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Feasibility of Using Fishwheels for Long-Term Monitoring of Chinook Salmon Escapement on the Copper River

Annual Report No. FIS01-020-1

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EXECUTIVE SUMMARY

The Copper River supports one of the largest chinook salmon (*Oncorhynchus tshawytcha*) subsistence fisheries in Alaska. Many stakeholders believe that escapement indices generated by traditional methods (aerial surveys and weirs on selected systems) have not adequately assessed the abundance of Copper River chinook salmon stocks. A recent three-year radio-telemetry study provided the first system-wide escapement estimates to the Copper River. Plans to end the telemetry study in 2001 created a need to develop a cost-effective, long-term program that could provide system-wide chinook salmon escapement estimates to the Copper River.

The objective of this study was to assess the feasibility of using fishwheels, as both the capture-tag and the recapture phases of a mark-recapture study, for long-term monitoring of chinook salmon escapement on the Copper River. In early 2001, the U.S. Fish and Wildlife Service (USFWS), through the Office of Subsistence Management, funded the Native Village of Eyak (NVE) to undertake this three-year study. Overall objectives for this study were to:

1. Evaluate the ability of fishwheels to capture chinook salmon on the Copper River and estimate the precision of mark-recapture escapement estimates;
2. Generate system-wide escapement estimates for chinook salmon returning to the Copper River; and
3. Develop a long-term program operated by NVE to estimate chinook salmon escapement to the Copper River.

Specific objectives for 2001 were to:

1. Evaluate the efficacy of installing and operating fishwheels in Baird Canyon;
2. Estimate the ability of fishwheels to capture chinook salmon throughout the entire run; and
3. Evaluate and compare potential fishwheel sites in Baird Canyon.

In May 2001, two large aluminum live-capture fishwheels were assembled on the banks of the Copper River near Chitina, Alaska, and floated 100 km downstream to Baird Canyon. Environmental variables were monitored at seven potential fishwheel sites in and near Baird Canyon from late May until mid-July. Two fishwheels were operated for a total of 986 hours from 29 May to 11 July 2001. One fishwheel was operated for 9 days and the other for 38 days.

Catches included 914 chinook salmon, 23,230 sockeye salmon (*O. nerka*), 146 Dolly Varden (*Salvelinus malma*), 68 Pacific lamprey (*Lampetra tridentata*), 3 whitefish (*Coregonus spp.*), 84 salmon smolts, 7 suckers (*Catostomus sp.*), 1 burbot (*Lota lota*), and 1 Arctic grayling (*Thymallus arcticus*). Peak catches for chinook salmon occurred on 17 June (64 fish), and for sockeye salmon on 9 July (2,110 fish). The average length (mid-eye-to-fork) of 333 chinook salmon measured was 82 cm. A total of 370 chinook salmon were marked by placing a single-

hole punch in the left operculum. Of these marked fish, ten were subsequently recaptured in the project fishwheels or upstream in subsistence fishwheels.

The proportion of the 2001 chinook salmon run captured by the fishwheels could not be estimated based on escapement estimates from an upstream telemetry project because these data were not available at the time of writing. However, given that the 2001 return was similar to that of recent years, past escapement numbers were used to estimate that the fishwheels caught between 1.5% and 2.75% of the estimated run. Considering the level of fishing effort achieved in 2001, two fishwheels should capture a sufficient portion of the chinook salmon run in the Copper River for the capture-tag phase of a mark-recapture study. The 2002 season will include further development of fishwheel sites in Baird Canyon and the development of upstream recovery effort using catch sampling and one or two fishwheels.

INTRODUCTION

The Copper River (Figure 1) supports one of the largest chinook salmon (*Oncorhynchus tshawytcha*) subsistence fisheries in Alaska. The importance of Copper River chinook salmon to subsistence users has focused attention on the lack of information about their escapement and distribution. Despite the importance of this fishery, fishery managers have found it difficult to obtain annual estimates of chinook salmon escapement to the drainage. Many stakeholders believe that escapement indices generated by traditional methods (aerial surveys and weirs on selected systems) have not adequately assessed the abundance of Copper River chinook salmon stocks.

For the past three years, Alaska Department of Fish and Game (ADF&G) biologists have conducted a radio-telemetry study to derive the first system-wide estimates of chinook salmon escapement to the Copper River (Evenson and Wuttig 2000). These estimates were derived from radio-tagging and recovering fish in the vicinity of Wood Canyon. Due to the project's high expense, biologists planned to terminate this telemetry-based escapement-monitoring project after the 2001 season. Termination of the radio-tagging project created a need for the development of a long-term program to monitor chinook salmon escapement in the Copper River.

Using fishwheels (Meehan 1961; Donaldson and Cramer 1971) combined with mark-recapture techniques can often be effective for estimating chinook salmon escapement. This technique has been used to generate system-wide salmon escapement estimates on numerous large rivers (Link and Nass 1999; Sturhahn and Nagtegaal 1999; Gordon et al. 1998; Cappiello and Bromaghin 1997; Link et al. 1996; McPherson et al. 1996; Johnson et al. 1992; Donaldson and Cramer 1971; Meehan 1961), and appears promising for use on the Copper River.

The objective of this study was to assess the feasibility of using fishwheels, as both the capture-tag and the recapture phases of a mark-recapture study, for long-term monitoring of chinook salmon escapement on the Copper River. In early 2001, the U.S. Fish and Wildlife Service (USFWS), through the Office of Subsistence Management, funded the Native Village of Eyak (NVE) to undertake this three-year study.

OBJECTIVES

Overall objectives for this three-year study were to:

1. Evaluate the ability of fishwheels to capture chinook salmon on the Copper River and estimate the precision of mark-recapture escapement estimates;
2. Generate system-wide escapement estimates for chinook salmon returning to the Copper River; and
3. Develop a long-term program operated by the Native Village of Eyak to estimate chinook salmon escapement to the Copper River.

In the first year, two fishwheels were operated in Baird Canyon, located approximately 100 km (62 miles) upstream of where the Copper River enters the Gulf of Alaska. Several potential fishwheel sites were examined across a range of water levels and fishwheels were operated at a subset of these sites. The purpose of this report is to document the methods, results and conclusions from the 2001 field program. Specific project objectives for 2001 were to:

1. Evaluate the efficacy of installing and operating fishwheels in Baird Canyon;
2. Estimate the ability of fishwheels to capture chinook salmon throughout the entire run; and
3. Evaluate and compare potential fishwheel sites in Baird Canyon.

METHODS

Study Area

The Copper River flows southward through Southcentral Alaska and enters the Gulf of Alaska near the town of Cordova (Figure 1). Between the ocean and Miles Lake, located 82 km upstream, the river channel traverses the Copper River Delta, which is highly braided and offers little chance to capture substantial proportions of migrating fish. The first major channel constriction occurs when the river enters Baird Canyon at the upstream end of Miles Lake. Baird Canyon extends another 6 km upstream where La Gorce Creek enters from the east. The uppermost 2 km of the canyon are the most constricted, and were thus deemed to have the greatest potential for fishwheel deployment.

Two project fishwheels were used to evaluate seven potential sites for capturing chinook salmon in Baird Canyon (Figure 2). Of these sites, two were used. Fishwheel 1 (located at Site 1) was operated 1 km down from the upstream end of the canyon, on the west bank of the river. Fishwheel 2 (located at Site 2) was operated further upstream on the east bank of the river, immediately below the upstream end of the canyon (Figure 2). The east bank of the canyon is a steep, often sheer, rock wall that rises over 600 m (1,969 ft) above the river and litters the east shoreline with rock and snow debris. The west bank slopes more moderately to a maximum height of 20 m above the river, is densely wooded, and has a substrate ranging from sand to boulders. The land beyond the west bank is primarily a wetland area that drains the Allen Glacier to the west. The north branch of the Allen River enters on the west bank, and is the only major tributary entering Baird Canyon.

Chinook and sockeye salmon generally return to the Copper River in early to mid-May, as rising temperatures and water flush the ice from the river. The majority of the chinook salmon run returns to six tributaries in the upper Copper River (Evenson and Wuttig 2000), all of which are upstream of Baird Canyon. Based on commercial harvests at the river mouth and upriver sport and subsistence harvests, nearly all chinook and sockeye salmon enter the river by early August (Evenson and Wuttig 2000; Morstad et al. 1999). A sonar station operates annually at the outlet of Miles Lake to estimate daily salmon escapement from mid-May to early August (16 May to 5 August in 2001; Morstad et. al. 1999). An estimated 833,600 salmon passed the sonar station between 16 May and 31 July 2001.

The United States Geological Survey (USGS) operated a discharge rating station about 20 km downstream from Baird Canyon at the exit of Miles Lake. Annual discharge on the lower Copper River averaged 1,625 m^3/s (57,400 f^3/s) from 1988 to 1995, with the majority coming in the summer from snow and glacier melt. Peak discharge in June ranged from 3,650 to 4,235 m^3/s, while annual peak discharge ranged from 6,681 to 11,750 m^3/s. A relatively high proportion of the Copper River's headwaters are glaciated (18% in 1995), resulting in very high unit discharge (volume per square mile of drainage area) and sediment loads (Brabets 1997). Water levels in Baird Canyon typically rise sharply from late May through June, level off in July, and then peak in August (USGS 2001; Appendix Figure A-1). Sediment loads cause the water to be unusually turbid and fill the river with numerous ephemeral sandbars and channel braids for most of its length. The river channel through Baird Canyon is one of the few constricted, unbraided reaches in the lower 200 km of the Copper River.

Project Operation

The 2001 season provided many unique challenges. The project was in a remote location, it was the first year, and it was a new collaboration among several organizations (NVE, LGL, ADF&G, and USFWS). Given these factors, a review of project mobilization and logistics may be particularly useful for future reference and project management. Appendix B-1 shows the timeline that was followed to accomplish these tasks.

Hiring and Training

An announcement for fisheries technician positions was circulated in Cordova in January 2001. Preferred skills of potential candidates included knowledge of mark-recapture studies, fish biology and physiology, fish handling, data management, water safety, watercraft operation, and mechanical aptitude (Appendix Table B-2). LGL and NVE staff screened all the applicants, selected candidates and sent out job-offer letters. Five people were hired for the positions. Pre-season training consisted of a project overview, shotgun safety class (Alaska Tactical, Anchorage, AK) and bear safety course (Derek Stonorov, retired ADF&G biologist). Inseason training occurred focused on fishwheel operation/maintenance, boat handling, fish sampling/marking and mark-recapture theory.

Permit Requirements

NVE obtained land use permits from the U.S. Forest Service and Chugach Corporation in order to operate a field camp at Baird Canyon, travel overland to the field camp, and to install the fishwheels on the Copper River (including anchoring them to the shore). LGL acquired permits from ADF&G for fish collection and sampling (with emphasis on chinook and sockeye salmon). All permits were obtained prior to the start of the field season (20 April 2001).

Fishwheel Fabrication

Fishwheel fabrication and shipping were planned several months before the project received final approval because of the limited time between the expected approval date and the start of the field season. Immediately following final approval of the project, the welding firm was given notice to initiate fabrication of the fishwheels. The two fishwheels were manufactured in Terrace, British Columbia (BC), by Neid Enterprises, and were designed similar to those used on the Nass (1993-present), Skeena (1993-present), Fraser (1997-present), and Wannock (1999-2000) rivers in BC, and those on the Skagit River, WA (2000-present), and the Roanoke River, NC (2000-present). Each fishwheel was made of two welded aluminum pontoons (11.6 m long x 0.9 m wide x 0.5 m deep), a 3.7 m long axle, three baskets (3.1 x 3.1 m), and a tower (6.1 m high) and boom (4.9 m long) assembly was used to raise and lower the axle (Figure 3). Baskets were designed to fish up to about 3 m below the water surface and were lined with 5.1 cm (2.0 in.) knotless nylon net (210/108). A tank for holding captured fish (4.3 m long x 1.5 m deep x 0.6 m wide) was fitted inside each pontoon and the base was fitted with windows of extruded aluminum mesh to allow ample water circulation.

Once fabricated, the pontoons, axles and three of the six fishwheel baskets, along with unassembled materials were shipped by tractor truck from Terrace, BC, to Chitina, AK. The crew further assembled the fishwheels in Chitina prior to floating the materials downstream. Three fishwheel baskets were assembled at the field camp near Baird Canyon and assembly of the fishwheels was completed at the final fishing sites.

Mobilizing the Field Project from Chitina

After assembling the fishwheels on the bank of the river near Chitina, they were floated 100 km to Baird Canyon. The fishwheels were trimmed for river transport by elevating the live-tanks, covering the undersides of the live-tank openings with plywood, and installing only two baskets per axle. The fishwheels were then towed separately downstream to Baird Canyon behind a 7.3 m boat equipped with a 7.4 l (454 in^3) engine and inboard jet propulsion unit.

Potential field camp sites were evaluated based on their proximity to expected fishwheel sites, elevation above river level, distance from the river, availability of clear stream water, snow coverage, estimated bear activity, boat landing sites, proximity to float plane landing sites, and wind exposure. The field camp was established at Baird Canyon on 24 May, and dismantled on 17 July.

Supply System

Overland and air transportation methods for re-supplying the field camp and transferring personnel to Baird Canyon were investigated. Access early in the season was limited by uncertainty in the amount of ice coverage, availability of boat launches on Miles Lake, as well as uncertainty in the availability of landing strips for aircraft (both on the ground and on the river).

Fishwheel Site Evaluation and Selection

The Baird Canyon area was scouted by boat to locate potential fishwheel sites. Sites were rated based on water depth, water velocity, accessibility, bank full width, and protection from floating debris and rock fall. Water depths greater than 3.0 m and velocities ranging from 0.5 to 1.5 m/s (1.6 to 4.9 ft/s) were needed for fishwheels to rotate at optimal speeds and force migrating fish to travel near shore. Narrow, fast-flowing channels were preferable to wide, slow areas because they tend to concentrate migrating salmon close to shore. Sites were evaluated and ranked for their suitability across a range of water levels during the season.

Fishwheel Installation and Operation

Anchors were installed at potential fishwheel sites prior to placement. Anchors included large boulders, trees, and iron pins drilled into boulders and cliff walls. Anchor-pin holes were drilled using a Hilti TE-55 rock drill equipped with a 3.2 cm drill bit and powered by a 2500 kilowatt Honda generator. Pins were placed at depths ranging from 7.5 to 38 cm. Pins were wrapped with duct tape and driven with a sledgehammer to ensure a tight fit in the holes.

Anchor lines consisted of 9.5 mm (0.375 in.) galvanized wire rope and 19.1 mm polypropylene rope. The wire-rope shorelines bore most of the fishwheel weight and were connected to the bow of the fishwheel pontoons with a bridle assembly to help equalize the force between the two pontoons. A polypropylene bridle was also attached to the bow of the pontoons for safety. Additional polypropylene lines were used to anchor the sides and stern of the fishwheel, and to adjust the position of the fishwheel (Appendix Figures C-1 and C-2).

Two techniques worked for moving fishwheels during the sampling season. Early in the project, fishwheels were towed behind a boat when moved between sites (Photo 1). A boat was sufficient to move a fishwheel until the middle of the field season. Later in the season, fishwheels were moved by supplementing the normal boat towing strategy with propulsion from two propeller-driven outboard engines (40-HP each) mounted on transoms attached to the stern of each pontoon (Photo 2).

The fishwheels were operated 24 hours per day, except for stoppages when adjustments or repairs were required. The fishwheels were re-positioned until target speeds of 1.5 to 3 RPM were obtained. When measuring fishwheel speed (RPM), the baskets were counted for a minimum of two minutes to mitigate the effects of temporary surges in water velocity. Fishwheels were re-positioned upriver and downriver by adjusting the bow anchor lines, and laterally by adjusting the stern and side anchor lines.

Fish Capture and Sampling

Two to five times per day, depending on capture numbers, the crew sampled all fish in the live tanks. Chinook salmon were counted, sexed, inspected for an adipose fin, and then released overboard. A subset of chinook salmon were measured (mid-eye to fork length, MEF) and marked with a single-hole punch on the upper half of the right operculum. This subset of the catch was sampled and marked opportunistically when time permitted, and was thus not a random sample of the catch.

All other fish were identified to species, counted, and released overboard. A subset of Dolly Varden (*Salvelinus malma*) and Pacific lamprey (*Lampetra tridentata*) were also measured (DV, snout-to-fork; PL, total length, cm). Small sockeye (*O. nerka*) and chinook salmon were counted separately from large fish. One-ocean chinook salmon were defined as fish that ranged from 30 to 50 cm in length.

Data Analysis

Fishwheel Effort And Capture Efficiency

Two forms of fishwheel effort were calculated. First, *daily fishing effort* was computed as the number of hours that the fishwheel operated on a given calendar day from midnight to midnight. Second, *effort for calculating CPUE* (or catch per unit effort) was computed as the number of hours that the fishwheel fished to obtain a given day's catch. These two effort values were often not the same for a given day because the fishwheel live tanks were not always emptied of fish at the exact same times each evening. For example, if fish were last sampled at 2200 hours on day t and last sampled on day t+1 at 2000 hours, then only 22 hours of fishing effort was used to obtain the *effort for calculating CPUE* on day t+1 (assuming uninterrupted fishwheel operation). However, in this example, the *daily fishing effort* on day t+1 would be 24 hours because the fishwheel operated continuously for the entire calendar day. *Effort for calculating CPUE* on day t+1 could also exceed 24 hours if the last sampling session on day t was earlier in the day than the last sampling session on day t+1.

Catch per unit effort (CPUE) in fish per fishwheel hour, was calculated by dividing the total number of fish captured on a given calendar day by that day's effort for CPUE.

Size Selective Capture by the Fishwheel

Potential size-selective capture in the fishwheel was examined by comparing cumulative length frequencies of fish measured from the fishwheel catch with that from upstream sampling by ADF&G (near Wood Canyon). This comparison provided an indication of whether the fish measured in the fishwheels were similar to those measured upstream by the ADF&G sampling effort. A high-powered test of the degree (or presence) of size-selective capture was not possible in 2001. Fish were not measured across the entire run at the fishwheels and there was no way of determining how representative the lengths obtained at Wood Canyon were of the entire run at the fishwheel. This analysis can be completed when ADF&G data is submitted.

RESULTS

Project Operation

Fishwheel Fabrication

Project staff compared the cost and availability of fabricating the fishwheels in Alaska and British Columbia. Fishwheel components are relatively complex and all Alaskan boat-builders that were contacted were unfamiliar with their construction. Furthermore, in order to implement the project on time, the fishwheels had to be built within a two-month time period. As such, Neid Enterprises, an experienced fishwheel supplier, fabricated and partially assembled the two project fishwheels in Terrace, BC. The partially assembled fishwheels were delivered by flatbed truck to Chitina on 18 May. A crew of three to six people assembled the pontoons and fishwheel superstructure from 18-23 May. The fishwheels were launched from Chitina on 23 May, and were delivered on 26 and 27 May to a staging area near 2 km downstream of the mouth of the Wernicke River. Fishwheel assembly continued until 4 June, when both fishwheels were operational.

Mobilizing the Field Project from Chitina

In May 2001, the most feasible method of transporting the fishwheels from Chitina to Baird Canyon was to tow them downstream using project boats and staff. The crew spent about six days partially assembling the fishwheels near Chitina. Local residents assisted the project by providing accommodation, information on river conditions, and assistance launching the fishwheels (Mr. E. Hem and Mr. D. Boone).

An airplane was chartered on 22 May to survey the river between Chitina and Baird Canyon prior to towing the first fishwheel. This aerial survey provided an efficient means of identifying the best routes through the highly braided river and helped to identify potential trouble spots.

The first fishwheel was towed on 23 May to an area just below Wood Canyon (near Haley Creek). On the same day, the second fishwheel was towed from Chitina to an area near Cirque Creek where staff secured the fishwheel and camped. The next day, the entire crew began hauling the fishwheel near Haley Creek to Baird Canyon. With a relatively uneventful trip by early afternoon, the second boat went ahead of the primary towing boat to establish a camp near Baird Canyon. The two boats remained in contact via VHF radios. Water levels were extremely low relative to past years and compared to descriptions provided by people who had traveled this stretch of river. In addition, a large complement of gear exacerbated problems associated with low water.

