Fishery Data Series No. 09-56

Assessment of Adult Steelhead Populations on Prince of Wales Island, Alaska: Big Ratz Creek and Natzuhini Creek, 2007 and 2005–2007 Final Report

by

Kelly S. Piazza

November 2009

Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Department of Fish and Game	ADF&G
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

In 2007, weirs were installed in Big Ratz Creek and Natzuhini Creek on Prince of Wales Island, Southeast Alaska to collect information on the escapement, run timing, composition, and the relationship between snorkel surveys and weir counts for the development of expansion factors. This report will summarize the information gathered from Big Ratz Creek and Natzuhini Creek, the final year of a 3-year project.

The minimum spawning escapement at Big Ratz Creek was 284 steelhead. Females comprised 62% of the run. Age classes 3.2 (59.5%) and 3.3 (35.7%) dominated among spawning fish in Big Ratz Creek. The average total lengths of female and male steelhead from Big Ratz Creek were 727 mm (SE = 5.4) and 806 mm (SE = 8.5), respectively. Of the 251 fish measured, one (0.6%) female fish was ≥36 inches (914 mm) TL. Twelve snorkel surveys were conducted during the season; on average, 24.4% (SD = 8.6%; n = 10) of the weir count count was observed.

The minimum spawning escapement at Natzuhini Creek was 78 steelhead. Females comprised 68% of the run. Age classes 4.2 (42.9%) and 3.3 (28.6%) dominated among spawning fish in Natzuhini Creek. The average total lengths of female and male steelhead from Natzuhini Creek were 736 (SE = 11.2) and 718 mm (SE = 13.6), respectively. Of the 74 fish measured, none were ≥36 inches TL. Eleven snorkel surveys were conducted during the season; on average 50.9% (SD = 9.4%; n = 6) of the weir count count was observed.

Key words: steelhead, *Oncorhynchus mykiss*, escapement, snorkel survey, weir, age-sex-length composition, expansion factor, Prince of Wales Island, Southeast Alaska

INTRODUCTION

Steelhead *Oncorhynchus mykiss* are an important subsistence resource for rural residents of Prince of Wales Island (PWI). Subsistence users have traditionally harvested steelhead from the island's streams during fall through spring. Nearly all of these streams are located within the Federal Conservation Unit boundaries of the Tongass National Forest. Explicit regulations for subsistence fishing for steelhead on PWI have existed under the Federal Subsistence Program since 2003.

Annual escapements of steelhead are known to occur in at least 309 watersheds in Southeast Alaska and there are 74 drainages known to contain steelhead on PWI (Figure 1). However, the amount of information on PWI steelhead populations is limited and estimates of adult abundance are largely unavailable. Prior to this project, assessments of PWI steelhead populations consisted of sporadic use of weirs (Jones 1984; Hoffman et al. 1990; Harding and Jones 1993; Hoffman 2007, 2008) and snorkel survey counts (Tables 1 and 2) in select systems. These data, along with casual observations by Alaska Department of Fish and Game (ADF&G) and U.S. Forest Service (USFS) staff during the 1980s to 1990s, were used to categorize *a priori* each steelhead system as "small" (less than 150 fish) or "large" (greater than 150 fish).

In the early 1990s, ADF&G fishery managers interpreted increasing sport fishing effort, coupled with decreasing harvest and total catch (all fish landed including both harvested and released fish), as strong indications of declining abundance throughout Southeast Alaska (Harding and Jones 2004). By the mid-1990s, harvest opportunities under sport fishing regulations were significantly restricted to the current regulations that only allow sport harvest of steelhead greater than 36 inches TL. Under these regulations, sport harvests dramatically declined while sport effort and catch stabilized or increased throughout the region. However, stable or even increasing angler catch of steelhead may disguise or mislead the true abundance of steelhead in streams (Hooten 2001); as anglers become more efficient their catches may increase, but steelhead abundance may be lower. ADF&G does believe, however, that the current conservative regulations provide for sustainability of steelhead stocks while allowing for a limited harvest opportunity.

Unfortunately, system-specific sport fishery data for PWI steelhead are limited. Onsite creel surveys were conducted by ADF&G on the Karta River (1983, 1989, and 1992), the Thorne River

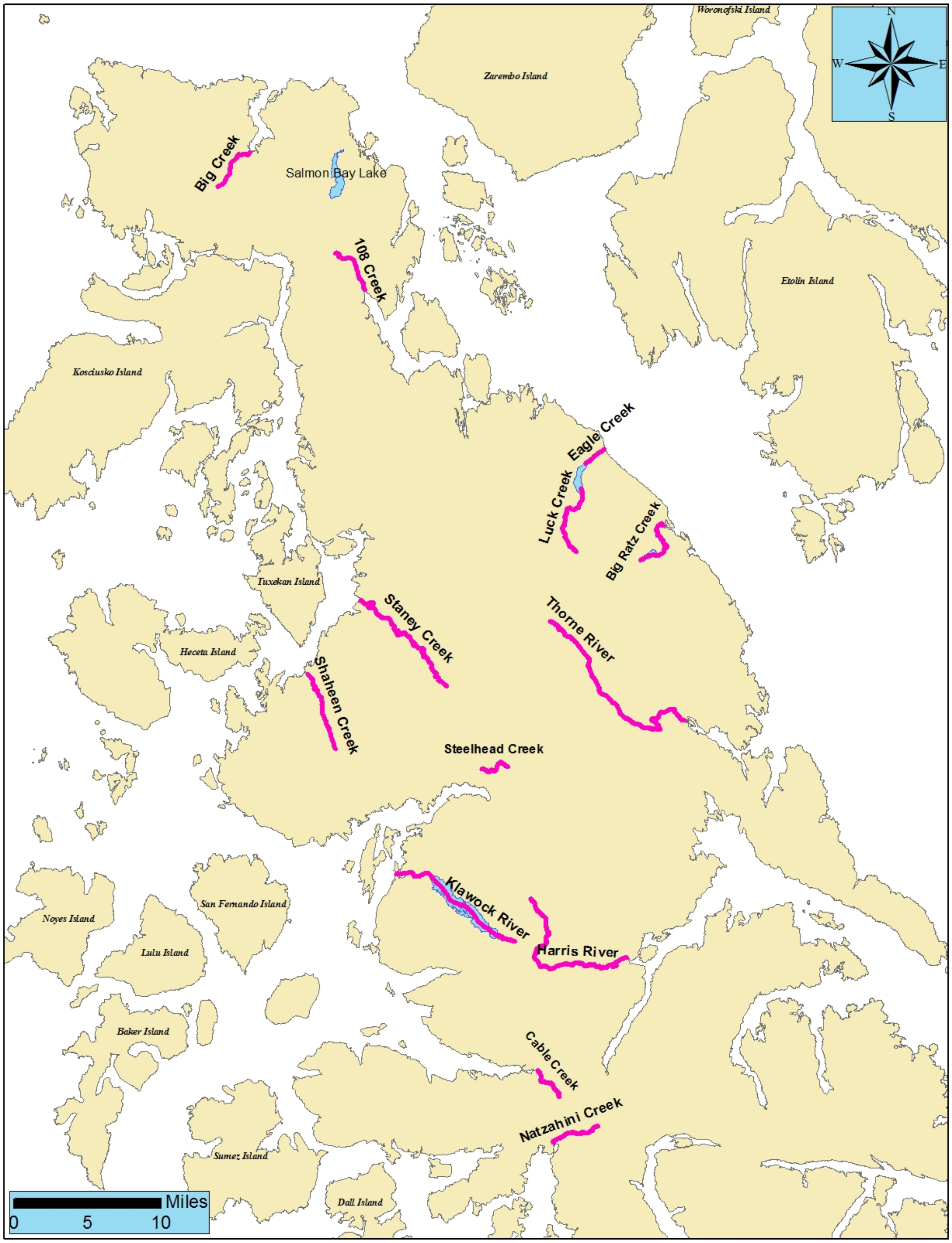

Figure 1.–Prince of Wales Island, Southeast Alaska: locations of "small" and "large" steelhead streams that support subsistence harvest, nominated for inclusion in this study.

Table 1.–Steelhead peak index counts for selected streams on Prince of Wales Island, 1994–2006. A peak count is defined as a bracketed count having a lower count before and after the high or peak count. (USFS 2002, *Unpublished*).

Year sampled	Harris River[a]	Trocadero Creek	Cable Creek	Maybeso Creek	Dog Salmon Creek	12-Mile Creek	Nutkwa Creek	Black Bear Creek	Big Ratz Creek	Shaheen Creek	Sal Creek
1994	94	18	34	6	50						
1995	151	30	52	19	13	40					
1996	127	21	24	17	6	33					
1997	99	18	26	6	15	28	32				
1998	140	4	10	19	14	20	42				
1999	192	28	31	13	17	42		51			
2000	80	22	7	1	14	5		24		33	3
2001	100	9	8	13	16	23			17	34	4
2002	188	43	30	6		47		18	19	32	21
2003	196	21	37	14	36	52					
2004				2		57					
2005		8	13	6	19	33					
2006			110			32					

[a] Harris River counts presented in Table 1 were conducted by USFS staff and differ from the counts presented in Table 2, which were conducted by ADF&G staff.

Table 2.–Steelhead snorkel surveys conducted in Eagle Creek and Harris River, 1997–2006. Peak count (P) is defined as a bracketed count having a lower count before and after the high or "peak" count; high count (H) is defined as an unbracketed count and is the highest count for that year (Harding 2005, *In prep;* Harding 2008).

	Peak (P) or high (H) steelhead count	
Year	Eagle Creek	Harris River
1997	90 (H)	104 (H)
1998	56 (P)	156 (P)
1999	118 (H)	192 (H)
2000	82 (P)	79 (P)
2001	NA	53 (H)
2002	36 (P)	200 (H)
2003	95 (H)	195 (H)
2004	67 (H)	124 (P)
2005	102 (H)	122 (P)
2006	154 (P)	92 (P)

(1988–1990), and the Klawock River (1987–1988) (Jones 1984; Hoffman et al. 1990; Harding and Jones 1993; Freeman and Hoffman 1989-1991). Sport catch and harvest for all species are annuallyestimated throughout Alaska from postal surveys of sport fishing license holders (Didier et al. 1990). However, sample sizes from these postal surveys are usually insufficient to accurately estimate system-specific sport harvest and catch of steelhead from these small sport fisheries. These results indicate that most of the sport fishing effort is directed at systems with spring run steelhead.

Some site specific angler information is available from anglers reserving and utilizing USFS recreational cabins to access steelhead streams (e.g., Harding et al. 2005). During 2006, a postal survey was sent to party heads utilizing USFS recreational cabins on five PWI systems (Karta, Kegan, Red Bay Lake, Staney and Sweetwater). Anglers fishing from these cabins caught an estimated 461 steelhead; most of this catch (444) and harvest (24) came from the three cabins on the Karta system (Harding et al. *In prep*).

Although not provided for in regulation at the time, subsistence harvest of steelhead by PWI residents was estimated from household surveys in 1997, 1998 and 1999. During these years, the total estimated harvest across all 12 PWI communities was 770 fish. This harvest estimate included harvest taken by commercial gear, non-commercial gear and rod and reel. Most of the harvest (636 fish) was taken using rod and reel, primarily by residents of Craig, Klawock, and Hydaburg (ADF&G 2000).

The federal subsistence fishery for steelhead is managed under different regulations for small and large systems, as well as spring and fall runs, and road-accessible and remote systems. Since inception of the federal subsistence fishery in

2003, subsistence harvest is required to be reported on permits. Annual subsistence harvest of steelhead on PWI tallied from permit returns totaled approximately 39 fish annually from 2003–2006 (USFS *Unpublished*). Turek (2005) conducted a study of subsistence harvest use patterns for steelhead on PWI. Although subsistence harvest was not rigorously estimated as part of this study, results from key respondent interviews suggest that actual subsistence harvest of steelhead by PWI residents in 2004 was in the hundreds of fish, similar to the results of household surveys from the 1990s. The large discrepancy in subsistence harvest estimates remains a conundrum and major source of uncertainty for federal subsistence fishery managers (Doug McBride, Office of Subsistence Management, personal communication).

