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Abundance and Run Timing of Adult Salmon in Tanada Creek in the Wrangell-St. Elias National Park and Preserve: 2003 Annual Report and 2000-2003 Final Report.

Final Report No. FIS00-013-3

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FINAL REPORT SUMMARY PAGE

Title: Abundance and Run Timing of Adult Salmon in Tanada Creek in the Wrangell-St. Elias National Park and Preserve

Study Number: FIS00-013-3

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Management Regions: Cook Inlet/Gulf of Alaska

Information Type: Fish stock status and trends

Issues Addressed: Tanada Creek salmon are highly susceptible to Federal and State subsistence users as well as commercial harvest. The Batzulnetas Area subsistence fisheries specifically target Tanada Creek salmon stocks. Monitoring Tanada Creek salmon stocks aids in assessing sockeye salmon escapement into the uppermost tributaries of the Copper River and in evaluating the harvest opportunity for subsistence fishers in the Batzulnetas Area fishery and the uppermost portion of the Glennallen Subdistrict. The dynamic nature of the flows in Tanada Creek has prevented a rigid picket weir from functioning successfully. The feasibility of a floating resistance board weir and a video counting tower as monitoring tools are tested in Tanada Creek.

Study Cost: **$**138,000

Study Duration: May 2000 to September 2003

Key Words: Batzulnetas, Copper River, Sockeye, Tanada Creek, Tanada Lake Stock/status and Trends, Use

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EXECUTIVE SUMMARY

The upper Copper River drainage is an important spawning area for both sockeye salmon, *Oncorhynchus nerka*, and Chinook salmon, *Oncorhynchus tshawytscha*. Both species of salmon are harvested from this drainage by commercial fisherman, subsistence users in the Copper River basin and sport fishermen. Data collected at the Tanada Creek weir, located in the upper reaches of the Copper River drainage, provides information essential to the management of healthy populations of fish in Wrangell-St. Elias National Park and Preserve and throughout the Copper River basin.

This report presents a summary of data collected by Wrangell-St. Elias National Park and Preserve at the Tanada Creek weir and in Tanada Lake over a three year period, 2001-2003. It also summarizes data collected previously by the Alaska Department of Fish and Game (1975-1979) and by the National Park Service (1997-2000).

The weir is located just downstream from the Batzulnetas fish camp, an area that has been used by local Athabascan Indians for centuries, and the location of the fishery that was part of the Katie John vs. State of Alaska civil suit that changed subsistence fishing regulations in the area.

In 2001 a floating picket weir replaced the rigid picket weir that had been used in previous years. During the three year period that this report describes, the weir was operated on a daily basis from early summer (May-June) until late summer (August-September). Staff gauge measurements and water and air temperatures were also taken on a daily basis. The salmon were enumerated as they passed through the weir. Ten percent of the sockeye salmon were sampled for length and sex, and a scale sample was taken from each of these fish. The scales were sent to the Alaska Department of Fish and Game in Cordova, Alaska for analysis. The left opercle plate on each sampled fish was marked with a hole punch. In 2002 leakage (due to incorrect weir installation) was observed at the weir and a mark-recapture project to estimate the sockeye population was conducted at Tanada Lake using the opercle marks. A video camera and time-lapse recording system was erected in 2001 and was in place for the remainder of this three year period. Fish were observed and counted on tape as well as at the weir.

Limnological data was collected five times throughout the summer at two sites in Tanada Lake in 2003: temperature, dissolved oxygen, pH, total nitrites/nitrates, total Kjeldahl nitrogen, total phosphate, chlorophyll a and zooplankton.

The weir was operated successfully during 2001, 2002 and 2003. During 2003 water flows were low in contrast to high flows in 2001 and 2002. Total number of fish counted through the weir each year was: 2001, 1,649 sockeye salmon; 2002, 6,186 sockeye salmon (this estimate was based on the mark-recapture sampling); 2003, 5,856 sockeye salmon. The median run time in 2003 was approximately three weeks later than in the previous two years. The video viewing functioned better each year with improved lighting and electrical power capacity and with the elimination of sun glare and the installation of a contrasting flash panel on the subsurface of the creek. In 2003 there was a strong relationship between the daily counts at the weir and the subsequent counts from the videos (R^2=0.9248).

Limnological data collected in 2003 showed surface temperature varying between 5.92° C and 15.68° C; temperature at depth varied between 3.0° C and 4.57° C. Dissolved oxygen ranged from 13.1 mg/L to 9.87 mg/L on the surface and from 5.67 mg/L to 0.70 mg/L at depth. Total Kjeldahl nitrogen and total phosphates were higher at depth than at the surface. Some of the lab results for the nutrients were below the Method Reporting Levels of Northern Testing Laboratories, where they were tested. There were 5 taxa of zooplankton present: Diaptomous, Cyclops, Bosmina, Daphnia and Copepod. The total mean biomass (dry weight) of all the taxa at the North station was 4,511 mg/m^2; at the South station it was 2,371 mg/m^2.

The weir was installed correctly in 2001 and in 2003 and no fish leakage was observed. There were no high water events in 2003. Using a floating resistance board weir worked well during the high water events in 2001 and 2002, and it also performed effectively during the low flow year in 2003.

The majority of the returning fish during this three years period were in the 1.3 age class group. The second highest age class group was 1.2 age fish. Sixteen Chinook salmon were enumerated in 2001, none in 2002 and two in 2003. Salmon escapement in the Copper River drainage was higher than average for all three years but does not seem to directly correlate to the salmon escapement at the Tanada Creek weir. There appears to be a strong correlation between the escapement at the weir and the subsistence harvest in the Batzulnetas fishery (R^2=0.9262). According to the data collected run timing in Tanada Creek seems to be highly variable. Aerial observations (by the National Park Service and the Alaska Department of Fish and Game) appear to only be effective in differentiating very small escapements (less than 2,000 salmon) from everything else. Over the three year period the Tanada Creek weir used as many as five local Slana residents to work at the weir each year and participated in the Batzulnetas culture camp event when invited. Video escapement estimations were better each year, with improved video recording conditions. Continued evaluation of this method of escapement estimation in conjunction with weir estimation is recommended. The limnological data collected in 2003 was useful in establishing some baseline nutrient levels in Tanada Lake. The nutrient levels tested in the lake appear to be low while zooplankton productivity appears to be high. Further limnological monitoring may be valuable in assessing the capacity of Tanada Lake to produce the high numbers of juvenile salmon that are needed for high adult sockeye salmon returns.

Recommendations from this three year project include a continuation of:

- Operating the video escapement estimation in conjunction with the weir
- Collection of data at the weir in order to more accurately assess the population abundance trends
- Collection and analysis of water and zooplankton samples

INTRODUCTION

The upper Copper River drainage provides spawning habitat for sockeye salmon, *Oncorhynchus nerka,* and Chinook salmon, *Oncorhynchus tshawytscha*. Significant numbers of adult salmon are harvested in commercial drift gillnet operations near the mouth of the Copper River from mid-May to September. Salmon escapement into the upper Copper River system contributes to Federal and State subsistence fishing through September 30. The monitoring and evaluation of these runs is essential to ensure that Wrangell - St. Elias National Park and Preserve (WRST) maintains natural and healthy populations of fish as required by the Alaska National Interest Lands Conservation Act (ANILCA).

The Copper River system supports over 124 known stocks of sockeye salmon of which at least 12 occur above the confluence of the Copper and Slana Rivers (Roberson 1987). Two of these stocks migrate through Tanada Creek and spawn along the shores of Tanada Lake or in the lake outlet (Figure 1). Chinook salmon are present in incidental numbers in Tanada Creek (Veach and Scotton, 2001).

Tanada Creek sockeye are one of the uppermost runs of sockeye in the Copper River and support a subsistence salmon fishery both in the Copper River and in Tanada Creek. Two native villages harvest salmon in the Batzulnetas Area fishery. Batzulnetas, the Ahtna name for the traditional fishing site on Tanada Creek, has been used by the Ahtna people for over 1,000 years (Kari, 1986). The Batzulnetas fishery was in litigation from 1985 –2000 as Katie John and others attempted to reestablish their traditional subsistence fishery. The “Katie John Decision” resulted in the expansion of Federal management of fisheries in waters under Federal jurisdiction throughout Alaska.

The Tanada Lake sockeye salmon stocks typically compose the largest population of sockeye spawning and rearing within Wrangell-St. Elias National Park/Preserve, among those stocks which spawn upstream of the Gulkana River. Good escapement data will allow us to assess management of these important sockeye salmon stocks.

OBJECTIVES

Specific objectives for this study were:

1. to monitor annual variations in abundance and timing of sockeye and Chinook salmon in Tanada Creek;
2. to compare video estimates with weir counts to determine the effectiveness of a video tower to estimate salmon escapement in Tanada Creek;

3. to test the feasibility of sampling water quality and zooplankton to determine if variations in water quality and zooplankton biomass correlate with variations in adult sockeye salmon escapement to Tanada Lake; and
4. to provide an educational opportunity for local students and residents to learn about the Tanada Creek salmon runs and how the weir counts help to provide information needed to manage subsistence fisheries on the Copper River.

This report presents a summary of assessment results for sockeye salmon escapements into Tanada Creek. First, assessment data prior to 2000 are summarized. During this time frame, some assessment of escapements was conducted by Alaska Department of Fish and Game (ADFG) annually through aerial surveys and sporadically through a weir. Also during this time, subsistence fishing was re-established at Batzulnetas in lower Tanada Creek, and assessment of this fishery has some relevance on escapement assessment. Second, assessment data during the period 2000-2003 are summarized. During this time frame, assessment of escapements was conducted by National Park Service (NPS) through a weir, and funded by the Office of Subsistence Management. This report serves as the final deliverable for funded work through 2003. Finally, conclusions and recommendations for management and further assessment are presented from synthesis of the entire data set.

SUMMARY OF ESCAPEMENT AND HARVEST ASSESSMENTS PRIOR TO 2000

Weir Estimates of Escapement

Assessments of sockeye salmon abundance using weirs in Tanada Creek were conducted in 1975, 1978 and 1979 by Ken Roberson, Alaska Department of Fish and Game (ADFG), Commercial Fisheries Division, and in 1997 and 1998 by Randall Raeder, National Park Service (NPS).

In 1975, ADFG located a rigid picket weir at the outlet of Tanada Lake. A large rainfall event early in the migration caused extremely high flows that completely submerged this weir and abruptly ended any reliable counts of escapement through the weir (Table 1). Substantially more fish were observed during subsequent aerial surveys than were counted at the weir (Table 2). In 1978 and 1979 the weir was relocated and placed approximately 21 km upstream of the mouth of Tanada Creek. The weir was constructed partially of pickets and partially of hog wire. Although the creek is braided in this section and multiple channels occur, the investigators only observed salmon migrating in the channel where the weir was installed. In 1978, high flows resulted in some fish leakage during a period of relatively high sockeye salmon passage, and again compromised the weir count (Tables 1 and 2). The count obtained in 1979 should be considered the first reliable estimate of adult sockeye escapement into Tanada Creek (K. Roberson, personal communication, 2005).

In 1997 and 1998, the NPS installed a rigid picket weir located 920 m upstream from the Copper River and approximately 160 m downstream from the Batzulnetas village site (Figure 1). Methods and results are fully described by Raeder and others (1998). One point worth noting is that in 1997, the weir was left open and not staffed during weekends. The number of salmon which may have passed during weekends was estimated by interpolating the counts from the previous Friday and following Monday. Therefore, the actual count of salmon in 1997 during periods of operation Monday – Friday was 20,729, while the reported cumulative total of 27,521 sockeye salmon includes estimates derived by interpolating weekday values for six days. In 1997, high flows compromised the weir on July 19 and prevented additional enumeration of sockeye salmon after this point.

