U.S. Fish & Wildlife Service

Abundance and Run Timing of Adult Steelhead in Crooked and Nikolai Creeks, Kenai Peninsula, Alaska, 2008

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Kenneth S. Gates and James K. Boersma

Abstract

Fish weirs with underwater video systems were installed and operated in Crooked and Nikolai creeks during 2008 to collect abundance and run timing information for immigrating adult steelhead *Oncorhynchus mykiss*. A combined total of 1,465 steelhead was counted past the Crooked (*N*=877) and Nikolai (*N*=588) creek weirs between 26 April and 5 June. Peak weekly passage in each creek occurred between 11 and 17 May. Age, sex, and length (ASL) information was collected from 116 steelhead returning to Crooked (*N*=50) and Nikolai (*N*=66) creeks. Females comprised (ASL and video combined) 58% (Crooked Creek) and 60% (Nikolai Creek) of the escapement. The average length of sampled fish during 2008 was 636 and 651 mm at Crooked and Nikolai creeks, respectively. Reported ages of steelhead were determined from scale samples collected at Crooked Creek between 2004 and 2006. Ages were comprised of 15 different life-history patterns including variations in smoltification, saltwater residence, and spawning activity. Females comprised 89% of repeat spawners for all years combined. The majority of the steelhead smolted at 3 years (64%) and returned to spawn after 2 years (66%) in salt water. Water temperatures during the 2008 operational periods ranged from 0.6°C to 9.4°C at Crooked Creek and 0.4°C to 6.1°C at Nikolai Creek.

Introduction

Crooked and Nikolai creeks are the only two streams in the Kasilof River watershed that support steelhead *Oncorhynchus mykiss* according to the Anadromous Waters Catalog (Johnson and Daigneault 2008). Crooked Creek historically supported a small wild run of steelhead 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 fisheries on the Kenai Peninsula because it provided anglers an opportunity to harvest fish. Sport catches of steelhead 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 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 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 available to anglers,

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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 is allowed from Crooked 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 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 with a daily bag limit of 2 per day/2 in possession with only one fish exceeding 20 inches in length. The annual bag limit is 2 rainbow/steelhead greater than 20 inches taken from Kenai Peninsula waters. Harvest of steelhead above the Sterling Highway Bridge is typically fewer than 50 fish annually.

Steelhead 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 returning to the Anchor River on the lower Kenai Peninsula. Begich (1997) has also described the Karluk River steelhead population, the largest steelhead population on Kodiak Island, as a fall run. More recently, USGS operated a weir on the Ninilchik River to enumerate emigrating steelhead (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. Kelts egressing Crooked Creek (16 May – 21 June) and Tustumena Lake tributaries (29 May – 23 June) during 2008 exhibited similar emigration timing to the Ninilchik River based on results from radio-tagged steelhead (Gates, in preparation).

Age of steelhead from the Kasilof River watershed are expected to follow the common pattern for costal wild steelhead in Southcentral Alaska. More than two spawning migrations is unusual although up to five have been recorded (Bali 1959, Lindsay et al. 1991). Repeat spawners are predominately female due to higher post-spawning mortality among males (Shapovalov and Taft 1954, Chapman 1958, Burgner et al. 1992). Wild steelhead have also been determined to primarily smolt at age 3 and return to spawn after 2 years in salt water (Sanders 1985). Steelhead reared in hatcheries usually smolt after 1 year (Chapman 1958, Lindsay et al. 1991) and rarely repeat spawn.

The overwintering distribution of steelhead in the Kasilof River watershed was poorly understood prior to 2008. Steelhead were thought to overwinter in the mainstem river, as indicated by harvest and catch information collected by the Department (Gamblin et al. 2004). The importance of the mainstem Kasilof River as an overwintering area was also supported by the spring migration of spawning steelhead into Crooked Creek (Gates and Palmer 2006a, 2006b, 2008). Since 2007, the Service has also identified Tustumena Lake and its outlet as important overwintering areas for populations of steelhead returning to the Kasilof River watershed (Gates, in preparation).

Preliminary investigations of steelhead were initiated by the Service in Crooked Creek during 2004. The primary objective in 2004 was to develop an underwater video system for enumerating steelhead. Video systems and weirs have been operated in both Crooked and Nikolai creeks since 2005. Escapement estimates for Crooked Creek have ranged from 206 to 766 steelhead. Information regarding the steelhead population in Nikolai Creek prior to 2005 was limited to visual observations made by U.S. Geological Survey (USGS) field technicians during the early 1990's (Carol Woody, U.S. Geological Survey, personal communication) and the presence of one steelhead captured in Tustumena Lake by Jones and Faurot (1991). Escapement estimates made by Gates and Palmer (2006a, 2006b and 2008) from 2005 to 2007 ranged between 84 and 569 fish in Nikolai Creek. Specific objectives during 2008 were to: 1) estimate the abundance and run timing of adult steelhead entering Crooked and Nikolai creeks; 2) estimate the age, sex and length of adult steelhead entering Crooked and Nikolai creeks; and 3) determine if the steelhead spawning in Crooked and Nikolai creeks are genetically distinct from one another and, if so, estimate the level of genetic differentiation. In addition, age determinations were recently finalized for steelhead scale samples collected from Crooked Creek between 2004 and 2006. We will be reporting the findings of this analysis in this report. Information pertaining to the run size, timing, and life-history of steelhead returning to Crooked and Nikolai creeks will provide a better understanding of tributary spawners and assist managers in refining existing management strategies.

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 31 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 11 (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.

