U.S. Fish & Wildlife Service

Abundance and Run Timing of Adult Steelhead Trout in Crooked and Nikolai Creeks, Kenai Peninsula, Alaska, 2006

Alaska Fisheries Data Series Number 2006-13

Kenai Fish and Wildlife Field Office
Kenai, Alaska
November, 2006

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Kenneth S. Gates and Douglas E. Palmer

Abstract

Fish weirs with underwater video systems were installed and operated on Crooked and Nikolai creeks during 2006 to collect abundance, run timing, and biological information for immigrating steelhead trout. Each weir and video system was installed prior to the spring steelhead trout spawning migration. A combined total of 977 steelhead trout were counted past the Crooked (*N*=604) and Nikolai (*N*=373) creek weirs between 21 April and 24 May. The escapement into Nikolai Creek is considered a conservative estimate because of high water which submerged the weir on three separate occasions. Peak weekly passage occurred between 7 and 13 May for both Crooked and Nikolai creeks. Age, sex, and length (ASL) data were collected from 118 steelhead trout at Crooked Creek. No ASL samples were collected at Nikolai Creek. Sex was also determined by examining video footage recorded at each weir. Females comprised 58% (ASL and video combined) of the escapement at Crooked Creek and 61% (video) of the escapement at Nikolai Creek. The average length of male and female steelhead trout from Crooked Creek was 599 mm and 627 mm, respectively. Water temperatures during the operational periods ranged from 1.1°C to 10.2°C at Crooked Creek and 1.4°C to 4.7°C at Nikolai Creek.

Introduction

Crooked and Nikolai creeks are the only two streams in the Kasilof River watershed known to support steelhead trout *Oncorhynchus mykiss* (Johnson et al. 2004). Crooked Creek historically supported a small wild run of steelhead trout estimated to consist of a maximum of several hundred fish (Gamblin et al. 2004). The Alaska Department of Fish and Game (Department) enhanced this run beginning in the 1980's to provide additional angling opportunity. Enhancement efforts created a fishery unique from other steelhead trout fisheries on the Kenai Peninsula because it provided anglers an opportunity to harvest fish. Sport catches of steelhead trout in the Kasilof River and Crooked Creek peaked during the mid-1990's and averaged 5,836 fish between 1993 and 1995 (Mills 1994; Howe et al. 1995, 1996). During the same period, harvest of steelhead trout averaged 1,397 fish annually. Higher catches during this period were a direct result of the enhancement program. The enhancement program was terminated in 1993 after concerns were raised about straying of hatchery steelhead trout into the Kenai River. Since termination of the enhancement program, catch has declined and has averaged 579 fish between 1997 and 2004 (Gamblin et al. 2004; Larry Marsh, Alaska Department of Fish and Game, personal communication). Anticipating a decline in the number of steelhead trout available to anglers, the Alaska Board of Fisheries restricted the fishery within Crooked Creek and the Kasilof River below the Sterling Highway Bridge to catch-and-release beginning in 1996.

Current fishery regulations limit fishing in Crooked Creek from 1 August through 31 December, and only unbaited, single hook, artificial lures may be used between 15 September and 31 December. In addition, no retention of rainbow or steelhead trout is allowed from Crooked

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Creek. Regulations pertaining to the Kasilof River from 1 September through 15 May allow fishing with one unbaited, single hook, artificial lure from the mouth to the Sterling Highway Bridge. In this same section of river from 16 May through 30 June, only one single hook may be used. Like Crooked Creek, no retention of rainbow or steelhead trout is allowed in the Kasilof River below the Sterling Highway Bridge. Fishing above the Sterling Highway Bridge and in Nikolai Creek is open year-round for rainbow and steelhead trout with a daily bag limit of 2 per day/2 in possession with only one fish exceeding 20 inches in length. Harvest of steelhead trout above the Sterling Highway Bridge is typically fewer than 50 fish annually.

Information regarding the steelhead trout population in Nikolai Creek is limited. Field technicians with the U.S. Geological Survey (USGS) reported the presence of steelhead trout in Nikolai Creek while monitoring emigrating sockeye salmon fry during the early 1990's (Carol Woody, U.S. Geological Survey, personal communication). In addition to the USGS observations, Jones and Faurot (1991) reported capturing one steelhead trout in Tustumena Lake that may have been returning to Nikolai Creek and Gates and Palmer (2006) identified 84 steelhead trout migrating upstream to spawn during 2005.

Steelhead trout returning to the Kasilof River watershed are considered fall-run fish, entering fresh water in the fall and over-wintering before spawning in tributaries in May and June. Larson and Balland (1989) documented similar behavior in steelhead trout returning to the Anchor River on the lower Kenai Peninsula. Begich (1997) has also described the Karluk River steelhead trout population, the largest steelhead population on Kodiak Island, as a fall run. More recently, USGS has operated a weir on the Ninilchik River to enumerate emigrating steelhead trout (kelts). The timing of kelts passing downstream through the weir varied considerably between years, starting as early as 19 May in 2000 and as late as 12 June in 2001 (USGS, unpublished data). Median cumulative downstream passage dates have ranged from 9 to 18 June in the Ninilchik River. Kelt information is limited for Crooked and Nikolai creeks, but timing of their downstream migration is likely very similar to that observed for the Ninilchik River.

Harvest and catch information collected by the Department indicate that the steelhead trout over-wintering in the Kasilof River do not enter Crooked Creek until late April or early May (Gamblin et al. 2004). The distribution of over-wintering steelhead trout in the Kasilof River is unknown, but fish probably occur throughout the river, as far upstream as Tustumena Lake. The spring migration of steelhead trout into Crooked Creek is thought to occur when water temperatures reach 6 to 7°C (Bob Och, Alaska Department of Fish and Game, personal communication).

The U.S. Fish and Wildlife Service (Service) conducted a preliminary investigation in Crooked Creek during 2004 to develop an underwater video system for enumerating steelhead trout. Steelhead trout were enumerated during May 2004 at the Crooked Creek Hatchery and concurrently at a weir equipped with an underwater video system 200 m upstream of the hatchery. Daily counts of steelhead trout from both locations were similar, indicating that the underwater video was an accurate and cost effective method to enumerate fish passage. A total of 206 steelhead trout were enumerated during 2004; however, this was likely a conservative estimate of abundance because weir and video counts were not initiated until 4 May (U.S. Fish and Wildlife Service, unpublished data). To gain more information pertaining to the run-size of steelhead trout in Crooked and Nikolai creeks, the Service installed and operated an underwater video system in each creek during 2005 and 2006. Specific objectives during 2006 were to: 1) enumerate adult steelhead trout entering Crooked and Nikolai creeks; 2) determine the run-timing of adult steelhead trout entering Crooked and Nikolai creeks; and 3) estimate the age, sex, and length of migrating adult steelhead trout in Cooked Creek.

