Fishery Data Series No. 07-34

Weir Enumeration and Assessment of Mark-Recapture Estimates for Steelhead Abundance in Twelve Mile Creek, 2004

by

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May 2007

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

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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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ABSTRACT

In 2004, a bipod weir was constructed on Twelve Mile Creek in Southeast Alaska to capture and enumerate all migrating steelhead *Oncorhynchus mykiss*. Between April 1 and June 3, a total of 87 immigrant and 84 emigrant steelhead were counted. Age classes 2.3, 3.2 and 3.3 and females dominated among spawning fish. The length of immigrant steelhead averaged 745 mm TL (SE = 12) and had SD = 71; no fish exceeded 914 mm (or 36 in, the regionwide legal size limit). Weekly snorkel surveys noted that, on average, 79% of the fish passed upstream through the weir were seen during survey counts. Using a modified Petersen model, an estimated 97 (SE = 2) steelhead immigrated above the weir based on fish marked at the weir. Additional mark-recapture studies conducted below the weir and using snorkel count observations of tagged fish failed to produce a reliable population estimate. Experimental spawning fish redd counts produced an estimate of 1.54 fish/redd.

Key words: Southeast Alaska, Twelve Mile Creek, Prince of Wales Island, steelhead, *Oncorhynchus mykiss*, escapement weir, age-sex-length, subsistence, mark-recapture, snorkel surveys, redd count, management decision

INTRODUCTION

Steelhead trout *Oncorhynchus mykiss* support an important subsistence fishery for rural residents of Prince of Wales Island (POW) in Southeast Alaska. Regulations that established a federally managed subsistence fishery for this species were approved by the Federal Subsistence Board in December 2002. In addition, a popular sport fishery exists and both urban and rural residents of Alaska and nonresident anglers from various sections of the lower 48 states and the world participate (S. Hoffman, Sport Fish Area Management Biologist, Alaska Department of Fish and Game, Ketchikan, personal observation; Jennings et al. 2006; Schwan 1984). The sport fishery is managed by the State of Alaska and has existed on POW since statehood. Little historical or current information is available to document steelhead population sizes, characteristics, run timing, and spatial distribution in the majority of the 85 POW streams that contain this species. The lack of data on these stocks has hampered efforts to assess the potential effects of directed subsistence harvest, and prevents the refinement of federal regulations that when coupled with conservative State sport fishing regulations, would ensure adequate conservation and allow for expanded subsistence harvest opportunities.

Steelhead are particularly valuable as a food resource because they provide for fresh fish harvest opportunities during a time period when other salmon species are unavailable. Information obtained from recent Alaska Department of Fish and Game (ADF&G) household surveys indicate that approximately 600 steelhead are harvested annually on POW by qualified users (Turek 2005); these data suggest that subsistence activities tend to occur in streams adjacent to their communities. Prior to the enactment of conservative sport fish regulations in the early 1990s, which restricted steelhead retention, the estimated recreational harvest on the island ranged from about 800 to 2,000 steelhead per year from 1987 to 1991 (Mills 1992). In contrast, recreational harvests averaged about 30 steelhead from 1999 to 2003 (Jennings et al. 2006).

During recent consultations between the United States Forest Service (USFS), ADF&G, and Bureau of Indian Affairs (BIA) staff, an agreement was reached to submit an updated jointly-operated project funding proposal to the Federal Subsistence Board to conduct needed biological assessment research on POW steelhead beginning in spring 2005. This project would be implemented for a minimum of three years and would begin to address subsistence fishery monitoring issues identified by the Southeast Regional Advisory Council (SERAC) during their fall 2002 meetings and listed in their current *Issues and Information Needs Assessment* ("Assessment of Fish Species Important to Subsistence Use, Particularly Prince of Wales Island Steelhead").

In addition, all three agencies agreed to a preliminary study in spring 2004 to test methods for conducting mark-recapture/weir escapement

studies. Twelve Mile Creek was selected for the preliminary study primarily because it is a road-accessible stream that, for management purposes, was considered a "small" (<150) steelhead system (however, anecdotal public comments indicate that the population size historically approached 200 fish annually). Twelve Mile Creek supports a spring run of steelhead.

The two main objectives of this study were to enumerate steelhead as they passed upstream through a weir and to assess the feasibility of performing mark-recapture studies on small populations of steelhead in Southeast Alaska. Concurrent with these objectives, age, length and sex data were collected, total counts from repeated snorkel surveys were compared to weir counts, and steelhead redds were counted.

STUDY AREA

Twelve Mile Creek (Figure 1) is a small stream located on the central east side of POW near Hydaburg and can be accessed at road km 9.7 of the Polk Inlet road (Forest Highway [FH] 21). The drainage is approximately 9.7 km long and is crossed by FH 21 0.2 km above the intertidal zone where it enters Twelve Mile Arm. The drainage has been extensively logged. Access to this stream is by foot. One can travel up and down the stream from the FH 21 bridge crossing, or hike decommissioned logging road spurs off FH 21 approximately 2.4 and 7.2 km up this drainage (Figure 2).

METHODS

ENUMERATION AND AGE, SEX, AND LENGTH COMPOSITION OF STEELHEAD CAPTURED AT THE WEIR

A bipod weir 25 m in length was constructed on Twelve Mile Creek to capture all migrating steelhead. The weir contained separate emigrant and immigrant traps, each 2.5 m square. The weir was located approximately 500 m upstream from tidewater and operated from April 1 through June 3. The integrity of the weir was checked daily, and fish in either trap were processed whenever necessary to avoid crowding. Additional information collected and recorded daily at the weir site included water temperature, measured using an instream thermograph, and stream depth, measured at 0800 hours each day using a stream level gauge.

Every adult steelhead captured in the immigrant trap was counted, tagged with a white anchor T-bar tag to identify it as being first caught at the weir, marked with an adipose finclip, measured to the nearest 5 mm FL and TL, inspected to determine sex, and released upstream of the weir. Date of capture was also recorded to assess run timing. Four scales were collected from a subsample of fish from the left side in the preferred location (Alword 1954) and pressed flat on gum cards in sequential order. Aging of scales was conducted using methods described by Narver and Withler (1977). Samples were read two times and if the readings did not agree, the sample was read a third time; a sample was considered successfully aged if two readings agreed (note that agreement was only a measure of bias, not true age). All other species of fish passed upstream through the weir were identified, counted, and recorded.

All adult steelhead captured in the emigrant trap were counted, examined for tags and marks, given an upper caudal fin lobe punch to prevent double sampling, and released downstream of the weir. Date of capture was recorded. Measurements and scale samples were collected as described above from previously unsampled fish. All other species of fish passed downstream through the weir were identified and recorded.