Low levels of steelhead harvest under the current federal subsistence steelhead fishery, coupled with potential illegal harvest and a popular sport fishery in 2003 and the lack of accurate contemporary data on PWI steelhead stocks, prompted the formation of a cooperative steelhead stock asessment project between ADF&G, the Organized Village of Kasaan (OVK), the Bureau of Indian Affairs (BIA), and the USFS in 2005. The purpose of this project was to gather baseline stock assessment data on a subset of PWI streams that support subsistence harvest of steelhead. Information was collected on the escapement, run timing, age-sex-length composition, and the relationship between snorkel surveys and weir counts for development of expansion factors. Knowledge about the strength and timing of these runs will provide a sound biological foundation upon which fishery managers can base management actions. This report will summarize the information gathered from Big Ratz Creek and Natzuhini Creek in 2007, the final year of a 3-year project.

The objectives of the 2007 study were to:

1) count all immigrant and emigrant steelhead in Big Ratz Creek and Natzuhini Creek;
2) determine or estimate the length composition of immigrant steelhead in each stream;
3) estimate the age composition of immigrant steelhead in each stream such that all estimated fractions are within 10 percentage points of the true value 95% of the time; and
4) estimate system-specific mean expansion factors for converting snorkel survey counts to concurrent weir counts such that each of this year's abundance estimates (one for each survey) using this mean expansion factor are within 50 percentage points of the true value 90% of the time.

An additional task included collection of tissue samples from immigrant steelhead for genetic stock identification.

METHODS

SELECTION OF STREAMS FOR STUDY

Six freshwater stream systems were selected from a list of systems that support spring steelhead runs for this 3-year project (Table 3). Streams were selected based on a combination of criteria:

1) Importance to the subsistence fishery. Streams to be studied needed to support subsistence fishing effort, as determined by 2003–2004 USFS subsistence permits, results of the 2003–2004 ADF&G Subsistence Division household surveys, discussions between state and federal biologists, and consultation with PWI Native organizations.
2) Abundance of the adult steelhead populations. Systems from each *a priori* category ("small system" = less than 150 returning adult fish, or "large system" = greater than 150 returning adult fish) were to be studied.
3) Accessibility. Streams were categorized as either road accessible or remote. Road-accessible streams support most of the subsistence effort, and therefore most remote systems were not included for study.

Big Ratz Creek and Natzuhini Creek were chosen to be studied during the third year of the project. Turek (2005) indicated that the local residents of PWI utilize Big Ratz Creek and Natzuhini Creek

Table 3.–Prince of Wales Island stream systems proposed for steelhead population studies by management category *("*" denotes systems with a high priority for inclusion*).

Population size management category	Access management category	Stream name
Small populations $(\hat{N} < 150)$	Road-accessible system	Cable Creek*
		Natzuhini Creek*
		Naukati Creek
		Big Ratz Creek*
		Hatchery Creek
		Shaheen Creek*
	Remote system	Salmon Bay Creek*
		Lake Creek
		Hunter Creek
		Cabin Creek
		Old Franks Creek
		Trout Creek (Kosciusko Island)
Large populations $(\hat{N} > 150)$	Road-accessible system	Harris River*
		Eagle Creek*
		Thorne River*
		Hydaburg River*
		Klawock River*
	Remote system	Karta River*

for subsistence steelhead fishing. In addition, local PWI fish biologists and representatives of the PWI Native organizations emphasized that these streams are targeted by both sport and subsistence users (R. Peterson, Organized Village of Kasaan, personal communication; S. McCurdy, ADF&G, personal communication; A. Cross, USFS, personal communication). Based on subsistence harvest records, popularity with local anglers, and road accessibility, Big Ratz Creek and Natzuhini Creek were found to be ideal choices. Big Ratz Creek was also studied in 2005, during the first year of this project. Big Ratz Creek was chosen for a second year of study to learn more about interannual variation within the system.

Big Ratz Creek is a "large" system located on the eastern side of central Prince of Wales Island, which flows into Clarence Straight via Ratz Harbor (Figure 2). Big Ratz Creek (ADF&G Anadromous Stream Catalog No. 106-10-10100) is about 6.4 km long and drains Trumpeter, Little and Big lakes. A USFS fish ladder is located immediately downstream from the Big Lake outlet. Big Ratz Creek is accessible via USFS road 30.

Natzuhini Creek is a "small" system located on the western side of central Prince of Wales Island, northwest of the community of Hydaburg (Figure 3). Natzuhini Creek (ADF&G Anadromous Stream Catalog No. 102-60-10820), with its 7 small unnamed tributaries, is about 14.5 km long, flows in a westerly direction, and drains into Natzuhini Bay. Natzuhini Creek is readily accessible via the Hollis and Hydaburg roads.

WEIRS

Aluminum bipod weirs were installed in each stream approximately 400m above saltwater (Figures 2 and 3). The weirs were comprised of 18 mm diameter aluminum pickets spaced 31 mm apart. Two separate immigrant and emigrant adult steelhead traps (2.5 m^2 each) were placed on the upstream and downstream sides of each weir. Weir integrity was checked daily, and each trap was checked every few hours for the presence of fish. Fish were processed as soon as possible after entering the trap. If debris became a problem, the weirs were brushed clean and cleared. Water temperature and depth were recorded at about 0800-0900 each day, and only after the weir surfaces were cleaned.

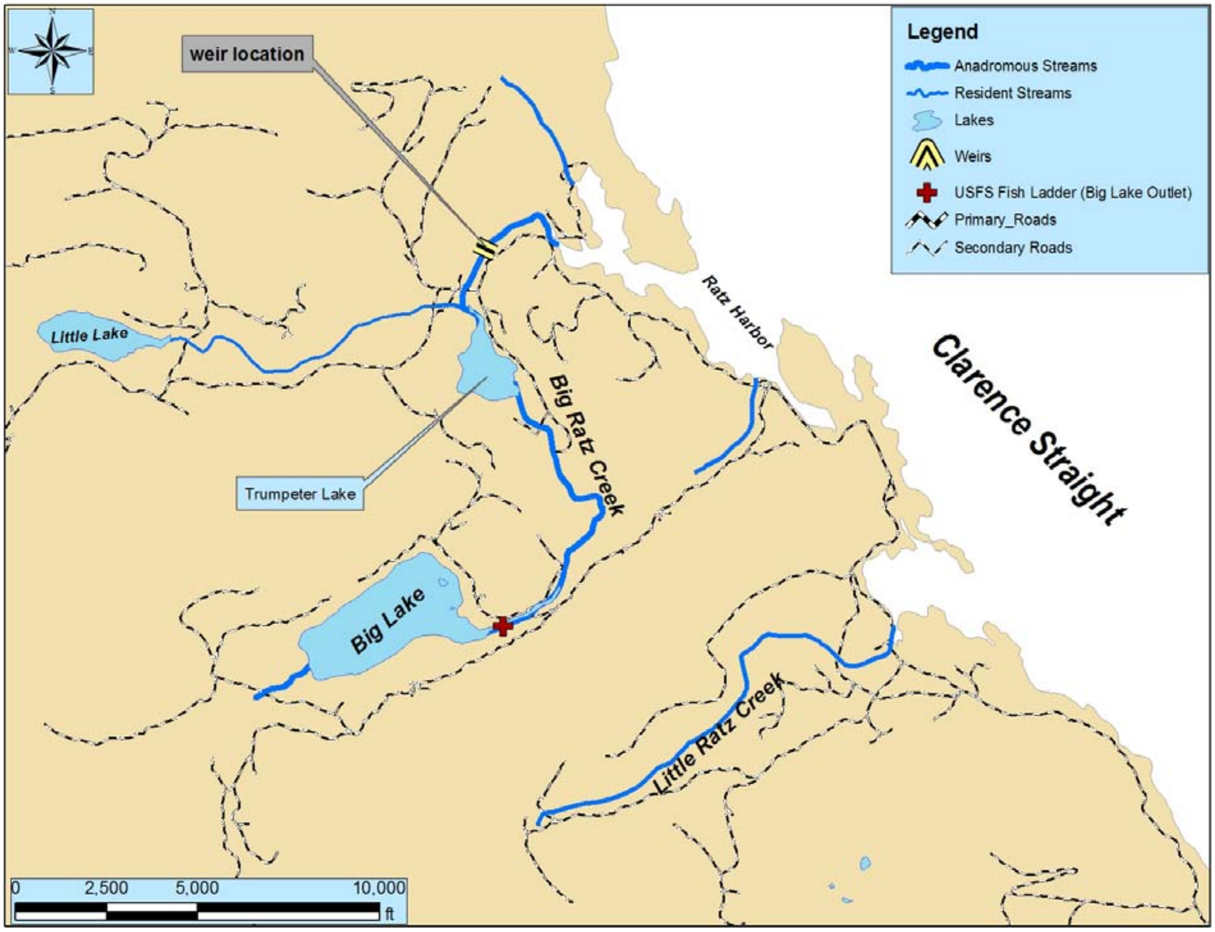

Figure 2.–Location of weir on Big Ratz Creek, Prince of Wales Island.

WEIR COUNTS AND AGE, SEX, LENGTH AND GENETIC SAMPLING

All immigrating adult steelhead captured at the weir were counted and measured to the nearest 5 mm FL and TL (current sport fishing regulations are based on total length, and additional comparisons between fork length and total length were desired), and gender was determined using secondary sexual characteristics. Scales samples were collected from all immigrating steelhead for age estimation. Four scales were collected from the left side of each fish. Scales were taken from the area 2 rows above the lateral line and along a line from the posterior end of the dorsal fin to the anterior end of the anal fin (Alvord 1954). Scales were then placed on labeled gum cards and pressed flat in sequential order for storage until aging and electronic imaging could be performed in the laboratory. After measuring length and determining sex, each fish was marked with a top caudal lobe finclip to indicate that it had been previously sampled. A small portion of the detached top caudal fin lobe was collected from 100 steelhead from each stream and placed into 70% ethanol for genetic analysis by U.S. Fish and Wildlife Service (USFWS) Genetics Laboratory in Anchorage. All steelhead kelts (post-spawned emigrant steelhead) were counted and checked for the presence of a caudal finclip. Scale samples removed from adult steelhead were removed from the gum cards, placed on glass slides, and analyzed with electronic imaging software. Images were aged using methods described by Jones (*Undated/Unpublished*). Two technicians independently estimated the age of each fish. Prior to each scale reading, the scale images were "shuffled" (or other measures were taken) to ensure