Study Area

The Kasilof River drains a watershed of 2,150 km^2, making it the second largest watershed on the Kenai National Wildlife Refuge (Refuge). The watershed consists of mountains, glaciers, forests, and the Kenai Peninsula's largest lake, Tustumena Lake. The Kasilof River is only 29 km long and drains Tustumena Lake, which has a surface area of 29,450 hectares, a maximum depth of 287 m, and a mean depth of 124 m. All tributary streams in the watershed which drain refuge lands enter Tustumena Lake except Crooked Creek (Figure 1).

Crooked Creek is a tannin-stained stream approximately 80 km long which intersects the Kasilof River at river-kilometer nine (60° 19.20'N and 151° 16.55'W; NAD83). The headwaters of Crooked Creek are on the Refuge and the watershed drains approximately 75.6 km^2 (Moser 1998). Crooked Creek has a highly sinuous channel and substrates ranging from sand to cobble.

Nikolai Creek enters the south shore of Tustumena Lake approximately 8 km SE of the lake outlet (60° 11.43'N and 151° 0.36'W; NAD83). Its watershed is approximately 95 km^2 and falls within the Refuge boundary and a designated wilderness area (Moser 1998). Nikolai Creek has a relatively steep gradient, low sinuosity, and predominately cobble substrate.

Methods

Weir and Video Operations and Design

The weir located at Crooked Creek Hatchery was installed to monitor the steelhead trout escapement in Crooked Creek. The hatchery weir is a permanent structure with a steel corrugated footer and bulkheads. Metal grates are placed onto the weir framework to divert fish migrating upstream into a hatchery raceway. An underwater video system was installed in the raceway to monitor fish passage. After passing the video system, fish exited the hatchery into Crooked Creek and continued their upstream migration. Fish moving downstream bypassed the hatchery and passed over the weir unharmed.

The Nikolai Creek weir was located approximately 200 m upstream from the mouth of the creek. The weir was constructed using a combination of floating resistance board panels (Tobin 1994) and flexible pickets (Palmer 2003). Flexible pickets were used in low velocity sections of the stream near each bank and were constructed from 2.5-cm inside-diameter polyvinyl chloride (PVC) electrical conduit. Each flexible panel measured 3 m long by 1.5 m high with 1.9-cm spacing between pickets. Panels were held together by 3-mm stainless wire rope. Metal tripods were used to support the flexible picket panels. The floating portion of the weir was constructed using specifications outlined by Tobin (1994), with minor modifications to the panel width, picket spacing and resistance board material. The setup and design of the weir allowed upstream movement of fish through a counting chute. Downstream movement of fish occurred over a partially submerged floating weir panel. Except when weir maintenance was required, the Nikolai Creek weir was unmanned and outfitted with a video and microwave system to monitor upstream fish passage.

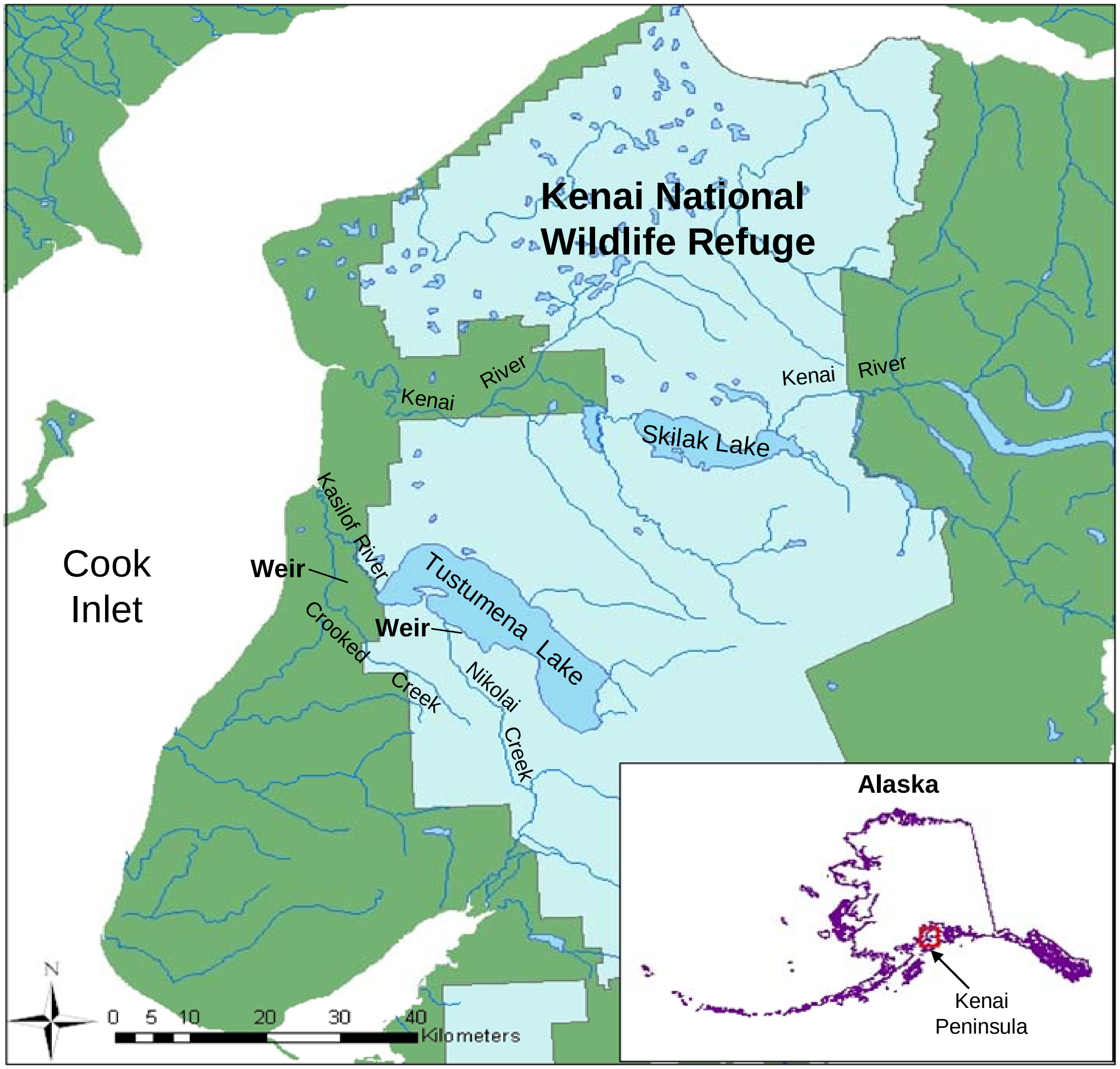

FIGURE 1. —Map of the Kasilof River watershed showing weir locations on Crooked and Nikolai creeks.