Use of the weir produced a census, not a sample, of the steelhead population, so length could theoretically be calculated directly with no variance. In practice, late initiation-early termination of weir operations, or high water events and weir failure can mean that some fish are not sampled. Evaluation of the number of unmarked fish in the emigration indicated whether or not a complete census was achieved. Because fish were subsampled for scales and some samples could not be aged, the following method was used for age composition:

$$\hat{p}_a = \frac{n_a}{n} \tag{1}$$

$$\mathrm{var}[\hat{p}_a] = \frac{\hat{p}_a(1-\hat{p}_a)}{n-1} \tag{2}$$

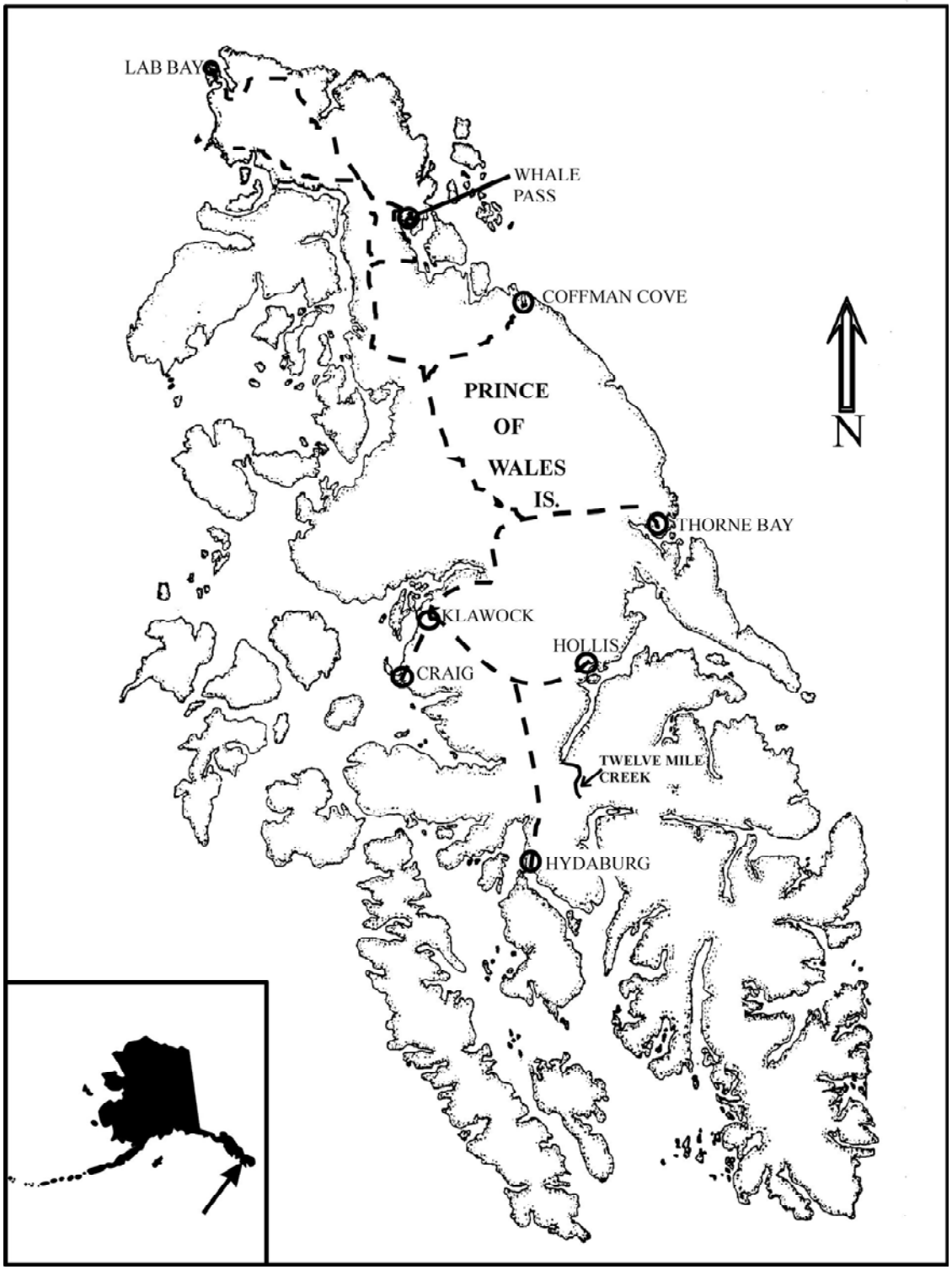

Figure 1.–Prince of Wales Island and Twelve Mile Creek. Dotted lines represent the Forest Highway road system.

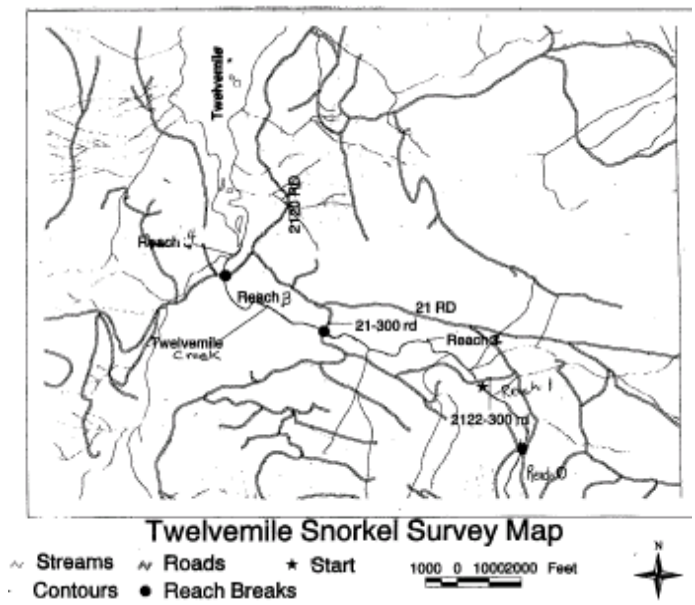

Figure 2.–Twelve Mile Creek drainage and snorkel survey reaches (0 to 4), 2004.

where n was the number of fish successfully aged, and n_a was the subset of n that belonged to age group a. If n was large relative to the estimated abundance N (= $\hat{N}$ or $\hat{N}^*$, see following section), equation 2 was multiplied by the term (1-n/N).

MARK-RECAPTURE FEASIBILITY STUDY

The feasibility of performing mark-recapture studies on other steelhead populations throughout Southeast Alaska was investigated with an experiment designed to run concurrently with the weir operations. Adult steelhead were captured independently of the weir operations and marked differently than those captured at the weir. Snorkel surveys were performed above and below the weir and served as the recapture event via observation of previously-tagged fish.

Capture and Marking (Event 1)

Marking events took place downstream of the weir. To minimize bias of the marked population, a variety of methods (beach seining, angling and dip nets) were employed to capture adult steelhead. Capture events were scheduled to occur between April 1 and June 3. Upon capture, data were collected in the same manner described above. Steelhead captured during these events were tagged with a yellow anchor T-bar tag. Also, each steelhead received a secondary mark but, unfortunately, the same mark was also administered at the weir (an adipose finclip).

Recapture (Event 2)

Beginning on April 6, a two-person snorkel crew and one shore line safety officer regularly (usually every 3–4 days) conducted snorkel surveys in Twelve Mile Creek. These surveys began at the upper logging road access point (road km 7.2) and continued to the intertidal zone below the weir (five reaches, Figure 2). During these surveys, the snorkel crew enumerated all observed steelhead. Any observed tags or marks were recorded for individual fish. For the purpose of the mark-recapture experiment, sighting a yellow tag constituted a recapture.