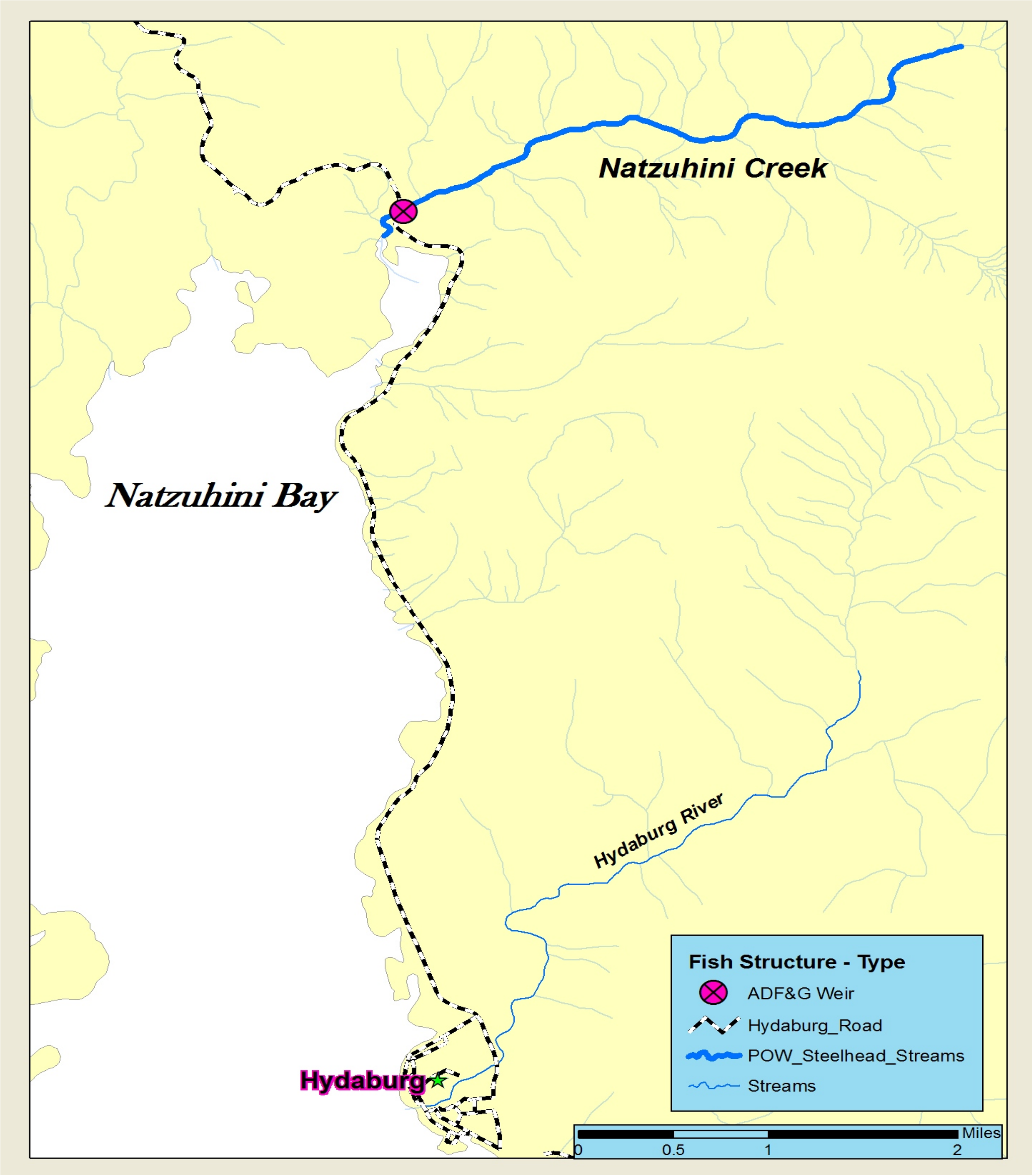

Figure 3.–Location of weir on Natzuhini Creek, Prince of Wales Island.

that no information from previous readings was available (to minimize observer bias). Disagreements between the replicate readings were tallied following the second reading, and those scales not in agreement were read a third time (after again being randomized). The modal age of the readings was taken as the correct age, thereby minimizing observer-related measurement error. If no correspondence occurred from any pair-wise combination among the 3 readings, the scale sample was rejected. Minimum spawning escapement for Big Ratz Creek was calculated as the sum of all marked immigrants released above the weir and all unmarked emigrants captured and released below the weir. Minimum spawning escapement for Natzuhini Creek was calculated as the sum of all immigrants, marked and unmarked, released above the weir and unmarked emigrants determined to be different from unmarked immigrants based on time of passage, gender, and length.

When field observations indicated that immigrant weir counts were not a complete census of the spawning population, an estimate of total immigration was made using the Chapman modification to the Petersen estimator (Chapman 1951):

$$\hat{N} = \frac{(C+1)(M+1)}{R+1} - 1; \quad (1)$$

and:

$$\text{var}(\hat{N}) = \frac{(C+1)(M+1)(C-R)(M-R)}{(R+1)^2(R+2)}; \quad (2)$$

where:

$\hat{N}$ = estimated abundance of steelhead;

M = the number of steelhead captured, marked and passed upstream through the weir;

R = the number marked steelhead from M passed downstream through the weir; and,

C = the total number of steelhead inspected for marks and passed downstream through the weir.

Tests for potential bias in the Chapman estimator were conducted when appropriate data were available. Tests for gender bias were conducted using contingency table analyses comparing the sex composition of the M vs R samples and the C vs. R samples. Similar tests for size bias were not possible because length data were only collected for fish during the first time they were handled (no marked fish were sampled during emigration). However, the length distribution of fish marked during immigration (M) was compared to the distribution of fish seen for the first time during emigration (C – R) using the Komolgorov-Smirnov (K-S) two-sample test (Conover 1980). Also, equal probability of capture over time during immigration was evaluated using the contingency table analysis described by Seber (1982) for consistency of the Chapman estimator.

Age composition of immigrant steelhead was estimated by:

$$\hat{p}_a = \frac{n_a}{n}; \quad (3)$$

$$\text{var}(\hat{p}_a) = \left(1 - \frac{n}{N}\right)\frac{\hat{p}_a(1-\hat{p}_a)}{n-1}; \quad (4)$$

where $\hat{p}_a$ is the estimate of the proportion of steelhead that belong to age group a, n is the number of fish successfully aged, n_a is the subset of n that belong to age group a, and N is the population size (or $\hat{N}$ if the estimator is used rather than the weir count to determine population abundance). In the event that a census was not achieved, sex composition and length composition by length group l was also estimated using these equations.

Average length was determined or estimated using standard summary statistics (Cochran 1977).

SNORKEL SURVEYS

Snorkel surveys of steelhead were conducted each week on both streams. Two teams comprised of ADF&G and USFS personnel conducted snorkel surveys in spring 2007 Ambient conditions were recorded (i.e., light conditions, water level, water clarity). In Big Ratz Creek, each survey began at the outflow of Trumpeter Lake and continued downstream to the weir site, 400m above tidewater. In Natzuhini Creek, each survey began about 5.6 km upstream and continued downstream to the weir site approximately 500m upstream of saltwater.

The percentage of the weir count observed (P_t) at time t was calculated for each snorkel survey. The percent of the weir count was calculated:

$$P_t = 100(C_t / N_t) \quad (5)$$

where C_t is the snorkel survey count at time t and N_t is the total weir count at the time of the snorkel survey (less any adults passed downstream and any known mortalities at the time plus the number of fish observed in the system prior to fish passage). The average ($\bar{P}$) of a series of weekly observations of the percentage observed and variance were calculated using standard sample summary statistics (Cochran 1977).

The use of weirs or mark–recapture experiments to census or estimate total escapement on individual streams also allows the calculation of snorkel survey count to escapement expansion factors (π). The expansion factor provides a means of predicting escapement in years when only an index count of the escapement is available, i.e., no weir counts or mark–recapture experiments are conducted. The expansion factor is the average over several years of the ratio of the escapement estimate (or weir count) to the index count (Weller and Evans 2009). An expansion factor was calculated for each weekly snorkel survey to evaluate within-year variation in expansion factor estimates over the course of the steelhead runs. The expansion factor at time t (π_t) was calculated:

$$\pi_t = N_t / C_t \,. \tag{6}$$

The average ($\bar{\pi}$) of a series of weekly observations of an expansion factor and variance were calculated using standard sample summary statistics (Cochran 1977).

The peak survey expansion factor (π_y) for a stream during any one year y is calculated:

$$\pi_y = \hat{N}_y / C_{p,y} \tag{7}$$

where $C_{p,y}$ is the peak snorkel survey count in year y and $\hat{N}_y$ is the total weir count or estimated spawning escapement in year y.

RESULTS

BIG RATZ CREEK

Abundance at the Weir

The Big Ratz Creek weir was not fish tight the entire season (19 March–31 May). A period of heavy rainfall and snow melt contributed to a major flood event that compromised the integrity of the weir. On 6 April, water levels rose dangerously high within a few hours and the debris load on the face of the weir became extremely heavy and difficult to keep clear. To prevent the weir structure from washing out, crews pulled pickets at 15:00. At 18:30, 2 sections of the weir structure, river left of the upstream trap, began shifting downstream as the substrate was being scoured away. By the following day, 1 section of the weir had shifted 4 feet downstream and 2 other sections of the weir had sunk about 3 feet where the substrate had been scoured away. Though the entire length of the weir remained intact, it was grossly warped and required significant repairs. When conditions were safe, the crews realigned the bipods, reset the anchors, filled the scoured pits with sandbags, replaced the pickets and checked the weir for holes. The weir was fish tight by 11:00 on 7 April.

A total of 266 immigrant adult steelhead were passed upstream through the Big Ratz Creek weir from 19 March to 31 May. The day after the weir was fish tight, a snorkel survey counted 1 steelhead that had likely arrived prior to weir installation. The first immigrant steelhead was caught in the weir trap on 22 March, and the last upstream migrant was captured on 27 May; the peak of run occurred on 21 April when 19 fish were passed through the weir (Figure 4, Appendix A1).

A total of 135 steelhead kelts were passed downstream from 10 May through 29 May, and any remaining emigrating steelhead left the drainage after the weir was removed (Figure 5, Appendix B1). Thirty-two post-spawned steelhead were unmarked, however 13 steelhead were inadvertently passed upstream without a mark. The minimum spawning escapement in Big Ratz Creek was 284 steelhead (266 immigrants + [32 unmarked emigrants - 13 immigrants passed upstream without marks - 1 mortality]).

Knowing some fish had passed upstream undetected, a Chapman's modified Peterson estimator for a closed population (Seber 1982) was considered to estimate the immigration into Big Ratz Creek. In order to yield an unbiased

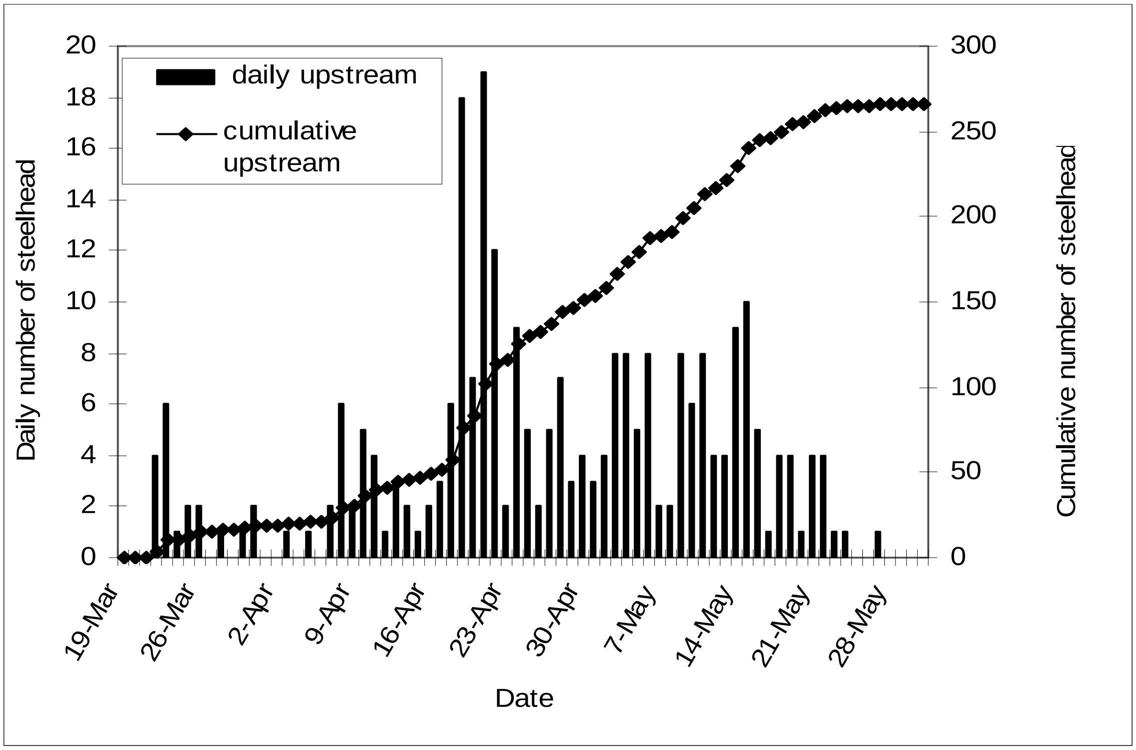

Figure 4.–Daily and cumulative counts of immigrant steelhead at Big Ratz Creek, 2007.

