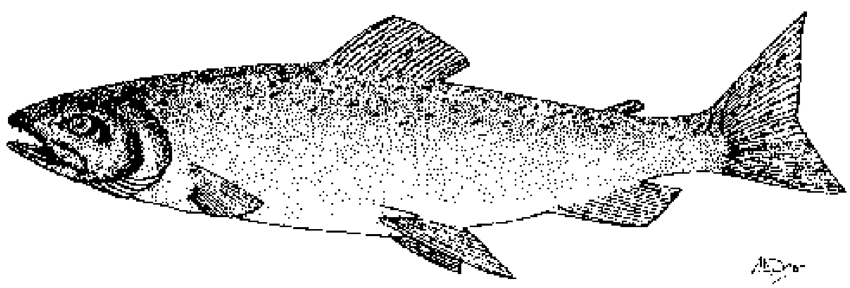
The Feasibility of Capturing Sufficient Skagit Chinook to Do a Mark-Recovery Population Estimate

SKAGIT RIVER SYSTEM COOPERATIVE

RESEARCH REPORT NO. (10)-1

BY JAKE MUSSLEWHITE



Report to the Sentinel Stock Committee
March 2010

Background and Introduction

This project was originally a component of a larger planned project designed to improve the escapement estimates of Chinook salmon on the Skagit River. In early 2009, the Skagit River System Cooperative (SRSC) proposed this project to the PSC Sentinel Stock Committee, which was soliciting proposals for projects that would help generate unbiased and statistically sound Chinook escapement estimates. The original SRSC proposal suggested several options, some of which called for a mark-recapture study, used to develop and calibrate several techniques to improve estimates based on redd counts.

When planning the original proposal, SRSC quickly realized that conducting the mark-recapture component was going to be challenging and expensive. Similar mark-recapture studies on Skagit coho and chum salmon used beach seines for the initial capture, which required large crews and expensive equipment. Other studies on the Skagit had attempted to use a fish wheel and gillnets to capture Chinook, with less than promising results. Also, the protracted run timing of Skagit Chinook would require capturing and marking fish from April into November, meaning that the effort would need to be sustained for six to seven months. The cost of such an effort would be high; and if history was any guide, the results would be uncertain.

To overcome these obstacles, SRSC proposed using a floating fish trap stationed at the mouth of the North Fork of the Skagit to capture Chinook for the initial marking. It was hoped that a fish trap could capture the 400 to 500 Chinook needed for the study at a fraction of the cost of a similar beach seining or gillnetting effort. After reviewing this proposal, the Sentinel Stock Committee asked SRSC to modify the proposal to a feasibility study, to test the effectiveness of the trap design before attempting the entire scope of the original project. The modified proposal was submitted and approved for funding in March 2009.

The decision to test the trap design before committing to the full project was a wise one. While the design, construction, and installation of the trap went smoothly, it failed to catch a single fish after two weeks of operation. While the zero catch simplified the analysis, it definitively showed that the trap was not an effective means to catch fish for the mark-recapture study. This report details the design, construction and operation of the fish trap.

Site description

The trap was located at the mouth of the North Fork of the Skagit River, adjacent to the McGlinn Island jetty (Figure 1). The jetty was constructed to separate the Skagit River from the navigable Swinomish Channel, and prevent sediment from filling the dredged channel. On the Skagit River side of the jetty, shallow water and sandbars prevent even small boats from entering except during high tide.   While most of the area is shallow, a deeper channel, or “gutter” runs along the jetty due to the scouring forces of the river flow.   At mid tide, this gutter is about four to ten feet deep, while the nearby flats are typically only one to three feet deep. The trap was positioned in the middle of the gutter, and nearly spanned the entire width of the deeper channel.

Access to the site from LaConner requires a small, shallow draft boat. At higher tides, a small boat can pass from Swinomish Channel to the trap site through a small gap in the jetty, known locally as the “fish hole.” At mid-tide, a small boat can travel around Goat Island and back upriver to the site. At lower tides, the only feasible access is to anchor a boat in Swinomish Channel and walk over the jetty to the trap site. We used a small Jon boat with a “beaver tail” motor, which is designed to operate in very shallow water. Even with the beaver tail, the tide-limited access was a major factor in our scheduling and operations.

