Evaluate Tangle Nets for Selective Fishing

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Effective management of mixed-stock salmon fisheries in the Pacific Northwest relies heavily on the ability to maximize the harvest of strong stocks while preventing the overexploitation of weak stocks, some of which may be listed as threatened or endangered under the Endangered Species Act. Achieving escapement goals for weak stocks often require the implementation of more restrictive harvest regulations that result in a surplus escapement of fish from strong stocks. The development of methods that enable fishers to selectively harvest strong stocks without jeopardizing weak stock recovery efforts is a key element in Pacific salmon conservation strategy. In this study, we explore the feasibility of using a tangle net to decrease capture-related mortality of non-target stocks (Figure 1). If non-target stocks can be returned to the water with reasonable certainty that their spawning migration will not be affected through capture and release, then restrictions governing the spatial and temporal limitations of the fishery may be relaxed, thus enabling more opportunity to harvest from strong stocks.

Figure 1: Comparison between the conventional monofilament gill net (left) and the multi-strand tangle net (right). The mesh size of a conventional net is chosen to fit the target species so that the target fish is caught around the gills and body. Fish caught in this way are often injured or killed in the net because they are unable to continue to respire. In contrast, the mesh size of the tangle net is designed to capture the fish around the face to prevent injury and to allow continued respiration. Fish caught live can be either kept for harvest, or released.

We had three objectives for this project, with several tasks related to each objective. All were scheduled for this work period.

Objective 1: Estimate the catch per set to +/- 10% at 95% confidence for the tangle net and conventional gill nets. Estimate the age and size for each species caught to +/- 10% at 95% confidence for the tangle net and conventional gill nets.

Objective 2: Estimate the proportion of fish caught in the tangle net and in the conventional gill net that is brought aboard dead (cannot be revived) by species, to +/- 2% at 95% confidence for each set.

Objective 3: For each species, estimate the percentage of fish released from the tangle net and conventional gear that survive to complete their migration, to +/- 25% at 90% confidence.

Four sites were selected as test areas for the tangle net (Figure 2). In Miller Bay, we cooperated with the Suquamish Tribe to capture, tag and release chinoook returning to Grovers Creek Hatchery. In Budd Inlet, we cooperated with the Squaxin Island Tribe to capture, tag and release chinook returning to Tumwater Falls Hatchery. We cooperated with the Puyallup Tribe to compare the catch efficiency of the tangle net to the conventional net for coho returning to

the Puyallup River. Finally, we worked with non-treaty fishermen on the Willapa River to compare the catch efficiency of the two types of nets in that area.

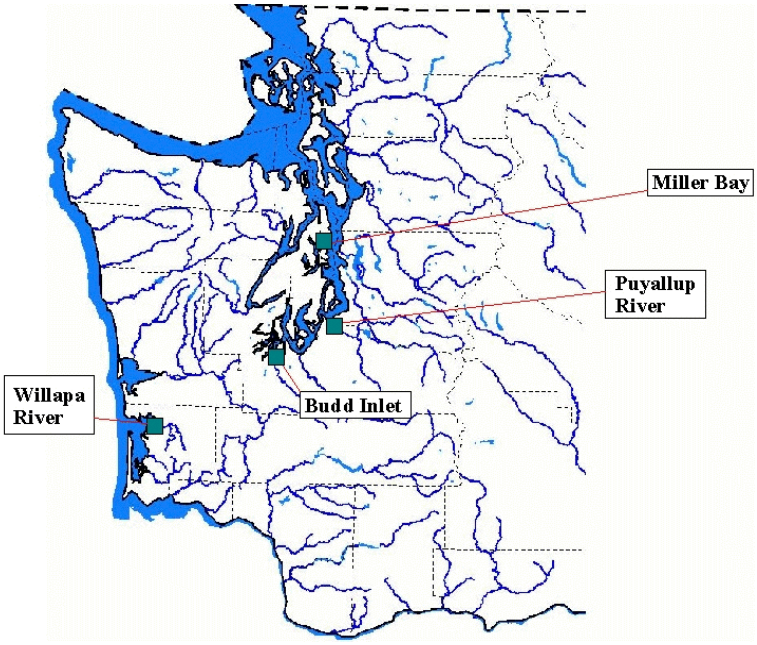

Figure 2: Locations for tests of tangle nets in 2000.