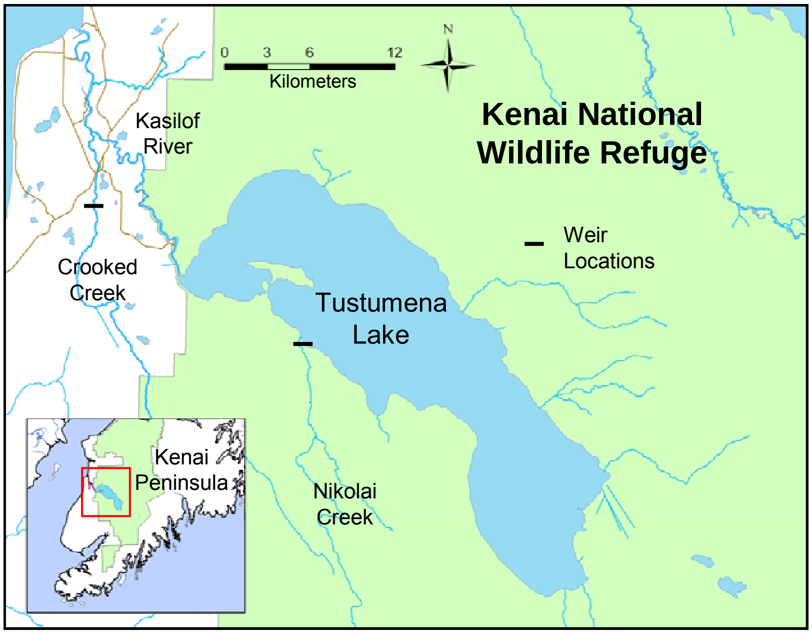

FIGURE 1. —Map of the Kasilof River watershed showing weir locations on Crooked and Nikolai creeks.

Methods

Weir and Video Operations and Design

The weir located at Crooked Creek Hatchery was installed to monitor the steelhead 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 exit the hatchery into Crooked Creek and continue their upstream migration. Fish moving downstream bypass the hatchery and pass 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.

Setup and design of the video system was similar to that used by Gates and Palmer (2006a and 2006b) in Crooked and Nikolai creeks during 2005 and 2006, and Anderson et al. (2004) in Big Creek during 2003. A live trap facilitated biological sampling and was attached to the upstream end of the fish passage panel. The video system, consisting of a sealed camera box and fish passage chute, was attached to the live trap. 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 video chute was constructed from aluminum angle and was enclosed in plywood isolating it from exterior light. The video chute from which video images were captured was modified in 2007 so that the backdrop could be adjusted laterally to minimize the number of fish passing through the chute at one time. The backdrop could also be easily removed from the video chute when dirty and replaced with a new one. Video images from Nikolai Creek were transmitted via a 2.4 GHz 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 500 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

Biological sampling consisted of age, sex, and length (ASL) sampling and genetic tissue collections. Sex was determined by observing external characteristics during sampling efforts and video review. Fish with no assigned sex were marked as unknown and omitted from any analysis. Length measurements were taken as a mid-eye to fork length (MEF) 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 and 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, mounted on gummed cards, scanned digitally and analyzed by the Department in Juneau, Alaska. Scale analysis and reporting utilized methods described by Mosher (1969). Age determination denotes the number of years spent in freshwater as a juvenile followed by the number of years spent in salt water as and adult prior to each spawning event. Spawning events are incorporated into the reporting methods described by Mosher and are denoted using the letter “S” (e.g. 3.2S1).

Genetic tissue was collected from adult steelhead by removing a portion of the axillary process and placing it in a vial containing alcohol. Genetic samples were forwarded to the Conservation Genetics Laboratory in Anchorage, Alaska for analysis. DNA will be extracted from the fin tissue and thirteen microsatellite loci will be used to estimate genetic variation. The laboratory methods will follow those reported in Wuttig et al. (2004). Estimates of intra-population genetic diversity (allele richness and observed and expected heterozygosity) will be computed for each sample. Randomization tests for conformity to Hardy-Weinberg equilibrium will be conducted for each locus, pooling populations, and for each population, pooling loci. Randomization tests for genotypic disequilibrium will be conducted for all locus pairs, pooling populations. A *G*-test of allele frequency homogeneity will be used to test for genetic differentiation between the two putative populations. An estimate of the level of genetic population structure will be computed using the relative measure F_{ST}. All analyses will be performed using the computer program FSTAT version 2.9.3 (Goudet 2001). Results of the genetic analysis will be reported in a subsequent report during 2010.

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 for the duration of each project.

Results

Weir and Video Operations

The weir and video systems at Crooked and Nikolai creeks were operated between 25 April and 5 June. Each project started prior to steelhead entering either stream. The Department assumed the operation of the Crooked Creek weir and video system after 28 May for Chinook salmon enumeration and reported no additional steelhead passing the video system. The video systems ran smoothly during the entire operational period for both creeks, with the exception of image loss at Nikolai Creek between 29 April and 1 May. During this period, the video box filled with turbid river water and images of fish became blurred resulting in incomplete counts. This issue was discovered and repaired the afternoon of 1 May. Once Tustumena Lake was free of ice on 9 May, the weir site was visited nearly each day for cleaning and maintenance. Parts of the weir would sometimes become submerged from high water and debris between visits which may have resulted in incomplete fish counts. Fish counts were not estimated for these periods.

Crooked Creek

A total of 877 steelhead was counted passing the video system at Crooked Creek Hatchery between 26 April and 28 May (Figure 2; Appendix 2). Peak weekly passage (N=330) occurred between 11 and 17 May and median cumulative passage occurred on 11 May. The highest daily count (N=100) occurred on 12 May. The number of steelhead counted after 20 May only represented 2.7% (N=24) of the total escapement. Water temperatures ranged between 4.0°C and 5.7°C between 11 and 17 May (Figure 2; Appendix 4). Half of the total passage occurred between 5 and 15 May at water temperatures ranging from 3.0°C to 4.8°C (Appendix 4).

