Fishery Data Series No. 12-13

Steelhead Usable Habitat Area in Southeast Alaska: Peterson Creek and Sashin Creek Watersheds, 2007-2009

by

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and

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March 2012

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 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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Month 2012

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-22, F-10-23, and F-10-24

The Division of Sport Fish Fishery Data Series was established in 1987 for the publication of technically oriented results for a single project or group of closely related projects. Since 2004, the Division of Commercial Fisheries has also used the Fishery Data Series. Fishery Data Series reports are intended for fishery and other technical professionals. Fishery Data Series reports are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

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This document should be cited as:
Crupi, A. P., and J. V. Nichols. 2012. Steelhead usable habitat area in Southeast Alaska: Peterson Creek and Sashin Creek watersheds, 2007-2009. Alaska Department of Fish and Game, Fishery Data Series No. 12-13, Anchorage.

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ABSTRACT

To better understand steelhead populations and habitat capability, we conducted stream habitat and fish use surveys in 2 steelhead *Oncorhynchus mykiss* systems in Southeast Alaska. The overall goal of this project is to develop a model to assess the carrying capacity of steelhead in Southeast Alaska streams, based on the relationship between usable habitat area and steelhead production. During 2007–2008 we seasonally surveyed Peterson Creek watershed near Juneau, and in 2009 surveys were conducted in Sashin Creek on Baranof Island. During the habitat surveys we mapped the stream network and classified individual reaches according to fluvial process group and channel type. Several stream reach characteristics, such as length and channel bed width, were measured, and large woody debris and macro-pools were counted to characterize the available habitat. These data have been found to be important indicators of fish habitat in other streams occupied by salmonids, and were used to describe the current conditions of the stream reaches in our study areas.

Snorkel surveys and minnow traps were used to identify stream reaches occupied by steelhead. When steelhead were observed, we multiplied the channel bed width and length to estimate steelhead usable habitat area. In Peterson Creek adult and juvenile steelhead occupied 4.56 ha of mainstem stream habitat; juvenile steelhead also utilized tributary reaches, which when combined with mainstem habitat, totaled 5.30 ha of usable habitat area. An ADF&G stock assessment project at Peterson Creek (1989–1991) estimated an average escapement of 205 adult steelhead, and when combined with this study, yielded an estimate of 39 adult steelhead/ha total usable habitat area. In Sashin Creek, adult steelhead have long been documented in the short (1km) anadromous section, below a geologic barrier to fish migration, totaling 2.25ha of usable habitat area. Juvenile steelhead occupied 2.35 ha of usable habitat area, which included the mainstem and tributary reaches. Since 1996, the National Oceanic and Atmospheric Administration has enumerated wild steelhead returns and outmigrants, which averaged 32 adult steelhead and 331 steelhead smolt. This resulted in an estimated 14 adults and 141 smolts/ha total usable habitat area.

Key words: large and key wood accumulations, macro-pools, *Oncorhynchus mykiss*, Peterson Creek, Sashin Creek, snorkel survey, steelhead, stream habitat survey, usable habitat area.

INTRODUCTION

Southeast Alaska (SEAK) is known to anglers for the high quality stream habitat that provides abundant opportunities to catch steelhead *Oncorhynchus mykiss*. Steelhead stocks have been managed conservatively since 1994 when the Board of Fisheries adopted restrictive regulations in response to concerns over population declines. However, given recent liberalization of federal subsistence steelhead regulations, there is an imminent need to better understand steelhead populations with respect to habitat capability. Small populations of steelhead are considered particularly vulnerable to overharvest and habitat degradation (Nehlsen et al 1991). Therefore a better understanding of how particular habitats contribute to steelhead production and rearing potential is important to the management of this species.

To address these concerns, the Alaska Department of Fish and Game, Sport Fish Division (ADF&G-SF) has outlined a research approach in its Strategic Plan for Southeast Alaska Steelhead Research and Monitoring Program (Harding et al., *unpublished*, fishery biologist, ADF&G-SF, Douglas, AK), referred to herein as the *Steelhead Strategic Plan*. The overall goal of this research is to collect information to be used in the development of a steelhead habitat capability model for SEAK. Achievement of this goal will augment a key strategy in the ADF&G-SF Division Strategic Plan: to develop and implement research programs to assess the relationships between fish production and associated habitats. We have begun developing the necessary parameters for this model in the Sitkoh Creek, Peterson Creek, Sashin Creek, and Ratz Creek watersheds. Future *Steelhead Strategic Plan* efforts will incorporate data from 5 other systems to enhance the applicability of the model. This current report will focus on activities carried out in the Peterson Creek and Sashin Creek watersheds.

Through this study we are exploring alternative stock assessment methods (i.e., habitat-based model), similar to efforts conducted by researchers in British Columbia and Oregon (Tautz et al. 1992; Bocking et al. 2005; Cramer and Ackerman 2009a). Tautz et al. (1992) described 3 categories of information used in developing a steelhead carrying capacity and production model for the Skeena River in British Columbia: distribution, fish use, and production. Distribution referred to the number and extent of streams or tributaries likely to contain steelhead; fish use involved estimating total area and total usable habitat area of potential steelhead bearing streams; and production included the possible number of steelhead smolts produced from a stream's expected usable area. This production estimate was based on demographic data from decades of research on the Keogh River (Ward, 2000). We intend to refine the Tautz model by calculating total steelhead usable habitat area from stream reaches with verified steelhead use, and by integrating population productivity from each watershed in which usable habitat area is calculated.

Our strategy for developing this steelhead habitat model requires production and habitat data from 8 steelhead supporting systems with greater than 5 years of escapement data. Four of the systems will provide adult production data, and the other 4 systems will contribute smolt and adult production estimates to the model. Habitat data, including usable habitat area, will be collected for all 8 systems. Because regional steelhead stocks are generally considered stable (Harding 2005), this is an ideal opportunity to pursue system specific stock assessment information with regards to habitat quality and availability. This project was initiated in the Sitkoh Creek watershed, beginning with a characterization of stream habitats to identify potential steelhead distribution (Crupi et al. 2010), followed by a seasonal assessment of habitat use by juvenile and adult steelhead (Crupi and Nichols *in prep*). Peterson Creek and Sashin Creek were the second and third steelhead systems studied in the *Steelhead Strategic Plan* design and this report will summarize the stream habitat characterization and fish use phases conducted in both of these systems. The protocols of the stream habitat surveys and fish use surveys were conducted identically in both watersheds and combining them in 1 document simplifies reporting of a consistent sampling approach. Given the size difference between these two watersheds, steelhead presence was verified in Sashin Creek during 1 sampling trip, whereas multiple seasonal sampling trips were necessary to survey Peterson Creek for 1 year to account for steelhead temporal migratory patterns between various stream channel habitats.

OBJECTIVES

Phase I: Measure and characterize physical stream habitat in the mainstem and tributaries of the Peterson Creek and Sashin Creek watersheds. Objectives that were addressed:

1) Estimate habitat metrics in each stream reach such that the estimate is within 35% of the actual value 95% of the time. The following metrics will be estimated:
    a. Mean channel bed width ($\overline{cbw}$);

2) Census stream attributes in each stream reach to calculate the following metrics:
    a. Macro-pool density (D);
    b. Large wood density (LWD);
    c. Key wood density (KWD).

Phase II: Measure the amount of steelhead usable habitat. The objective that was addressed:

1) Estimate usable area for juvenile and adult steelhead in the Peterson Creek and Sashin Creek watersheds such that the estimate is within 35% of the actual value 95% of the time.

STUDY AREAS

Peterson Creek

Peterson Creek (ADF&G Anadromous Waters Catalog Stream No. 111-50-10100) is located in northern SEAK 30 km northwest of Juneau, Alaska, and is considered a northern-lake system for purposes of the steelhead habitat model (Figure 1). Several fish species inhabit Peterson Creek as identified in the Anadromous Waters Catalog (AWC) including: coho, pink, and chum salmon; steelhead and cutthroat trout; and Dolly Varden (Johnson and Daigneault 2008). ADF&G operated a weir to count adult steelhead, and the number of immigrating steelhead totaled 222 in 1989, 179 in 1990, and 215 in 1991 (Harding and Jones 1992). Peterson Creek provides an important freshwater recreational fishery as it is easily accessed by the Juneau road system. In 2007, it was estimated that 520 anglers fished 946 days, and no steelhead harvest was reported (Jennings et al. 2010). For comparison, an unspecified number of anglers in 1990 fished an estimated 111 days to catch 34 steelhead, of which 16 were released, yielding the lowest CPUE rate in SEAK (Harding and Jones 1991). In 2009, Peterson Creek was closed by the Alaska Board of Fisheries to the retention of steelhead.

Landownership within the Peterson Creek watershed is primarily held by the US Forest Service-Tongass National Forest (USFS), City and Bureau of Juneau (CBJ Park/General Lands), ADF&G (General Access), and private entities. The watershed has not been managed for timber harvest and drains 26.47 km^2 into Amalga Harbor. The anadromous portion of Peterson Creek extends approximately 3 km above the mouth and ends at a 6 m tall geologic barrier to fish migration. The lower portion of Peterson Creek is characterized by a 13 ha salt chuck lake that becomes inundated with saltwater when tides exceed 5 m. Above this salt lake, the mainstem habitat of Peterson Creek is classified as palustrine (PA) (1.12 km), flood plain (FP) (0.91 km), moderate gradient mixed control (MM) (0.38 km), and low gradient contained (LC) habitat (0.27 km).

Sashin Creek

Sashin Creek (ADF&G Anadromous Waters Catalog Stream No. 109-10-10090) is a small system located on Baranof Island, 215 km southwest of Juneau, Alaska, and is considered in the model a northern system without lake access for rearing juvenile steelhead (Figure 2). Sashin Creek empties into Little Port Walter and Chatham Strait. There is 1.22 km of anadromous habitat in Sashin Creek below a 30 m tall geologic barrier known to impede upstream fish migration. Several fish species inhabit this portion of the creek as identified in the AWC including: coho, pink, and chum salmon; steelhead trout; and Dolly Varden (Johnson and Daigneault 2008).

The National Oceanic and Atmospheric Administration (NOAA) Fisheries Service's Little Port Walter facility on Sashin Creek provides research on pink salmon production dating back to 1934 (Thrower et al. 2004). Estimates of female pink salmon spawning escapement have totaled nearly 50,000 females seeding an estimated 1.36 ha of available spawning habitat (McNeil et al. 1964).

