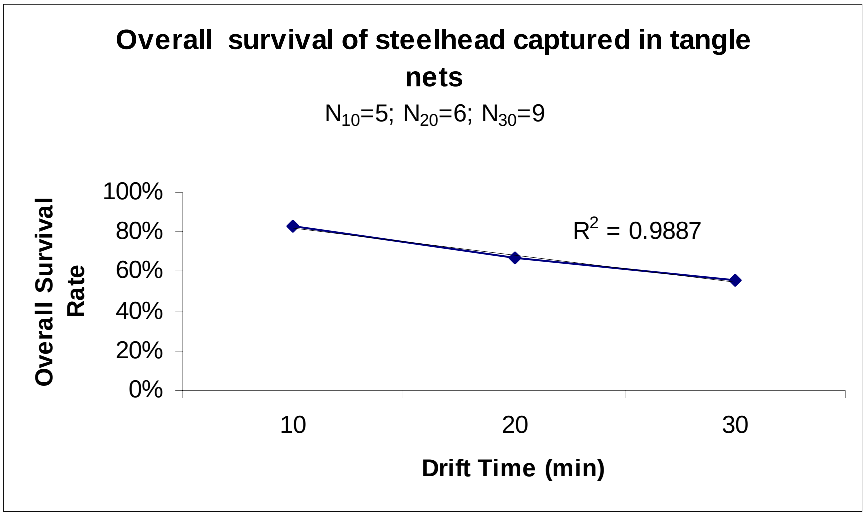
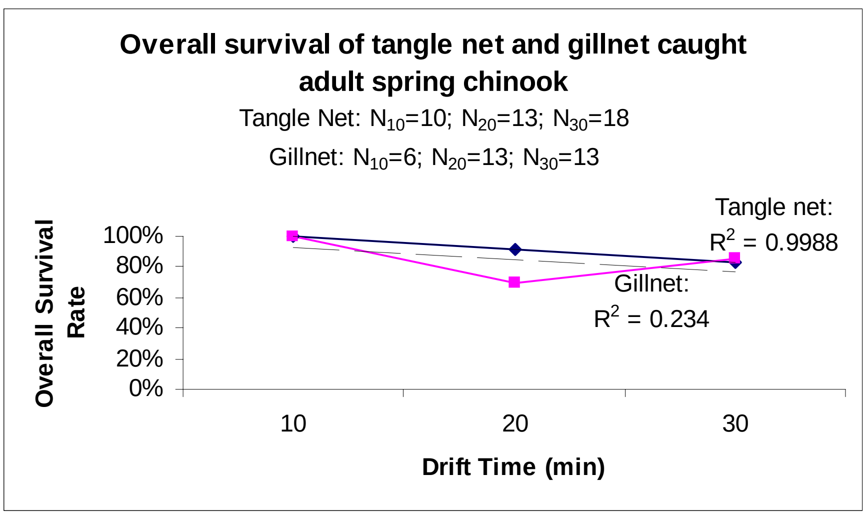
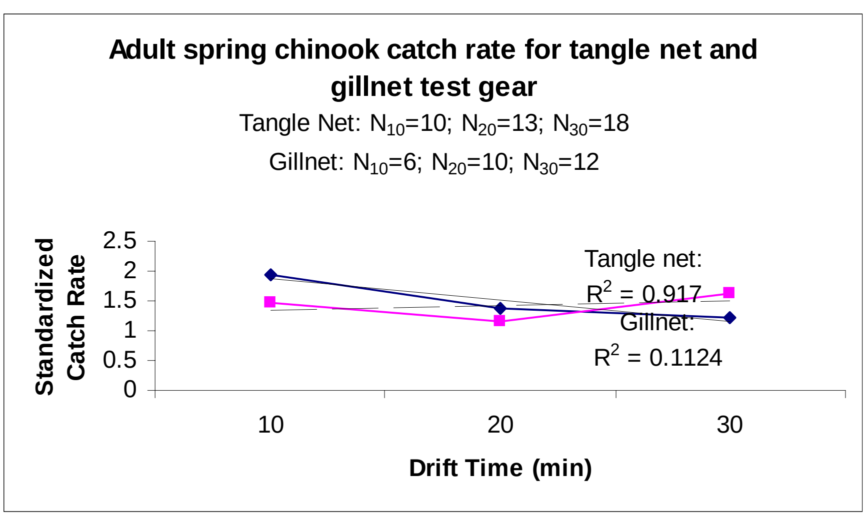


Appendix A. Live Capture Test Fishing Sites and Demonstration Fishery Areas in the Lower Columbia River, April-May, 2001.