ASL samples were collected from 50 steelhead between 7 and 22 May, 2008. Sex composition was determined from the review of video records and ASL sampling. Females comprised 58% of the spawning population. Sex ratios favored males during the first half of the run but shifted to a dominant female component during the second half (Figure 3). Mid-eye to fork lengths of steelhead sampled at Crooked Creek during 2008 averaged 623 and 642 mm for males and females, respectively.

Nikolai Creek

A total of 588 steelhead was counted passing Nikolai Creek weir between 27 April and 4 June 2008 (Figure 4; Appendix 3). Peak weekly passage (N=203) occurred between 11 and 17 May. Passage observed during this week accounted for 35% of the total escapement. Median cumulative passage occurred on 11 May. Nearly all of the steelhead (96%) passage occurred at water temperatures less than 5°C with 50% of the total passage occurring between 5 and 17 May at water temperatures ranging from 1.9°C to 3.4°C (Figure 4; Appendix 4).

ASL samples were collected from 66 steelhead between 9 and 16 May. Sampled steelhead averaged 651 mm in length for both sexes. Females accounted for 59% (*N*=39) of the ASL sample and comprised 60% of the total sexed escapement based on the review of video records and ASL samples. Sex composition was skewed towards males early in the run but quickly changed to predominately females throughout the remainder of the run (Figure 5).

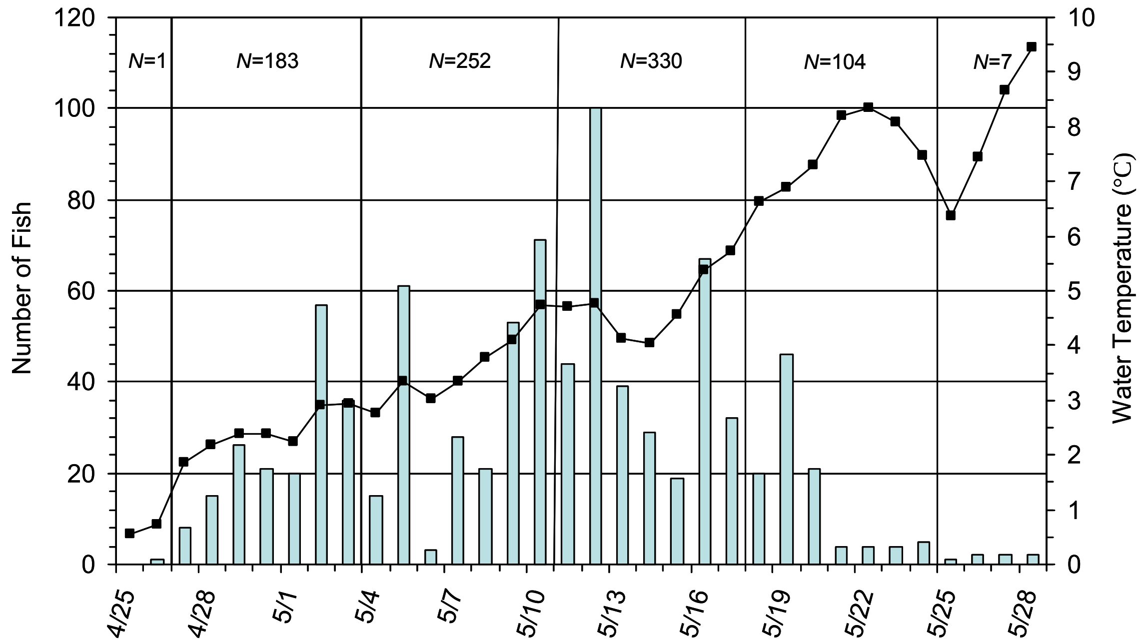

FIGURE 2. —Daily and weekly escapement of adult steelhead and water temperatures in Crooked Creek during 2008. Counts did not begin until mid-day on 25 April.

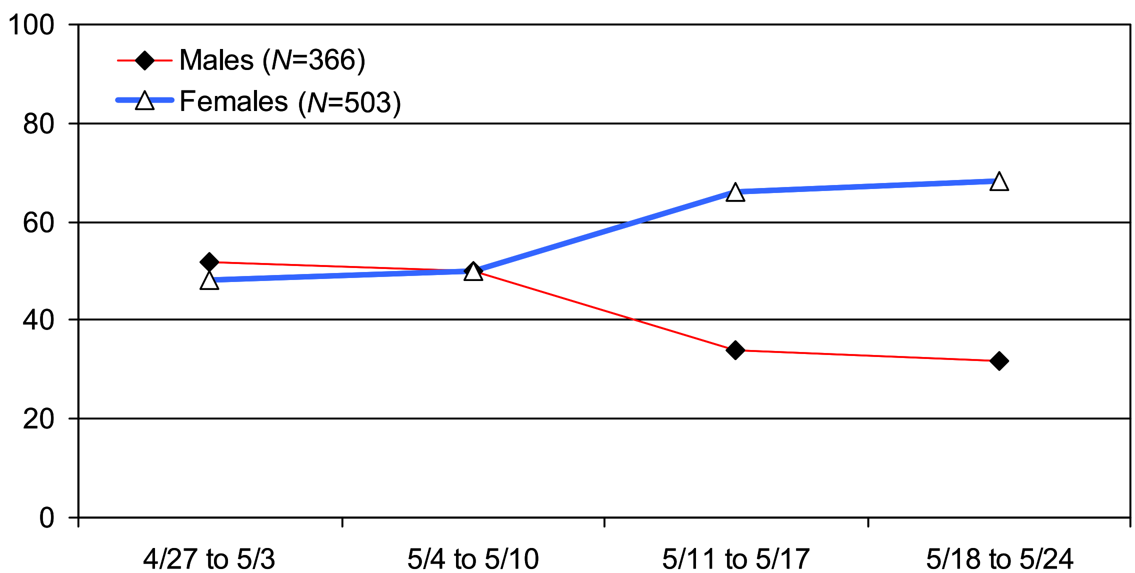

FIGURE 3. —Weekly percent of male and female adult steelhead observed at Crooked Creek during 2008. Steelhead observed prior to 27 April (*N*=1 male) and after 24 May (*N*=3 females and *N*=4 males) were omitted from this figure.