We consider the 1979 and the 1998 counts to be the only reliable estimates of total sockeye salmon escapement prior to 2000. The 1975, 1978, and 1997 weir counts were all compromised by flood events, were substantially less than the actual escapements, and are not useful for analysis. The 1997 weir data were further compromised by no enumeration two out of seven days each week (Table 1).

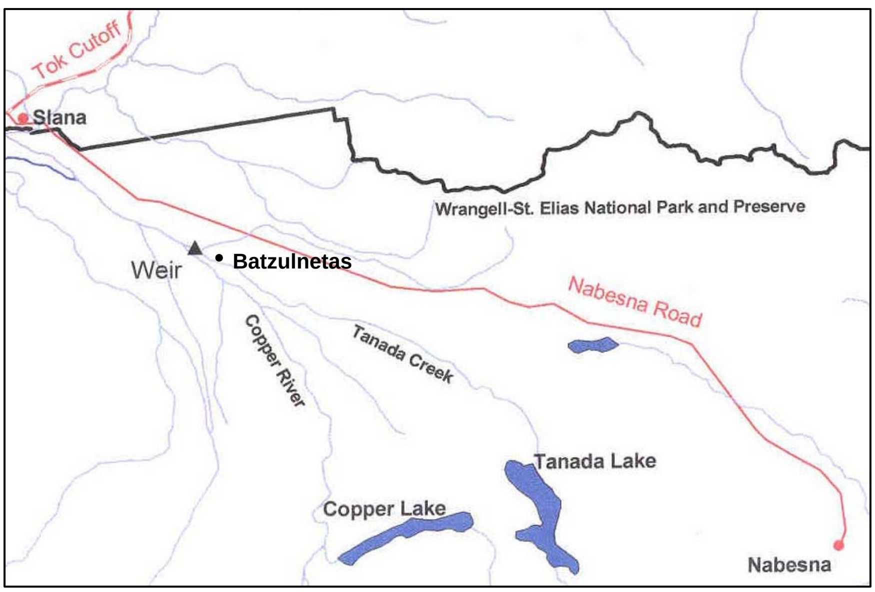


Figure 1. Tanada Lake, Tanada Creek and Tanada Creek weir.

Date	1975	1978	1979	1997	1998	Date	1975	1978	1979	1997	1998
23-Jun	-	0	-	1,134	0	23-Jul	0	0	284		460
24-Jun	-	0	-	686	0	24-Jul	0	0	199		291
25-Jun	-	0	7	730	0	25-Jul	0	0	118		895
26-Jun	-	0	104	1,692	0	26-Jul	0	0	86		190
27-Jun	-	0	452	1,640	0	27-Jul	-	0	374		887
28-Jun	2	0	8	*1,666	0	28-Jul	-	1,300	55		427
29-Jun	0	0	68	*769	0	29-Jul	-	0	337		1,019
30-Jun	0	0	24	694	0	30-Jul	-	0	295		1,262
1-Jul	0	0	16	844	0	31-Jul	-	21	22		1,008
2-Jul	0	0	130	1,615	0	1-Aug	-	41	155		703
3-Jul	1	0	558	1,099	0	2-Aug	-	1	509		21
4-Jul	0	0	40	1,585	0	3-Aug	-	6	147		1,058
5-Jul	2	0	15	*1,342	0	4-Aug	-	2	269		429
6-Jul	0	0	55	*1,582	0	5-Aug	-	0	138		597
7-Jul	77	0	404	2,145	0	6-Aug	-	8	110		409
8-Jul	37	306	201	1,018	0	7-Aug	-	16	27		578
9-Jul	8	377	310	638	0	8-Aug	-	0	99		1
10-Jul	0	1	575	572	0	9-Aug	-	1	183		260
11-Jul	0	116	424	300	0	10-Aug	-	0	211		392
12-Jul	1	0	52	*436	0	11-Aug	-	0	209		448
13-Jul	0	3	881	*997	6,831	12-Aug	-	0	312		276
14-Jul	0	0	1	852	1,095	13-Aug	-	3	38		397
15-Jul	0	0	0	1,142	1,246	14-Aug	-	60	4		93
16-Jul	0	1	126	1,054	702	15-Aug	-	-	17		3
17-Jul	0	0	63	801	**2,188	16-Aug	-	-	144		161
18-Jul	0	0	53	488	507	17-Aug	-	-	1		2
19-Jul	0	0	189		1,956	18-Aug	-	-	229		0
20-Jul	0	0	232		1,138	19-Aug	-	-	35		2
21-Jul	0	0	74		616	20-Aug	-	-	0		1
22-Jul	0	0	574		443	21-Aug	-	-	1		0
						Total	128	2,263	10,244	27,521	28,992

*In 1997 the weekend counts were estimated by interpolating the preceding Friday and following Monday numbers.
**Value includes an estimated 1,030 salmon passed due to a breach in the weir

Table 1. Daily sockeye counts, 1975, 1978, 1979, 1997 and 1998.

Aerial Survey Estimates of Escapement

ADFG conducted aerial surveys of Tanada Creek from 1962-1992, 1994-1995, and 1999-2003. Estimates since 1977 include spawning fish at the outlet of Tanada Lake and are not comparable to prior years, which do not include spawning fish at the outlet of Tanada Lake. In 1997 and 1998 aerial surveys were performed by the National Park Service. The 1997 survey was conducted by helicopter while the 1998 survey was conducted by fixed-wing aircraft. A detailed review of aerial survey data found in on-file records was performed; this report presents this updated data which contains some differences from previously reported data (Details of on-file historic aerial survey data are included in Appendix A.) A comparison of weir and aerial survey data for Tanada Creek indicates there is no correlation between the methods of estimation (Nelson, 1999).

Batzulnetas Subsistence Fishery

A brief summary of the Batzulnetas Fishery will be useful to assist in interpreting the salmon harvest permit data. An excellent history of the Batzulnetas subsistence fishery is contained in Morstad, *et al*., 1999. That history is summarized as:

1985 Katie John filed civil suit in U.S. Court (A85-698 Civil). The suit requested that the residents of Dot Lake and Mentasta be allowed to subsistence fish with fish wheels, dip nets, and spears in the closed waters of the Copper River and Tanada Creek. These are traditional fishing waters of the old Batzulnetas village site.

1986 No action taken.

1987 An interim subsistence fishery at Batzulnetas was provided by ADFG by Emergency Regulation (ER) to achieve settlement in the U.S. District Court. The ER established fishery boundaries near the mouth of Tanada Creek and within Tanada Creek near the historic village site of Batzulnetas. Fish wheels were legal gear in the Copper River; spears in Tanada Creek. The quota was 1,000 sockeye salmon with open fishing periods of two days per week in June and 3.5 days per week in July and August. Eight permits were issued that year to residents of Mentasta and Dot Lake. The fishery occurred in July and August. A harvest of 22 sockeye salmon was reported.

1988 The fishery was reviewed prior to the season by the Board of Fisheries (BOF). BOF established seasons and eliminated the 1,000 fish quota. BOF allowed a harvest of 30 salmon for a household with one individual, 60 salmon for a household of two, and 10 additional salmon for each additional household member. Upon request, additional fish would be permitted. An emergency order (EO) opened the same waters as in 1987 for 48-hour per week fishing from June 17 through June 30 and for 84-hour per week fishing for the months of July and August. No permits were issued for the fishery and no harvest was reported.

1989 A civil suit was filed by John, Doris Charles, and the Mentasta Village Council seeking an injunction against the State and that continuous fishing be allowed in the open waters area adjacent to Batzulnetas. The U.S. District Court of Alaska ruled in favor of John, ordered a continuous fishery, and imposed a quota of 1,000 sockeye salmon. The court did not require a permit or reporting requirement. The fishery opened from 8:00 a.m. Friday, June 23 until 12:00 midnight September 1.

1990 Another injunction was filed against the State to allow the use of gillnets along with continuous fishing. The U.S. District court ruled for continuous fishing through September 1 or until the 1,000 sockeye quota obtained. The Court ruled against the use of gillnets. No permits issued and no harvest was reported.

1991 No permits issued and no harvest reported.

1992 No permits issued and no harvest reported.

1993 One permit issued; reported harvest of 160 sockeye salmon.

1994 John *et al* filed an injunction on June 3 in the U.S. District Court seeking the allowance of continuous fishing in Batzulnetas area from June 25 through September. The Court denied the request for injunction. The subsistence fishery opened for 48-hours per week in June and for 84-hours per week from July 1 to September 1. Four permits were issued and 997 sockeye salmon were reported harvested.

1995 Four permits were issued; two permits were fished, reporting a harvest of 16 sockeye salmon.

1996 No permits issued and no harvest reported.

1997 Three permits issued. One household reported fishing and harvesting 176 sockeye salmon.

1998 One permit issued. A harvest of 386 sockeye salmon reported.

1999 One permit issued. A harvest of 52 salmon reported.

2000 Injunctions were issued by the U.S. District Court enjoining both the State and Federal governments from enforcing fishing regulations specific to the Batzulnetas Fishery. However, no permits were requested and no harvest was reported.

2001 First Federal subsistence fishery was implemented for the Batzulnetas Fishery. There was no harvest limit for salmon. One permit was issued and 62 salmon were harvested.

2002-2003 No changes in regulation. Permits issued and harvest is displayed in Tables 12 and 13.

This history is relevant to the data analysis in that the investigators considered the following points:

1.) In 1989, the harvest is unknown, therefore no correlation should be made between estimates of escapement in 1989.

2.) Some level of harvest was reported in all years that a permit was obtained. Therefore, years in which no harvest is reported are not relevant to the data analysis because there was no attempt to harvest salmon.

3.) The 1994 harvest of 997 salmon may not represent the maximum possible harvest for that year because the limit was 1,000 salmon and the subsistence fishers may have stopped fishing to avoid the potential for illegal over harvest.

ESCAPEMENT ASSESSMENT 2000-2003

METHODS

Study Area

Watershed Description

Tanada Creek is a third order perennial stream and a tributary to the upper Copper River in southeast interior Alaska (Figure 1). The stream flows through the Copper River Plateau and encompasses a watershed area of approximately 550 km^2. Originating at Tanada Lake (62°27'N, 143°23'W), Tanada Creek runs 30 km northwest to its confluence with the Copper River (62°37'N, 143°48'W). The terrain is nearly level to gently rolling throughout the creek basin and the stream gradient is less than 2%. The vegetation is dominated by mosses, sedges, dwarf birch and willows. Black and white spruce are the primary evergreens, with stands of cottonwoods interspersed. The soils are poorly drained and are underlain by shallow permafrost (USDA 1979). Annual precipitation in the area averages 39 cm and ambient temperature ranges from a high of 32° C to a low of - 46° C. Average annual temperature is - 2.5° C (NOAA 1995). Breakup normally occurs in May, and water bodies freeze in September or October.

Weir Site Description

The weir site was located 920 m upstream from the Copper River and approximately 160 m downstream from the Batzulnetas village site (Figure 1). Stream width is about 9 m. The vertical banks are approximately 0.7 to 1.0 m high and bank undercutting ranges between 0 to .5 m. Maximum water depth at midstream during bank-full conditions is estimated at 1.2 m. Channel substrate is predominately cobble, with interstitial sand and gravel. The stream banks are stabilized by spruce, willow, alder and an understory of moss and horsetail ferns. Spruce and cottonwoods contribute to stream shading.