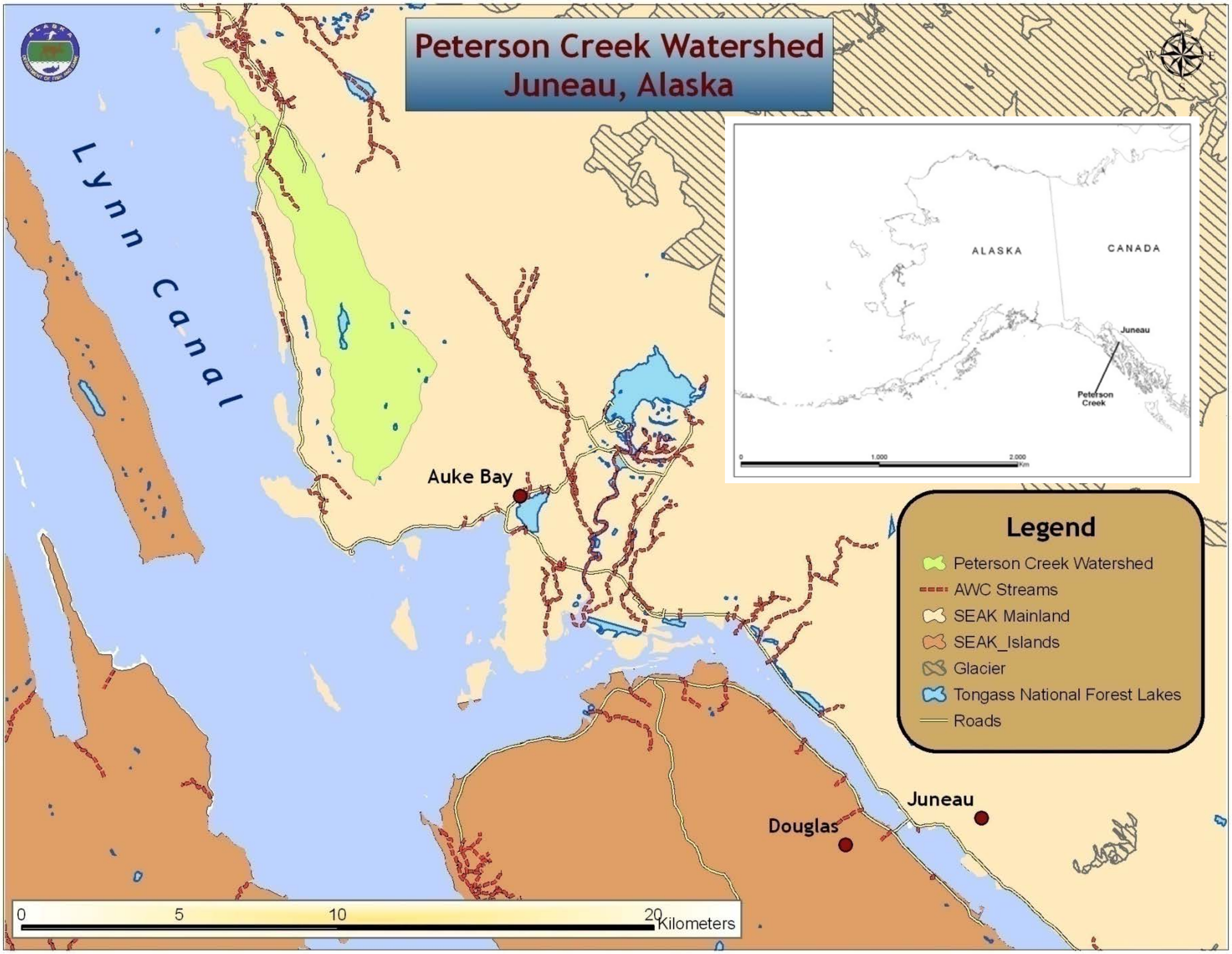

Figure 1. Location of Peterson Creek watershed in Juneau, Alaska.

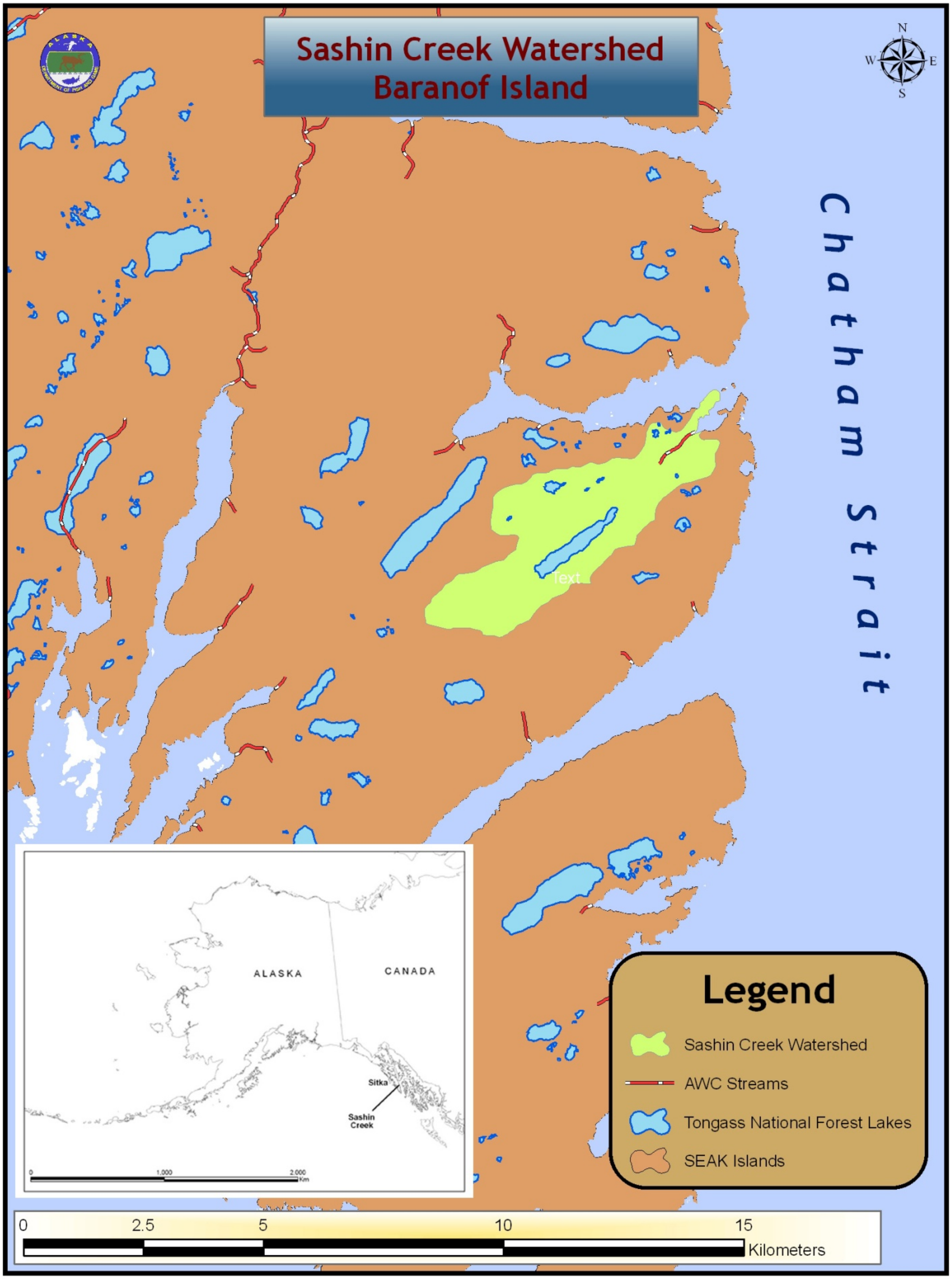

Figure 2. Location of Sashin Creek watershed on Baranof Island in Southeast Alaska.

In 1926 cannery workers transplanted juvenile *O. mykiss* from the lower portion of Sashin Creek above 2 barriers into Sashin Lake (Anonymous 1939). That stocking resulted in a situation where it is possible to study the genetic effects of isolating an anadromous species (Nielsen 1999; Thrower et al. 2004). Steelhead escapement and juvenile emigration in Sashin Creek have been monitored by NOAA through a counting weir since 1996. The average number of wild steelhead counted at the weir was 32 adults (1996–2009) and 331 smolt (2000–2009) (Thrower, *unpublished*, Research Fishery Biologist, NOAA, Auke Bay, AK).

Landownership within the Sashin Creek watershed, is held by the U.S. Forest Service (USFS). The watershed has not been managed for timber harvest. The watershed drains 11.12 km^2, including Sashin Lake (50.9 ha, 121-m maximum depth). The anadromous portion of Sashin Creek is comprised of the following channel types: moderate gradient contained (MC2) (0.20 km); flood plain (FP4) (0.68 km); and palustrine habitat (PA2) (0.33 km).

METHODS

STREAM HABITAT SURVEYS

Following established stream habitat survey protocols (Frenette et al., *unpublished*, regional supervisor, ADF&G-SF, Douglas, AK), we surveyed the mainstem reaches and the prioritized tributaries of Peterson Creek (July-August 2007) and Sashin Creek (May 2009). The core components of the stream habitat survey protocol used in the current study were derived from the USFS Region 10 Tier II Aquatic Habitat Survey (USFS 2001), and the USFS Channel-type Users Guide (USFS 1992). The stream habitat survey provided key data necessary for conducting coarse assessments of the habitat that may be important to fish at both the watershed and geomorphic reach scales. The stream habitat survey methodology included the collection of both physical and biological features and/or events encountered while transiting along the stream network. The locations of these features/events were recorded on Global Positioning Satellite (GPS) receivers, adding the necessary spatial data for full integration with a GIS, using ArcGIS software (Version 9.3, ESRI 2008).

The underlying unit of scale at which physical habitat parameter statistics were aggregated and reported for the stream habitat survey method used in this project was the geomorphic stream reach (stream reach, hereafter) level. Identification of distinct reaches was synonymous with the stream classification system used to describe geomorphically distinct stream segments in the context of the watershed, or better known as the “Tongass Channel-type Classification” system. This classification scheme was based on the geomorphic process groups, which describe the interrelationship between watershed runoff, landform relief, geology, and glacial or tidal influences on fluvial erosion and deposition processes. Individual stream reaches have a minimum mapping unit or length of 100 m, and they are generally homogeneous throughout their length with regard to macro-habitat characteristics. Therefore, individual stream reaches were classified by the physical attributes found within their geomorphic boundaries (Frenette et al., *unpublished*, regional supervisor, ADF&G-SF, Douglas, AK).

Data collected to achieve this objective included: (1) mapping the stream course; (2) mapping physical habitat features and fish observations; (3) characterizing physical habitat of stream reaches and side-channels; and (4) documenting features/events with photos. Physical habitat measures recorded within each reach include: stream gradient; channel bed width; incision depth; bankfull width; predominant bank composition; channel pattern; dominant substrates (primary, secondary and tertiary)(Appendix A); length of stream reach; length of side-channel(s); length of riparian disturbance (by type); number of barriers (by type); number of large-wood accumulations; number of key-wood pieces; and counts of macro-pools (Appendix B) following protocols discussed in Crupi et al. (2010). All data collected during this project were entered into the division's *Odyssey* database following established protocols (Frenette et al., *unpublished*, regional supervisor, ADF&G-SF, Douglas, AK), and handled identically with respect to data processing and quality assurance/quality control (QA/QC) measures.