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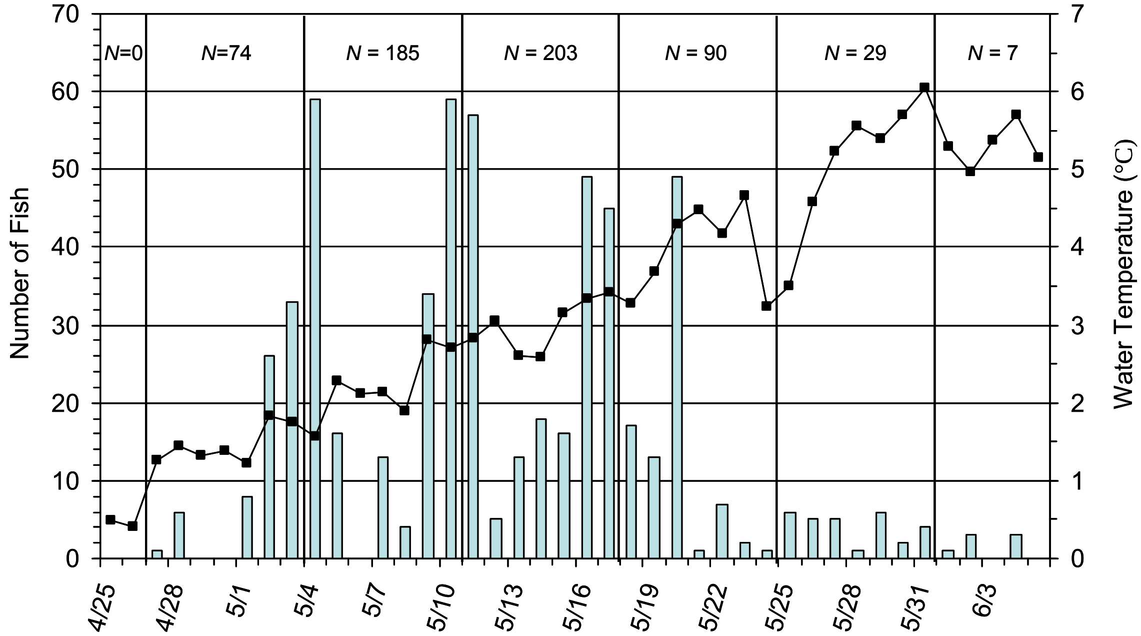

FIGURE 4. —Daily and weekly escapement of adult steelhead and water temperatures in Nikolai Creek during 2008. Counts did not begin until mid-day on 25 April.

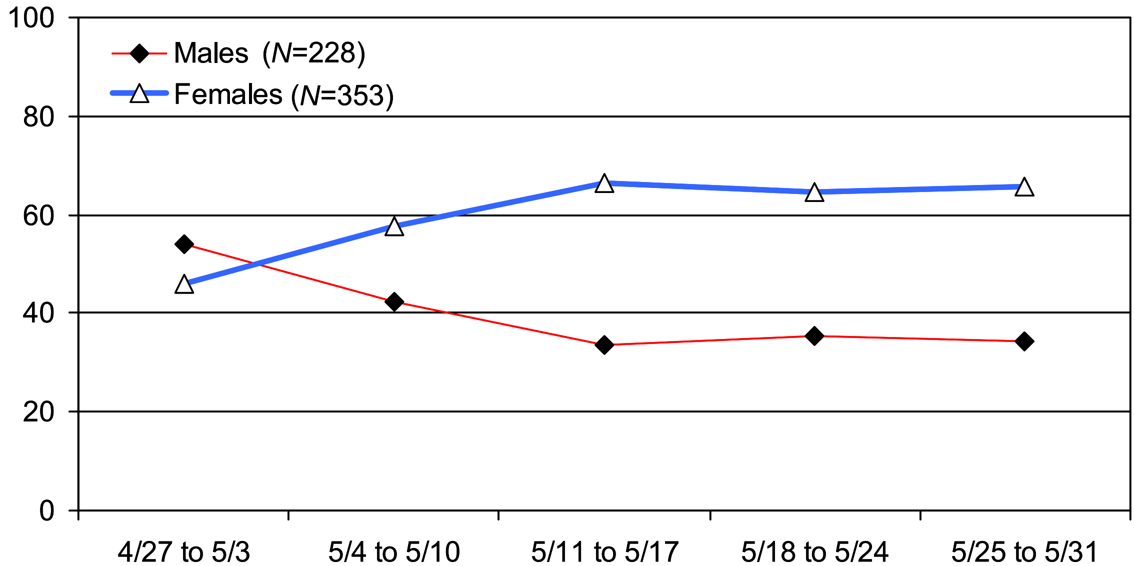

FIGURE 5. —Weekly percent of male and female adult steelhead observed at Nikolai Creek during 2008. Steelhead observed after 31 May (*N*=2 females and *N*=5 males) were omitted from this figure.