In Miller Bay, Budd Inlet and the Willapa River, we contracted with local fishermen to fish nets that were one shackle of tangle net, and one shackle of conventional gill net commonly used in their areas for the target species. In each of these areas, the fishermen were paid on a per day basis and all live fish were released. On the Puyallup River, members of the Puyallup Tribe volunteered to fish the gears and kept the fish caught as compensation. In Budd Inlet and Miller Bay, dead fish were donated to the cooperating tribe, and on the Willapa River, dead fish were sold to a local buyer with the proceeds going back to this project.

In each area, the contracted fishermen selected the time for fishing, and the location for the sets. Observers were on board during every set to handle and tag fish and to record biological data and other observations. For each set, we recorded the time, location, weather conditions, water temperature and noted the presence of seals. For each fish caught, we noted the species, size, sex, net type where it was captured and the condition the fish was in at capture as follows: 1 (vigorous and not bleeding); 2 (vigorous and bleeding); 3 (lethargic and not bleeding); 4 (lethargic and bleeding); or 5 (no movement or apparent ventilation). In Miller Bay and Budd Inlet, fish receiving scores of 1 or 2 were immediately tagged and released, and on the Willapa River, immediately released without tagging. Fish receiving scores greater than 2 were transferred to the recovery tank (Figure 3) in an attempt to resuscitate them to a lower score. The fish were re-scored at the time of release and the total time in the recovery box was recorded. These resuscitation attempts were not always successful, but did allow recovery of a significant number of fish.

Figure 3: Recovery box used to revive fish stressed by capture. The box is designed so that a continual flow of fresh water is directed at the fish's face. Fish may need more than an hour in the box before they are fully recovered, and will begin to swim. This box had a ruler built in so that the fish did not need to be removed from the water for measuring. When the fish was ready to be released, it was gently lifted out of the box and placed overboard.

We intended to collect scale samples from each fish at capture to compare the age composition of fish caught in each net to the general run. However, because we were not using any anesthetic to calm the fish, it became quickly apparent that attempts to take scale samples would compromise the health of the fish and affect post-release survival. We therefore decided to collect scale samples from tagged fish as they were recovered at the hatcheries. As this did not occur (see later), we were unable to collect age information this year. In retrospect, we should have collected scales from the fish that died during capture.

The progress and data analysis to date are presented by location below.

Budd Inlet

We used a 300' long nylon monofilament net constructed from two panels of equal length; one of 6.5" single-strand mesh (gill net), the other of 3.5" four-strand mesh (tangle net). The panels were hung at a ratio of 2:1 and 3:1 respectively and suspended from a single 3/8 inch polypropylene float line. The net fished to a depth of about 23 feet. The overall length, depth, and color of the net, and the mesh type and size of the gill net panel, was similar to that ordinarily used by local fisherman to harvest chinook in Budd Inlet.

The net was fished by hand from an open power skiff. The net was either set by tying one end to the shore and anchoring the other end (then referred to as a “set net”) or by allowing both ends to drift freely (then referred to as a “drift net”). Because the net had to be pulled by hand, it was impractical to keep the set time to the desired 20-30 minutes. Rather, the net was laid out and instead of pulling the entire net into the boat, we continually checked the gear and searched for trapped fish. The set length, defined as the time the first float went into the water until the last float was removed was somewhat irrelevant, so in this case, we recorded the time at which a fish was caught. Deploying the net typically took fewer than 5 min, but retrieving the

net was often slow (as long as two hours) because of the use of hand picking and the need to remove crabs and other non-target species. All fishing occurred between 1900 h and 0400 h, except one time when we fished from 0200 h to 0700 h. Several different sites were fished from Boston Harbor south to the inlet of Capitol Lake in Olympia. The exact locations of each set were recorded using GPS and will be mapped.

The gears were fished for 11 nights, catching 139 chinook, with 102 (73.4%) in the conventional gill net and 37 (26.6%) in the tangle net. We also recorded a wide difference in the percent of male and female chinook caught in each net. In the gill net, the ratio was nearly equal with 48.5% females and 51.5% males. In contrast, 75.7% of the fish caught in the tangle net were males (24.3% females). This difference is logically attributable to the morphological differences in males and females, with the more developed kype in males making capture by the tangle net more efficient than for females.