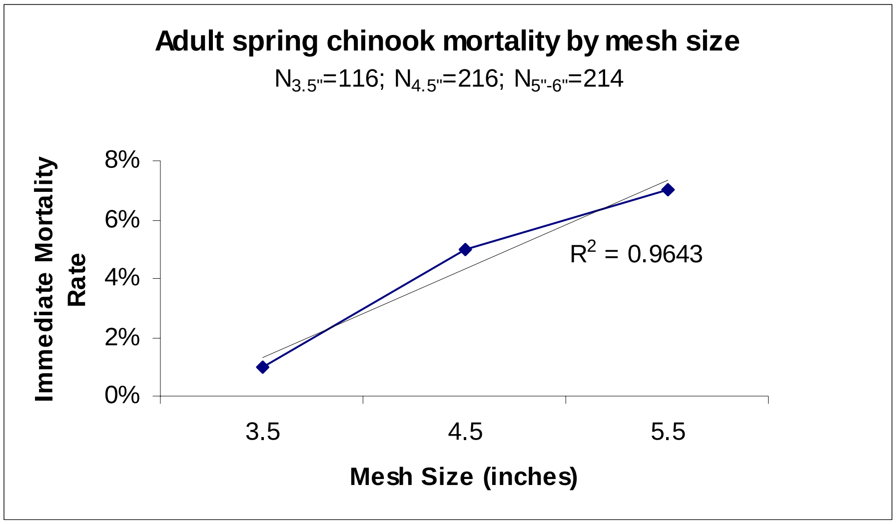
Appendix B. Regression Charts Used in Objective 2 Analyses

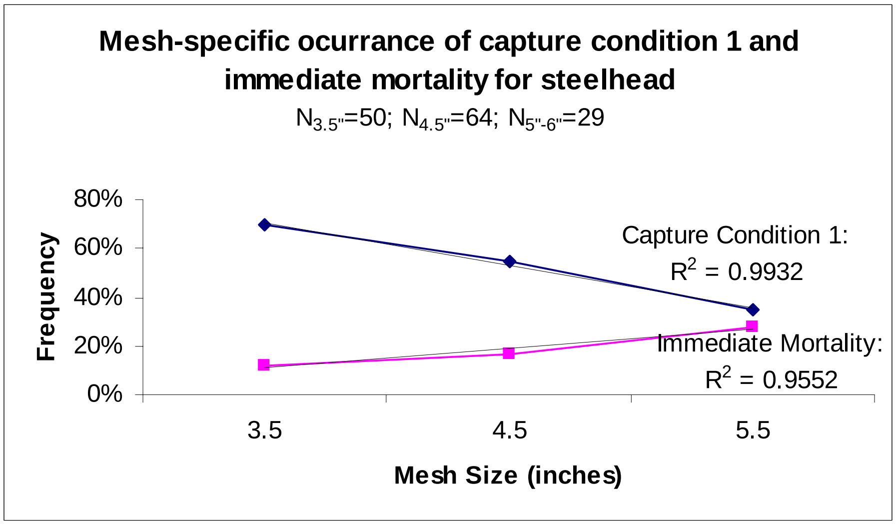






Appendix B. (continued) Regression Charts Used in Objective 3 Analyses





Appendix C. Permit Issued to Fishers Participating in Limited Entry Demonstration Fishery, April – May, 2001.