Unexpected river conditions on the float trip caused several problems during the float downstream, including slower river velocity which extended the length of the trip and a couple of occurrences where the boat and/or fishwheel ran aground from low water depth. Problems occurred from a few kilometers upstream of the Tasnuna River junction down to Bremner "flats." The most difficult section of the river for the three-member crew occurred opposite the confluence of the Tasnuna River (upstream of the Bremner River on the Copper River's left bank, near the southern tip of "The Peninsula"). Late in the day on 24 May the crew ran the boat aground attempting to navigate between two shallow channels. The crew spent the night in the boat at this location with the fishwheel floating, still tethered to the boat with the towline. In the morning (25 May), the crew pulled the fishwheel up to the stern of the boat, unloaded most of the gear from the boat onto the fishwheel and, using the fishwheel as a "dock", used a bumper jack to lift the boat off of the bottom. Once underway, the crew encountered more shallow water within a few minutes of freeing the boat. Many shallow channels and riffles characterized this area of the river and were nearly impassable with the draught of the fully loaded fishwheel. The crew decided to leave the fishwheel in this area and wait for a little higher water level.

On 26 May, a boat and crew retrieved the fishwheel that was left near the Tasnuna River confluence. On 27 May, both boats and four of the five crewmembers returned to Cirque Creek to retrieve the second fishwheel. The river level had risen 15 or 20 cm in the preceding few days due to sunny, warm weather and this additional water made the second float downstream much less eventful than the first. However, between the Tasnuna River confluence and the Bremner "flats," the boat and/or fishwheel brushed the bottom on three occasions. These difficulties were encountered with experienced boat operators who, by this point, had also traveled the difficult sections of the river multiple times.

The field camp was located on the river's left bank (eastern shore), just downstream of where the Wernicke River enters the Copper River. Bare ground (i.e., no snow cover), accessible water, substantial elevation above the river, and sufficient landing room for several boats and the fishwheels made this field campsite ideal. As the season progressed, the site became accessible by float plane and had relatively little bear activity. The main drawback of this site was its distance from the fishwheel sites (approximately 4.8 km).

Supply System

There is limited access to Baird Canyon for re-supplying the field camp. Float planes were able to land on the river directly below camp and were used often. Cordova Air (Cessna 206 on floats) made twelve supply flights at two locations over the course of the season. Boats were also used to ferry gear and personnel to and from camp after 31 May when Miles Lake became ice-free. Boats were either launched from the Miles Lake outlet or downstream of the Million Dollar Bridge. The field crew was also able to access a truck and gear cache near the confluence of the south branch of the Allen River. A helicopter was used once to sling fuel to the camp on 26 May. Lack of suitable landing strips prevented the use of wheeled-airplanes.

Fishwheel Site Selection, Installation and Operation

Between 24 May and 2 June 2001, seven fishwheel test sites were identified for use at various times between late May and mid-July (Figure 2). Aside from Site 2, no other site was suitable for the entire study period because of substantial changes in water depth, velocity, and current dynamics largely caused by fluctuations in water level (Figure 4). Anchor systems were installed at Sites 1, 2, 3 and 7 (Appendix Table D-1), but were only used at Sites 1 and 2.

Fishwheel 1 was installed on 29 May at Site 1, along the right bank of the river approximately 100 m upstream of the mouth of the north branch of the Allen River (Figure 2; Photo 3). The fishwheel was secured alongside a large house-sized boulder using three different anchor lines (Appendix Figure C-1). The first anchor line (wire rope) ran from the bow bridle to a second boulder on shore about 50 m upstream. The second anchor line (polypropylene rope) ran from the port bow of the fishwheel to an iron pin set into the house-sized boulder. The third anchor (polypropylene rope) ran from the port stern of the fishwheel to an iron pin set into a rock onshore. This third line was given enough slack to allow the fishwheel to move with current surges. This site was the same location that a fishwheel was fished in the early 1970s as part of a salmon tagging program (Ken Roberson, pers. comm., Glenallen, AK; Merritt and Roberson 1986)

Fishwheel 2 was installed on 4 June at Site 2, along the left bank of the river just downstream from the upper end of Baird Canyon (Figure 2, Photo 4). The fishwheel was installed alongside a cliff wall, just behind an outcropping that partially sheltered the fishwheel from the main current. The fishwheel was secured with five anchor lines (Appendix Figure C-2). The main line was wire rope that ran from the bow bridle to three pins set into a rock on shore approximately 50 m upstream. A second anchor line (polypropylene rope) ran from a separate bridle to the same anchor pins. The final three anchor lines consisted of polypropylene rope anchored to iron pins set into the adjacent cliff wall. These three lines ran, respectively, from the bow of the port pontoon to the cliff (15 m upstream), from the bow of the starboard pontoon to the adjoining cliff, and from the stern of the starboard pontoon to the cliff.

Moving and re-positioning the fishwheels with a boat was effective when surface velocities were relatively slow (≤ 1.4 m/s), or when traveling downstream. Upstream towing was not effective in areas of steeper gradient (≥ 3% slope) or faster water velocity (≥ 1.9 m/s). Under these conditions, the bow of the pontoons would drag in the water (dive), instead of planing on the surface. In order to move the fishwheel upstream at high water, two outboard propeller engines (40 HP each) were mounted on the stern of the pontoons (Photo 2).

Fishwheel 1 operated (Photo 5) between 29 May and 7 June 2001 for a total of 169 hours, or 84% of the time it was in place and operable (Table 1, Appendix Figure A-2). During this time, the fishwheel was adjusted slightly (< 3 m upstream or downstream) on two occasions to keep it fishing effectively, and was shut down for a total of one hour as a result. The fishwheel was also shut down from 1630 hours on 30 May to 2000 hours on 1 June while the crew installed Fishwheel 2. Rising water levels on 7 June created an eddy that eliminated downstream flow and the fishwheel stopped turning (Figure 5 and 6, Appendix Figure A-1). Subsequent attempts to re-position the fishwheel in downstream current were unsuccessful.

Site 1 appeared to be the most suitable for early-season operation. This site was approximately 4.9 m deep on 29 May, and therefore would have been available even earlier in the season when water levels were lower. Fishwheel 1 did not encounter much debris and neither the basket frames nor webbing were ever damaged. Initial water velocities at the site were relatively fast, spinning the fishwheel at 3 RPM in late May, but decreased to a standstill by 7 June before reversing direction and flowing upstream halted operations for the remainder of June and July.

Fishwheel 2 operated (Photo 6) between 4 June and 11 July for a total of 817 hours, or 90% of the time it was in place (Table 1, Appendix Table E-1). Fishwheel 2 was re-positioned only slightly (< 2 m) on occasion. The fishwheel was shut down 13 times for repairs, position adjustments, or because of unrelated transportation difficulties. The fishwheel was also shut down twice in mid-July during high sockeye catches.

Site 2 was suitable for fishwheel operation for most of the season. Prior to 4 June, the site was deep enough to fish, but water velocities might have been too slow to turn the baskets effectively. As water levels rose, the current shifted towards the left bank and increased the fishwheel speed. By mid-June, fishwheel speeds rose to 3 RPM, and they remained close to 3 RPM for the remainder of the season (Appendix Figure A-1). The fishwheel was re-positioned several times to maintain a speed of 3 RPM or less.

Although Fishwheel 2 was somewhat sheltered from debris, it was slightly damaged on 20 June. Torn basket webbing and broken bolts were common after mid-June and appeared to be due to the high speeds the fishwheel maintained.

Fish Capture and Sampling

A total of 883 large (i.e., multiple years at sea) and 31 small (one year at sea, length < 50 cm) chinook salmon were captured in the two fishwheels (Table 1, Photo 7). From 4 June to 11 July, Fishwheel 2 captured 780 (88%) of the large chinook salmon and from 29 May to 7 June, Fishwheel 1 captured 103 (12%). From 29 May to 11 July chinook salmon were captured on all but two days (Appendix Tables F-1 and F-2). Catches were highest from 7-18 June (Figure 7, Appendix Table F-2), with a peak catch of 63 chinook salmon on 17 June (CPUE = 2.98 fish per hour). The majority of chinook salmon at both fishwheels (54% for Fishwheel 1, 68% for Fishwheel 2) were captured in the holding tank farthest from shore (Appendix Tables F-1 and F-2).

Of the 883 large chinook salmon captured, a subsample of 361 fish (41%) was marked with opercular punches (Photo 8 and 9). Of the marked fish, 10 (2.8%) were subsequently recaptured in Fishwheel 2 (Table 2). Two fish recaptured immediately after their release were excluded from the ten recaptures. The majority (314 out of 362, or 87%) of marking occurred from 5-14 June (Appendix Table F-2). Of the 31 small chinook captured, nine were marked and none were recaptured (Table 2).

A total of 23,161 sockeye salmon were captured in the two fishwheels (Table 1). From 4 June to 11 July, Fishwheel 2 captured 21,646 (93%) and from 29 May to 7 June, Fishwheel 1 captured 1,515 (7%) of the sockeye salmon caught (Appendix Tables F-1 and F-2). From 29 May to 11 July sockeye salmon were captured on all but two days (Appendix Tables F-1 and F-2). Sockeye salmon catches were highest from 8-11 July (Figure 8, Appendix Table F-2), with a peak catch of 2,110 fish on 9 July (CPUE = 89.5 fish per hour). The majority of sockeye at each fishwheel (60% for Fishwheel 1, 70% for Fishwheel 2) were captured in the holding tank farthest from shore (Appendix Tables F-1 and F-2).

Other species captured by the fishwheels included 146 Dolly Varden, 68 Pacific lamprey, 35 whitefish (*Coregonus sp.*), 7 suckers (*Catostomus sp.*), 1 Arctic grayling (*Thymallus arcticus*), 1 burbot (*Lota lota*), and numerous outmigrating coho (*O. kisutch*), sockeye, and chinook smolts (Table 1, Appendix Tables G-1 and G-2).

Fish Mortality Events

There were four occasions in 2001 (6 June, 17 June, 9 July and 10 July) when fish captured in the fishwheel died prior to release back to the river. In total, there were 145 sockeye and four chinook salmon mortalities (or 0.6% of the total sockeye catch and 0.4% of the chinook catch). Three of these events resulted from crowding in the live tanks during high-catch periods, and one event was the result of improper fish handling. Although the crew was diligent about monitoring catch rates and adjusting the frequency of visits to prevent overcrowding, unexpected changes in catch rates between sampling sessions resulted in occasions where high catches filled the offshore live tank in Fishwheel 2.

Data Analysis

Fishwheel Effort and Capture Efficiency

Peak daily chinook salmon CPUE came in the first half of the season. CPUE at Fishwheel 1 peaked at 1.9 fish per hour on 29 May, and then declined before leveling off around 0.5 in early June (Figure 5). Fishwheel 2 CPUE was three to six times as high during this period, suggesting that Fishwheel 2 may have been more effective at capturing fish (due to greater efficiency and/or a greater proportion of the run moving passed Fishwheel 2 than Fishwheel 1). Daily CPUE at Fishwheel 2 ranged from 1.0 to 3.2 fish per hour from 5-18 June, and ranged from 0 to 1.2 fish per hour between 19 June and 11 July (Figure 5).

Sockeye salmon CPUE ranged from 3.8 to 15 fish per hour in Fishwheel 1, and from 4.9 to 105 fish per hour in Fishwheel 2 (Figure 6). Daily CPUE at Fishwheel 2 was three to four times higher than at Fishwheel 1 during the three days (5-7 June) that the fishwheels ran simultaneously. Daily CPUE for Fishwheel 2 ranged from 4.9 to 37 fish per hour for the period 5 June to 7 July. For the period 8-11 July, daily CPUE for sockeye salmon ranged from 42 to 105 fish per hour (Figure 6).

Fish Length and Sex Composition

Of the 780 chinook salmon captured at Fishwheel 2, a subsample of 247 were sexed and measured. Of the 247, 129 (52%) were female and 118 (48%) were male (Table 3). Lengths (MEF) were nearly the same for both sexes, averaging 83 cm for females and 84 cm for males. The additional 86 chinook salmon that were not sexed averaged 76.7 cm. There were no differences in length detected between fish captured in the port versus the starboard live tank (Appendix Figure H-1).

There appeared to be three modes in the length frequency distribution of chinook salmon (Appendix Figure H-2). The three size-classes were composed of fish ranging from 30-50 cm (2% of the sample), 60-80 cm (8% of the sample), and 80-110 cm (90% of the sample). The post-season observation of low CPUE from 20 to 22 June (Figure 5) prompted a comparison of fish lengths before and after 20 June. This analysis showed that fish returning prior to 20 June were smaller than those returning later in the year (Appendix Figure H-3).

Mean lengths were also measured for other species, including Dolly Varden (45 cm), Pacific lamprey (59 cm), and sucker (30 cm; Table 3).

DISCUSSION

Fishwheels

Project Mobilization

Fabricating the pontoons, axles and three of the six baskets in Terrace, BC, and shipping them directly to Chitina was efficient and effective. Towing the fishwheels from Chitina to Baird Canyon allowed them to be installed and operating sooner than if they had been towed upstream from Miles Lake. Miles Lake was not free of ice until 31 May, 2001. Moving the fishwheels via Cordova, the Copper River Highway and upstream via the river would have setback the fishwheel operations to about 10 June. Given that fish were caught immediately upon operation of Fishwheel 1 (29 May), mobilizing via Cordova using the road and the river would have resulted in at least some of the early-run chinook salmon being missed.

However, despite an apparently early start of getting the fishwheels fishing, the float from Chitina to Baird Canyon came with several logistical and safety challenges. Constructing the fishwheels on the banks of the river near Chitina in mid-May posed some difficulties. Frequent high winds and dust storms made working conditions poor and caused problems getting additional hardware and supplies to Chitina once the crew was on site. Most importantly, river conditions during the float from Chitina to Baird Canyon in 2001 were difficult and dangerous at times, in large part due to low water levels. In 2001, water levels at Miles Lake between 16 May and 2 June were lower than the historical mean (1982-2001) during the same period (Appendix Figure I-3). However, these data also show that water levels continue to rise throughout most of the summer, so mobilizing the Baird Canyon fishwheels in early to mid-May appears to be the most appropriate time.

Fishwheel Site Evaluation and Selection

Of the seven fishwheel sites evaluated, Sites 1 and 2 were the best options in 2001. Site 2, located immediately below the upstream end of the canyon (Figure 2), was suitable for the longest period of time for several reasons: (1) current dynamics remained relatively constant with changing water levels; (2) the adjacent cliff wall offered multiple anchor points at different water levels; (3) chinook salmon clearly migrated past the site throughout the season; (4) the fishwheel could be re-positioned slightly as needed; and (5) the fishwheel could be dropped back into a recess in the cliff wall for protection from debris or for repairs. Site 2 also had several drawbacks. Early-season water velocities may be too slow, and the site may be too deep for fishing at high water. For example, when the fishwheel was installed on 5 June, it turned at only 1 RPM. If water velocity is slower in May than it was on 5 June 2001, the fishwheel may not operate at desired speeds (1.5 to 2.5 RPM). Under these conditions, the fishwheel may have to be held offshore with a spar in higher flowing water, thereby reducing its efficiency. During high water, the baskets of Fishwheel 2 fished 5.2 m off the river bottom and fish likely migrated beneath the fishwheel.

Site 1 was potentially the best site during low-water periods, and was likely deep enough to fish prior to the 29 May installation date. Fishwheel 1 operated behind a large boulder, which protected it from debris. However, Site 1 was unusable at higher water levels (after 6 June) because an eddy formed that eliminated downstream flows. Until other sites can be identified, Site 1 should be used early in the season when it is effective at catching chinook salmon.

Site 6 appeared suitable from 10-20 June, after which rising water levels made the site too exposed to debris. Site 7 was fishable after 17 June, and remained so throughout the rest of the chinook salmon run. If a fishwheel were operated at Site 7, it would need to be held at least 1 m offshore with a spar to prevent the baskets from hitting bottom. Also, a large eddy located upstream might substantially reduce flows at Site 7 if the current dynamics change over time.

Site 5 is slightly downstream of Site 6 with nearly identical characteristics. Site 5 was rated lower than Site 6 because of susceptibility to debris. Sites 3 and 4 appeared useable only within a narrow range of water levels, and were ranked the lowest of the seven sites identified in

2001. Site 3 appeared useable during a brief four-day period (6-10 June) when the water was deep enough for the baskets but was not moving too fast. Site 4 appeared suitable for approximately one week.

The anchor systems at Sites 1, 2 and 7 were left in place for the 2002 season. Since Site 7 will likely require additional anchor pins if used in 2002, those at Site 3 were removed and placed at Site 7.

Fishwheel Installation and Operation

The two fishwheels operated with few mechanical or site-specific difficulties during suitable water conditions. Continuous operation at Sites 1 and 2 should be possible with minor troubleshooting. Down time at Site 1 was almost entirely due to crew efforts in getting Fishwheel 2 operational from 30 May to 1 June. Re-positioning the fishwheel at Site 1 went smoothly and there was only one hour of down time.

Down time at Site 2 was due to boat malfunctions (which forced the crew to stop fishing the wheel to safeguard fish), fishwheel repairs and elevated sockeye catches in concert with camp breakdown. Boat malfunctions occurred frequently early in the season, and likely accounted for the greatest amount of foregone chinook salmon catches. Most fishwheel repairs were required during high water periods after 20 June, at a time when chinook salmon catches were declining (Figure 5). However, lost catch opportunity should be reduced as equipment and maintenance procedures improve. Fishwheel shutdowns from high sockeye catches were confined to later in the chinook salmon run. These shutdowns could be eliminated if a method to lower sockeye catch rates can be developed.

In mid-June, project staff encountered great difficulty moving Fishwheel 1 upstream when the river velocity was high. When towing the fishwheel with a boat, it was possible to move the fishwheel slowly upstream through the canyon, but impossible to move it through the constricted part of the canyon. On 19 June, an additional large, powerful boat was chartered in an attempt to move Fishwheel 1 upstream, but was unsuccessful. The hydrodynamics of the bow of the pontoons and the overall structure of the fishwheel caused it to dive beneath the river surface when being towed by a boat. Subsequently, transom mounts were developed for the stern of the fishwheels and outboard motors were used to assist with propelling the fishwheel while it was being towed. Although supplementing the towing with propulsion from stern-mounted outboard engines increased fishwheel mobility, it was not attempted in the most difficult section of the canyon. We expect to continue to encounter difficulty moving the fishwheels upstream during high discharge and therefore recommend that moving the fishwheels upstream of the narrowest constriction should be done before water levels rise to the height reached on 10 June 2001

Fish Capture and Sampling

In order to maximize chinook salmon catches in 2001, the crew minimized fish handling and sampling. Only a subsample of chinook salmon were measured and marked, and sockeye salmon were simply counted and released. Decreased fish handling and sampling allowed more time to position and repair the fishwheels, and reduced the time spent on the fishwheels. Crew time on the fishwheels increased between 6-19 June because of high chinook salmon catches, and after 8 July because of peak sockeye salmon catches. Although chinook salmon catches were highest before mid-June, the daily ratio of sockeye to chinook was still 20:1 (Figure 9). The daily ratio of sockeye to chinook increased to over 80:1 after 8 July.

As expected, high sockeye salmon catches in 2001 resulted in logistical challenges. Crowding increased stress on all fish captured by the fishwheel, and increased crew time on the fishwheel may have decreased the trapping efficiency of the fishwheel. Fishwheel catch rates typically drop significantly whenever people are sampling fish from the tanks (M. Link, unpublished data). This decrease in effectiveness may be because fish are scared away from entering the path of the fishwheel by the noise of the dipnetting activity and/or additional slime released into the water during dipnetting. Even if fishwheel efficiency (% of run captured) from the two fishwheels are sufficiently high in the future to reach tagging goals, this type of decrease in catch rates on days of high passage of sockeye salmon introduces unnecessary intra-season variation in fishwheel efficiency.

In 2001, tank overcrowding at times resulted in fish mortality. In order to reduce high densities in the live tanks, the following options should be considered:

1. Placing the fishwheels in less effective locations;
2. Shutting the fishwheels down for a period during high fish passage;
3. Increasing the sampling frequency of fishwheels;
4. Installing sorting device(s) on the fishwheel slides to exclude sockeye salmon from being placed into the live tanks while retaining chinook salmon; and
5. Installing escape panels within the live tanks that allow sockeye salmon to return to the river while retaining the chinook salmon.

Options 1 and 2 (above) don't seem like viable alternatives given the need to capture 1,000 to 2,000 chinook salmon. Decreasing the fishing time or fishwheel effectiveness would likely jeopardize tagging goals for a mark-recapture estimate of chinook salmon escapement. Given the expected sockeye-to-chinook ratio of about 20:1 over the course of the season (e.g., 700,000 sockeye and 35,000 chinook salmon), it seems reasonable that in order to catch 1,000 to 2,000 chinook for a tagging study, we will need to handle 20,000 to 40,000 sockeye salmon. The problem with Option 3 is that increasing the frequency with which live tanks are emptied may interfere with the catch efficiency of the fishwheel, possibly jeopardizing tagging goals. Moreover, the crew in 2001 was vigilant in trying to maximize the frequency of site visits, yet was unable to avoid all problems of crowding. For short periods within some days, sockeye catches peaked at 180 fish per hour – a rate that clearly precludes a single crew from keeping the densities low in both fishwheels. In order to increase the frequency of fishwheel visits beyond what was done in 2001, a second crew would be required during periods of peak sockeye catch; but note that we expect less chinook salmon to be captured as a result of increased dipnetting activity.