Scale Analysis

Ages of steelhead returning to Crooked Creek were determined by analyzing scales sampled from 246 fish between 2004 and 2006. Regeneration occurred in 13% (*N*=31) of the 246 samples. These samples were unreadable and omitted from any further analysis. Freshwater ages were unreadable in 42% (*N*=91) of the remaining 215 fish. Saltwater ages and spawning events were identified in all of the 215 samples. The number of unique age classes identified for female steelhead ranged from 5 to 10 between 2004 and 2006 (Tables 1, 2 and 3). Male age classes ranged between 1 and 6 during the same period. Overall, females averaged 629 mm in length, were comprised primarily of 7-year old fish (63%), and accounted for 73% (*N*=158) of the sample for all years combined. The majority of the male steelhead were 6-year old fish (55%) and averaged 580 mm in length. Freshwater ages at smoltification were primarily 3-year old fish (64%) and ranged between 2 and 4 years regardless of sex. Saltwater ages prior to the first spawning event ranged between 1 and 3 years. The majority of the fish remained in saltwater for 2 years (66%) prior to the first spawning event followed by 3-ocean fish (33%). Repeat spawners were dominant among females (70%) whereas males (75%) were predominately first time spawners (Table 4). Regardless of sex, spawning beyond two events only comprised 12% of the sample (*N*=26) (Table 4).

TABLE 1. —Length-at-age for adult steelhead sampled at Crooked Creek during 2004.

				Mid-Eye to Fork Length	
Sex	Brood Year[a]	Age[b]	*N* [c]	Mean	Range
Female	1998	3.2	1	555	N/A
	1997	3.3	1	600	N/A
	1996	4.3	1	665	N/A
	1997	3.2S1	7	641	570 - 705
	1996	3.2S1S1	7	708	670 - 750
	Unknown	X.2S1	5	640	625 - 680
	Unknown	X.2S1S1	2	630	625 - 635
	Unknown	X.3	5	637	590 - 660
	Unknown	X.3S1S1	1	635	N/A
Total			30		
Male	1998	3.2	10	531	510 - 570
	1997	3.3	1	640	N/A
	1997	4.2	2	485	465 - 505
	1997	3.2S1	1	490	N/A
	Unknown	X.2	6	465	465 - 545
Total			20		

[a] Brood years could not be determined for fish with incomplete ages (*N* =19).
[b] "X" denotes unreadable freshwater age (*N* =19); "S" denotes spawning event.
[c] Fish with unreadable freshwater and saltwater ages were omitted from this table (*N* =8).

TABLE 2. —Length-at-age for adult steelhead sampled at Crooked Creek during 2005.

				Mid-Eye to Fork Length	
Sex	Brood Year[a]	Age[b]	*N*[c]	Mean	Range
Female	2000	2.2	2	590	565 - 615
	1999	3.2	1	620	N/A
	1999	2.2S1	5	623	605 - 660
	1998	3.3	6	613	560 - 640
	1998	4.2	1	680	N/A
	1998	2.3S1	20	614	520 - 700
	1997	3.2S1S1	5	637	600 - 670
	1996	3.2S1S1S1	1	695	N/A
	Unknown	X.2	1	645	N/A
	Unknown	X.3	4	626	615 - 645
	Unknown	X.2S1	10	606	540 - 650
	Unknown	X.2S1S1	1	635	N/A
Total			57		
Male	1999	3.2	3	587	500 - 725
	Unknown	X.2	3	547	535 - 560
	Unknown	X.3	1	690	N/A
	Unknown	X.2S1	1	565	N/A
	Unknown	X.2S1S1	1	730	N/A
	Unknown	X.2S1S1S1	1	690	N/A
Total			10		

[a] Brood years could not be determined for fish with incomplete ages (*N* =23).
[b] "X" denotes unreadable freshwater age (*N* =23); "S" denotes spawning event.
[c] Fish with unreadable freshwater and saltwater ages were omitted from this table (*N* =3).

TABLE 3. —Length-at-age for adult steelhead sampled at Crooked Creek during 2006.

				Mid-Eye to Fork Length	
Sex	Brood Year[a]	Age[b]	*N*[c]	Mean	Range
Female	2001	2.2	1	605	N/A
	2000	2.3	1	670	N/A
	1999	3.3	7	624	590 - 650
	1998	4.3	1	685	N/A
	2000	2.2S1	5	632	615 - 650
	1999	3.1S2	1	650	N/A
	1999	3.2S1	17	618	555 - 675
	1998	4.2S1	2	630	630 - 630
	1997	4.2S1S1	1	700	N/A
	1997	4.3S1	1	555	N/A
	Unknown	X.2	5	532	385 - 645
	Unknown	X.3	9	641	385 - 705
	Unknown	X.2S1	16	629	570 - 685
	Unknown	X.2S1S1	3	683	640 - 735
	Unknown	X.2S1S1S1	1	795	N/A
Total			71		
Male	2001	2.2	1	515	N/A
	2000	3.2	2	508	505 - 510
	1999	3.3	5	615	575 - 705
	2000	2.2S1	1	615	N/A
	1999	3.2S1	2	650	645 - 655
	1998	3.2S1S1	1	690	N/A
	Unknown	X.1S2	1	615	N/A
	Unknown	X.2	2	520	515 - 525
	Unknown	X.3	7	602	550 - 695
	Unknown	X.2S1	4	621	520 - 670
	Unknown	X.3S1S1S1	1	700	N/A
Total			27		

[a] Brood years could not be determined for fish with incomplete ages (*N* =49).
[b] "X" denotes unreadable freshwater age (*N* =49); "S" denotes spawning event.
[c] Fish with unreadable freshwater and saltwater ages were omitted from this table (*N* =20).

TABLE 4. —Frequency of spawning events determined from scale analysis for steelhead sampled at Crooked Creek between 2004 and 2006.