Field crews acquired channel bed width (CBW) measurements using a range finder (>10 m, +/- 0.5m) or measuring tape (<10 m, rounded to nearest 0.25 m), at intervals of up to 100 m along the reach, with a minimum sample size of 3 measurements per reach. These measurements were used to calculate average channel bed width ($\overline{cbw}_i$) for each reach, necessary to determine total area and total usable area. The importance of this measurement to the model (estimating usable area) warrants the effort necessary to measure CBW with sufficient frequency within each reach to estimate the mean according to criteria specified in the objectives. At the end of each reach, crews calculated the sample coefficient of variation (CV) for each reach (CV = sample SD / mean) to determine if additional sampling was required. If reach sampling was not sufficient the field crew calculated an additional approximate sample CV (CV_a = sample range / 4 / mean). Using the larger of CV or CV_a, we estimated how much additional sampling effort was required for the reach. When additional samples were required they were distributed roughly uniformly across the reach at locations approximately mid distance from initial sampling locations as recorded by GPS.

Calculated metrics include mean channel bed width.

Mean channel bed width ($\overline{cbw}_i$) for each reach was calculated as:

$$\overline{cbw}_i = \frac{\sum cbw_k}{n_i} \qquad (1)$$

where:

cbw_k = individual channel bed width measures taken within reach *i*; and

n_i = number of measures taken within reach *i*.

Censused metrics include: macro-pool density; large-wood accumulation density; and key-wood density.

Macro-pool density (D_i) for each reach were calculated as:

$$D_i = \frac{p_i}{a_i} \qquad (2)$$

where:

p_i = number of qualifying macro-pools counted in reach *i*; and

a_i = area of reach *i* (length of reach *i* * $\overline{cbw}_i$).

Large-wood density (*LWD*) and key-wood density (*KWD*) for each reach were calculated the same as in the macro-pool density calculation (2).

Adult steelhead density (A_j) for each watershed was calculated as:

$$A_i = \frac{\bar{a}_j}{U_j} \tag{3}$$

where:

$\bar{a}_j$ = mean adult steelhead escapement counted in watershed $_j$; and

U_j = total usable area (Equation 5) in watershed $_j$.

Juvenile steelhead density was calculated similarly with Equation 3, providing an estimate of smolt production per hectare of usable habitat area.

FISH HABITAT USE ASSESSMENT AND ESTIMATE OF STEELHEAD USABLE HABITAT AREA

To meet our objectives the individual stream reaches occupied by steelhead were identified and then the total area used by both adult and juvenile steelhead in Peterson Creek and Sashin Creek watersheds were calculated. To effectively identify steelhead usable area, snorkel surveys of the entire mainstem and all significant tributaries below geologic barriers documented the presence of steelhead. Underwater observation has been identified as one of the most functional and cost-effective methods available to acquire information on fish abundance, behavior, and distribution over long reaches in small streams (Hankin and Reeves 1988; Dolloff et al. 1996).

Snorkel surveys were performed by 2-person crews, and these surveys were supplemented in some stream reaches with minnow trap sampling. Minnow traps were baited with salmon roe, placed <100 m apart throughout the reach, and soaked for 1 hr minimum following procedures outlined in Magnus et al. (2006). To maximize our potential to observe steelhead within all reaches actually occupied, sampling was repeated in the spring, summer, and fall seasons at Peterson Creek. When steelhead were observed the stream reach, spatial location (i.e., GPS coordinates), species, and number of fish in each size class (0–50 mm, 51–150 mm, 150–200 mm, and >200 mm), as well as the meso-habitat occupied by these fish were documented. Meso-habitat was categorized as scour pools, backwater pools, glides, and riffles.

In survey reaches where steelhead were observed, the entire area of that reach was considered usable habitat. When steelhead were not observed the reach was not considered usable habitat. The following calculations were performed to calculated steelhead usable habitat area and total area.

The amount of usable habitat of the i^{th} usable reach (u_i) was calculated as:

$$u_i = l_i \times \overline{cbw_i} \tag{4}$$

where:

l_i = total length of reach i; and

$\overline{cbw_i}$ = average channel bed width of reach i.

The total usable area in the system (U) was calculated as:

$$U = \sum u_i \quad (5)$$

When the reach was identified as not being used by steelhead, the area of that reach was considered non-usable. The non-usable area of the j^{th} non-usable reach (v_j) and total non-usable area (V) was calculated in the same manner as usable area (equations 4 and 5).

The total area (T) was calculated as:

$$T = U + V \quad (6)$$

When the identification of a potential steelhead was uncertain, the stream reach was not considered occupied by steelhead. Juvenile steelhead smaller than 50 mm were particularly difficult to distinguish from cutthroat trout. Through repeated seasonal surveys at Peterson Creek we improved our likelihood of observing steelhead within these reaches, but acknowledge that it was possible we did not detect and/or identify all steelhead present. Therefore, the total usable area (U) is considered a minimum.

RESULTS

STREAM HABITAT SURVEYS

Peterson Creek

Stream habitat surveys were conducted in the Peterson Creek watershed between July and August 2007 (Table 1). A total of 1,122 stream habitat features at 883 individual waypoints were recorded to precisely map the stream network and document current stream habitat conditions. A total of 12.1 km of stream habitat was surveyed, and the reaches were characterized into fluvial process groups and channel types. Compared to available USFS stream maps, this represents more than twice the length of stream hydrography previously identified below the fish passage barrier. Palustrine (PA) process group habitats accounted for 81% of the stream network surveyed (Table 2). Additionally, 26 individual stream reaches were classified into distinct channel types, and summary statistics of the primary habitat characteristics and species observed are presented in Table 3. The average channel bed width, density of large and key wood accumulations, and density of macro-pools in 20 stream reaches were calculated. Five stream reaches surveyed were not classified, representing an additional 0.3 km of stream habitat.The highest density of large wood accumulation was found in MM and FP process groups and the greatest density of key wood was found in MM habitats. LC and MM channel types provided the most macro-pool habitat.

The stream habitat survey of the mainstem of Peterson Creek resulted in the classification of 4 distinct fluvial process groups; flood plain (FP), moderate gradient-mixed control (MM), low gradient-contained (LC), and palustrine (PA). Immediately downstream of the geologic barrier was a short section (0.27 km) of LC habitat that was generally characterized by substrates ranging from large cobbles to very coarse gravels and was dominated by 20 m incised bedrock walls. This stream reach provided considerable pool habitat, with the greatest density of all mainstem reaches. The next reach below this channel was MM habitat (0.38 km), with substrates ranging from very fine gravels to large cobbles. As is common in MM reaches, this reach had considerable LWD; the greatest LWD density of all mainstem reaches surveyed. The next stream reach was a FP channel (0.91 km) with the second greatest density of large wood. The lowest portion of Peterson Creek is a PA reach which empties into Salt Lake and then Amalga Harbor.

Table 1.–Field survey trips, timing, and distances sampled in Peterson Creek and Sashin Creek watersheds.

Location	Season –trip ID	Survey type	Survey dates	# Reaches surveyed	Distance snorkeled (km)
Peterson Creek	Summer –PTR17	Habitat	7/11 - 8/3/2007	31	12.1
Peterson Creek	Summer – PTR27	Snorkel – fish use	8/3 -8/8/2007	31	12.1
Peterson Creek	Fall – PTR37	Snorkel – fish use	10/9 - 10/12/2007	31	12.1
Peterson Creek	Spring – PTR18	Snorkel – fish use	3/25 - 3/27/2008	21	10.2
Peterson Creek	Spring – PTR28	Snorkel – fish use	5/27 - 5/28/2008	30	11.8
Peterson Creek	Summer – PTR19	Habitat	6/26/2009	15	7.8
Sashin Creek	Spring – SAS19	Habitat	5/18 -5/22/2009	6	1.8
Sashin Creek	Spring – SAS19	Snorkel – fish use	5/18 - 5/22/2009	6	1.8

Table 2.–Mapped hydrography of Peterson Creek watershed below the geologically fixed barrier that impedes fish migration.

Reporting metric	ADF&G reach length[a] surveyed (km)	USFS length[b] (km)	Comments/description
Stream length – AF	0.00	0.00	Stream length of alluvial fan (AF) process group below geologically-fixed barrier
Stream length – FP	0.91	0.36	Stream length of flood plain (FP) process group below geologically-fixed barrier
Stream length – FS	0.04	0.00	Stream length of foot slope (FS) process group below geologically-fixed barrier
Stream length – ES	0.00	0.00	Stream length of estuarine (ES) process group below geologically-fixed barrier
Stream length – LC	0.27	1.61	Stream length low gradient contained (LC) process group below barrier
Stream length – MC	0.15	0.00	Stream length of moderate gradient contained (MC) process group below barrier
Stream length – MM	0.93	0.35	Stream length of moderate gradient mixed control (MM) process group below barrier
Stream length - PA	9.52	3.11	Stream length of palustrine (PA) process group below geologically-fixed barrier

[a] Reach length measured in July/August 2007 ADF&G Stream Habitat Characterization Surveys (Phase I).
[b] Stream length available from current USFS hydrography.

Table 3.–Stream reach habitat characteristics and fish species observed in Peterson Creek watershed.

