Fishery Data Series No. 12-45

Hatchery Chum Salmon Straying in Southeast Alaska, 2011

by

Andrew W. Piston

and

Steven C. Heinl

September 2012

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

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

FISHERY DATA SERIES NO. 12-45

HATCHERY CHUM SALMON STRAYING IN SOUTHEAST ALASKA, 2011

By
Andrew W. Piston and Steven C. Heinl
Alaska Department of Fish and Game, Division of Commercial Fisheries, Ketchikan

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

September 2012

Development and publication of this manuscript were partially funded through award AR45900/GR45006 [project# 45975] from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, administered by the Alaska Department of Fish and Game. Statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration and the U.S. Department of Commerce.

ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and peer review.

Andrew W. Piston and Steven C. Heinl,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
2030 Sea Level Drive, Suite 205, Ketchikan, Alaska 99901, USA

This document should be cited as:
Piston, A. W., and S. C. Heinl. 2012. Hatchery chum salmon straying in Southeast Alaska, 2011. Alaska Department of Fish and Game, Fishery Data Series No. 12-45, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

In 2011, we collected otoliths from chum salmon at wild stock index streams in the Northern Southeast Inside Subregion (NSEI) of Southeast Alaska to estimate the overall proportion of stray hatchery fish in the escapement index for the subregion. Sixteen of 63 index streams were randomly selected for sampling and collections of otoliths at each stream were designed to be representative of the entire escapement. Samples of greater than 50 fish were obtained from 14 of 16 streams and hatchery fish were detected in 12 of those streams. The overall estimated proportion of hatchery fish in the NSEI escapement index in 2011 was 9.8% (95% CI=8.9%–10.7%), which was lower than the 2010 estimate of 13.5%, and the difference was statistically significant. We observed considerable year-to-year variation in the proportion of hatchery fish in five of eight streams that had been sampled in prior years. The proportion of hatchery strays in all samples collected from 2008 to 2011 decreased as distance from release sites increased and the proportions were generally highest at streams located within 50 km of the nearest hatchery release site. Modification of summer chum salmon escapement indices to account for the proportions of hatchery strays observed during our studies would result in little or no change to current escapement goals due to the method used to establish goals. Information on hatchery chum salmon straying will be considered in future assessments of wild chum salmon stocks.

Key words: chum salmon, escapement, enhancement, hatchery stray, *Oncorhynchus keta*, otolith, Southeast Alaska, straying, thermal mark.

INTRODUCTION

Chum salmon (*Oncorhynchus keta*) spawn in more than 1,200 streams in Southeast Alaska (Eggers and Heinl 2008). Annual commercial harvests of chum salmon in Southeast Alaska reached their highest levels in the 1920s after commercial fisheries developed in the early 1900s, then gradually declined to their lowest levels in the 1970s (Figure 1; Eggers and Heinl 2008). Chum salmon harvests increased again in the mid-1980s and reached historic high levels in the 1990s and 2000s, primarily due to increased production of hatchery chum salmon (Van Alen 2000). In 1980, hatchery operators in Southeast Alaska released 8.7 million chum salmon fry at eight locations. By 2007, this number had risen to 454 million fry released at 22 locations (Eggers and Heinl 2008). In Southeast Alaska, hatchery-produced chum salmon accounted for an average of 73% of the common property commercial harvest of this species—nearly 5 million fish per year—from 2001 to 2010.

While it is clear that the hatchery program in Southeast Alaska provides major economic benefits to the region's commercial fisheries (Clark et al. 2006), it is also widely recognized that there are risks to wild stocks associated with large-scale hatchery production (Chilcote et al. 2011; Araki and Schmid 2010; Naish et al. 2008; Myers et al. 2004; Waples 1999). The State of Alaska has numerous policies designed to minimize impacts of the salmon enhancement program on wild stocks, including a genetics policy (Davis et al. 1985), disease policies (McDaniel et al. 1994; Meyers 2000, Meyers 2010), a policy for the management of sustainable salmon fisheries (5 AAC 39.222), and a policy for management of mixed stock salmon fisheries, which gives the conservation of wild stocks, consistent with the sustained yield principle, the highest priority (5 AAC 39.220). Of particular concern is the possibility that hatchery-produced salmon might stray in large numbers to wild stock streams, with potential genetic, ecological, and management implications (Naish et al. 2008).

High straying rates could make it difficult for fisheries managers to monitor chum salmon populations through standard survey techniques and reduce the Alaska Department of Fish and Game's (ADF&G) ability to formulate meaningful escapement goals and determine whether those goals are being met for wild chum salmon populations as required by the Sustainable Salmon Fisheries Policy. Chum salmon escapements are assessed primarily through aerial surveys at 81 summer-run and seven fall-run chum salmon index streams distributed across the Southeast region (Eggers and Heinl 2008). These surveys do not provide a measure of total escapement but provide indices of relative abundance that are useful for assessing long-term trends in chum salmon escapement. Escapement goals for summer chum salmon are based on peak survey counts to aggregates of these streams in three broad subregions. Although ADF&G has assumed that hatchery-reared chum salmon successfully home to their release site, no organized, region-wide studies have been conducted to assess straying of hatchery salmon in Southeast Alaska.

Coded-wire tag data supported ADF&G's observation that chum salmon straying did not appear to be significant in Southeast Alaska during most of the growth of the hatchery program (Josephson 2010). Josephson (2010) examined coded-wire tag recoveries of hatchery chum salmon in Southeast Alaska since the late 1970s and found that only 10 of more than 8,000 tags recovered at hatchery brood stock collections were recovered more than five miles from the original release site. Marking fractions were extremely low (typically less than 0.003%), however, due to the large numbers of chum salmon fry released, and detection of coded-wire tagged hatchery fish in samples on the spawning grounds would have been difficult in most situations. Starting in the early 1990s, hatcheries in Southeast Alaska began mass-marking entire release groups of chum salmon fry with thermal-otolith marks, which has greatly improved the ability of fishery managers and hatchery operators to evaluate and monitor all aspects of hatchery programs, and to estimate contributions of hatchery fish to mixed-stock fisheries (Munk et al. 1993; Hagen et al. 1995; Joyce and Evans 2000; Jensen and Milligan 2001). Since 2004, an average of 84% of all hatchery chum salmon released in Southeast Alaska have been otolith-marked (Figure 2). Most hatcheries have recently otolith marked 100% of their releases, including 100% of Douglas Island Pink and Chum (DIPAC) and Southern Southeast Regional Aquaculture Association (SSRAA) releases. Other hatcheries have released unmarked fish; e.g., 100% of Metlakatla Indian Community (MIC) chum salmon released at Annette Island from 2006 to 2009. In a few cases, hatcheries have marked a portion of their releases; e.g., Northern Southeast Regional Aquaculture Association (NSRAA) marked approximately 25% of their Medvejie stock chum salmon released at Deep Inlet from 2007 to 2009.

Limited otolith sampling conducted since 1995 indicated that hatchery fish stray with greater frequency than was indicated by coded-wire tag data. From 1995 to 2006, ADF&G collected chum salmon otolith samples from 22 streams in southeast Alaska, primarily in the Juneau area (Josephson 2010). Although many of the samples were small and often collected on a single date, the results indicated that a large number of hatchery strays were present in many of the summer chum salmon systems that were examined. Approximately 50% of the fish sampled in three Juneau-area chum salmon index streams (Berners River, Sawmill Creek, and Fish Creek) were hatchery strays from local release sites. In 2006, otolith samples were collected from chum salmon carcasses at Traitors Creek, which is located in the next bay south of SSRAA's Neets Bay hatchery, in southern Southeast Alaska (Figure 3). Approximately 87% of the sampled fish were stray hatchery fish, primarily from Neets Bay. Traitors Creek was historically an important producer of wild chum salmon (e.g., chum salmon escapement of 32,000 in 1962; Mattson and Rowland 1963). Samples were also collected from fall chum salmon at Disappearance Creek, Prince of Wales Island, from 2008 to 2010 (Piston and Heinl 2010a, Piston and Heinl 2010b, and Piston and Brunette 2011), and the Chilkat River, near Haines, in 2009. No hatchery fish were detected in samples collected at the Chilkat River, which is not unexpected considering the lack of fall chum salmon releases in northern Southeast Alaska. The proportion of hatchery strays in the escapement at Disappearance Creek did not exceed 1.0%.

From 2008 to 2010, we collected chum salmon otoliths at wild stock index streams throughout Southeast Alaska, to document the presence and distribution of stray hatchery fish in the region (Piston and Heinl 2012). Hatchery fish were found in nearly every stream that was sampled, which indicated that most chum salmon streams in Southeast Alaska, even at long distances from hatchery release sites, have at least some hatchery fish present. The proportions of stray hatchery fish were generally highest in streams within 50 km to release sites, but stray proportions greater than 10% were detected in six streams at distances more than 50 km from the nearest release site (Piston and Heinl 2012). Considerable year-to-year variation in the proportion of hatchery fish was found at four streams sampled in multiple years. In all three years the estimated overall proportion of hatchery strays in the Northern Southeast Outside Subregion (NSEO) was less than 2%, and streams sampled in the Southern Southeast Subregion (SSE) had similar low proportions of hatchery fish (Piston and Heinl 2012). In the Northern Southeast Inside Subregion (NSEI), proportions of stray hatchery fish in excess of 5% were detected at the majority of index streams sampled, and the overall estimated proportion of hatchery fish in the NSEI escapement index in 2010 was 13.5% (95% CI=12.1%–15.0%). The NSEI Subregion was identified in the first three years of this study as the index most affected by hatchery chum salmon straying in the region (Piston and Heinl 2012).

In 2011, we sampled a random selection of summer chum salmon index streams to estimate the overall proportion of stray hatchery fish in the NSEI subregion. We focused our effort on this subregion to provide more information on the year-to-year variation in the proportion of hatchery fish in the index. Increased understanding of the range in variation of hatchery chum salmon straying may be useful for future escapement goal revisions and for making general assessments regarding wild chum salmon stocks.

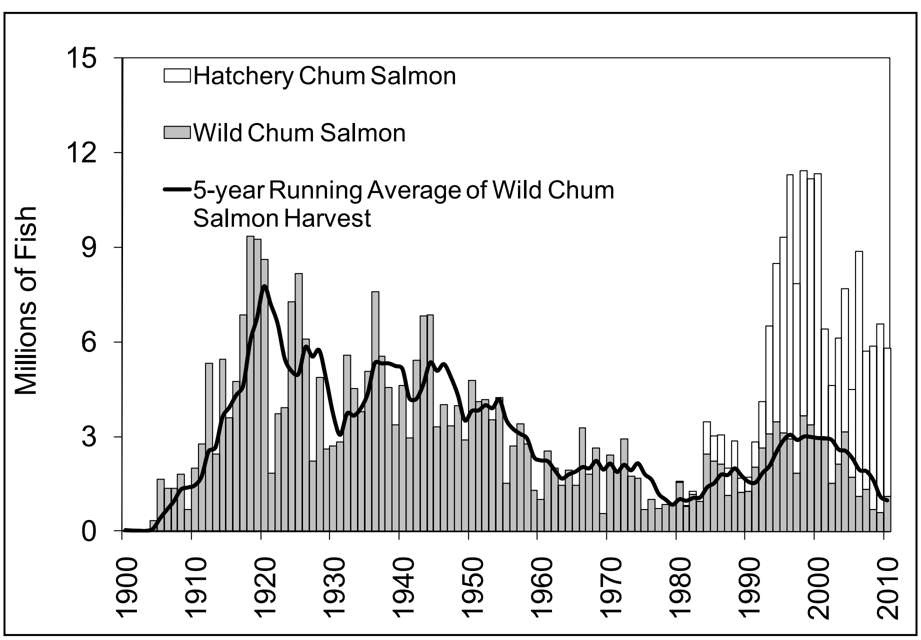

Figure 1.–Annual common property harvest of chum salmon in Southeast Alaska from 1890 to 2010 showing the estimated harvest of both hatchery-produced and wild chum salmon. (Data prior to 1960 are from Byerly et al. 1999.)

