Special Publication No. 12-10

Buskin River Sockeye Salmon Smolt Abundance Assessment, Kodiak, Alaska, 2010–2011

Final Report for Study 10-404

USFWS, Office of Subsistence Management

Fishery Information Service Division

by

Julia S. Schmidt

April 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)

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

SPECIAL PUBLICATION NO. 12-10

BUSKIN RIVER SOCKEYE SALMON SMOLT ABUNDANCE ASSESSMENT, KODIAK, ALASKA, 2010–2011

by
Julia S. Schmidt
Alaska Department of Fish and Game, Division of Sport Fish, Kodiak

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

April 2012

This investigation was partially financed by the U.S. Fish and Wildlife Service, Office of Subsistence Management through the Fisheries Resource Monitoring Program, under agreement number 70181-AJ036.

The Special Publication series was established by the Division of Sport Fish in 1991 for the publication of techniques and procedures manuals, informational pamphlets, special subject reports to decision-making bodies, symposia and workshop proceedings, application software documentation, in-house lectures, and became a joint divisional series in 2004 with the Division of Commercial Fisheries. Special Publications are intended for fishery and other technical professionals. Special Publications are available through the Alaska State Library, Alaska Resources Library and Information Services (ARLIS) and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and internal review.

Julia S. Schmidt
Alaska Department of Fish and Game, Division of Sport Fish
211 Mission Road, Kodiak, AK 99615-6399, USA

This document should be cited as:
Schmidt, J. S. 2012. Buskin River sockeye smolt abundance assessment, Kodiak, 2010–2011. Alaska Department of Fish and Game, Special Publication No. 12-10, Anchorage.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

In 2010, the Alaska Department of Fish and Game, Division of Sport Fish, initiated a 2-year study to evaluate the feasibility of annually estimating the total abundance of sockeye salmon smolt (*Oncorhynchus nerka*) emigrating from the Buskin River drainage in the Kodiak Management Area. This report presents data collected during the 2010 and 2011 study years, in which smolt counts were obtained using floating incline plane and modified Canadian fan trap designs. Total abundance was assessed using census counts, mark–recapture experiments, and genetics-based mixed stock analysis. In 2010, a total of 14,950 sockeye salmon smolt were counted in traps operated at 2 locations on the Buskin River drainage from 28 April to 30 June. Emigration from the Louise-Catherine lakes tributary was estimated to be composed of 2,981 freshwater-age-1 smolt and 6,304 freshwater-age-2 smolt. Estimated smolt emigration and age composition from the Buskin Lake outlet was not determined. At both locations, freshwater-age-2 smolt were most abundant during the first month (17 May–13 June) of the emigration, whereas freshwater-age-1 smolt were predominant from 14 to 29 June. Due to chronic flooding and other operational problems, estimates of total smolt emigration were not obtainable in 2010. Mark–recapture techniques deployed in 2010 were also unsuccessful for estimating Buskin drainage sockeye salmon smolt abundance. In 2011, a total of 87,217 smolt were counted (and an additional 3,361 estimated) in traps operated between 25 April and 30 June. Emigration from the Louise-Catherine lakes tributary was estimated to be composed of 40,706 freshwater-age-1 and 4,870 freshwater-age-2 smolt and freshwater-age-1 was the predominant age class throughout the observed emigration. The 2011 mark–recapture based estimate of Buskin drainage sockeye salmon smolt abundance was 118,377 smolt (SE 5,868). Freshwater-age-1 and freshwater-age-2 smolt emigrating from the Louise-Catherine lakes tributary in 2010 were larger, heavier, and had a better mean condition factor than those emigrating in 2011. Freshwater-age-1 and freshwater-age-2 smolt emigrating from Buskin Lake were smaller in 2010 but had a better condition factor than those observed emigrating in 2011.

Key words: Buskin Lake, Buskin River drainage, age, emigration, enumeration, escapement, Kodiak Island, *Oncorhynchus nerka*, smolt, sockeye salmon, subsistence harvest, inclined plane trap, Canadian fan trap, mark–recapture.

INTRODUCTION

In recent years, adult runs of Buskin River drainage sockeye salmon (*Oncorhynchus nerka*) have fallen well below historical levels of abundance. Escapements failed to reach the sustainable escapement goal (SEG) range of 8,000 to 13,000 fish in 2008 and 2009 (Schmidt and Evans 2010). As a result, during both years, commercial, sport, and subsistence fisheries were closed or otherwise restricted. A weak run in 2010 prompted closure of sport fishing for most of the season. State and Federal subsistence fisheries for Buskin River sockeye salmon were also greatly restricted in 2008, 2009, and 2010. The unprecedented subsistence fishing closures remained in effect through 1 August in 2008, 15 July in 2009, and 29 June in 2010.

Harvests and escapements of adult sockeye salmon returning to the Buskin River have been monitored annually by Alaska Department of Fish and Game (ADF&G) since 1980. Buskin drainage sockeye salmon production is estimated only in terms of adult escapements obtained from a weir on the Buskin River, operated since 1985; and a weir on the Louise-Catherine lakes tributary, operated since 2002. Production, distribution, and relative abundance of sockeye salmon juveniles have not been previously studied. In response to the recent poor runs and associated concerns of local subsistence users, ADF&G received funding in 2009 through the Office of Subsistence Management's Fisheries Resource Monitoring Program to conduct a 2-year (2010–2011) study to assess the feasibility of estimating Buskin River drainage sockeye salmon smolt abundance and emigration timing. This report describes project results from both study years.

OBJECTIVES

The project originally had the following 2 objectives:

1) Estimate the sockeye salmon smolt emigration from Buskin, Louise, and Catherine lakes between 15 April and 30 June in 2010 and 2011.
2) Estimate the age composition of emigrating smolt such that each age class proportion is estimated within 5% of the true values 95% of the time.