	Spawning Events							
	≥ 1		≥ 2		≥ 3		≥ 4	
Sex	*N*	%	*N*	%	*N*	%	*N*	%
Female	158	100	111	70.3	22	13.9	2	1.27
Male	57	100	14	24.6	4	7.02	2	3.51
Total	215	100	125	59	26	12	4	1

Discussion

A combined total of 1,465 steelhead was counted past the Crooked (*N*=877) and Nikolai (*N*=588) creek weirs between 26 April and 4 June. We feel that these estimates of abundance accurately represent the relative run strength of the steelhead return to each of these streams; however, estimates from Nikolai Creek are likely conservative because high water occasionally submerged the weir. In addition, turbid river water filled the video box between 29 April and 1 May resulting in blurred images of fish and incomplete counts. Steelhead were not immediately observed passing either weir following installation, suggesting that the steelhead migration started after the weirs were installed.

The return of steelhead to Crooked Creek during 2008 was greater than that observed between 2004 and 2007 (Appendix 2). Similarly, steelhead returning to Nikolai Creek were observed in greater numbers during 2008 than in 2005 (*N*=84) 2006 (*N*=373) and 2007 (*N*=569) (Appendix 3). The increase in escapement observed at Nikolai Creek is thought to be attributed to more frequent maintenance of the weir and estimating the early component of the steelhead return. The 2006 escapement may have been similar to the 2007 and 2008 escapement levels if the weir had not been flooded on three occasions during times of peak passage. Estimating the early component of each run is made possible by either one or a combination of the following: earlier weir installation dates and/or a later return of steelhead during 2007 and 2008. Periodic submergence of Nikolai Creek weir and operation of the fish traps at both weir locations likely account for the pulses observed in run intensity (Figures 2 and 4; Appendices 2 and 3).

Observations of sex ratios for steelhead in Crooked and Nikolai creeks have favored females for all years since 2004. Female to male sex ratios were nearly identical between 2006 (1.3:1), 2007 (1.1:1) and 2008 (1.4:1) for Crooked Creek and were the same among years for Nikolai Creek (1.5:1). These sex ratios are considered representative for steelhead 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 2008 are similar to those observed for spring run steelhead populations currently being monitored by the Department in Southeast Alaska (David Love, Alaska Department of Fish and Game, personal communication).

The age composition of steelhead observed in Crooked Creek from 2004 to 2006 exhibited a diverse array of life-history patterns with variations in smolt age, saltwater residence, and spawning activity. The steelhead population in Crooked Creek appears to predominantly smolt after 3 years and tends to spawn for the first time after 2 years in salt water regardless of sex. These observations are congruent with observations made by Sanders (1985) of other wild steelhead populations in Alaska. Repeat spawners were comprised primarily of females (89%) due to higher post-spawning mortality among males (Table 4). The higher mean comprehensive age of females likely explains the greater mean adult length and why sex ratios favor females.

Water temperature and flow regime remain the two factors which likely have the most influence on run timing of steelhead in Crooked and Nikolai creeks. The mean water temperature recorded in Crooked Creek (5.1°C) between 25 April and 31 May, 2008 was slightly cooler than what was recorded during 2007 (5.5°C) for the same period. The mean water temperature recorded in Nikolai Creek (2.5°C) between 15 April and 30 May, 2008 was the coldest recorded since 2004. During 2008, water temperatures in Crooked Creek remained cooler earlier in the steelhead run before gradually increasing to 9.4°C on 28 May (Appendix 4). Water temperatures in Nikolai Creek remained even colder never exceeding 6.1°C during the operational period (Appendix 4). Although the run timing of steelhead in Nikolai Creek was similar to Crooked Creek, the average daily water temperatures did not reach 2°C until 5 May (Appendix 4). In this instance, increases in discharge may have had a greater influence than water temperature in triggering the immigration of steelhead in Nikolai Creek. Other studies have also noted that water temperature and discharge are important environmental factors influencing the upstream movement of steelhead (Shapovalov and Taft 1954; Kesner and Barnhart 1972; Jones 1972).

In conclusion, installing Crooked and Nikolai creek weirs during the third week of April has 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 inexpensive and reliable tools to monitor the abundance and run timing of these two steelhead populations. We plan to monitor steelhead escapement in both streams during 2009. The Nikolai Creek weir and video operations during 2009 will be funded by the Office of Subsistence Management, Fisheries Resource Monitoring Program. All genetic samples will be processed by the Conservation Genetics Laboratory to determine if the two populations are distinct from one another and to what level. Weather conditions permitting, both weirs will be installed and operational by 25 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 in the Kasilof River watershed.

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APPENDIX 1. —List of video and microwave equipment used to monitor adult steelhead abundance at Crooked and Nikolai creeks during 2008.

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 500 GB	Maxtor.com	http://www.maxstore.com
2.4 GHz Microwave Transmitter	BE-530T	Premier Wireless, Inc	http://www.premierwirelessinc.com
2.4 GHz Microwave Receiver	BE-322R	Premier Wireless, Inc	http://www.premierwirelessinc.com
2.4 GHz Parabolic Antennas	130135	California Amplifier	http://www.calamp.com
80 W Solar Module	NE-80EJEA	Sharp	http://solar.sharpusa.com
400 Ah 6 Volt Battery	S-530	Rolls	http://www.rollsbattery.com/
100 Ah 12 Volt Battery	ES27	Exide Technologies	http://www.exide.com/
Charge Controller	ASC8-12	Specialty Concepts, Inc.	http://www.specialtyconcepts.com/
Charge Controller	ASC16-12	Specialty Concepts, Inc.	http://www.specialtyconcepts.com/

APPENDIX 2. —Daily counts and cumulative proportion of adult steelhead observed passing the Crooked Creek weir between 2004 and 2008. Boxed areas represent the second and third quartile and median passage dates. Shaded areas are periods when the fish trap was operated for age, sex, and length sampling.