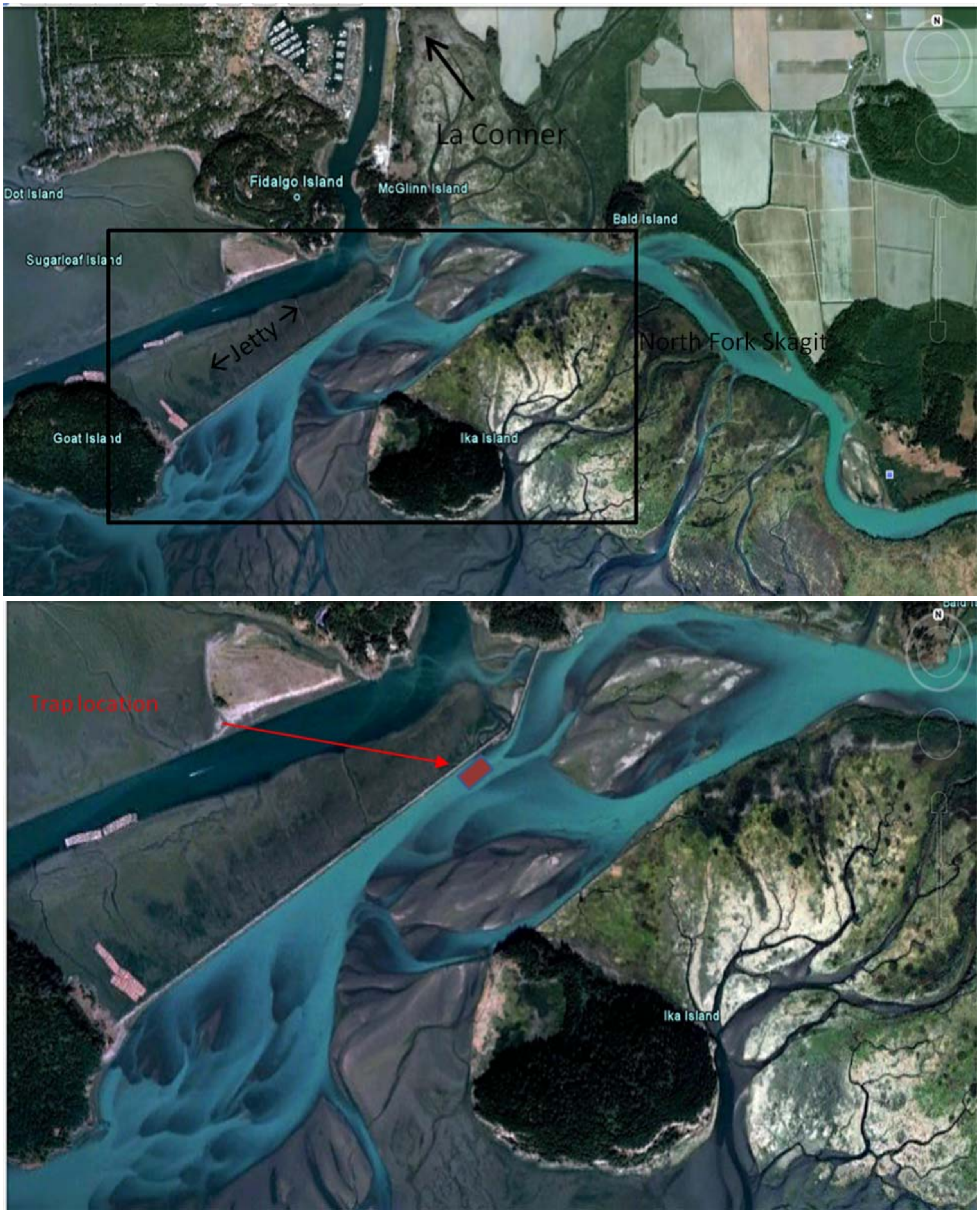


Figure 1. Aerial photographs of the trap site at the mouth of the North Fork of the Skagit River.

Design

The trap design was modeled on contemporary reef nets, which are themselves derived from ancient Indian fishing methods. Reef nets use lines fashioned in a ladder arrangement to guide fish into a floating net pen, where they can then be captured (figure 2). One of the advantages of a reef net is that fish can be captured alive with little or no injury and released unharmed if necessary. This made the reef net design advantageous for use in a mark-recapture experiment, where mortality is an important concern.