Setup and design of each video system was similar to that used by Hetrick et al. (2004) on the Ongivinuk River during 2001 and 2002 and more recently on Big Creek in 2003 (Anderson et al. 2004). One underwater video camera was located inside a sealed video box attached to the fish passage chute. The video box was constructed of 3.2-mm aluminum sheeting and was filled with filtered water. Safety glass was installed on the front of the video box to allow for a scratch-free, clear surface through which images were captured. The passage chute was constructed from aluminum angle and was enclosed in plywood isolating it from exterior light. Video images from Nikolai Creek were transmitted via a 2.4 MHz microwave frequency to a digital video recorder (DVR) located at a private residence near the Sterling Highway. Microwave transmission of the video signal minimized power requirements needed at the remote site and allowed the crew to remotely monitor fish passage. The underwater camera, microwave transmitter, and underwater lights at Nikolai Creek were powered by three 80-watt solar panels. Two solar panels wired in parallel supplied power to two 360Ah 6-volt batteries wired in series which powered the underwater lights. The remaining solar panel maintained the charge on one 12-volt battery which powered the underwater camera and microwave transmitter. All video images from each project were recorded on a removable 120 gigabyte hard drive at 20 frames-per-second using a computer-based DVR. Fish passage was recorded 24 hours per day seven days each week. Stored video files were reviewed daily. The video box and fish passage chute at each weir were artificially lit using a pair of 12-volt underwater pond lights. Pond lights at Crooked Creek were equipped with 20-watt bulbs which provided a quality image. Lights used at Nikolai Creek were equipped with 10-watt bulbs to conserve battery power. The lights provided a consistent source of lighting during day and night hours. Each DVR was equipped with motion detection to minimize the amount of blank video footage and review time. Appendix 1 contains a complete list of video and microwave equipment.

Biological Sampling

Data on fish age, sex, and length (ASL) were collected from Crooked Creek using a temporally stratified sample design (Cochran 1977). Samples were collected in the raceways from immigrating steelhead trout. The sampling effort was divided into strata and was based upon in-season run strength. Each stratum was a calendar week consisting of seven days.

Sampling consisted of sex determination, length measurements, and scale and tissue collections. Sex was determined by observing external characteristics. Length measurements were taken from the mid-eye to fork-length to the nearest 5 mm. Scales were removed from the preferred area using methods described by Mosher (1968) and Koo (1962). The preferred area is located on the left side of the fish, two scale rows above the lateral line on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin. Four scales were taken from each steelhead trout and mounted on gummed cards. Scales have been forwarded to Department biologists in Southeast Alaska for age determination. Results from the scale analysis will be reported in a subsequent report after the Department completes current research validating scale ages of Southeast steelhead trout stocks using PIT tags.

In addition to age, sex, and length, a small fin clip, less than 20 mm in length, was taken from the right pelvic fin of each steelhead trout sampled and placed in 90% ethanol alcohol. Tissue samples will be archived for future analysis at the Service's Conservation Genetics Laboratory in Anchorage.

Water temperatures were recorded at each weir location using an Optic StowAway Temp logger (ONSET Computer Corporation®). Temperatures were recorded every 30 minutes and averaged for the day. Temp loggers were operated between 15 April and 31 May.

Results

Weir and Video Operations

The weir and video system at Crooked Creek were installed on 21 April 2006 and operated through 24 May. The Department operated the weir and video system after 31 May for Chinook salmon enumeration and reported no additional steelhead trout passing the video system. The video system operated smoothly except during 26 and 27 April when the DVR stopped recording at 00:00 hours on each day. The DVR was not restarted until 15:00 hours on 26 April and 10:00 hours on 27 April. The problem was corrected on 27 April by changing out the removable hard drive. These video malfunctions occurred prior to any observations of steelhead trout passing the video system.

The weir and video system at Nikolai Creek were installed on 26 April and operated through 22 May. A helicopter was used to access the weir site during installation because of ice conditions on Tustumena Lake. The weir was installed and operational prior to spring run-off. Three high water events during May submerged the weir and interrupted steelhead counts. The first event occurred between 6 and 8 May, the second between 14 and 15 May, and the third from 17 to 18 May. The most notable impact on daily counts occurred during the first high water event when numbers dropped from over 20 to less than five fish per day (Appendix 3). Estimates for these periods were not calculated.

Biological Data

A total of 604 steelhead trout were counted passing the video system at Crooked Creek Hatchery between 27 April and 24 May (Figure 2; Appendix 2). Peak weekly passage (*N*=285) occurred between 7 and 13 May and median cumulative passage occurred on 11 May. The highest daily count (*N*=91) occurred on 10 May. The number of steelhead trout counted after 18 May only represented 4% (*N*=23) of the total escapement. Water temperatures ranged between 2.4°C and 5.6°C between 7 and 13 May, the week of peak steelhead trout passage (Figure 2; Appendix 4).

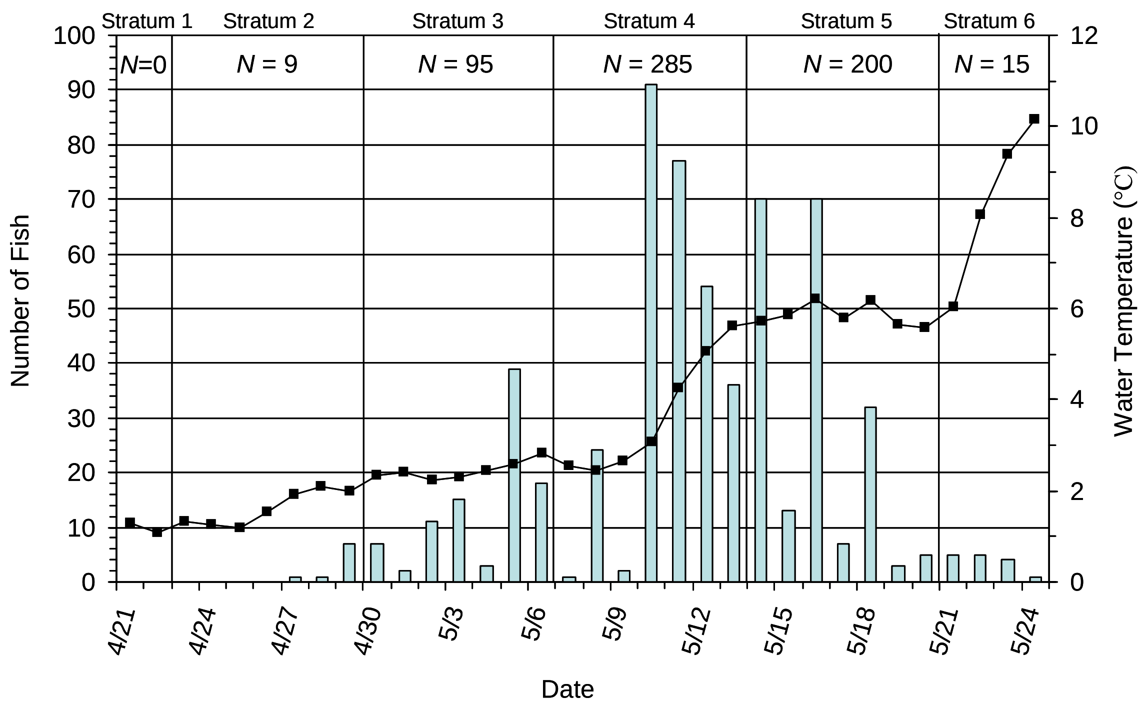

FIGURE 2. —Daily and weekly escapement of steelhead trout and water temperatures in Crooked Creek, Alaska, 2006. Counts did not begin until mid-day on 21 April.