	2004		2005		2006		2007		2008	
Date	Daily	Cumulative Proportion	Daily	Cumulative Proportion	Daily	Cumulative Proportion	Daily	Cumulative Proportion	Daily	Cumulative Proportion
4/21					0	0.0000				
4/22					0	0.0000				
4/23					0	0.0000				
4/24					0	0.0000				
4/25					0	0.0000	0	0.0000	0	0.0000
4/26					0	0.0000	1	0.0013	1	0.0011
4/27					1	0.0017	1	0.0026	8	0.0103
4/28					1	0.0033	2	0.0052	15	0.0274
4/29			20	0.0528	7	0.0149	2	0.0078	26	0.0570
4/30			35	0.1451	7	0.0265	10	0.0209	21	0.0810
5/1			38	0.2454	2	0.0298	15	0.0405	20	0.1038
5/2			34	0.3351	11	0.0480	19	0.0653	57	0.1688
5/3			32	0.4195	15	0.0728	15	0.0849	36	0.2098
5/4	6	0.0291	19	0.4697	3	0.0778	23	0.1149	15	0.2269
5/5	11	0.0825	25	0.5356	39	0.1424	47	0.1762	61	0.2965
5/6	21	0.1845	16	0.5778	18	0.1722	38	0.2258	3	0.2999
5/7	25	0.3058	24	0.6412	1	0.1738	22	0.2546	28	0.3318
5/8	20	0.4029	42	0.7520	24	0.2136	33	0.2977	21	0.3558
5/9	15	0.4757	24	0.8153	2	0.2169	52	0.3655	53	0.4162
5/10	31	0.6262	27	0.8865	91	0.3675	21	0.3930	71	0.4971
5/11	21	0.7282	18	0.9340	77	0.4950	27	0.4282	44	0.5473
5/12	5	0.7524	0	0.9340	54	0.5844	39	0.4791	100	0.6613
5/13	9	0.7961	6	0.9499	36	0.6440	24	0.5104	39	0.7058
5/14	4	0.8155	4	0.9604	70	0.7599	33	0.5535	29	0.7389
5/15	4	0.8350	2	0.9657	13	0.7815	49	0.6175	19	0.7605
5/16	7	0.8689	2	0.9710	70	0.8974	97	0.7441	67	0.8369
5/17	2	0.8786	4	0.9815	7	0.9089	44	0.8016	32	0.8734
5/18	2	0.8883	1	0.9842	32	0.9619	36	0.8486	20	0.8962
5/19	12	0.9466	3	0.9921	3	0.9669	26	0.8825	46	0.9487
5/20	7	0.9806	1	0.9947	5	0.9752	35	0.9282	21	0.9726
5/21	1	0.9854	1	0.9974	5	0.9834	15	0.9478	4	0.9772
5/22	2	0.9951	0	0.9974	5	0.9917	16	0.9687	4	0.9818
5/23	0	0.9951	1	1.0000	4	0.9983	7	0.9778	4	0.9863
5/24	0	0.9951			1	1.0000	9	0.9896	5	0.9920
5/25	1	1.0000					3	0.9935	1	0.9932
5/26							2	0.9961	2	0.9954
5/27							2	0.9987	2	0.9977
5/28							1	1.0000	2	1.0000
Total	206		379		604		766		877	

APPENDIX 3. —Daily counts and cumulative proportion of adult steelhead observed passing the Nikolai Creek weir between 2005 and 2008. 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, the video system was rendered inoperable, or a fish trap was operated for age, sex, and length sampling.

	2005		2006		2007		2008	
Date	Daily	Cumulative Proportion	Daily	Cumulative Proportion	Daily	Cumulative Proportion	Daily	Cumulative Proportion
4/25					0	0.0000	0	0.0000
4/26			0	0.0000	0	0.0000	0	0.0000
4/27			0	0.0000	1	0.0018	1	0.0017
4/28			1	0.0027	1	0.0035	6	0.0119
4/29			0	0.0027	3	0.0088	0	0.0119
4/30			3	0.0107	19	0.0422	0	0.0119
5/1			3	0.0188	2	0.0457	8	0.0255
5/2			3	0.0268	2	0.0492	26	0.0697
5/3			13	0.0617	7	0.0615	33	0.1259
5/4	3	0.0357	22	0.1206	5	0.0703	59	0.2262
5/5	0	0.0357	24	0.1850	15	0.0967	16	0.2534
5/6	5	0.0952	1	0.1877	10	0.1142	0	0.2534
5/7	8	0.1905	2	0.1930	6	0.1248	13	0.2755
5/8	19	0.4167	4	0.2038	8	0.1388	4	0.2823
5/9	8	0.5119	25	0.2708	11	0.1582	34	0.3401
5/10	2	0.5357	25	0.3378	16	0.1863	59	0.4405
5/11	21	0.7857	48	0.4665	6	0.1968	57	0.5374
5/12	4	0.8333	70	0.6542	7	0.2091	5	0.5459
5/13	0	0.8333	52	0.7936	45	0.2882	13	0.5680
5/14	7	0.9167	16	0.8365	67	0.4060	18	0.5986
5/15	1	0.9286	11	0.8660	60	0.5114	16	0.6259
5/16	1	0.9405	14	0.9035	105	0.6960	49	0.7092
5/17	0	0.9405	8	0.9249	32	0.7522	45	0.7857
5/18	3	0.9762	6	0.9410	18	0.7838	17	0.8146
5/19	0	0.9762	3	0.9491	25	0.8278	13	0.8367
5/20	2	1.0000	12	0.9812	41	0.8998	49	0.9201
5/21			4	0.9920	13	0.9227	1	0.9218
5/22			3	1.0000	14	0.9473	7	0.9337
5/23					1	0.9490	2	0.9371
5/24					3	0.9543	1	0.9388
5/25					8	0.9684	6	0.9490
5/26					4	0.9754	5	0.9575
5/27					13	0.9982	5	0.9660
5/28					1	1.0000	1	0.9677
5/29							6	0.9779
5/30							2	0.9813
5/31							4	0.9881
6/1							1	0.9898
6/2							3	0.9949
6/3							0	0.9949
6/4							3	1.0000
6/5							0	1.0000
Total	84		373		569		588	