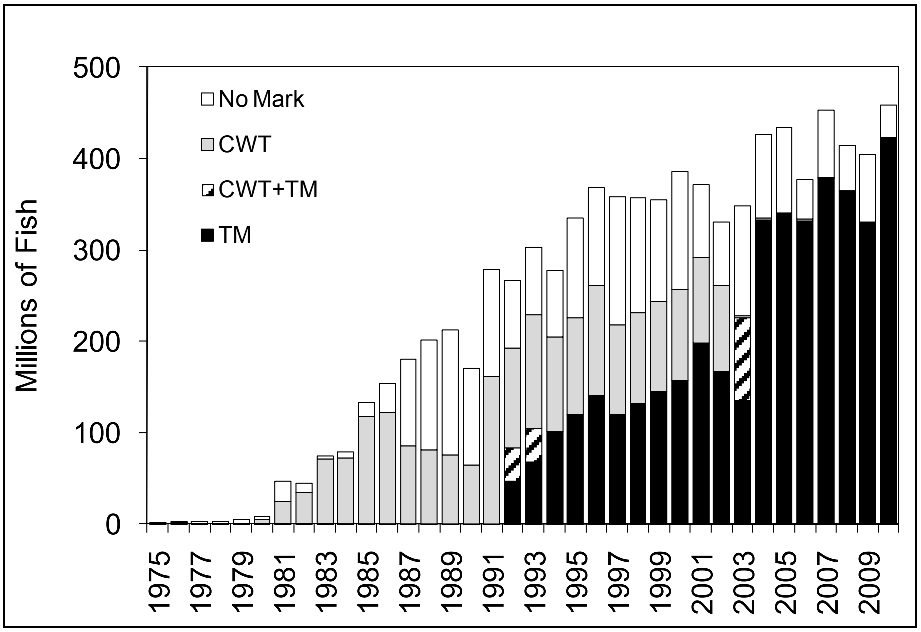

Figure 2.–Total releases of hatchery chum salmon in Southeast Alaska, 1975–2010. Releases are presented by type of mark: CWT=coded-wire tag; TM=thermal mark.

OBJECTIVES

- Estimate the proportion of hatchery summer chum salmon in 16 randomly selected index streams in the NSEI Subregion of Southeast Alaska such that the point estimate is within 5% of the true value 80% of the time.
- Estimate the proportion of hatchery fish in the NSEI summer chum salmon escapement index using annual peak aerial survey counts as a weighting factor.
- Describe the relationship between the proportion of hatchery fish in a stream and the distance to hatchery release sites.

STUDY SITE

We sampled ADF&G summer chum salmon index streams in the NSEI Subregion of Southeast Alaska, from the Stikine River, near Wrangell, in the south, to Berners Bay, near Juneau, in the north—a distance of approximately 250 km (Figure 3). Index streams throughout Southeast Alaska provide the foundation for escapement indices and goals for summer chum salmon in Southeast Alaska, which are based on peak aerial surveys to aggregates of index streams in three broad subregions—Southern Southeast, Northern Southeast Inside, and Northern Southeast Outside (Figure 4, Appendix A; Piston and Heinl 2011). The Northern Southeast Inside Subregion (NSEI) includes 63 streams on the inside waters of northern Southeast Alaska north of Sumner Strait (Districts 8–12, 14, and District 13 subdistricts 51 to 59).

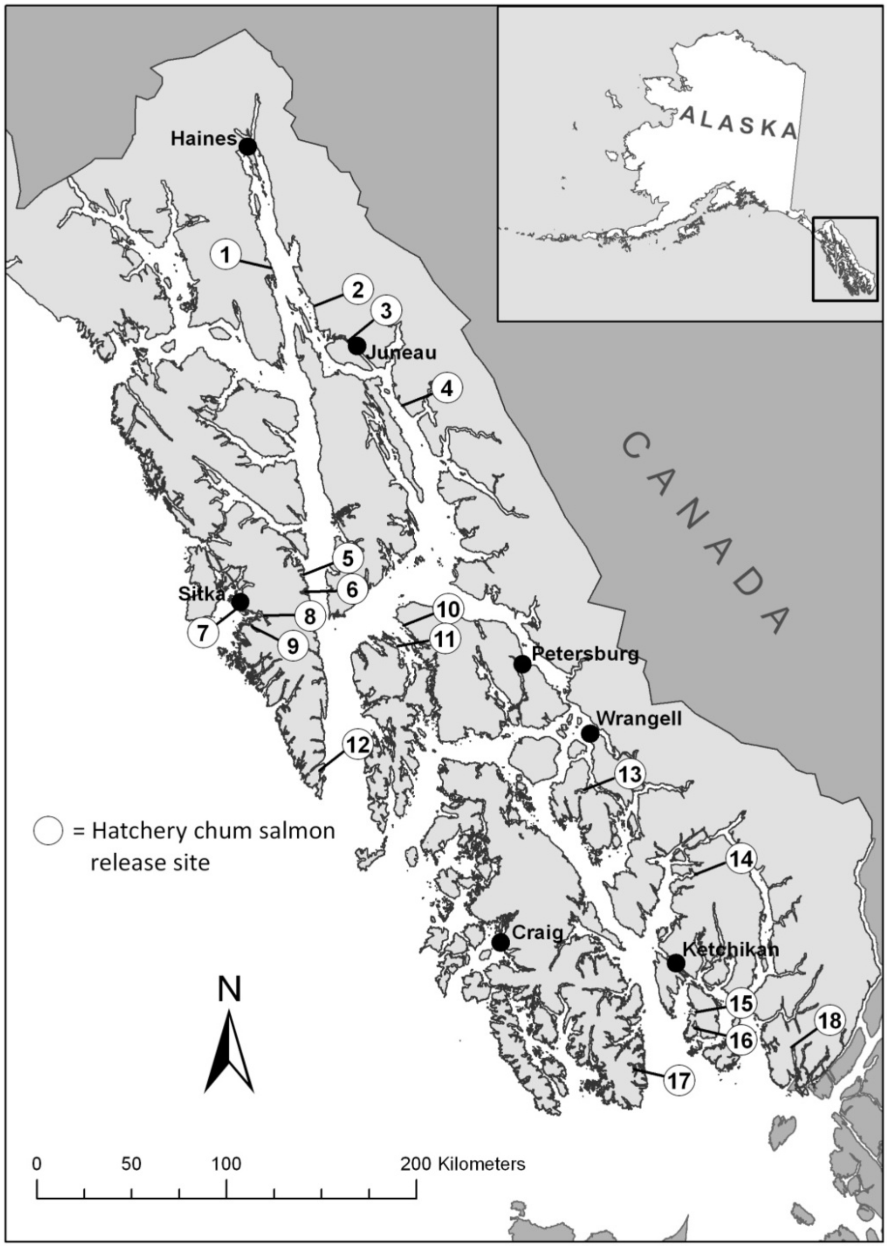

Figure 3.–Map of Southeast Alaska showing major towns and current hatchery chum salmon release sites. Hatchery release sites and operators are represented by numbered circles: 1) Boat Harbor (DIPAC), 2) Amalga Harbor (DIPAC), 3) Gastineau Channel (DIPAC), 4) Limestone Inlet (DIPAC), 5) Kasnyku Bay (NSRAA), 6) Takatz Bay (NSRAA), 7) Crescent Bay (SJC), 8) Bear Cove (NSRAA), 9) Deep Inlet (NSRAA), 10) Kake (KNFC), 11) Southeast Cove (KNFC), 12) Port Armstrong (AKI), 13) Anita Bay (SSRAA), 14) Neets Bay (SSRAA), 15) Chester Bay (MIC), 16) Tamgas Harbor (MIC), 17) Kendrick Bay (SSRAA), 18) Nakat Inlet (SSRAA).

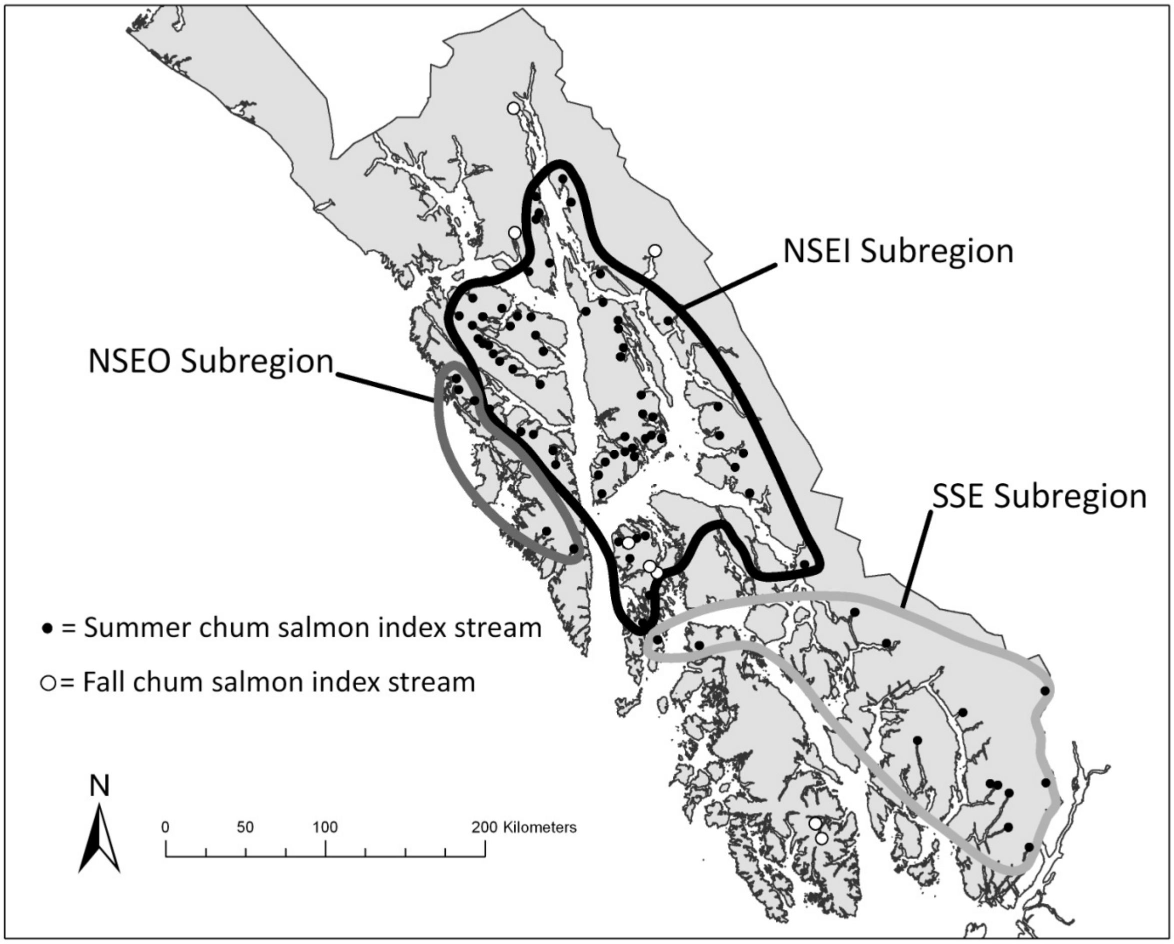

Figure 4.–The location of ADF&G chum salmon index streams and summer chum salmon stock groups in Southeast Alaska.

METHODS

STREAM SELECTION

For this study, the statistical population of interest was the 63 summer chum salmon index streams that the department currently surveys to monitor wild chum salmon escapements in the NSEI Subregion of Southeast Alaska. We had resources to sample 16 index streams in 2011, or 25% of the streams in the NSEI Subregion index. We assigned each of the 63 index streams a random number, sorted the numbers from smallest to largest, and chose the first 16 streams to be sampled (Appendix A; Figure 5).