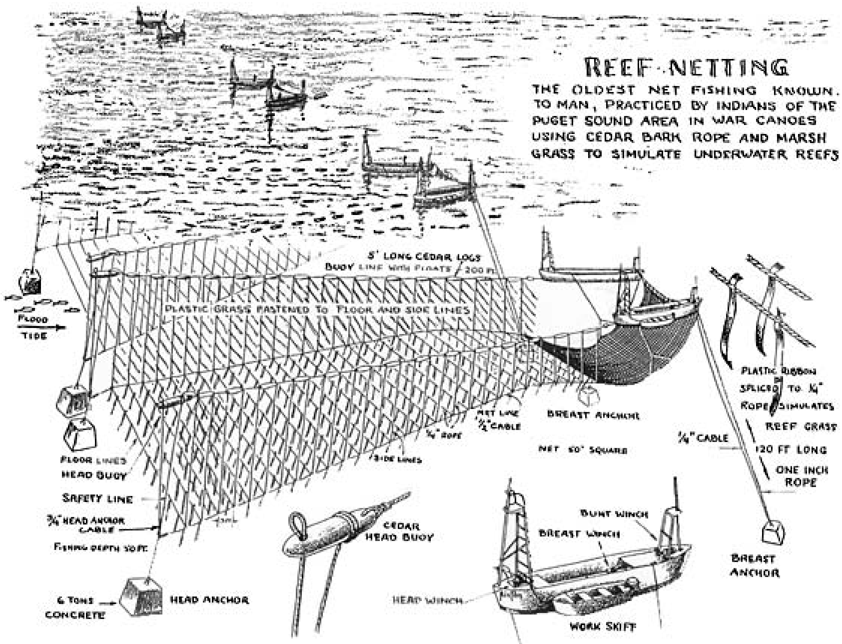


Figure 2. Traditional reef net gear (from http://www.lummi-island.com/reefnetfishing.htm)

While typical reef nets use two long leads of approximately equal length, our trap used a single long lead extending into the flats, and a short lead connecting to the jetty. In effect, we used the jetty itself as one of the leads. The long lead consisted of a ½" braided nylon cork line supported by commercial crab floats spaced six feet apart; a sinking lead line (150 lbs/100 feet); and ¼" orange polyethylene side lines connecting the cork and lead lines (figure 3). The side lines were spaced four to six feet apart, farther apart at the outer part of the lead, and spaced closer near the trap. In each side line, we tucked three to four clumps of beach grass through the line, about two vertical feet apart. These clumps of grass helped give the lead the appearance of a reef, so that the fish would follow along it, rather than swim through it. The original long lead was 260 feet long; and was extended to 400 feet in the second week of operation.