Table 1 summarizes the condition at capture and final condition of the chinook caught in Budd Inlet in each net. We were only able to revive about 50% of the fish that were not ranked as condition 1 at capture to a condition where they could be released. This highlights the importance of bringing fish on board in the best possible condition. Based on our experience from this year, several of these factors could be changed, and if so, we expect the recovery rate to improve. For example, we could use shorter nets, with a slightly larger mesh size to reduce catch of other species (which slows removal of target species), and more frequent checking to improve survival. Some modifications to our holding tanks and set-up may also improve revival of fish that are not in condition 1.

Table 1: Condition at capture and final condition after attempts to revive chinook caught in the tangle net or gill net in Budd Inlet.

Condition at Capture	Gill Net		Tangle Net	
	Number	Percent	Number	Percent
1 (Lively, not bleeding)	17	16.7	19	51.4
2 (Lively, bleeding)	6	5.9	2	5.4
3 (Lethargic, not bleeding)	28	27.5	7	18.9
4 (Lethargic, bleeding)	18	17.6	0	0.0
5 (No visible signs of life)	33	32.4	9	24.3
Final Condition				
1 (Lively, not bleeding)	57	55.9	28	75.7
2 (Lively, bleeding)	3	2.9	0	
3 (Lethargic, not bleeding)	1	1.0	0	
6 (Dead , not released)	32	31.4	7	18.9
7 (Dead, killed by seal, not released)	9	8.8	2	5.4

The observed difference in catch efficiency would severely impede the economic viability of the chinook fishery in this, and most any area. However, the great improvement in survival and the condition at capture makes the tangle net worthy of further investigation. Discussions with fishermen indicate that some changes to the gear would improve the catch efficiency. For example, we suspect that the mesh size was too small to effectively entangle these large chinook, and that we should perhaps use a mesh size of 4" to 5". Also, it was clear that the fish

were able to see the mesh easily - we observed fish swim up to the mesh and turn away. This is partly due to the smaller mesh size and the multi-stranded material that the tangle net is made from, but the color may also play a role in the net's visibility. We suspect that a slightly lighter color will decrease the visibility of the tangle net.

We released 59 fish with tags from the gill net, and 27 from the tangle net. We expected to recover tags at Tumwater Falls Hatchery, from other fishermen, during stream surveys, and on subsequent days in our nets. In spite of good stream surveys, and careful observation of fish returning to the hatchery, we only recovered two tags by these methods. None were recovered from other fishermen, and we recaptured four tags later in the same night they were originally caught. All four died in the second capture which was from 2 to 3 hours after the original captured. These small numbers of tags tell us little about the post-release survival of chinook, and this subject warrants further work.

Puyallup River

We used a 100' long nylon monofilament net constructed from two panels of equal length; one of 5 inch single-strand mesh (gill-net), the other of 3.5 inch four-strand mesh (tangle net). The panels were hung at a ratio of 2:1 and 3:1 respectively and suspended from a single 3/8 inch polypropylene float line. The net fished to a depth of about 14' and was weighted with a continuous length of 3/8 inch lead line (approx. 16 lbs/100'). The overall length, depth, and color of the net, and the mesh type and size of the gill-net panel, was similar to that ordinarily used by local fishers to harvest coho from the Puyallup River.

The net was fished by hand from an open 23' power skiff. Set length was defined as the difference in time between when the first part of the net entered the water and when the last part was retrieved and ranged from 5 to 60 minutes. Deployment generally took fewer than two minutes and the net was allowed to drift downstream with the current for the duration of the set. All fishing occurred during daylight between the hours of 0900 and 1600 between river miles 1.8 and 5.8.
Thirty-five coho were captured from 21 separate sets made over 4 days (Table 2). Twenty-five coho were captured in the gill-net and ten were captured in the tangle net. Two starry flounder (*Platichthys stellatus*) were incidentally captured in the tangle net. As we saw with chinook in Budd Inlet, more coho were caught in the conventional gill net in this fishery than in the tangle net. Nearly all of the fish were in excellent condition at the time of capture irrespective of web type. Future studies aimed at evaluating tangle nets in this fishery may benefit from increased fishing effort and minor gear modifications such as a lighter lead line as recommended by local fishers.

Table 2: Date, distribution of harvest by web type, and location for each set made during the Puyallup River experimental coho fishery.