The advantage of Options 4 and 5, in addition to not requiring a doubling of crew size, is that they offer the greatest chance of reducing fish density in the live tanks while not decreasing the overall catch of chinook salmon. Although only in the conceptual stage, these devices could possibly sort sockeye from chinook salmon based on size and/or weight. A slide-sorter device might rely on weight alone (trap door into the live tank), while a live tank escape panel could use the differences in girth or body size between sockeye and chinook salmon. The efficacy of escape panels would have to be closely monitored to avoid releasing large numbers of smaller chinook salmon and their use might preclude using the fishwheel information to assess the size and abundance of the sockeye salmon run.

It might also be possible to correlate high or peak sockeye catches with fluctuations in water level and use this information to strategically increase the frequency of visits to the fishwheels. The sudden increase in sockeye catches on 8 July occurred four days after water levels began to drop in Baird Canyon (Appendix Figure A-1 and I-3). One explanation for this is that sockeye salmon may stage in Miles Lake until water levels begin to decline in Baird Canyon, and then move upstream on the falling limb of the hydrograph. If so, the magnitude and timing of water level fluctuations may be a better predictor of Baird Canyon sockeye densities than the sonar counts at the downstream end of Miles Lake.

Data Analysis

Fishwheel Effort And Catch Efficiency

Chinook salmon catches in 2001 indicate that fishwheels operating in the Baird Canyon area might be able to capture enough fish to yield mark-recapture escapement estimates. The two fishwheels combined to fish for the equivalent of one fishwheel operating continuously from 29 May to 11 July 2001. Although an escapement estimate has not yet been generated for 2001, historical numbers and 2001 inseason data may be used to provide a rough preliminary estimate of fishwheel capture efficiency. The most sophisticated estimate of chinook salmon escapement beyond Miles Lake was ADF&G's estimate of 32,090 fish in 1999 (Evenson and Wuttig 2000). Escapements in 2000 and 2001 do not seem radically different from 1999 because the CPUE in marine fisheries and upriver sampling programs were similar among the three years (ADF&G unpublished data). An escapement of 60,000 fish in 2001 would appear to be an improbably high estimate; using this as an upper escapement boundary would mean that the 883 large chinook salmon captured by the fishwheels represented a conservative minimum of 1.5% of the run. If the escapement of chinook salmon at Baird Canyon was 32,000, then the 883 fish we captured would represent 2.75% of the run. These estimates should be viewed with caution until 2001 escapement estimates are released, but they may be helpful for project planning until then.

Several findings from 2001 should help increase total fishing effort next year. The fishwheels are already at Baird Canyon and can thus be installed earlier in the season. Sites 6 and 7 have been identified, appear suitable, and an anchor system has already been installed at Site 7. Finally, Sites 6 and 7 should be suitable shortly after Site 1 becomes unsuitable, allowing the fishwheel to continue operating among these sites with relatively little interruption.

Fish Length and Sex Composition

Length frequency histograms show three distinct size-classes of chinook salmon caught in the fishwheels, and suggest that fish returning prior to 20 June are smaller than fish returning after 20 June. The length frequency analysis was based on 320 fish, and may not have had enough power to distinguish age-classes within the 80 to 110 cm size-classes. Although the sample after 20 June is relatively small (49 fish), it indicates a potential difference in the size of fish between these two periods.

The sex ratio was nearly 50:50 (52% males, 48% females), and the mean length of males (84 cm) and females (83 cm) was similar. The mean length of chinook salmon of undetermined gender (77 cm) was smaller than that of fish of known sex. The difference was likely attributed to smaller fish being caught early in the run, at a time when the crewmembers were still learning to differentiate gender based on secondary characteristics.

Technical and Community Workshops 2001

Technical (29 November) and Community (30 November) workshops were held in Cordova to review project progress and results prior to completion of the annual report (Appendix J). Posters were prepared that explained the concept and preliminary results from the first year of the study (Appendix J). Biologists, managers and administrators from several agencies were able to attend and information exchange among participants was very worthwhile. In addition, several fishermen and other local residents from around the Copper River basin provided input and local traditional knowledge to the study team. These workshops were an excellent means of presenting the results to those who manage and depend on Copper River salmon. Moreover, input from these people clearly improved the synthesis of the results presented in this report.

CONCLUSIONS

Fishwheels were effective at capturing chinook salmon in Baird Canyon in 2001. The capture efficiency cannot be determined without the ADF&G escapement estimates, but will be presented in subsequent annual reports. Based on historical escapement levels, essentially one fishwheel operating from 29 May to 11 July captured at least 1.5% and probably closer to 2.75% of the chinook salmon run in 2001. Therefore, it appears that two fishwheels operated over the entire run could capture a sufficient portion of the chinook salmon run in the Copper River for the capture-tag phase of a mark-recapture study. Fishwheel capture efficiencies should improve in subsequent years because of improvements in the three main components of fishing effort: length of run coverage, operational time, and the number of sites fished. Increased crew experience will also be an essential part of increasing the fishing effort and fishwheel efficiencies.

RECOMMENDATIONS

Based on results from the 2001 season, and feedback at the fall workshop in Cordova, AK), we recommend the following be implemented in 2002:

1. Fishwheel 2 operate at the same site in Baird Canyon as it did in 2001.
2. If there is sufficient flow early in the season, Fishwheel 1 should be installed at Site 7; if not, it should be installed at Site 1 and moved to Site 7 when flows there are adequate.
3. One or more methods be developed and evaluated that can allow sockeye to be returned to the river while retaining the chinook salmon catch.
4. Transoms be built on the back of the fishwheels to mount outboards for moving the fishwheels.
5. One additional fishwheel be operated below Wood Canyon to provide upstream recovery effort.

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FIGURES

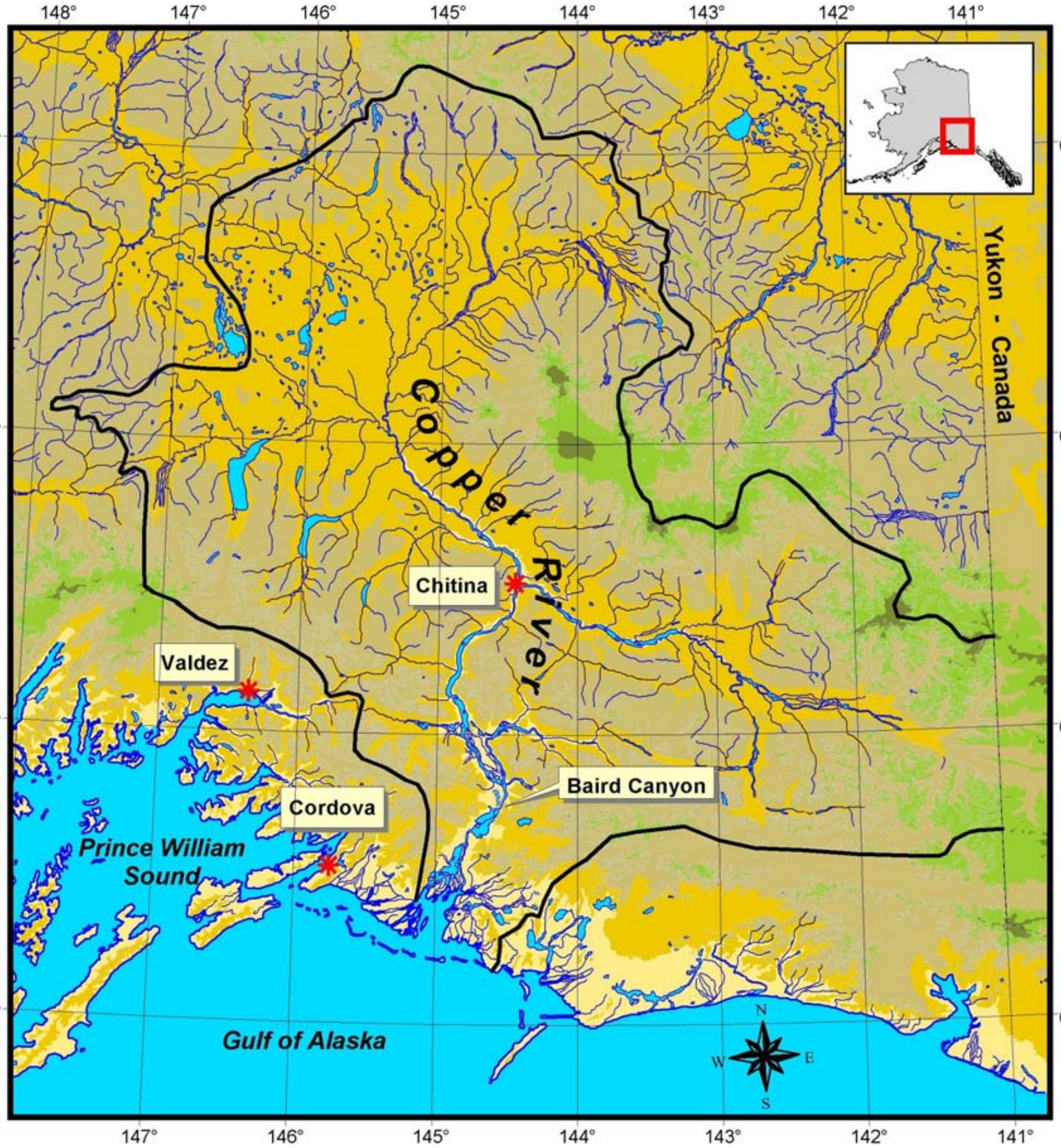


Figure 1. Map of the study area showing the location of the Copper River in Alaska.

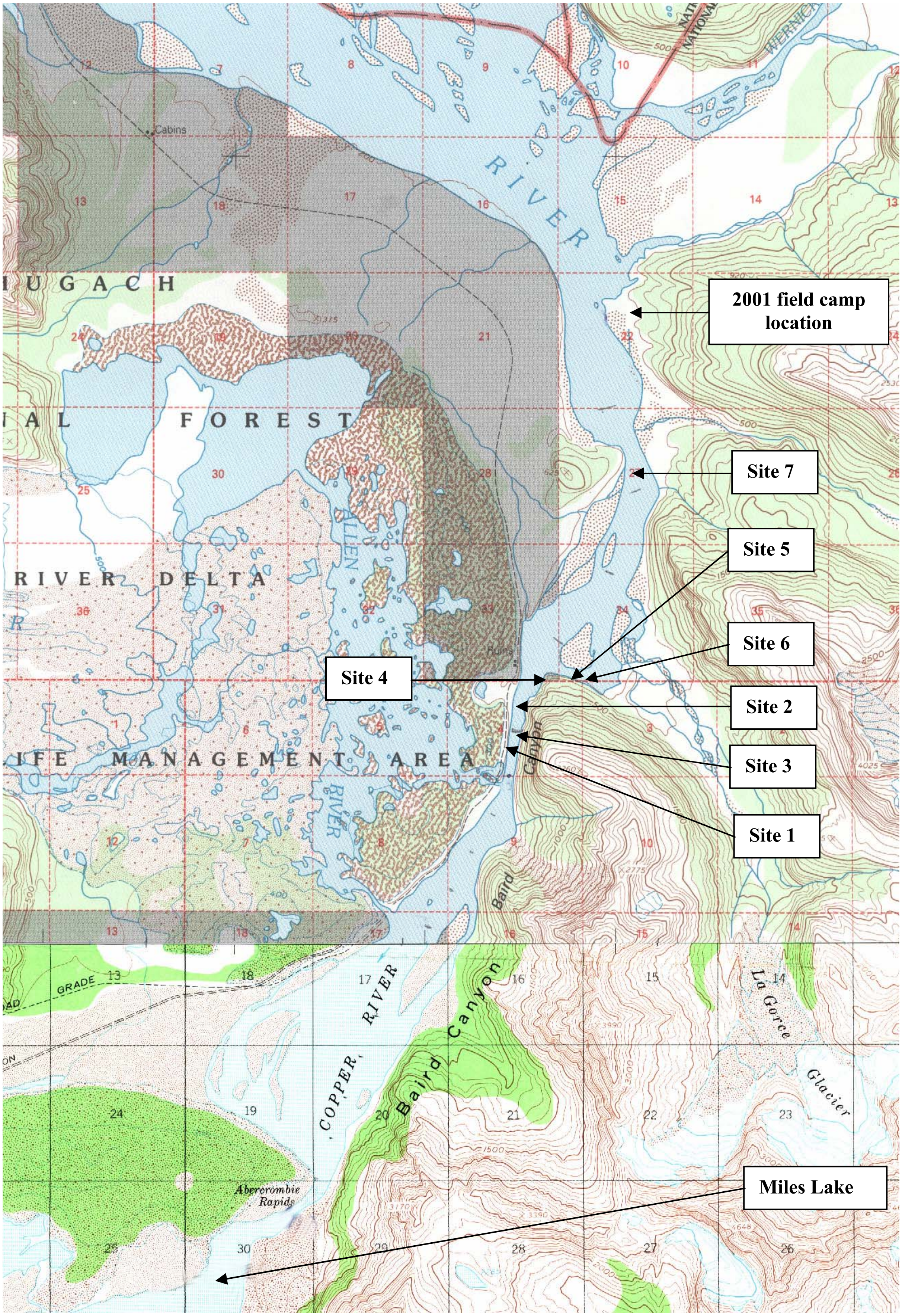


Figure 2. Map of Baird Canyon on the Copper River and potential fishwheel Sites 1-7.

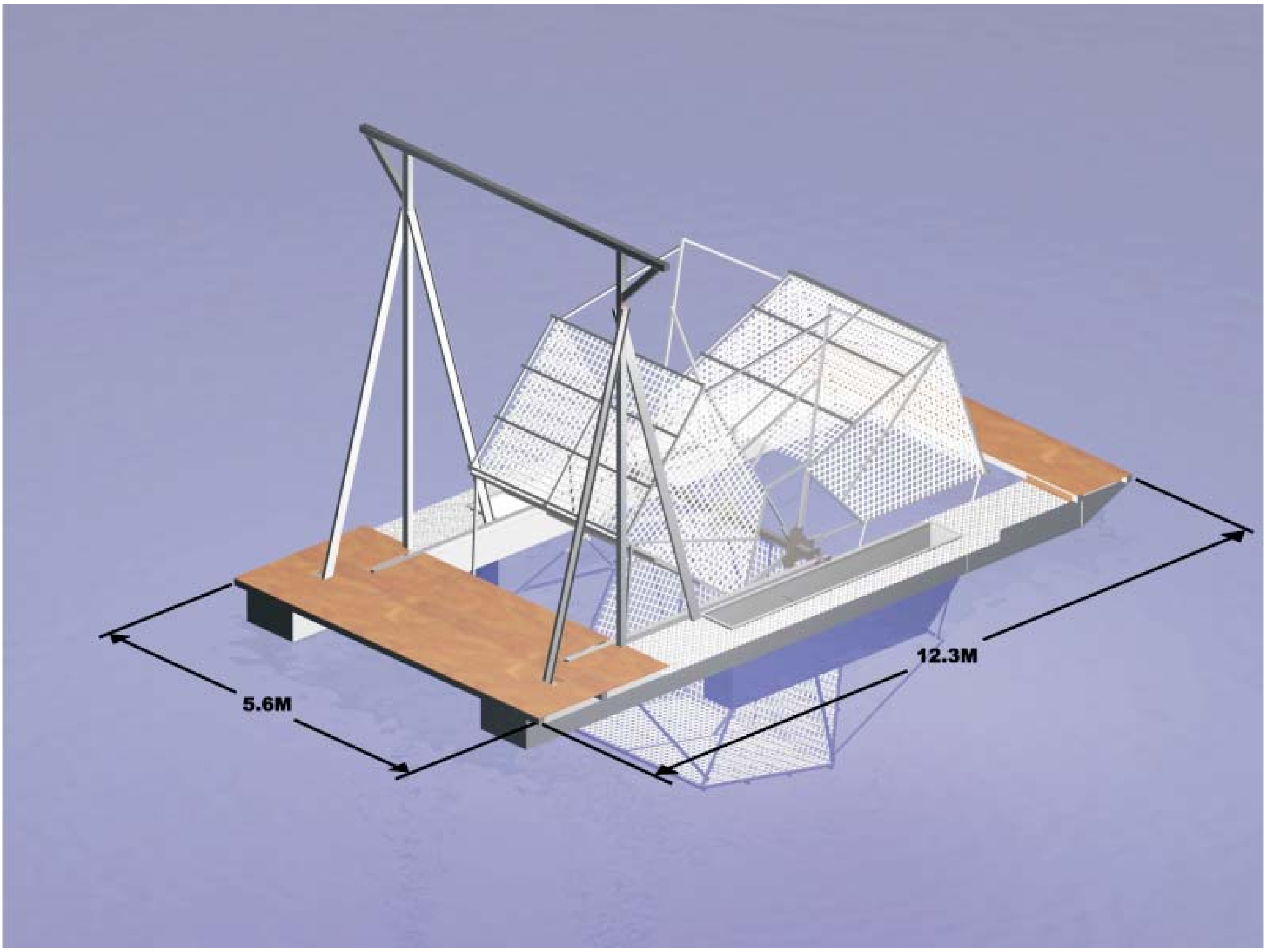


Figure 3. Drawing of a three-basket, aluminum fishwheel similar to that used on the Copper River in 2001.

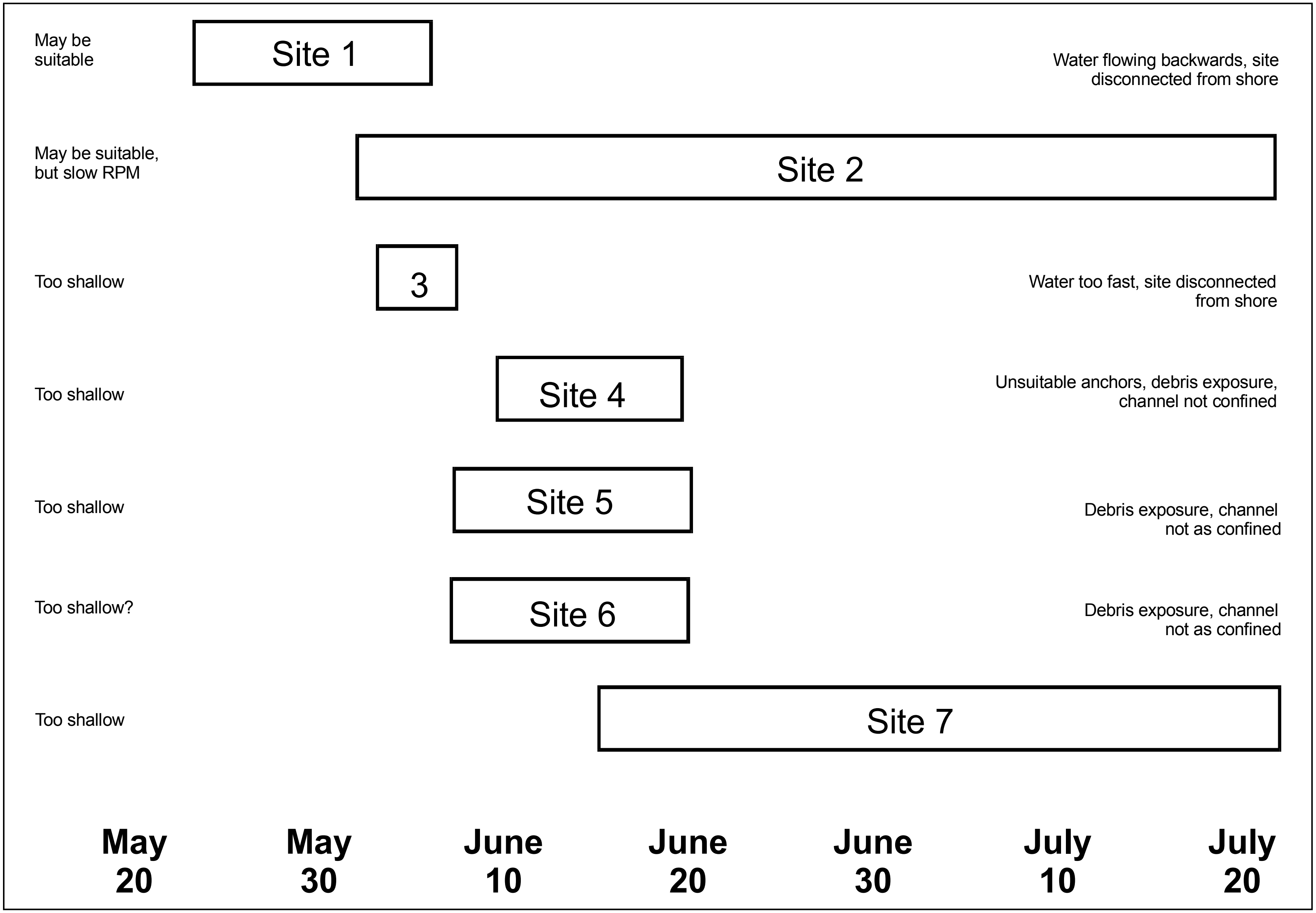


Figure 4. Suitability of potential fishwheel sites examined in 2001. The boxes indicate periods when sites were suitable for fishwheel operation, and the text explains why the site was unsuitable outside these periods.