Abundance Estimation

This experiment was designed to use Bailey's modification of the Petersen model (Seber 1982) to estimate the abundance of adult steelhead in *the entire system* $\hat{N}$:

$$\hat{N} = \frac{n_1(n_2+1)}{(m_2+1)} \tag{3}$$

$$\mathrm{var}\left[\hat{N}\right] = \frac{n_1^{\,2}(n_2+1)(n_2-m_2)}{(m_2+1)^2(m_2+2)} \qquad (4)$$

where:

n_1 = the number marked during the first sampling event;

n_2 = the number examined during the second sampling event; and,

m_2 = the number captured during the second sampling event with marks from the first sampling event.

A number of assumptions needed to be met to obtain an unbiased estimate. These assumptions were (Seber 1982):

1. the population was closed;
2. all steelhead had the same probability of capture in the marking sample;
3. marking did not affect the catchability of an individual;
4. the recapture event was a simple random sample of the marking event;
5. there was no tag loss;
6. all marked steelhead were reported on recovery.

When using snorkel surveys to recapture steelhead, the following issues and concerns were considered:

a. the visual "recovery" of marks during the snorkel surveys was likely a function of many variables (fish position relative to the observer, fish speed relative to the observer, distance from observer, water clarity, numbers of fish encountered at once, snorkeling difficulty, and other factors that could not be easily quantified). This could have led to a violation of assumption 6 above. Also, use of visual recovery would not allow for adequate testing of assumption 5, no tag loss;

b. experimental assumptions such as equal probability of capture and no size selectivity would either not be verifiable or not made with confidence using visual recoveries; and

c. even if the above concern could be addressed, low capture rates could prevent testing the assumptions of a mark-recapture experiment and not permit the use of a stratified (by time or area) design. Therefore it would be difficult to test the validity of assumption 4.

Operation of the weir would address some of these concerns. For instance, it would sufficiently test if the population was closed (assumption 1), and by assessing population parameters for emigrating steelhead captured at the weir, assumption 2 could be verified. The weir could indirectly test certain aspects of assumption 4 in that the timing of marked fish leaving the system could be monitored. The weir could not address violations in assumptions 3 or 6, and because the same secondary mark was used to mark immigrant steelhead at the weir and during Event 1 of the mark-recapture experiment, tag loss (assumption 5) could not be reliably attributed to the marking event below the weir.

Alternative Method for Estimating Abundance

The immigration and emigration events at the weir provided an opportunity to estimate the abundance of steelhead *above the weir* $\hat{N}^*$ via a mark-recapture experiment using Chapman's modification of the Petersen estimator (Seber 1982):

$$\hat{N}^* = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1 \qquad (5)$$

$$\mathrm{var}\left[\hat{N}^*\right] = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)} \qquad (6)$$

Necessary conditions for accurate use of a Petersen-type estimator (Seber 1982) included:

1. every fish had an equal probability of being marked in the first event, <u>or</u> that every fish had an equal probability of being captured in the second event, <u>or</u> that marked fish mixed completely with unmarked fish; <u>and</u>

2. both recruitment and mortality did not occur between events; and
3. marking did not affect the catchability of a fish; and
4. fish did not lose their marks in the time between the two events; and
5. all marks were reported on recovery in the second event; and
6. double sampling did not occur.

Given the obvious nature of the weir, a large majority of the steelhead population was captured both immigrating and emigrating, which meant that the sum of the mark and recapture events was larger than the total population size. When $n_1 + n_2 > N$, the Chapman modification is unbiased (Seber 1982). As an added assurance, Kolmogorov-Smirnov (K-S, Conover 1980) two-sample tests were used to test the hypothesis that fish of different lengths were captured with equal probability during both first and second sampling events (Appendix A1), and consistency tests (Appendix A2) were used to test for temporal violations of assumption 1. The experiment was assumed closed to recruitment because first event sampling essentially spanned the entire immigration, and while mortality undoubtedly occurred, it could be ignored if marked and unmarked fish died at the same rate. The use of multiple marks during the first event, careful inspection of all fish captured during the second event, and additional marking of all fish inspected helped to ensure assumptions 4, 5, and 6 were met. In this experiment, the use of an adipose finclip as a secondary mark was not a confounding factor because a known number of fish were passed upstream with tags and marks and all tag loss could be attributed to a single release site.

SNORKEL SURVEY EXPANSION FACTOR

During the surveys, the snorkel teams counted the number of steelhead observed in the four survey reaches above the weir (Figure 2). System-specific snorkel survey expansion factors were calculated for each survey as:

$$\pi_t = N_t / C_t \tag{7}$$

where:

C_t = the snorkel count above the weir (reaches 0-3) at time t; and

N_t = the net number of steelhead passed upstream through the weir (i.e., the upstream weir count minus the number passed downstream and known mortalities) at time t.

After all surveys were conducted, $\hat{\pi}$ was calculated as the average of k available estimates:

$$\hat{\pi} = \sum_{i=1}^{k} \pi_t / k \tag{8}$$

Each snorkel survey count C_t was expanded by the average expansion factor $\hat{\pi}$ to obtain a point estimate $\hat{N}_t$. The number of point estimates that fell within ± 50% of the true value (defined as the net upstream weir count at time t) was divided by k as a measure of the intraannual reliability of $\hat{\pi}$.

REDD COUNTS

Beginning on April 20, 2004 and thereafter approximately every ten days, spawning redds were counted by a two-person foot crew in the five reaches covered during the snorkel surveys (Figure 2). During each survey, redds were marked by hanging a piece of red flagging tape adjacent to the location with the date observed; a GPS coordinate was taken to prevent duplicate counts during subsequent surveys. Redds counted above the weir were used to estimate the number of fish/redd $\hat{R}$, based on the above-weir mark-recapture estimate $\hat{N}^*$:

$$\hat{R} = \hat{N}^* / r \tag{9}$$

$$\mathrm{var}[\hat{R}] = \mathrm{var}[\hat{N}^*] / r^2 \tag{10}$$

where r was the number of redds counted above the weir.

RESULTS

ENUMERATION AND AGE, SEX, AND LENGTH COMPOSITION OF STEELHEAD CAPTURED AT THE WEIR

The Twelve Mile Creek weir operated from April 1 through June 3, 2004. During this period, 87

steelhead were passed upstream. Of those, 75 were marked and released with white anchor T-bar tags, six had yellow anchor T-bar tags from the marking event downstream of the weir, and six unmarked fish were observed upstream of the weir before it was fish tight. A total of 84 post-spawn fish, or kelts, were passed downstream Of those, 53 had white anchor T-bar tags, four had yellow anchor T-bar tags, 14 were unmarked, and 13 had lost their anchor T-bar tags, as evidenced by a missing adipose fin (Table 1, Figure 3, Appendix A3).

Table 1–. Numbers of steelhead by mark/tag status released (immigration) and inspected (emigration) at the weir on Twelve Mile Creek, 2004.