Reach label	Reach ID	Reach length (m)	Mean channel bed width (m)	Total area (ha)	Stream gradient (%)	Large wood count	Key wood count	Macro pool count	Large wood density	Key wood density	Macro pool density	Species present[a]
FP4-1	193334	908.09	13.27	1.21	0.45	295	26	22	244.76	21.57	18.25	STH, SCO, CDV, SCM
FS0-1	850061	40.58	1.17	0.00	11.70	2	0	1	422.45	0.00	211.22	None
LC2-1	850045	266.15	11.88	0.32	1.50	34	1	15	107.58	3.16	47.46	STH, SCO, CDV
MC1-1	850054	153.96	3.08	0.05	6.40	31	6	9	653.02	126.39	189.59	STH, CDV
MM0-1	850062	101.87	2.62	0.03	3.20	9	0	0	337.79	0.00	0.00	None
MM1-1	850061	364.29	1.31	0.05	6.70	92	16	8	1924.14	334.63	167.32	SCO
MM1-2	850053	83.58	3.40	0.03	5.25	19	5	2	668.60	175.95	70.38	STH, SCO, CDV
MM2-1	193386	381.02	20.30	0.77	1.50	257	78	9	332.27	100.85	11.64	STH, SCO, CDV
PA0-10	850057	307.96	0.75	0.02	0.60	0	0	0	0.00	0.00	0.00	SCO
PA0-11	850063	80.20	0.54	0.00	ND	ND	ND	ND	ND	ND	ND	SCO
PA0-12	850060	354.44	0.55	0.02	0.30	0	0	0	0.00	0.00	0.00	SCO
PA0-13	850064	98.98	0.61	0.01	ND	ND	ND	ND	ND	ND	ND	SCO
PA0-14	850050	582.69	0.75	0.04	0.60	17	1	0	389.00	22.88	0.00	STH, SCO
PA0-2	850065	85.77	0.50	0.00	ND	ND	ND	ND	ND	ND	ND	None
PA0-3	850066	74.95	0.95	0.01	ND	ND	ND	ND	ND	ND	ND	SCO
PA0-4	850052	171.68	1.00	0.02	0.60	0	0	0	0.00	0.00	0.00	IDA
PA0-5	850055	586.78	0.77	0.05	0.70	0	0	0	0.00	0.00	0.00	SCO
PA0-6	850067	66.82	0.25	0.00	ND	ND	ND	ND	ND	ND	ND	None
PA0-7	850068	196.21	1.00	0.02	ND	ND	ND	ND	ND	ND	ND	SCO
PA1-1	850059	300.97	1.58	0.05	0.70	1	0	0	21.07	0.00	0.00	SCO
PA1-2	192990	2137.43	2.50	0.53	0.30	0	0	0	0.00	0.00	0.00	SCO, KSB
PA1-3	850056	535.85	1.38	0.07	0.60	0	0	0	0.00	0.00	0.00	SCO, CDV
PA1-4	850058	478.31	5.79	0.28	1.70	0	0	0	0.00	0.00	0.00	SCO, KSB
PA1-5	193216	1866.87	2.91	0.54	0.60	119	15	2	219.21	27.63	3.68	STH, SCO, KSB
PA1-8	850051	481.41	1.47	0.07	0.30	8	1	1	112.88	14.11	14.11	STH, SCO, KSB, ULP
PA2-1	193167	1114.95	20.36	2.27	0.90	3	2	1	1.32	0.88	0.44	STH, SCO, SCM, KSB

[a] Species codes: CDV- Dolly Varden; IDA- unidentified salmonid; KSB- unidentified stickleback; SCM- chum salmon; SCO- coho salmon; STH- steelhead; ULP- unidentified sculpin.

Sashin Creek

In May 2009, stream habitat surveys were conducted in the Sashin Creek watershed (see Table 1). A total of 147 stream habitat features at 96 individual waypoints were recorded to precisely map the stream network and identify significant habitat features. A total of 1.83 km of stream habitat was surveyed and the reaches were characterized into fluvial process groups and channel types. This represents 0.79 km more stream habitat than identified below the fish passage barrier by the USFS stream hydrography (1.04 km). Palustrine (PA) process group habitats accounted for nearly half of the stream network surveyed (Table 4). Six individual stream reaches were classified into distinct channel types. For each stream reach the summary statistics and several of the primary habitat characteristics were recorded as defined in the objectives, including: average channel bed width; density of large and key wood accumulations; and macro-pools (Table 5).

The mainstem of Sashin Creek was classified into 3 distinct fluvial process groups; flood plain (FP), moderate gradient-contained (MC), and palustrine (PA). Immediately downstream from the geologic barrier was a short section (0.20 km) of MC habitat that had substrates ranging from small cobbles to bedrock. The stream reach following the MC reach was 0.68 km of FP habitat with gravel substrates. Of the mainstem reaches surveyed, this reach had the greatest density of large woody debris. The lowest portion of Sashin Creek was a placid PA channel with minimal stream gradient and measured 0.33 km. The stream then flows through a concrete weir before emptying into Little Port Walter.

FISH HABITAT USE ASSESSMENT

Peterson Creek

Between July 2007 and May 2008, 4 snorkel surveys were conducted at Peterson Creek to assess the distribution patterns of adult and juvenile steelhead (Table 1), which were necessary to estimate steelhead usable habitat area. We repeated surveys on the majority of the stream reaches identified as potential steelhead habitat combining for a total length of 46 km of stream habitat surveyed for steelhead presence. The seasonal use of stream reaches by steelhead, cutthroat trout, coho salmon, and Dolly Varden for spawning and rearing was evident and species occupied in each reach were documented (Table 3). A total of 11.47 km of anadromous habitat was documented, compared to 4.24 km currently listed in the AWC, which also inaccurately includes 0.82 km of anadromous habitat above the barrier to fish migration. Staff from ADF&G Division of Habitat will prepare AWC nominations for Peterson Creek and stream habitat and fish use surveys collected in this study will be utilized.

Steelhead were observed in the 4 mainstem stream reaches and 5 tributary reaches of Peterson Creek (Figure 3). During spring surveys, adult steelhead were detected in all mainstem stream reaches of Peterson Creek. Adult steelhead were never observed in tributary reaches. The majority of adult steelhead were observed in the FP reach (FP4-1) of the mainstem (Figure 4). This figure represents the combined distribution of 14 steelhead observed in May 2008.

Table 4.–Mapped hydrography of Sashin Creek watershed below the geologically fixed barrier that impedes fish migration.

Reporting metric	ADF&G reach length[a] surveyed (km)	USFS length[b] (km)	Comments/description
Stream length – AF	0.00	0.00	Stream length of alluvial fan (AF) process group below geologically fixed barrier
Stream length – FP	0.68	0.72	Stream length of flood plain (FP) process group below geologically fixed barrier
Stream length – FS	0.00	0.00	Stream length of foot slope (FS) process group below geologically fixed barrier
Stream length – ES	0.00	0.00	Stream length of estuarine (ES) process group below geologically fixed barrier
Stream length – LC	0.00	0.00	Stream length of low gradient contained (LC) process group below barrier
Stream length – MC	0.33	0.00	Stream length of moderate gradient contained (MC) process group below barrier
Stream length – MM	0.00	0.00	Stream length of moderate gradient mixed control (MM) process group below barrier
Stream length – PA	0.82	0.32	Stream length of palustrine (PA) process group below geologically fixed barrier

[a] Reach length measured in May 2009 ADF&G Stream Habitat Characterization Surveys (Phase I).

[b] Expected stream length calculated from current USFS hydrography.

Table 5.–Stream reach habitat characteristics and fish species observed in Sashin Creek watershed.

Reach label	Reach ID	Reach length (m)	Mean channel bed width (m)	Total area (ha)	Stream gradient (%)	Large wood count	Key wood count	Macro pool count	Large wood density	Key wood density	Macro pool density	Species present[a]
FP4	177930	682.82	18.63	1.27	0.7	95	5	9	74.70	3.93	7.08	STH, SPI
MC0	850086	123.29	2.41	0.03	5.1	20	5	9	674.16	168.54	303.37	STH, SCO, CDV
MC2	850080	201.97	5.30	0.11	2.1	6	0	3	56.05	0.00	28.03	STH
PA0-1	850085	211.67	1.77	0.04	0.7	13	1	2	347.14	26.70	53.41	STH, SCO, SPI, CDV
PA0-2	850091	272.24	1.83	0.05	0.9	0	0	0	0.00	0.00	0.00	STH, SCO
PA2	177899	334.28	25.63	0.86	0.4	27	1	2	31.52	1.17	2.33	STH, SPI

[a] Species codes: CDV- Dolly Varden; SCO- coho salmon; SPI- pink salmon; STH- steelhead.

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Juvenile steelhead were observed in each reach of the mainstem and 5 tributary reaches during the spring, summer, and fall surveys. Individual locations of juvenile steelhead show the majority of fish distribution throughout the mainstem reaches of Peterson Creek and occasional occurrence within tributaries (Figure 5). Within the mainstem we found juvenile steelhead were distributed more throughout the middle 2 reaches (MM2-1 and FP4-1).

Meso-habitat within the stream reach where steelhead were observed was documented. This information was recorded for 14 adult and 3,408 juvenile steelhead. We found that adult steelhead were most frequently observed in glide habitat (50%) and juvenile steelhead were commonly observed in backwater meso-habitats (55%; Figure 6).

Sashin Creek

In May 2009, a complete snorkel survey of Sashin Creek and its tributaries was conducted to assess the distribution of adult and juvenile steelhead (Table 1), which was necessary to estimate steelhead usable habitat area. A total of 1.83 km of stream habitat in 6 stream reaches was identified as potential steelhead habitat. In each reach, the presence of steelhead, coho and pink salmon, and Dolly Varden was recorded (Table 5). The surveys documented 1.83 km of anadromous fish habitat.

Steelhead were observed in 3 mainstem stream reaches and 3 tributary reaches of Sashin Creek. Depictions of each stream reach verified for steelhead presence and the associated channel type classification were created (Figure 7). Adult steelhead have been observed in all mainstem stream reaches of Sashin Creek, and only 2 wild adult steelhead had passed through the weir when the survey was conducted (Thrower, Research Fishery Biologist, NOAA, Auke Bay, AK, personal communication). The 2009 return was considered substantially late and ended with only 9 wild adult steelhead returning to spawn. Juvenile steelhead were observed in the FP mainstem reach (FP4) and all tributary reaches. Individual locations of adult and juvenile steelhead were recorded (Figure 8). An inadequate number of steelhead were observed to provide a meaningful assessment of meso-habitats occupied in Sashin Creek.

STEELHEAD USABLE HABITAT AREA

Peterson Creek

To calculate usable habitat area for steelhead in the Peterson Creek watershed, A total of 215 channel bed width measurements in 26 stream reaches were collected (Table 6). The total area (*T)* of stream reaches identified for potential steelhead distribution equaled 6.46 ha. Adult steelhead were observed in the entire mainstem during spring snorkel surveys; therefore, all 4 reaches were used to calculate adult usable habitat area totaling 4.53 ha. In addition to the mainstem, juvenile steelhead were positively observed in 5 tributary stream reaches for a combined total of 5.30 ha of usable habitat area (*U*).

As we develop the steelhead habitat model for SEAK it will be important to provide the metrics of usable area in terms of production. In this model the Peterson Creek watershed will represent 1 of 2 lake systems in northern SEAK. The 3-yr average number of steelhead counted through the Peterson Creek weir was 205 adults; therefore, adult steelhead density (A_i), the average number of adults per hectare of total usable habitat area, equaled 38.7.

Table 6.–Stream reach measurements used in calculation of steelhead usable habitat area in Peterson Creek watershed.