ASL samples were collected from 118 steelhead trout at the Crooked Creek Hatchery between 1 and 23 May. Females averaged 627 mm in length and accounted for 68% of the sample. Males averaged 599 mm in length. Sex determination based on examination of video records also favored females (56%). Sex composition for the entire return of steelhead trout, including both ASL and video records, was 58% female. Sex ratios favored males during the first half of the run but shifted to a dominant female component during the second half of the run (Figure 3).

A total of 373 steelhead trout were counted passing Nikolai Creek weir between 28 April and 22 May 2006 (Figure 4; Appendix 3). Peak weekly passage (*N*=226) occurred between 7 and 13 May. Passage observed during this week accounted for 61% of the total escapement. Median cumulative passage occurred on 12 May. The majority of the steelhead trout passage occurred at water temperatures less than 4°C with the peak weekly passage occurring between 1.4°C and 3.6°C (Figure 4; Appendix 4). Females comprised 61% of the total escapement based on review of the video records. Sex composition was skewed towards females throughout the entire run (Figure 5).

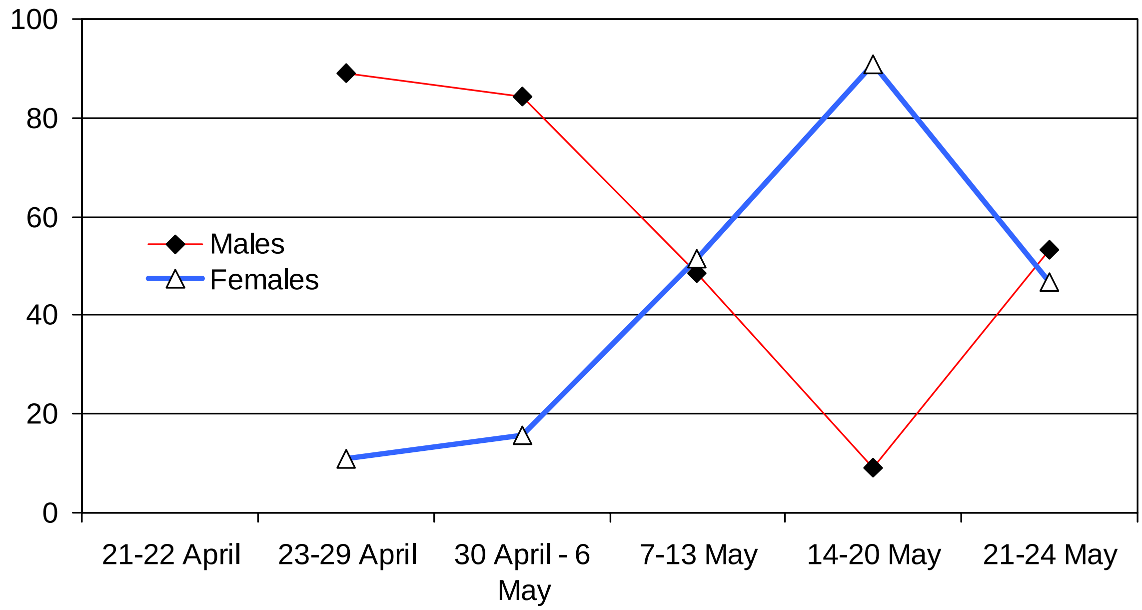

FIGURE 3. —Weekly percent of male and female of steelhead trout observed at Crooked Creek, Alaska, 2006.

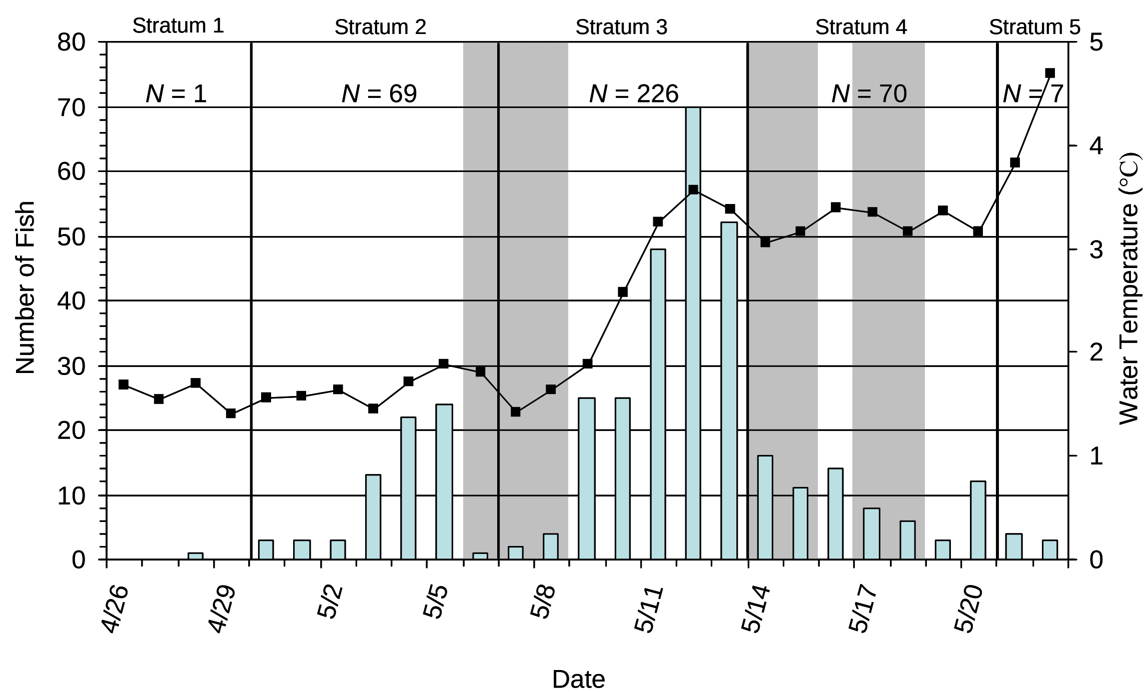

FIGURE 4. —Daily and weekly escapement of steelhead trout and water temperatures in Nikolai Creek, Alaska, 2006. Counts did not begin until mid-day on 26 April and shaded areas represent periods of high water and incomplete counts.