		# Coho Captured (Sex)		
Set #	Date	Gill-net (% male)	Tangle net (% male)	River Mile (drift name)
1	09/28/00	2(50)	1(100)	5.8 (Clark'sCreek)
2	09/28/00	0	2(50)	4.4 (PowerLine)
3	09/28/00	2(0)	0	3.6 (UpperCreek)
4	09/28/00	0	1(0)	2.7 (LowerCreek)
5	09/28/00	8(50)	0	2.2 (CarDrift)
6	09/28/00	4(75)	4(25)	2.7 (LowerCreek)
7	TBA	1(0)	0	5.8 (Clark'sCreek)
8	TBA	5(20)	0	4.4 (PowerLine)
9	TBA	1(100)	0	3.6 (UpperCreek)
10	TBA	0	0	2.7 (LowerCreek)
11	TBA	0	0	2.2 (CarDrift)
12	10/18/00	0	0	5.8 (Clark'sCreek)
13	10/18/00	1(0)	0	4.4 (PowerLine)
14	10/18/00	1(100)	0	3.6 (UpperCreek)
15	10/18/00	0	1(100)	2.7 (LowerCreek)
16	10/18/00	0	0	2.2 (CarDrift)
17	11/03/00	0	0	5.8 (Clark'sCreek)
18	11/03/00	0	0	4.4 (PowerLine)
19	11/03/00	0	0	3.6 (UpperCreek)
20	11/03/00	0	0	2.7 (LowerCreek)
21	11/03/00	0	0	2.2 (Car Drift)
Total		25	10	

Miller Bay

We used a 300' long nylon monofilament net constructed from two panels of equal length; one of 7.5" gill-net, the other of 3.5 inch tangle net. The panels were hung at a ratio of 2:1 and 3:1 respectively and suspended from a single 3/8 inch polypropylene float line. Each panel was 145' in length and the two panels were connected with 10' of line at the top and bottom, forming an opening in the center. The opening helped eliminate cause and effect between panels by ensuring that fish attempting to avoid one panel could escape without being directed toward, and possibly captured by, the other. The net fished to a depth of about 60' and was weighted with a continuous length of 3/8 inch lead line. The overall depth, and color of the net,

and the mesh type and size of the gill-net panel, was similar to that ordinarily used by local fishermen to harvest chinook.

The net was fished from a 30' commercial fishing vessel equipped with a single deck-mounted hydraulic reel used to deploy and retrieve the gear. A portable 150 liter recovery tank was fitted and supplied with constant flow fresh seawater at a rate of about 126 l/min. The tank was divided into two equally sized compartments used to temporarily house fish before their release as described below. Each compartment measured 112 cm long, 21 cm wide, and 33 cm high.

Set length was defined as the difference in time between when the first part of the net entered the water and when the last part was retrieved and ranged from 25 to 80 minutes. Deployment generally took fewer than five minutes and the net was usually allowed to drift freely; however, during inclement weather, the net was anchored. The flip of a coin was used to determine which end of the net to retrieve first and the opposite end was deployed first on the following set. Fishing occurred after dusk, between 1800 h and 0100 h within 1 mile of the mouth of Miller Bay.

All chinook salmon captured were sexed, measured, and tagged with a numbered wire jaw-tag. A salmon hatchery located on Grovers Creek near the head of Miller Bay was monitored for tag recoveries. Additionally, the tidal flats at the mouth of Grovers Creek were surveyed for tagged chinook each week during low tide.

Fifteen chinook were captured from 38 separate sets made on 9 days (Table 3). Thirteen were captured in the gill-net and two in the tangle net. There were two immediate mortalities, one from each mesh type. In both instances the fish were judged not suitable for recovery efforts due to substantial damage to the gill tissue and surrounding skeletal structures. Therefore, a total of 13 chinook were tagged and released. Three were subsequently recovered at the hatchery, two of which were captured on the same day (17 Aug.) and recovered after 29 days at liberty; the third, captured on 28 Aug., was recovered after 28 days. They were captured in the gill-net; graded 1, 2, and 3 respectively at the time of capture; and all three were released at condition 1. The condition 3 fish was revived in the recovery tank for seven minutes prior to release. Of the four remaining fish that were transferred to the recovery tank, three, including one fish that was scored as a 5 at time of capture, experienced notable improvements in condition and were released at condition 1. The fourth (scored as a 3) showed no notable improvement after 1.5 hours in the recovery tank.