Mark/tag status	Immigration	Emigration
White Floy tag	75	53
Yellow Floy tag	6	4
Unmarked	6	14
No Floy tag or adipose fin		13
Total	87	84

The peak of the immigration occurred on April 23 when 12 fish were passed upstream, and the 50% point in the run was reached on April 22; the 50% point of the emigration was reached on May 19, and the peak occurred on May 22 when 15 fish were passed downstream (Figures 3 and 4, Appendix A3). Water temperature ranged from approximately 3°C during March to about 11°C in late May. Water temperature was above 4.5°C during the period of peak immigration. Stream depths taken at the weir gauging station varied from 75 cm during late March to around 30 cm during to the period of peak immigration (Figure 3, Appendix A3).

A total of 70 of the 87 immigrant steelhead passed through the weir were sampled for scales. Of these, 35 were successfully aged, but two fish were omitted from the analysis because they were not sexed. The sample was composed of 12% (SE = 5%) age-2.2, 27% (SE = 6%) age-2.3, 22% (SE = 6%) age-3.2, and 33% (SE = 7%) age-3.3 fish; females (58%, SE = 7%) predominated the sample (Table 2). Eighty-one of the 87 immigrants were measured. Total length averaged 745 mm (SE = 12) and had SD = 71; no fish exceeded 914 mm (or 36 in, the regionwide legal size limit).

The emigrant age sample was composed of 23 fish that were sampled as immigrants and subsequently recaptured in the emigrant trap, and 11 scale samples collected from previously unsampled fish. Of these, 29 were successfully aged. Age-2.3 fish (38%, SE = 8%) and females (55%, SE = 8%) predominated the sample (Table 2).

MARK-RECAPTURE FEASIBILITY STUDY

Eight steelhead were marked with yellow anchor T-bar tags below the weir from April 13 to 21. In order to fulfill the closure assumption, only surveys performed at peak escapement, as indicated by the upstream weir count, were used. During this time period, three complete snorkel surveys of all five survey reaches were conducted (May 14, 17, and 21 surveys; Table 3). Using Bailey's modification of the Petersen model, the estimated abundance of the steelhead run, *germane to the entire system*, was 292 (SE = 129; 95% CI = 40, 544; n_1 = 8, n_2 = 145, m_2 = 3). While the 95% confidence interval undoubtedly captured the true value, an estimate this imprecise was not useful.

Alternatively, run abundance was estimated using fish tagged and inspected at the weir. Chapman's modified Petersen estimator (Seber 1982) was used to estimate run abundance at 97 (SE = 2; 95% CI = 94, 101), where n_1 = 81, n_2 = 84, and m_2 = 70 (Table 1). *This estimate was germane to the abundance of steelhead above the weir*. Because $n_1 + n_2 > N$, the Chapman estimate was unbiased, and other observations support that. There was no evidence that sampling of immigrant or emigrant steelhead at the weir was size-selective. Length distributions of fish marked at the weir (marks) and subsequently recaptured (recaptures) were not significantly different (KS: d_{max} = 0.046; n =81, 69; P = 1.0; Figure 5), nor were the length distributions of fish inspected for marks at the weir (captures) and recaptured fish (KS: d_{max} = 0.043; n =56, 69; P = 1.0; Figure 5). Length distributions of fish marked and inspected for marks at the weir were also similar (KS: d_{max} = 0.050; n =81, 56; P = 0.99; Figure 5). These results indicate that sampling was not size-selective during either event (Appendix A1).

Additional evidence supports the supposition that every steelhead passing by the weir site had an

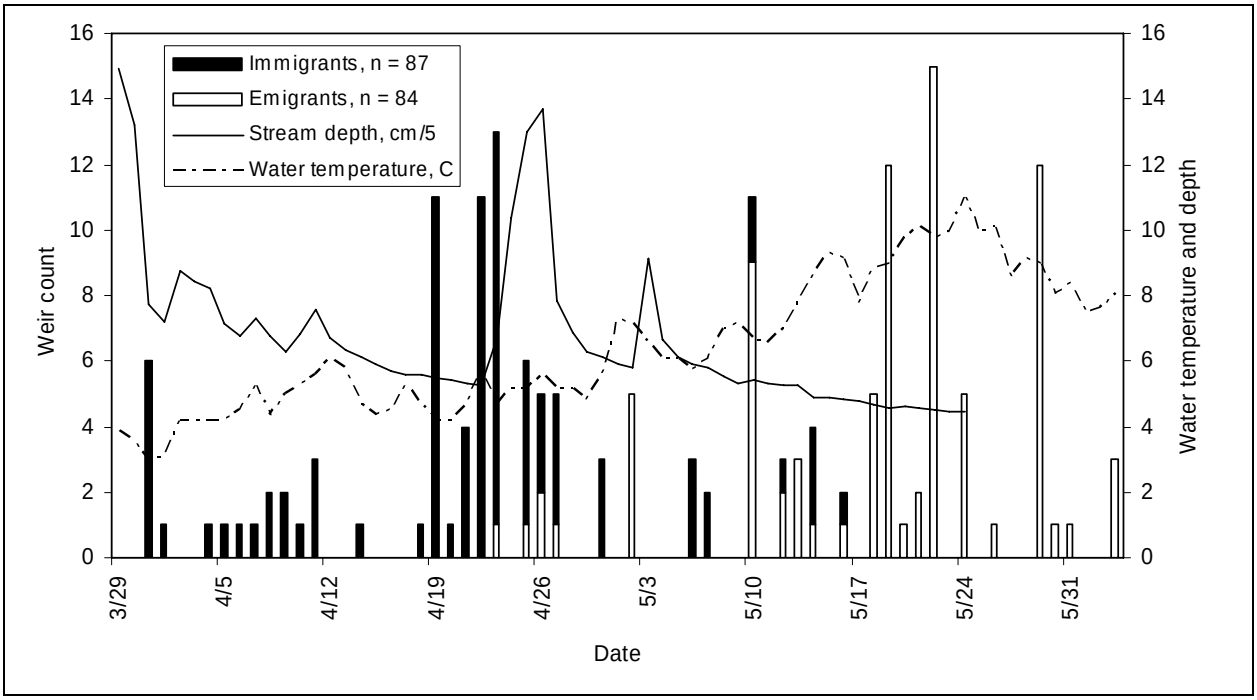

Figure 3.–Steelhead immigration and emigration, water temperature, and stream depth in Twelve Mile Creek, 2004.