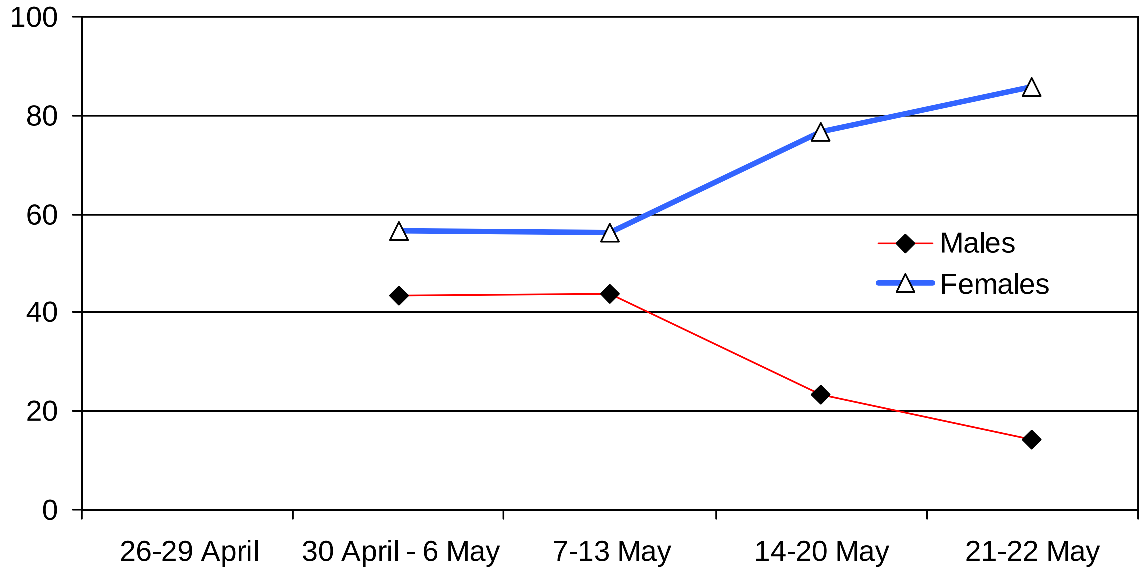

FIGURE 5. —Weekly percent of male and female steelhead trout observed at Nikolai Creek, Alaska, 2006. One male steelhead trout was observed between 26 and 29 April and was omitted from this figure.

Discussion

A combined total of 977 steelhead trout were counted past the Crooked (*N*=604) and Nikolai (*N*=373) creek weirs between 27 April and 24 May. We feel that these estimates of abundance accurately represent the relative strength of the steelhead trout return on each of these streams; however, estimates from Nikolai Creek are likely conservative because of high water submerging the weir on three different occasions. Steelhead trout were not observed passing either weir for at least two days following weir installations, suggesting that the steelhead trout migration started after the weirs were installed.

The return of steelhead trout to Crooked Creek during 2006 (*N*=604) was over one and a half times that observed during 2005 (*N*=379; Figure 6) and nearly three times that observed during 2004 (*N*=206; Figure 6). Similarly, steelhead trout returning to Nikolai Creek were observed in greater numbers during 2006 (*N*=373) than in 2005 (*N*=84; Figure 7). The larger escapements observed in 2006 can be attributed to estimating the early component of each steelhead trout return. Estimating the early component of each run is made possible by either one or a combination of the following; earlier weir installation dates and a later return of steelhead trout during 2006. Peak weekly passage at Crooked Creek occurred one week later in 2006 than in 2005 suggesting a delayed steelhead trout migration compared to observations made in 2005. Delayed spring weather conditions could have been the cause for a later return of steelhead trout during 2006. We are uncertain if the migration of steelhead trout into Nikolai Creek was delayed during 2006 because the observed run-timing during 2006 was similar to 2005 based on peak weekly passage. Run-timing might have differed between years if we had been able to estimate the early portion of the run during 2005.

Female to male sex ratios of steelhead trout were similar between Crooked (1.3:1) and Nikolai (1.5:1) creeks during 2006. These sex ratios are considered representative for steelhead trout returning to Crooked and Nikolai creeks and much different from the highly skewed female to male sex ratios (3:1) observed during 2005. Sex ratios during 2005 were likely biased heavily toward females because both weirs were installed late and females tend to dominate the later part of the return. Sex ratios observed at Crooked and Nikolai creeks during 2006 are similar to those observed for spring run steelhead trout populations currently being monitored by the Department in Southeast, Alaska (David Love, Alaska Department of Fish and Game, personal communication). Determining the age composition and spawning histories of steelhead trout in Crooked Creek through scale analysis may provide some additional knowledge regarding the sex ratios observed in Crooked and Nikolai creeks.

Water temperature and flow regime are probably two factors which have the most influence on run-timing of steelhead trout in Crooked and Nikolai creeks. Mean water temperatures in both Crooked (4.5°C) and Nikolai (3.1°C) creeks during 2006 were below the means recorded in 2004 and 2005. During 2006, Crooked Creek water temperature gradually increased and never exceeded 6.2°C through 22 May, unlike water temperatures observed in 2005 which increased rapidly from 2.0°C on 23 April to 7.0°C on 28 April (Appendix 2; Appendix 4). Nikolai Creek water temperatures remained even colder only exceeding 4.0°C once during the operational period (Appendix 3; Appendix 4). Passage at Crooked Creek began on 27 April as soon as the average daily water temperatures approached 2°C. Unlike Crooked Creek, over a quarter of the steelhead trout run had passed the weir at Nikolai Creek prior to the average daily water temperatures reaching 2°C on 10 May (Appendix 3). In this instance, increases in discharge may have had a greater influence than water temperature in triggering the immigration of steelhead trout in Nikolai Creek. Other studies have also noted that water temperature and discharge are important environmental factors influencing the upstream movement of steelhead trout (Shapovalov and Taft 1954; Kesner and Barnhart 1972; Jones 1972). We are planning to measure discharge in 2007 to gain further knowledge regarding which environmental factors influence steelhead trout run-timing in Crooked and Nikolai creeks.

In conclusion, installing Crooked and Nikolai creek weirs during the third week of April enabled us to monitor fish passage during the beginning of each run and provide better estimates of run timing and abundance. The use of underwater video on both streams and microwave transmission for Nikolai Creek video have proven to be a relatively inexpensive and reliable tools to monitor the abundance and run-timing of these two steelhead trout populations. We plan to monitor steelhead escapement in both streams during 2007. Weather conditions permitting, both weirs will be installed and operational by 20 April to provide an accurate assessment of run-timing, abundance, and composition of the return. This assessment information will be useful in formulating future management strategies for steelhead trout in the Kasilof River watershed.