Reach label	Channel type	Reach length (m)	#CBW[a] (n)	Mean channel bed width (m)	CV	SD (+/-)	Total area (ha)	Steelhead present	Useable area (ha)
FP4-1	FP4	908.09	11	13.27	0.28	3.72	1.21	Yes	1.21
FS0-1	FS0	40.58	3	1.17	0.12	0.14	0.00	No	
LC2-1	LC2	266.15	4	11.8	0.14	1.65	0.32	Yes	0.32
MC1-1	MC1	153.96	6	3.08	0.11	0.34	0.05	Yes	0.05
MM0-1	MM0	101.87	13	2.62	0.50	1.32	0.03	No	
MM1-1	MM1	364.29	4	1.31	0.18	0.24	0.05	No	
MM1-2	MM1	83.58	5	3.4	0.28	0.96	0.03	Yes	0.03
MM2-1	MM2	381.02	5	20.30	0.24	4.93	0.77	Yes	0.77
PA0-10	PA0	307.96	6	0.75	0.30	0.22	0.02	No	
PA0-11	PA0	80.20	7	0.54	0.83	0.44	0.00	No	
PA0-12	PA0	354.44	5	0.55	0.20	0.11	0.02	No	
PA0-13	PA0	98.98	11	0.61	0.38	0.23	0.01	No	
PA0-14	PA0	582.69	11	0.75	0.37	0.27	0.04	Yes	0.04
PA0-2	PA0	85.77	3	0.50	0.00	0.00	0.00	No	
PA0-3	PA0	74.95	5	0.95	0.51	0.48	0.01	No	
PA0-4	PA0	171.68	6	1.0	0.32	0.32	0.02	No	
PA0-5	PA0	586.78	11	0.77	0.57	0.44	0.05	No	
PA0-6	PA0	66.82	3	0.25	0.00	0.00	0.00	No	
PA0-7	PA0	196.21	4	1.00	0.00	0.00	0.02	No	
PA1-1	PA1	300.97	13	1.58	0.28	0.45	0.05	No	
PA1-2	PA1	2,173.43	22	2.50	1.63	4.08	0.53	No	
PA1-3	PA1	535.85	8	1.38	0.26	0.35	0.07	No	
PA1-4	PA1	478.31	7	5.79	0.31	1.78	0.28	No	
PA1-5	PA1	1,866.87	19	2.91	0.26	0.73	0.54	Yes	0.54
PA1-8	PA1	481.41	9	1.47	0.22	0.32	0.07	Yes	0.07
PA2-1	PA2	1,114.95	14	20.36	0.19	3.78	2.27	Yes	2.27
Total							6.46		5.30

[a] Channel bed width.

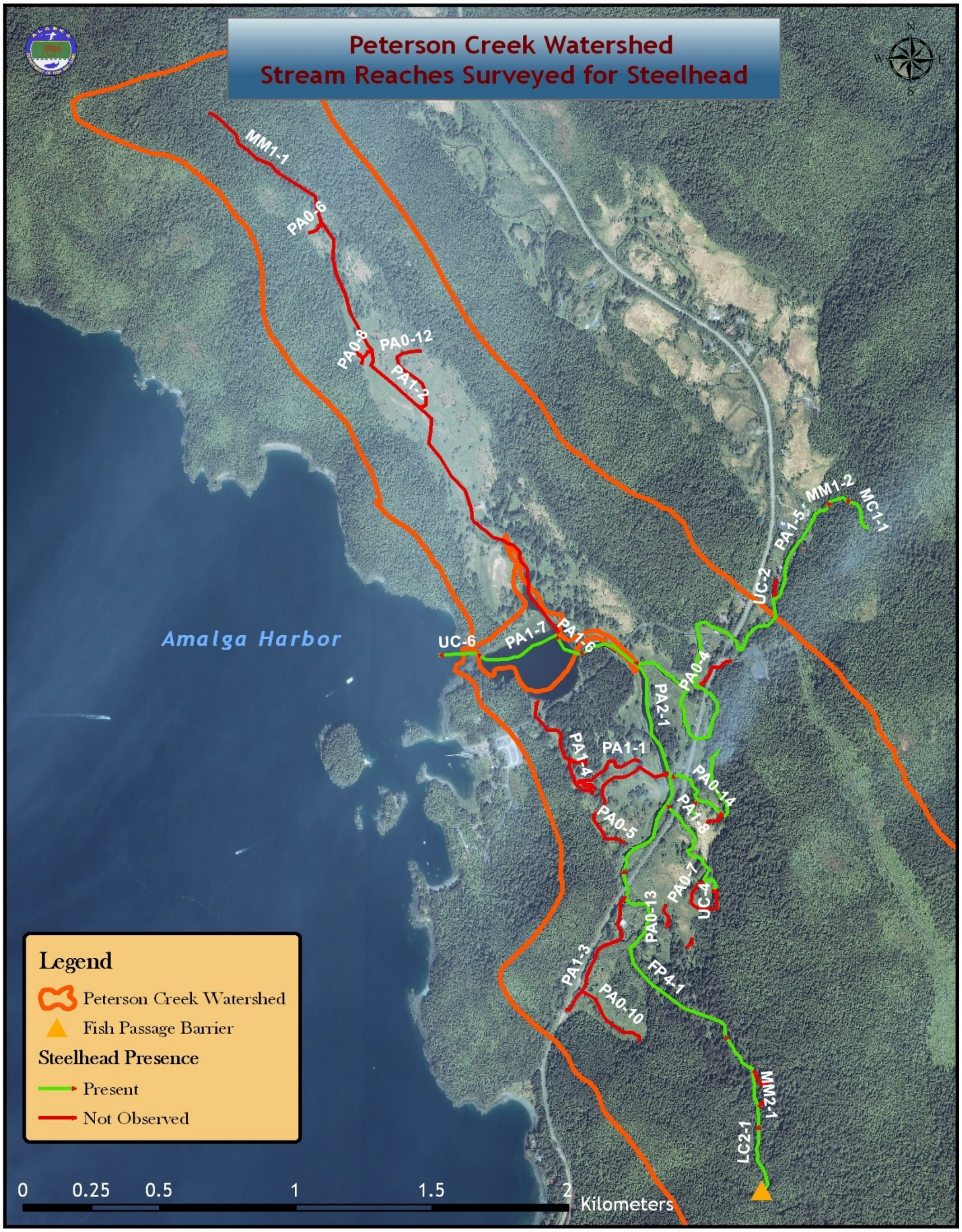

Figure 3.–Snorkel survey results for steelhead in the Peterson Creek watershed.

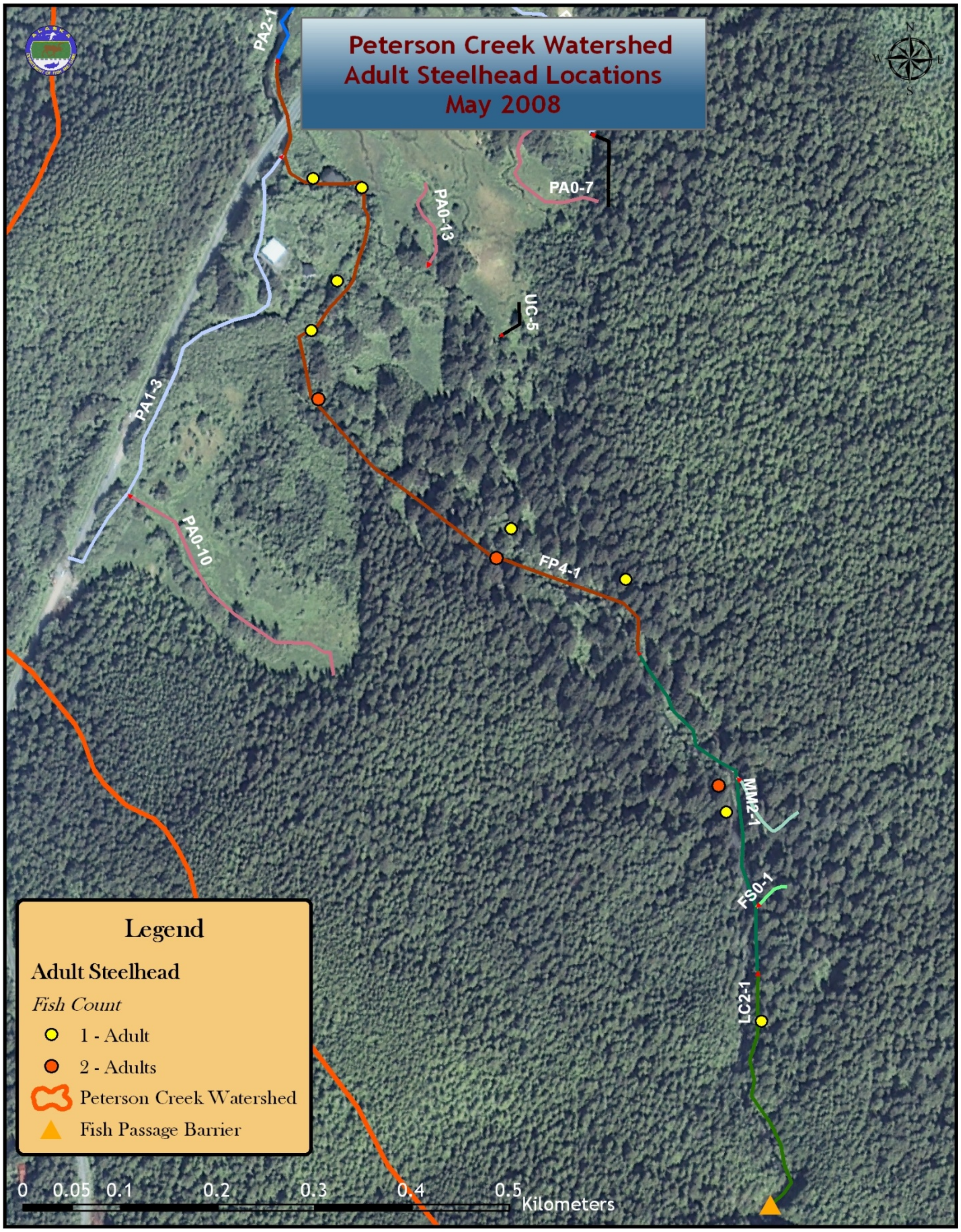

Figure 4.–Locations of adult steelhead observed in Peterson Creek watershed.