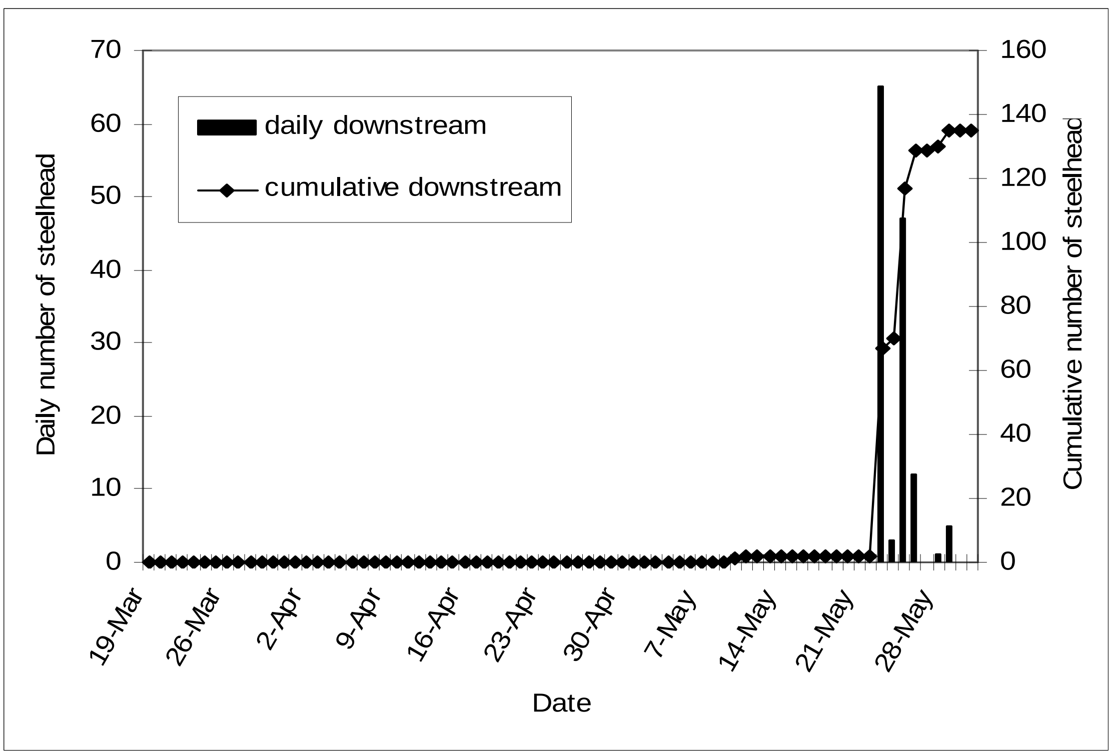

Figure 5.–Daily and cumulative counts of emigrant steelhead at Big Ratz Creek, 2007.

estimate of abundance, the Chapman model requires (among other assumptions) that at least one of the three following conditions are satisfied:

a) all fish have an equal probability of being captured and marked during the first sampling event; or

b) all fish have an equal probability of being inspected for marks during the second sampling event; or,

c) marked and unmarked fish mix completely between sampling events.

These assumptions were examined with regard to size and gender biased sampling. The proportion of females among fish marked during immigration was significantly higher than the proportion of females observed among marked fish during emigration ($P < 0.01$), suggesting gender bias in the sampling during emigration. However, the proportions of females among all fish observed during emigration was not different from the marked fish during emigration ($P = 0.80$), indicating no gender bias during immigration sampling. Based on the K-S test, there was not a difference in the length distribution of 245 marked and 24 unmarked fish observed during the emigration, suggesting little potential for size-biased sampling during the emigration. Therefore, there was little potential for bias in the abundance estimate due to either gender- or size-biased sampling.

It was also necessary to examine these assumptions with respect to equal probability of capture over time. The marked: unmarked ratio observed during early emigration sampling (10–23 May) was significantly lower ($P = 0.04$) than the ratio observed during later (24–29 May) emigration sampling. This result suggests potential for bias in the abundance estimate due to unequal probability of sampling over time during immigration. Additional tests described by Seber (1982) to evaluate potential for bias are not possible due to lack of data. The single diagnostic test that could be performed indicated that probability of capture was not equal throughout the marking event (immigration), so condition (a) was not satisfied. In addition to the weir failure described above, it is possible that some spawning steelhead were upstream of the weir site prior to the weir being installed. It is apparent from our field schedule and data that the weir was pulled prior to the completion of the kelt emigration, so condition (b) was not satisfied. Also, condition (c) was probably not satisfied; otherwise the diagnostic test performed for condition (a) would not have yielded a significant test result. So, an estimate based on the Chapman model is likely to be biased. Because sampling data from uniquely identified fish were unavailable, alternate models for estimating abundance could not be considered. While the direction of bias is unclear when temporal and/or geographic variability in probability of capture occurs during both sampling events, simple simulations were conducted to evaluate the direction of bias. The first event probability of capture was assumed to be lower during early immigration than during late immigration, and that the second event probability of capture was higher during early emigration than during late emigration. These assumptions are consistent with how sampling occurred in the field. If it is also assumed that the earliest immigrants to the system tended to emigrate earlier than later immigrants, the simulations show that the Chapman estimator would be biased high. The estimated abundance of spawning steelhead in Big Ratz Creek in 2007 was 331 (SE = 12) using the Chapman estimator.

Water temperatures ranged from approximately 2°C on 21 March to 9°C during late May. Temperatures were between 3° and 4°C during the peak escapement in late April (Figures 4 and 6, Appendix C1). Water levels taken at the weir gaging station varied from 150 cm on 21 March to 285 cm on 9 April (Figure 6, Appendix C1).

Age, Sex and Length

A total of 249 immigrating steelhead were measured, sexed, and sampled for scales prior to being released upstream to spawn in Big Ratz Creek. In addition, 2 fish were sampled for scales and sexed but not measured for length, 2 fish were measured for length and sexed but not sampled for scales, and 9 fish were sexed but not measured for length or sampled for scales.

Females comprised 62% (162 fish) of the total immigrant run, while males represented 38% (100 fish). The length of immigrant steelhead averaged 760 mm TL (SE = 4.8) and ranged from 475 mm

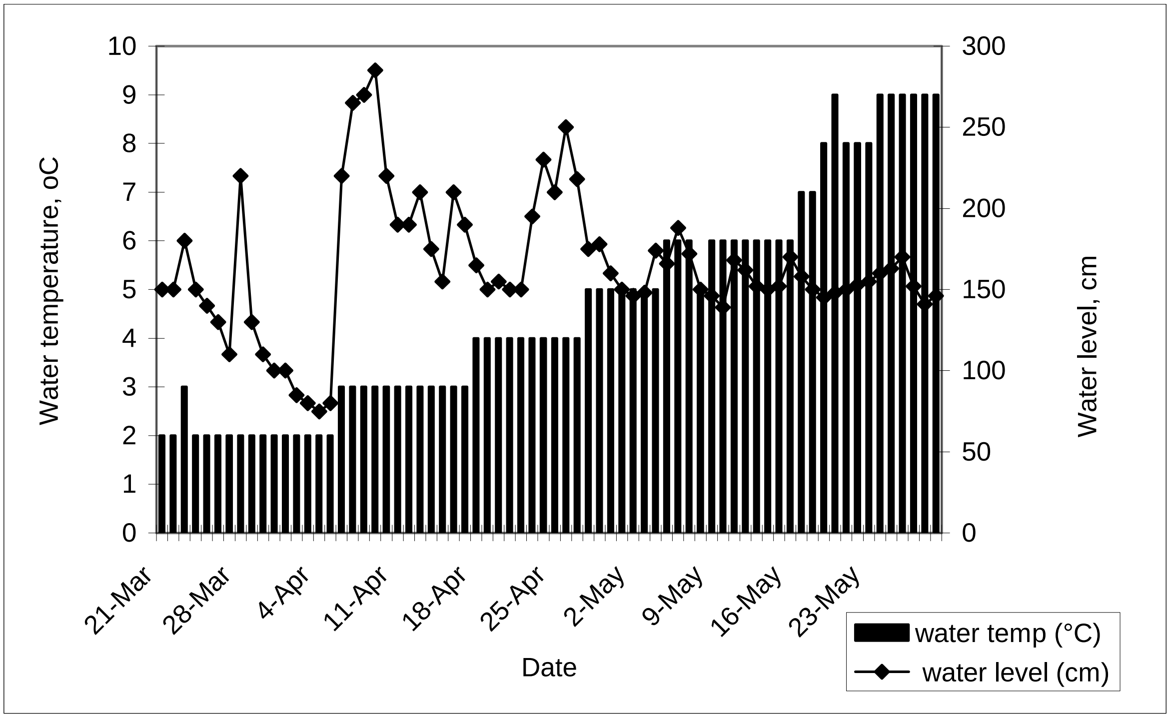

Figure 6.–Daily measurements of water level (cm) and water temperature (^oC) at Big Ratz Creek, 2007.

to 920 mm. The length of immigrant males averaged 806 mm TL (SE = 8.5), and the average length of immigrant females was 727 mm TL (SE = 5.4). One female fish, or 0.6% of the total immigrant steelhead run, met the minimum length requirements for sport fish retention (≥914 mm TL, or ≥36 inches TL; Table 4).

Of the 251 immigrant steelhead sampled for scales, 201 samples were analyzed for age, and 131 were successfully aged; the freshwater age could not be determined for 62 of the samples, 4 were not readable, and no match could be determined for 4 samples. Of the initial spawners that were successfully aged (85 fish), females made up the majority (52.4%, SE = 5.5), and ages 3.2 (59.5%, SE = 5.4) and 3.3 (35.7%, SE = 5.3) were the predominant age classes (Table 5). Initial spawners composed 64% (SE = 2.6) of the Big Ratz Creek spring immigrant run (Table 6).

Snorkel Surveys

During the operation of the Big Ratz Creek weir, 12 snorkel surveys were conducted from 20 March to 27 May. Visibility conditions varied from poor to excellent. During the first snorkel survey, conducted 1 day after the weir was fish tight (20 March), 1 steelhead was observed in Big

Table 4.–The estimated proportion $\hat{p}$ by length (mm TL), and associated statistics, of spring run immigrant steelhead in Big Ratz Creek, 2007.

Length	Sample size	$\hat{p}$	$SE(\hat{p})$
475–494	2	0.008	0.002
495–514	0	0.000	0.000
515–534	0	0.000	0.000
535–554	0	0.000	0.000
555–574	0	0.000	0.000
575–594	0	0.000	0.000
595–614	2	0.008	0.002
615–634	4	0.016	0.003
635–654	7	0.028	0.004
655–674	15	0.060	0.005
675–694	19	0.076	0.006
695–714	27	0.108	0.007
715–734	18	0.072	0.006
735–754	18	0.072	0.006
755–774	26	0.104	0.007
775–794	23	0.092	0.006
795–814	18	0.072	0.006
815–834	25	0.100	0.006
835–854	13	0.052	0.005
855–874	20	0.080	0.006
875–894	9	0.036	0.004
895–914	4	0.016	0.003
≥915	1	0.004	0.001
	n = 251		

Table 5.–Estimated age and sex composition of spring immigrant steelhead sampled at the weir in Big Ratz Creek, 2007.