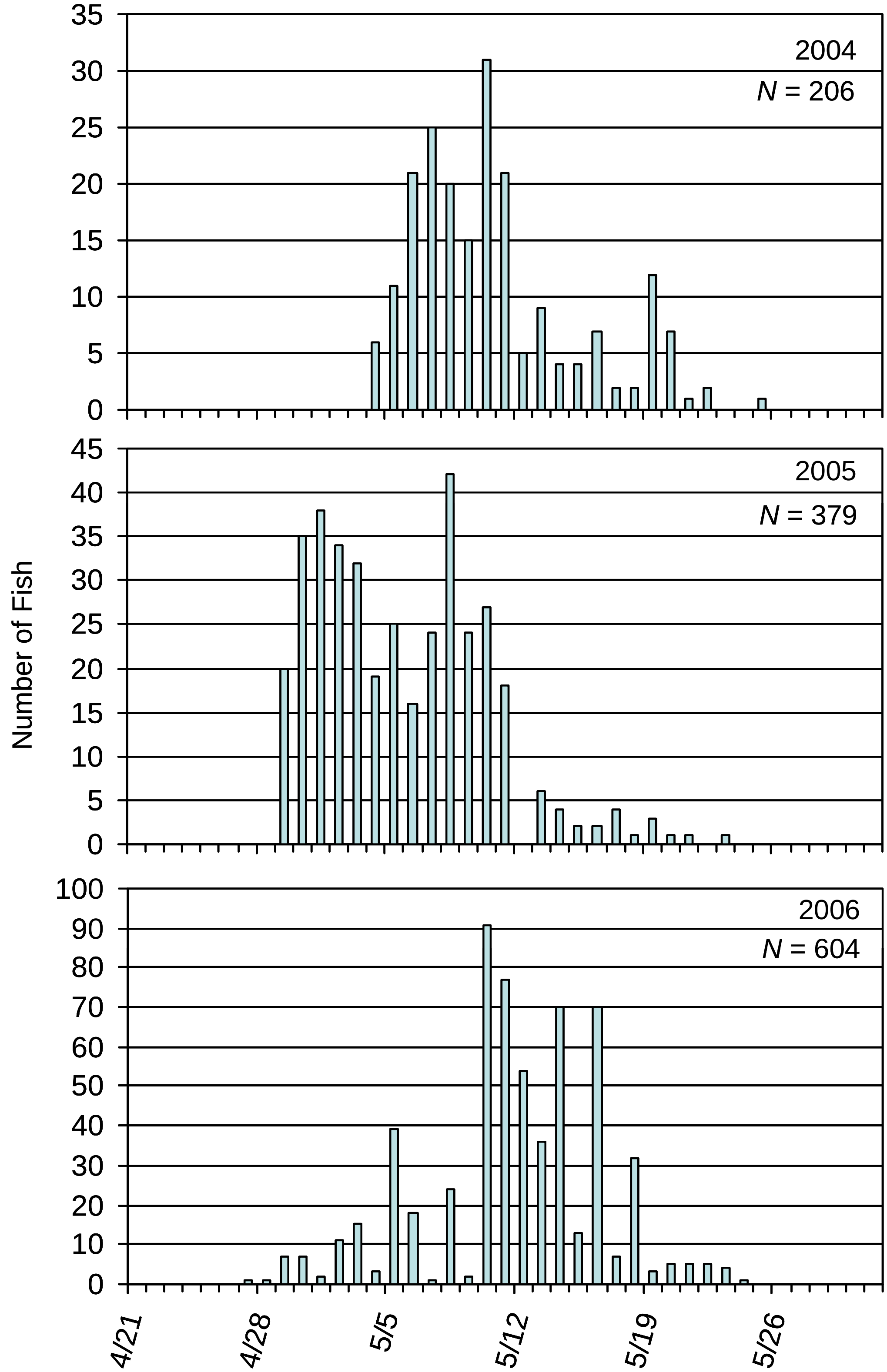

FIGURE 6. —Daily escapement of steelhead trout in Crooked Creek, Alaska, 2004, 2005 and 2006.