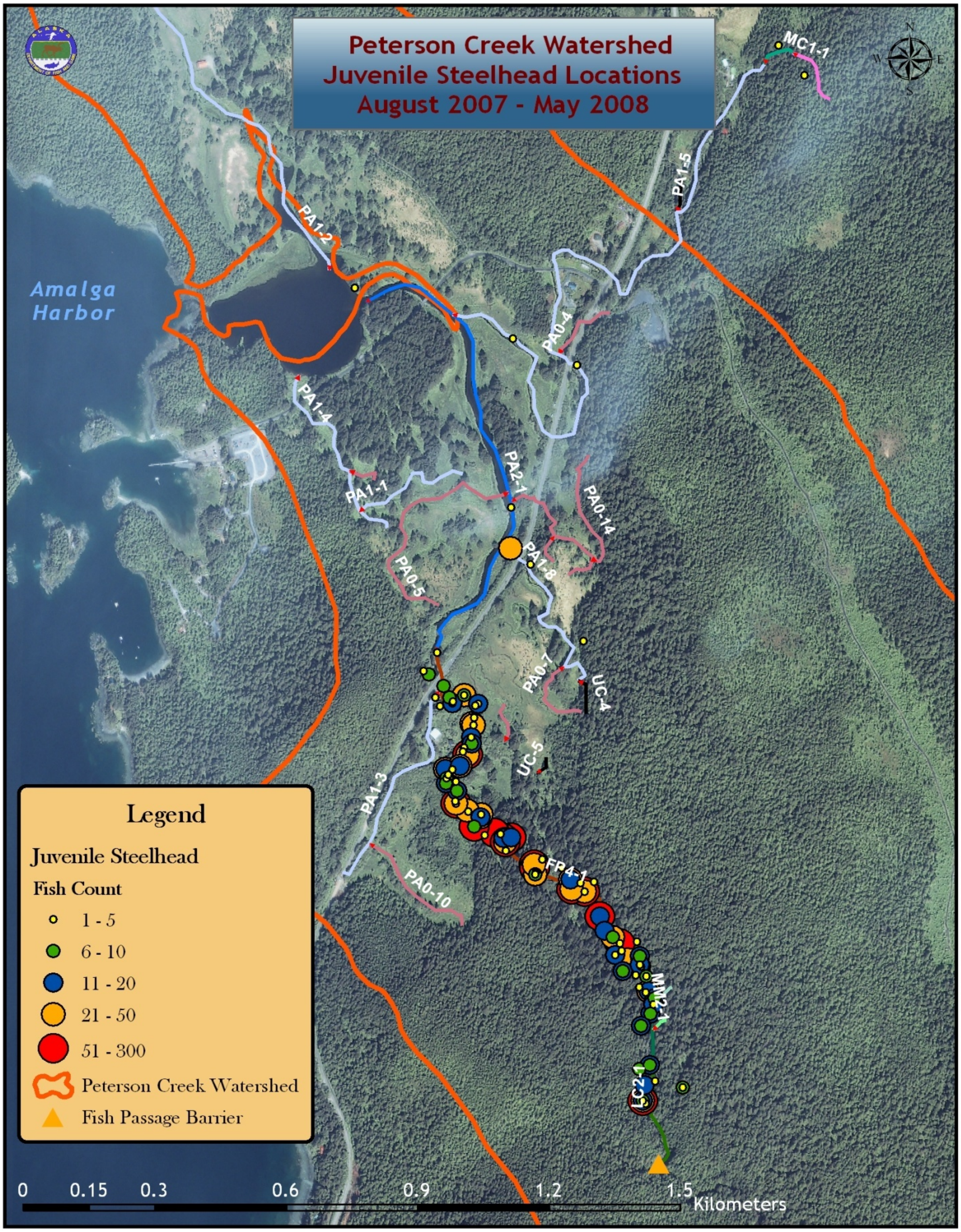

Figure 5.–Locations of juvenile steelhead observed in Peterson Creek watershed

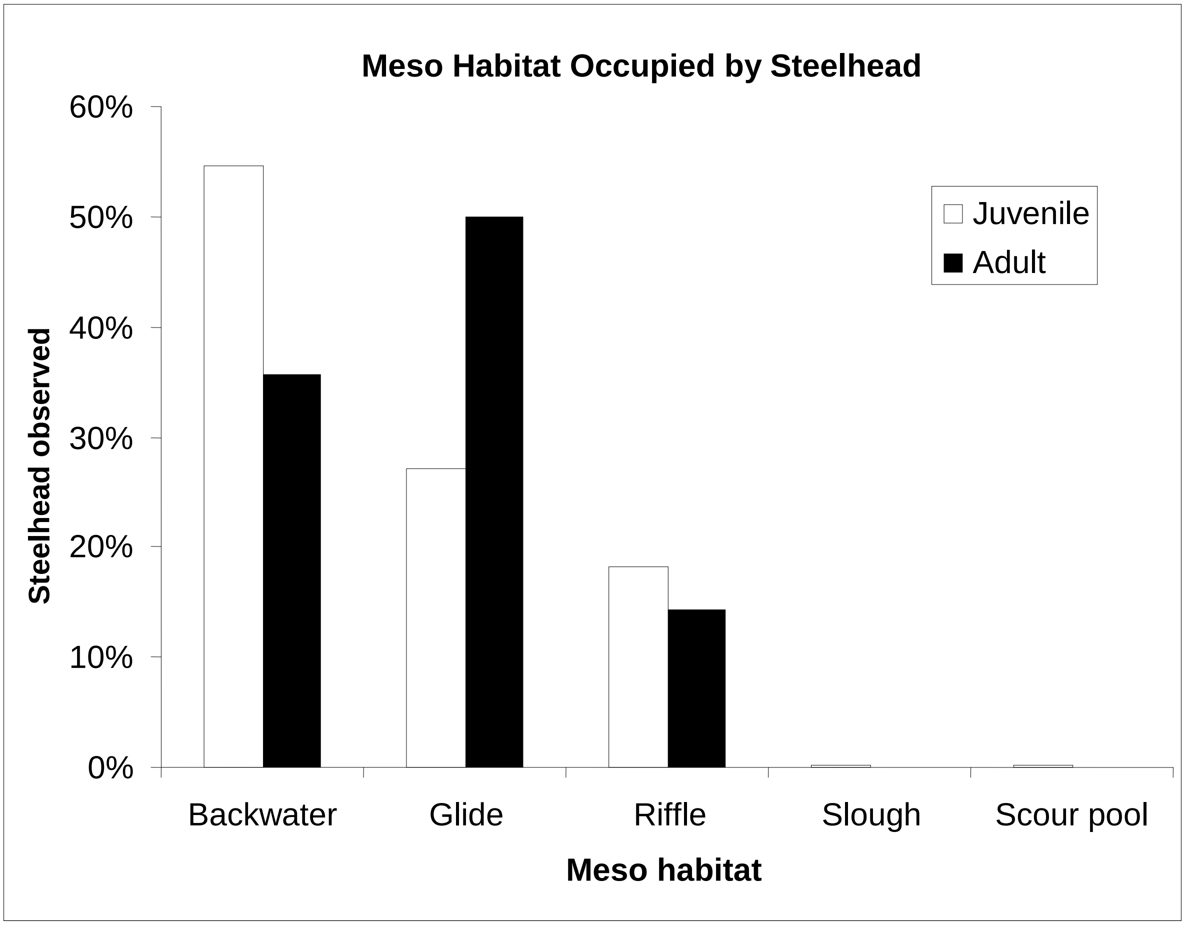

Figure 6.–Meso habitat occupied by steelhead in the Peterson Creek watershed.

Sashin Creek

A total of 52 channel bed width measurements in 6 stream reaches were used to calculate usable habitat area for steelhead in the Sashin Creek watershed (Table 7). The total area (*T)* of stream reaches identified for potential steelhead distribution equaled 2.35 ha. Adult steelhead occupied the entire mainstem totaling 2.24 ha. In addition to the mainstem, juvenile steelhead were observed in 3 tributary stream reaches for a combined total of 2.35 ha of usable habitat area (*U).*

In this steelhead habitat model the Sashin Creek watershed will represent 1 of 2 systems in northern SEAK that do not have access to a lake for rearing. The 14-yr average number of steelhead counted through the Sashin Creek weir was 32 adults and when combined with this study equals an adult steelhead density of 13.6 adults per hectare of usable habitat area. Juvenile steelhead density, calculated by averaging smolt production (331) divided by total usable habitat area equaled 140.7 smolt per hectare of usable habitat area.

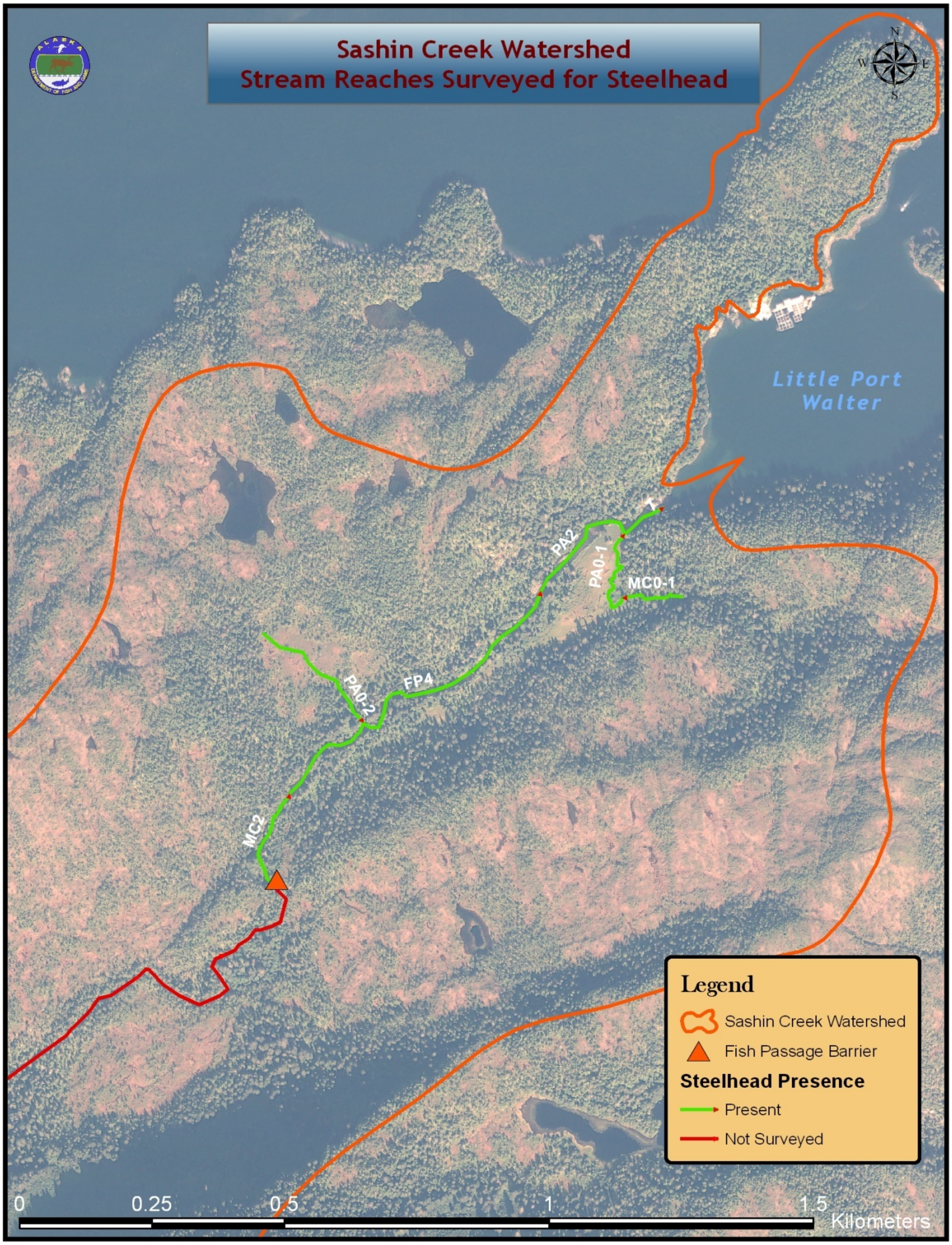

Figure 7.–Snorkel survey results for steelhead in the Sashin Creek watershed.