APPENDIX 4. —Daily water temperatures for Crooked and Nikolai creeks from 2004 to 2008.

	Crooked Creek					Nikolai Creek			
Date	2004	2005	2006	2007	2008	2005	2006	2007	2008
4/15	0.76	0.57	0.00			0.38	0.45	0.06	0.16
4/16	0.86	1.55	0.00			0.78	0.29	0.06	0.37
4/17	0.89	1.82	0.00			1.18	1.07	0.06	0.66
4/18	1.44	2.02	0.14	0.05		1.67	1.38	0.06	1.14
4/19	1.51	2.29	0.88	0.14		1.61	1.15	0.06	1.19
4/20	1.80	2.19	1.15	0.17		1.25	1.14	0.06	1.02
4/21	2.41	2.85	1.29	0.15		1.12	1.63	0.07	0.90
4/22	3.10	2.05	1.09	0.16		1.51	1.03	0.16	0.62
4/23	3.06	1.87	1.31	0.53		0.74	1.10	0.49	0.92
4/24	2.83	3.60	1.25	0.49		1.42	0.81	0.53	0.99
4/25	3.37	5.08	1.17	1.12	0.56	2.04	0.96	0.62	0.48
4/26	4.30	6.09	1.54	2.45	0.73	2.58	1.68	1.12	0.40
4/27	3.46	6.83	1.92	2.76	1.85	3.35	1.55	1.32	1.26
4/28	3.16	7.00	2.09	2.65	2.17	3.35	1.70	1.22	1.45
4/29	3.94	7.10	2.00	2.87	2.37	3.05	1.40	1.35	1.32
4/30	4.39	7.73	2.32	3.04	2.38	3.43	1.56	1.60	1.38
5/1	5.56	7.11	2.39	3.13	2.24	3.73	1.58	1.56	1.22
5/2	6.01	6.95	2.24	2.95	2.91	3.71	1.63	2.08	1.83
5/3	5.85	6.59	2.31	3.73	2.95	3.62	1.45	2.40	1.75
5/4	7.43	5.90	2.45	4.80	2.75	4.10	1.72	2.44	1.57
5/5	8.09	6.10	2.57	5.00	3.34	3.29	1.88	2.47	2.27
5/6	8.93	7.81	2.83	4.63	3.03	4.27	1.81	2.34	2.12
5/7	9.51	8.80	2.53	4.67	3.35	5.90	1.42	2.19	2.14
5/8	8.75	9.39	2.44	5.06	3.79	6.38	1.63	2.58	1.89
5/9	7.46	9.92	2.66	4.98	4.10	6.99	1.88	2.60	2.81
5/10	7.90	10.04	3.06	4.41	4.74	7.41	2.58	2.30	2.70
5/11	8.29	10.10	4.27	5.06	4.72	7.30	3.26	2.67	2.82
5/12	8.24	8.89	5.07	4.95	4.76	7.92	3.56	2.80	3.06
5/13	9.14	8.47	5.63	4.61	4.14	7.09	3.38	3.13	2.61
5/14	8.58	7.99	5.73	5.24	4.04	7.43	3.05	3.34	2.58
5/15	7.02	8.33	5.85	6.10	4.57	7.14	3.17	4.17	3.15
5/16	6.41	9.18	6.22	6.98	5.38	7.55	3.40	3.72	3.34
5/17	6.11	8.97	5.79	6.66	5.73	7.76	3.35	3.75	3.41
5/18	7.18	9.71	6.18	6.84	6.64	7.45	3.17	3.67	3.28
5/19	8.61	10.75	5.64	6.94	6.90	8.20	3.36	4.28	3.68
5/20	9.86	10.08	5.58	7.78	7.31	8.91	3.17	4.58	4.29
5/21	10.74	10.13	6.05	8.11	8.19	8.59	3.82	4.89	4.48
5/22	11.78	10.28	8.06	7.96	8.33	8.37	4.69	4.58	4.18
5/23	11.00	10.05	9.39	6.03	8.09	8.32	4.85	4.15	4.65
5/24	9.11	10.71	10.16	6.50	7.48	8.47	5.16	4.93	3.23
5/25	8.78	10.85	10.46	6.92	6.36	9.63	6.05	4.86	3.49
5/26	9.05	10.22	11.00	6.29	7.43	9.40	7.10	4.93	4.57
5/27	9.10	10.07	11.24	7.06	8.66	8.91	8.24	5.62	5.22
5/28	8.21	10.33	11.47	6.98	9.44	9.29	8.67	5.70	5.55
5/29	8.93	9.86	11.17	8.72	9.37	9.51	9.20	5.00	5.40
5/30	10.37	10.26	11.09	10.41	9.43	9.03	9.33	6.45	5.70
5/31	9.86	9.76	9.69	10.41	9.72	8.77	7.74		6.05
6/1									5.30
6/2									4.97
6/3									5.37
6/4									5.70
6/5									5.15