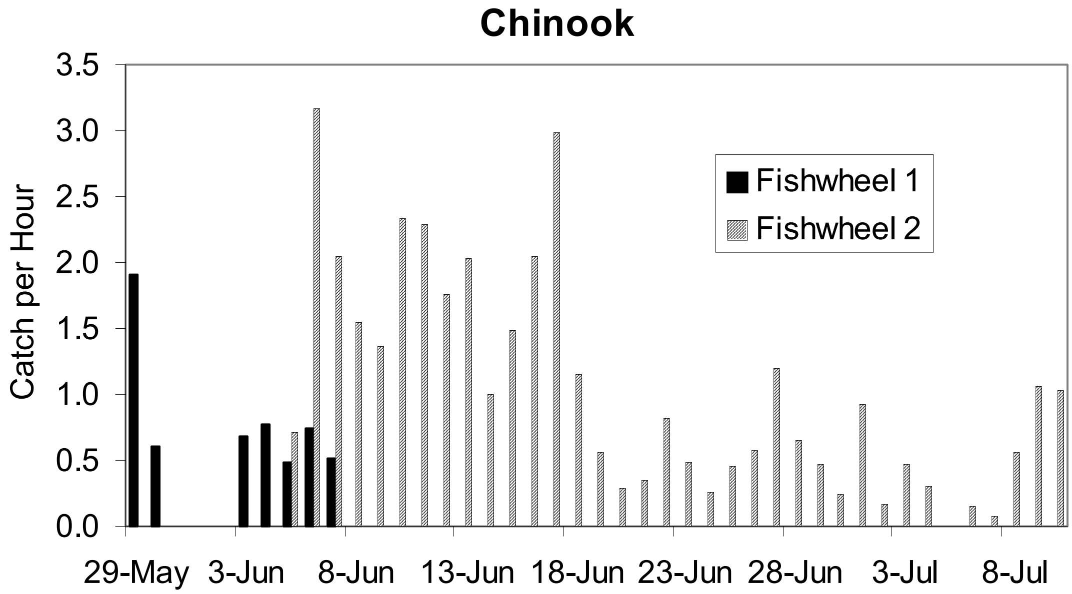


Figure 5. Daily catch per hour of chinook salmon in each Baird Canyon fishwheel, 2001.

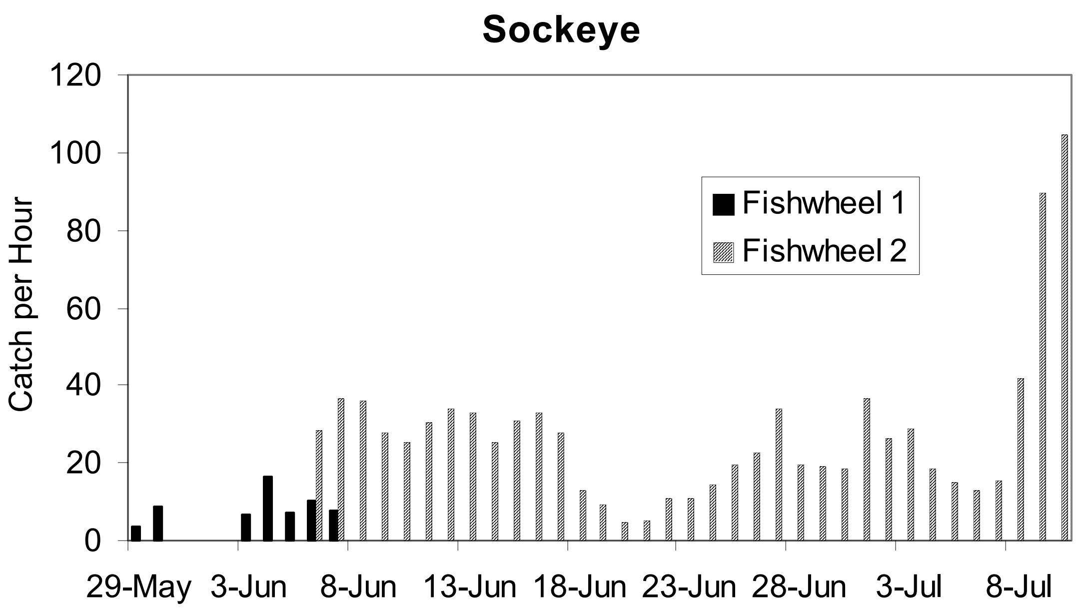


Figure 6. Daily catch per hour of sockeye salmon in each Baird Canyon fishwheel, 2001.

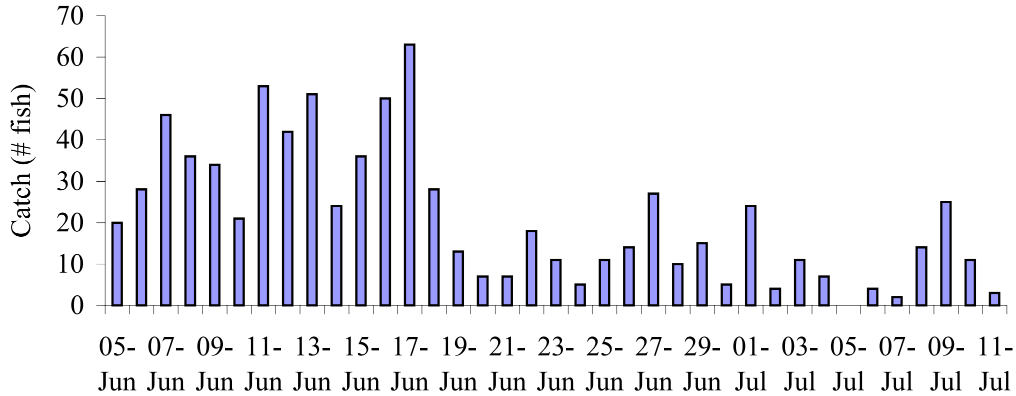


Figure 7. Daily catch of chinook at Fishwheel 2, 2001.

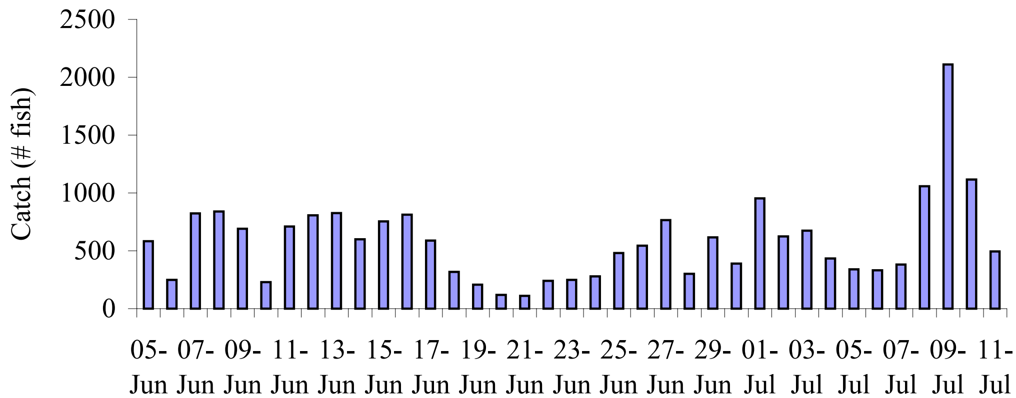


Figure 8. Daily catch of sockeye at Fishwheel 2, 2001.

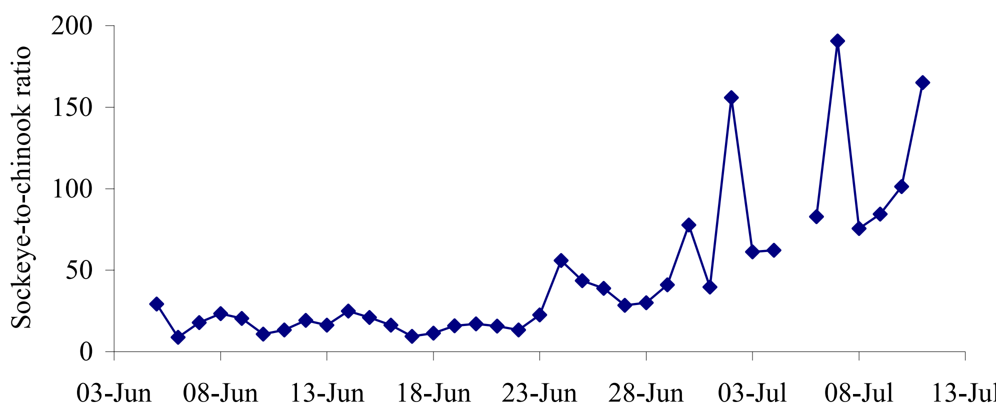


Figure 9. Daily sockeye-to-chinook ratio for Fishwheel 2, 2001.

TABLES

Table 1. Summary of hours fished, days operated, and total catch (by species) for both fishwheels, 2001.

	Fishwheel		
	1	2	Total
Hours fished	169	817	986
Days operated	9	38	47
Chinook			
Large	103	780	883
Small [a]	6	25	31
Total	109	805	914
Sockeye			
Large	1515	21646	23161
Small [b]	0	69	69
Total	1515	21715	23230
Juvenile salmon	71	13	84
Other species			
Dolly Varden	2	144	146
Pacific lamprey	30	38	68
Whitefish	26	9	35
Sucker	3	4	7
Burbot	0	1	1
Grayling	0	1	1

[a] Length < 50 cm

[b] Length < 40 cm

Table 2. Mark and recapture data for chinook captured at both fishwheels, 2001.

Chinook size	Total catch	Number marked	Number recaptured	Proportion recaptured (%)
Large	883	361	10	2.8
Small [a]	31	9	0	0.0
Total	914	370	10	2.7

[a] Length < 50 cm

Table 3. Mean lengths of fish captured in the Baird Canyon fishwheels, 2001. Lengths were measured from mid-eye to fork (MEF).

Species	Sample size (# fish)	Mean length (cm)	Standard deviation (cm)
Chinook			
Male	118	83.8	10.8
Female	129	83.0	7.5
Unknown [a]	86	76.7	14.8
Total	333	81.6	11.3
Dolly Varden	29	45.1	5.4
Pacific Lamprey	4	58.8	2.8
Sucker	3	30.0	6.2

[a] Eight chinook were captured in Fishwheel 1, and 78 were captured in Fishwheel 2.

APPENDICES

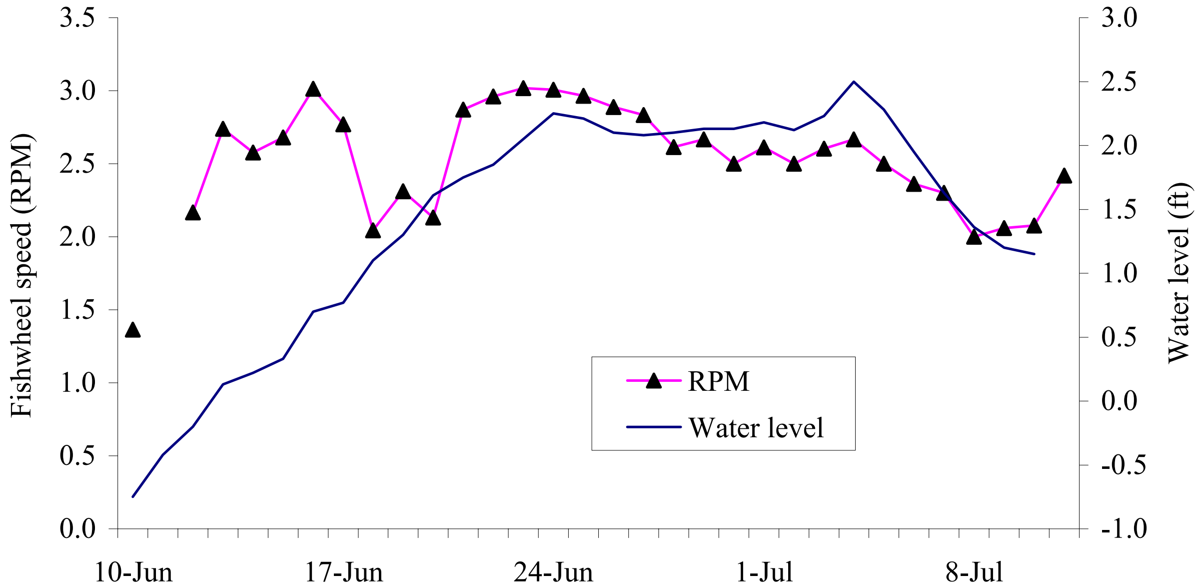


Figure A-1. Water level at Baird Canyon and speed of Fishwheel 2, 2001.

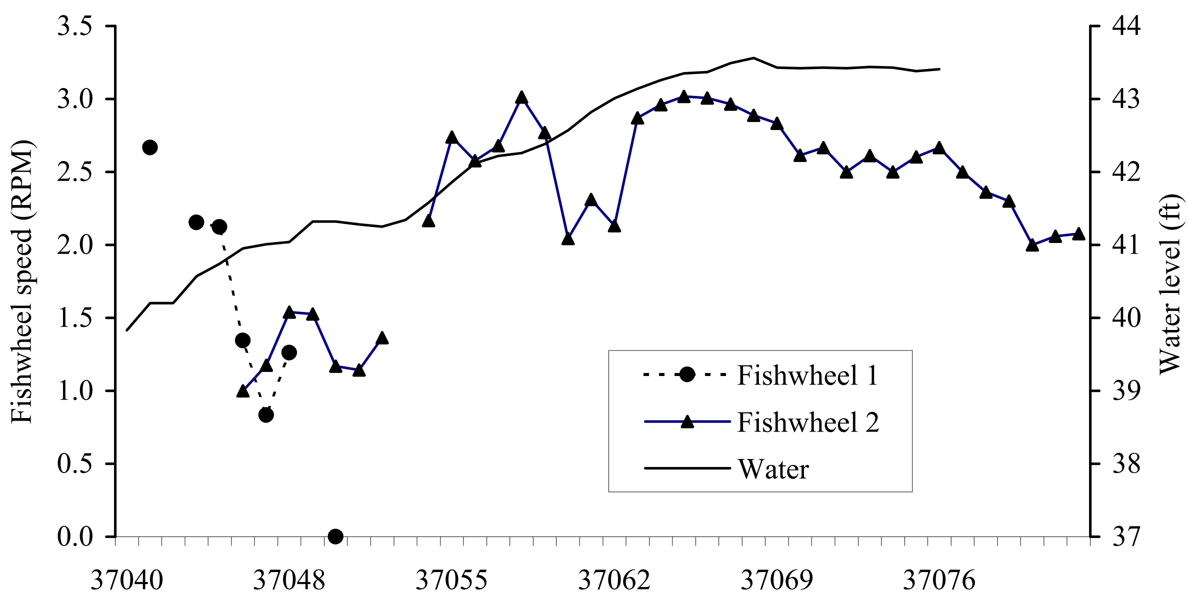


Figure A-2. Water level at Miles Lake outlet and fishwheel speed at each fishwheel, 2001.

Table B-1. Timeline of project tasks identified in the original operational plan in March, 2001.

Task	Description	Factors affecting timing	Original target timeline	Actual completion
1	Acquire sampling and access permits	Number of permit issuers involved	March	April
2	Assess and select 3 field technicians	OSM/NVE/LGL contracts; efficiency of applicant review process	March	April
3	Purchase, shipping, and initial assembly of fishwheels	Efficiency of contractor selection; contractor expertise; potential shipping time to Cordova	March to mid-May	mid-May
4	Design appropriate logistics, grocery re-supply and daily safety check system for field camp	Radio/phone reception area; crew work schedule; field camp location; cost of boat vs. plane re-supply; presence of other crews in area	March to April	March - May
5	Purchase and shipping of sampling equipment and field camp gear	Field camp design; sampling design; time needed to locate, purchase, and ship items	March to mid-May	mid-May
6	Transport of gear and wheels to Baird Canyon	Arrival of fishwheels in Cordova; clearance of road to Copper River; breakup of ice in river	mid- to late-May	late-May
7	Establish camp, complete fishwheel assembly	Arrival of fishwheels in Cordova; clearance of road to Copper River; breakup of ice in river	Late May to early June	Late May / early June
8	Establish sampling protocol and train crew	Sampling design	April	April–May
9	Install fishwheels in river, train the sampling crew	River ice-out	Early June	Early June
10	Search for suitable fishwheel sites	Crew quality; boat quality; water conditions	Early June–early July	May–July
11	Capture, biosample, and tag chinook; capture and biosample other salmon	Fishwheel installation; chinook run timing	Early June–late July	May–July
12	Tear down camp, stow wheels at season end	Chinook run timing; budget	Late July–early Aug	mid-July
13	Analyze data	Amount and complexity of data	June–October	June–October
14	Organize and conduct community consultation meeting in Cordova in September, 2001	Data analysis progress	August–September	November
15	Write annual report documenting 2001 work and results	Data analysis progress	October–December	September–October

Table B-2. Proposed staff requirements and responsibilities for the 2001 season.

Organization	Position (s)	Role	Skills	Persons
NVE	(3) Field technicians	Camp establishment, fishwheel installation and operation, chinook sampling and tagging, camp removal	Comfortable in boats on the river; fish tagging and data collection skills; able to live and work in remote setting	-
NVE	Administrative management	Accounting	Payroll for NVE, invoice processing, permitting	Cain
LGL	1 or more Biologists	Project management	Lead and direct research	Link, Nemeth, Haley, and Stevens (Nisga'a)
ADF&G	Biologist	Fish recovery in upstream dipnet fishery	Data collection	Evenson/Wuttig crew

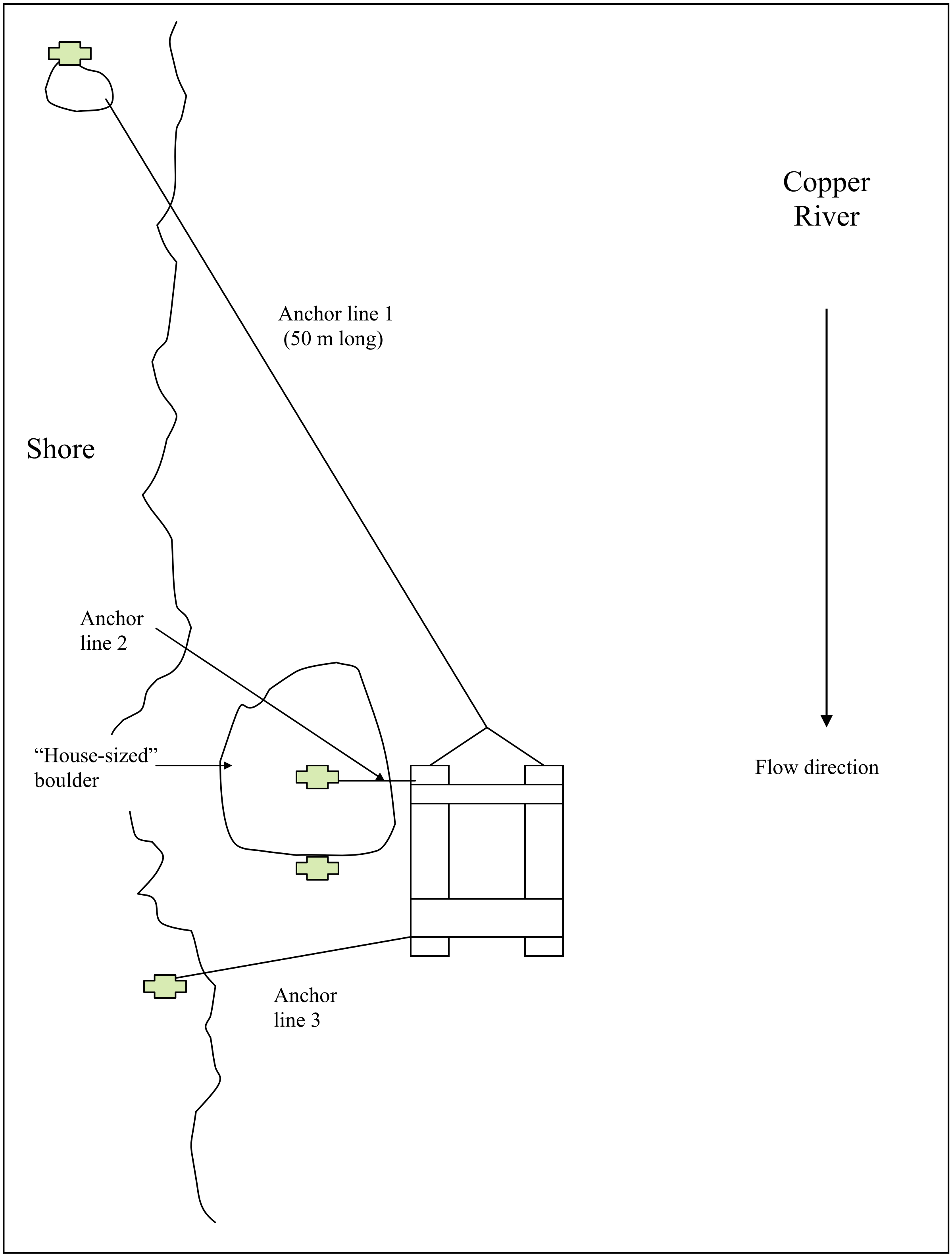


Figure C-1. Schematic of fishwheel Site 1 and the anchoring system used in 2001. Crosses represent pins used to anchor the fishwheel.