Table 3: Date, distribution of harvest by web type, and location for each set made during the Miller Bay experimental chinook fishery.

Set # (Set length, min)	Date	# Chinook Captured (% males)		Latitude	Longitude
		Gill net	Tangle net		
1 (78)	08/17/00	0	0	47° 44' 14"	122° 32' 20"
2 (38)	08/17/00	0	1 (100)	47° 44' 21"	122° 32' 27"
3 (31)	08/17/00	5 (60)	1 (100)	47° 44' 23"	122° 32' 23"
4 (29)	08/17/00	2 (50)	0	47° 44' 20"	122° 32' 33"

5 (29)	08/17/00	0	0	47° 44' 20"	122° 32' 28"
6 (41)	08/17/00	0	0	47° 44' 27"	122° 32' 28"
7 (55)	08/21/00	1 (100)	0	47° 44' 10"	122° 32' 32"
8 (42)	08/21/00	0	0	47° 44' 10"	122° 32' 09"
9 (48)	08/21/00	0	0	47° 44' 11"	122° 32' 41"
10 (44)	08/21/00	0	0	47° 44' 20"	122° 32' 34"
11 (44)	08/21/00	0	0	47° 44' 20"	122° 32' 30"
12 (41)	08/24/00	0	0	47° 44' 17"	122° 32' 38"
13 (50)	08/24/00	0	0	47° 44' 15"	122° 32' 36"
14 (43)	08/24/00	1 (0)	0	47° 44' 14"	122° 32' 34"
15 (51)	08/24/00	0	0	47° 44' 31"	122° 32' 24"
16 (41)	08/24/00	0	0	47° 44' 26"	122° 32' 20"
17 (27)	08/24/00	0	0	47° 44' 30"	122° 32' 22"
18 (38)	08/28/00	3 (33)	0	47° 44' 09"	122° 32' 38"
19 (53)	08/28/00	0	0	47° 44' 04"	122° 32' 33"
20 (46)	08/28/00	1 (100)	0	47° 44' 05"	122° 32' 24"
21 (35)	08/31/00	0	0	47° 44' 10"	122° 32' 34"
22 (28)	08/31/00	0	0	47° 44' 20"	122° 32' 55"
23 (37)	08/31/00	0	0	47° 44' 15"	122° 32' 31"
24 (49)	08/31/00	0	0	47° 44' 12"	122° 32' 38"
25 (26)	08/31/00	0	0	47° 44' 17"	122° 32' 29"
26 (44)	09/05/00	0	0	47° 43' 56"	122° 32' 39"
27 (64)	09/05/00	0	0	47° 43' 56"	122° 32' 37"
28 (50)	09/05/00	0	0	47° 44' 21"	122° 32' 28"
29 (30)	09/11/00	0	0	47° 44' 23"	122° 32' 32"
30 (31)	09/11/00	0	0	47° 44' 19"	122° 32' 15"
31 (30)	09/11/00	0	0	47° 44' 21"	122° 32' 06"
32 (58)	09/14/00	0	0	47° 44' 25"	122° 32' 27"
33 (60)	09/14/00	0	0	47° 44' 25"	122° 32' 23"

34 (44)	09/14/00	0	0	47° 44' 37"	122° 32' 18"
35 (52)	09/14/00	0	0	47° 44' 37"	122° 32' 27"
36 (44)	10/05/00	0	0	47° 44' 28"	122° 32' 31"
37 (57)	10/05/00	0	0	47° 44' 34"	122° 32' 36"
38 (62)	10/05/00	0	0	47° 44' 32"	122° 32' 30"

We captured 811 non-targeted animals in the tangle net and 37 in the gill net. These species included spiny dogfish (*Squalus acanthias*), ratfish (*Hydrolagus colliei*), sand sole (*Psettichys melanostictus*), starry flounder (*Platichthys stellatus*), American shad (*Alosa sapidissima*), Pacific herring (*Clupea pallasii*), Pacific cod (*Gadus macrocephalus*), red rock crab (*Cancer productus*), and Dungeness crab (*Cancer magister*). Most of the difference in incidental capture between the two mesh types can be attributed to an increased capture rate of spiny dogfish in the tangle net which was nearly three orders of magnitude greater than that of the gill net. In addition, more than ten times as many ratfish and sole were captured in the tangle net. Six of the nine non-targeted species were captured in the gill net.