A permanent cross section was established on June 9, 1998 about 10 m upstream of the weir. Four brass cap reference markers were set along the transect. A staff-gage was placed in the stream near the north bank intersecting the cross section.

Weir Installation and Operation

In 2000, a rigid picket weir was installed as described by Raeder et. al (1998). Figure 2 displays a photo of the rigid picket weir used in 2000. In 2001 through 2003 a floating resistance board weir was installed as described by Tobin (1994) (Figure 3). The weir with picket spacing of 3.75

cm was placed at the end of a straight 120 m section of stream with moderate water velocity and laminar flow. When resistance boards were in the "up" position the downstream end of the weir lay flat on the water surface. When resistance boards were in the "down position", the downstream end of the weir was raised approximately 75 cm above the surface of the water (Figure 4). In 2002, the hooks attaching the weir panels to the cable were installed upside down. This unfortunate oversight was not discovered until after the run ended. This resulted in a gap between the substrate rail and the angle iron forming the base of the weir panels larger than 3.75 cm. While the cause of the gap was not determined during the run, the gap was observed and we attempted to correct this by covering the gap with sand bags. The improper attachment of the panel hooks to the substrate rail that occurred in 2002 was corrected in 2003. A sampling box, 1 m x 3 m, was constructed of 2x4 lumber, aluminum channel and cyclone fencing. Gates that could be raised and lowered were installed at either end to allow for holding, sampling, and releasing fish. The box was placed on the north bank side of the weir. Dates that the weir was operational are displayed by year in Table 2. A staff gauge and water temperature reading was taken at the beginning of each shift. Gates on the box were closed when the weir was not monitored. The number of salmon counted was recorded hourly.

Figure 2. Rigid picket weir in Tanada Creek in June 2000.

One *HOBO® TEMP* data logger was placed in a submersible case at the base of the staff gauge to collect water temperature data throughout the summer. The data logger recorded temperatures every 15 minutes. Two depth readings were recorded daily; an average was calculated when different depths were recorded in a 24-hour period.

Figure 3. Floating resistance board weir in Tanada Creek 2001-2003.

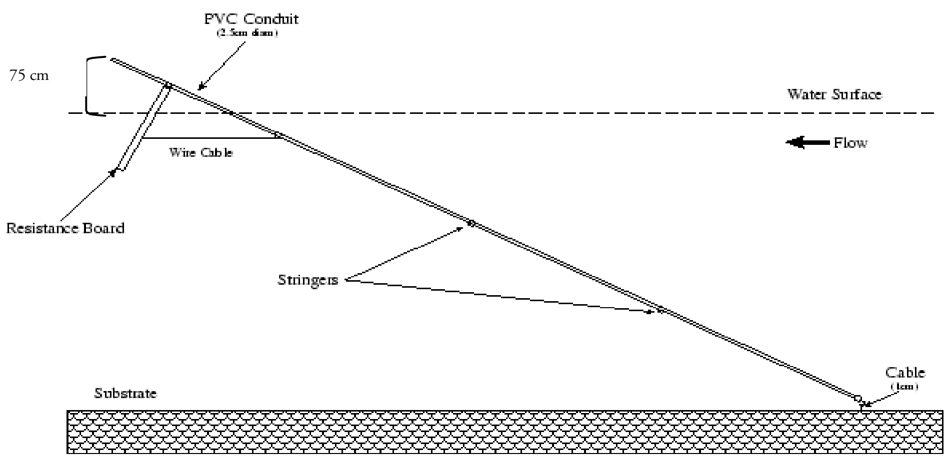


Figure 4. Placement of resistance boards in "down" position

Year	Start date	End date	Days operational
2000	June 8	July 13	2
2001	June 5	August 23	60
2002	June 27	August 15	49
2003	May 31	September 19	112

Table 2. Dates of weir operation.

Biological Data

Approximately 10 percent of the sockeye salmon were sampled to estimate the age, sex, and length composition of the escapement. Sampling was designed to be proportionate to their abundance with a minimum of 100 fish per week and a maximum of 100 fish per day. Ages were measured from scales and sex determined from external characteristics. Two measurements were taken on each fish, from mid-eye to fork length (MEF) and mid-eye to posterior insertion of anal fin (anal) length. Lengths were recorded to the nearest millimeter. A tagging cradle was used to facilitate handling. Scales were collected from the preferred area, located on the left side of the fish and two rows above the lateral line on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, according to Alaska Department of Fish and Game sampling protocol. One scale was taken from each sockeye salmon in accordance with this protocol. One scale is typically sampled from sockeye salmon while multiple scales would typically be sampled from Chinook salmon (Steve Moffitt, personal communication). Sampled fish were marked with a round left opercle punch. Scale samples were analyzed by the ADFG Commercial Fisheries Division in Cordova. Ages were adjusted for resorbed margins based on length frequency aggregations. The weir was checked regularly for gaps and fish leakage both above the water level and underwater by technicians using dry suits, face masks and snorkels.

In 2002, the investigators observed fish leakage through the weir and conducted a mark and recapture project to estimate the total population that migrated through Tanada Creek (Veach, 2002). A mark and recapture estimate was not performed in 2003. The investigators did not feel that an additional estimate was necessary because no fish leakage was observed. The weir was constructed very tightly in 2003. The gap that occurred underneath it in 2002 was eliminated by installing the floating resistance boards properly. Water flow was low in 2003 and water did not flow over the top of the panels. The integrity of the weir was inspected periodically by using a snorkel, mask and dry suit to check for gaps along the base of the weir. Daily monitoring of the weir took place and no fish leakage was observed around, under or over the weir in 2003 by the technicians working at the weir site.

Video Escapement Operation

The effectiveness of a video escapement recorder system was tested in 2001, 2002 and 2003. In 2003, the video escapement recorder was installed on June 8. To alleviate the problem of salmon milling and moving back and forth under the cameras, as we encountered in 2002, the location of the video towers was changed in 2003 to 10 m upstream from the weir.

A 1.5 inch in diameter pipe 15 m long was affixed horizontally between two spruce trees on either side of the creek. A 3 mm cable was attached to the trees above the pipe and was looped through guides along the pipe to provide extra support. Two remote cameras, sealed in waterproof housings were suspended from the pipe above the water surface approximately 5.5 m (Figure 5). The cameras were equipped with a 3.5 mm ultra-wide angle lens to allow for field of view up to five meters. Four red lights were suspended with the cameras and aimed at the water surface. The lights were evenly spaced across the wetted width of the channel. A waterproof case containing a time-lapse frame recording system and multiplexer unit was housed on the north bank of the creek. Two to six 12-volt deep cycle batteries provided power to the system. An immersible water turbine served to provide power to the system and keep the batteries charged. A high contrast, permeable substrate panel was fixed to the streambed below the overhead cameras (Oatis and Dickson 2001). A row of pickets 2 m long was placed in the streambed perpendicular to the panel. The pickets, which bisected the creek at approximately 4.8 m from each bank, served two purposes; (1) to delineate the midstream field of view of the two cameras, providing a defined edge for the mid stream frame of the video; (2) to prevent salmon from moving between one camera view and the other while swimming upstream. To eliminate glare from the water surface, a net was placed over the creek above the cameras in late July. Another pair of red lights was installed in August to improve night filming.

The time-lapse recorder was programmed to capture one image every .15 seconds allowing for up to 64 hours of video to be collected on a single T-160 tape when recorded in extended play (EP) mode. Tapes were changed every 48 hours. The recorder was later reprogrammed to record in standard play (SP) mode, allowing for 48 hours of viewing on each T-160 tape. Regular VHS tapes were changed to S-VHS tapes after the crew had trouble viewing the recordings.

Figure 5. Video counting tower at Tanada Creek.

Limnological Data

Limnological data was collected in Tanada Lake five times throughout the summer of 2003. The intervals between sampling dates were at least two weeks apart: sampling dates were June 26, July 18, August 19, September 8, and September 22. Sampling took place either from the floats of the plane or from a small motor craft. The two deepest areas of the lake were sampled both at the surface and at depth (Figure 6). On-site parameters were measured for temperature, pH and dissolved oxygen (DO). DO and temperature were measured at 1 m intervals from the surface to the bottom using a Hydrolab meter. The pH was measured at the surface and at the bottom. A Secchi disk was used to measure the depth of light penetration. Water samples were collected at each site (surface and depth approximately .5m above bottom) and sent to Northern Testing Laboratory (NTL) to be measured for Total Nitrites/Nitrates, Total Kjeldahl Nitrogen, Total Phosphate, and Chlorophyll a. NTL uses a quantitative detection method; their Method Reporting Limits (MRL) are the lowest minimum concentrations at which a method or instrument will measure a relatively low value with low uncertainty in accuracy. The MRL for Kjeldahl Nitrogen was 1.0 mg/L; for Total Phosphate was 0.025 mg/L; and for Total Nitrites/Nitrates was 0.10 mg/L.

Zooplankton samples were collected at two stations using a 0.5 m diameter, 153 um mesh, 1:3 conical net. Vertical zooplankton tows were pulled from a maximum depth of 50 m, or 2 m from the bottom of the lake if shallower than 50 m, at a constant speed of 0.5 m sec^{-1}. The net was rinsed prior to removing the organisms, and all specimens were preserved in neutralized 10% formalin (Koenings et al. 1987). Zooplankton samples were analyzed at the ADF&G Commercial Fisheries Limnology Laboratory in Soldotna, Alaska, where identification to genus or species, enumeration, and density and biomass estimates were performed. Zooplankton density (individuals per m^2 surface area) and biomass (weight per m^2 surface area) were estimated by species and by the sum of all species (referred to as total zooplankton density or biomass).

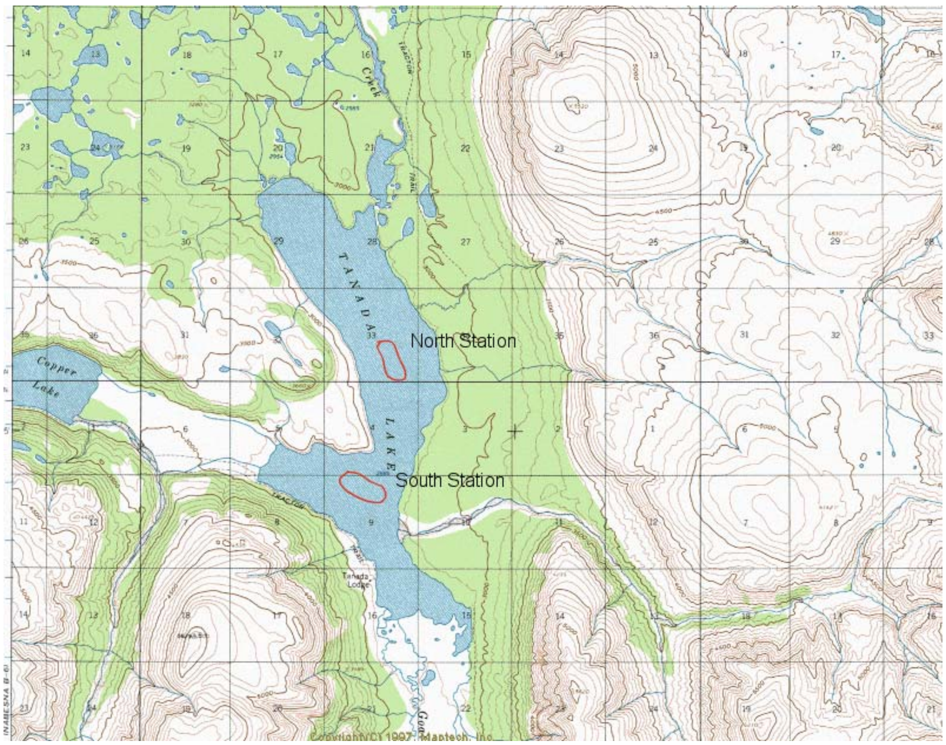


Figure 6. Location of North and South sampling stations, Tanada Lake

RESULTS

Weir Operation

The weir was operated during the dates displayed in Table 2. The rigid picket weir could not be successfully operated at the high flows encountered in 2000. The floating resistance board weir was successfully operated during 2001 through 2003. In 2002, the incorrect installation of the panels resulted in fish leakage and approximately 50 percent of the run was not enumerated through the weir. However, by utilizing a mark and recapture project at the lake the entire run abundance was estimated (Veach, 2002). In 2003, staff gauge readings ranged from .95 feet to

2.10 feet, with a mean depth of 1.26 feet. Flows at these staff heights range from approximately 60 to 90 cubic feet per second (cfs) averaging around 70 cfs. In 2003, flow was consistently low in the early part of the summer and from June 29 until the weir was removed on September 19. Staff gauge readings for 2000-2003 are displayed in Figure 7. The low flows in 2003 were in contrast to the high flows experienced from 2000 through 2002. Flows in 2003 were on average the lowest flows experienced since 1998. When the *HOBO® TEMP* data logger was accessed for the information recorded in 2003, the data logger had mechanical difficulties and would not connect with the computer. In 2001, high flows broke the clip holding the data logger and it was lost. No temperature data is available for 2001 or 2003. Temperature data for 2002 is displayed in Figure 8.