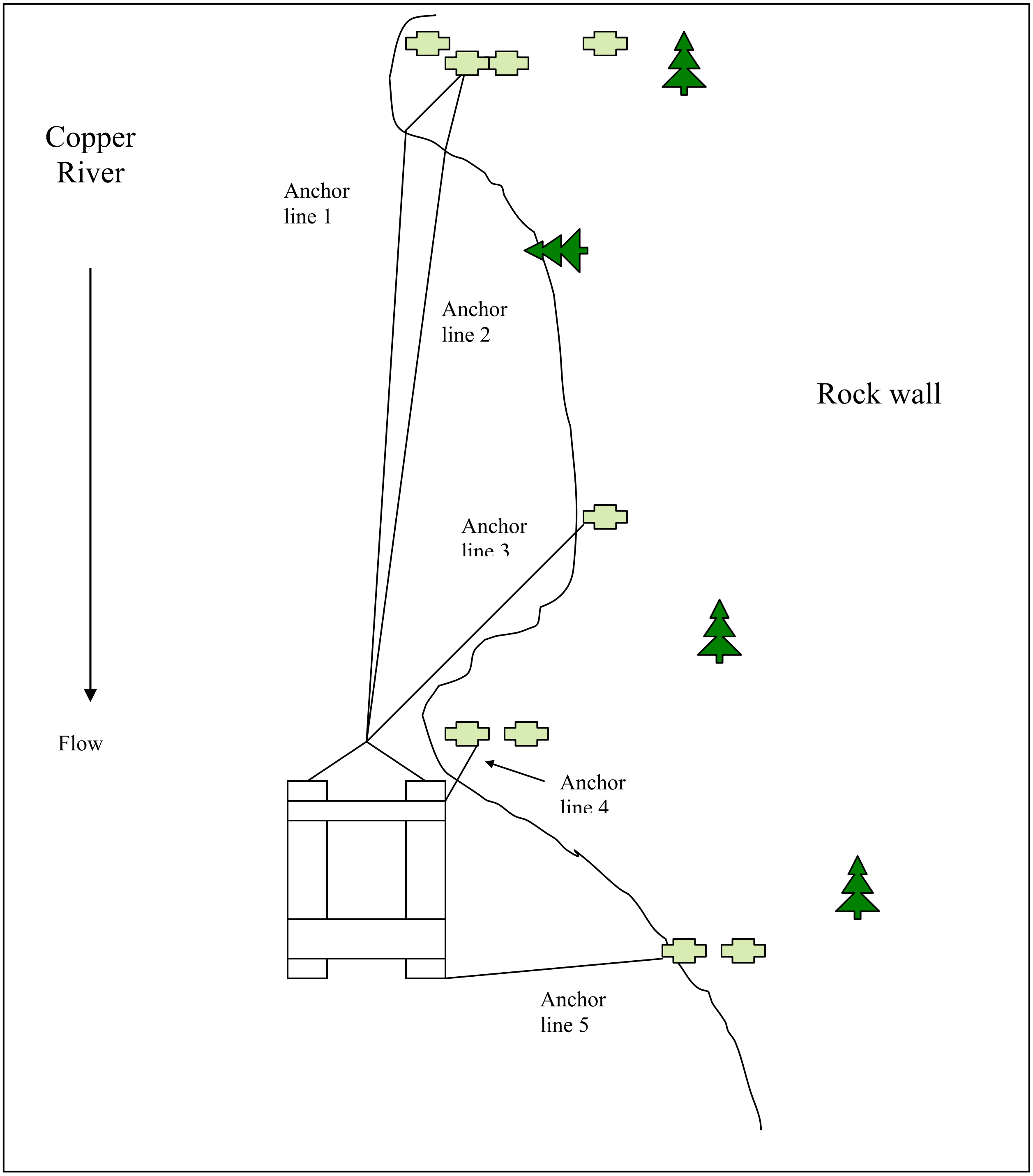


Figure C-2. Schematic of fishwheel Site 2 and the anchoring system used in 2001. Crosses represent pins used to anchor the fishwheel.

Table D-1. Coordinates of fishwheel sites where anchoring systems were installed in 2001.

Site	Latitude	Longitude
1	N 60° 48.490’	W 144° 29.757’
2	N 60° 48.204’	W 144° 29.659’
3	N 60° 48.535’	W 144° 29.740’
7	N 60° 48.135’	W 144° 29.969’

Table E-1. Summary of water level, daily fishing effort (hours), effort used to calculate CPUE, and fishwheel speed (RPM) for each Baird Canyon fishwheel, 2001.

		Fishwheel 1			Fishwheel 2		
Date	Water level (ft)	Total effort (h)	RPM	CPUE effort (h)	Total effort (h)	RPM	CPUE effort (h)
29-May	39.8	8.5		5.3			
30-May	40.2	16.4	2.7	19.6			
01-Jun	40.2	4.0		3.7			
02-Jun	40.6	23.0	2.2	23.0			
03-Jun	40.7	24.0	2.1	24.8			
04-Jun	41.0	24.0	1.3	23.3	4.5	1.0	0.0
05-Jun	41.0	24.0	0.8	26.9	23.4	1.2	27.9
06-Jun	41.0	24.0	1.3	22.9	11.3	1.5	8.8
07-Jun	41.3	21.3		23.3	23.0	1.5	22.5
08-Jun	41.3				20.3	1.2	23.3
09-Jun	41.3				21.2	1.1	24.8
10-Jun	41.3				12.0	1.4	9.0
11-Jun	41.3				24.0		23.2
12-Jun	41.6				24.0	2.2	23.9
13-Jun	41.9				24.0	2.7	25.1
14-Jun	42.1				24.0	2.6	23.9
15-Jun	42.2				24.0	2.7	24.3
16-Jun	42.3				24.0	3.0	24.4
17-Jun	42.4				21.0	2.8	21.1
18-Jun	42.6				24.0	2.0	24.4
19-Jun	42.8				23.3	2.3	23.0
20-Jun	43.0				24.0	2.1	24.5
21-Jun	43.1				20.8	2.9	20.4
22-Jun	43.3				22.0	3.0	21.9
23-Jun	43.4				24.0	3.0	22.7
24-Jun	43.4				18.5	3.0	19.3
25-Jun	43.5				24.0	3.0	24.5
26-Jun	43.6				24.0	2.9	24.1
27-Jun	43.4				22.5	2.8	22.7
28-Jun	43.4				24.0	2.6	15.4
29-Jun	43.4				24.0	2.7	32.2
30-Jun	43.4				22.7	2.5	21.1
01-Jul	43.4				24.0	2.6	26.0
02-Jul	43.4				24.0	2.5	23.6
03-Jul	43.4				23.0	2.6	23.4
04-Jul	43.4				23.5	2.7	23.4
05-Jul					24.0	2.5	22.4
06-Jul					24.0	2.4	25.5
07-Jul					24.0	2.3	24.4
08-Jul					24.0	2.0	25.3
09-Jul					23.0	2.1	23.6
10-Jul					11.2	2.1	10.7
11-Jul					14.0	2.4	7.3
Total		169		173	817		814

Table F-1. Daily catch of chinook and sockeye salmon by Fishwheel 1, 2001

	Chinook								Sockeye						Ratio of sockeye to chinook
	Large								Large						
	Live-tank								Live-tank						
Date	Port	Strbd	Unk	Total	Cum.	Marked	Recaps	Jacks	Port	Strbd	Unk	Total	Cum.	Jacks	
29-May	0	0	10	10	10	0	0	1	0	0	20	20	20	0	2
30-May	2	1	9	12	22	0	0	1	27	44	101	172	192	0	14
31-May	0	0	0	0	22	0	0	0	0	0	0	0	192	0	
01-Jun	0	0	0	0	22	0	0	0	0	0	0	0	192	0	
02-Jun	2	11	4	17	39	0	0	0	49	88	33	170	362	0	10
03-Jun	6	8	4	18	57	0	0	0	128	203	50	381	743	0	21
04-Jun	4	3	6	13	70	0	0	1	35	59	100	194	937	0	15
05-Jun	9	8	0	17	87	0	0	0	95	142	0	237	1,174	0	14
06-Jun	7	5	0	12	99	10	0	2	77	105	0	182	1,356	0	15
07-Jun	2	2	0	4	103	4	0	1	70	89	0	159	1,515	0	40
Totals	32	38	33	103		14	0	6	481	730	304	1,515		0	15

Table F-2. Daily catch of chinook and sockeye salmon by Fishwheel 2, 2001.

	Chinook							Sockeye						
	Large							Large						Ratio of
	Live-tank							Live-tank						sockeye to
Date	Port	Strbd	Total	Cum.	Marked	Recaps	Jacks	Port	Strbd	Unk	Total	Cum.	Jacks	chinook
05-Jun	17	3	20	20	0	0	3	474	110	0	584	584	0	29
06-Jun	22	6	28	48	25	0	0	191	57	0	248	832	0	9
07-Jun	35	11	46	94	42	1	0	653	170	0	823	1,655	0	18
08-Jun	27	9	36	130	35	0	1	668	173	0	841	2,496	0	23
09-Jun	28	6	34	164	24	2	1	548	143	0	691	3,187	0	20
10-Jun	16	5	21	185	20	1	3	192	36	0	228	3,415	0	11
11-Jun	40	13	53	238	48	2	3	569	140	0	709	4,124	0	13
12-Jun	29	13	42	280	42	0	2	635	173	0	808	4,932	0	19
13-Jun	31	20	51	331	39	2	0	657	170	0	827	5,759	0	16
14-Jun	18	6	24	355	24	0	0	441	158	0	599	6,358	0	25
15-Jun	20	16	36	391	0	0	2	598	155	0	753	7,111	0	21
16-Jun	35	15	50	441	0	0	1	624	187	0	811	7,922	0	16
17-Jun	48	15	63	504	0	0	1	117	113	358	588	8,510	0	9
18-Jun	18	10	28	532	8	0	1	248	71	0	319	8,829	0	11
19-Jun	10	3	13	545	0	0	0	148	59	0	207	9,036	0	16
20-Jun	5	2	7	552	0	0	0	76	44	0	120	9,156	0	17
21-Jun	6	1	7	559	0	0	0	75	35	0	110	9,266	0	16
22-Jun	9	9	18	577	0	0	0	155	86	0	241	9,507	0	13
23-Jun	4	7	11	588	0	0	1	163	85	0	248	9,755	0	23
24-Jun	5	0	5	593	5	0	0	187	93	0	280	10,035	0	56
25-Jun	4	7	11	604	4	0	0	283	197	0	480	10,515	0	44
26-Jun	9	5	14	618	6	0	0	364	180	0	544	11,059	0	39
27-Jun	15	12	27	645	3	1	1	413	353	0	766	11,825	0	28
28-Jun	7	3	10	655	1	1	1	190	110	0	300	12,125	0	30
29-Jun	10	5	15	670	0	0	1	413	203	0	616	12,741	0	41
30-Jun	4	1	5	675	0	0	0	248	141	0	389	13,130	0	78
01-Jul	14	10	24	699	0	0	0	597	356	0	953	14,083	0	40
02-Jul	3	1	4	703	0	0	0	390	233	0	623	14,706	0	156
03-Jul	7	4	11	714	0	0	0	426	248	0	674	15,380	9	61
04-Jul	5	2	7	721	6	0	0	289	146	0	435	15,815	7	62
05-Jul	0	0	0	721	0	0	0	207	133	0	340	16,155	6	
06-Jul	1	3	4	725	0	0	0	225	106	0	331	16,486	3	83
07-Jul	0	2	2	727	0	0	0	264	117	0	381	16,867	6	191
08-Jul	6	8	14	741	3	0	1	776	283	0	1,059	17,926	13	76
09-Jul	15	10	25	766	8	0	2	1,464	646	0	2,110	20,036	12	84
10-Jul	6	5	11	777	4	0	0	857	258	0	1,115	21,151	9	101
11-Jul	3	0	3	780	0	0	0	184	63	248	495	21,646	4	165
Total	532	248	780		347	10	25	15,009	6,031	606	21,646		69	28

Table G-1. Daily catch of juvenile salmon and other species by Fishwheel 1, 2001.

Date	Species						
	SM	DV	PL	WF	SU	GR	BU
29-May	2	0	0	1	0	0	0
30-May	12	0	7	3	0	0	0
31-May	0	0	0	0	0	0	0
01-Jun	0	0	0	0	0	0	0
02-Jun	25	2	3	1	1	0	0
03-Jun	20	0	5	7	0	0	0
04-Jun	6	0	5	2	0	0	0
05-Jun	2	0	5	7	2	0	0
06-Jun	2	0	4	3	0	0	0
07-Jun	2	0	1	2	0	0	0
Total	71	2	30	26	3	0	0

Species abbreviations: SM = salmon smolt, DV = Dolly Varden, PL = Pacific lamprey, WF = whitefish, SU = sucker, GR = grayling, BU = burbot

Table G-2. Daily catch of juvenile salmon and other species by Fishwheel 2, 2001.

Date	Species						
	SM	DV	PL	WF	SU	GR	BU
05-Jun	2	0	2	2	0	0	0
06-Jun	0	0	0	0	0	0	0
07-Jun	2	0	2	0	0	0	0
08-Jun	1	0	2	4	0	0	0
09-Jun	2	0	4	2	0	0	0
10-Jun	1	0	0	0	0	0	1
11-Jun	0	1	2	1	0	0	0
12-Jun	0	0	1	0	0	0	0
13-Jun	0	0	3	0	2	0	0
14-Jun	1	0	1	0	0	0	0
15-Jun	0	0	0	0	0	0	0
16-Jun	0	0	0	0	0	0	0
17-Jun	1	0	2	0	0	0	0
18-Jun	0	1	0	0	1	0	0
19-Jun	0	0	3	0	0	0	0
20-Jun	1	1	2	0	0	0	0
21-Jun	0	0	0	0	0	0	0
22-Jun	0	0	0	0	0	0	0
23-Jun	0	1	0	0	0	0	0
24-Jun	0	1	0	0	0	0	0
25-Jun	0	3	2	0	0	0	0
26-Jun	0	0	1	0	0	0	0
27-Jun	0	5	2	0	0	0	0
28-Jun	1	0	1	0	0	0	0
29-Jun	0	7	2	0	0	0	0
30-Jun	1	5	0	0	0	0	0
01-Jul	0	8	2	0	1	0	0
02-Jul	0	7	2	0	0	0	0
03-Jul	0	7	1	0	0	0	0
04-Jul	0	3	0	0	0	0	0
05-Jul	0	9	0	0	0	0	0
06-Jul	0	16	0	0	0	0	0
07-Jul	0	16	0	0	0	0	0
08-Jul	0	14	0	0	0	0	0
09-Jul	0	27	1	0	0	0	0
10-Jul	0	6	0	0	0	0	0
11-Jul	0	6	0	0	0	0	0
Total	13	144	38	9	4	0	1

Species abbreviations: SM = salmon smolt, DV = Dolly Varden, PL = Pacific lamprey, WF = whitefish, SU = sucker, GR = grayling, BU = burbot

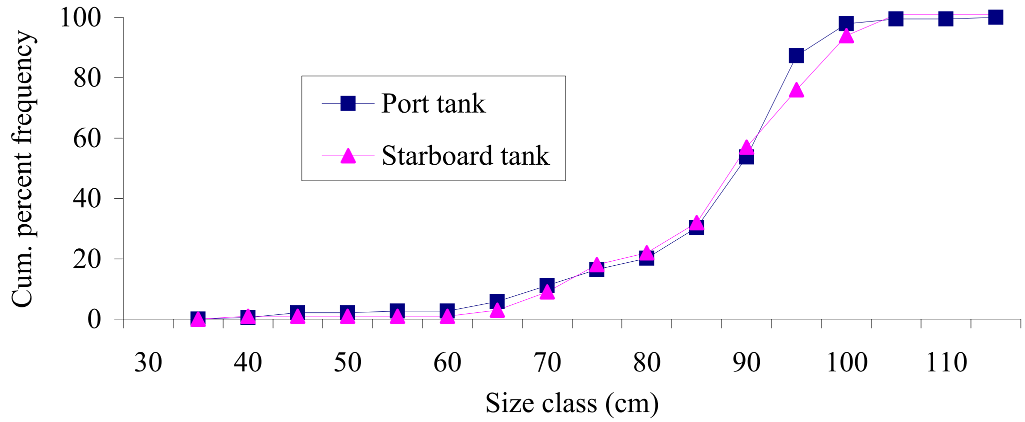


Figure H-1. Frequency distributions of chinook size classes captured in port and starboard tanks of Baird Canyon Fishwheel 2, 2001.

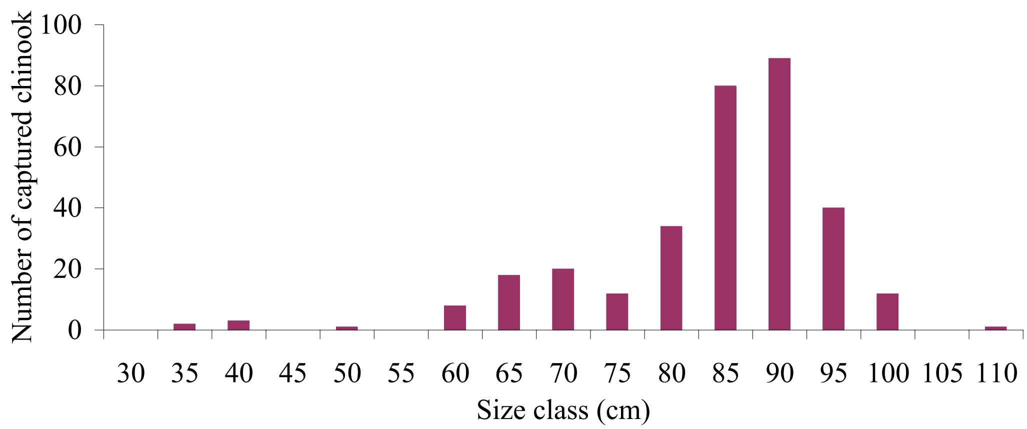


Figure H-2. Frequency distributions of chinook size classes captured in Baird Canyon Fishwheel 2, 2001.