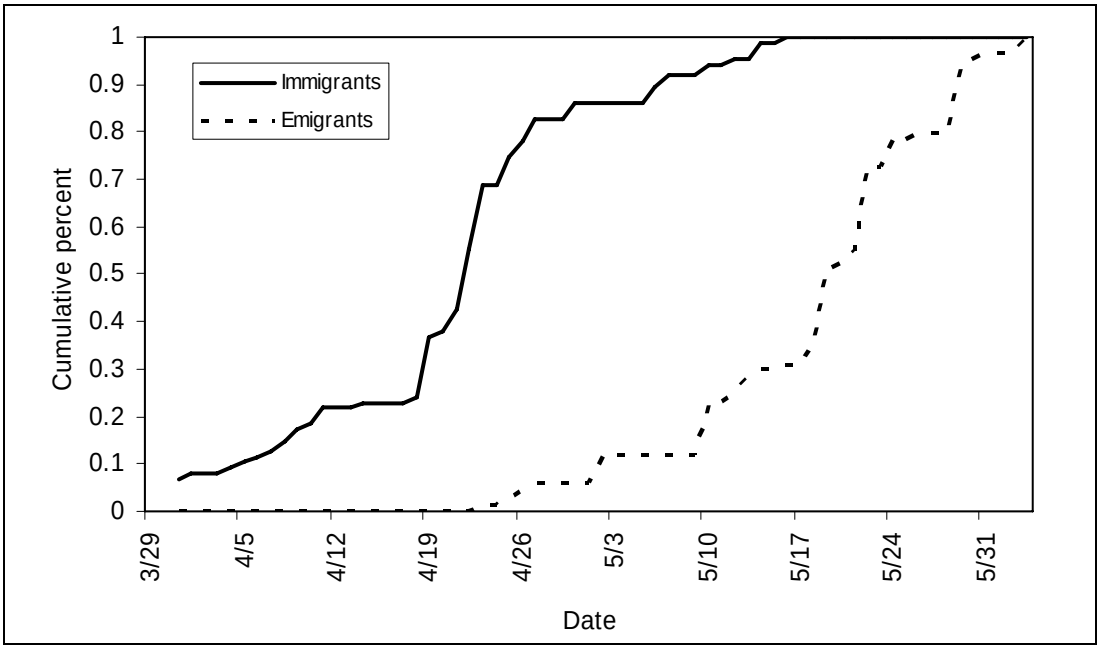

Figure 4.–Run timing of steelhead in Twelve Mile Creek, 2004.

equal chance of being marked during the first event. Marked fractions over time were compared by arbitrarily splitting the recapture data at the date when 50% of the tags were recovered (Table 4, Appendix A2). The marked fractions were not significantly different ($\chi^2 = 0.24$, df = 1, P = 0.62), thus satisfying one of the "or" assumptions of a Petersen-type estimator.

Table 2.–Age, sex, and length composition of steelhead sampled at the weir in Twelve Mile Creek, 2004. Lengths are in mm.

		IMMIGRATION						
		Brood year and age class						
		1999	1998	1998	1997	1997	1996	
		2.2	2.3	3.2	2.4	3.3	3.4	Total
Females	n	1	7	3	1	7		19
	%	5.3	36.8	15.8	5.3	36.8		57.6
	SE [%]		10.2	7.7		10.2		7.1
	Average FL	730	739	655	765	778		741
	SE [average FL]		23	28		21		15
	Average TL	760	765	683	800	801		767
	SE [average TL]		21	22		20		14
Males	n	3	2	4		4	1	14
	%	21.4	14.3	28.6		28.6	7.1	42.4
	SE [%]	10.5	9.0	11.6		11.6		7.1
	Average FL	655	775	631		734	695	691
	SE [average FL]	18	85	4		26		20
	Average TL	678	800	656		759	715	715
	SE [average TL]	21	90	8		29		21
Combined	n	4	9	7	1	11	1	33
	%	12.1	27.3	21.2	3.0	33.3	3.0	100.0
	SE [%]	4.7	6.4	5.9		6.8		0.0
	Average FL	674	747	641	765	762	695	720
	SE [average FL]	23	23	12		17		13
	Average TL	699	773	668	800	785	715	745
	SE [average TL]	25	23	11		17		12
		EMIGRATION						
Females	n	1	7		1	5		16
	%	6.3	43.8	12.5	6.3	31.3		55.2
	SE [%]		11.7	7.8		10.9		7.9
	Average FL	730	754	635	765	783		747
	SE [average FL]		27	35		29		18
	Average TL	760	782	668	800	807		775
	SE [average TL]		26	28		28		18
Males	n	2	4	4		2	1	13
	%	15.4	30.8	30.8		15.4	7.7	44.8
	SE [%]	9.7	12.4	12.4		9.7		7.9
	Average FL	660	759	701		768	695	722
	SE [average FL]	30	37	36		28		19
	Average TL	685	788	719		800	715	747
	SE [average TL]	35	39	38		20		20
Combined	n	3	11	6	1	7	1	29
	%	10.3	37.9	20.7	3.4	24.1	3.4	100.0
	SE [%]	4.8	7.7	6.4		6.8		0.0
	Average FL	683	755	679	765	779	695	736
	SE [average FL]	29	21	28		21		13
	Average TL	710	784	702	800	805	715	763
	SE [average TL]	32	20	27		20		13