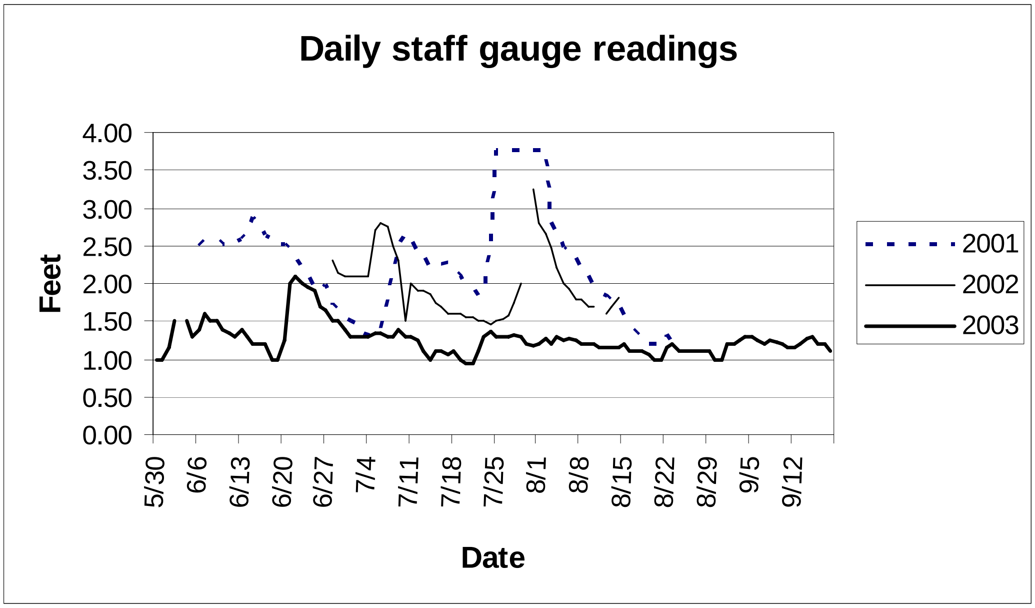


Figure 7. Staff gauge readings at the weir, 2001-2003.

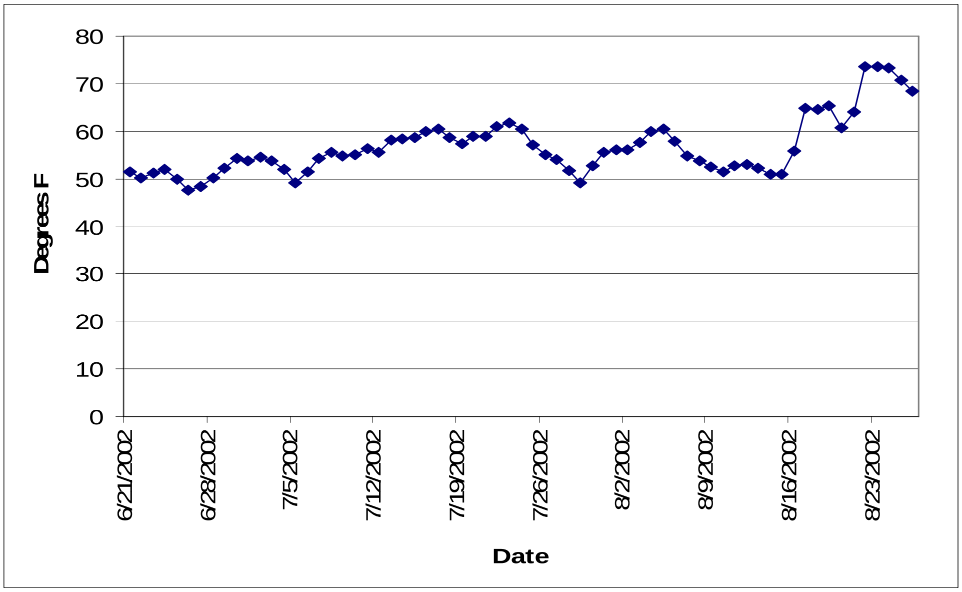


Figure 8. Daily water temperature in Tanada Creek at the weir in 2002.

Biological Data

Total sockeye salmon, *O. nerka,* observed at the weir are displayed in Table 3, daily salmon counts are provided in Appendix B. In 2003, between May 31 and September 19 the number of sockeye salmon observed totaled 5,856 (Table 3). Two Chinook salmon, *Oncorhynchus tshawytscha*, were enumerated on July 10, 2003. A total of 920 sockeye were sampled for length and sex information in 2003. Length and sex information is displayed in Table 4. The age composition of the population did not substantially change during the run in 2003 (Table 5). The majority of the population sampled in 2001-2003 was composed of age 1.3 fish (Table 6).

Year	Weir	Aerial	***Year***	Weir	Aerial	***Year***	Weir	Aerial
1962	—	1,500[1]	***1976***	—	2,200	***1990***	—	3,000
1963	—	1,060[1]	***1977***	—	9,100	***1991***	—	3,050
1964	—	1,500[1]	***1978***	2,265 [4]	2,525	***1992***	—	3,450
1965	—	3,300[1]	***1979***	10,244	5,225	***1993***	—	—
1966	—	10[1]	***1980***	—	13,700	***1994***	—	6,270[1]
1967	—	26[1]	***1981***	—	11,200	***1995***	—	3,100[1]
1968	—	175[1]	***1982***	—	11,680	***1996***	—	—
1969	—	6[1]	***1983***	—	10,900	***1997***	20,729 [4]	7,875
1970	—	1,000[1]	***1984***	—	16,100	***1998***	28,992	4,470
1971	—	4,093	***1985***	—	11,700	***1999***	----	350[1]
1972	—	930	***1986***	—	8,260	***2000***	—	4,720
1973	—	10[1]	***1987***	—	8,350	***2001***	1,649	400[3]
1974	—	3,100	***1988***	—	3,750	***2002***	6,186[2]	1,950
1975	128 [4]	700[1]	***1989***	—	3,175	***2003***	5,856	—

Table 3. Weir counts and peak aerial estimates of sockeye salmon in Tanada Creek and Tanada Lake.

[1]Non-Comparable estimate; may exclude estimate of lake outlet area.
[2]Estimate based upon mark-recapture sampling; actual weir estimate 2,489.
[3]Survey conditions were rated "Poor".
4Weir compromised by flood, unreliably low estimate.

June 5 - August 19 2001										
		Age Class								
Sex		0.2	0.3	1.1	1.2	1.3	1.4	2.1	2.2	2.3
F	Mean Length (mm)	540	580	0	521.1	589.3	0	0	0	0
	SE	0	4.88	0	5.64	2.54	0	0	0	0
	Sample Size	1	7	0	9	97	0	0	0	0
M	Mean Length (mm)	570	650	0	553.2	617.3	0	0	0	0
	SE	0	0	0	3.66	2.12	0	0	0	0
	Sample Size	1	1	0	17	98	0	0	0	0
Total	Mean Length (mm)	555	615	0	537	603	0	0	0	0
	SE	15	10	0	4	2				
	Sample Size	2	4	0	26	195	0	0	0	0

2001

June 5 - August 19 2001										
		Age Class								
Sex		0.2	0.3	1.1	1.2	1.3	1.4	2.1	2.2	2.3
F	Mean Length (mm)	540	580	0	521	589	0	0	0	0
	SE		5		6	3				
	Sample Size	1	7	0	9	97	0	0	0	0
M	Mean Length (mm)	570	650	0	553	617	0	0	0	0
	SE				3.646	2				
	Sample Size	1	1	0	17	98	0	0	0	0
Total	Mean Length (mm)	555	615	0	537	603	0	0	0	0
	SE	15	10		4.30	2				
	Sample Size	2	4	0	26	195	0	0	0	0

2002

May 30 - September 18, 2003										
		Age Class								
Sex		0.2	0.3	1.1	1.2	1.3	1.4	2.1	2.2	2.3
F	Mean Length (mm)	520	576	0	504	575	530	0	0	0
	SE	0	12		3	2				
	Sample Size	1	3	0	85	235	1	0	0	0
M	Mean Length (mm)	560	590	0	542	607	0	0	0	640
	SE		7.07		2	2				
	Sample Size	1	8	0	62	345	0	0	0	1
Total	Mean Length (mm)	540	586	0	520	594	530	0	0	640
	SE	20	6		2	1				
	Sample Size	2	11	0	147	580	1	0	0	1

2003

Table 4. Average lengths of sampled sockeye salmon.

Stratum Dates: May 30 - August 5, 2003												
		Age Class									Total Fish Counted	N
Sex		0.2	0.3	1.1	1.2	1.3	1.4	2.1	2.2	2.3		
F	Percent	0.0	1.2	0.0	22.8	75.7	0.4	0.0	0.0	2.1		259
	Number	0	13	0	261	866	4	0	0	13	1,144	
	SE	0.0	8.0		30.0	31.0	4.0			8.0		
M	Percent	0.3	1.2	0.0	14.2	84.3	0.0	0.0	0.0	0.0		331
	Number	4	18	0	208	1,233	0	0	0	0	1,463	
	SE	4.0	9.0		28.0	29.0						
Total	Percent	0.2	1.2	0.0	18.0	80.5	0.2	0.0	0.0	0.0		590
	Number	4	31		468	2,099	4	0	0	0	2,607	
	SE	4.0	12.0		41.0	43.0	4.0					

Stratum Dates: August 6 - September 18, 2003												
		Age Class									Total Fish Counted	N
Sex		0.2	0.3	1.1	1.2	1.3	1.4	2.1	2.2	2.3		
F	Percent	1.5	0.0	0.0	39.4	59.1	0.0	0.0	0.0	0.0		66
	Number	21	0	0	556	834	0	0	0	0	1,411	
	SE	21.0		0.0	85.0	85.0						
M	Percent	0.0	4.7	0.0	17.4	76.7	0.0	0.0	0.0	1.2		86
	Number	0	86	0	321	1,411	0	0	0	21	1,838	
	SE		42.0		75.0	84.0				21.0		
Total	Percent	0.7	2.6	0.0	27.0	69.1	0.0	0.00	0.0	0.7		152
	Number	21	86	0	876	2,244	0	0	0	21	3,249	
	SE	21.0	42.0		117.0	122.0				21.0		

Table 5. Proportion of age of sampled fish by period in 2003.