		Brood year and age class				
		2002	2001	2001	2000	
		3.2	3.3	4.2	4.3	Total
Females	Sample size	17	23	3	1	44
	$\hat{p}_a$ X 100	38.6	52.3	6.8	2.3	52.4
	$SE(\hat{p}_a)$ X 100	5.3	5.5	2.8	1.6	5.5
Males	Sample size	33	7	1		41
	$\hat{p}_a$ X 100	82.5	17.5	2.5		47.6
	$SE(\hat{p}_a)$ X 100	4.2	4.2	1.7		5.5
Combined	Sample size	50	30	4	1	85
	$\hat{p}_a$ X 100	59.5	35.7	4.8	1.2	
	$SE(\hat{p}_a)$ X 100	5.4	5.3	2.3	1.2	

Table 6.–Estimated proportions by age class $\hat{p}_a$, and associated statistics, of immigrant Big Ratz Creek steelhead sampled in 2007.

Age class	Number of steelhead sampled	Number of females sampled	Number of males sampled	$\hat{p}_a$	$SE(\hat{p}_a)$
3.2	50	17	33	0.26	0.002
3.3	30	23	7	0.16	0.020
4.2	4	3	1	0.02	0.008
4.3	1	1		0.01	0.004
3.2s1	34	20	14	0.18	0.021
3.2s1s1	4	3	1	0.02	0.008
3.3s1	6	5	1	0.03	0.009
4.2s1	1		1	0.01	0.004
4.2s1s1	1		1	0.01	0.004
x.2[a]	22	7	15	0.11	0.017
x.2s1[a]	10	6	4	0.05	0.012
x.2s1s1[a]	6	5	1	0.03	0.009
x.3[a]	17	12	5	0.09	0.015
x.3s1[a]	6	5	1	0.03	0.009
x.3s1s1[a]	1	1		0.01	0.004
Initial spawners	75	52	23	0.64	0.026
Repeat spawners	69	45	24	0.36	0.026
Total	144	97	47	1.00	

[a] x = freshwater age undetermined.

Ratz Creek. It is assumed that this fish moved into the system prior to weir installation as either a spring or fall-run immigrant.

Our estimates of the percentage of fish seen during snorkel surveys (P_t) are biased high because of unaccounted for fish upstream of the weir. On average, $\overline{P}$ = 24.4% (SD = 8.6%; *n* = 10 of the cumulative weir count was observed (Table 7). Using later surveys conducted from 28 April to 27 May, after approximately half of the steelhead had entered the system, $\overline{P}$ = 29.8% (SD = 6.2%; *n* = 6) of the cumulative weir count was observed.

The peak snorkel survey count occurred on 18 May when 71 steelhead were counted, and the expansion factor was calculated to be 3.69 based on that day's weir counts. The peak survey expansion factor for 2007 for Big Ratz Creek

Table 7.–Weekly snorkel surveys of adult steelhead, the number of steelhead observed, cumulative upstream weir counts, cumulative downstream weir counts, the percentage of the upstream weir count observed during each survey, the survey expansion factor, and visibility conditions in Big Ratz Creek, 20 March–27 May, 2007.

Date	Survey number	Steelhead observed	Cumulative upstream weir count	Cumulative downstream weir count	Percent of weir count observed[a] (P_t)	Expansion factor (π_t)	Visibility conditions
20-Mar-07	1	1					normal
27-Mar-07	2	3	15		18.8	5.33	normal-excellent
03-Apr-07	3		19				poor
12-Apr-07	4	8	40		19.5	5.12	normal
14-Apr-07	5	5	44		11.1	9.00	normal-excellent
17-Apr-07	6	8	50		15.7	6.38	normal
28-Apr-07	7	35	137		25.4	3.94	normal
01-May-07	8	45	149		30.0	3.33	normal
08-May-07	9	62	191		32.3	3.10	normal
15-May-07	10	56	240	2	23.4	4.27	normal
22-May-07	11	71	263	2	27.1	3.69	normal
27-May-07	12	56	266	129	40.6	2.46	normal
Average (SD)	2,4–12				24.4 (8.6)	4.66 (1.92)	
Average (SD	7–12				29.8 (6.2)	3.47 (0.64)	

[a] One fish was observed during the first snorkel survey on 3/20, prior to any fish passage through the weir. This fish has been factored into the percentage of the weir count observed.

would be calculated to be π_{2007} = 4.00. The mean expansion factor for surveys conducted from 28 April to 27 May was $\bar{\pi}$ = 3.47 (SD = 0.64; n = 6). These values, and the estimates based on individual surveys are biased low due to unaccounted for fish above the weir.

NATZUHINI CREEK

Abundance at the Weir

The Natzuhini Creek weir was not fish tight the entire season (10 March–31 May). A period of heavy rainfall and snow melt contributed to a major flood event (6 April) that compromised the integrity of the weir. Water levels rose dangerously high (above the catwalk) within a few hours and peaked approximately one foot below the top of the weir structure. To prevent the weir structure from washing out, crews pulled pickets around 16:00. At 10:00 the following day, when conditions were safe, crews replaced pickets, cleared debris, reinforced the weir structure, filled a scoured pit along the face of the weir with sandbags, and checked for holes.

A total of 78 adult immigrant steelhead were passed through the Natzuhini Creek weir from 10 March to 31 May. Four of these fish were inadvertently passed upstream without a mark. The day after the weir was fish-tight, a snorkel survey was conducted and zero steelhead were observed. The first adult steelhead was passed on 18 March, the last on 30 May, and the peak of run occurred on 19 April when 6 immigrants were counted (Figure 7, Appendix A2).

Eighteen kelts were passed downstream from 18 April through 30 May (Figure 8, Appendix B2); 17 steelhead kelts passed downstream were marked, and 1 was unmarked. The 1 unmarked kelt was assumed to be one of the 4 immigrants passed upstream unmarked, therefore the minimum spawning escapement in Natzuhini Creek is equal to the weir count (78 steelhead).

Assuming some fish had passed upstream undetected, a Chapman's modified Peterson estimate was considered. Diagnostic tests to evaluate potential bias in the Chapman estimate were not performed because of lack of sufficient data. As only 1 unmarked fish was observed during emigration, the C and R samples (as defined for equation 1) differed by only this 1 fish, precluding the chance of detecting differences between these samples. The Chapman model provided a point estimate of 77 (95% CI: 70 to 84), which was slightly lower than the minimum count of individual steelhead, although the minimum count is captured by the 95% confidence interval from the Chapman estimator.

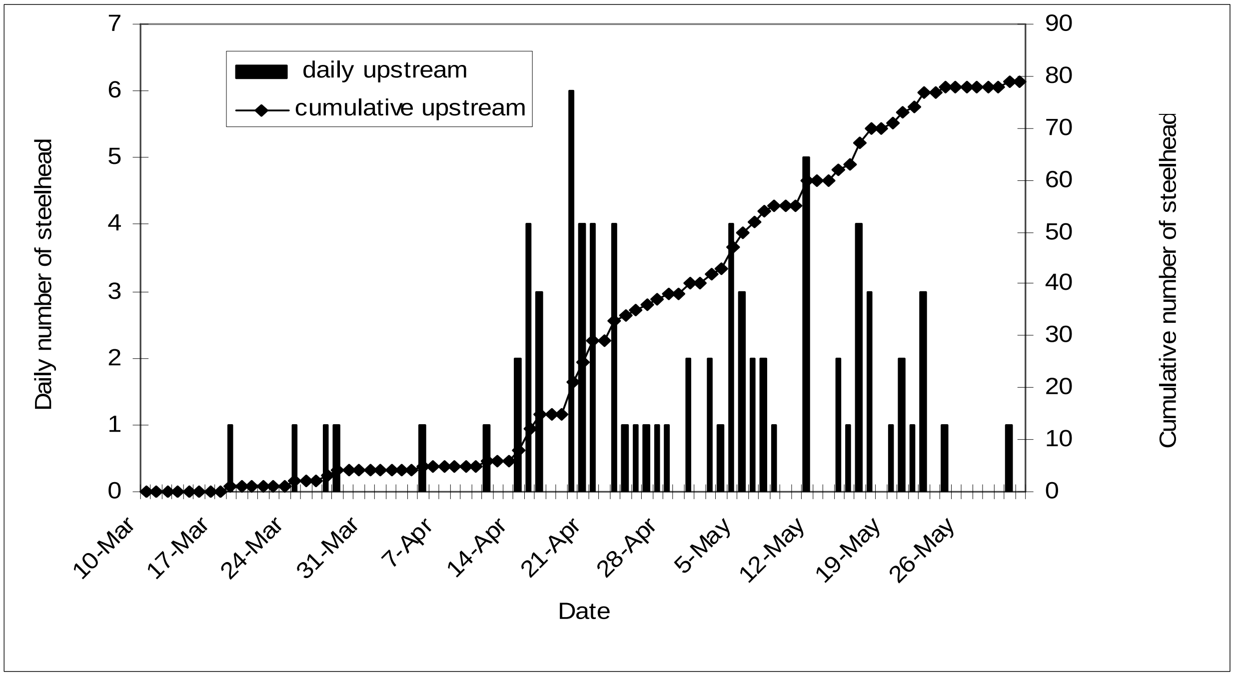

Figure 7.–Daily and cumulative counts of immigrant steelhead at Natzuhini Creek, 2007.

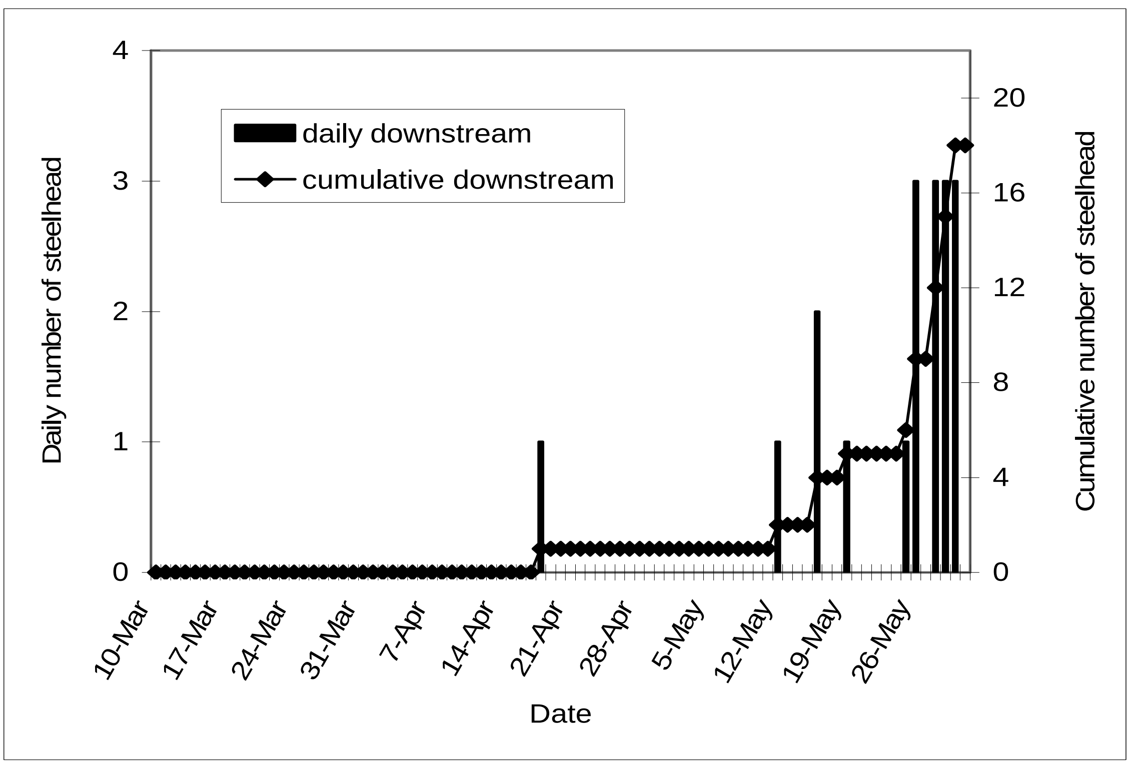

Figure 8.–Daily and cumulative counts of emigrant steelhead at Natzuhini Creek, 2007.