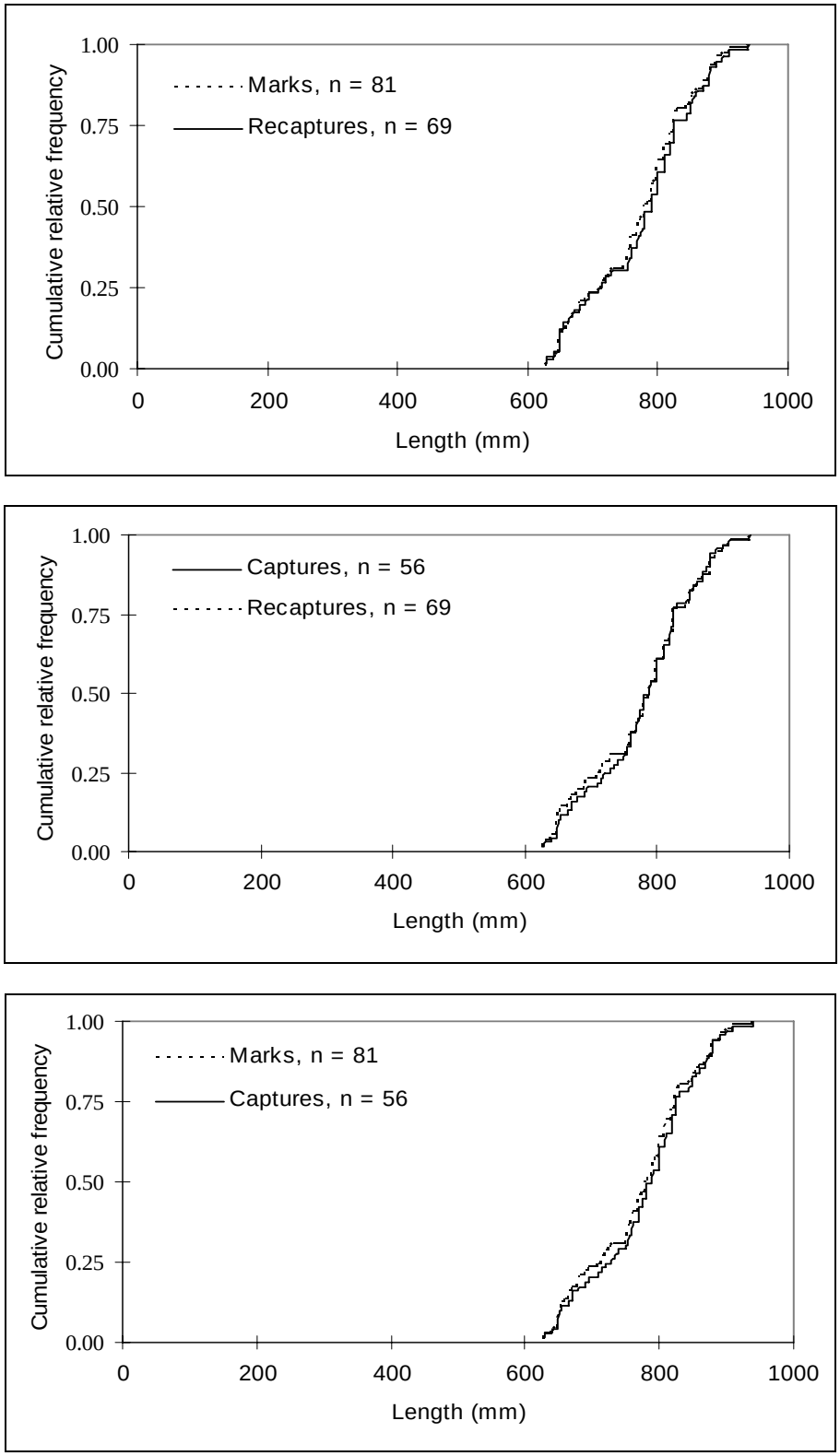

Figure 5.–Cumulative relative frequencies of steelhead marked in Event 1 and recaptured in Event 2 (upper graph), captured and recaptured in Event 2 (middle graph), and marked in Event 1 and captured in Event 2 (bottom graph) at the weir in Twelve Mile Creek, 2004.

SNORKEL SURVEY EXPANSION FACTOR

A total of 14 snorkel surveys were conducted between April 1 and June 3, 2004 (Table 3). Survey expansion factors ranged from 1.67 to 1.00, and averaged 1.27 (or 60 to 100% of net upstream weir count at time *t*, average = 79%). Seventy-nine percent of the snorkel surveys conducted above the weir, expanded by the average expansion factor, fell within ± 50% of the net upstream weir count at time *t*. The peak above-weir snorkel survey count was 66 fish (May 7 survey, reaches 0-3, Table 3). This equates to an above-weir estimate of 84 when the count is expanded by the average expansion factor, well within ± 50% of both the mark recapture estimate and the upstream weir count.

REDD COUNTS

A total of five surveys were conducted from April 20 to May 30. During these surveys, a total of 63 redds were counted above the weir that were produced by an estimated 97 spawners. The estimated number of fish/redd $\hat{R}$ was 1.54 (SE = 0.03). An additional 10 redds were counted below the weir (Appendix A4).

DISCUSSION

The above-weir mark-recapture abundance estimate was comparable to the upstream weir count (97 vs. 87, respectively). If the six unmarked fish observed upstream of the weir before it was fish tight are subtracted from the number of unmarked emigrant fish passed downstream (14, Table 1) and the difference (8 fish) is added to the upstream weir count, the results are nearly identical (97 vs. 95). These results agree with the designation of Twelve Mile Creek as a "small" (<150) steelhead system. Note that the number of fish below the weir that were never passed upstream was not estimable. However, snorkel surveys conducted below the weir suggest the number of fish that did not immigrate through the weir was small (Table 3).

The mark-recapture experiment based on marking fish below the weir and snorkel survey recoveries failed to produce a reliable escapement estimate. The point estimate (292) was considered unreasonably high, even though the exact number of fish residing below the weir was not known with certainty. The most probable reasons this method failed to produce a usable estimate were: significant tag loss, the inability to reliably quantify tag loss, the small number of marked fish released in Event 1, and problems encountered distinguishing yellow from white anchor T-bar tags in the tannic water of Twelve Mile Creek. If implemented in the future, mark-recapture studies on small populations of steelhead could be improved by using an easily identifiable primary mark and a unique secondary mark (note that the recently administered adipose finclips were easily observed by the snorkel surveyors; often the "white" scar was the first feature identified). However, this study demonstrated that it is extremely difficult to capture and tag a sufficient number of fish during the marking event using beach seines, dip nets, and sport gear.

The snorkel survey research conducted during this project was promising. Although weirs can impact run timing (e.g., see Bain et al. 2003), they can provide an effective method for calibrating snorkel counts. Note, however, that expansion factors based on one year of data fail to capture interannual variability and such studies should be conducted over several years.

Utilization of redd counts within a drainage to estimate steelhead escapement appears to be a feasible method based on the preliminary work conducted on Twelve Mile Creek. The results from this study indicate that frequency and timing of surveys, experience of the observer, and water clarity are all critical factors that influence the success of this methodology. Before this method can be adopted on a wider basis and used for management decisions, additional feasibility work needs to be completed to determine if fish/redd ratios are system-specific and constant over time. Redd counts have been used extensively in the Pacific Northwest to monitor steelhead escapements (Busby et al. 1996) but have traditionally not been utilized in Southeast Alaska. The potential exists in some systems to investigate the reliability of redd counts as an index of adult escapements.

Aging steelhead scales proved to be difficult and the results presented herein should be viewed in that light. Of the 70 samples collected from immigrant steelhead at the weir, 35 were

Table 3.–Upstream and downstream cumulative weir counts, snorkel survey counts, snorkel survey expansion factors, and tags recovered during snorkel surveys in Twelve Mile Creek, 2004. Reaches 0-3 were upstream from the weir, and reach 4 was downstream. Numbers in bold were used in the mark-recapture analysis based on fish marked below the weir.

Date	Cumulative weir count		Net upstream weir count, N_t	Yellow Floy tags seen, reaches 0-4	Total snorkel survey count, reachs 0-3, C_t	Total snorkel survey count, reachs 0-4	Snorkel survey counts by reach					Expansion factor, π_t [a,b]
	Up	Down					Reach 0	Reach 1	Reach 2	Reach 3	Reach 4	
04/06	10	0	10		8		1	0	2	5	--	1.25
04/12	19	0	19		19		1	1	8	9	--	1.00
04/16	20	0	20		18		3	5	3	7	--	1.11
04/19	32	0	32	2	23	28	5	3	2	13	5	1.39
04/23	60	1	59	5	44	45	5	2	8	29	1	1.34
04/27	72	5	67	3	49	49	5	3	11	30	0	1.37
04/30	75	5	70		52		3	3	12	34	--	1.35
05/04	75	10	65	2	52	52	2	0	7	43	0	1.25
05/07	80	10	70		66		2	0	0	64	--	1.06
05/14	86	25	61	**1**	40	**49**	0	1	4	35	9	1.53
05/17	87	26	61	**1**	54	**57**	1	0	6	47	3	1.13
05/21	87	46	41	**1**	37	**39**	3	0	3	31	2	1.11
05/24	87	66	21		17		1	0	2	14	--	1.24
05/28	87	67	20	0	12	16	0	0	1	11	4	1.67
06/03	87	85										
Average, $\hat{\pi}$												1.27
Total without 4/19 survey				**3**		**145**						

[a] N_t/C_t.