Stratum Dates: June 5 - August 19. 2001												
Sex		Age Class									Total Fish Counted	N
		0.2	0.3	1.1	1.2	1.3	1.4	2.1	2.2	2.3		
F	Percent	0.9	6.1	0.0	7.9	85.10	0.0	0.0	0.0	0.0		114
	Number	7	49	0	63	679	0	0	0	0	798	
	SE	7.0	18.0		20.0	27.0						
M	Percent	0.9	0.9	0.0	14.5	83.8	0.0	0.0	0.0	0.0		117
	Number	7	7	0	119	686	0	0	0	0	819	
	SE	7.0	7.0		27.0	28.0						
Total	Percent	0.9	3.5	0.0	11.3	84.4	0.0	0.0	0.0	0.0		231
	Number	14	56	0	182	1,365	0	0	0	0	1,617	
	SE	10.0	19.0		34.0	39.0						

2001

Stratum Dates: June 28 - August 15, 2002												
Sex		Age Class									Total Fish Counted	N
		0.2	0.3	1.1	1.2	1.3	1.4	2.1	2.2	2.3		
F	Percent	0.0	0.7	0.0	10.6	86.6	0.0	0.0	0.0	2.1		142
	Number	0	4	0	67	553	0	0	0	13	638	
	SE		4.0		16.0	18.0				8.0		
M	Percent	0.2	0.0	0.0	4.0	68.1	0.2	0.0	0.2	1.8		412
	Number	4	0	0	99	1,694	4	0	4	45	1,851	
	SE	4.0			18.0	43.0	4.0		4.0	12.0		
Total	Percent	0.2	0.2	0.0	6.7	90.3	0.2	0.0	0.2	2.3		554
	Number	4	4	0	166	2,246	4	0	4	58	2,489	
	SE	4.0	4.0		26.0	31.0	4.0		4.0	16.0		

2002

Stratum Dates: May 30 - September 18, 2003												
Sex		Age Class									Total Fish Counted	N
		0.2	0.3	1.1	1.2	1.3	1.4	2.1	2.2	2.3		
F	Percent	1.5	0.0	0.0	39.4	59.1	0.0	0.0	0.0	0.0		66
	Number	21	0	0	556	834	0	0	0	0	1,411	
	SE	21.0		0.0	85.0	85.0						
M	Percent	0.0	4.7	0.0	17.4	76.7	0.0	0.0	0.0	1.2		86
	Number	0	86	0	321	1,411	0	0	0	21	1,838	
	SE		42.0		75.0	84.0				21.0		
Total	Percent	0.7	2.6	0.0	27.0	69.1	0.0	0.0	0.0	0.7		152
	Number	21	86	0	876	2,244	0	0	0	21	3,249	
	SE	21.0	42.0		117.0	122.0				21.0		

2003

Table 6. Proportion of age in sample by sex for entire population, 2001-2003.

Run Timing

In 2003, the first sockeye salmon was observed at the weir June 10. Only one fish was observed on this date and there were no additional fish passing through the weir until June 19 when two more were enumerated (Figure 9). The run started the following day when 23 sockeye were counted through the weir (Appendix B) which fits well with observations in prior years.

Migratory time-density functions (Mundy 1982) were computed for each year's weir counts. The median point in the run occurred August 6 when the cumulative total of sockeye salmon reached 2,929 (Figure 9). The last sockeye was counted through the weir on September 16. Approximately 300 salmon were observed still downstream of the weir when it was removed from the creek on September 19. The 2003 run appears to have been longer than runs documented in previous years, with the median date of the run occurring approximately 1 month later than in 1997 and approximately three weeks later than in 2001 and 2002.

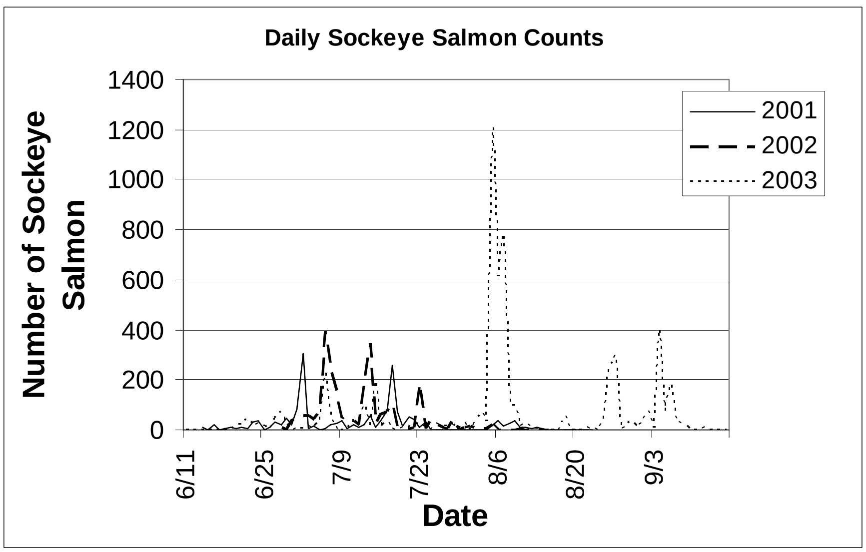


Figure 9. Cumulative and daily counts of sockeye salmon observations at the weir.

Aerial Observations

ADFG flew an aerial survey of Tanada Lake and Tanada Creek on August 5, 2003. No salmon were observed. At this point 1,398 salmon had been counted through the weir. A second survey was scheduled on September 4 but was cancelled because of bad weather. Peak aerial observations are displayed in Table 3.

Capacity Building

The Batzulnetas culture camp took place from July 21 through July 25 this year. The weir was operational throughout the entirety of this event. The weir crew assisted in transporting people, water, and food from the Nabesna Road to the camp. Throughout the week, when the crew was present, the weir was open to visitation. On July 23 the fisheries program provided staff for short workshops on fisheries related activities for children attending the culture camp. Approximately 15 young people, ranging in age from four to 15, participated and shared in the experience.

Video Escapement Estimation

In 2001, we were only able to briefly test the video tower, but we were able to observe Arctic grayling moving underneath the video tower. In 2002, we observed many sockeye salmon in the video tower recordings. However, the video tower was installed downstream of the weir which resulted in a substantial amount of milling beneath the cameras. The milling beneath the cameras made it impossible to obtain an accurate estimate of the run size with the video tower. In 2003, the video tower was installed upstream of the weir and the problem of milling was eliminated.

In 2003, the video tower was erected and functioning while the weir was in operation. The new upstream site selected for the video recording equipment provides full coverage of the creek (Figure 5). Forty-five tapes recorded the creek from June 8 until the equipment was removed on September 26. Tape 1 did not record, but a clear picture of the stream was visible on the remainder of the tapes. A contrasting panel consisting of white pvc pipes was installed on the substrate on July 16, increasing the visibility of the fish as they swam under the cameras. A glare problem was improved slightly by placing a length of netting over the cameras across the creek but a more opaque canopy would be better. Prior to the installation of two additional red lights on August 27, visibility was poor during the period of the night when no sunlight was present. The new lights improved night filming although two additional lights will be added in 2004 to increase visibility further during total darkness. The weir was operational in conjunction with the video cameras for 92 days, from June 19 through September 18. Twenty four of the 45 days had time gaps in the filming ranging from 25 minutes to 9 hours and 57 minutes. These gaps were caused by breaks in the electrical current caused by a faulty gas generator, incorrect placement of the water generator, and an insufficient number of battery storage. By early August 2003 a new gas generator was installed, the water generator location was corrected, and two more batteries were added to the storage bank. There was a strong relationship between daily passage measured at the weir and subsequently at the video station (Figure 10, R^2=0.9248.

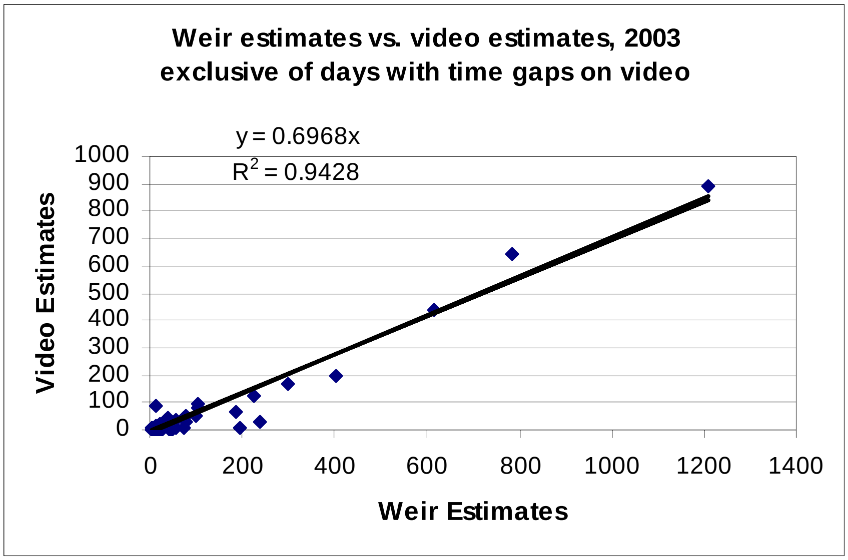
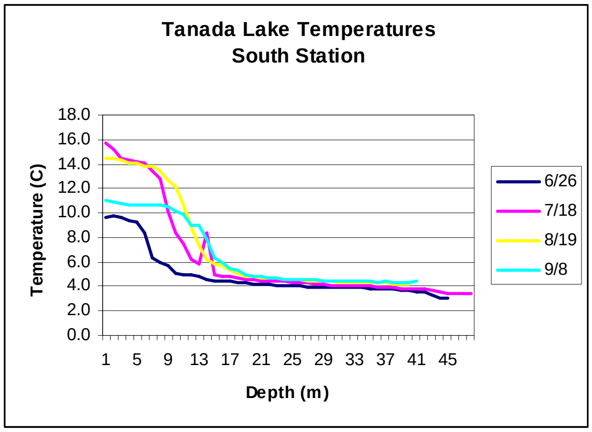


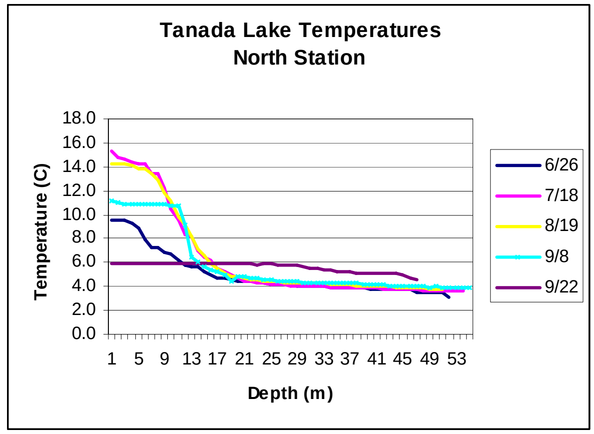
Figure 10. Relationship between daily weir fish counts and video estimates excluding days with time gaps on the videos, 2003.