OTOLITH COLLECTION

Distribution of Samples

We attempted to collect otoliths during two sampling events at each stream. The number of days between sampling trips and the number of sampling events varied for each stream, depending on chum salmon abundance, run timing, and weather (Appendices B1–B2). We communicated regularly with ADF&G management biologists responsible for conducting aerial surveys in the

NSEI Subregion regarding inseason chum salmon abundance and the availability of carcasses at target streams. All sampling was conducted on foot, starting from mouth of the creek and walking upstream. Samples were collected throughout the accessible length of the stream on each sampling event; however, we were only able to sample the lower few miles of available spawning habitat at a few of the larger streams. At Saginaw and Sanborn creeks, spawning chum salmon and carcasses were only available for a very short time and samples were collected on one sampling event (Appendix B1).

Condition of Sampled Fish

Otolith samples were primarily collected from chum salmon carcasses on the spawning grounds to ensure that we sampled fish that had spawned and to avoid fish that may have been probing into a stream. We sampled carcasses in all stages of decay, to ensure that samples represented the entire run. When sufficient carcass numbers were unavailable, we also used snagging gear to capture live fish for sampling. These samples were pooled with samples from carcasses for analysis. When live fish were sampled, we targeted fish that were spawned out, which ensured that the vast majority of the sampled fish had spawned in the stream where they were captured.

Sample Size

We wanted to estimate the proportion of hatchery fish in the escapement at each creek so that we were 80% confident that the point estimate was in error by less than 5%. We chose an 80% confidence level in an effort to balance the precision of our estimates with the need to keep sample sizes to a level that allowed for sampling a large number of streams while staying within budget constraints. The sample size (*n*) for each stream was calculated using methods described in Thompson (1992) for determining the sample size for estimating a proportion:

$$n = \frac{z^2 p(1-p)}{d^2}.$$

The value of z is equal to 1.28, which is the upper 0.10 limit of the normal distribution, and d is our maximum error tolerance of 5%. Since the proportion of hatchery fish in the escapement was unknown, we used a value of 0.5 for p to estimate the sample size that would meet our objective for any proportion of hatchery fish. Using this formula, we obtained a sampling goal of 164 fish per stream. We increased the sample size to 192 otoliths per stream (which conveniently filled two otolith trays) to ensure that we met our sampling goal if a number of samples were damaged or unreadable.

If we assume that the presence of hatchery fish in stream i has a binomial distribution, with p representing the true proportion of hatchery fish in the stream, we can calculate the probability of at least one hatchery fish in a sample size of 192 for different sizes of p. Using the binomial distribution, $p^0(1-p)^{192}$ is the probability of exactly zero hatchery fish in a sample size of 192. Therefore, $1 - p^0(1-p)^{192}$ is the probability of at least one hatchery fish in the sample. If, on average, 5% of the fish in a particular stream are hatchery fish, the probability of detecting at least one marked otolith in a sample of 192 is nearly 100%. Even in cases where only 50 samples were obtained, the probability of detecting at least one hatchery fish was still greater than 90% when the true proportion of hatchery fish was only 5%. A sample size of 192 provided reasonable precision in our estimates of the proportion of hatchery fish and ensured that we would detect the presence of hatchery fish in streams with low proportions of hatchery strays. We did not calculate standard errors and confidence intervals for samples of less than 50 fish, and only consider those samples to be potentially useful for identifying the presence or absence of hatchery strays.

Otolith Extraction and Preparation

The left and right sagittal otoliths were removed from each fish and each pair was placed into a single cell of a 96-cell assay tray. Otoliths were cleaned using a treatment described by Hagen et al. (1995): otoliths were soaked in a 0.5% chlorine solution for up to 8 minutes, followed by a rinse in dechlorinating solution (0.7% sodium thiosulfate), and a rinse in tap water. Otolith samples were subsequently analyzed for thermal marks at the ADF&G Commercial Fisheries Mark, Tag, and Age Laboratory in Juneau, Alaska.

DATA ANALYSIS

The estimated proportion, $\hat{p}$, of otolith-marked fish in the escapement was calculated as,

$$\hat{p} = m/n,$$

where *m* denotes the number of fish sampled that had otolith marks, and *n* denotes the number of fish sampled for otolith marks. To calculate an overall proportion of hatchery strays in the entire NSEI Subregion, streams were the basic sampling unit, and fish within streams were a second-stage sampling unit. Each of the 63 index streams (i) had a true proportion, p_i, of hatchery strays, $i = 1, \ldots 63$, as a basic attribute of the sampling unit. Then if each stream had an escapement h_i, the true proportion of hatchery fish in the NSEI escapement index was given by,

$$p = \frac{\sum_i p_i h_i}{\sum_i h_i}.$$

After all otoliths were examined for thermal marks, the sample proportion of hatchery otoliths in the ith stream was denoted as $\hat{p}_i$. The estimated proportion of hatchery fish in the NSEI Sub-region's chum salmon escapement index was constructed from a weighted average of the sample proportions, with weights constructed from a consistent chum salmon escapement surrogate for the year. We let h^* denote the peak escapement count, which served as that surrogate, so that the estimated proportion of hatchery strays in the entire NSEI Subregion was given by,

$$\hat{p} = \frac{\sum_{sample} \hat{p}_i h_i^*}{\sum_{sample} h_i^*}.$$

The variance of the estimated proportion of otolith-marked fish in each stream and the NSEI Subregion was calculated as (Cochran 1977, page 52),

$$\hat{\text{var}}(\hat{p}) = \left[\frac{\hat{p}(1-\hat{p})}{n-1}\right],$$

and the standard error was calculated as the square root of the variance.

If a sample proportion is close to 0 or 1, calculation of confidence intervals using methods based on the normal distribution may be inappropriate (Morisette and Khorram 1998). Therefore, the

80% confidence interval of the proportion of hatchery strays was calculated using methods based on the relationship between the *F* distribution and the binomial distribution (Zar 2010), where *X* equals the number of marked fish in a random sample of *n* fish, and $F_{\alpha(2),v_1,v_2}$ is the upper 100•(1-alpha)th percentile from the *F* distribution, with v_1 and v_2 degrees of freedom. The lower 80% confidence limit (L_1) was calculated as,

$$L_1 = \frac{X}{X + (n - X + 1)F_{\alpha(2),v_2,v_1}},$$

where

$$v_1 = 2(n - X + 1),$$

and

$$v_2 = 2X.$$

The upper 80% confidence limit (L_2) was calculated as,

$$L_2 = \frac{(X + 1)F_{\alpha(2),v_1'v_2'}}{n - X + (X + 1)F_{\alpha(2),v_1'v_2'}},$$

where

$$v_1' = 2(X + 1) = v_2 + 2,$$

and

$$v_2' = 2(n - X) = v_1 - 2.$$

For cases in which no hatchery fish were detected in a sample, we calculated exact confidence limits following Zar (2010):

$$L_1 = 0$$

and,

$$L_2 = 1 - \sqrt[n]{\alpha/2}.$$

To compare the year-to-year variability in the proportion of hatchery fish present in the index streams in 2011, and from 2008 to 2010 (Piston and Heinl 2012; Appendices B1–B2), a test for differences between proportions was conducted for streams where a sample size of >50 fish was reached in two years. We used a level of significance of 0.05 for each test, which were calculated following Zar (2010):

$$Z_c = \frac{|\hat{p}_1 - \hat{p}_2| - \frac{1}{2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}{\sqrt{\frac{\bar{p}\bar{q}}{n_1} + \frac{\bar{p}\bar{q}}{n_2}}},$$

where

$$\bar{p} = \frac{(X_1 + X_2)}{(n_1 + n_2)}$$

and

$$\bar{q} = 1 - \bar{p}.$$

The 95% confidence interval for the difference between the two population proportions was calculated as,

$$95\%\ \text{C.I. for } p_1 - p_2 = (\hat{p}_1 - \hat{p}_2) \pm \left[Z_{0.05(2)} \sqrt{\frac{\bar{p}\bar{q}}{n_1} + \frac{\bar{p}\bar{q}}{n_2}} + \frac{1}{2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right) \right].$$

For cases in which we obtained three or more years of data from a single stream, we used the Chi-square contingency-table analysis outlined by Zar (2010) to test for differences between proportions among years:

$$\chi^2 = \sum\sum \frac{(f_{ij} - \hat{f}_{ij})^2}{\hat{f}_{ij}},$$

where f_{ij} is the observed frequency of unmarked fish in a sample and $\hat{f}_{ij}$ is the expected frequency of unmarked fish in the sample, assuming the null hypothesis that there is no difference between proportions among samples is true. The degrees of freedom (DF) were calculated as,

$$DF = (r - 1)(c - 1),$$

which, in the case of a two column (*c*) by three row (*r*) contingency table, is equal to two.

Not all releases of hatchery chum salmon have been otolith marked, and we could not account for hatchery releases that were 100% unmarked in some years of interest to our study. In the NSEI Subregion, the unmarked releases most likely to contribute undetected strays to wild stock index streams originated at Kake Nonprofit Fisheries Corporation release sites at Southeast Cove and Kake (Figure 3). Approximately 34 million unmarked chum salmon were released at these sites in 2007 and approximately 18 million were released in 2008. In 2009, NSRRA released approximately 40 million unmarked brood-year 2008 chum salmon at their Takatz Bay release site (Figure 3), which may have contributed undetected strays to some index streams. Chum salmon primarily mature at age 4, however, and only three brood-year 2008 hatchery fish originating from other release sites were recovered in 2011. Thus, the impact of the unmarked Takatz release may have been minimal in 2011.

We incorporated data from this study and data collected from 2008 to 2010 (Piston and Heinl 2012) to compare stray proportions and distance to nearest release site of otolith-marked hatchery fish. We measured the approximate water distance in km (i.e., the distance a fish would have to swim) using the measuring tool in Google Earth[1]. Straight line measurements between two points would be misleading for comparing salmon straying distances due to the numerous islands and passages in Southeast Alaska; e.g., the straight line distance between the Kasnyku Bay hatchery release site and the Mole River is approximately 65 km, but the distance for a swimming fish is more than 125 km.

RESULTS

Our sampling objective of 192 otoliths per stream proved difficult or impossible for some streams, given our limited resources, because chum salmon runs were below average in 2011.

[1] Reference to trade names does not imply endorsement by the Alaska Department of Fish and Game.

We obtained samples of greater than 50 fish from 14 of 16 summer chum salmon index streams sampled in 2011 (Table 1; Figure 5). The proportion of hatchery fish was greater than 5.0% in 7 of those 14 streams. Samples from two streams, Tenakee Inlet Head and Game Creek, contained no hatchery fish. The highest proportions of stray hatchery fish were found at Sawmill Creek (65.6%) and Wilson River (25.0%). We used all the streams except Saginaw Creek (only 17 otoliths collected; Appendix B) to calculate the overall proportion of hatchery fish in the entire index. The estimated proportion of hatchery fish in the NSEI escapement index in 2011, weighted by peak survey counts, was 9.8% (80% CI=8.9–10.7%; Table 1). Detailed results of all samples collected from 2008 to 2011, including distances from nearest release sites and samples by date, are presented in Appendix B.

Table 1.–Streams sampled for hatchery chum salmon strays in the NSEI Subregion of Southeast Alaska in 2011 and the estimated overall proportion of hatchery fish in the NSEI index.