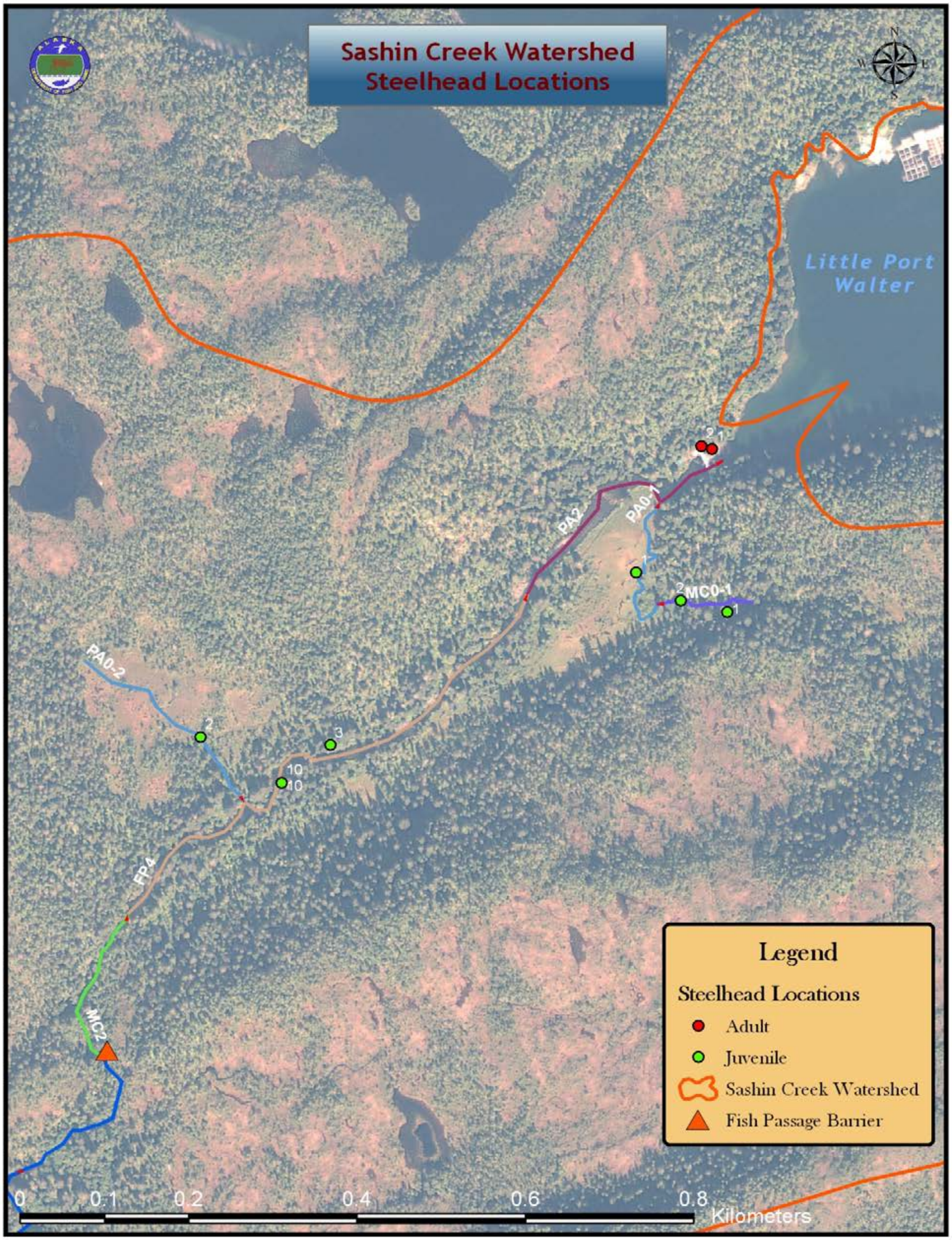

Figure 8.–Locations of adult and juvenile steelhead observed in Sashin Creek watershed.

Table 7.–Stream reach measurements used in calculation of steelhead usable habitat area in Sashin Creek watershed.

Reach Label	Channel type	Reach length (m)	# CBW[a] (n)	Mean channel bed width (m)	CV	SD (+/-)	Total area (ha)	Steelhead present	Usable area (ha)
FP4	FP4	682.82	12	18.63	0.11	2.04	1.27	Yes	1.27
MC0	MC0	123.29	8	2.41	0.38	0.91	0.03	Yes	0.03
MC2	MC2	201.97	5	5.30	0.23	1.20	0.11	Yes	0.11
PA0-1	PA0	211.67	13	1.77	0.31	0.55	0.04	Yes	0.04
PA0-2	PA0	272.24	6	1.83	0.32	0.58	0.05	Yes	0.05
PA2	PA2	334.28	8	25.63	0.15	3.81	0.86	Yes	0.86
Total							2.35		2.35

[a] Channel bed width.

DISCUSSION

The development of a steelhead habitat capability model for SEAK will be a useful tool for fisheries managers, as it will help improve understanding of steelhead production in terms of available habitat. The main contribution of this study is the calculation of steelhead usable habitat area from direct observation of occupied habitats. The amount of usable habitat area is important as it relates to concurrent stock assessment work necessary to generate an estimate of the number of adult and juvenile steelhead per unit usable area. While the goal is similar to Tautz et al.'s (1992) study, our approach of verifying fish use and physically measuring usable habitat area is empirically based and represents an improvement in the applicability of information that may be used for management decisions. As we develop this relationship for 8 steelhead watersheds throughout SEAK, it is important to recognize we currently only have data to represent 2 lake systems and 1 non-lake system in the northern portion of SEAK. The full utility of this model will be realized once we incorporate long-term production and habitat data from a variety of steelhead systems throughout SEAK. Short-term achievements of this project include: mapped stream hydrography; additional length and species compositions for AWC nominations; and improved knowledge of salmonid species distribution patterns and habitat relationships.

Comparison of the carrying capacity results from this study to predictions of other authors working on similar models is challenging due to the differences in model parameters. Tautz et al. (1992) indicated that the Keogh River produced 0.058 smolt/m^2 or 580 smolt/ha of usable area, and Snow Creek in Washington produced 0.039 smolt/m^2 or 390 smolt/ha. Production in both of these systems was substantially more than the 141 smolt/ha produced at Sashin Creek, and 158 smolt/ha at Sitkoh Creek (Love and Harding *in prep*). Tautz et al. calculated usable area as the product of stream reach length and estimated wetted width during summer low flows, and found 1,140 ha usable habitat area with this approach. This estimate of usable habitat area which incorporated only minimum wetted width could explain some of the elevated production but likely not all, as they report the derived carrying capacities as being 2 to 4 times higher than current run size estimates. The authors therefore included numerous adjustments to generate adult estimates for the Skeena River drainage resulting in 92,500 adults or 81 adults/ha usable area, still substantially greater than any of the systems studies for the SEAK model: Sitkoh Creek, 35 adults/ha; Peterson Creek, 39 adults/ha and Sashin Creek 14 adults/ha. Cramer and

Ackerman (2009 b) presented data from 6 steelhead creeks in Oregon and included several habitat quality parameters in their carrying capacity predictions that ranged from 0.01 to 0.06 smolt/m^{2}, or 100 to 600 smolt/ha. Sashin Creek smolt production was within the lower end of this range at 0.014 smolt/m^{2}, or 141 smolt/ha. If the results from these studies are comparable to this study then the Sashin Creek stock produces fewer fish per unit of habitat area. One possible explanation is that southern stocks are more productive given an increased duration of their growing season and primary production of available prey (Withler 1966). Although comparisons between different models may assist in providing some corroboration, the various parameters used in these models are likely not similar enough to afford meaningful interpretation.

SEASONAL SNORKEL SURVEY ASSESSMENT AT PETERSON CREEK

Repeated seasonal assessment of fish use in Peterson Creek allowed us to document several stream reaches that would not have been verified for various species from just 1 survey. Beyond the one spring survey, which primarily verified adult steelhead, 4 stream reaches were positively verified for the presence of steelhead in the spring or fall, supporting the approach of repeated seasonal snorkel surveys to verify fish use. We recommend this seasonal approach when verifying fish utilization of habitat.

We did not observe a seasonal migration of juvenile steelhead from the mainstem of Peterson Creek to the tributaries due to increased stream flows as was observed by Bramblett et al. (2002) in Staney Creek on Prince of Wales Island in SEAK. Rather we found steelhead to be rare or absent in tributaries, and therefore contributed minimally to steelhead usable habitat area. In Peterson Creek, sampling occurred under a variety of seasons and stream flow conditions, and we did not detect this migratory behavior. While seasonal differences in flows were not found to affect juvenile steelhead movement, temperature did appear to influence our ability to detect them. We did not observe many fish of any species when water temperatures were below 4º C, a threshold temperature also reported by Bryant et al. (2009). Therefore, we recommend timing these seasonal surveys in the spring after temperatures increase and before late fall when temperatures decrease.

We did not observe adult steelhead in any tributary reaches, and we do not believe that it is likely that any additional usable area is occupied by adult steelhead in the tributaries. While we did not observe adults occupying tributaries, use of tributaries in other watersheds is quite possible; therefore, we recommend continued surveying of tributaries for potential distribution to ensure the total usable area of other watersheds is fully assessed.

CONCLUSIONS

Through this study we have refined our habitat-based modeling approach by directly identifying the types and quantities of freshwater habitat important to spawning adults and rearing juvenile steelhead. Future work should continue to identify the level of production data that is necessary to find a significant relationship between habitat carrying capacity and sustainable production.

Currently, there are several systems in SEAK with one or more annual weir counts, and this project should strive to utilize data from these systems. To expedite the process of completing the experimental design (2 replicates for 4 treatments: northern vs. southern and lake vs. non-lake), it is imperative that these existing data be utilized to the extent practical and possible. Identifying the timing priority for the 4 remaining systems to be assessed (1 northern and 2 southern systems without lake rearing access, and 1 southern system with a lake) will be influenced by management needs, including the threat or risk of overexploitation in more accessible or more heavily utilized streams. The design itself may be modified in the future as data are collected and analyzed over several years and as identified management priorities change. For example, if southern SEAK non-lake systems are thought to be at risk of overexploitation, and accumulated data indicate large variation between the two systems initially assessed for this design, additional assessments in these types of systems (e.g., larger sample size) may become a higher priority than the 2 replicates in the other treatment systems necessary to complete the design. Future steelhead projects should take into consideration the initial design, current management priorities, and relevant data on spawning steelhead abundance. Development of a steelhead model to estimate the annual escapement necessary for sustainable steelhead production in exploited systems based on steelhead spawning and rearing habitat in these systems is the ultimate long-term goal of this research program.