Limnological Data

Limnological data was only collected in 2003. Surface temperature varied from 5.92° C on September 22 to 15.68° on July 18. Temperatures at depth (approximately 50 m) varied from 3.0° C on June 26 to 4.57° C on September 22 (Figure 11). Dissolved oxygen at the surface was highest (13.1 mg/L) on June 26 and lowest (9.87 mg/L) on July 18. At depth, dissolved oxygen measurements varied from 5.67 mg/L (50 m) on August 19 to 0.70 mg/L (54 m) on September 8 (Figure 12). The average of the DO profile was lower at the North station (Table 7). The average of the temperature profile was higher at the North station (Table 8). Total Kjeldahl nitrogen and total phosphate were higher at depth than at the surface. Some of the lab results for nutrients were low, coming in below the Method Reporting Levels for nitrogen, phosphate and nitrite/nitrate (Table 9).

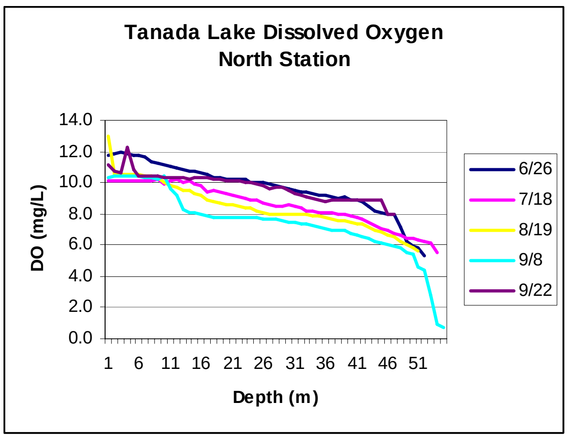
Zooplankton tows were done on only 3 of the 5 sampling days at the South station because of gear and weather problems. Zooplankton tows showed the presence of 5 taxa of macrozooplankton: Diaptomus, Cyclops, Bosmina, Daphnia, and Copepod. All of the tows included ovigerous (egg-carrying) zooplankton. The seasonal mean density (No/m^2) of all taxa at the North station was 1,640,829 (Table 10). Total mean biomass of all the taxa (dry weight, mg/m^2) for the North station was 4,511. The South station mean biomass of all the taxa (dry weight, mg/m^2) was 2,371 but this was based on only three sampling events and is not believed to be representative of the entire season. A zooplankton bloom is evident in the September 22 tow.

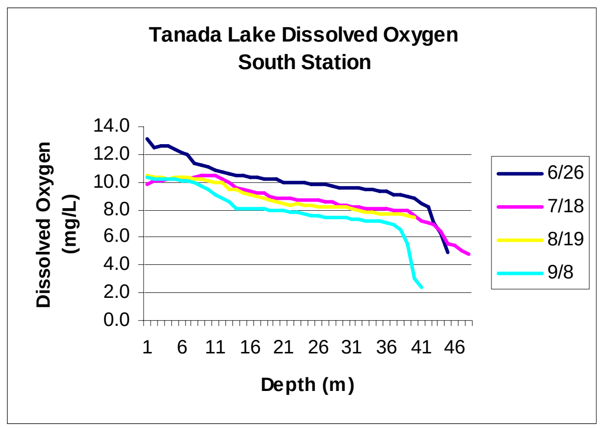




Temperatures at North Station **Temperatures at South Station**

Figure 11. Temperature profiles at North and South stations Tanada Lake, 2003





Dissolved oxygen North Station **Dissolved oxygen South Station**

Figure 12. Dissolved oxygen profiles at North and South stations Tanada Lake, 2003

Date	6/26	7/18	8/19	9/8	9/22
North station DO profile average (mg/L)	5.0	6.24	6.47	5.81	5.61
South station DO profile average (mg/L)	10	8.59	8.98	7.98	*

Table 7. Average dissolved oxygen measurements at North and South stations

Date	6/26	7/18	8/19	9/8	9/22
North station Temperature profile average (°C)	9.7	8.57	8.45	7.42	9.76
South station Temperature profile average (°C)	4.9	6.26	7.25	6.57	*

*No data available

Table 8. Average temperatures at North and South stations.

Location	Total P (mg/L)	Total Kjeldahl N (mg/L)	Total Nitrates/ Nitrites (mg/L)	Chlorophyll a (mg/m^3)
North surface	0.74	1.4	<MRL	2.93
North depth	0.12	2.03	0.18	
South surface	<MRL	1.1	<MRL	2.65
South depth	0.181	3.05	<MRL	

Table 9. Mean totals for the measured lab analysis.

North Station 2003 Macrozooplankton Density (no/m²)						
Date:	26-Jun	18-Jul	19-Aug	8-Sep	22-Sep	Seasonal Mean
Diaptomus	222,537	195,662	136,728	50,919	763,791	273,927
Ovigerous Diaptomus						
Cyclops	722,301	459,689	226,308	480,905	3,314,474	1,040,735
Ovigerous Cyclops	0	33,003	21,216	12,730	174,446	48,279
Bosmina	9,430	47,148	89,580	15,559	28,289	38,001
Ovigerous Bosmina	0	2,357	2,357	1,414	14,144	4,054
Daphnia l.	52,805	106,082	42,433	31,117	193,305	85,148
Ovigerous Daphnia l.	5,658	25,931	0	7,072	33,003	14,333
Daphnia r.	5,658	84,866	49,505	14,144	386,610	108,157
Ovigerous Daphnia r.	1,886	14,144	2,357	0	94,295	22,536
Copepod nauplii	28,289					
Totals	1,048,564	968,882	570,484	613,860	5,002,357	1,640,829

South Station 2003 Macrozooplankton Density (no/m²)						
Date:	26-Jun	18-Jul	19-Aug	8-Sep	22-Sep	Seasonal Mean
Diaptomus	280,057	193,305		128,241		200,534
Ovigerous Diaptomus	1,414	0		0		471
Cyclops	814,710	439,651		675,153		643,171
Ovigerous Cyclops	0	1,179		32,060		11,080
Bosmina	1,414	41,254		22,631		21,766
Ovigerous Bosmina	0	3,536		1,886		1,807
Daphnia l.	11,315	60,113		13,201		28,210
Ovigerous Daphnia l.	1,414	12,966		5,658		6,679
Daphnia r.	2,829	36,539		54,691		31,353
Ovigerous Daphnia r.	1,414	4,715		13,201		6,443
Copepod nauplii	16,973	0		0		5,658
Totals	1,131,540	793,258		946,722		957,173

Table 10. Macrozooplankton density by species, North and South stations.

DISCUSSION

Weir Operation

While a rigid picket weir may be utilized at this site in years when flows are low, it can not be consistently used in years when flows are moderate to high. The floating resistance board design appears to be substantially more functional at moderate to high flows and still functions effectively during years when the flow remains low. The floating resistance board weir was installed correctly in 2003 and performed well. There were no flood waters during the 2003 field season and the weir was operable from May 30 to September 19. We were able to install the weir before the end of May, well before returning salmon have been documented in Tanada Creek in previous years. In 2003, the technicians checked the weir periodically both above the water surface and below using a mask and snorkel and no fish leakage was observed. No gaps greater than 3.75cm were observed between the weir and the substrate. Water flows were low throughout the season which assisted in maintaining the integrity of the weir. Improper installation during 2002 did result in some fish leakage. Minor fish leakage may have occurred during flood flows in 2001 when, although the weir was correctly installed, the downstream ends of some panels were submerged by the extremely high flows.

Biological Data

The adult sockeye salmon population returning to Tanada Creek in 2003, estimated at 5,856, appears to be slightly lower than the population returning in 2002 but remains substantially lower than the populations that returned in 1997 and 1998. However, the escapement is substantially larger than in 2001 (Figure 13). The majority (74%) of the returning adults were 5 year-old fish having spent two years in freshwater and 3 years in marine waters (Table 5). There is no pronounced difference in the proportion of age classes sampled over the last 3 years. All three years show that the 1.3 age class represents the highest number of returning sockeyes, 74% or more. The second highest age class group for all three years was 1.2 age fish (Table 5). Chinook salmon typically return to Tanada Creek in small numbers. In 2003, only two Chinook salmon were enumerated, while in 2001 16 Chinook salmon were enumerated through the weir.

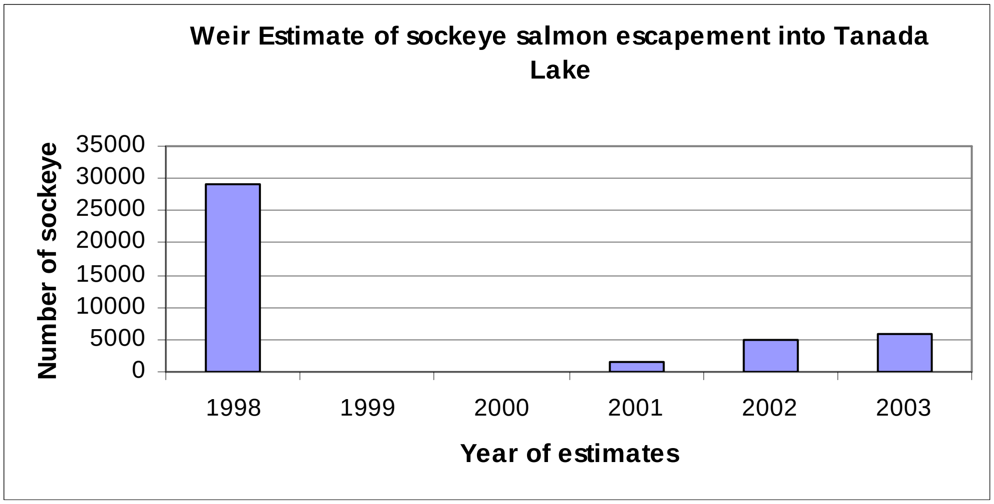


Figure 13. Weir estimated escapement by year, 1998, 2001, 2002, and 2003.

Post-season analysis of commercial harvest and escapement at Miles Lake indicated a good return of sockeye salmon throughout the Copper River Basin (ADFG). Based on the 25-year average of 605,989 sockeye salmon, escapement in 2003 of 695,233 salmon was about 13 % higher than average (Table 11). While the escapement past the Miles Lake sonar does not directly correlate with returns to Tanada Creek, this does indicate that ADFG successfully implemented the Copper River Salmon Management Plan established by the Alaska Board of Fisheries.

Year	Total Salmon	Year	Total Salmon	Year	Total Salmon	Year	Total Salmon
1978	107,011	1985	436,313	1992	601,952	1999	848,921
1979	237,173	1986	507,477	1993	833,387	2000	587,592
1980	276,538	1987	483,478	1994	715,577	2001	833,569
1981	535,263	1988	488,398	1995	599,215	2002	816,825
1982	467,306	1989	607,797	1996	906,867	2003	695,233
1983	545,724	1990	581,859	1997	1,148,079		
1984	536,806	1991	579,435	1998	866,957		

Table 11. Miles Lake Sonar Fish Counts

Sockeye escapement in Tanada Creek has fluctuated substantially during the years the weir has been in operation from a high of 28,992 in 1998 to a low of 1,649 in 2001. During those years the sockeye harvest in the Batzulnetas fishery has varied from a high of 582 in 1998 to a low of 62 in 2001 (there were 7 years of no reported harvest during the years that no permits were issued) (Table 12). During the five years in which both credible estimates of subsistence harvest and escapement were obtained, subsistence harvest appeared strongly correlated with escapement (Figure 14).