[b] Seventy-nine percent of the snorkel surveys conducted above the weir C_t, expanded by the average expansion factor (1.27), fell within ± 50% of the net upstream weir count N_t

successfully aged, 32 could not be read because of regenerated scales or otherwise poor samples, and agreement could not be reached on three. Of the 35 samples that were successfully aged, 14 had to be read three times because of disagreements in saltwater age (eight cases), freshwater age (five cases), and both freshwater and saltwater ages (one case).

In easily accessed road system streams such Twelve Mile Creek, consideration of conservative management strategies such as catch and release regulations, size restrictions, or small seasonal bag limits may be appropriate to ensure continuation of an ongoing subsistence and/or sport fisheries.

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APPENDIX A

Appendix A1.–Detection of size- and/or sex-selective sampling during a two-sample mark-recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling: Contingency table analysis (Chi^2-test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather an observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two sample test (e.g. Student's t-test).

M vs. R	**C vs. R**	**M vs. C**
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o
There is no size/sex selectivity detected during either sampling event.		
Case II:		
Reject H_o	Fail to reject H_o	Reject H_o
There is no size/sex selectivity detected during the first event but there is during the second event sampling.		
Case III:		
Fail to reject H_o	Reject H_o	Reject H_o
There is no size/sex selectivity detected during the second event but there is during the first event sampling.		
Case IV:		
Reject H_o	Reject H_o	Either result possible
There is size/sex selectivity detected during both the first and second sampling events.		
Evaluation Required:		
Fail to reject H_o	Fail to reject H_o	Reject H_o
Sample sizes and powers of tests must be considered:		

-continued-

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C test are very large, the M vs. C test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the second event which the M vs. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less), and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the first event which the C vs. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), the rejection of the null in the M vs. C test may be the result of size/sex selectivity during both events which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

-continued-

If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameter (p_k) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \qquad (1)$$

and,

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \left(\sum_{i=1}^{j} \hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + \left(\hat{p}_{ik} - \hat{p}_k \right)^2 \hat{V}[\hat{N}_i] \right) \qquad (2)$$

.

where: j = the number of sex/size strata;

$\hat{p}_{ik}$ = the estimated proportion of fish that were age or size k among fish in stratum i;

$\hat{N}_i$ = the estimated abundance in stratum i; and,

$\hat{N}_\Sigma$ = sum of the $\hat{N}_i$ across strata.

Appendix A2.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).

Tests of consistency for Petersen estimator

Of the following conditions, at least one must be fulfilled to meet assumptions of a Petersen estimator:

1. Marked fish mix completely with unmarked fish between events;
2. Every fish has an equal probability of being captured and marked during event 1; or,
3. Every fish has an equal probability of being captured and examined during event 2.

To evaluate these three assumptions, the chi-square statistic will be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all three tests are rejected, a temporally or geographically stratified estimator (Darroch 1961) should be used to estimate abundance.

I.-Test for complete mixing [a]

Area/time where marked	Time/area where recaptured				Not recaptured
	1	2	…	t	(n_1-m_2)
1					
2					
…					
s					

II.-Test for equal probability of capture during the first event [b]

	Area/time where examined			
	1	2	…	t
Recaptured (m_2)				
Unmarked (n_2-m_2)				

III.-Test for equal probability of capture during the second event [c]

	Area/time where marked			
	1	2	…	s
Recaptured (m_2)				
Not recaptured (n_1-m_2)				

[a] This tests the hypothesis that movement probabilities (θ) from time or area *i* (*i* = 1, 2, ...s) to section *j* (*j* = 1, 2, t) are the same among sections: H_0: $\theta_{ij} = \theta_j$.

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked to unmarked ratio among time or area designations: H_0: $\Sigma_i a_i \theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum j at the time of sampling, and a_i = number of marked fish released in stratum i.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities among time or area designations: H_0: $\Sigma_j \theta_{ij} p_j = d$, where p_j is the probability of capturing a fish in section j during the second event, and d is a constant.

Appendix A3.–Upstream and downstream weir counts of steelhead, water temperature, and stream depth at Twelve Mile Creek, 2004. Box indicates 50% point in run.

Date	Upstream count	Cumulative % upstream count	Downstream count	Cumulative % downstream count	Water temperature, °C	Stream depth, cm
03/29					3.9	75
03/30					3.6	66
03/31[a]	6	0.07	0	0.00	2.9	39
04/1	1	0.08	0	0.00	3.1	36
04/2	0	0.08	0	0.00	4.2	44
04/3	0	0.08	0	0.00	4.2	42
04/4	1	0.09	0	0.00	4.2	41
04/5	1	0.10	0	0.00	4.2	36
04/6	1	0.11	0	0.00	4.5	34
04/7	1	0.13	0	0.00	5.3	37
04/8	2	0.15	0	0.00	4.3	34
04/9	2	0.17	0	0.00	5.0	31
04/10	1	0.18	0	0.00	5.3	34
4/11	3	0.22	0	0.00	5.6	38
04/12	0	0.22	0	0.00	6.1	34
04/13	0	0.22	0	0.00	5.8	32
04/14	1	0.23	0	0.00	4.7	30
04/15	0	0.23	0	0.00	4.3	30
04/16	0	0.23	0	0.00	4.5	28
04/17	0	0.23	0	0.00	5.3	28
04/18	1	0.24	0	0.00	4.7	28
04/19	11	0.37	0	0.00	4.2	27
04/20	1	0.38	0	0.00	4.2	27
04/21	4	0.43	0	0.00	4.7	27
04/22	11	0.55	0	0.00	5.8	26
04/23	12	0.69	1	0.01	4.7	34
04/24	0	0.69	0	0.01	5.1	52
04/25	5	0.75	1	0.02	5.1	65
04/26	3	0.78	2	0.05	5.6	69
04/27	4	0.83	1	0.06	5.1	39
04/28	0	0.83	0	0.06	5.1	34
04/29	0	0.83	0	0.06	4.8	31
04/30	3	0.86	0	0.06	5.6	30
05/1	0	0.86	0	0.06	7.3	30
05/2	0	0.86	5	0.12	7.2	29
05/3	0	0.86	0	0.12	6.5	46
05/4	0	0.86	0	0.12	6.1	33
05/5	0	0.86	0	0.12	6.1	30
5/6	3	0.90	0	0.12	5.8	30
5/7	2	0.92	0	0.12	6.1	29
5/8	0	0.92	0	0.12	7.0	28
5/9	0	0.92	0	0.12	7.2	27
5/10	2	0.94	9	0.23	6.7	27
5/11	0	0.94	0	0.23	6.5	27
5/12	1	0.95	2	0.25	7.0	26
5/13	0	0.95	3	0.29	7.8	26
5/14	3	0.99	1	0.30	8.7	24
5/15	0	0.99	0	0.30	9.3	24
5/16	1	1.00	1	0.31	9.2	24
5/17	0	1.00	0	0.31	7.8	24

-continued-

Appendix A3.–Page 2 of 2.