The number of non-target fish that are deemed to be of little or no value to the fisher is an important consideration in the comparative analysis of the two net types. Managing incidental harvest is labor intensive and curtails the amount of time productively spent capturing and managing species of greater value to the fisher. Further, while incidentally harvested species may be of little value to the fisher, their ecological importance is often poorly understood. Little effort is made to ensure the survival of these species and they are, in fact, often killed before being discarded. Increasing the mesh size of the tangle net may help to reduce the number of non-target fish caught, as will as possibly improve the catch efficiency. The use of monofilament tangle nets should be reviewed for effectiveness in reducing the catch of non-target species.

So few chinook were caught in this fishery that we stopped fishing before the intended end of the project because we could see that we would not be able to meet any of our objectives. The results suggest that fewer fish would be caught in the tangle net, but because there was such a low abundance, little can be concluded. It is likely that this fishery would follow the same patterns as the chinook fishery in Budd Inlet and benefit from a larger mesh size to increase the catch efficiency of the tangle net and to reduce the number of non-target fish caught. The use of monofilament tangle nets should be reviewed as a solution to reduce the catch of non-target species. No conclusions about the effect of capture and release on long term survival can be drawn given the small number of fish tagged. Further, while it appears that fish landed in poor condition may derive some short term benefit from placement in the recovery tank, it is not clear to what extent these fish derive long term benefit.

Willapa River

We fished 2 boats per day for 5 days in September before the regular fishery opening in this area, then two more days with one boat after the opening in October and 2 days with the other

boat in November. The net was made from one shackle of 3.5" tangle net, and one shackle of 7.25" monofilament similar to the nets ordinarily used in this area for coho. Fish caught in this fishery were not tagged, but biological data was collected before release.

During the fishery, we caught 773 salmon, and the tangle net caught as many as the conventional gill net (Table 4). The abundance of fish was very high in the September fisheries, and even very short sets yielded good numbers of fish in both nets. In this fishery, the tangle net showed a clear advantage in an improved condition at capture, particularly for chinook (Table 5). Of the chinook caught in the gill net, 57 were not ranked as condition 1, and of those, we were able to revive 72% to release. Of the chinook caught in the tangle net, 36 were not ranked as condition 1, and we were able to revive 83% of those to release. Of the coho caught, 190 and 159 were not ranked as condition 1 from the gill net and tangle net respectively. In each case, we were able to revive about 63% to release.

Table 4: Catch summary for the Willapa River test fishery.

Date	Sex	Chinook		Coho		Steelhead		Chum		Total
		Gill	Tangle	Gill	Tangle	Gill	Tangle	Gill	Tangle	
11-Sep-00	F	5	3	21	18	0	0	0	0	47
	M	14	8	39	54	0	0	0	0	115
12-Sep-00	F	4	8	12	10	0	2	0	0	36
	M	5	6	39	53	0	0	0	0	103
13-Sep-00	F	15	11	45	29	1	2	0	0	103
	M	15	15	41	43	2	1	0	0	117
14-Sep-00	F	4	10	19	23	0	1	0	0	57
	M	5	2	27	31	1	0	0	0	66
15-Sep-00	F	5	6	15	6	4	1	0	0	37
	M	6	4	16	17	0	0	0	0	43
17-Oct-00	F	0	0	1	0	1	0	1	1	4
	M	0	0	1	0	0	0	1	0	2
18-Oct-00	F	0	0	5	2	0	0	1	0	8
	M	1	2	3	6	0	0	1	1	14
08-Nov-00	F	0	0	3	2	0	0	0	1	6
	M	0	0	2	2	0	0	0	1	5
09-Nov-00	F	0	0	1	2	0	0	0	0	3
	M	0	0	5	2	0	0	0	0	7
	Total	79	75	295	300	9	7	4	4	773

Table 5: Condition at capture and final condition of chinook and coho caught in the gill net and tangle net on the Willapa River. The percent of the total caught in each gear is given in parentheses.