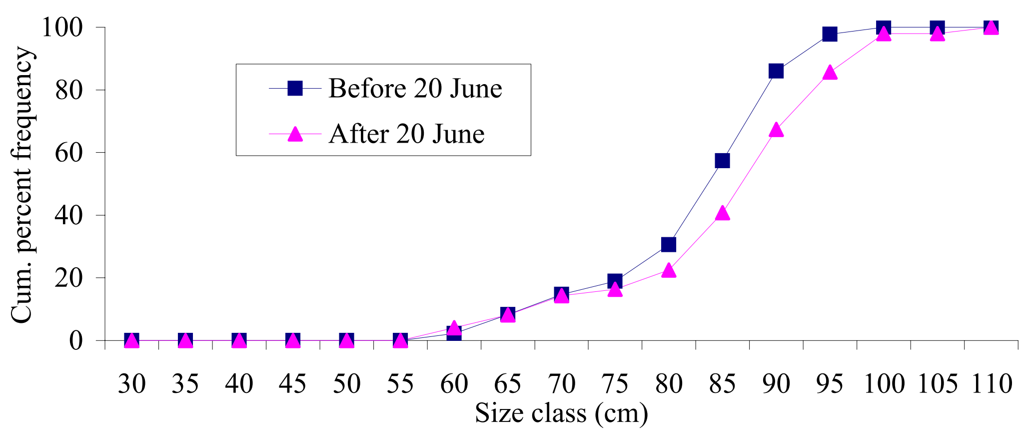


Figure H-3. Frequency distributions of chinook size-classes captured before and after 20 June in Baird Canyon Fishwheel 2, 2001. Small chinook (length < 50 cm) were excluded from the analysis.

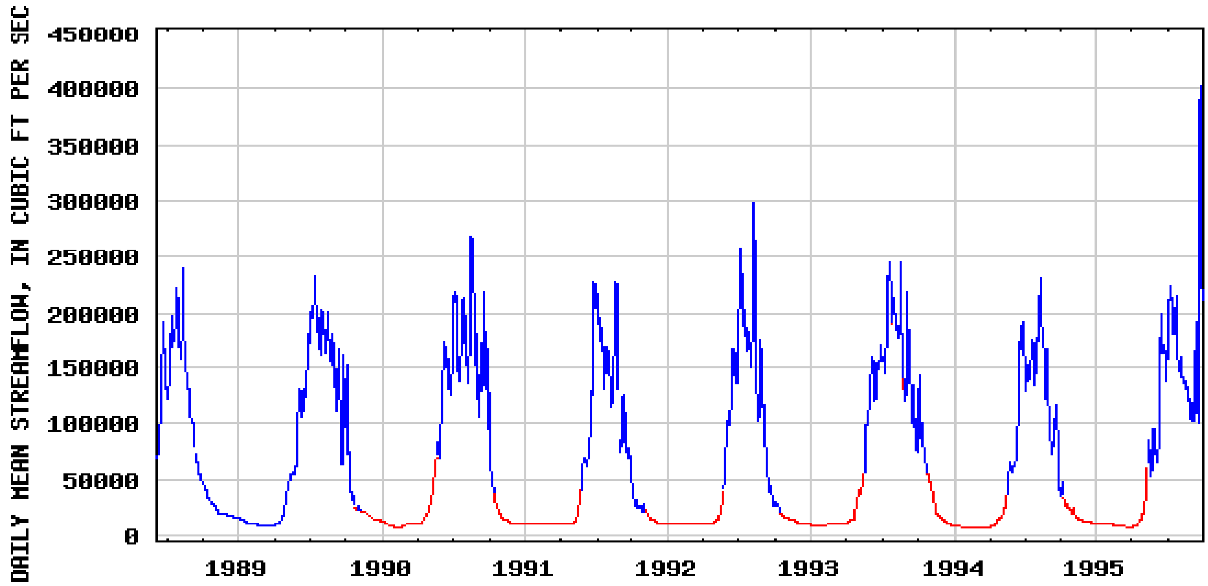


Figure I-1. Mean monthly discharge of the Copper River at Miles Lake, 1988-1994.

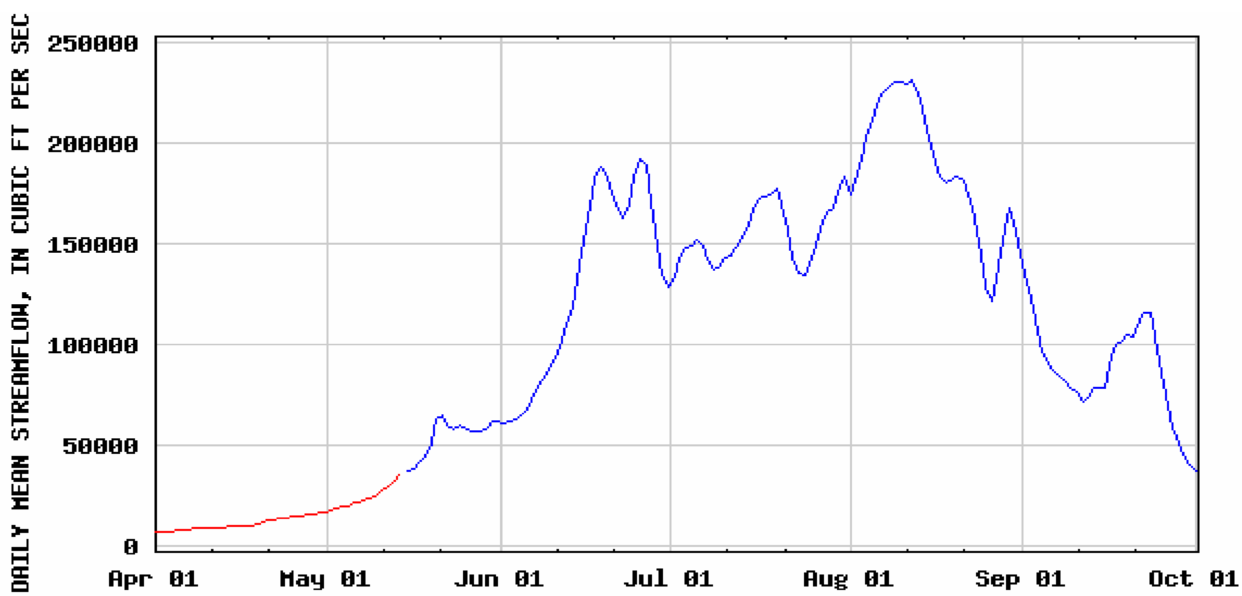


Figure I-2. Mean daily discharge of the Copper River at Miles Lake between 1 May and 1 October, 1994.

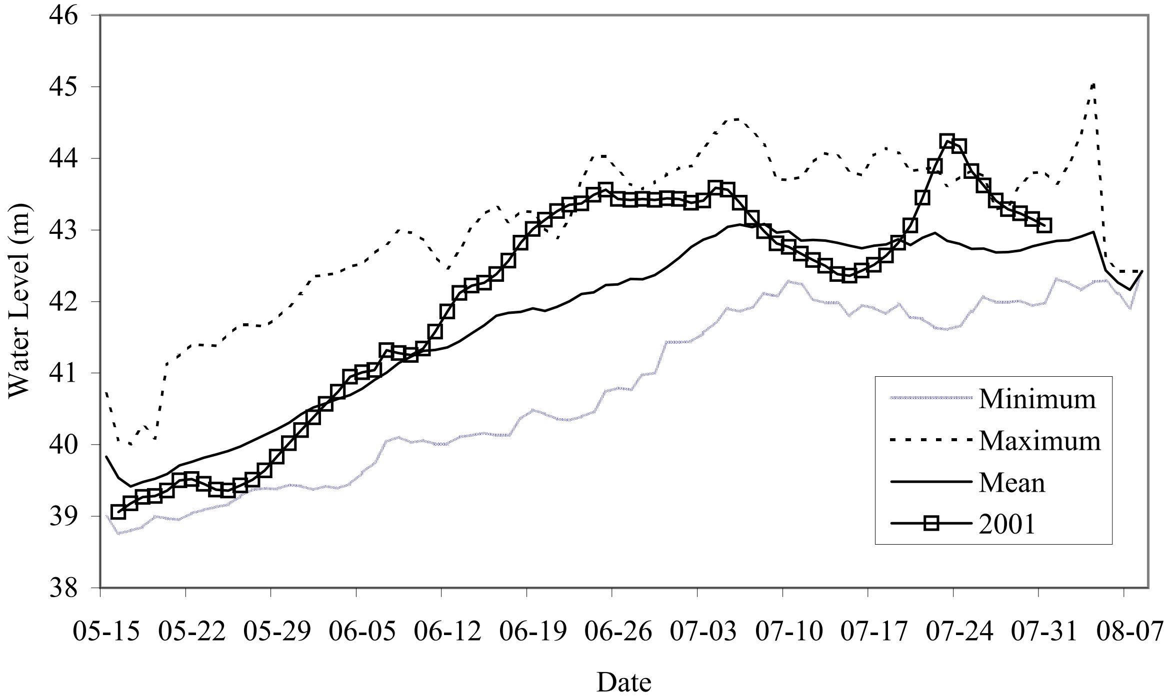


Figure I3. Water level at the Million Dollar Bridge (1982-2001).

Appendix J – List of participants and posters displayed at the 2001 NVE Fisheries Symposium in Cordova, Alaska

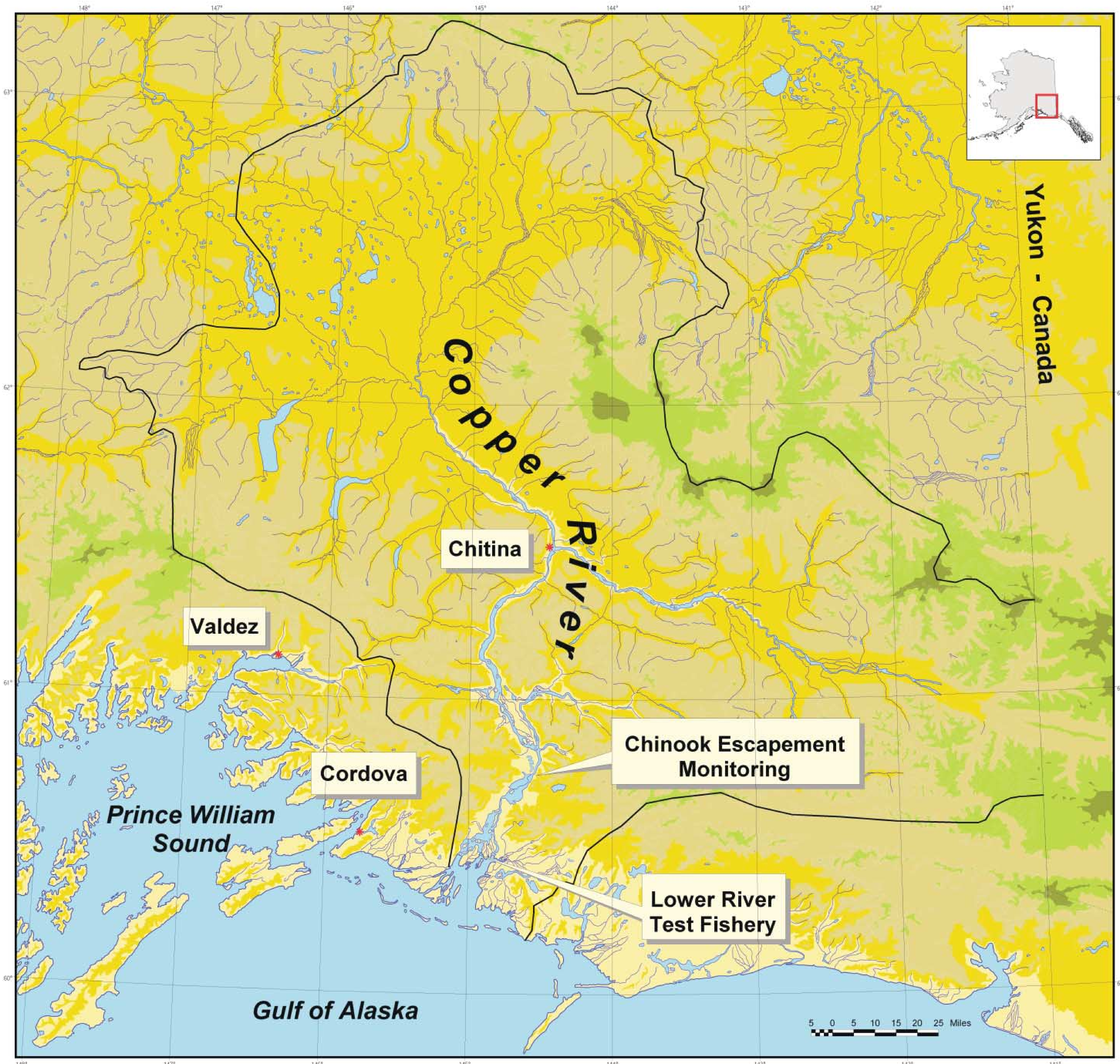
The Native Village of Eyak (NVE) hosted a technical meeting and public symposium (29-30 November 2001) to review two three-year fisheries projects initiated in 2001. One project was designed to examine the feasibility of monitoring sockeye salmon escapement in the Copper River Delta (Lower River Test Fishery), and the other project was designed to estimate the annual escapement of chinook salmon to the Copper River (Chinook Escapement Monitoring).

Technical meeting participants:

Brady, James (ADFG)	Henrichs, Bob (NVE)	Merizon, Rick (ADFG)
Bue, Brian (ADFG)	Hoover, Mark (NVE)	Moffit, Steve (ADFG)
Cain, Bruce (NVE)	Joyce, Tim (USFS)	Regnart, Jeff (ADFG)
Degan, Don (Aquacoustics)	King, Mark (NVE)	Savereide, James (ADFG)
Evenson, Matt (ADFG)	Lambert, Michael (NVE)	Smith, Jason (LGL)
Gove, Nancy (ADFG)	Link, Michael (LGL)	Veach, Eric (NPS)
Gray, Dan (ADFG)	McBride, Doug (USFWS)	Webber, Mike (NVE)
Haley, Beth (LGL)	Maxwell, Suzanne (ADFG)	Williams, Kate (NVE)

Community Fisheries Symposium
Native Village of Eyak, 2001

The Native Village of Eyak (NVE) welcomes you to our first Community Fisheries Symposium. NVE has been actively involved in environmental programs since 1997. In 2001, two projects were initiated to monitor salmon abundance in the lower Copper River.



Lower River Test Fishery (LRTF)
Designed to identify methods of assessing the escapement of sockeye salmon upstream of the commercial fishing district.

Chinook Escapement Monitoring (CEM)
Designed to estimate the escapement of chinook salmon for the entire Copper River each year.

These projects will provide information to fishery managers to regulate commercial and subsistence harvests to ensure the long-term sustainability of our valuable salmon resource.

Project partners:

Native Village of Eyak
Alaska Department of Fish and Game
LGL Alaska Research Associates, Inc.
Aquacoustics, Inc.

Projects funded by:

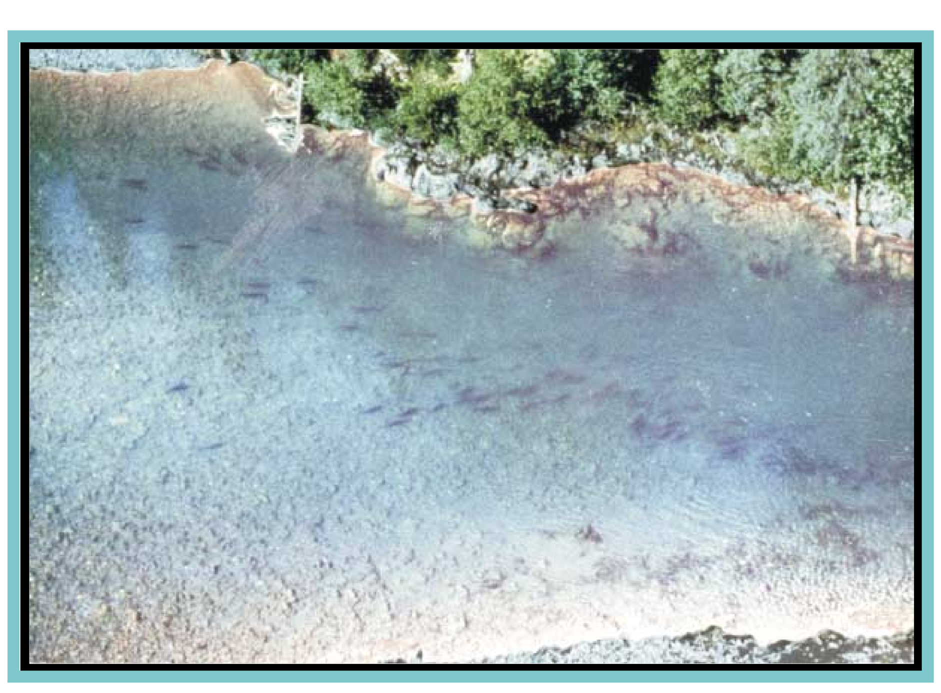
U.S. Fish and Wildlife Service
Office of Subsistence Management
Fisheries Resource Monitoring Program
Anchorage, AK
CEM: FIS01-020-1
LRTF: FIS01-021-1

Background (CEM)

Native Village of Eyak

Each year, chinook salmon return to the Copper River. As they make their way to the spawning grounds, Copper River chinook salmon are harvested by commercial (48,000 fish), subsistence (6,000 fish) and sport (6,000 fish) fisheries.

The first priority in Alaska salmon management is to ensure sufficient numbers of fish make it back to spawn. For the Copper River, managers have relied in the past on aerial surveys of a few clear-water spawning areas. Unfortunately, these aerial surveys represent less than 10% of what is believed to be the chinook salmon escapement to the Copper River and many believe this is inadequate to safeguard stocks.



Estimating chinook salmon escapement in the Copper River is difficult because of its high discharge, turbid water, and large drainage area.

A method used successfully elsewhere on rivers like the Copper River involves a tagging program combined with upstream recovery efforts. This method is known as a mark-recapture experiment.

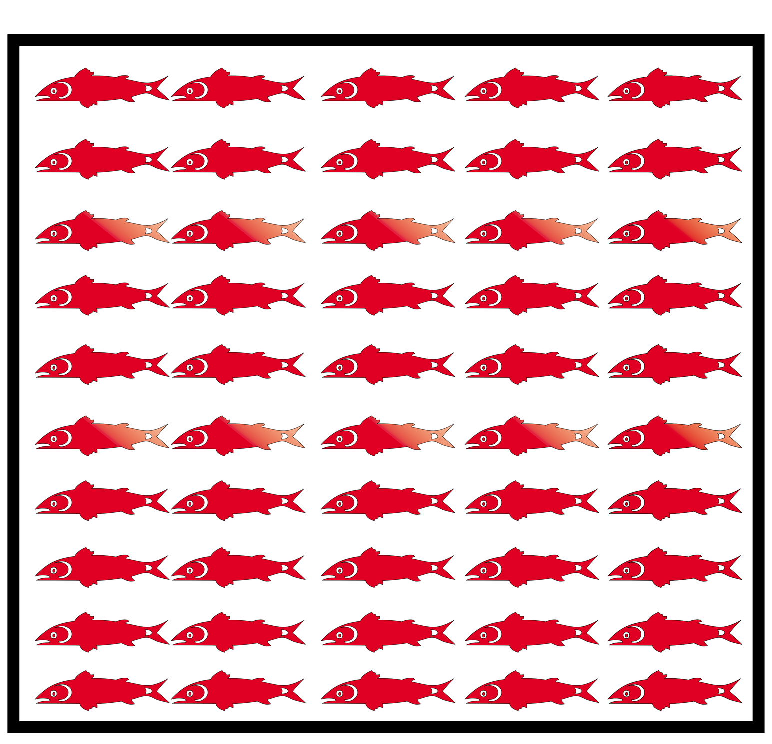
Study Design (CEM)

For the Copper River, the mark-recapture method requires that we:

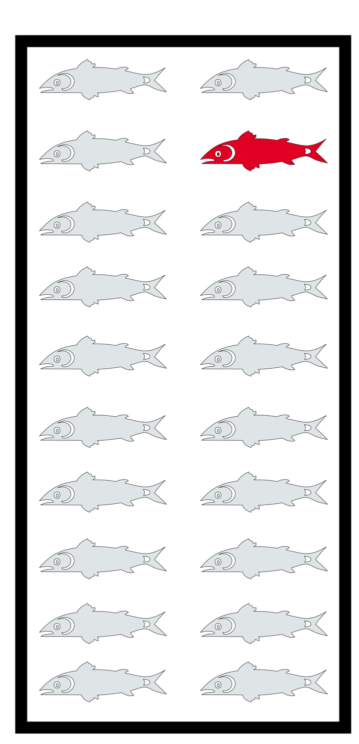
- Mark a portion of the chinook salmon in the lower river, upstream of the ocean but downstream of major spawning areas, and
- Subsequently examine a portion of the chinook salmon run upstream of the tagging site.

An **escapement estimate** can then be made using a simple relationship between the tagged and not tagged fish at the upstream recovery site.