Stream	Sample Size	% Hatchery Fish	80% CI	Peak Survey Count	Hatchery Fish
North Arm Creek	149	8.7%	5.9–12.5%	1,324	115
Sample Creek	188	0.5%	0.1–2.1%	660	3
Amber Creek-Pybus Bay	88	5.7%	2.8–10.3%	300	17
Snug Cove-Gambier Bay	49	6.1%	2.3–13.1%	100	6
Laura’s Creek	208	1.0%	0.3–2.5%	1,088	11
Sanborn Creek	191	1.6%	0.6–3.5%	2,000	32
Mole River	121	10.7%	7.2–15.3%	1,900	203
Admiralty Creek	190	11.1%	8.2–14.5%	731	81
Wilson River	60	25.0%	17.7–33.6%	2,500	625
Seal Bay Creek	176	1.7%	0.6–3.8%	6,500	111
Tenakee Inlet Head	139	0.0%	0.0–1.6%	2,500	0
Weir Creek-N. Arm Hood Bay	62	3.2%	0.9–8.4%	500	16
Saook Bay West Head	146	0.7%	0.1–2.6%	1,420	10
Game Creek	63	0.0%	0.0–3.6%	2,500	0
Sawmill Creek	209	65.6%	61.0–69.9%	2,000	1,312
Total	2,039	9.8%	8.9–10.7%	26,023	2,542

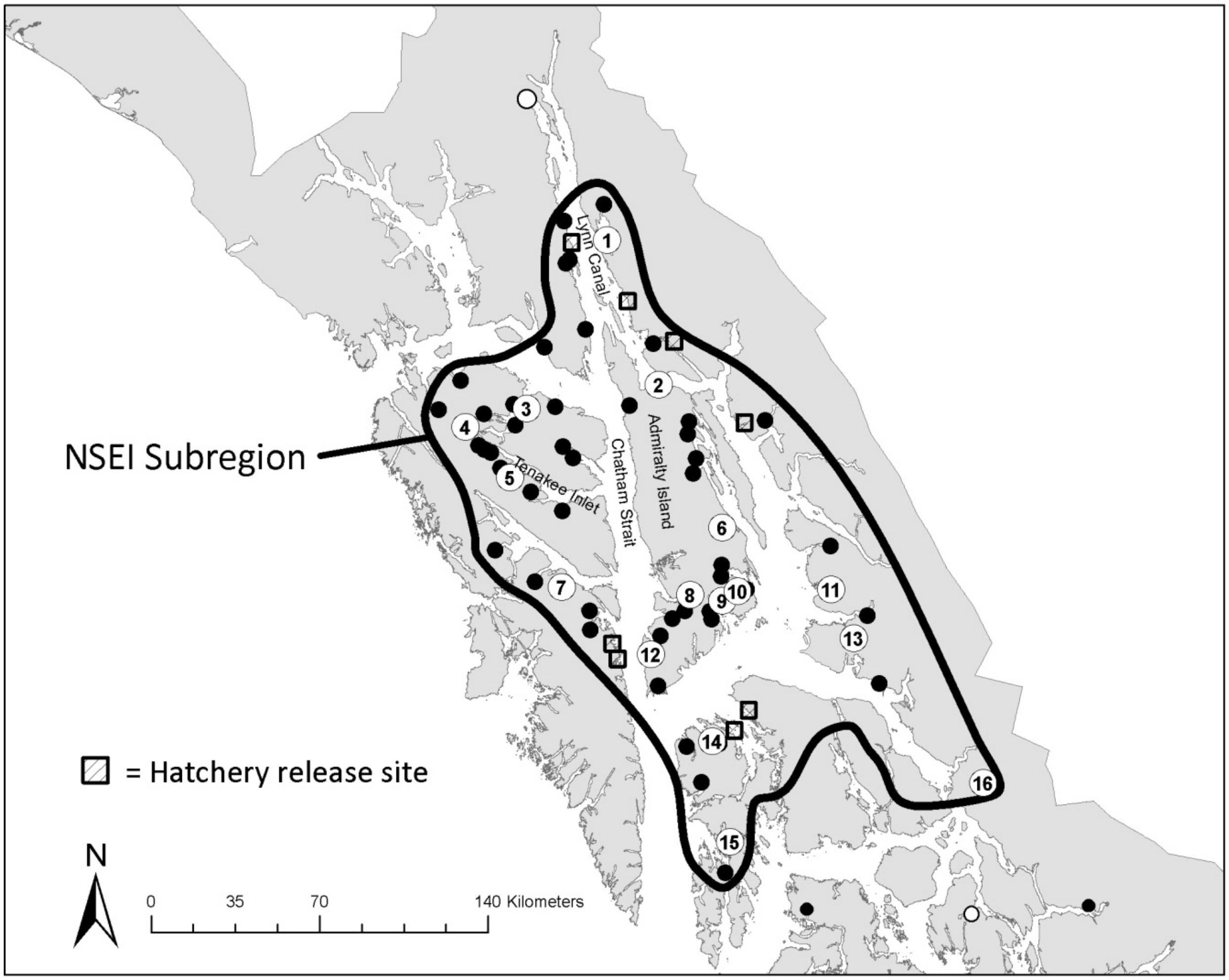

Figure 5.–Index streams sampled in 2011 in the Northern Southeast Inside Subregion of Southeast Alaska. Index streams are represented by black dots and streams sampled in 2011 are white numbered dots: 1) Sawmill Creek, 2) Admiralty Creek, 3) Game Creek, 4) Tenakee Inlet Head, 5) Seal Bay Creek, 6) Mole River, 7) Saook Bay West Head, 8) Weir Creek-North Arm Hood Bay, 9) Amber Creek-Pybus Bay, 10) Snug Cove-Gambier Bay, 11) Laura's Creek, 12) Wilson River, 13) Sanborn Creek, 14) Saginaw Creek, 15) Sample Creek, 16) North Arm Creek.

The proportion of hatchery strays in all samples collected from 2008 to 2011 decreased as distance from release sites increased (Figure 6). The mean proportion of hatchery strays in the 13 sampled streams located within 50 km of the nearest hatchery release site was 25.5% (range: 0.5–87.5%), and all samples of greater than 40% hatchery fish were from these streams. The mean proportion of hatchery strays in streams located 50–100 km from the nearest release site was 6.7% (range: 0.0–17.8%). For streams greater than 100 km from the nearest release site, the mean proportion of hatchery strays dropped to 3.1% (range: 0.0–16.6%).

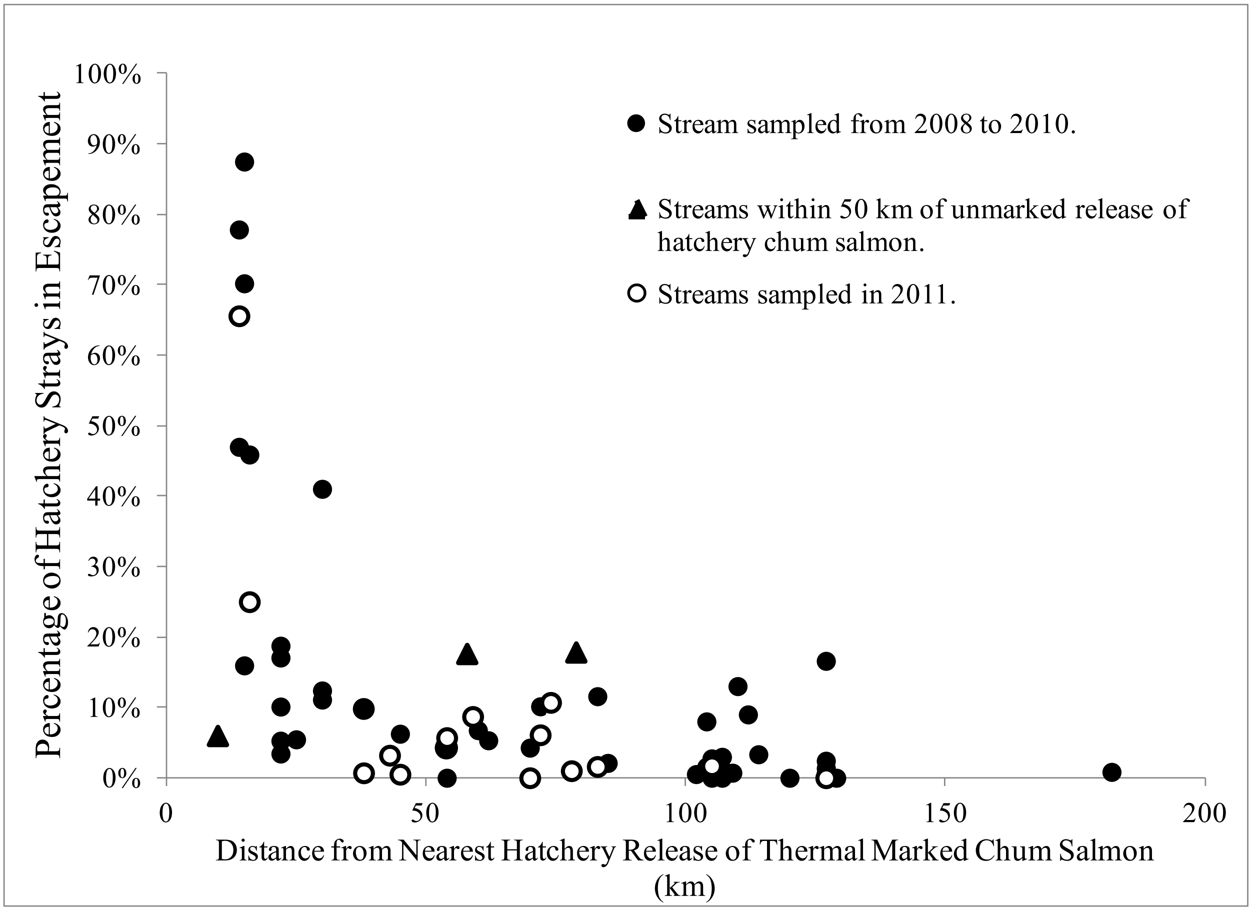

Figure 6.–The relationship between distance from the nearest release site of thermal-otolith marked chum salmon and the proportion of hatchery strays in Southeast Alaska chum salmon streams sampled from 2008 to 2011. Data points include only index streams and non-index streams with past survey estimates >1,000 fish (indicating they are historic producers of chum salmon), and sample sizes >50 fish (63 annual data points from 42 streams).

We observed considerable year-to-year variation in the proportion of hatchery fish in some streams that were sampled in multiple years. The proportions of strays in three streams located near the Chatham Strait corridor were significantly lower in 2011 than in 2010 (Sample Creek, Wilson River, Saook Bay West Head; Table 2; Figure 5). Farther north, in the Juneau area, the proportion of stray hatchery fish at Admiralty Creek was 41.0% in 2009, but only 12.4% in 2010 and 11.1% in 2011 (Table 3). The proportion of hatchery fish at Sawmill Creek, in Berners Bay, north of Juneau, dropped from 78% in 2009 to 47.0% in 2010 and increased to 65.6% in 2011. There were no statistically significant differences in proportions of hatchery strays between years at two Tenakee Inlet streams (Tenakee Inlet Head and Seal Bay Creek). Both of these streams are located over 100 km from the nearest release site. The estimated proportion of stray hatchery fish in the entire NSEI index in 2011 (9.8%) was lower than in 2010 (13.5%) and the difference between the two proportions was statistically significant.

Table 2.–Year-to-year variability in the proportions of hatchery fish in individual chum salmon index streams, 2008–2011, and in the NSEI Subregion 2010–2011. The 95% confidence intervals are for the difference between proportions.