	Chinook				Coho			
	Gill Net		Tangle Net		Gill Net		Tangle Net	
Condition at capture	Num.	%	Num.	%	Num	%	Num	%
1 (Lively, not bleeding)	21	26.9	38	51.4	104	35.4	137	46.3
2 (Lively, bleeding)	2	2.6	4	5.4	18	6.1	5	1.7
3(Lethargic, not bleeding)	40	51.3	23	31.1	91	31	106	35.8

4 (Lethargic, bleeding)	4	5.1	5	6.8	26	8.8	7	2.4
5 (No visible signs of life)	11	14.	4	5.4	55	18.	41	13.
Total captured	78		74		294		296	
Final condition								
1 (Lively, not bleeding)	59	75. 6	66	89. 2	209	71. 1	234	79. 1
2 (Lively, bleeding)	3	3.8	2	2.7	11	3.7	1	0.3
3 (Lethargic, not bleeding)	0		0		2	0.7	2	0.7
6 (Dead, not released)	16	20. 5	6	8.1	72	24. 5	59	19. 9
Total	78		74		298		300	

For each species, we observed a higher mortality rate for fish caught in the gill net than for fish caught in the tangle net. However, the overall survival of coho caught in the tangle net was still lower than we had expected from other experiments done in British Columbia. We found that the coho were very sensitive to handling during the September fishery and were unable to withstand stress. They were silver-bright, still had sea lice on them, and descaled easily. These were clearly fish arriving freshly from the ocean - a physiological stage that is known to make fish susceptible to stress. Furthermore, because of the abundance of fish, and our goal of releasing all fish live, we were frequently inundated by fish and unable to keep pace with reviving fish, collecting data and releasing the fish, in spite of set times as short as 5 minutes. We also made sure to complete the processing of all fish from one set before beginning another. In the other studies, coho that were to be revived were not encountered at this rate, allowing more care per fish during the critical first minutes, and those studies were not done on fish during the critical time of adaptation between salt and fresh water. However, we have learned a considerable amount about fish handling this year, and are confident that this experience will improve survival somewhat. Further work in this area will help to define what types of selective fisheries are acceptable for a given area.

It was also observed, as we had in the other fisheries, that fish were much easier to remove from the tangle net than from the gill net. As in the other fisheries, we also noted more non-target species were caught in the tangle net than in the gill net.

A preliminary look at the lengths of chinook (Figure 4) and coho (Figure 5) showed that with the exception of the tangle net catching more jacks (small males) than the gill net, as is expected from the smaller mesh size, there was little difference in the sizes of fish caught in the two nets.