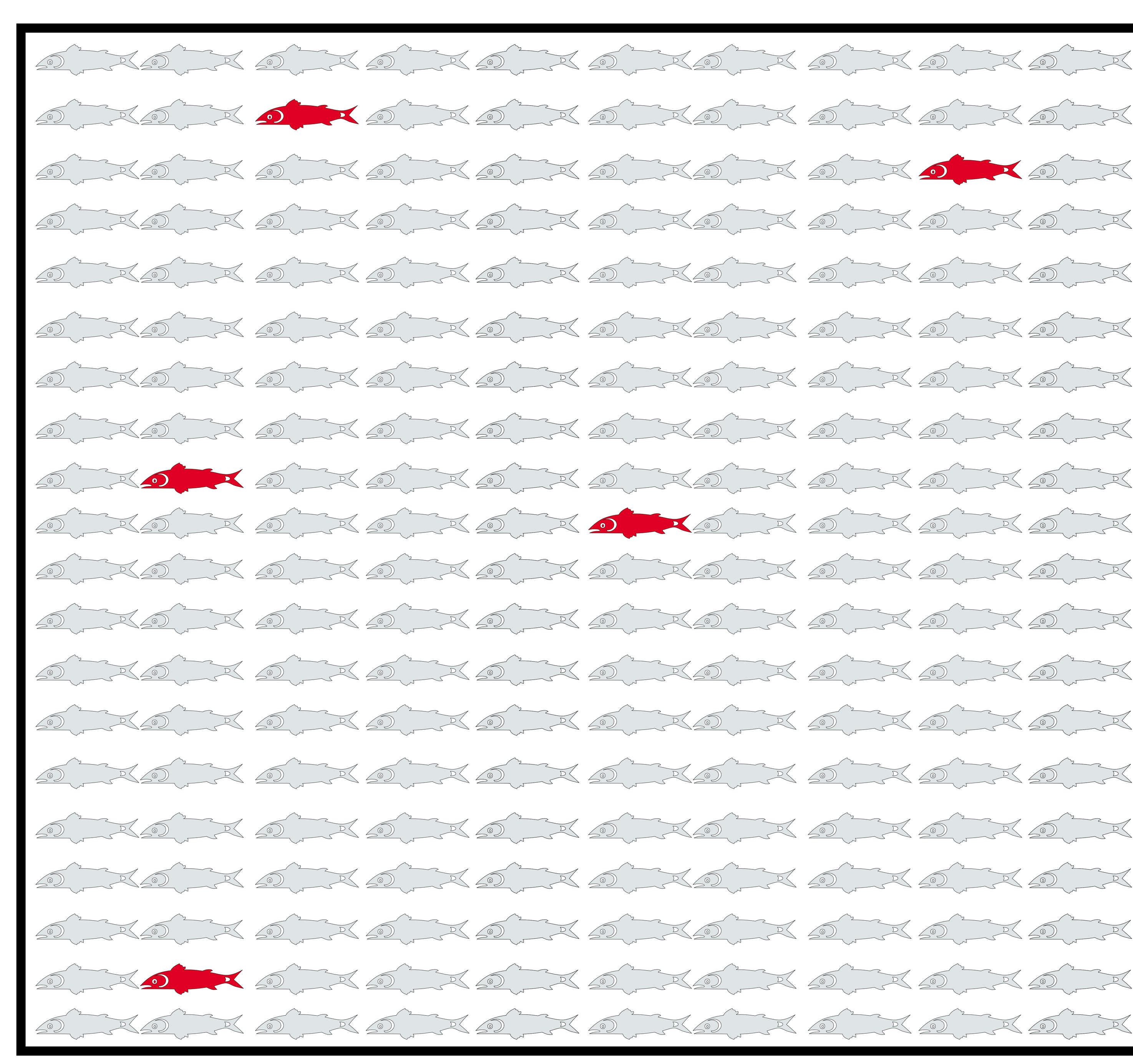
For example, if we **tag 1,000 fish at Baird Canyon,** and later examine a portion of the run upstream near Chitina and find that **1 in 40 chinook has a tag;** it would be possible to estimate the chinook escapement that passed by Baird Canyon as follows:



1,000 fish tagged at Baird Canyon



1 tagged fish in every 40 fish caught upstream



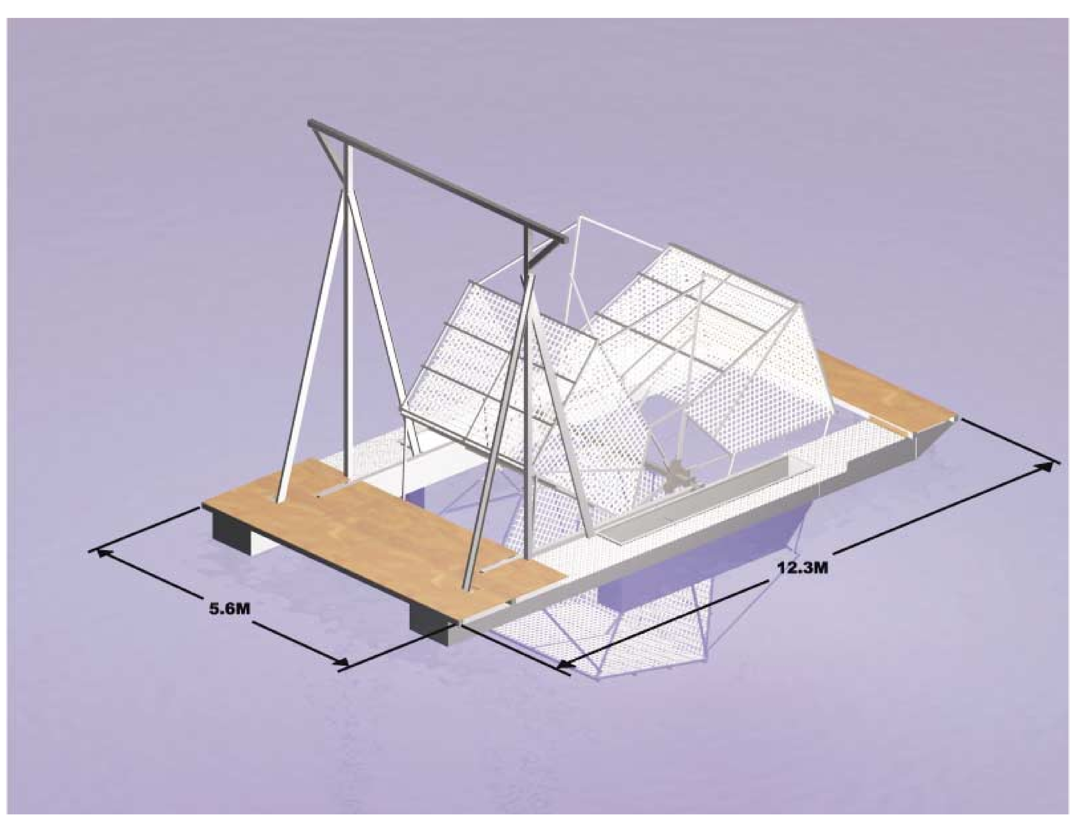
Estimate run at 40,000 fish

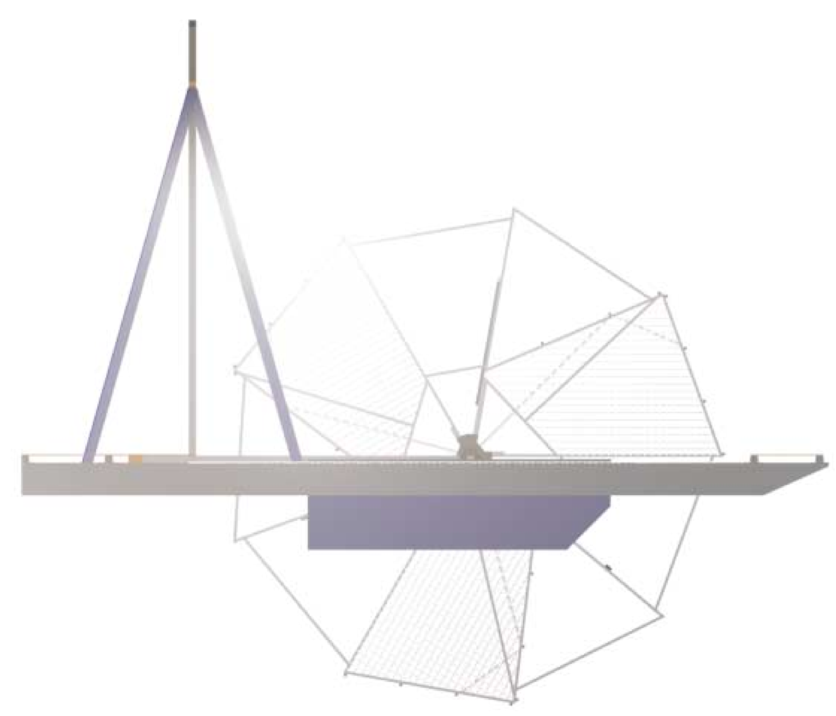
40:1	**Ratio of captured fish to tagged fish**
x <u>1,000</u>	**Total tags applied**
40,000	**Estimated escapement at the tagging site**

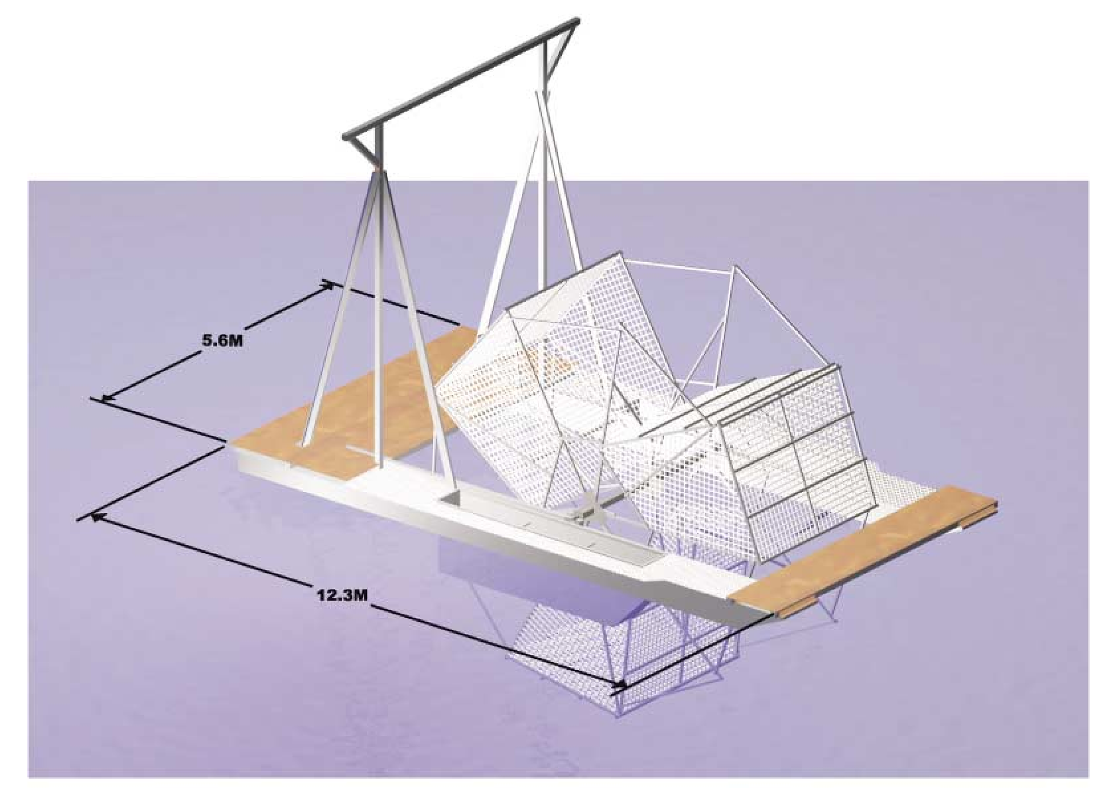
A Method For Mark Recapture (CEM)

Native Village of Eyak

In large rivers such as the Copper River, an effective means of catching sufficient numbers of salmon for mark-recapture studies is large fishwheels that are fitted with tanks to hold fish alive.







Live capture fishwheels and mark-recapture studies to estimate salmon escapement have been used on several rivers in Alaska

Taku R, AK

Roanoke R, NC

Nass R, BC

Kuskokwim R, AK

Chilkat R, AK

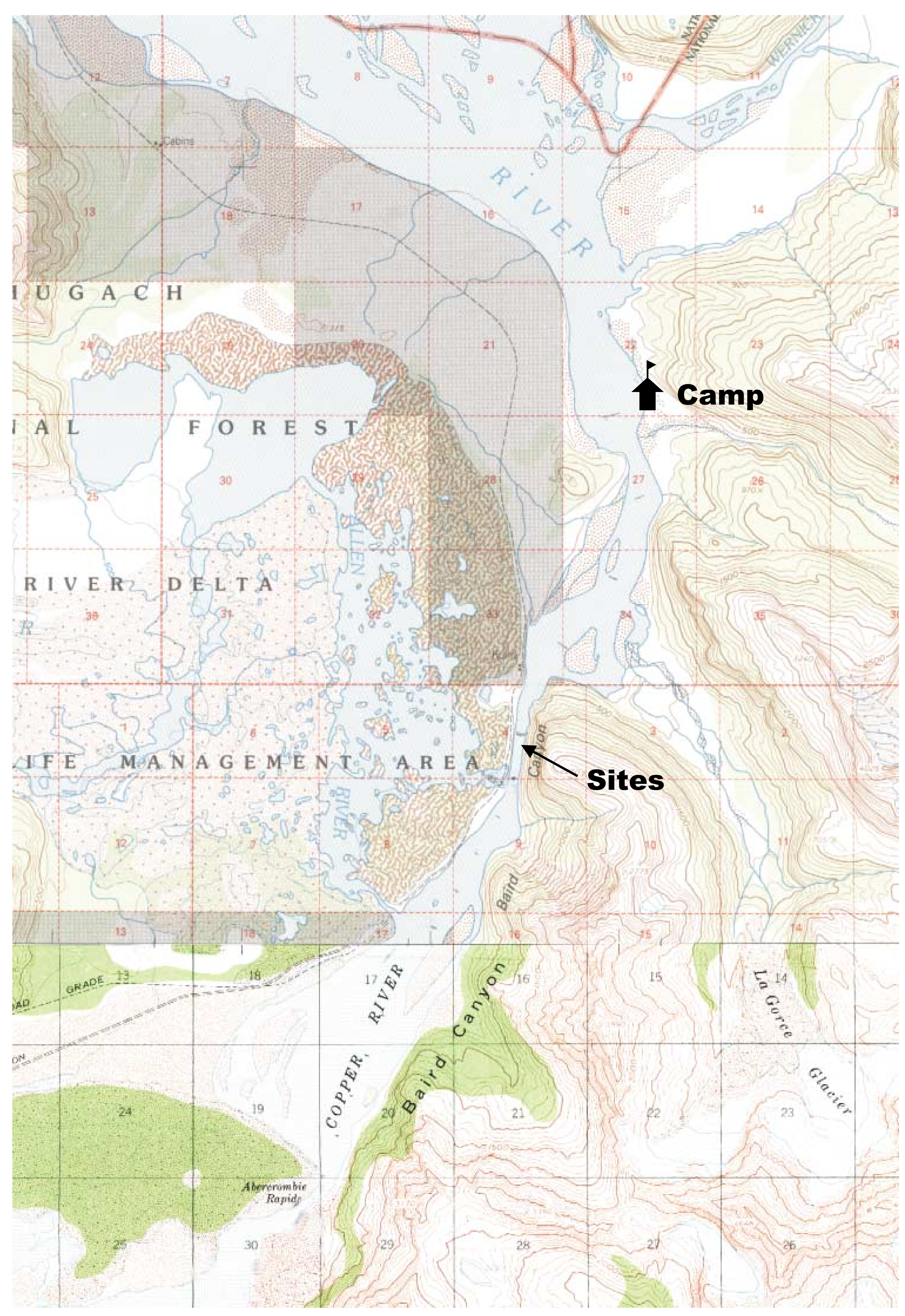
Skagit R, WA

In 2001, the Native Village of Eyak initiated a three-year project to adapt this mark-recapture method to the Copper River.

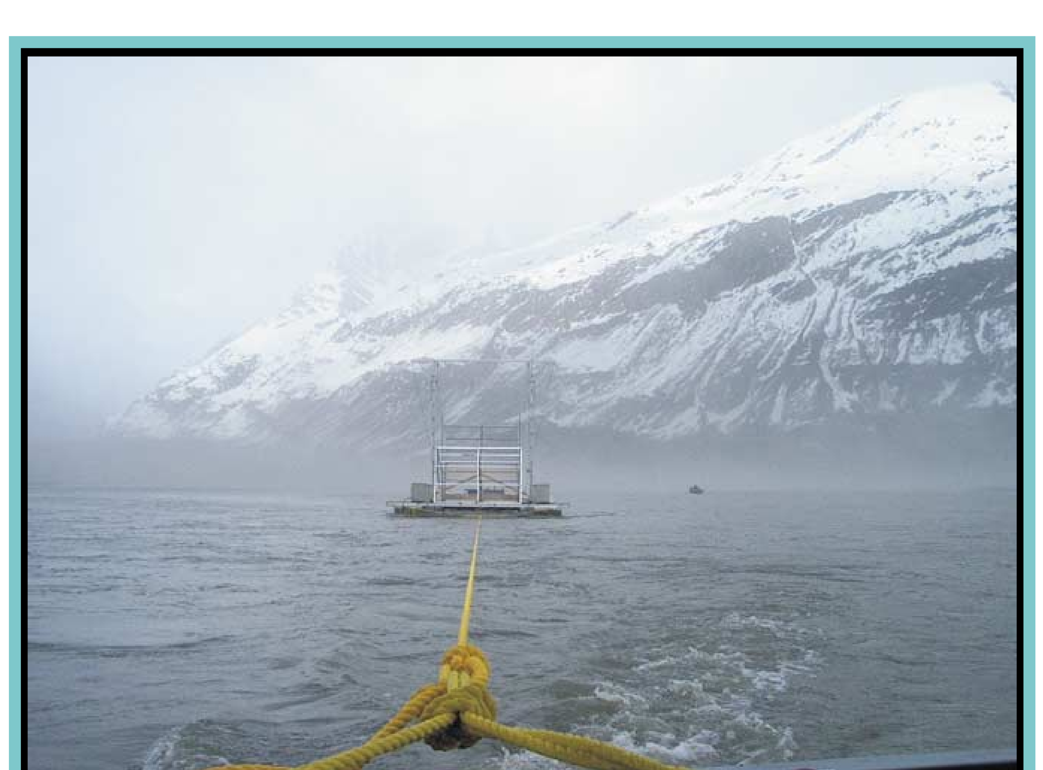
Setup & Operation (CEM)

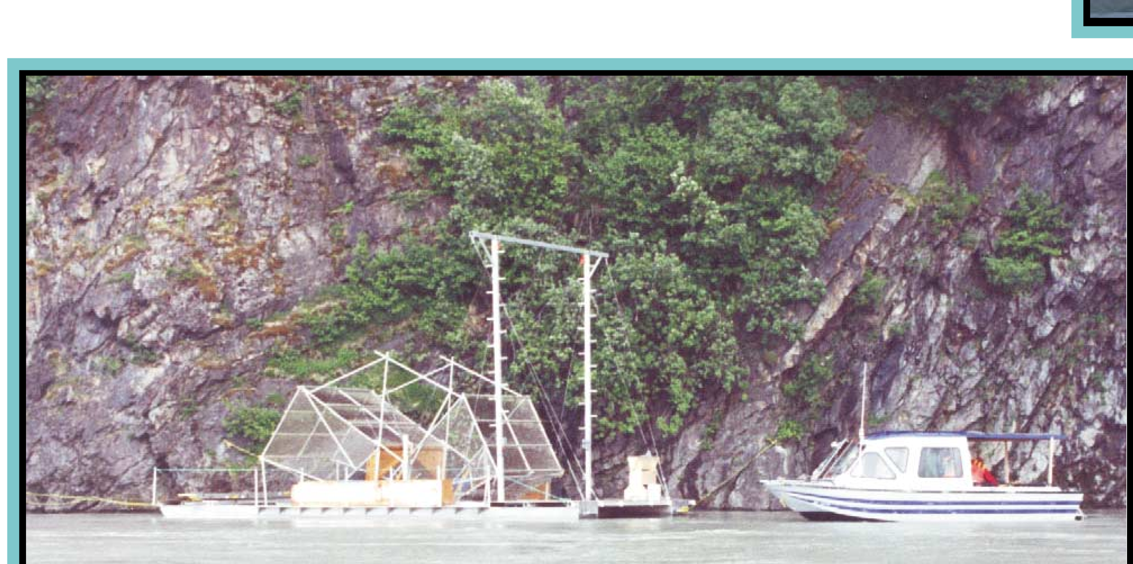
In the first year, we set out to examine the feasibility of using fishwheels to capture chinook salmon on the Copper River near Baird Canyon.