Year	Stream[a]	Sample Size	% Hatchery Fish	SE of Proportion	Z Value	Critical Value	95% CI Lower	95% CI Upper
2010	Sample Creek	224	6.3%	1.6%				
2011	Sample Creek	188	0.5%	0.5%				
	Test for diff. in proportions				2.68	±1.96	1.6%	9.8%
2010	Wilson River	122	45.9%	4.5%				
2011	Wilson River	60	25.0%	5.6%				
	Test for diff. in proportions				2.45	±1.96	4.6%	37.2%
2008	Tenakee Inlet Head	146	0.7%	0.7%				
2011	Tenakee Inlet Head	139	0.0%	0.0%				
	Test for diff. in proportions				-0.54	±1.96	–[b]	–
2010	Saook Bay West Head	93	9.7%	3.1%				
2011	Saook Bay West Head	145	0.7%	0.7%				
	Test for diff. in proportions				2.91	±1.96	2.9%	15.1%
2009	Game Creek	117	4.3%	1.9%				
2011	Game Creek	63	0.0%	0.0%				
	Test for diff. in proportions				0.88	±1.96	–	–
2010	NSEI Subregion	2,262	13.5%	0.7%				
2011	NSEI Subregion	2,039	9.8%	0.7%				
	Test for diff. in proportions				3.70	±1.96	1.7%	5.7%

[a] Only streams sampled in 2011 are shown—additional comparisons were reported in Piston and Heinl (2012).
[b.] No significant difference between years.

Table 3. Chi-square contingency-table analysis tests for differences in the proportions of hatchery fish in individual chum salmon index streams, 2008–2011.

Year	Stream	Index	Sample Size	% Hatchery Fish	SE of Proportion	χ^2 Value	Critical Value	*p*-Value
2008	Seal Bay Creek	NSEI	188	0.0%	0.0%			
2009	Seal Bay Creek	NSEI	182	2.7%	1.2%			
2010	Seal Bay Creek	NSEI	188	2.7%	1.2%			
2011	Seal Bay Creek	NSEI	176	1.7%	1.0%			
	Test for diff. in proportions					6.0	7.8	0.11
2009	Sawmill Creek	NSEI	149	77.9%	3.4%			
2010	Sawmill Creek	NSEI	83	47.0%	5.5%			
2011	Sawmill Creek	NSEI	209	65.6%	3.3%			
	Test for diff. in proportions					22.8	6.0	<0.01
2009	Admiralty Creek	NSEI	117	41.0%	4.6%			
2010	Admiralty Creek	NSEI	99	12.4%	3.1%			
2011	Admiralty Creek	NSEI	190	11.1%	2.3%			
	Test for diff. in proportions					46.3	6.0	<0.01

DISCUSSION

Our sampling objective of 192 otoliths per stream was difficult to achieve in some cases due to low wild summer chum salmon abundance over most of the NSEI Subregion. The 2011 escapement index for the NSEI Subregion was 125,000; only slightly above the current lower-bound sustainable escapement goal of 119,000 (Piston and Heinl 2011) and less than half of the 1991–2010 average. Despite poor escapements, we obtained more than 100 samples from 10 of 16 targeted index streams, and more than 50 samples from 14 of 16 streams. Since the probability of detecting at least one hatchery stray in a sample of 50 fish from a population with a true proportion of 5% hatchery strays was still greater than 90%, we deemed this sample size sufficient to document the presence and distribution of stray otolith-marked hatchery fish in the region, with the understanding that smaller sample sizes reduced the precision of our estimates for individual streams.

Over the four years of our study, 2008–2011, the highest proportions of stray hatchery fish were consistently found in index streams in Lynn Canal and the Juneau area in northern Southeast Alaska (Figure 5). Most streams in this area are located in close proximity (<50 km) to three hatchery release sites. Estimated proportions of hatchery fish in the five streams sampled in Lynn Canal and the Juneau area (three sampled in multiple years) were all greater than 10%, and the only Southeast Alaska index stream samples of greater than 50% hatchery fish came from two streams in this area: Fish Creek (near Juneau) and Sawmill Creek (in Lynn Canal).

In 2010, the estimated proportion of hatchery fish in the NSEI Subregion (13.5%) was not influenced to a large degree by any one stream, and was still greater than 10% even when the three streams with the highest stray proportions were removed from the calculation (Piston and Heinl 2012). The overall estimated proportion of strays in the NSEI Subregion in 2011, however, was heavily influenced by large numbers of strays at Sawmill Creek in Lynn Canal. Approximately 50% of the hatchery chum salmon strays estimated to have been counted during the peak surveys at the 15 sampled index streams in 2011 were in Sawmill Creek (Table 1). The estimated overall proportion of stray hatchery fish in the NSEI Subregion dropped from 9.8% to only 5.1% when Sawmill Creek was removed from the calculation. There are six index streams in Lynn Canal that represent approximately 10% of the 63 streams in the NSEI index, so the single stream from Lynn Canal included in the 2011 sample should provide a representative sample for the entire index and would certainly not over represent Lynn Canal. Streams in Lynn Canal had a greater influence on the overall calculated proportion of hatchery fish in the NSEI index in 2011 as a result of overall lower stray proportions at streams outside of Lynn Canal, and because escapements to Lynn Canal were much higher in 2011 than in 2010.

Streams in Tenakee Inlet, Chichagof Island, had the lowest proportions of stray hatchery fish in the NSEI Subregion in all four years of the study (Table 1; Piston and Heinl 2012). Stray proportions for individual streams in the inlet were all less than 5%. Many of the largest producers of summer chum salmon in Southeast Alaska are found within Tenakee Inlet, including eight of the 63 index streams in the NSEI Subregion (Heinl et al. 2004). Index streams in upper Tenakee Inlet are among the farthest index streams from release sites in the NSEI Subregion. The mouth of Tenakee Inlet is approximately 60 km from the nearest hatchery release site and the index streams are all 80–130 km from the nearest release site. Throughout the remainder of the NSEI Subregion, hatchery stray proportions for individual streams were typically in the 3–20% range, with the highest proportions in streams on the southern half of Admiralty Island, particularly in 2010. The Wilson River, southwest Admiralty Island, had the highest proportions of stray hatchery fish of any sampled index stream away from Lynn Canal and the Juneau area (45.9% in 2010, 25.0% in 2011).

We estimate that hatchery chum salmon represented approximately 9.8% of the overall NSEI escapement index in 2011. The overall proportion was less than the 2010 estimate of 13.5% for the subregion, and the difference between the two proportions was statistically significant (Table 2; Piston and Heinl 2012). The difference in the proportion of hatchery fish between 2010 and 2011 was partly explained by the weak 2011 run of NSRAA hatchery chum salmon at Hidden Falls, the primary source of hatchery chum salmon in the Chatham Strait corridor.

Despite similar releases of approximately 85 million hatchery chum salmon for the associated brood years, the total run of chum salmon to Hidden Falls was estimated to be only 371,000 fish in 2011, versus 994,000 in 2010 (White 2011; Vercessi 2012). The total harvest of chum salmon in the Hidden Falls terminal harvest area in 2011 was approximately 25% of the 2001–2010 average. Only 18 stray hatchery fish originating from releases in the Hidden Falls terminal area (Takatz and Kasnyku bays, Figure 3) were recovered in 2011, versus 121 stray hatchery fish from those release sites recovered from a similar sample of NSEI index streams in 2010. The proportions of hatchery fish in three streams close to the Chatham Strait corridor, near Hidden Falls, were all lower in 2011 than in 2010 (Table 2).

INFLUENCE OF HATCHERY FISH ON ESCAPEMENT GOALS FOR WILD CHUM SALMON

The current NSEI escapement goal would not have been met in 2011 if not for the presence of stray hatchery fish (Figure 7). Approximately 26% of the NSEI Subregion index value in 2011 originated from six index streams in Lynn Canal, including a record peak aerial survey count at the Endicott River that accounted for nearly 20% of the overall index. The Endicott River is located almost directly across Lynn Canal from Sawmill Creek where the proportion of hatchery strays was 66% in 2011. The Endicott River was not sampled in 2011 and it is not known if the record escapement to this system represented a strong wild chum salmon run, large numbers of stray hatchery fish, or both. This result exemplifies some of the questions regarding stray hatchery fish: whether or not to adjust escapement goals to account for stray hatchery fish, how exactly escapement goals or indices would be adjusted, and what effect stray hatchery fish have on the productivity of wild chum salmon populations?

Modification of summer chum salmon escapement indices to account for the proportions of hatchery strays observed during our studies would result in little or no change to current escapement goals due to the method used to establish goals. The current Southeast Alaska chum salmon escapement goals were based on a simple percentile approach (Bue and Hasbrouck Unpublished [2]) used extensively in Alaska (Munro and Volk 2011) to set sustainable goals when data were insufficient to establish goals based on estimates of escapement and recruitment. Summer chum salmon goals were set at the 25th percentile of historic escapement indices, 1960–2007 (Piston and Heinl 2011). The NSEI Subregion goal would remain unchanged if we reduced the index to account for 10% (or even 15%) hatchery strays since 1990 (when hatchery production of chum salmon reached high levels), because of the long time series and the fact that most index values are either below or well above the 25th percentile of the time series (Figure 7). The NSEI Subregion goal would be lowered only slightly (by 1,000 index fish) if we reduced the index to account for 20% hatchery strays. Similarly, the NSEO and SSE subregion escapement goals would remain virtually unchanged if indices were modified to account for the low proportions (<5%) of hatchery strays generally found in index streams in those subregions (Piston and Heinl 2012). Fine tuning escapement goals to account for proportions of stray hatchery fish less than 5% would be meaningless given the variability in the indices, the high degree of variation in observer counting rates, and the uncertainty inherent in aerial survey estimates (Bevan 1961; Jones et al. 1998).

---

[2] Bue, B. G., and J. J. Hasbrouck. *Unpublished*. Escapement goal review of salmon stocks of Upper Cook Inlet. Alaska Department of Fish and Game, Report to the Alaska Board of Fisheries, November 2001 (and February 2002), Anchorage.

If sufficient data were available to conduct a more rigorous escapement goal analysis based on stock-recruit methods, the presence of stray hatchery fish would complicate the analysis due to uncertainties regarding the reproductive success of stray hatchery chum salmon. A study in Prince William Sound that compared pre-hatchery and contemporary genetic population structure of four chum salmon populations showed that introgression between wild and hatchery fish has occurred (Chris Habicht, Fishery Geneticist, ADF&G, Anchorage, personal communication). These results suggest that some level of spawning success likely occurs for stray hatchery chum salmon in Southeast Alaska. The majority of studies showing reductions in fitness due to interbreeding of hatchery and wild salmon have been with species that spend a year or more in fresh water, such as steelhead (*O. mykiss*), coho (*O. kisutch*), and Chinook (*O. tshawytscha*) salmon (Chilcote et al. 2011; Naish et al. 2008). Tallman and Healey (1994) found that the gene flow among three wild populations of chum salmon in two streams on Vancouver Island was substantially lower than expected based on the observed rates of straying, which suggested that the stray chum salmon had lower reproductive success than fish returning to their natal streams. Berejikian et al. (2009) did not find a significant difference in the relative reproductive success between hatchery and natural origin Hood Canal summer chum salmon in an experimental spawning channel; however, their experiment had low statistical power to detect such differences. Currently, it is not known whether or not stray hatchery chum salmon successfully spawn with their wild counterparts in Southeast Alaska, and, if so, how their productivity compares to wild salmon.