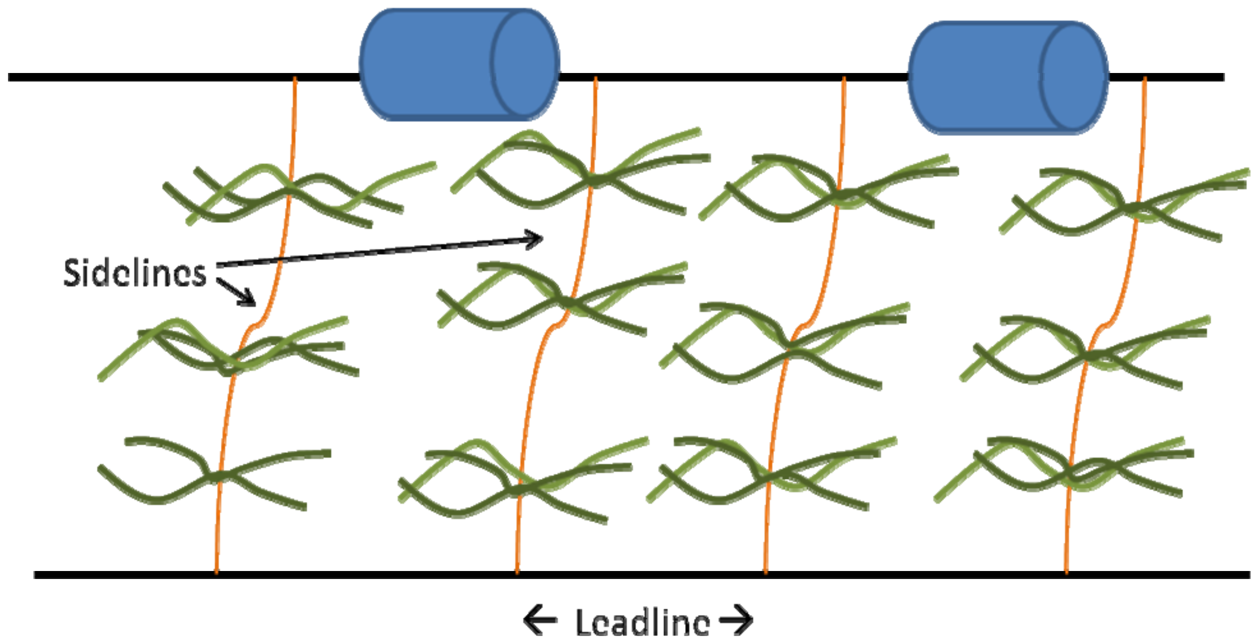


Figure 3. Schematic of lead construction

We used reef-net style leads because they had been proven to work for centuries, and they avoided many of the drawbacks of netting or other materials. The wide spacing between side lines allowed passage of most floating debris, which would not be possible with even large mesh netting. Even large logs could easily be cleaned from the lead by maneuvering them between the side lines and allowing them to drift downstream. Also, the lower resistance of the reef-net style leads made them easier to handle and moor in the currents at our site. Another potential drawback of netting leads would be the possibility of entangling and killing fish or other animals, which was much less likely with the leads we used. While reef-net style leads avoided these problems, the tradeoff was that they did not prevent fish from swimming through them, but only guided fish along them. We believed that since we only had to capture a small percentage of the fish passing through the area, this was an acceptable tradeoff.

The leads were connected to a 14’ x 28’ floating pen frame suspending a 10’ wide x 20’ long x 8’ deep net pen (figure 4). The downstream end of the pen was equipped with a eight foot wide by three feet high rectangular opening into an eight foot long fyke tunnel. This tunnel was designed to lead fish into the pen, but prevent them from escaping easily. The end of the tunnel was pulled taut by lines tied to each top corner of the tunnel’s inside opening. The position of the tunnel could be adjusted by changing the tension and angle of these lines. Weights attached to the bottom corners helped to hold the tunnel open. To keep the net pen open in the current, we placed 10 pound lead cannonballs at each corner and at the middle of each long side. The cannonballs were suspended on lines tied to the pen frame so that they could be removed to pull up the net. Since the depth of the water was usually about the same as the net pen depth, the bottom of the pen often sat on or near the bottom of the channel.

The pen frame was constructed of 12" polyethylene pipe, which was filled with foam and fusion-welded. The pipe frame was decked with 2x12 pressure-treated planks, two wide, to form a walkway around the entire pen. The upstream end of the pen was covered with additional decking to form a 6' x 14' work platform. Vertical stanchions welded to the main frame around the inside of the pen provided attachment points for suspending the net pen.

The pen frame was moored in place using two heavy shore lines and two anchor lines, so that a line extended from each corner of the pen. The position of the pen could be adjusted by loosening or tensioning each line. For the anchor tackle, we used a 45 pound plow-style anchor with about twelve feet of very heavy 4" chain, which weighed about 150-200 pounds. These anchors were very effective in the soft sand, and we had no problems with anchor dragging despite the heavy current at the site. On shore, we wrapped large rocks with the same heavy chain, and attached the shore lines to those chains with heavy shackles. Because we wanted to keep the pen in the channel that runs along the jetty, the pen was moored only a few feet from shore, so that much of the time it was possible to step from the jetty directly onto the pen frame. To protect the pen from floating debris, we also tethered a boom log to shore upstream of the pen, and tied the floating end to the outside corner of the pen frame.