Year	Permits Issued	Sockeye Harvest	Year	Permits Issued	Sockeye Harvest
1987	8	22	**1996**	0	0
1988	0	0	**1997**	1	428
1989	0	0	**1998**	3	582
1990	0	0	**1999**	1	55
1991	0	0	**2000**	0	0
1992	0	0	**2001**	1	62
1993	1	160	**2002**	1	208
1994	4	997	**2003**	1	164
1995	4	16			

Table 12. Participation and harvest in the Batzulnetas Area fishery, 1987-2003

Year	# of Permits	Sockeye Harvested	# of Days Fished	CPUE (no. fish caught/day)	Weir Escapement Estimate	% of Weir Estimate Harvested
1993	1	160	no data	no data	no data	no data
1994	8	997	8	124.6	no data	no data
1995	4	16	2	8	no data	no data
1997	10	428	9	47.6	27,521	1.6
1998	15	582	14	41.6	28,992	2.0
1999	1	55	no data	no data	no data	no data
2000	0	0	0	0	no data	no data
2001	26	62	26	2.4	1,660	3.7
2002	19	208	19	10.9	6,186	3.4
2003	29	164	29	5.7	5,856	2.8

Table 13. Harvest and effort in the Batzulnetas Area fishery, 1993-2003.

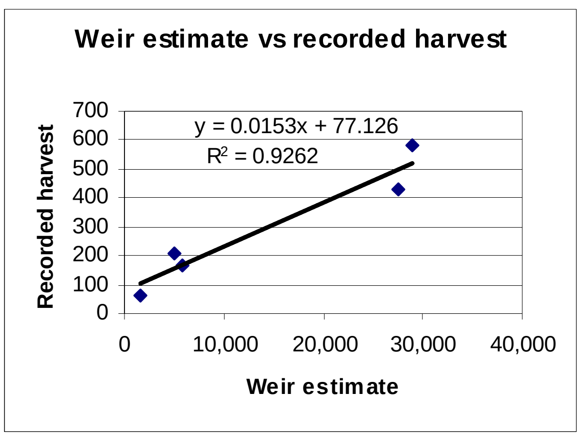


Figure 14. Weir estimate compared with reported harvest.

Run Timing

Run timing of the escapement into Tanada Creek appears highly variable (Figure 15). Consistent migratory timing could be useful in making inseason forecasts of total escapement. The average mean date over four years of weir data occurs on July 17. However, the variability in the mean date of each year's migration is very large and ranges over approximately three weeks. Without an independent prediction of run timing, these data have little utility for inseason forecasts of total escapement.

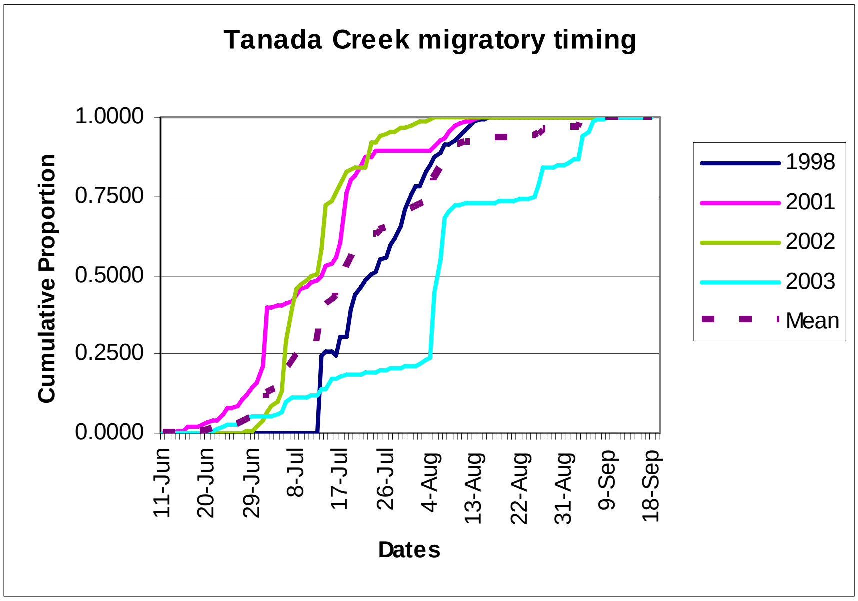


Figure 15. Tanada Creek migratory timing, 1998, 2001, 2002, 2003.

Aerial Observations

To date, there are only four years in which there were both credible estimates of escapement coupled with aerial surveys (1979, 1998, 2001, and 2002; Table 3). Aerial surveys have only been effective in differentiating very small escapements (less than 2,000) from everything else. For instance the surveys in 1979 and 1998 are very similar at approximately 5,000 sockeyes; however the actual escapements were approximately three-fold different.

Capacity Building

During the educational program prepared for the participants of the Batzulnetas culture camp, WRST provided a forum for community members to observe the weir project in operation and ask questions about the abundance, timing and management of the Tanada Creek run. Five local residents of the Slana area were employed by WRST to staff the weir. Through this employment, they gained experience in monitoring, sampling, problem solving, and collecting, reporting and entering data.

Video Escapement Estimation

Video monitoring appears to be a potentially useful tool to estimate escapement in Tanada Creek. In 2003 we changed the location of the video cameras from downstream of the weir to upstream of the weir. This location greatly reduced the 2002 problem of the salmon milling back and forth under the cameras. Installation of a contrasting panel on the substrate beneath the cameras on July 16 greatly improved the visibility of the salmon as they swam upstream. Building a wider panel next year will increase it more. Purchasing a second Sony S-VHS time lapse recorder would allow the crew to view the videos within a day or two of filming and enable them to continually improve the camera recordings. When viewed in the fall and winter on the recording VCR, approximately 70% of the fish counted at the weir were observed. There was a strong correlation between the number of fish enumerated per day at the weir and the number counted on the tapes, $R^2 = 0.9428$ (Figure 10). Reflective glare from the water surface was a problem during many of the daytime hours. This could be reduced substantially with the installation of a tarp over the video cameras. Low light during periods of no sunlight was a problem during the night. The addition of an extra set of red lights in August helped but two more will improve counting conditions even further as will installation of 4 of these lights under water. The low flows throughout the season also resulted in good water clarity which likely improved the effectiveness of the video cameras. Improvements in the substrate panels, glare reduction, power supply, and lighting may result in an even higher R^2 value in the future. We feel it is important to continue the operation of the weir in conjunction with the video cameras and that the video cameras should be tested thoroughly at high flows before they are used to solely estimate escapement in Tanada Creek. However, existing work suggests that this may be a feasible substitute for operating the weir in the future.

Limnological Data

Water temperature on the surface was highest in July and August and lowest in late September. Some of the samples tested at NTL came back under the MRLs of 1.0 mg/L for Kjeldahl N, 0.25 mg/L for Total Phosphate, 0.1 mg/L for Total Nitrites/Nitrates: 46% of the Kjeldahl N samples, 46% of the Total P and 73% of the Total Nitrates/Nitrites. While the low levels of these nutrients may suggest that low nutrients limit productivity in the lake, finding a laboratory that is capable of determining the exact levels of nutrients will be necessary before reaching a conclusion regarding the role of nutrients in Tanada Lake. The zooplankton tows showed high productivity. According to John Edmundson (personal communication, 2004), Fishery Biologist from the ADFG Limnology Lab, several other lakes in the Copper basin (Crosswinds, Summit and Paxson) also show high zooplankton activity although it is generally low in cold, oligotrophic Alaskan lakes. Further monitoring of nutrient and zooplankton levels throughout the calendar year may be valuable in assessing the capacity of Tanada Lake to produce the high numbers of juvenile sockeye salmon necessary for high adult sockeye salmon returns. Nutrient and zooplankton levels may provide insight into assessment of future adult returns of juvenile sockeye salmon rearing in the lake in 2003.

CONCLUSIONS

Weir Operation

The floating resistance board weir outperformed the rigid picket weir and can be successfully operated at this site.

Biological Data

The escapements into Tanada Creek in 2002 and 2003 were similar and approximately 6,000 sockeye salmon. In 2001, the escapement was substantially smaller at 1,649 sockeye salmon. Neither the age composition nor the sizes of the sockeye salmon appear substantially different throughout the 3 years of the project.

Run Timing

The 2003 run was longer and the mean date occurred later than in 2001 and 2002. Run timing is highly variable in Tanada Creek. The average mean date does not appear to be a useful tool for projecting total escapement using the existing data.

Video Escapement Estimation

The new location of the video towers was a great improvement. Using permeable reflective panels also worked well, allowing for undisturbed visibility of the water column. A correlation was drawn between the weir count of sockeye salmon and the video count with approximately 70 percent of the sockeye salmon that passed through the weir daily also observed by the video viewer. We believe that this may be a useful tool for estimating sockeye salmon escapement in Tanada Creek; however more work, particularly during periods of high flows, is needed to develop an index of weir counts and video escapement estimates.

Limnological Data

This year’s limnological data is useful in establishing some baseline nutrient levels in Tanada Lake. Measurements of nutrients occasionally were less than the method reporting limit used by Northern Test Labs, complicating the analysis of this data. Zooplankton measurements suggest that zooplankton production is high within the lake. Additional work measuring these levels and the zooplankton productivity throughout the year will provide us with better baseline information and allow us to compare salmon counts with productivity patterns.

RECOMMENDATIONS

Video Escapement Operation

1. Continue operating the video escapement operation in conjunction with the weir to produce a reliable index of video estimates at a range of flow conditions.

Management

1. Continue monitoring to work towards defining what natural and healthy sockeye escapement is for Tanada Creek stocks.
2. Collect additional weir data to more accurately assess the trend in population abundance. While the aerial counts suggest a downward trend, additional weir data is likely to more accurately assess this trend.

Limnological Data

1. Continue to collect and analyze water and zooplankton samples. The nutrient level suggests production limiting factors in the water chemistry, but zooplankton productivity is high. Find a lab that is capable of detecting low nutrient levels. Continuing this work is likely to provide future insight into the strength of adult sockeye salmon returns.

ACKNOWLEDGEMENTS

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Appendix A. Details of historic sockeye salmon peak aerial survey estimates of Tanada Lake and lake outlet.

Year	Date	Estimate	Time	Conditions[1]			Aircraft	Source	Observer
				Sky	Water	Survey			
1962	July 25	1,500[2]	--	--	--	--	--	ADFG	Van Wyne
1963	August 11	1,060[2]	--	--	--	--	--	ADFG	--
1964	September 10	1,500[2]	--	--	--	--	--	ADFG	--
1965	--	3,300[2]	--	--	--	--	--	ADFG	--
1966	July 31	10[2]	--	--	--	--	--	ADFG	--
1967	--	26[2]	--	--	--	--	--	ADFG	--
1968	August 13	175	--	--	--	1	--	ADFG	--
1969	August 15	6[2]	--	--	--	--	--	ADFG	--
1970	August 23	1,000[2]	--	--	--	--	--	ADFG	--
1971	August 27	4,093	--	--	--	1	--	ADFG	--
1972	September 20	930	--	--	--	2	--	ADFG	--
1973	August 20	10[2]	--	--	--	2	--	ADFG	K. Roberson
1974	August 29	3,100	--	--	--	--	--	ADFG	K. Roberson
1975	September 30	700[2]	--	--	--	--	--	ADFG	K. Roberson
1976	October 1	2,200	--	--	--	--	--	ADFG	K. Roberson
1977	September 19	9,100	--	--	--	--	--	ADFG	K. Roberson
1978	August 23	2,525	--	--	--	--	--	ADFG	K. Roberson
1979	September 7	5,225	--	--	--	--	--	ADFG	K. Roberson
1980	--	13,700	--	--	--	--	--	ADFG	K. Roberson
1981	--	11,200	--	--	--	--	--	ADFG	K. Roberson
1982	September 28	11,680	--	--	--	--	--	ADFG	K. Roberson
1983	September 6	10,900	--	--	--	--	--	ADFG	K. Roberson
1984	--	16,100	--	--	--	--	--	ADFG	K. Roberson
1985	September 25	11,700	--	--	--	--	--	ADFG	K. Roberson
1986	September 5	8,260	--	--	--	--	--	ADFG	K. Roberson
1987	September 15	8,350	--	--	--	--	--	ADFG	K. Roberson
1988	September 14	3,750	--	--	--	--	--	ADFG	K. Roberson
1989	September 15	3,175	--	--	--	--	--	ADFG	K. Roberson
1990	September 21	3,000	--	--	--	--	--	ADFG	K. Roberson
1991	August 29	3,050	--	--	--	--	--	ADFG	--
1992	September 16	3,450	--	--	--	--	--	ADFG	--
1993	--	--	--	--	--	--	--	--	--
1994	--	6,270[2]	--	--	--	--	--	ADFG	--
1995	--	3,100[2]	--	--	--	--	--	ADFG	--
1996	--	--	--	--	--	--	--	--	--
1997	August 26	7,875	12:30	1	3	2	Helicopter	NPS	R. Raeder
1998	August 19	4,470	12:00	1	2	2	Fixed-Wing	NPS	R. Raeder
1999	--	350[2]	--	--	--	--	--	ADFG	--
2000	September 5	4,720	12:00	3	2	2	Fixed-Wing	ADFG	D. Sarafin
2001	August 26	400	13:20	4	2	4	Fixed-Wing	ADFG	D. Sarafin
2002	September 23	1,950	11:10	1	3	3	Fixed-Wing	ADFG	D. Sarafin
2003	(August)	0	--	--	--	--	Fixed-Wing	ADFG	D. Ashe