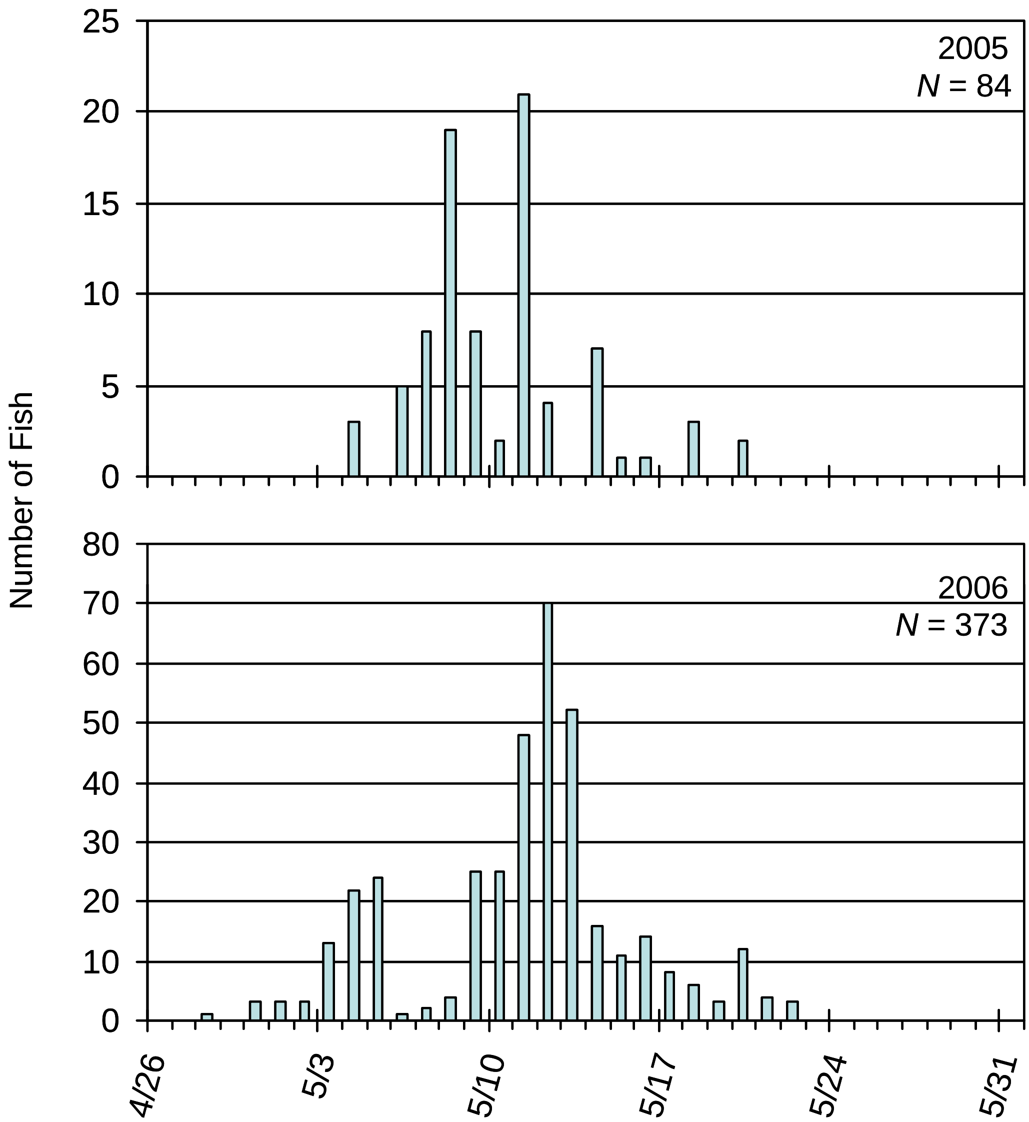

FIGURE 7. —Daily escapement of steelhead trout in Nikolai Creek, Alaska, 2005 and 2006.

Acknowledgements

Special appreciation is extended to those who participated in project setup, data collection, and video review including Waylon Marler, Dan Spencer, Jeff Breakfield, Adam Reimer, and Mark Hattfield. Special appreciation is also extended to Jeffrey Bromaghin for assisting with project design.

The Service would also like to thank the Department for allowing us to use their facilities at the Crooked Creek Hatchery. Utilizing the hatchery as a platform to operate the video system was instrumental in creating a smooth operating project. In addition, special appreciation is extended to Michael and Linda Sipes for providing us access to their property to operate the microwave equipment and DVR for Nikolai Creek.

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APPENDIX 1. —List of video and microwave equipment used to monitor steelhead trout abundance at Crooked and Nikolai creeks, Alaska, 2006.

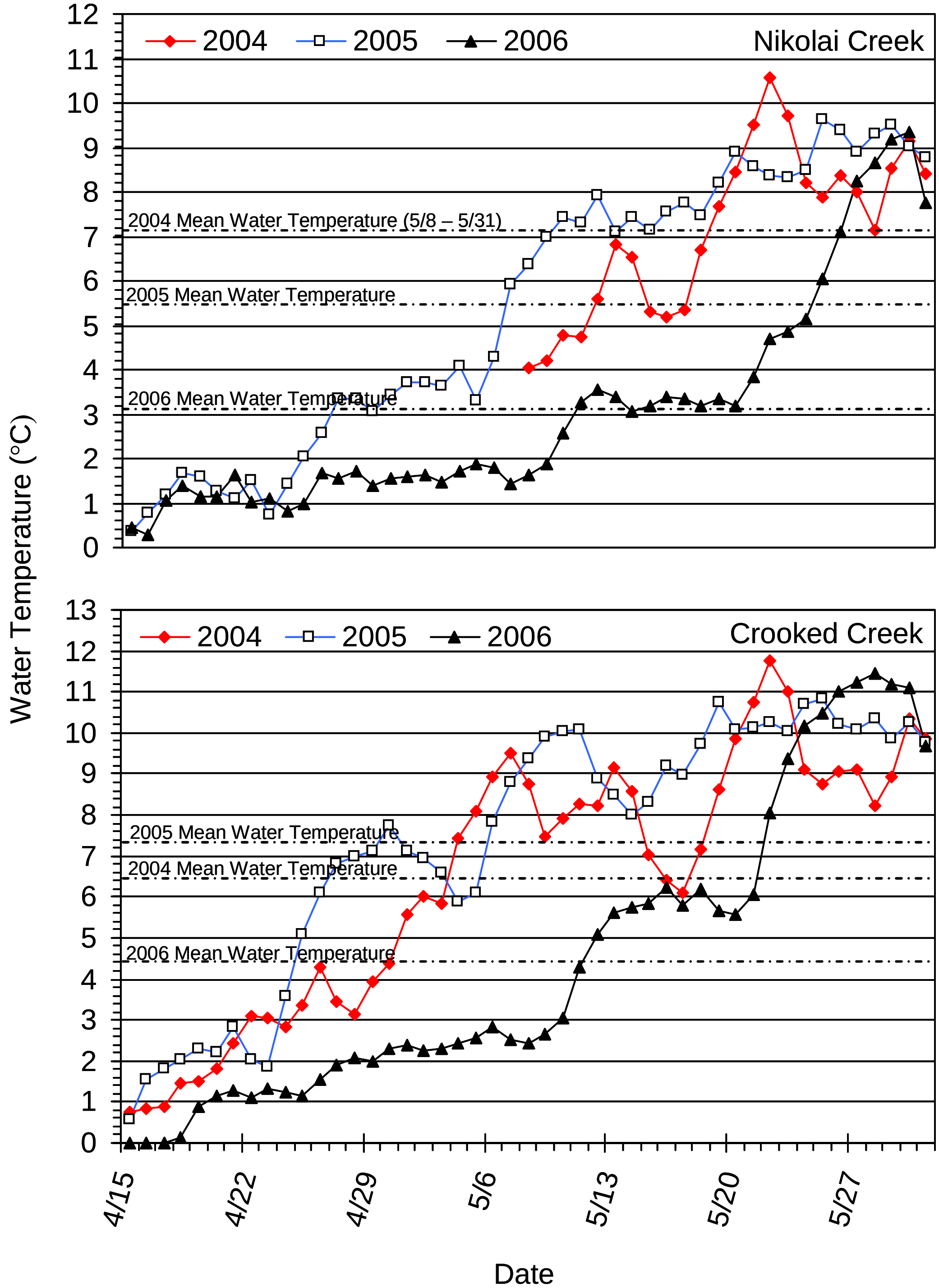
Item	Model #	Manufacturer	Contact
Digital Video Recorder	DVSM 4-120	Veltek International, Inc.	http://www.veltekcctv.com/
Underwater Camera	Model 10	Applied Micro Video	http://www.appliedmicrovideo.com/
Underwater Lights	Lunaqua 2 12-v	OASE	http://www.pondusa.com
External Harddrive	One Touch 250 GB	Maxtor.com	http://www.maxstore.com
Microwave Transmitter	BE-530T	Premier Wireless, Inc	http://www.premierwirelessinc.com/
Microwave Recievers	BE-322R	Premier Wireless, Inc	http://www.premierwirelessinc.com/
Parabolic Antennas	130135	California Amplifier	http://www.calamp.com

APPENDIX 2. —Daily counts and cumulative proportion of steelhead trout and water temperatures from Crooked Creek during 2004, 2005, and 2006. Boxed areas represent the second and third quartile and median passage dates.