Two aluminum fishwheels were shipped to Chitina and assembled.



We towed the fishwheels 65 miles downstream to Baird Canyon (Miles Lake was still covered with ice).



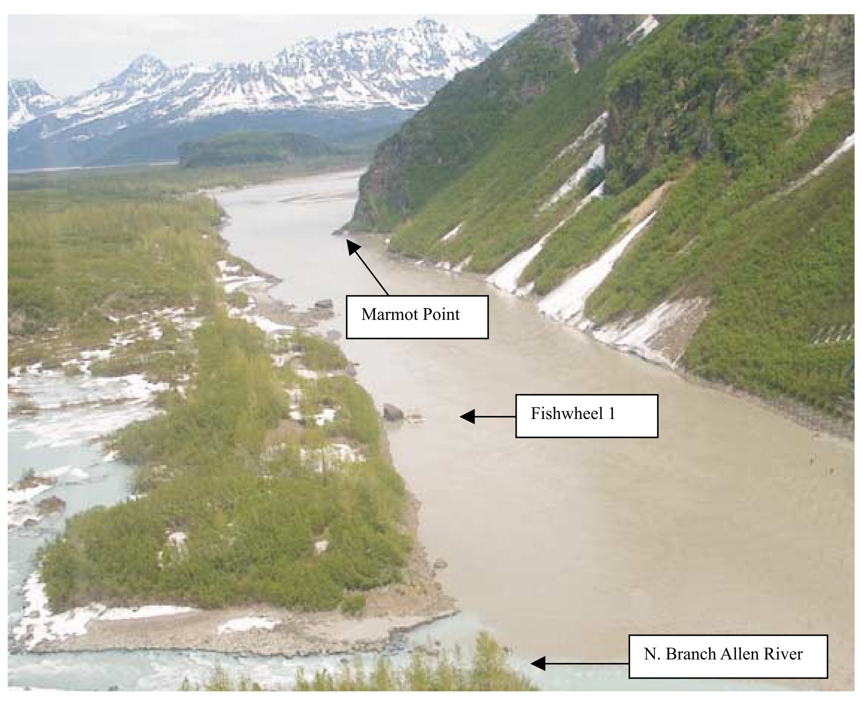


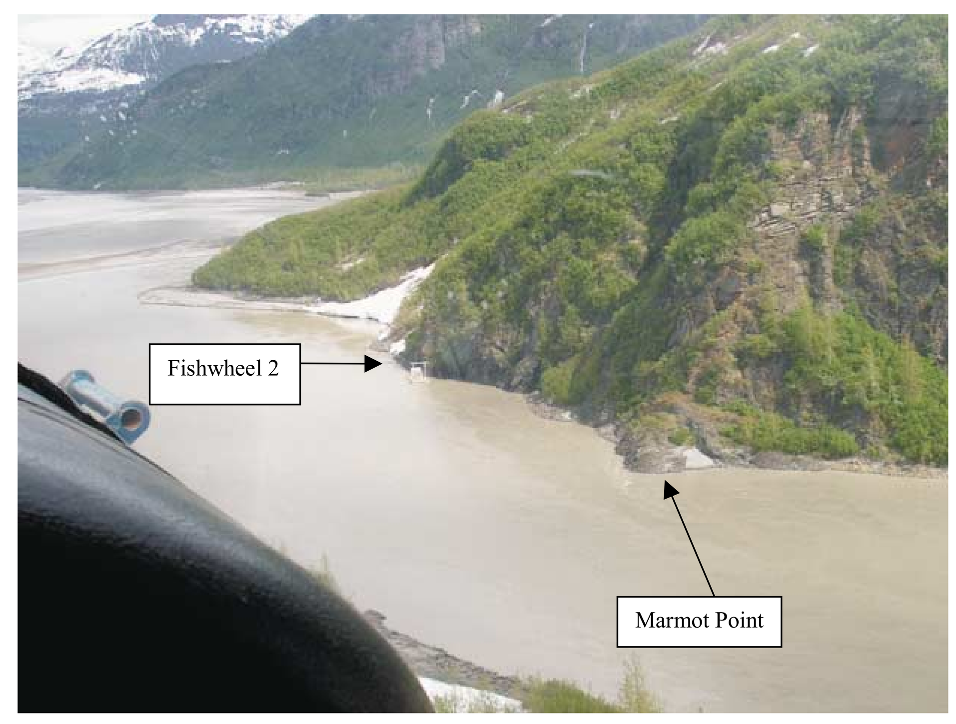
The fishwheels operated at Baird Canyon from May 29 to July 11, 2001.

Results (CEM)

Native Village of Eyak

Seven potential fishwheel sites in Baird Canyon were evaluated during the season.

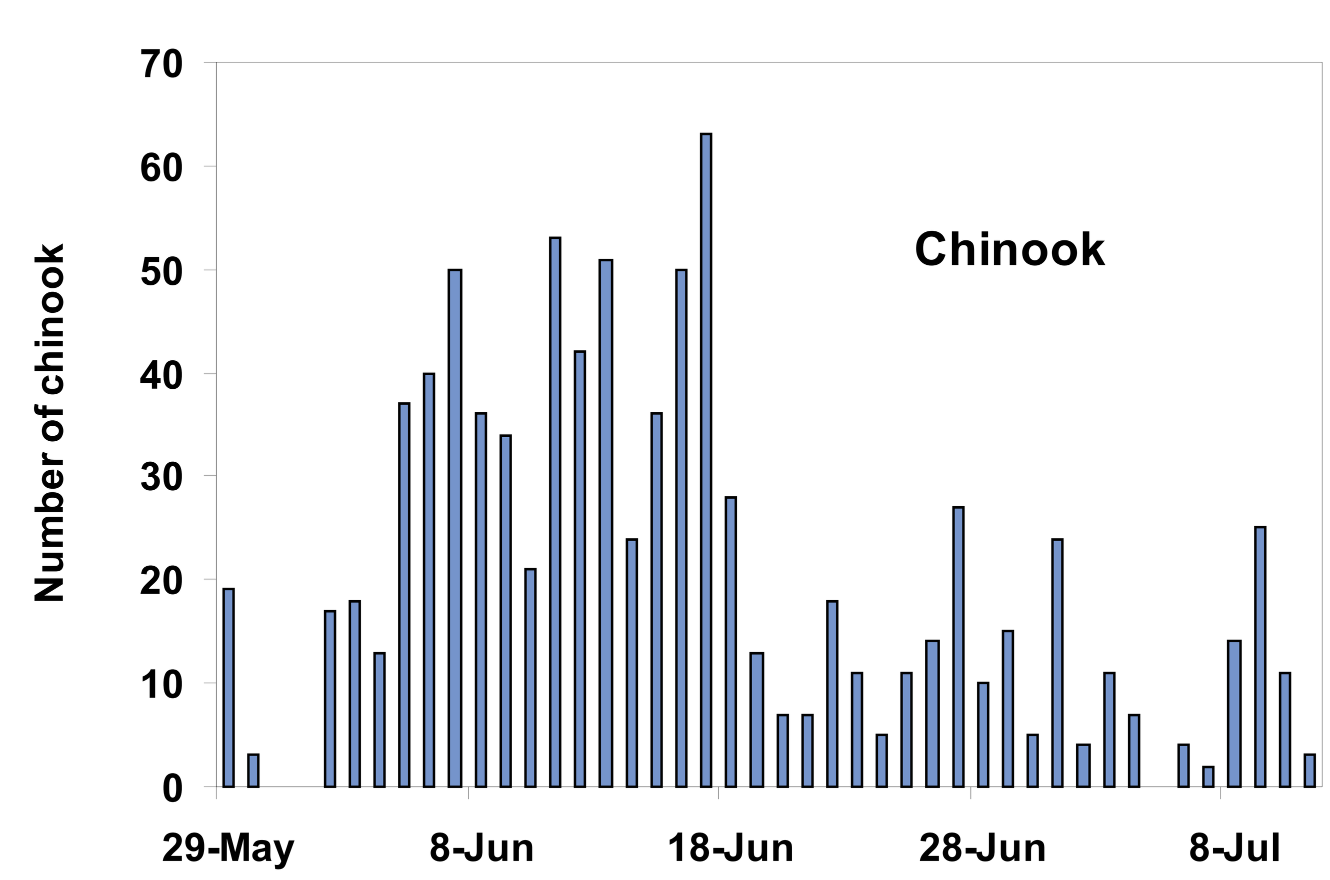


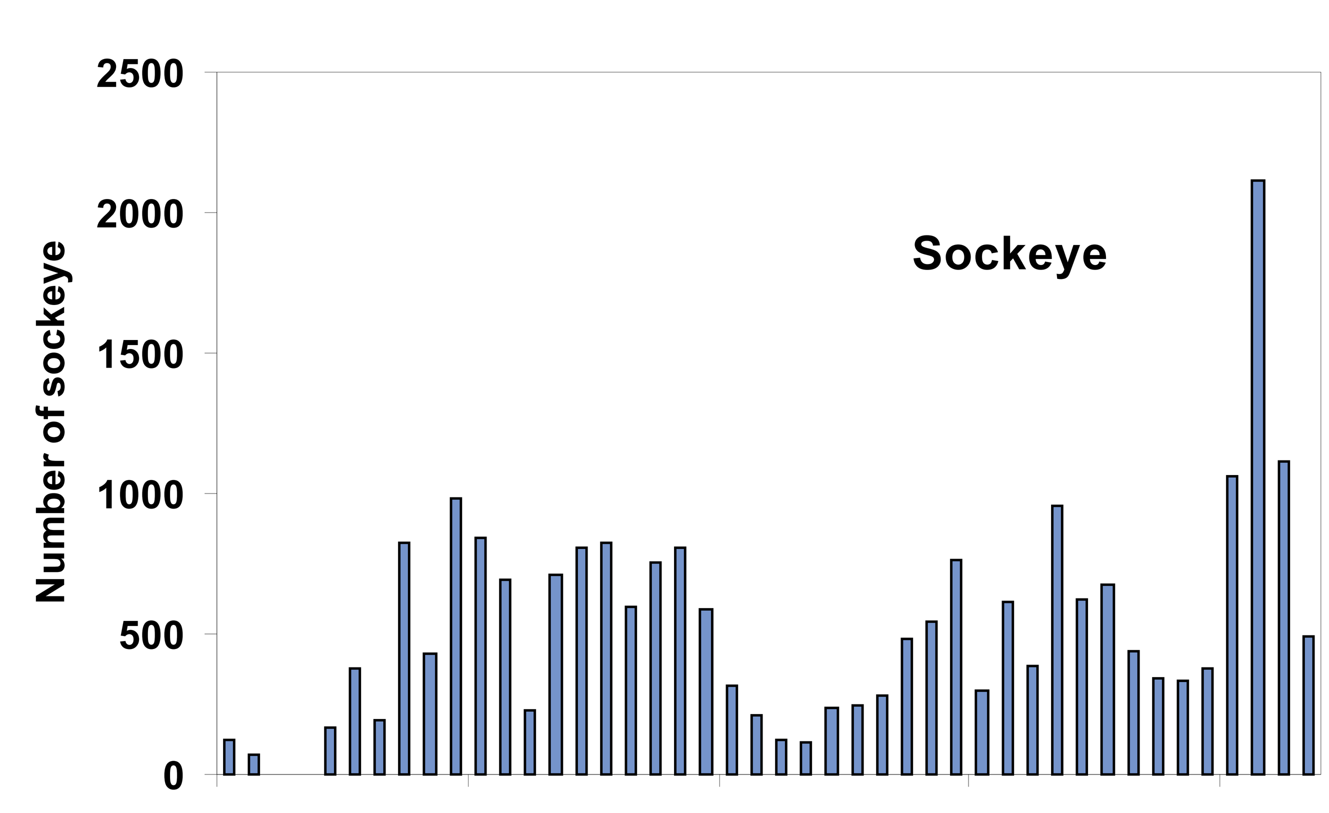


Fishwheel operation and capture:

Table 1. Summary of hours fished, days operated, and total catch of each fish species for both fishwheels, 2001.

	Fishwheel		
	1	2	Total
Hours fished	169	817	986
Days operated	9	38	47
Chinook			
Large	103	780	883
Jack	6	25	31
Total	109	805	914
Sockeye			
Large	1515	21646	23161
Jack	0	69	69
Total	1515	21715	23230
Juvenile salmon	71	13	84
Other species			
Dolly Varden	2	144	146
Pacific lamprey	30	38	68
Whitefish	26	9	35
Sucker	3	4	7
Burbot	0	1	1
Grayling	0	1	1





Conclusions (CEM)

Native Village of Eyak

Based on the 2001 season, it appears that fishwheels located in Baird Canyon can catch enough fish to make a mark-recapture program possible.

One fishwheel caught an estimated 2-3% of the entire chinook salmon run.

In 2002, we will focus on establishing a second fishwheel site at Baird Canyon.

We will also initiate an upstream recovery program using a fishwheel and subsistence catch sampling.

We would like to acknowledge the people who helped make the first year of this project a success:

Fieldwork
Luke Bohr
Beth Haley
Mark King
Brian Johansson
Roger Johnson
Michael Link
Peter Masolini
Scott Metzger
Matthew Nemeth
Iris O'Brien
Tim Patronski
Lawrence Stephens
Glenn Ujioka

USFWS - OSM
Doug McBride

Logistics Support
Bruce Cain
Seawan Gehlbach
Howard Teas
Kate Williams

ADF&G
Dave Bernard
Brian Bue
Matt Evenson
Steve Moffit
Ken Roberson (retired)

USFS
Cal Caspit
Ken Hodges

PHOTO PLATES

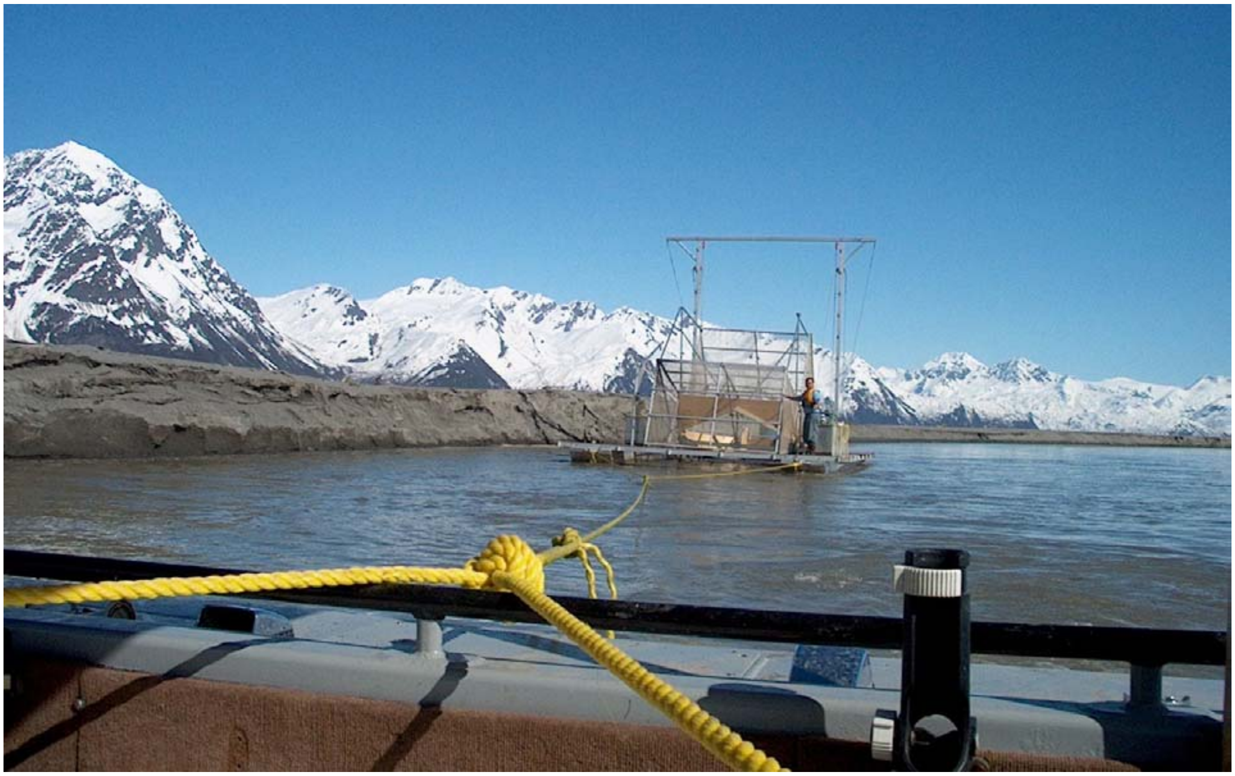


Photo 1. Towing a fishwheel down the Copper River from Chitina to Baird Canyon in May,2001.

Photo 2. Moving Fishwheel 2 upstream with a towboat (not pictured) and stern-mounted outboard motors, July 2001.

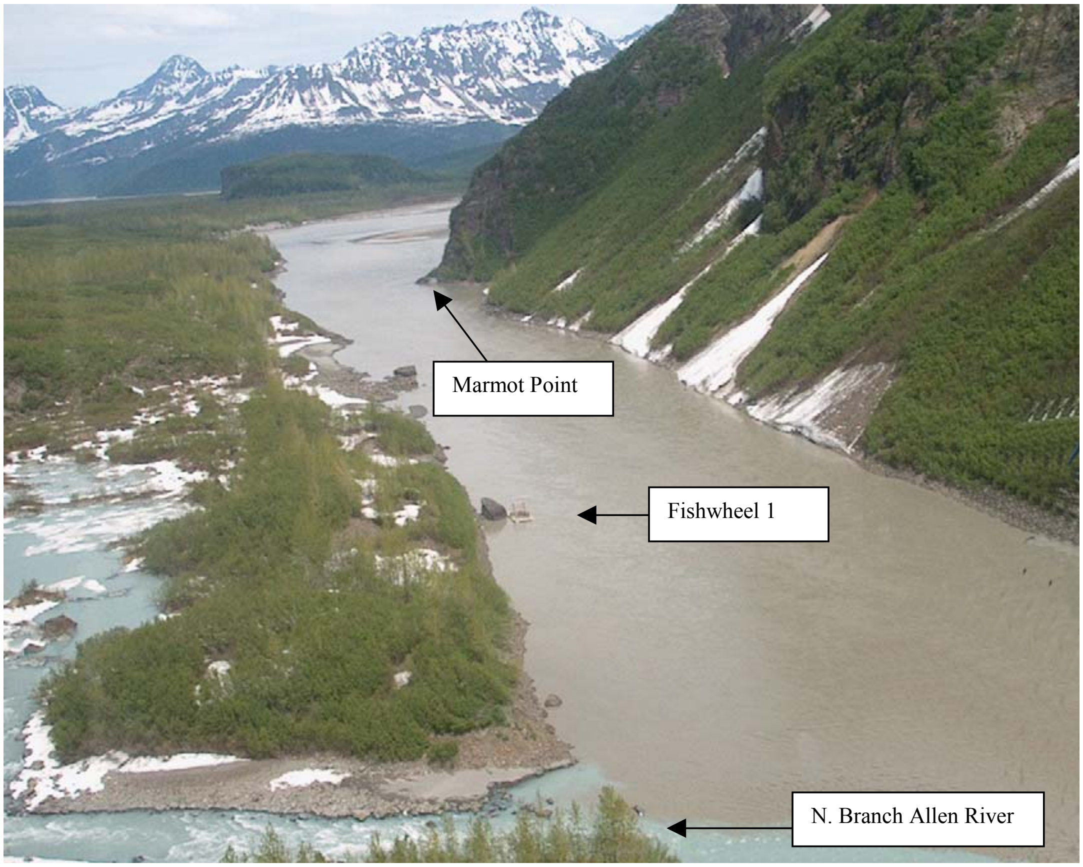


Photo 3. Aerial view (looking upstream) of Baird Canyon and Fishwheel 1, 2001.

Photo 4. Aerial view (looking upstream) of Baird Canyon and Fishwheel 2, 2001.

Photo 5. Fishwheel 1 operation site at Baird Canyon, June 2001.

Photo 6. Fishwheel 2 in operation at Baird Canyon, June 2001.

Photo 7. Sockeye salmon falling from a basket into the starboard holding tank on Fishwheel 2. The protective plywood skirt that fits over the holding tank (in foreground) was removed for the picture.

Photo 8. Chinook salmon being removed from a holding tank with a dipnet.

Photo 9. Marking a chinook salmon with an opercular punch at Fishwheel 2 in July, 2001. The fish are quickly released into the river after being marked and continue their upstream migration.