Date	Upstream count	Cumulative % upstream count	Downstream count	Cumulative % downstream count	Water temperature, °C	Stream depth, cm
5/18	0	1.00	5	0.37	8.8	23
5/19	0	1.00	12	0.51	9.0	23
5/20	0	1.00	1	0.52	9.8	23
5/21	0	1.00	2	0.55	10.1	23
5/22	0	1.00	15	0.73	9.8	23
5/23	0	1.00	0	0.73	9.9	22
5/24	0	1.00	5	0.79	11.0	22
5/25	0	1.00	0	0.79	9.9	
5/26	0	1.00	1	0.80	10.1	
5/27	0	1.00	0	0.80	8.5	
5/28	0	1.00	0	0.80	9.2	
5/29	0	1.00	12	0.94	9.0	
5/30	0	1.00	1	0.95	8.1	
5/31	0	1.00	1	0.96	8.4	
6/1	0	1.00	0	0.96	7.5	
6/2	0	1.00	0	0.96	7.6	
6/3	0	1.00	3	1.00	8.1	
Total	87		84			

[a] Six steelhead were observed above the weir before it was fish tight.

Appendix A4.–Steelhead redd counts in Twelve Mile Creek, 2004. Reaches 0-3 were upstream from the weir, and reach 4 was downstream.

Reach	Redd number	Seen on 4/20	Seen on 4/28	Seen on 5/8	Seen on 5/19	Seen on 5/30	GPS coordinates
0	1	yes	no	no	no	no	No GPS
0	2	yes	no	no	no	no	N 55 19.026' W 132 41.571'
0	3	yes	yes	yes	yes	yes	N 55 19.373' W 132 41.595'
0	4	yes	no	no	no	no	N 55 19.690' W 132 41.638'
0	5	yes	no	no	no	no	N 55 19.812' W 132 41.550'
0	6	yes	no	no	no	no	N 55 19.812' W 132 41.550'
1	7	yes	yes	yes	yes	yes	N 55 20.012' W 132 41.674'
1	8	yes	no	no	no	no	N 55 20.012' W 132 41.674'
1	9	yes	no	no	no	no	N 55 20.012' W 132 41.674'
2	10	yes	no	no	no	no	N 55 20.205' W 132 42.026'
2	11	yes	no	no	no	no	N 55 20.205' W 132 42.026'
2	12	yes	no	no	no	no	N 55 20.223' W 132 42.055'
2	13	yes	no	no	no	no	N 55 20.295' W 132 42.243'
2	14	yes	no	no	no	no	N 55 20.338' W 132 42.542'
2	15	yes	no	no	no	no	N 55 20.319' W 132 42.635'
2	16	yes	no	no	no	no	N 55 20.289' W 132 42.773'
3	17	yes	no	no	no	no	N 55 20.435' W 132 43.393'
3	18	yes	no	no	no	no	N 55 20.446' W 132 43.587'
3	19	yes	no	no	no	no	N 55 20.500' W 132 43.713'
3	20	yes	no	no	no	no	N 55 20.576' W 132 43.922'
3	21	yes	no	no	no	no	N 55 20.576' W 132 43.922'
3	22	yes	yes	yes	yes	yes	N 55 20.515' W 132 44.042'
3	23	yes	no	no	no	no	N 55 20.628' W 132 44.212'
0	24		yes	yes	yes	yes	N 55 19.522' W 132 41.695'
1	25		yes	yes	yes	yes	N 55 19.963' W 132 41.603'
1	26		yes	yes	yes	yes	N 55 19.987' W 132 41.667'
2	27		yes	yes	no	no	N 55 20.319' W 132 42.635'
2	28		yes	yes	yes	yes	N 55 20.376' W 132 43.096'
2	29		yes	yes	yes	yes	N 55 20.385' W 132 43.163'
2	30		yes	yes	yes	yes	N 55 20.385' W 132 43.163'
2	31		yes	yes	yes	yes	N 55 20.390' W 132 43.179'
3	32		yes	yes	no	no	N 55 20.549' W 132 43.876'
3	33		yes	yes	yes	yes	N 55 20.576' W 132 43.922'
0	34			yes	yes	yes	no GPS
0	35			yes	yes	yes	N 55 19.021' W 132 41.594'
0	36			yes	yes	yes	N 55 19.119' W 132 41.597'
0	37			yes	yes	yes	N 55 19.187' W 132 41.555'
0	38			yes	yes	yes	N 55 19.243' W 132 41.526'
0	39			yes	yes	yes	N 55 19.422' W 132 41.627'
0	40			yes	yes	yes	N 55 19.433' W 132 41.590'
0	41			yes	yes	yes	N 55 19.458' W 132 41.609'
0	42			yes	yes	yes	N 55 19.469' W 132 41.614'
0	43			yes	yes	yes	N 55 19.575' W 132 41.697'
0	44			yes	yes	no	N 55 19.622' W 132 41.666'
1	45			yes	yes	yes	N 55 19.785' W 132 41.572'
1	46			yes	no	no	N 55 19.808' W 132 41.557'
1	47			yes	yes	no	N 55 19.936' W 132 41.494'
1	48			yes	yes	yes	N 55 20.102' W 132 41.901'
2	49			yes	yes	no	N 55 20.299' W 132 42.220'

-continued-

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Reach	Redd number	Seen on 4/20	Seen on 4/28	Seen on 5/8	Seen on 5/19	Seen on 5/30	GPS coordinates
2	50			yes	yes	no	N 55 20.303' W 132 42.240'
2	51			yes	yes	no	N 55 20.280' W 132 42.681'
2	52			yes	yes	yes	N 55 20.307' W 132 42.931'
2	53			yes	yes	yes	N 55 20.368' W 132 42.996'
2	54			yes	yes	yes	N 55 20.388' W 132 43.291'
2	55				yes	yes	N 55 20.340' W 132 42.524'
2	56				yes	yes	N 55 20.461' W 132 42.447'
3	57				yes	yes	N 55 20.549' W 132 43.876'
3	58				yes	yes	N 55 20.556' W 132 43.878'
3	59				yes	yes	N 55 20.564' W 132 43.917'
3	60				yes	yes	N 55 20.572' W 132 43.974'
3	61				yes	yes	N 55 20.619' W 132 44.225'
2	62					yes	N 55 20.275' W 132 42.729'
2	63					yes	N 55 20.454' W 132 43.586'
4	1	yes	no	no	no	no	N 55 20.761' W 132 44.226'
4	2	yes	no	no	no	no	N 55 20.761' W 132 44.226'
4	3	yes	no	no	no	no	N 55 20.761' W 132 44.226'
4	4	yes	yes	yes	yes	yes	N 55 20.775' W 132 44.220'
4	5	yes	yes	yes	no	no	N 55 20.988' W 132 44.030'
4	6	yes	no	no	no	no	N 55 20.976' W 132 44.004'
4	7	yes	no	no	no	no	N 55 21.010' W 132 44.022'
4	8			yes	no	no	N 55 21.010' W 132 44.022'
4	9			yes	no	no	N 55 21.010' W 132 44.022'
4	10				yes	yes	N 55 20.806' W 132 44.106'

APPENDIX B

Appendix B1.–S Computer file containing raw data and analyses for assessment of the Twelve Mile Creek steelhead stock in 2004.

Computer file	Description
12 mile steelhead 04.xls	Excel file containing physical data, weir counts, snorkel survey counts, redd counts, KS tests, consistency tests, abundance estimates, age-sex-length estimates, and charts