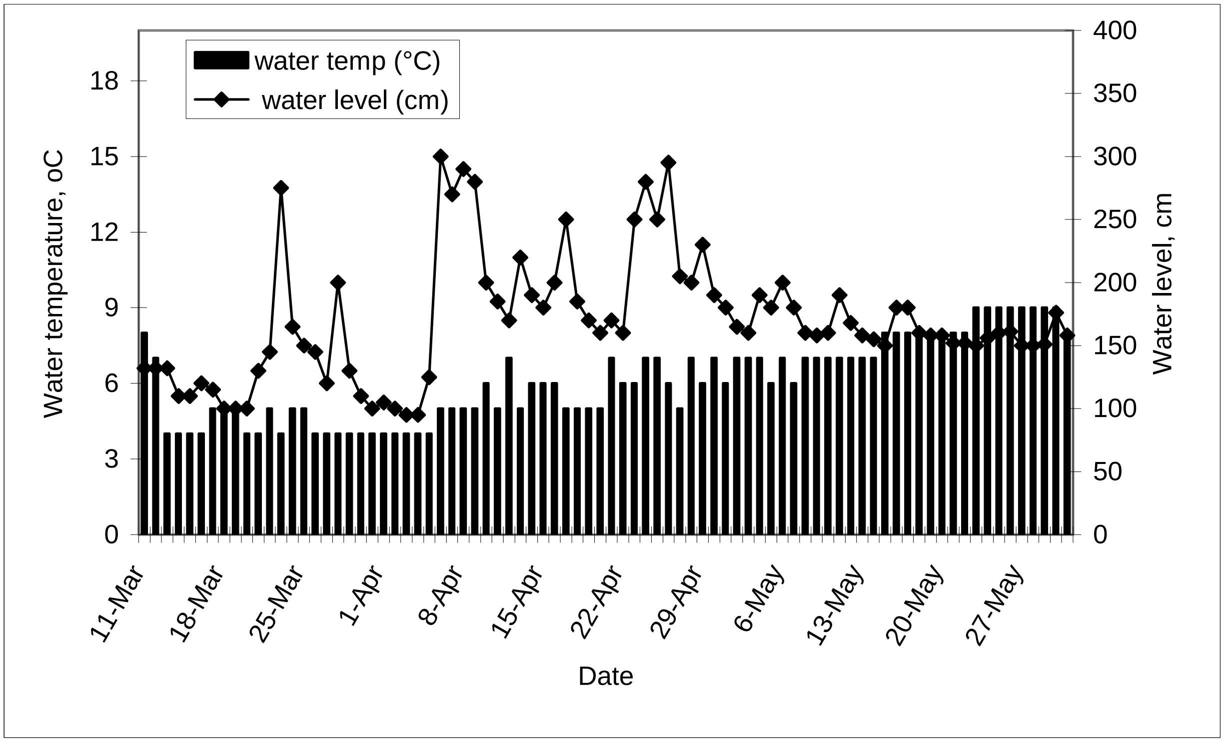

Figure 9.–Daily measurements of water level (cm), and water temperature (°C) at Natzuhini Creek, 2007.

Water temperatures in Natzuhini Creek ranged from approximately 4°C on 13 March to 9°C on 30 May and were between 5 and 7°C during the peak upstream migration in late April (Figures 7 and 9, Appendix C2). Water levels taken at the weir gaging station varied from 95 cm on 4 April to 300 cm on 5 April (Figure 9, Appendix C2).

Age, Sex and Length

Seventy-three immigrating mature steelhead were measured, sexed and sampled for scales prior to being released upstream to spawn in Natzuhini Creek. One additional fish was measured and sexed, but not sampled for scales, and 4 additional fish were sexed, but not measured or sampled for scales. One unmarked emigrating steelhead was measured, sexed, and sampled for scales prior to being released downstream. In addition, 1 apparent juvenile steelhead was measured, sexed and sampled for scales prior to being released upstream of the weir.

Females comprised 68% (54 fish) of the total immigrant run while males represented 32% (25 fish). The length of all immigrating steelhead averaged 730 mm TL (SE = 8.8), and ranged from 360 mm to 870 mm. The length of males averaged 718 mm TL (SE = 13.6), and the length of females averaged 736 mm TL (SE = 11.2). No immigrant steelhead met the minimum length requirements for sport fish retention (≥914 mm TL, or ≥36 inches TL; Table 8).

Table 8.–The estimated proportions by length (l, mm TL) $\hat{p}_l$, and associated statistics, of spring immigrant steelhead sampled in Natzuhini Creek, 2007.

Length	Sample size	$\hat{p}_l$	$SE(\hat{p}_l)$
615–634	5	0.068	0.007
635–654	4	0.054	0.007
655–674	5	0.068	0.007
675–694	4	0.054	0.007
695–714	8	0.108	0.009
715–734	10	0.135	0.100
735–754	8	0.108	0.009
755–774	9	0.122	0.009
775–794	8	0.108	0.009
795–814	5	0.068	0.007
815–834	4	0.054	0.007
835–854	2	0.027	0.005
855–874	1	0.014	0.003
875–894		0.000	0.000
895–914	1	0.014	0.003
	n = 74		

Of the 75 steelhead sampled for scales, 38 were successfully aged; the freshwater age could not be determined for 33 of the samples, 2 were unreadable, and no match was determined for 1 sample. One sample was from an age-4.0 steelhead smolt (FL = 350mm). Of the initial spawners that were successfully aged (21 fish), females made up the majority (62%, SE = 10.9), and ages 4.2 (42.9%, SE = 11.1) and 3.3 (28.6%, SE = 10.1) were the predominant age classes (Table 9). Initial spawners composed 56% (SE = 1.9) of the Natzuhini Creek spring immigrant run (Table 10).

Table 9.–Estimated age and sex composition of spring immigrant steelhead sampled at the weir in Natzuhini Creek, 2007.

		Brood year and age class					
		2001	2001	2000	2000	1999	
		3.3	4.2	4.3	5.2	5.3	Total
Females	Sample size	5	3	3	1	1	13
	$\hat{p}_a$ x 100	38.5	23.1	23.1	7.7	7.7	61.9
	$SE(\hat{p}_a)$ x 100	10.9	9.4	9.4	6.0	6.0	10.9
Males	Sample size	1	6		1		8
	$\hat{p}_a$ x 100	12.5	75.0		12.5		38.1
	$SE(\hat{p}_a)$ x 100	7.4	9.7		7.4		10.9
Combined	Sample size	6	9	3	2	1	21
	$\hat{p}_a$ x 100	28.6	42.9	14.3	9.5	4.8	
	$SE(\hat{p}_a)$ x 100	10.1	11.1	7.8	6.6	4.8	

Table 10.–Estimated proportions by age class $\hat{p}_a$, and associated statistics, of immigrant Natzuhini Creek steelhead sampled in 2007.

Age class	Number of steelhead sampled	Number of females sampled	Number of males sampled	$\hat{p}_a$	$SE(\hat{p}_a)$
3.3	6	5	1	0.08	0.011
4.2	9	3	6	0.13	0.013
4.3	3	3		0.04	0.008
5.2	2	1	1	0.03	0.006
5.3	1	1		0.01	0.004
3.2s1	3	3		0.04	0.008
3.2s1s1	6	4	2	0.08	0.011
3.3s1	2	1	1	0.03	0.006
4.2s1	3	2	1	0.04	0.008
4.2s1s1	3	3		0.04	0.008
x.2	10	5	5	0.14	0.013
x.2s1[a]	5	3	2	0.07	0.010
x.2s1s1[a]	6	4	2	0.08	0.011
x.2s1s1s1[a]	1	1		0.01	0.004
x.3[a]	9	8	1	0.13	0.013
x.3s1[a]	2	2		0.03	0.006
Initial spawners	40	26	14	0.56	0.019
Repeat spawners	31	23	8	0.44	0.019
Total	71	49	22	1.00	

[a] x = freshwater age undetermined.

Snorkel Surveys

During the operation of the Natzuhini Creek weir, 11 snorkel surveys were conducted from 10 March to 28 May. Visibility conditions were poor to excellent. During the most comprehensive surveys conducted during 27 April–28 May, $\overline{P}$ = 50.9% (SD = 9.4%; n = 6) of the cumulative weir count was observed (Table 11).

The peak snorkel survey count occurred on 18 May, when 45 steelhead were counted, and the expansion factor was calculated to be 1.56 based on that day's weir counts. The peak survey expansion factor for 2007 for Natzuhini Creek would be calculated to be π_{2007} = 1.69. The mean expansion factor for surveys conducted from 27 April to 28 May was $\overline{\pi}$ = 2.02 (SD = 0.36; n = 6).

Table 11.–Weekly snorkel surveys of adult steelhead, the number of steelhead observed, cumulative upstream weir counts, cumulative downstream weir counts, the percentage of the weir count observed during each survey, and visibility conditions in Natzuhini Creek, 10 March–28 May, 2007.

Date	Survey number	Steelhead observed	Cumulative upstream weir count	Cumulative downstream weir count	Percent of weir count observed[a] (P_t)	Expansion factor (π_t)	Visibility conditions
10 Mar	1	0	0	0			normal
22 Mar	2	0	0	0			normal-poor
29 Mar	3	1	4	0	12.5	8.00	normal
12 Apr	4	3	6	0	30.0	3.33	normal-excellent
19 Apr	5	4	20	1	17.4	5.75	excellent
27 Apr	6	19	36	1	48.7	2.05	normal
7 May	7	23	53	1	41.1	2.44	normal
10 May	8	31	55	1	53.4	1.87	normal
18 May	9	45	70	4	64.3	1.56	normal
24 May	10	33	78	5	42.9	2.33	normal
28 May	11	37	78	12	52.9	1.89	normal
Average (SD)	3–11				40.4 (17.3)	3.25 (2.19)	
Average (SD)	6–11				50.9 (9.4)	2.02 (0.36)	

[a] The survey areas were not consistent for surveys 1-5; the upper boundary was moved upstream as new steelhead habitat was identified. The survey area for surveys 6-11 were more comprehensive and did not change.

DISCUSSION

The 2007 minimum escapement estimate into Big Ratz Creek of 284 steelhead is preferred over the Chapman estimate of 331. While the minimum escapement estimate is known to be biased low, it represents an unambiguous count of the number of individual fish observed. The Chapman estimate is known to be biased high, and is also estimated with uncertainty. No additional data or tools are available to guide a choice between or blending of these 2 numbers, so the less ambiguous number is preferred. During the first snorkel survey conducted 1 day after the weir was fish tight (20 March), 1 steelhead was observed in Big Ratz Creek. Although we did not study fall immigration during this project, it is likely that Big Ratz Creek supports a fall run of steelhead. There is a lake in the system that could serve as prime overwintering habitat. If fall immigration and overwintering occur, a well designed mark–recapture experiment will be required to provide an unbiased or minimally biased estimate of the abundance of steelhead spawning in Big Ratz Creek. The 2007 Big Ratz Creek steelhead escapement estimate was down 29% from the 2005 weir count of 399 steelhead (Piazza et al. 2008). This difference is likely primarily attributed to the interannual variation of escapement to Big Ratz Creek. Interannual variation of up to 25% was documented at Sitkoh Creek (Harding and Jones 1994). Overall, the 2007 steelhead escapement appears similar in both magnitude and timing to the escapement in 2005 (Figure 10).