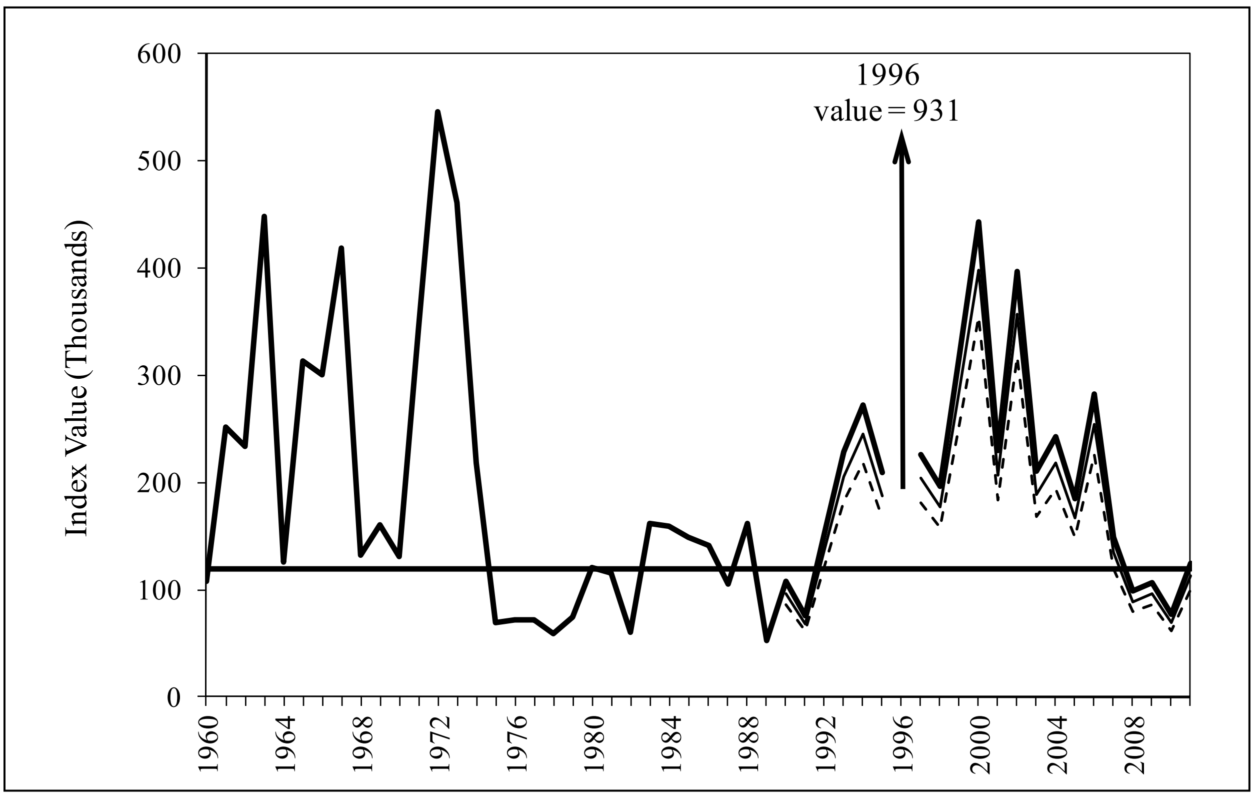

Figure 7.–The Northern Southeast Inside Subregion summer chum salmon escapement index, 1960–2011. The horizontal black line represents the current lower-bound sustainable escapement goal of 119,000 fish, which is based on the 25th percentile of annual escapement indices, 1960–2007. The thin black line shows the index of wild fish assuming 10% of the index was composed of hatchery fish since 1990, and the dashed line is based on an assumption of 20% hatchery strays in those years.

Additional sampling would clarify the range of variation in the proportions of stray hatchery fish in wild stock index streams and would be necessary to document the effects of increased hatchery production on straying in Southeast Alaska. Incremental increases in permitted capacity, maximization of current permitted capacity, and the development of new release sites may result in additional hatchery strays and changes to the distribution of hatchery strays in the region. Studies are also needed to clarify the genetic stock structure of chum salmon in Southeast Alaska, determine if hatchery strays effectively spawn with wild fish and, if so, the consequences of that interaction on the genetic structure and productivity of wild stocks. ADF&G is currently working with the University of Alaska, private non-profit aquaculture corporations, and the National Marine Fisheries Service to develop research projects to assess impacts of large-scale chum salmon enhancement on wild stocks.

ACKNOWLEDGEMENTS

We would like to thank the following individuals for their significant contributions to this study. Bev Agler, Lorna Wilson, Megan Lovejoy, and the rest of the staff at ADF&G's Commercial Fisheries Tag, Mark, and Age Laboratory decoded all of the otoliths and provided insights into the challenges involved with reading the numerous and variable marks applied to chum salmon in Southeast Alaska. The collection of otoliths in the field would not have been possible without the efforts of Nick Olmstead, Molly Kemp, Malika Brunette, Eric Parker, Jess Coltharp, Julie Bednarski, Scott Hinton, Bess Ranger, John Livermore, and Randy Bachman. Kim Vicchy provided administrative support for the project. Sherri Dressel and Haixue Shen provided biometric review for the study. Zachary Liller provided an extensive review that improved the final report.

REFERENCES CITED

Araki, H., and C. Schmid. 2010. Is hatchery stocking a help or harm? Evidence, limitations and future directions in ecological and genetic surveys. Aquaculture 308:S2-S11.

Berejikian, B. A, D. M. Van Doornik, J. A. Scheurer, and R. Bush. Reproductive behavior and relative reproductive success of natural- and hatchery-origin Hood Canal summer chum salmon. Canadian Journal of Fisheries and Aquatic Sciences 66:781–789.

Bevan, D. E. 1961. Variability in aerial counts of spawning salmon. Journal of the Fisheries Research Board of Canada 18:337–348.

Byerly, M., B. Brooks, B. Simonson, H. Savikko, and H. J. Geiger. 1999. Alaska commercial salmon catches, 1878–1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 5J99-05, Juneau.

Clark, J. H., A. McGregor, R. D. Mecum, P. Krasnowski, and A. M. Carroll. 2006. The commercial salmon fishery in Alaska. Alaska Fishery Research Bulletin 12:1–146.

Chilcote, M. W., K. W. Goodson, and M. R. Falcy. 2011. Reduced recruitment performance in natural populations of anadromous salmonids associated with hatchery-reared fish. Canadian Journal of Fisheries and Aquatic Sciences 68:511–522.

Cochran, W. G. 1977. Sampling techniques, 3rd Ed. John Wiley and Sons, New York.

Davis, B., B. Allee, D. Amend, B. Bachen, B. Davidson, T. Gharrett, S. Marshall, and A. Wertheimer. 1985. Alaska Department of Fish and Game Genetic Policy. Alaska Department of Fish and Game, Fisheries Rehabilitation, Enhancement, and Development Division, Special Report, Juneau.

Eggers, D. M., and S. C. Heinl. 2008. Chum salmon stock status and escapement goals in Southeast Alaska. Alaska Department of Fish and Game, Special Publication No. 08-19, Anchorage.

REFERENCES CITED (Continued)

Hagen, P, K. Munk, B. Van Alen, and B. White. 1995. Thermal mark technology for inseason fisheries management: a case study. Alaska Fishery Research Bulletin 2(2):143–155.

Heinl, S. C., T. P. Zadina, A. J. McGregor, and H. J. Geiger. 2004. Chum salmon stock status and escapement goals in Southeast Alaska [in] H. J. Geiger, and S. McPherson, editors. Stock status and escapement goals for salmon stocks in Southeast Alaska. Alaska Department of Fish and Game, Special Publication No. 04-02, Anchorage.

Jensen, K. A., and P. A. Milligan. 2001. Use of thermal mark technology for the in-season management of transboundary river sockeye fisheries. N. Pac. Anadr. Fish Comm. Tech. Rep. No. 3:37–38.

Jones, E. L., III, T. J. Quinn, and B. W. Van Alen. 1998. Observer accuracy and precision in aerial and foot survey counts of pink salmon in a Southeast Alaska stream. North American Journal of Fisheries Management 18:832–846.

Josephson, R. P. 2010. Observations of the distribution of hatchery chum salmon in Southeast Alaska, 1980–2006. Alaska Department of Fish and Game, Regional Information Report No. 5J10-07, Juneau.

Joyce, T. L., and D. G. Evans. 2000. Otolith marking of pink salmon in Prince William Sound Salmon Hatcheries. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 99188). Alaska Department of Fish and Game, Cordova.

Mattson, C. R., and R. G. Rowland. 1963. Chum salmon studies at Traitors Cove field station June 1960 to March 1963. Manuscript Report, Department of the Interior, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Biological Laboratory, Auke Bay, Alaska.

McDaniel, T. R., K. M. Pratt, T. R. Meyers, T. D. Ellison, J. E. Follett, and J. A. Burke. 1994. Alaska Sockeye Culture Manual. Special Publication No. 6, Alaska Dept. Fish and Game, Juneau.

Meyers, T. R. 2000. Fish Pathology Section Laboratory Manual. 2nd edition, Alaska Department of Fish and Game, Special Publication No. 12, Juneau.

Meyers, T. 2010. Regulation changes, policies and guidelines for Alaska fish and shellfish health and disease control. Alaska Department of Fish and Game, Regional Information Report No. 5J10-01, Juneau.

Morisette, J. T., and S. Khorram. 1998. Exact binomial confidence interval for proportions. Photogrammetric Engineering and Remote Sensing 64:281–283.

Munk, K. M., W. W. Smoker, D. R. Beard, and R. W. Mattson. 1993. A hatchery water-heating system and its application to 100% thermal marking of incubating salmon. Progressive Fish-Culturist 55:284–288.

Munro, A. R., and E. C. Volk. 2011. Summary of Pacific salmon escapement goals in Alaska with a review of escapements from 2002 to 2010. Alaska Department of Fish and Game, Fishery Manuscript Series No. 11-06, Anchorage.

Myers, R. A., S. A. Levin, R. Lande, F. C. James, W. W. Murdoch, and R. T. Paine. 2004. Hatcheries and endangered salmon. Science 303:1980.

Naish, K. A., J. E. Taylor III, P. S. Levin, T. P Quinn, J. R. Winton, D. Huppert, and R. Hilborn. 2008. An evaluation of the effects of conservation and fishery enhancement hatcheries on wild populations of salmon. Advances in Marine Biology 53:61–194.

Piston, A. W., and S. C. Heinl. 2012. Hatchery chum salmon straying studies in Southeast Alaska, 2008–2010. Alaska Department of Fish and Game, Fishery Manuscript Series No. 12-01, Anchorage.

Piston, A. W., and M. T. Brunette. 2011. Disappearance Creek chum salmon weir study, 2010. Alaska Department of Fish and Game, Fishery Data Series No. 11-09, Anchorage.

Piston, A. W., and S. C. Heinl. 2011. Chum salmon stock status and escapement goals in Southeast Alaska. Alaska Department of Fish and Game, Special Publication No.11-21, Anchorage.

Piston, A. W., and S. C. Heinl. 2010a. Disappearance Creek chum salmon weir study, 2008. Alaska Department of Fish and Game, Fishery Data Series No. 10-15, Anchorage.

REFERENCES CITED (Continued)

Piston, A. W., and S. C. Heinl. 2010b. Disappearance Creek chum salmon weir study, 2009. Alaska Department of Fish and Game, Fishery Data Series No. 10-48, Anchorage.

Tallman, R. F., and M. C. Healey. 1994. Homing, straying, and gene flow among seasonally separated populations of chum salmon. Canadian Journal of Fisheries and Aquatic Sciences 51:577–588.

Thompson, S. K. 1992. Sampling. Wiley-Interscience, New York.

Van Alen, B. W. 2000. Status and stewardship of salmon stocks in Southeast Alaska. Pages 161–194 [*In*] E. E Knudsen, C. R. Steward, D. D. McDonald, J. E. Williams, and D. W. Reiser, editors. Sustainable Fisheries Management: Pacific salmon. CRC Press. Boca Raton, Florida.

Vercessi, L. 2012. Alaska salmon fisheries enhancement program 2011 annual report. Alaska Department of Fish and Game, Fishery Management Report No. 12–04, Anchorage.

Waples, R. S. 1999. Dispelling some myths about hatcheries. Fisheries 24:2.

White, B. 2011. Alaska salmon fisheries enhancement program 2010 annual report. Alaska Department of Fish and Game, Fishery Management Report No. 11–04, Anchorage.

Zar, J. H. 2010. Biostatistical Analysis. Pearson Prentice Hall, Upper Saddle River, New Jersey.

APPENDICES

Appendix A1.–Northern Southeast Inside Subregion Index Streams.