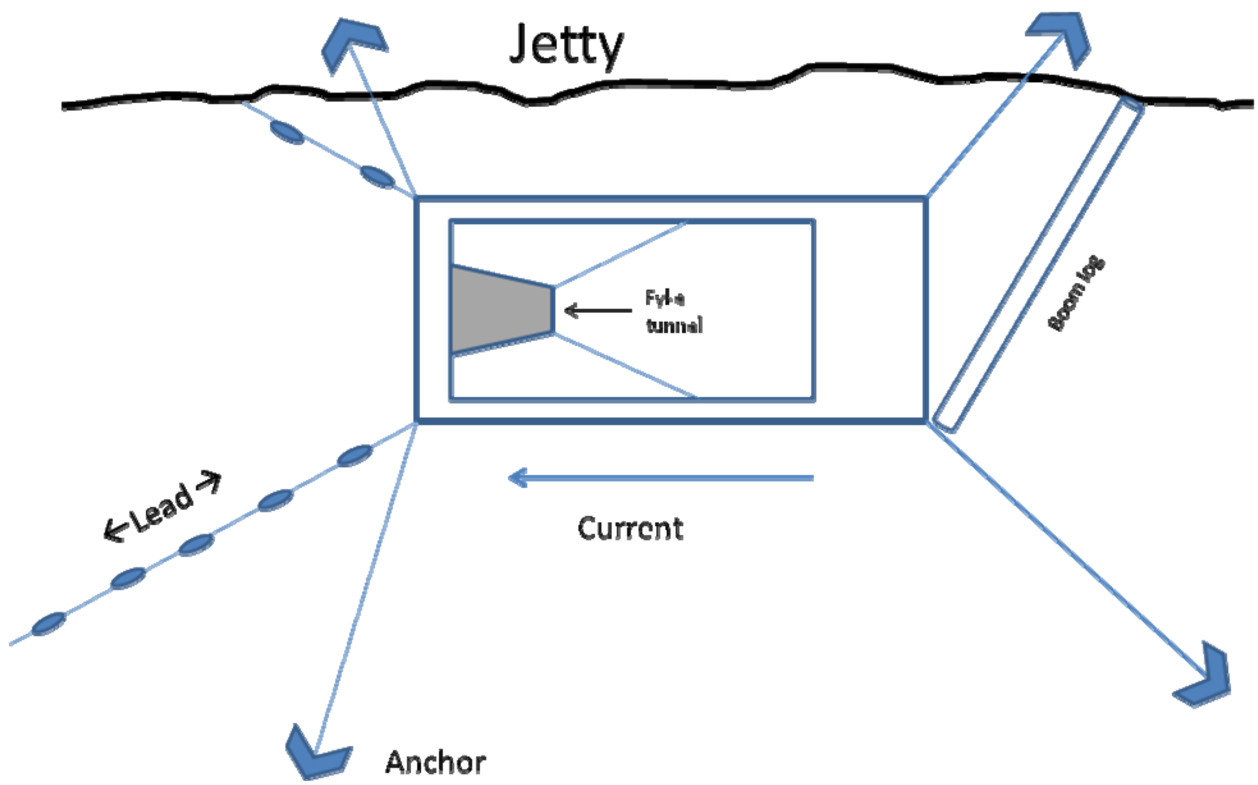


Figure 4. Schematic of pen configuration. Not to scale.

A number of permits were required to legally operate the trap (table 1). While we were able to secure these permits within a few months, the time and effort involved was a considerable portion of the overall project. In our case, a total of about two to three weeks of staff time were used for the permitting process.

Permit	Agency	Comments
Section 10 Permit	U.S. Army Corps of Engineers	Requires compliance with ESA to issue permit.
Hydraulic Project Approval	Washington Dept. of Fish and Wildlife	
Shoreline Exemption	Skagit County	
Aquatic Lands Use Authorization	Washington Dept. of Natural Resources	
Private Aids to Navigation	U.S. Coast Guard	Required lighting of trap structure

Table 1. Permits required for construction and operation of fish trap.

Operation

Unlike beach seining, tangle netting, or other methods of capturing fish, operation of the trap was essentially passive. A crew of two people monitored the trap while in operation, and checked it at one hour intervals. To check the trap, the crew would release the lines tensioning the fyke tunnel, allowing it to collapse and seal off the trap opening. They would then retrieve the cannonball weights holding down the net and "dry up" or pull in the net pen until the bottom could be seen, and any fish present would be visible. The crew would then release the net, replace the cannonballs, and retension the tunnel lines to return the trap to "fishing mode." To avoid spooking any fish that might be approaching the trap, the crew would usually wait on top of the jetty, rather than on the trap frame itself. This vantage point also allowed them better visibility down into the trap and nearby water. Throughout each day, the crew would also adjust the position of the fyke tunnel, the leads, and other factors that might affect the performance of the trap.