Oregon
John A. Kitzhaber, M.D., Governor

Department of Fish and Wildlife
Columbia River Management
17330 SE Evelyn Street
Clackamas, OR 97015-9514
(503) 657-2000
FAX (503) 657-2095
Internet WWW:http://www.dfw.state.or.us/

Date Issued, 2001

Permit to Use Experimental Tangle Net Gear to Live Capture Spring Chinook

The Oregon Department of Fish and Wildlife (ODFW) hereby authorizes (*Fisher's Name*) in accordance with OAR 635-006-0020 to use experimental live fish capture gear, known as tangle or tooth nets, to capture spring chinook for the purpose of collecting necessary information to profile catch rates and handling impacts associated with this type of gear. Adipose fin-clipped spring chinook will be sold by the permit holder as compensation for services rendered. Permit holder must abide by the following requirements:

1. All fishing schedules will be determined in consultation with Jeff Whisler of the ODFW. Any modifications to the fishing times, fishing locations, or gear specifications described below will be made in consultation with ODFW and WDFW. Fisher must contact Project Leader, Jeff Whisler at (503) 325-3418.

2. Fishing may occur between the dates of April 23, 2001 and May 18, 2001 in the Columbia River commercial fishing area between the mouth and Bonneville Dam. Each permit holder will be allowed to fish one fishing period, consisting of one tide or 6-10 hours each week, unless circumstances preclude at the discretion of ODFW and WDFW.

3. A Department (ODFW or WDFW) observer shall be present on board vessel during all on-water fishing activities. Permit holder shall follow the directions of said observer with regard to soak time, handling of fish, and recovery of fish.

4. (*Fisher's Name*) will fish in (*assigned area*) which is defined as the mainstem Columbia River (*geographical locations*).

5. (*Fisher's Name*) will fish on the following dates: (*assigned fishing dates*). Times of fishing period will be developed in consultation with ODFW and WDFW, fisher must contact Project Leader Jeff Whisler at (503)-325-3418.

6. (*Fisher's Name*) gear will meet the following specifications: One 75-fathom shackle of 3-½" mesh gear and one 75-fathom shackle of 4"-4½" mesh gear. Both shackles of gear will be hung in 3:1 without slackers, stringers, or trammels. Both shackles of net will be attached together and fished simultaneously.

7. (*Fisher's Name*) will provide a recovery box meeting department specifications.

8. Each fishing period must end prior to permit holder capturing 181 spring chinook.

9. Soak time, as defined by time when first buoy enters the water until first buoy leaves the water, shall not exceed 30 minutes.

10. Nets should be fished in alternating order each succeeding fishing day to prevent bias. Net will be retrieved from the end that entered the water first.

11. Permit holder may not initiate a drift if fish are still present in the recovery box.

12. All adipose fin-clipped spring chinook and all shad may be sold. All non-adipose fin-clipped spring chinook and all steelhead must be revived in accordance with the direction of authorized Department personnel and released into the water unharmed. All other species must be released immediately into water unharmed. All sold catch must be sold to a licensed wholesale fish dealer or buyer.

13. Permit holder must communicate to Jeff Whisler of the ODFW the name and location of the licensed wholesale fish dealer or buyer to which they intend to sell their fish and approximate time of delivery prior to departing the dock that day.

14. Permit holder shall allow the collection of all necessary data by the Department observer.

15. Permit holder must possess required commercial fishing licenses in accordance with OARs 635-006-0140 and 635-006-0145 and RCW 75.28.010.

16. Permit holder shall allow authorized Department personnel to inspect fishing gear at any time prior to and during fishing period.

17. All gear provided by or compensated for by this Project shall remain property of the permit holder unless permit holder fails to abide by restrictions set forth in this permit.

18. Permit holder shall have in his possession this permit at all times when conducting this experimental fishery.

19. Permit may be revoked if permit holder fails to appear as per the predetermined fishing schedule without contacting Jeff Whisler with ODFW. Additionally permit may be revoked if permit holder fails to obey directions of Department observer or exceeds the spring chinook handle limit described in provision 6 of this permit.

Approved by____Date__________________