Stream Name	Anadromous Stream Number	SurveyType	Sampled for Stray Hatchery Fish, 2011
North Arm Creek	108-40-10150-2007	Foot	Yes
Tyee Head East	109-30-10160	Aerial	No
Saginaw Bay S Head	109-44-10370	Aerial	No
Saginaw Creek	109-44-10390	Aerial	Yes
Lookout Point Cr Sec B	109-45-10170	Aerial	No
Rowan Creek	109-52-10060	Aerial	No
Sample Creek	109-62-10140	Aerial	Yes
Petrof Bay W Head	109-62-10240	Aerial	No
Dry Bay Creek	110-13-10040	Foot	No
Amber Creek - N Arm Pybus	110-22-10040	Aerial	Yes
Donkey Creek	110-22-10100	Aerial	No
Cannery Cove - Pybus Bay	110-22-10140	Aerial	No
Johnston Creek	110-23-10100	Aerial	No
Bowman Creek	110-23-10150	Aerial	No
Snug Cove - Gambier Bay	110-23-10190	Aerial	Yes
East of Snug Cove	110-23-10400	Aerial	No
Chuck River - Windham Bay	110-32-10090	Aerial	No
Lauras Creek	110-33-10130	Aerial	Yes
Glen Creek	110-34-10060	Aerial	No
Sanborn Creek	110-34-10080	Aerial	Yes
Mole River	111-13-10100	Aerial	Yes
Windfall Harbor W Side	111-15-10240	Aerial	No
Pack Creek	111-15-10300	Aerial	No
Swan Cove Creek	111-16-10450	Aerial	No
King Salmon River	111-17-10100	Aerial	No
Prospect Creek - Speel	111-33-10100	Aerial	No
Admiralty Creek	111-41-10050	Aerial	Yes
Fish Creek-Douglas I	111-50-10690	Foot	No
Robinson Creek	112-15-10620	Aerial	No
Wilson River	112-19-10100	Aerial	Yes
Clear River - Kelp Bay	112-21-10050	Aerial	No
Ralphs Creek	112-21-10060	Aerial	No
Kadashan Creek	112-42-10250	Aerial	No
Saltery Bay Head	112-44-10100	Aerial	No
Seal Bay Head	112-46-10070	Aerial	Yes
Long Bay Head	112-47-10100	Aerial	No
Big Goose Creek	112-48-10150	Aerial	No

-continued-

Appendix A1.–Page 2 of 2.

Stream Name	Anadromous Stream Number	SurveyType	Sampled for Stray Hatchery Fish, 2011
Little Goose Creek	112-48-10190	Aerial	No
West Bay Head Creek	112-48-10230	Aerial	No
Tenakee Inlet Head	112-48-10350	Aerial	Yes
Kennel Creek	112-50-10250	Aerial	No
Freshwater Creek	112-50-10300-2001	Aerial	No
Greens Creek	112-65-10240	Aerial	No
Weir Creek N Arm Hood Bay	112-72-10110	Aerial	Yes
Weir Creek S Arm Hood Bay	112-73-10240	Aerial	No
Chaik Bay Creek	112-80-10280	Aerial	No
Whitewater Creek	112-90-10140	Aerial	No
Saook Bay West Head	113-53-10030	Aerial	Yes
Rodman Creek	113-54-10070	Aerial	No
Ushk Bay W End	113-56-10030	Aerial	No
Mud Bay River	114-23-10700	Aerial	No
Homeshore Creek	114-25-10100	Aerial	No
Spasski Creek	114-27-10300	Aerial	No
Game Creek	114-31-10130	Aerial	Yes
Seagull Creek	114-32-10040	Aerial	No
Neka River	114-33-10230	Aerial	No
Humpback Creek	114-34-10100	Aerial	No
Trail River	114-40-10350	Aerial	No
St James Bay NW Side	115-10-10420	Aerial	No
St. James River	115-10-10460	Aerial	No
Endicott River	115-10-10800	Aerial	No
Berners River	115-20-10100	Aerial	No
Sawmill Creek - Berners River	115-20-10520	Aerial	Yes

Appendix B1.–Straying study results for the Northern Southeast Inside Subregion, 2008–2011.

Date Collected	Stream	Anadromous Stream Number	Sample Size	Unmarked	Marked	% Hatchery Fish	SE of Proportion	80% CI Lower	80% CI Upper	Distance from Nearest Release Site (km)	Within 50 km of Unmarked Hatchery Releases
8/8/2011	North Arm Creek	108-40-10150-2007	94	87	7	7.4%					
8/18/2011	North Arm Creek	108-40-10150-2007	55	49	6	10.9%					
	Total		149	136	13	8.7%	2.3%	5.9%	12.5%	59	No
8/12/2010	Saginaw Creek	109-44-10390	25	18	7	28.0%					
8/26/2010	Saginaw Creek	109-44-10390	32	29	3	9.4%					
	Total		57	47	10	17.5%	5.1%	11.2%	25.7%	27	Yes
8/11/2011	Saginaw Creek	109-44-10390	17	17	0	0.0%				27	Yes
8/27/2010	Rowan Creek	109-52-10060	26	25	1	3.8%				52	No
8/13/2010	Sample Creek	109-62-10140	130	119	11	8.5%					
8/25/2010	Sample Creek	109-62-10140	94	91	3	3.2%					
	Total		224	210	14	6.3%	1.6%	4.3%	8.9%	45	No
8/7/2011	Sample Creek	109-62-10140	92	91	1	1.1%					
8/17/2011	Sample Creek	109-62-10140	96	96	0	0.0%					
	Total		188	187	1	0.5%	0.5%	0.1%	2.1%	45	No
8/28/2010	Dry Bay Creek	110-13-10040	146	127	19	13.0%	2.8%	9.5%	17.3%	110	No
8/18/2011	Amber Creek	110-22-10040	64	60	4	6.3%					
8/26/2011	Amber Creek	110-22-10040	24	23	1	4.2%					
	Total		88	82	5	5.7%	2.5%	2.8%	10.3%	54	No
8/13/2010	Cannery Cove-Pybus Bay	110-22-10140	47	37	10	21.3%					
8/27/2010	Cannery Cove-Pybus Bay	110-22-10140	167	139	28	16.8%					
	Total		214	176	38	17.8%	2.6%	14.4%	21.6%	79	Yes
8/12/2010	Snug Cove-Gambier Bay	110-23-10190	77	69	8	10.4%					
8/25/2010	Snug Cove-Gambier Bay	110-23-10190	61	55	6	9.8%					
	Total		138	124	14	10.1%	2.6%	7.0%	14.3%	72	No
8/10/2011	Snug Cove-Gambier Bay	110-23-10190	47	44	3	6.4%					
8/23/2011	Snug Cove-Gambier Bay	110-23-10190	2	2	0	0.0%					
	Total		49	46	3	6.1%				72	No
8/9/2011	Laura’s Creek	110-33-10130	127	125	2	1.6%					
8/19/2011	Laura’s Creek	110-33-10130	81	81	0	0.0%					
	Total		208	206	2	1.0%	0.7%	0.3%	2.5%	78	No
8/14/2010	Glen Creek	110-34-10060	50	46	4	8.0%	3.9%	3.5%	15.4%	104	No
8/10/2011	Sanborn Creek	110-34-10080	191	188	3	1.6%	0.9%	0.6%	3.5%	83	No
8/16/2009	Mole River	111-13-10100	12	9	3	25.0%				74	No
8/11/2010	Mole River	111-13-10100	44	37	7	15.9%				74	No
8/4/2011	Mole River	111-13-10100	48	41	7	14.6%					
8/11/2011	Mole River	111-13-10100	73	67	6	8.2%					
	Total		121	108	13	10.7%	2.8%	7.2%	15.3%	74	No

-continued-

Appendix B1.–Page 2 of 4.

Date Collected	Stream	Anadromous Stream Number	Sample Size	Unmarked	Marked	% Hatchery Fish	SE of Proportion	80% CI Lower	80% CI Upper	Distance from Nearest Release Site (km)	Within 50 km of Unmarked Hatchery Releases
8/12/2009	Swan Cove Creek	111-16-10450	10	8	2	20.0%				112	No
7/29/2010	Swan Cove Creek	111-16-10450	94	89	5	5.3%					
8/5/2010	Swan Cove Creek	111-16-10450	95	83	12	12.6%					
	Total		189	172	17	9.0%	2.1%	6.4%	12.3%	112	No
7/30/2010	Prospect Creek	111-33-10100	27	19	8	29.6%					
8/13/2010	Prospect Creek	111-33-10100	125	105	20	16.0%					
	Total		152	124	28	18.4%	3.2%	14.4%	23.1%	22	No
8/12/2009	Admiralty Creek	111-41-10050	96	57	39	40.6%					
8/17/2009	Admiralty Creek	111-41-10050	21	12	9	42.9%					
	Total		117	69	48	41.0%	4.6%	34.9%	47.4%	30	No
8/6/2010	Admiralty Creek	111-41-10050	66	54	12	18.2%					
8/20/2010	Admiralty Creek	111-41-10050	47	45	2	4.3%					
	Total		113	99	14	12.4%	3.1%	8.5%	17.3%	30	No
7/28/2011	Admiralty Creek	111-41-10050	94	80	14	14.9%					
8/5/2011	Admiralty Creek	111-41-10050	96	89	7	7.3%					
	Total		190	169	21	11.1%	2.3%	8.2%	14.5%	30	No
7/23/2009	Fish Creek-Douglas Island	111-50-10690	96	14	82	85.4%					
8/6/2009	Fish Creek-Douglas Island	111-50-10690	96	10	86	89.6%					
	Total		192	24	168	87.5%	2.4%	83.9%	90.5%	15	No
7/28/2010	Fish Creek-Douglas Island	111-50-10690	94	28	66	70.2%	4.7%	63.3%	76.4%	15	No
8/11/2009	Robinson Creek	112-15-10620	82	68	14	17.1%	4.2%	11.8%	23.6%	22	No
8/16/2010	Wilson River	112-19-10100	122	66	56	45.9%	4.5%	39.8%	52.1%	16	No
8/14/2011	Wilson River	112-19-10100	54	40	14	25.9%					
8/30/2011	Wilson River	112-19-10100	6	5	1	16.7%					
	Total		60	45	15	25.0%	5.6%	17.7%	33.6%	16	No
7/21/2008	Ralphs Creek	112-21-10060	94	89	5	5.3%					
7/30/2008	Ralphs Creek	112-21-10060	95	94	1	1.1%					
	Total		189	183	6	3.2%	1.3%	1.7%	5.5%	22	No
7/24/2009	Ralphs Creek	112-21-10060	93	84	9	10.1%	3.1%	5.9%	14.8%	22	No
7/26/2010	Ralphs Creek	112-21-10060	95	90	5	5.3%	2.3%	2.6%	9.5%	22	No
8/15/2009	Kadashan Creek	112-42-10250	12	12	0	0.0%					
8/28/2009	Kadashan Creek	112-42-10250	1	1	0	0.0%					
	Total		13	13	0	0.0%				85	No
9/1/2010	Kadashan Creek	112-42-10250	12	10	2	16.7%				85	No
8/21/2008	Saltery Bay Creek	112-44-10100	26	25	1	3.8%				95	No

-continued-

Appendix B1.–Page 3 of 4.