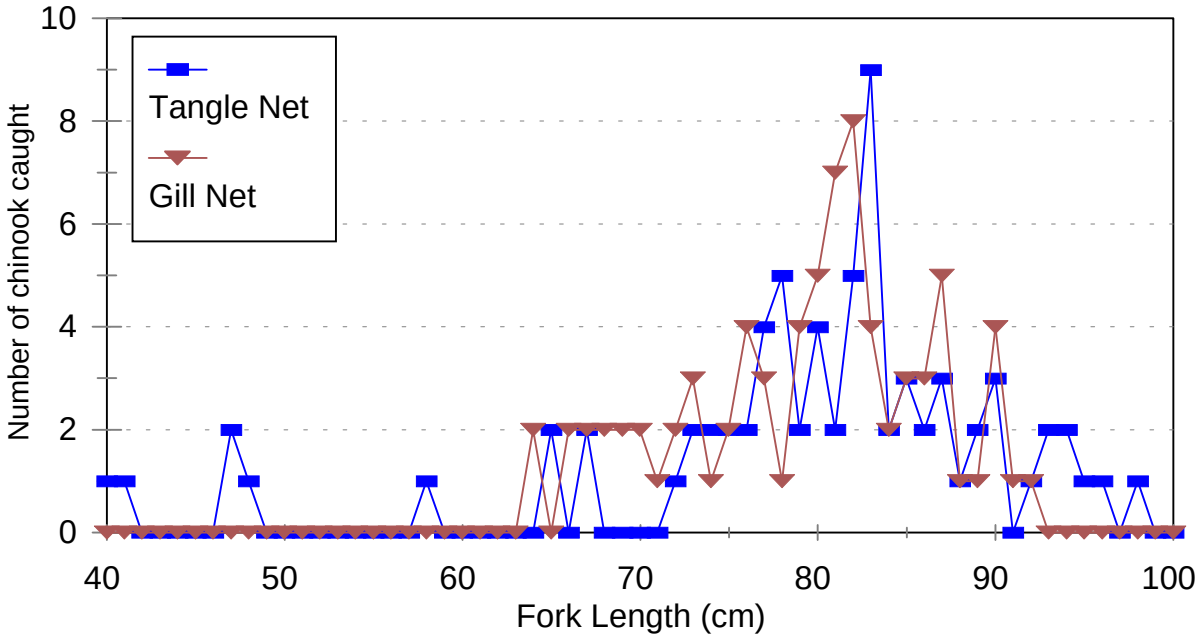

Figure 4: Length frequency distribution of chinook caught in the Willapa River test fishery.

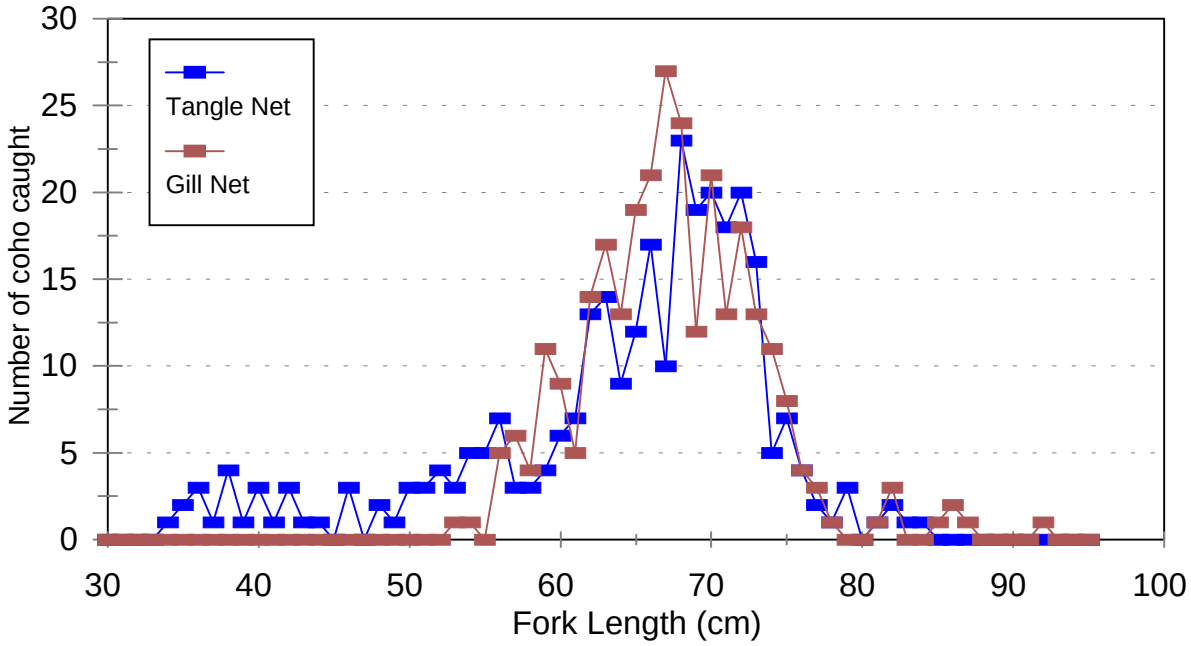

Figure 5: Length frequency distribution of coho caught in the tangle net compared to coho caught in the conventional gill net.

Our analysis is continuing, but we can make the following general statements about the effectiveness of tangle nets for live capture of chinook and coho:

1) The tangle net was less effective for catching chinook than the conventional gill net.

2) The tangle net was as effective as the conventional gill net for catching coho on the Willapa River, but not on the Puyallup River. Fish abundance was high on the Willapa River, and the effectiveness of the net may be related to abundance.

3) The tangle net shows promise in terms of better condition of the fish at capture, and lower initial mortality, and warrants further exploration.

4) The tangle net catches more non-salmonid species than the conventional gill net. Design changes are needed to reduce this catch, and to improve live release of these species. The effects of the tangle net on non-salmonid species must be a consideration if the gear is implemented.

5) We were unable to evaluate any post-release survival of tagged fish, and this issue requires further consideration.

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