In the event that any Chinook were captured, the crew would roll the fish into the bunt of the net, dip them out with a dip net, and place them in a measuring trough. The length and sex of each Chinook would be recorded, and a uniquely numbered hog ring-style jaw tag would be placed on their lower jaw. The fish could then be returned to the water and allowed to recover before being released.

Results

The trap frame was moved and anchored at the study site on July 14, 2009. The leads were installed on July 16, and the net pen was installed the next day, on July 17. The trap was operated for 3 hours on July 17, but much of that time was spent making adjustments to lines and weights.

The first full day of trap operation began on July 20, 2009. Over the first week of operation, the trap was actively fished for almost 30 hours (table 2). The trap was checked for fish and reset hourly.

On July 24, after the trap had been operating for several days without catching any fish, we attempted to inspect and monitor the trap with a submersible video camera. Our hope was to determine whether Chinook were approaching the trap tunnel, and to see how the trap and leads appeared from a salmon's perspective. The turbidity limited visibility with the camera to less than a foot, and we were unable to determine much about the performance of the trap.

By the second week of operation, the turbidity had increased so that visibility was less than six inches, and the water was colored a chocolate brown. This condition persisted through the rest of the study. When we still hadn't caught any fish by the middle of the second week, we constructed an extension to the main lead, so that it could reach farther into the flats and hopefully intercept more fish. The 140 foot lead extension was installed on July 31, and extended the total length of the main lead to 400 feet.

Over the course of operation, we had observed Chinook swimming through the lead on multiple occasions, and it was becoming apparent that the reef-net style lead was not guiding fish to the trap as intended. In order to make a lead that fish couldn't swim through, we replaced the section of lead closest to the pen with a 260 foot long beach seine with 3.875" mesh. This mesh size would not allow Chinook to pass through it, as we believed was happening with the original leads. We attached the 140 foot lead extension to the end of the beach seine, so that the total length remained at about 400 feet.

Unfortunately, the anchoring system could not handle the increased drag of the beach seine. Upon returning to the trap the morning following its installation, we found that it had pulled its anchors downstream, so that it ran parallel to the jetty, and entangled in a root wad. We attempted to recover and reinstall the beach seine, but could not free it from the root wad. With this last setback, operation of the trap was stopped. We were unable to recover the beach seine until August 11, nearly a week later.

No Chinook or other salmon were captured during operation of the trap.

Date	Trap opened	Trap closed	elapsed time	Notes
7/20/2009	10:00	17:00	7:00	
7/21/2009	14:50	20:41	5:51	
7/22/2009	6:40	13:45	7:05	
7/23/2009	10:35	14:24	3:49	
7/24/2009	17:00	23:00	6:00	Underwater camera observation
Week 1 total			29:45	
7/27/2009	9:03	15:21	6:18	Heavy turbidity, 6” visibility
7/28/2009	9:33	14:48	5:15	
7/29/2009	9:37	19:12	9:35	
7/30/2009	14:31	21:15	6:44	
7/31/2009	15:13	21:36	6:23	Extended lead to 400’
Week 2 total			34:15	
8/3/2009	9:00	16:00	7:00	
8/4/2009	N/A	N/A	0:00	Pulled leads and set beach seine
8/5/2009	N/A	N/A	0:00	Beach seine pulled moorings
8/6/2009	N/A	N/A	0:00	Attempted to reinstall
8/7/2009	N/A	N/A	0:00	Ended operations
Week 3 total			7:00	
	Overall total		71:00	

Table 2. Timeline and hours of effort for the experimental fish trap.

Discussion

This was a feasibility study, attempting to develop an alternative to the expensive and labor-intensive methods currently used to catch salmon for mark-recapture experiments. Because mark-recapture experiments are a widely used tool in fisheries research (Cousens et. al 1982; Schwarz et. al. 1993), any improvement in the effectiveness or cost of capturing the fish could be of great utility to fisheries managers. The traditionally used methods – beach seining, gill- or tangle-netting – typically require large crews and/or expensive equipment, which may be prohibitive. For example, beach seining for Chinook in the Skagit would require a crew of at least four to five people working several days a week between April and November. The cost of just the initial marking component of such a study would likely be more than $100,000. In contrast, operating a small fish trap would require a crew of only one or two people, possibly working only part time.