	2004			2005			2006		
Date	Daily	Cumulative Proportion	Water Temperature	Daily	Cumulative Proportion	Water Temperature	Daily	Cumulative Proportion	Water Temperature
4/15			0.76			0.57			0.00
4/16			0.86			1.55			0.00
4/17			0.89			1.82			0.00
4/18			1.44			2.02			0.14
4/19			1.51			2.29			0.88
4/20			1.80			2.19			1.15
4/21			2.41			2.85	0	0.0000	1.29
4/22			3.10			2.05	0	0.0000	1.09
4/23			3.06			1.87	0	0.0000	1.31
4/24			2.83			3.60	0	0.0000	1.25
4/25			3.37			5.08	0	0.0000	1.17
4/26			4.30			6.09	0	0.0000	1.54
4/27			3.46			6.83	1	0.0017	1.92
4/28			3.16			7.00	1	0.0033	2.09
4/29			3.94	20	0.0528	7.10	7	0.0149	2.00
4/30			4.39	35	0.1451	7.73	7	0.0265	2.32
5/1			5.56	38	0.2454	7.11	2	0.0298	2.39
5/2			6.01	34	0.3351	6.95	11	0.0480	2.24
5/3			5.85	32	0.4195	6.59	15	0.0728	2.31
5/4	6	0.0291	7.43	19	0.4697	5.90	3	0.0778	2.45
5/5	11	0.0825	8.09	25	0.5356	6.10	39	0.1424	2.57
5/6	21	0.1845	8.93	16	0.5778	7.81	18	0.1722	2.83
5/7	25	0.3058	9.51	24	0.6412	8.80	1	0.1738	2.53
5/8	20	0.4029	8.75	42	0.7520	9.39	24	0.2136	2.44
5/9	15	0.4757	7.46	24	0.8153	9.92	2	0.2169	2.66
5/10	31	0.6262	7.90	27	0.8865	10.04	91	0.3675	3.06
5/11	21	0.7282	8.29	18	0.9340	10.10	77	0.4950	4.27
5/12	5	0.7524	8.24	0	0.9340	8.89	54	0.5844	5.07
5/13	9	0.7961	9.14	6	0.9499	8.47	36	0.6440	5.63
5/14	4	0.8155	8.58	4	0.9604	7.99	70	0.7599	5.73
5/15	4	0.8350	7.02	2	0.9657	8.33	13	0.7815	5.85
5/16	7	0.8689	6.41	2	0.9710	9.18	70	0.8974	6.22
5/17	2	0.8786	6.11	4	0.9815	8.97	7	0.9089	5.79
5/18	2	0.8883	7.18	1	0.9842	9.71	32	0.9619	6.18
5/19	12	0.9466	8.61	3	0.9921	10.75	3	0.9669	5.64
5/20	7	0.9806	9.86	1	0.9947	10.08	5	0.9752	5.58
5/21	1	0.9854	10.74	1	0.9974	10.13	5	0.9834	6.05
5/22	2	0.9951	11.78	0	0.9974	10.28	5	0.9917	8.06
5/23	0	0.9951	11.00	1	1.0000	10.05	4	0.9983	9.39
5/24	0	0.9951	9.11	0	1.0000	10.71	1	1.0000	10.16
5/25	1	1.0000	8.78	0	1.0000	10.85			10.46
5/26	0	1.0000	9.05	0	1.0000	10.22			11.00
5/27	0	1.0000	9.10	0	1.0000	10.07			11.24
5/28	0	1.0000	8.21	0	1.0000	10.33			11.47
5/29	0	1.0000	8.93	0	1.0000	9.86			11.17
5/30	0	1.0000	10.37	0	1.0000	10.26			11.09
5/31	0	1.0000	9.86	0	1.0000	9.76			9.69

APPENDIX 3. —Daily counts and cumulative proportion of steelhead trout and water temperatures from Nikolai Creek during 2005 and 2006. Boxed areas represent the second and third quartile and median passage dates. Shaded areas are periods when the weir had been breached by high water.

	2005			2006		
Date	Daily	Cumulative Proportion	Water Temperature	Daily	Cumulative Proportion	Water Temperature
4/15			0.38			0.45
4/16			0.78			0.29
4/17			1.18			1.07
4/18			1.67			1.38
4/19			1.61			1.15
4/20			1.25			1.14
4/21			1.12			1.63
4/22			1.51			1.03
4/23			0.74			1.10
4/24			1.42			0.81
4/25			2.04			0.96
4/26			2.58	0	0.0000	1.68
4/27			3.35	0	0.0000	1.55
4/28			3.35	1	0.0027	1.70
4/29			3.05	0	0.0027	1.40
4/30			3.43	3	0.0107	1.56
5/1			3.73	3	0.0188	1.58
5/2			3.71	3	0.0268	1.63
5/3			3.62	13	0.0617	1.45
5/4	3	0.0357	4.10	22	0.1206	1.72
5/5	0	0.0357	3.29	24	0.1850	1.88
5/6	5	0.0952	4.27	1	0.1877	1.81
5/7	8	0.1905	5.90	2	0.1930	1.42
5/8	19	0.4167	6.38	4	0.2038	1.63
5/9	8	0.5119	6.99	25	0.2708	1.88
5/10	2	0.5357	7.41	25	0.3378	2.58
5/11	21	0.7857	7.30	48	0.4665	3.26
5/12	4	0.8333	7.92	70	0.6542	3.56
5/13	0	0.8333	7.09	52	0.7936	3.38
5/14	7	0.9167	7.43	16	0.8365	3.05
5/15	1	0.9286	7.14	11	0.8660	3.17
5/16	1	0.9405	7.55	14	0.9035	3.40
5/17	0	0.9405	7.76	8	0.9249	3.35
5/18	3	0.9762	7.45	6	0.9410	3.17
5/19	0	0.9762	8.20	3	0.9491	3.36
5/20	2	1.0000	8.91	12	0.9812	3.17
5/21	0	1.0000	8.59	4	0.9920	3.82
5/22	0	1.0000	8.37	3	1.0000	4.69
5/23	0	1.0000	8.32			4.85
5/24	0	1.0000	8.47			5.16
5/25	0	1.0000	9.63			6.05
5/26	0	1.0000	9.40			7.10
5/27	0	1.0000	8.91			8.24
5/28	0	1.0000	9.29			8.67
5/29	0	1.0000	9.51			9.20
5/30	0	1.0000	9.03			9.33
5/31	0	1.0000	8.77			7.74



APPENDIX 4. —Daily and mean water temperatures for Crooked and Nikolai creeks during 2004, 2005, and 2006.