[1]Conditions: 1=Excellent, 2=Good, 3=Fair, 4=Poor, 5=Unsurveyable.
[2]Non-Comparable estimate; may exclude estimate of lake outlet area.

Appendix B. Tanada Creek daily salmon counts, 2001-2003.

2001 Date	Daily Sockeye Count	Cumulative Sockeye Count	Daily Chinook Count	Cumulative Chinook Count
5-Jun	0	0	0	0
6-Jun	0	0	0	0
7-Jun	0	0	0	0
8-Jun	0	0	0	0
9-Jun	0	0	0	0
10-Jun	0	0	0	0
11-Jun	0	0	0	0
12-Jun	0	0	0	0
13-Jun	0	0	0	0
14-Jun	11	11	0	0
15-Jun	1	12	0	0
16-Jun	19	31	0	0
17-Jun	2	33	0	0
18-Jun	5	38	0	0
19-Jun	8	46	0	0
20-Jun	6	52	0	0
21-Jun	11	63	0	0
22-Jun	3	66	0	0
23-Jun	29	95	0	0
24-Jun	38	133	0	0
25-Jun	0	133	1	1
26-Jun	10	143	1	2
27-Jun	29	172	2	4
28-Jun	22	194	0	4
29-Jun	44	238	1	5
30-Jun	23	261	2	7
1-Jul	84	345	0	7
2-Jul	305	650	0	7
3-Jul	3	653	0	7
4-Jul	15	668	0	7
5-Jul	0	668	0	7
6-Jul	4	672	0	7
7-Jul	20	692	0	7
8-Jul	27	719	1	8
9-Jul	36	755	0	8
10-Jul	5	760	6	14
11-Jul	23	783	1	15
12-Jul	10	793	0	15
13-Jul	23	816	0	15
14-Jul	55	871	0	15

2001 Date	Daily Sockeye Count	Cumulative Sockeye Count	Daily Chinook Count	Cumulative Chinook Count
15-Jul	9	880	0	15
16-Jul	36	916	0	15
17-Jul	78	994	0	15
18-Jul	258	1,252	1	16
19-Jul	73	1,325	0	16
20-Jul	17	1,342	0	16
21-Jul	52	1,394	0	16
22-Jul	43	1,437	0	16
23-Jul	9	1,446	0	16
24-Jul	29	1,475	0	16
25-Jul	0	1,475	0	16
26-Jul	0	1,475	0	16
27-Jul	0	1,475	0	16
28-Jul	0	1,475	0	16
29-Jul	0	1,475	0	16
30-Jul	0	1,475	0	16
31-Jul	0	1,475	0	16
1-Aug	0	1,475	0	16
2-Aug	0	1,475	0	16
3-Aug	0	1,475	0	16
4-Aug	0	1,475	0	16
5-Aug	19	1,494	0	16
6-Aug	35	1,529	0	16
7-Aug	16	1,545	0	16
8-Aug	28	1,573	0	16
9-Aug	36	1,609	0	16
10-Aug	8	1,617	0	16
11-Aug	9	1,626	0	16
12-Aug	5	1,631	0	16
13-Aug	9	1,640		
14-Aug	6	1,646		
15-Aug	1	1,647		
16-Aug	0	1,647		
17-Aug	0	1,647		
18-Aug	0	1,647		
19-Aug	0	1,647		
20-Aug	0	1,647		
21-Aug	0	1,647		
22-Aug	2	1,649		
23-Aug	0	1,649		

2002	Sockeye Count		Chinook Count	
Date	Daily	Cumulative	Daily	Cumulative
28-Jun	11	11		
29-Jun	1	12		0
30-Jun	37	49		0
1-Jul	50	99		0
2-Jul	58	157		0
3-Jul	58	215		0
4-Jul	39	254	2	2
5-Jul	76	330	2	4
6-Jul	392	722		4
7-Jul	259	981		4
8-Jul	149	1,130	1	5
9-Jul	47	1,177		5
10-Jul	26	1,203		5
11-Jul	38	1,241		5
12-Jul	19	1,260		5
13-Jul	189	1,449		5
14-Jul	347	1,796		5
15-Jul	28	1,824		5
16-Jul	63	1,887		5
17-Jul	71	1,958		5
18-Jul	101	2,059		5
19-Jul	17	2,076		5
20-Jul	9	2,085		5
21-Jul	3	2,088		5
22-Jul	11	2,099		5
23-Jul	188	2,287		5
24-Jul	7	2,294		5
25-Jul	43	2,337		5
26-Jul	21	2,358		5
27-Jul	10	2,368		5
28-Jul	5	2,373		5
29-Jul	39	2,412		5
30-Jul	0	2,412		5
31-Jul	10	2,422		5
1-Aug	13	2,435		5
2-Aug	14	2,449		5
3-Aug	10	2,459		5
4-Aug	7	2,466		5
5-Aug	19	2,485		5
6-Aug	1	2,486		5

7-Aug	0	2,486	5
8-Aug	0	2,486	5
9-Aug	0	2,486	5
10-Aug	3	2,489	5
11-Aug	0	2,489	5
12-Aug	0	2,489	5
13-Aug	0	2,489	5
14-Aug	0	2,489	5
15-Aug	0	2,489	5
16-Aug		2,489	5
17-Aug		2,489	5
18-Aug		2,489	5
19-Aug		2,489	5
20-Aug		2,489	5
21-Aug		2,489	5
22-Aug		2,489	5
23-Aug		2,489	5

2003	Sockeye Count		Chinook Count	
Date	Daily	Cumulative	Daily	Cumulative
5/30/2003	0	0	0	0
5/31/2003	0	0	0	0
6/1/2003	0	0	0	0
6/2/2003	0	0	0	0
6/3/2003	0	0	0	0
6/4/2003	0	0	0	0
6/5/2003	0	0	0	0
6/6/2003	0	0	0	0
6/7/2003	0	0	0	0
6/8/2003	0	0	0	0
6/9/2003	0	0	0	0
6/10/2003	0	0	0	0
6/11/2003	1	1	0	0
6/12/2003	0	1	0	0
6/13/2003	0	1	0	0
6/14/2003	0	1	0	0
6/15/2003	0	1	0	0
6/16/2003	0	1	0	0
6/17/2003	0	1	0	0
6/18/2003	0	1	0	0
6/19/2003	2	3	0	0
6/20/2003	23	26	0	0
6/21/2003	23	49	0	0
6/22/2003	46	95	0	0
6/23/2003	18	113	0	0
6/24/2003	27	140	0	0
6/25/2003	16	156	0	0
6/26/2003	7	163	0	0
6/27/2003	44	207	0	0
6/28/2003	74	281	0	0
6/29/2003	20	301	0	0
6/30/2003	0	301	0	0
7/1/2003	3	304	0	0
7/2/2003	7	311	0	0
7/3/2003	13	324	0	0
7/4/2003	7	331	0	0
7/5/2003	42	373	0	0
7/6/2003	225	598	0	0
7/7/2003	57	655	0	0
7/8/2003	2	657	0	0
7/9/2003	0	657	0	0
7/10/2003	6	663	2	2
7/11/2003	33	696	0	2
7/12/2003	15	711	0	2

7/13/2003	102	813	0	2
7/14/2003	10	823	0	2
7/15/2003	194	1,017	0	2
7/16/2003	8	1,025	0	2
7/17/2003	35	1,060	0	2
7/18/2003	7	1,067	0	2
7/19/2003	2	1,069	0	2
7/20/2003	11	1,080	0	2
7/21/2003	10	1,090	0	2
7/22/2003	20	1,110	0	2
7/23/2003	25	1,135	0	2
7/24/2003	8	1,143	0	2
7/25/2003	2	1,145	0	2
7/26/2003	24	1,169	0	2
7/27/2003	14	1,183	0	2
7/28/2003	16	1,199	0	2
7/29/2003	22	1,221	0	2
7/30/2003	3	1,224	0	2
7/31/2003	29	1,253	0	2
8/1/2003	0	1,253	0	2
8/2/2003	37	1,290	0	2
8/3/2003	72	1,362	0	2
8/4/2003	36	1,398	0	2
8/5/2003	1,209	2,607	0	2
8/6/2003	617	3,224	0	2
8/7/2003	783	4,007	0	2
8/8/2003	105	4,112	0	2
8/9/2003	99	4,211	0	2
8/10/2003	17	4,228	0	2
8/11/2003	19	4,247	0	2
8/12/2003	16	4,263	0	2
8/13/2003	3	4,266	0	2
8/14/2003	1	4,267	0	2
8/15/2003	0	4,267	0	2
8/16/2003	0	4,267	0	2
8/17/2003	0	4,267	0	2
8/18/2003	55	4,322	0	2
8/19/2003	0	4,322	0	2
8/20/2003	2	4,324	0	2
8/21/2003	0	4,324	0	2
8/22/2003	10	4,334	0	2
8/23/2003	3	4,337	0	2
8/24/2003	0	4,337	0	2
8/25/2003	47	4,384	0	2
8/26/2003	238	4,622	0	2
8/27/2003	301	4,923	0	2
8/28/2003	4	4,927	0	2
8/29/2003	8	4,935	0	2

8/30/2003	38	4,973	0	2
8/31/2003	8	4,981	0	2
9/1/2003	34	5,015	0	2
9/2/2003	76	5,091	0	2
9/3/2003	8	5,099	0	2
9/4/2003	403	5,502	0	2
9/5/2003	79	5,581	0	2
9/6/2003	186	5,767	0	2
9/7/2003	37	5,804	0	2
9/8/2003	26	5,830	0	2
9/9/2003	10	5,840	0	2
9/10/2003	1	5,841	0	2
9/11/2003	1	5,842	0	2
9/12/2003	12	5,854	0	2
9/13/2003	1	5,855	0	2
9/14/2003	0	5,855	0	2
9/15/2003	0	5,855	0	2
9/16/2003	1	5,856	0	2
9/17/2003	0	5,856	0	2
9/18/2003	0	5,856	0	2