ACKNOWLEDGMENTS

Funding for this project was provided by Dingell-Johnson/Wallop-Breaux (DJ) funds through the Federal Aid in Sport Fish Restoration Program. Assistance with stream habitat surveys and snorkel surveys was provided by Kercia Schroder, Jeff Williams, Chris S'Gro, Matt Kern, Lacey Smith, and Keegan Birchfield. Dan Reed provided substantive biometric support and guidance throughout the course of this study, and for this I am greatly appreciative. We offer many thanks to Roger Harding and Brian Frenette for supporting this project from initial conceptual designs to final implementation. The management of this species has been furthered by their commitment to this research.

REFERENCES CITED

Bramblett, R.G., M.D. Bryant, B.E. Bryant, R.G. White. 2002. Seasonal use of small tributary and main-stem habitats by juvenile steelhead, coho salmon, and Dolly Varden, in a southeastern Alaska drainage basin. Transactions of the American Fisheries Society 131:498–506.

Bryant, M.D., M.D. Lukey, J.P. McDonell, R.A. Gubernick, and R.S. Aho. 2009. Seasonal movement of Dolly Varden and cutthroat trout with respect to stream discharge in a second-order stream in southeast Alaska. North American Journal of Fisheries Management 29(4): 1728–1742.

Bocking, R.C., C.K. Parken, and D.Y. Atagi. 2005. Nass River steelhead habitat capability production model and preliminary escapement goals. Ministry of Water, Land and Air Protection, Smithers, B.C.

Cramer, S.P. and N.K. Ackerman. 2009a. Linking stream carrying capacity for salmonids to habitat features. In Knudsen E.E. and H. Michael, editors. Pacific Salmon Environment and Life History Models: Advancing Science for Sustainable Salmon in the Future. American Fisheries Society, Symposium 71, Bethesda, MD.

Cramer, S.P. and N.K. Ackerman. 2009b. Prediction of stream carrying capacity for steelhead (*Oncorhynchus mykiss*): the unit characteristic method. [*In*] Knudsen E.E. and H. Michael, editors. Pacific Salmon Environment and Life History Models: Advancing Science for Sustainable Salmon in the Future. American Fisheries Society, Symposium 71, Bethesda, MD.

Crupi, A.P., J.V. Nichols, B.J. Frenette, and R.S. Mullen. 2010. Steelhead habitat capability pilot study. Phase I: remote sensing/GIS acquisition, and on ground stream habitat characterization surveys. Alaska Department of Fish and Game, Fishery Data Series No. 10-91, Anchorage.

Crupi, A.P., and J.V. Nichols. In prep. Steelhead usable habitat area in the Sitkoh Creek watershed. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Dolloff, C.A., J. Kershner, and R. Thurow. 1996. Underwater observation. Pages 533–554 [*In*] B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

Hankin, D. G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:834–844.

Harding, R. D. 2005. Southeast Alaska steelhead snorkel surveys of regional index streams, 2002 and 2003. Alaska Department of Fish and Game, Fishery Data Series No. 05-74, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds05-74.pdf

Harding, R. D. and J.D. Jones. 1991. Peterson Creek and Lake system steelhead evaluation, 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-31, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds91-31.pdf

Harding, R. D. and J.D. Jones. 1992. Peterson Creek and Lake system steelhead evaluation, 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-46, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds92-46.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2010. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2007. Alaska Department of Fish and Game, Fishery Data Series No. 10-02, Anchorage.

Johnson, J. and M. Daigneault. 2008. Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Southeastern Region, Effective June 2, 2008. Alaska Department of Fish and Game, Special Publication No. 08-06, Anchorage.

Love, D. C., and R. D. Harding. *In prep*. Steelhead trout production studies at Sitkoh Creek, Alaska, 2009. Alaska Department of Fish and Game, Fisheries Data Series, Anchorage.

Magnus, D.L., D. Brandenburger, K.F. Crabtree, K.A. Pahlke, and S.A. McPherson. 2006. Juvenile salmon capture and coded wire tagging manual. Alaska Department of Fish and Game, Special Publication No. 06-31, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/sp06-31.pdf

REFERENCES CITED (Continued)

McNeil, W.J., R.A. Wells, D.C. Brickell. 1964. Disappearance of dead pink salmon eggs and larvae from Sashin Creek, Baranof Island, Alaska. United States Fish and Wildlife Service, Special Scientific Report-Fisheries No. 485, Washington, D. C.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2): 4–21.

Nielsen, J. L. 1999. The evolutionary history of steelhead (*Oncorhynchus mykiss*) along the US Pacific Coast: Developing a conservation strategy using genetic diversity. ICES Journal of Marine Science, 56: 449–458.

Tautz, A.F., B.R. Ward, and R.A. Ptolemy. 1992. Steelhead trout productivity and stream carrying capacity for rivers of the Skeena River drainage. Pacific Stock Assessment Review Committee. PSARC Working Paper 292-6 AND 8.

Thrower, F. P., J. J. Hard and J. E. Joyce. 2004. Genetic architecture of growth and early-life history transitions in anadromous and derived freshwater populations of steelhead. Journal of Fish Biology 65 (Supp. A): 286–307.

USFS (United States Forest Service). 1992. A channel type users guide for the Tongass National Forest, Southeast Alaska. Region 10 Technical Paper 26. USDA Forest Service. Washington, D.C.

USFS (United States Forest Service). 2001. Chapter 20: Fish and aquatic stream habitat survey [*In*] Aquatic ecosystem management handbook- R-10 amendment 2090.21-2001-1. USDA Forest Service. Washington, D.C.

Ward, B. R. 2000. Declivity in steelhead (*Oncorhynchus mykiss*) recruitment at the Keogh River over the past decade. Canadian Journal of Fisheries and Aquatic Sciences 57:298–306.

Withler, I. L. 1966. Variability in life history characteristics of steelhead trout (*Salmo gairdneri*) along the Pacific coast of North America. Journal of the Fisheries Research Board of Canada 23(3): 365–393.

APPENDIX A

Appendix A1.–Size classes and codes used for identification of dominant substrates.

Substrate	Code	Size class
Organic	ORG	Organic
Sand/Silt	SS	<2mm
Very Fine Gravel	VFG	2–3.9mm
Fine Gravel	FGR	4–7.9mm
Medium Gravel	MGR	8–15.9mm
Coarse Gravel	CGR	16–31.9mm
Very Coarse Gravel	VCG	32–63.9mm
Small Cobble	SC	64–127.9mm
Large Cobble	LC	128–255.9mm
Small Boulder	SB	256–512mm
Large/Med Boulder	LMB	>512 mm
Bedrock	BR	Bedrock

APPENDIX B

At a representative section of each stream reach, termed a Channel Type Verification (CTV) point, pertinent habitat features necessary for characterizing channel-type were recorded. To classify the stream reach according to fluvial process group and channel type, we recorded stream gradients, channel bed widths, incision depth, bankfull width, bank composition, channel pattern, dominant substrates, and surrounding riparian vegetation types. Stream gradient measurements were taken at the extents of the reach, as well as at the CTV point, and the mean gradient ($\bar{g}$) for reach *i* was calculated as:

$$\bar{g} = \frac{\sum g_i}{n} \tag{1}$$

where:

g_i = individual gradient measures taken within reach *i*; and

n = number of measures taken within reach *i*.

Incision depth, to the nearest 0.5 m, was measured as the vertical distance (m) between the first major slope break above bankfull stage and the channel bottom at the thalweg. Bankfull width was measured from the lateral extent of the water surface at bankfull depth, where bankfull depth is the water surface elevation required to completely fill the channel to a point above which water would spill onto the floodplain. Bankfull width, similar to channel bed width, is also independent of the current flow regime, although past high-flow events ultimately control the extent of this parameter and its effect on the floodplain. Bank composition refers to the dominant geologic material composing the stream bank. Channel pattern indicates the connectivity of the mainstream channel, i.e., single or multiple. We visually identified and measured the 3 most dominant substrate size classes, with the exception of bedrock. Distance of the stream reach was calculated using ArcGIS extension X Tools Pro (Version 2.0.0) based on the waypoints attributed to the top and bottom stream reach break (BRK) points. Side channels and disturbance feature lengths were measured in the field using a hand-held laser range finder.

When surveyors encountered accumulations of woody debris, the number of pieces of large wood and key wood were counted. Large wood is defined simply as all pieces of wood (including rootwads) within the bankfull width that are greater than 10 cm diameter, and longer than 1 m in length. Wood pieces that were large relative to the channel size and appeared to contribute to important geomorphic functions (including the formation of pools and cover) are termed key pieces. The qualifying dimensions of key pieces are scaled to the average channel bed width (Table B1). The density of large wood and key wood were calculated similarly using Equation 2.

Large wood density (D_i) for each reach was calculated as:

$$D_i = \frac{\sum w_i}{l_i} \tag{2}$$

where:

w_i = number of large (or key) wood pieces counted in reach *i*; and

l_i = length of reach *i*.

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As we surveyed each stream reach, macro-pools were counted. A detailed definition of macro-pools is included in Frenette et al., *unpublished*, Regional Supervisor, ADF&G-SF, Douglas, AK, but in general they were defined by surrounding characteristics, such as average channel bed width, residual pool depth and the length of the macro-pools themselves. Macro-pool density for each reach was calculated similarly using Equation 2.

Appendix Table B1.–Qualifying dimensions of key wood pieces based on average channel bed width.

Average channel bed width (m)	Key piece diameter (m)	Key piece stem length (m)	Rootwad diameter (m)
0 – 4.9	0.3	> 3	> 1
5 – 9.9	0.3	> 7.6	> 3
10 – 19.9	0.6	> 7.6	> 3
≥ 20	0.6	> 15	> 3

APPENDIX C

Appendix C1.–List of computer data files archived from this study.

Data File	Description
Peterson_Hydro.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all stream delineation for the Peterson Creek watershed
Sashin_Hydro.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all stream delineation for the Sashin Creek watershed
Peterson_Barrier.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing location of the Peterson Creek geologic barrier
Sashin_Barrier.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing location of the Sashin Creek geologic barrier
PTR_Features_ALL.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all mapping features encountered during stream habitat surveys within the Peterson Creek watershed.
SAS_Features_ALL.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all mapping features encountered during stream habitat surveys within the Sashin Creek watershed.
PTR17-28_FOP_ALL.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all Fish Observation Points (FOP's) observed during snorkel surveys within the Peterson Creek watershed.
SAS19_FOP_ALL.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all Fish Observation Points (FOP's) observed during snorkel surveys within the Sashin Creek watershed.
Peterson_Creek_Watershed.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing border of the Peterson Creek watershed.
Sashin_Creek_Watershed.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing border of the Sashin Creek watershed.
FDS_Peterson_Sashin_data_archive.xlsx	Excel spreadsheet containing data for Peterson and Sashin Creeks FDS report tables and figures.
Usable Area_Peterson.xlsx	Excel spreadsheet containing data used in the calculation of usable habitat area for Peterson Creek watershed.
Usable Area_Sashin.xlsx	Excel spreadsheet containing data used in the calculation of usable habitat area for Sashin Creek watershed.