The development of a functional fish trap would also address some of the problems inherent in using nets to capture fish. The statistical assumptions of a mark-recapture experiment require an equal probability of capture for each fish, a low (or at least known) mortality, and minimal size- and sex-selectivity (Jolly 1982; Seber 1982). An effective fish trap design would improve the ability to meet all of these assumptions.

A passive trap can be used to sample continuously, or over longer time periods than active gear like nets. It can also be used to sample with a consistent level of effort, unlike nets. The consistent and long-term effort possible with a fish trap makes it more likely that the "equal probability of capture" assumption could be met. A trap is also less likely to kill, injure or seriously stress a captured fish, reducing the problematic effects of having an unknown mortality rate. Finally, a trap would be less likely to be size or sex-selective, unlike gillnets, and could produce reliable results across all ages, sizes, and sexes.

Unfortunately in this case, the most important characteristic of a capture method is that it actually captures something. Since our trap failed to catch a single fish, it obviously failed in that regard. The reasons for this failure are not entirely clear. Test fisheries conducted upriver caught Chinook that must have passed the trap site, so we know that Chinook were present. The most likely explanation is that the leads did not guide Chinook to the trap as intended. While turbidity made direct observation of fish behavior difficult, we occasionally witnessed Chinook surfacing immediately behind the lead, and then surfacing again above the lead. This suggests that rather than encountering and following the lead, Chinook were simply swimming through it. We had assumed that many Chinook would do so, but that enough would follow the lead and enter the trap to capture an adequate sample. Also, the lead design had been proven by literally centuries of use in both modern and Indian reef net gears. However, these reef nets are usually placed in marine waters, where visibility is better and the leads may be more effective. It is possible that the reef net style lead is not suitable for turbid riverine or estuarine environments.

Another possibility is that some Chinook were following the leads and encountering the trap itself, but were reluctant to swim through the fyke tunnel and into the pen. During our design of the trap, this was actually our biggest concern, since the lead design had been proven in other applications, but the "fyke pen" design was not. In our design, w tried to balance the need to retain fish in the pen (with a narrow opening) and entice fish into the pen (with a wider opening). It may be that the fyke opening was too small, or that some other aspect of its design deterred fish from entering it. Conversely, it may be that the opening was too wide, and that fish entering the pen and finding themselves trapped could quickly find their way back out, before the trap was checked. However, if that was occurring regularly, it seems likely that at least one of those fish would have been detected and captured before escaping.

Unfortunately, we can only conjecture as to the reason for the failure, because the turbidity we experienced during the trap's operation prevented almost all direct observation of its performance. When planning the project, we had anticipated making constant adjustments to the configuration of the trap and "tuning it" to maximize its effectiveness. But, without any way to gauge how the fish were behaving, adapting the trap design became an exercise in guesswork. By the end of the study, we knew that the trap had been unsuccessful, but did not know why.

The underlying reason for its failure might rest with its underlying concept. When we planned this project, we reasoned that fish traps, which have historically been banned because of their effectiveness, would be a great way to capture fish for a mark-recapture study. However, traditional fish traps were expensive and involved massive amounts of infrastructure, making them unsuitable for cash-strapped fisheries researchers. To get around that problem, we attempted to create an inexpensive and "portable" version that could be operated by a small crew. In the end, the effectiveness of fish traps probably depended on their massive infrastructure, which can't easily be replaced by a cheap lightweight substitute. For example, our leads coped with current and debris by being low-resistance and permeable, while traditional leads used pilings and heavy nets to do the same thing. Our leads were easy to build and install, but fish probably swam right through them, something they couldn't do in the traps of 100 years ago. While the fish trap still holds promise as a fisheries research tool, our study demonstrated that they might not be a cheap and easy one.

References

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Appendix I. Photos of trap installation

1. Left – trap frame facing downstream to
2. Lower left – trap frame facing upstream
   River
3. Lower right – trap and leads facing upst