The 2007 minimum escapement estimate into Natzuhini Creek of 78 steelhead is preferred over the Chapman estimate of 77. The Chapman model provided a 95% confidence interval of 70 to 84

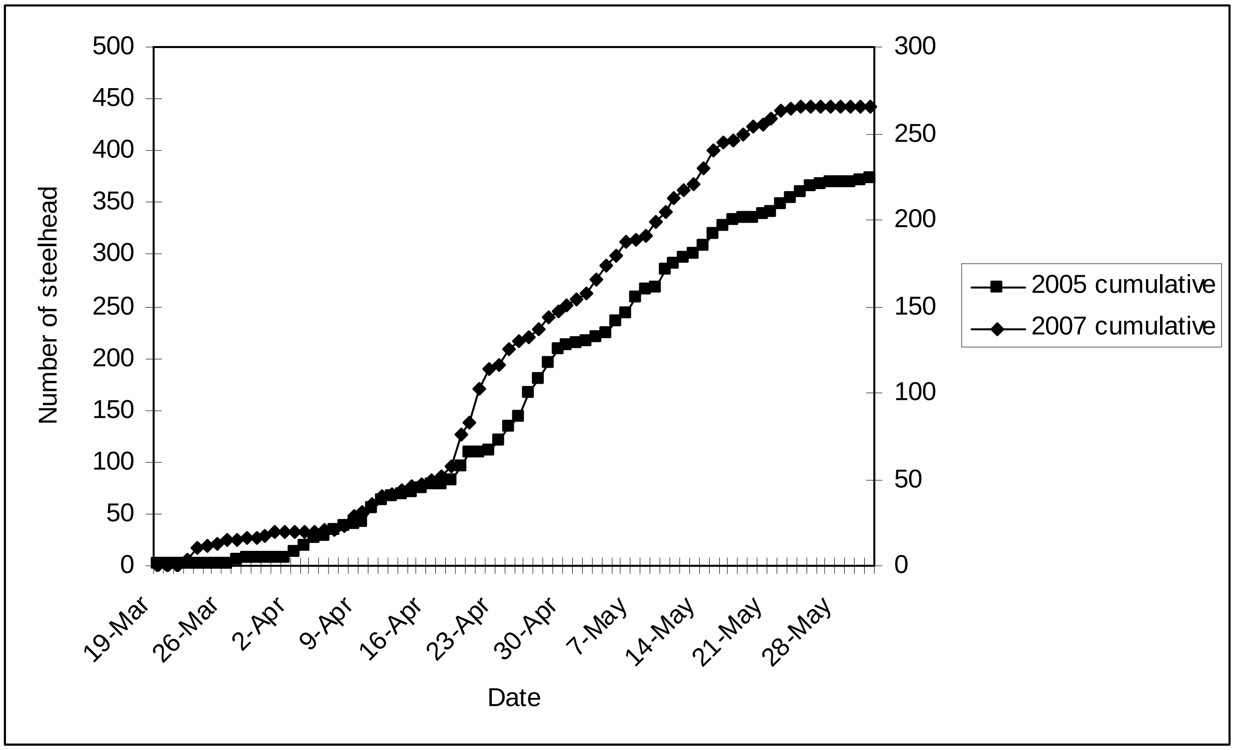

Figure 10.–Cumulative steelhead immigration in Big Ratz Creek, 2005 and 2007.

and the minimum count is captured by this confidence interval. The Natzuhini Creek steelhead escapement of 78 fish should be considered a minimum count, with 84 as an upper bound.

In 2007, 0.6% of the steelhead in Big Ratz Creek and none in Natzuhini Creek met minimum length requirements for sport fish retention (≥914 mm TL, or ≥36 inches TL). Results from the previous 2 years of this study indicated that 1.7% of the steelhead in Big Ratz Creek, 2.3% in Harris River, 3.6% in Cable Creek, and 1.3% in Eagle Creek, were greater than 36 inches in length (Piazza 2009; Piazza et al. 2008). In 2004, no fish greater than 36 inches were encountered at the 12-Mile weir (Hoffman 2007). Similarly, no fish over 36 inches were encountered during creel surveys conducted at the Karta River in 1989 or 1991, and less than 1% of the steelhead run in the Karta River were larger than 36 inches in 1989 and 1992, (Freeman and Hoffman 1989; Harding and Jones 1993; Hoffman et al. 1990). Biologists estimate that less than 5% of adult steelhead in Southeast Alaska are greater than 36 inches in total length, so current sport fish regulations, established in 1994, protect approximately 95% of the fish returning to systems within the region (Harding et al. 2006).

Steelhead returning to Big Ratz Creek were predominantly comprised of fish that spent 3 years in fresh water before smolting, while steelhead returning to Natzuhini Creek were dominated by fish that spent 3-4 years. In both systems steelhead spent 2 to 3 years in saltwater prior to returning to spawn as adults. Similar age patterns were documented in 2005 at Big Ratz Creek and the Harris River (Piazza et al. 2008), Eagle Creek and Cable Creek (Piazza 2009), the Thorne River (Freeman and Hoffman 1989) and in Ward Creek (Hubartt 1989). These age patterns were also observed in 1983, 1989, 1992 and 2005 in the Karta River (Harding and Jones 1993; Hoffman et al. 1990; Hoffman 2008; Jones 1984).

The importance of using weirs to enumerate steelhead returns on Prince of Wales Island continues to be highlighted by the additional results obtained from both the Big Ratz Creek and Natzuhini Creek systems. Initially, Big Ratz Creek and Natzuhini Creek were categorized by managers as “small” (N < 150) systems. Big Ratz Creek was originally thought to support an adult steelhead population of 100 fish or less. In 2005, the minimum escapement numbers obtained for Big Ratz Creek (N = 399) greatly exceeded expectations, and Big Ratz Creek was subsequently reclassified as a “large” system (N > 150). The minimum escapement (N = 284) obtained in 2007 reconfirmed its classification as a “large” system. Natzuhini Creek steelhead populations were estimated at 100 fish or less, and the minimum escapement estimate obtained for Natzuhini Creek (N = 78), confirmed its classification as a “small” system.

The results obtained from 2004 to 2007 (includes the 2004 pilot study) confirmed the management classification of five steelhead systems (12-Mile, Cable Creek, Eagle Creek, Harris River, Natzuhini Creek) and changed the management classification of 1 system (Big Ratz Creek). In addition, study results led to changes in the federal management of steelhead in 2 systems and inseason management actions were implemented in 1 system. In 2005, the steelhead escapement of 172 fish confirmed the management classification of the Harris River as a “large” system. Because this escapement was much lower than anticipated, and the Harris is a popular road-accessible stream, federal managers added the Harris River (in 2006) to their list of streams with special protection (small, road accessible) where the annual household limit is 2 steelhead and no bait is allowed (USFS *Unpublished*). In contrast, a weir count of 399 fish on Big Ratz Creek in 2005 resulted in a management classification change from a “small” to a “large” system (Piazza et al. 2008). In 2006, federal mangers liberalized the subsistence fishery in Big Ratz Creek by removing it from the list of streams with special protection. All systems without special protection have an annual household limit of 5 steelhead and bait is allowed. In 2006, 2 regulatory actions were implemented in Cable Creek. Both the sport and the subsistence fishery were closed from mid April through 31 May when the total steelhead harvest was estimated to be approximately 30% (11 fish) of the weir count (N = 38) at the time.

In 2007 the feasibility of using snorkel survey calibration methods as a management tool to estimate steelhead abundance was further examined. Snorkel survey methods are used extensively throughout Southeast Alaska to develop indices of adult steelhead populations in freshwater streams. Typically, such data have been interpreted as an indicator of peak abundance. However, the study enabled us to calibrate the snorkel survey counts using weir censuses as coincident estimates of abundance.

The average percent of the weir count observed during snorkel surveys ($\overline{P}$) differed greatly between the 2 streams studied in 2007. The averages from the later surveys, after approximately one third to one half of the spawners had immigrated into the streams, are used for comparison. In Big Ratz Creek, observers were able to count an average (biased low) of 30% (SD = 6.2%) of the adult fish that had migrated upstream of the weir during 28 April to 27 May. In 2005, 37% (SD = 8.3%) of the weir count was observed during 26 April–24 May (derived from Piazza et al. 2008). Given the potential bias in the 2007 data, the results from the 2 years cannot be considered dissimilar. In Natzuhini Creek, observers were able to account for an average of 51% (SD = 9.4) of immigrant fish passed at the weir.

Several factors may have contributed to the variability in the percentage of fish seen between the 2 streams. Big Ratz Creek is a tannic-stained system in which visibility is limited to an average of 2 m or less. Big Ratz Creek also has a number of deep, dark pools (up to 4.5 m deep) with moderate to high levels of turbidity that further obstruct visibility. When steelhead congregated in these pools, observers, on most occasions, were only able to accurately count steelhead milling close to the surface. Counting under these conditions was challenging and required a number of snorkel passes to ensure that the majority of fish were counted and that each fish was only counted once. Counts from multiple snorkel passes were usually averaged, and likely under represented the actual number of fish present. In addition, the Big Ratz Creek system contains 2 upstream lakes that serve as holding areas for steelhead prior to spawning. Counting of adult steelhead in the lakes was restricted by water depth so they were not included in the survey area. A combination of these factors likely contributed to a significant decrease in the accuracy of the snorkel counts for this system. Based on the potential inaccuracy of snorkel counts at Big Ratz Creek, developing an expansion factor for Big Ratz Creek may be more challenging than for non-lake steelhead systems, and expansion factors for lake systems may be generally less precise than for non-lake systems. Our 2007 results should not be used as part of a multi-year effort to develop an expansion factor for Big Ratz Creek because of bias in our estimate of spawning escapement.

Natzuhini Creek also proved to be a challenging system to survey. Natzuhini Creek had not been snorkeled in the past, nor was the upper boundary of steelhead habitat identified prior to this project. A typical survey was 4.5–5.5 hours long, which included a 2.5 hour hike through difficult terrain to the upper reaches of the system. Natzuhini Creek forks approximately 3 miles upstream of the weir. The South Fork becomes impassable at a steep waterfall approximately 1 mile upstream from the mainstem of the creek. The North Fork is a wide section of pools and shallow water riffles that, under higher water conditions, becomes passable to steelhead. The mainstem of Natzuhini Creek has many wide sections of braided channels with a number of small feeder streams, many of which are impassable to fish except under high water conditions. Conducting surveys in this type of habitat was a challenging process. The snorkel crew focused on following the main channel and braided channels that appeared to hold steelhead or allow passage. During the first few surveys water conditions were low. As snow melt and rainfall increased, the survey crew noticed that the upper boundary of the survey became passable by fish into areas with good spawning habitat. Over the next 3 snorkel surveys, the upper boundary was expanded further upstream to include both the South Fork to the falls and approximately 1 mile of the North Fork; this became the upper boundary for the remaining snorkel surveys. The area surveyed varied during the first 5 snorkel surveys; however the area surveyed during the last 6 surveys was consistent and more comprehensive. The average percentage of the weir count observed during the last 6 snorkel surveys was 50.9% (SD = 9.4%). The CV of 0.18, representing the relative variability between these counts, was similar in magnitude to that of the last 6 surveys conducted at Big Ratz Creek (CV = 0.21). This variability is also similar in magnitude to the relative interannual variability in data used to estimate the peak survey expansion factor for Sitkoh Creek (CV = 0.17, average % observed = 53%, SD = 9%; R. Harding, ADF&G, personal communication). While the within-year variability in the percentage of fish seen when approximately one third to one half of the steelhead had immigrated appears similar to the interannual variability observed at Sitkoh Creek, a robust expansion factor for either Natzuhini Creek or Big Ratz Creek would require multiple years of observations.

Substantial variability exists between the snorkel results obtained at the 6 systems studied to date: 51.9% in Eagle Creek, 43.0% in Cable Creek, 82.5% in Harris River, 74% in 12-Mile Creek, 50.5% in Natzuhini Creek, and 32.1% and 24% in Big Ratz Creek during 2005 and 2007, respectively. The intent of generating snorkel expansion factors based using weir counts is to have a management tool for estimating steelhead abundance when weirs or other means of enumeration are unavailable. Data collected during 2005, 2006, 2007 and that of the pilot study on 12 Mile Creek in 2004 suggest that snorkel survey expansion factors (generated from weir counts) are site specific and may not be comparable across systems (Hoffman 2008; Piazza et al. 2008; Piazza 2009). Each system is unique in its habitat complexity (including presence of lakes), and water clarity. Information collected in 2007 further indicates that such variables limit the scope in which snorkel survey calibrations can be applied. However, as more snorkel-weir comparisons are made, snorkel counts will contribute information to assist managers in accurately categorizing the PWI systems into proper management categories, i.e., small or large.