Date Collected	Stream	Anadromous Stream Number	Sample Size	Unmarked	Marked	% Hatchery Fish	SE of Proportion	80% CI Lower	80% CI Upper	Distance from Nearest Release Site (km)	Within 50 km of Unmarked Hatchery Releases
8/6/2008	Seal Bay Head	112-46-10070	95	95	0	0.0%					
8/11/2008	Seal Bay Head	112-46-10070	93	93	0	0.0%					
	Total		188	188	0	0.0%	0.0%	0.0%	1.2%	105	No
8/8/2009	Seal Bay Head	112-46-10070	90	86	4	4.4%					
8/20/2009	Seal Bay Head	112-46-10070	92	91	1	1.1%					
	Total		182	177	5	2.7%	1.2%	1.3%	5.0%	105	No
8/9/2010	Seal Bay Head	112-46-10070	95	94	1	1.1%					
8/26/2010	Seal Bay Head	112-46-10070	93	89	4	4.3%					
	Total		188	183	5	2.7%	1.2%	1.3%	4.9%	105	No
8/11/2011	Seal Bay Head	112-46-10070	96	95	1	1.0%					
8/17/2011	Seal Bay Head	112-46-10070	43	43	0	0.0%					
8/25/2011	Seal Bay Head	112-46-10070	37	35	2	5.4%					
	Total		176	174	2	1.7%	1.0%	0.6%	3.8%	105	No
7/29/2008	Long Bay Head	112-47-10100	44	44	0	0.0%					
8/3/2008	Long Bay Head	112-47-10100	96	95	1	1.0%					
	Total		140	139	1	0.7%	0.7%	0.1%	2.7%	109	No
7/28/2008	Big Goose Creek	112-48-10150	37	37	0	0.0%					
8/4/2008	Big Goose Creek	112-48-10150	40	40	0	0.0%					
8/15/2008	Big Goose Creek	112-48-10150	95	95	0	0.0%					
	Total		172	172	0	0.0%	0.0%	0.0%	1.3%	120	No
8/3/2008	Tenakee Inlet Head	112-48-10350	2	2	0	0.0%					
8/20/2008	Tenakee Inlet Head	112-48-10350	96	95	1	1.0%					
8/20/2008	Tenakee Inlet Head	112-48-10350	48	48	0	0.0%					
	Total		146	145	1	0.7%	0.7%	0.1%	2.6%	127	No
8/12/2011	Tenakee Inlet Head	112-48-10350	75	75	0	0.0%					
8/27/2011	Tenakee Inlet Head	112-48-10350	64	64	0	0.0%					
	Total		139	139	0	0.0%	0.0%	0.0%	1.6%	127	No
8/19/2008	Kennel Creek	112-50-10250	2	2	0	0.0%				85	No
8/5/2009	Kennel Creek	112-50-10250	11	11	0	0.0%				85	No
8/19/2008	Freshwater Creek	112-50-10300-2001	5	5	0	0.0%				83	No
8/23/2010	Freshwater Creek	112-50-10300-2001	95	84	11	11.6%	3.3%	7.5%	17.0%	83	No
8/17/2010	Weir Creek N Arm Hood Bay	112-72-10110	1	1	0	0.0%					
8/31/2010	Weir Creek N Arm Hood Bay	112-72-10110	20	19	1	5.0%					
	Total		21	20	1	4.8%				44	No
8/16/2011	Weir Creek N Arm Hood Bay	112-72-10110	37	36	1	2.7%					
8/29/2011	Weir Creek N Arm Hood Bay	112-72-10110	25	24	1	4.0%					
	Total		62	60	2	3.2%	2.3%	0.9%	8.4%	43	No

-continued-

Appendix B1.–Page 4 of 4.

Date Collected	Stream	Anadromous Stream Number	Sample Size	Unmarked	Marked	% Hatchery Fish	SE of Proportion	80% CI Lower	80% CI Upper	Distance from Nearest Release Site (km)	Within 50 km of Unmarked Hatchery Releases
8/9/2009	Chaik Creek	112-80-10280	1	1	0	0.0%					
8/19/2009	Chaik Creek	112-80-10280	10	7	3	30.0%					
	Total		11	8	3	27.3%				25	No
8/18/2010	Chaik Creek	112-80-10280	11	11	0	0.0%					
8/30/2010	Chaik Creek	112-80-10280	154	145	9	5.8%					
	Total		165	156	9	5.5%	1.8%	3.3%	8.5%	25	No
7/3/2010	Saook Bay West Head	113-53-10030	93	84	9	9.7%	3.1%	5.9%	14.8%	38	No
7/26/2011	Saook Bay West Head	113-53-10030	50	49	1	2.0%					
8/9/2011	Saook Bay West Head	113-53-10030	96	96	0	0.0%					
	Total		146	145	1	0.7%	0.7%	0.1%	2.6%	38	No
8/6/2009	Game Creek	114-31-10130	8	7	1	12.5%					
8/24/2009	Game Creek	114-31-10130	109	105	4	3.7%					
	Total		117	112	5	4.3%	1.9%	2.1%	7.8%	70	No
7/29/2011	Game Creek	114-31-10130	40	40	0	0.0%					
8/26/2011	Game Creek	114-31-10130	23	23	0	0.0%					
	Total		63	63	0	0.0%	0.0%	0.0%	3.6%	70	No
8/13/2009	St. James Bay NW Side	115-10-10420	94	79	15	16.0%	3.8%	11.2%	21.9%	15	No
7/31/2009	Sawmill Creek	115-20-10520	149	33	116	77.9%	3.4%	72.9%	82.2%	14	No
8/2/2010	Sawmill Creek	115-20-10520	38	20	18	47.4%					
8/11/2010	Sawmill Creek	115-20-10520	25	10	15	60.0%					
8/16/2010	Sawmill Creek	115-20-10520	20	14	6	30.0%					
	Total		83	44	39	47.0%	5.5%	39.5%	54.6%	14	No
7/20/2011	Sawmill Creek	115-20-10520	23	18	5	21.7%					
8/12/2011	Sawmill Creek	115-20-10520	186	54	132	71.0%					
	Total		209	72	137	65.6%	3.3%	61.0%	69.9%%	14	No

Appendix B2.–Straying study results for the Southern Southeast Subregion, 2008–2010.

Date Collected	Stream	Anadromous Stream Number	Index Stream	Sample Size	Unmarked	Marked	% Hatchery Fish	SE of Proportion	80% CI Lower	80% CI Upper	Distance from Nearest Release Site (km)	Within 50 km of Unmarked Hatchery Releases
8/13/2009	Hidden Inlet	101-11-01010	Yes	74	69	5	6.8%	2.9%	3.3%	12.2%	60	No
7/27/2009	Fish Creek-Portland Canal	101-15-10500-2028	Yes	2	2	0	0.0%					
8/26/2009	Fish Creek-Portland Canal	101-15-10500-2028	Yes	118	117	1	0.8%					
	Total			120	119	1	0.8%	0.8%	0.1%	3.2%	182	No
8/6/2009	Marten River	101-30-10600	Yes	23	22	1	4.3%					
8/10/2009	Marten River	101-30-10600	Yes	27	27	0	0.0%					
8/18/2009	Marten River	101-30-10600	Yes	29	29	0	0.0%					
8/26/2009	Marten River	101-30-10600	Yes	8	8	0	0.0%					
	Total			87	86	1	1.1%	1.1%	0.1%	4.4%	104	No
8/9/2010	Marten River	101-30-10600	Yes	41	40	1	2.4%					
8/22/2010	Marten River	101-30-10600	Yes	23	23	0	0.0%					
	Total			64	63	1	1.6%	1.6%	0.2%	5.9%	104	No
9/4/2008	Carroll River	101-45-10780	Yes	190	190	0	0.0%	0.0%	0.0%	1.2%	107	No
8/11/2009	Carroll River	101-45-10780	Yes	109	103	6	5.5%					
9/2/2009	Carroll River	101-45-10780	Yes	93	93	0	0.0%					
	Total			202	196	6	3.0%	1.2%	1.6%	5.2%	107	No
8/4/2010	Ketchikan Creek	101-47-10250	No	95	26	69	72.6%					
8/13/2010	Ketchikan Creek	101-47-10250	No	93	38	55	59.1%					
	Total			188	64	124	66.0%	3.5%	61.2%	70.5%	38	Yes
8/21/2010	Harris River	102-60-10820	No	37	37	0	0.0%					
8/26/2010	Harris River	102-60-10820	No	47	46	1	2.1%					
	Total			84	83	1	1.2%	1.2%	0.1%	4.6%	107	No
8/22/2010	Staney Creek	103-90-10310	No	29	27	2	6.9%					
9/2/2010	Staney Creek	103-90-10310	No	31	31	0	0.0%					
	Total			60	58	2	3.3%	2.3%	0.9%	8.6%	114	No
8/9/2010	Harding River	107-40-10490	Yes	96	91	5	5.2%					
9/3/2010	Harding River	107-40-10490	Yes	92	87	5	5.4%					
	Total			188	178	10	5.3%	1.6%	3.3%	8.1%	62	No

Appendix B3.–Straying study results for the Northern Southeast Outside Subregion, 2008–2010.

Date Collected	Stream	Anadromous Stream Number	Index Stream	Sample Size	Unmarked	Marked	Expanded Marked	% Hatchery Fish	SE of Proportion	80% CI Lower	80% CI Upper	Distance from Nearest Release Site (km)	Within 50 km of Unmarked Hatchery Releases
8/9/2010	Whale Bay Great Arm Head	113-22-10150	Yes	95	93	2		2.1%	1.5%	0.6%	5.5%	85	No
8/12/2008	West Crawfish NE Arm Head	113-32-10050	Yes	96	95	1	1	1.0%					
8/18/2008	West Crawfish NE Arm Head	113-32-10050	Yes	96	94	2	7	7.3%					
	Total			192	189	3	8	4.2%	1.4%	2.4%	6.7%	54	No
8/9/2009	West Crawfish NE Arm Head	113-32-10050	Yes	96	96	0		0.0%	0.0%	0.0%	2.4%	54	No
9/4/2009	Camp Coogan	113-41-10340	No	94	90	4	5.5	5.9%	2.4%	3.0%	10.3%	10	Yes
8/20/2008	Sisters Lake SE Arm Head	113-72-10040-2025	Yes	96	96	0		0.0%					
8/24/2008	Sisters Lake SE Arm Head	113-72-10040-2025	Yes	96	95	1		1.0%					
	Total			192	191	1		0.5%	0.5%	0.1%	2.0%	102	No
8/17/2008	Lake Stream Ford Arm	113-73-10030-0010	Yes	47	45	2		4.3%					
8/26/2008	Lake Stream Ford Arm	113-73-10030-0010	Yes	46	46	0		0.0%					
9/9/2008	Lake Stream Ford Arm	113-73-10030-0010	Yes	43	43	0		0.0%					
9/16/2008	Lake Stream Ford Arm	113-73-10030-0010	Yes	12	12	0		0.0%					
9/22/2008	Lake Stream Ford Arm	113-73-10030-0010	Yes	36	36	0		0.0%					
	Total			184	182	2		1.1%	0.8%	0.3%	2.9%	127	No
8/19/2009	Lake Stream Ford Arm	113-73-10030-0010	Yes	28	24	4	6	21.4%					
8/25/2009	Lake Stream Ford Arm	113-73-10030-0010	Yes	41	41	0	0	0.0%					
9/1/2009	Lake Stream Ford Arm	113-73-10030-0010	Yes	89	89	0	0	0.0%					
9/7/2009	Lake Stream Ford Arm	113-73-10030-0010	Yes	90	90	0	0	0.0%					
9/21/2009	Lake Stream Ford Arm	113-73-10030-0010	Yes	21	19	2	2	9.5%					
	Total			269	263	6	8	3.0%	1.0%	1.7%	4.8%	127	No
8/16/2010	Lake Stream Ford Arm	113-73-10030-0010	Yes	51	49	2	3	5.9%					
8/23/2010	Lake Stream Ford Arm	113-73-10030-0010	Yes	90	85	5	27	30.0%					
9/6/2010	Lake Stream Ford Arm	113-73-10030-0010	Yes	52	50	2	2	3.8%					
9/13/2010	Lake Stream Ford Arm	113-73-10030-0010	Yes	93	90	3	16.2	17.4%					
9/20/2010	Lake Stream Ford Arm	113-73-10030-0010	Yes	5	5	0	0	0.0%					
	Total			291	279	12	48.2	16.6%	2.2%	13.8%	19.7%	127	No
7/1/2010	Black River	113-81-10110	Yes	92	92	0		0.0%	0.0%	0.00%	2.5%	129	No