After 3 years of study, our results are inconclusive about whether snorkel surveys may be a good indicator of abundance. Multiple-year studies should be considered in the future to determine how much interannual variation exists within a system and to obtain broader scope of knowledge about a particular steelhead stock. Based on our experience at Big Ratz Creek, experiments using weirs should be designed to enable robust application of a mark–recapture model as a backup strategy in the event of weir failure or detected immigration prior to weir installation.

This would require individual steelhead to be uniquely marked during immigration (first event sampling) so that they may be identified during emigration (second event sampling). This would require use of a visible individually numbered tag, or an imbedded PIT tag. Also, the weir must remain in place throughout the period of kelt emigration to ensure a non-zero probability of sampling later emigrants. Other methods that may warrant further exploration include the use of redd surveys, video counters, sonar, and radiotelemetry.

Big Ratz Creek has been chosen by ADF&G for a multi-year project beginning in 2010 that will investigate juvenile and adult steelhead production. During that study, snorkel survey calibrations will be conducted. Such information will assist biologists and regulators from tribal, state, and federal agencies to manage for sustainability and take action to conserve stocks if needed.

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APPENDIX A
DAILY AND CUMULATIVE WEIR COUNTS FOR IMMIGRATING STEELHEAD

Appendix A1.–Daily and cumulative counts of immigrating steelhead at Big Ratz Creek weir, 2007.

Date	Daily steelhead count	Cumulative steelhead count	Mortalities
19 Mar		0	
20 Mar		0	
21 Mar		0	
22 Mar	4	4	
23 Mar	6	10	
24 Mar	1	11	
25 Mar	2	13	
26 Mar	2	15	
27 Mar		15	
28 Mar	1	16	
29 Mar		16	
30 Mar	1	17	
31 Mar	2	19	
1 Apr		19	
2 Apr		19	
3 Apr	1	20	
4 Apr		20	
5 Apr	1	21	
6 Apr		21	
7 Apr	2	23	
8 Apr	6	29	
9 Apr	2	31	
10 Apr	5	36	
11 Apr	4	40	
12 Apr	1	41	
13 Apr	3	44	
14 Apr	2	46	
15 Apr	1	47	
16 Apr	2	49	
17 Apr	3	52	
18 Apr	6	58	
19 Apr	18	76	
20 Apr	7	83	
21 Apr	19	102	
22 Apr	12	114	
23 Apr	2	116	
24 Apr	9	125	
25 Apr	5	130	
26 Apr	2	132	1
27 Apr	5	137	
28 Apr	7	144	
29 Apr	3	147	
30 Apr	4	151	
1 May	3	154	
2 May	4	158	
3 May	8	166	
4 May	8	174	
5 May	5	179	
6 May	8	187	
7 May	2	189	

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Appendix A1.–Page 2 of 2.

Date	Daily steelhead count	Cumulative steelhead count	Mortalities
8 May	2	191	
9 May	8	199	
10 May	6	205	
11 May	8	213	
12 May	4	217	
13 May	4	221	
14 May	9	230	
15 May	10	240	
16 May	5	245	
17 May	1	246	
18 May	4	250	
19 May	4	254	
20 May	1	255	
21 May	4	259	
22 May	4	263	
23 May	1	264	
24 May	1	265	
25 May		265	
26 May		265	
27 May	1	266	
28 May		266	
29 May		266	
30 May		266	
31 May		266	

Appendix A2.–Daily and cumulative counts of immigrating steelhead at Natzuhini Creek weir, 2007.

Date	Daily steelhead count	Cumulative steelhead count
10 Mar		0
11 Mar		0
12 Mar		0
13 Mar		0
14 Mar		0
15 Mar		0
16 Mar		0
17 Mar		0
18 Mar	1	1
19 Mar		1
20 Mar		1
21 Mar		1
22 Mar		1
23 Mar		1
24 Mar	1	2
25 Mar		2
26 Mar		2
27 Mar	1	3
28 Mar	1	4
29 Mar		4
30 Mar		4
31 Mar		4
1 Apr		4
2 Apr		4
3 Apr		4
4 Apr		4
5 Apr	1	5
6 Apr		5
7 Apr		5
8 Apr		5
9 Apr		5
10 Apr		5
11 Apr	1	6
12 Apr		6
13 Apr		6
14 Apr	2	8
15 Apr	4	12
16 Apr	3	15
17 Apr		15
18 Apr		15
19 Apr	6[a]	21[a]
20 Apr	4	25
21 Apr	4	29
22 Apr		29
23 Apr	4	33
24 Apr	1	34
25 Apr	1	35
26 Apr	1	36
27 Apr	1	37
28 Apr	1	38

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Appendix A2.–Page 2 of 2.

Date	Daily steelhead count	Cumulative steelhead count
29 Apr		38
30 Apr	2	40
1 May		40
2 May	2	42
3 May	1	43
4 May	4	47
5 May	3	50
6 May	2	52
7 May	2	54
8 May	1	55
9 May		55
10 May		55
11 May	5	60
12 May		60
13 May		60
14 May	2	62
15 May	1	63
16 May	4	67
17 May	3	70
18 May		70
19 May	1	71
20 May	2	73
21 May	1	74
22 May	3	77
23 May		77
24 May	1	78
25 May		78
26 May	0	78
27 May	0	78
28 May	0	78
29 May	0	78
30 May	1	79
31 May	0	79

[a] One juvenile steelhead (age-4 smolt) was passed upstream on this date.

APPENDIX B
DAILY AND CUMULATIVE WEIR COUNTS FOR EMIGRATING STEELHEAD

Appendix B1.–Daily and cumulative weir counts of emigrating steelhead at Big Ratz Creek weir, 2007.

Date	Daily steelhead count	Cumulative steelhead count
10 May[a]	1	1
11 May	1	2
12 May		2
13 May		2
14 May		2
15 May		2
16 May		2
17 May		2
18 May		2
19 May		2
20 May		2
21 May		2
22 May		2
23 May	65	67
24 May	3	70
25 May	47	117
26 May	12	129
27 May		129
28 May	1	130
29 May	5	135
30 May		135
31 May		135

[a] The weir was operated daily beginning 19 March; the first steelhead was passed on 10 May.

Appendix B2.–Daily and cumulative counts of emigrating steelhead at Natzuhini Creek weir, 2007.

Date	Daily steelhead count	Cumulative steelhead count
18 Apr[a]	1	1
19 Apr		1
20 Apr		1
21 Apr		1
22 Apr		1
23 Apr		1
24 Apr		1
25 Apr		1
26 Apr		1
27 Apr		1
28 Apr		1
29 Apr		1
30 Apr		1
1 May		1
2 May		1
3 May		1
4 May		1
5 May		1
6 May		1
7 May		1
8 May		1
9 May		1
10 May		1
11 May		1
12 May	1	2
13 May		2
14 May		2
15 May		2
16 May	2	4
17 May		4
18 May		4
19 May	1	5
20 May		5
21 May		5
22 May		5
23 May		5
24 May		5
25 May	1	6
26 May	3	9
27 May		9
28 May	3	12
29 May	3	15
30 May	3	18
31 May		18

[a] The weir was operated daily beginning 10 March; the first steelhead was passed on 18 April.

APPENDIX C
STREAM GAGE AND TEMPERATURE DATA

Appendix C1.–Daily water temperature (^oC) and water level (cm) at Big Ratz Creek weir, 2007.

Date	Water temperature (^oC)	Water level (cm)
21 Mar	2	150
22 Mar	2	150
23 Mar	3	180
24 Mar	2	150
25 Mar	2	140
26 Feb	2	130
27 Mar	2	110
28 Mar	2	220
29 Mar	2	130
30 Mar	2	110
31 Mar	2	100
1 Apr	2	100
2 Apr	2	85
3 Apr	2	80
4 Apr	2	75
5 Apr	2	80
6 Apr	3	220
7 Apr	3	265
8 Apr	3	270
9 Apr	3	285
10 Apr	3	220
11 Apr	3	190
12 Apr	3	190
13 Apr	3	210
14 Apr	3	175
15 Apr	3	155
16 Apr	3	210
17 Apr	3	190
18 Apr	4	165
19 Apr	4	150
20 Apr	4	155
21 Apr	4	150
22 Apr	4	150
23 Apr	4	195
24 Apr	4	230
25 Apr	4	210
26 Apr	4	250
27 Apr	4	218
28 Apr	5	175
29 Apr	5	178
30 Apr	5	160
1 May	5	150
2 May	5	146
3 May	5	148
4 May	5	174
5 May	6	166
6 May	6	188
7 May	6	172
8 May	5	150
9 May	6	146
10 May	6	139

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Appendix C1.–Page 2 of 2.

Date	Water temperature (^oC)	Water level (cm)
11 May	6	168
12 May	6	162
13 May	6	152
14 May	6	150
15 May	6	152
16 May	6	170
17 May	7	158
18 May	7	150
19 May	8	145
20 May	9	148
21 May	8	150
22 May	8	153
23 May	8	155
24 May	9	160
25 May	9	163
26 May	9	170
27 May	9	152
28 May	9	141
29 May	9	146

Appendix C2.–Daily water temperature (°C) and water level (cm) at Natzuhini Creek weir, 2007.

Date	Water temperature (°C)	Water level (cm)
11 Mar	8	132
12 Mar	7	132
13 Mar	4	132
14 Mar	4	110
15 Mar	4	110
16 Mar	4	120
17 Mar	5	115
18 Mar	5	100
19 Mar	5	100
20 Mar	4	100
21 Mar	4	130
22 Mar	5	145
23 Mar	4	275
24 Mar	5	165
25 Mar	5	150
26 Mar	4	145
27 Mar	4	120
28 Mar	4	200
29 Mar	4	130
30 Mar	4	110
31 Mar	4	100
1 Apr	4	105
2 Apr	4	100
3 Apr	4	95
4 Apr	4	95
5 Apr	4	125
6 Apr	5	300
7 Apr	5	270
8 Apr	5	290
9 Apr	5	280
10 Apr	6	200
11 Apr	5	185
12 Apr	7	170
13 Apr	5	220
14 Apr	6	190
15 Apr	6	180
16 Apr	6	200
17 Apr	5	250
18 Apr	5	185
19 Apr	5	170
20 Apr	5	160
21 Apr	7	170
22 Apr	6	160
23 Apr	6	250
24 Apr	7	280
25 Apr	7	250
26 Apr	6	295
27 Apr	5	205
28 Apr	7	200
29 Apr	6	230
30 Apr	7	190

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Appendix C2.–Page 2 of 2.

Date	Water temperature (°C)	Water level (cm)
1 May	6	180
2 May	7	165
3 May	7	160
4 May	7	190
5 May	6	180
6 May	7	200
7 May	6	180
8 May	7	160
9 May	7	158
10 May	7	160
11 May	7	190
12 May	7	168
13 May	7	158
14 May	7	155
15 May	8	150
16 May	8	180
17 May	8	180
18 May	8	160
19 May	8	158
20 May	8	158
21 May	8	152
22 May	8	152
23 May	9	150
24 May	9	156
25 May	9	160
26 May	9	161
27 May	9	150
28 May	9	150
29 May	9	151
30 May	9	176
31 May	8	158

APPENDIX D
COMPUTER FILES

Appendix D1.–Computer files containing data, statistics, and interim calculations used to assess steelhead stocks in Big Ratz Creek and Natzuhini Creek, 2007.

Computer file	Description
Big Ratz Creek steelhead_07	Excel file containing physical data, weir counts, snorkel survey counts, sex-length estimates, charts and appendices.
Natzuhini Creek steelhead_07	Excel file containing physical data, weir counts, snorkel survey counts, sex-length estimates, charts and appendices.