The objectives were modified during the course of the project to the following:

1) Census the sockeye salmon smolt emigration through a weir and integrated Canadian fan trap at the Louise-Catherine lakes outlet between 16 April and 30 June in 2010 and 2011.
2) Estimate the age composition of emigrating smolt such that for each of the Buskin Lake and Louise-Catherine lakes drainages, each age class proportion is estimated within 5 percentage points of the true values 95% of the time.
3) Estimate the drainage-wide (Buskin plus Louise-Catherine lakes) sockeye salmon smolt emigration using mark–recapture techniques (dye-based) such that the estimate is within 15% of the true value 95% of the time.
4) Estimate the proportion of smolt of Buskin Lake origin in the emigration downstream of the confluence the Buskin River and the Louise-Catherine drainage using a genetics-based approach such that the estimate is within 5 percentage points of the true value 95% of the time.

TASKS

1) Estimate mean weight and mean length-at-age of smolt during emigration.
2) Estimate the condition factor (Bagenal and Tesch 1978) of smolt by age from the length and weight data.
3) Estimate the Buskin Lake smolt emigration as a product of the dye-based estimate of the total emigration and the genetics-derived estimate of the proportion of Buskin Lake smolt in the total emigration.
4) Estimate total smolt emigration as a mark–recapture estimate based on the Louise-Catherine smolt emigration counted at the weir (first event sample: marks) and the genetics–derived estimate of the number of Louise-Catherine smolt (recaptures) in the downstream trap catch (second event sample).

BACKGROUND

The Buskin River drainage (Figure 1) contains 1 of only 3 native populations of sockeye salmon found on the Kodiak Island road system. The drainage supports the largest subsistence salmon fishery in the Kodiak Archipelago and also within the Kodiak/Aleutian Islands Federal Subsistence Region. The subsistence fishery occurs entirely within the Alaska Maritime National Wildlife Refuge, mostly in nearshore marine waters adjacent to the river mouth. Sockeye salmon, consequently assumed to be of Buskin River origin, typically comprise as much as 82% of the total subsistence salmon harvest, with reported annual harvests ranging from 1,514 to 13,333 fish between 2001 and 2010 (Table 1). Since 2001, the Buskin River subsistence harvest has averaged 50% of the total sockeye salmon subsistence harvest reported for the entire region.

Subsistence harvest effort has ranged from 165 (2010) to 517 (2002) participants during this time period.

The Buskin River is also the most popular recreational fishing stream on Kodiak Island, recently representing approximately 37% of the total freshwater recreational fishing effort in the Kodiak Management Area (Jennings et al. 2004, 2006 a-b, 2007, 2009a-b, 2010a-b, 2011a-b). Recreational fishing effort on the Buskin River is directed primarily toward sockeye salmon and coho salmon (*O. kitsuch*), but some anglers also fish for steelhead and rainbow trout (*O. mykiss*), pink salmon (*O. gorbuscha*), and Dolly Varden (*Salvelinus malma*). From 2001 through 2010, sport harvests of sockeye salmon from the Buskin River ranged from approximately 300 to 3,000 fish and averaged approximately 1,500 fish (Table 1). Sport harvest of sockeye salmon and fishing effort on the Buskin River are estimated by ADF&G, Division of Sport Fish, through the Statewide Harvest Survey (SWHS).

Some commercial harvests of Buskin River sockeye salmon occur in the adjacent marine waters of Chiniak Bay. These harvests are small and do not occur during all years. Fish ticket harvest receipts available from ADF&G, Division of Commercial Fisheries, indicate that between 2001 and 2011, the greatest harvest of Buskin River sockeye salmon was 1,098 fish in 2004 and was less than 45 fish in the other years.

Freshwater production in sockeye salmon systems throughout Alaska has been evaluated by enumerating sockeye salmon smolt emigrating from lakes to the ocean, and by measuring primary and secondary production in the lakes in which they rear (Koenings et al. 1987). Currently, annual juvenile production data are collected from 6 sockeye salmon systems in the Kodiak archipelago and on the Alaska Peninsula.

DESCRIPTION OF STUDY AREA

The Buskin River drainage is located on the northeast end of Kodiak Island (Figure 2), approximately 8 km southwest of the city of Kodiak. The United States Coast Guard and State of Alaska Department of Transportation and Department of Natural Resources own uplands surrounding the entire drainage. The subsistence fishery occurs in Alaska Maritime National Wildlife Refuge waters within Chiniak Bay. Buskin Lake (lat 57°46′42″N, long 152°32′54″W) lies approximately 20 m above sea level and covers 101.5 hectares. The lake has a mean depth of 10.4 m, maximum depth of 16.8 m, and volume of 11.6×10^6 m^3. Runoff from Buskin Lake flows in a southeasterly direction via the 4.8 km Buskin River, emptying into Chiniak Bay. Within the Buskin drainage, Buskin Lake constitutes the primary spawning and rearing habitat for sockeye salmon.

A major Buskin River tributary, Lake Catherine (57°46′01″N, 152°29′29″W), lies 19 m above sea level, covers 19.1 hectares, has a mean depth of 7.3 m, maximum depth of 15.8 m, and volume of 1.4×10^6 m^3. A small outlet creek totaling 183 m in length flows out of Lake Catherine and into Lake Louise. Lake Louise (57°45'26″N, 152°29'34″W) lies 19 m above sea level, covers 16.1 hectares, has maximum depth of 14 m, and volume of 8.39×10^6 m^3. Outflow from Lake Louise travels 853 m before draining into the Buskin River, approximately 2.4 km below the Buskin Lake outlet. Mean depth of the outflow creek is less than 0.3 m, but can rise quickly to as much as 1.2 m following heavy precipitation. These small lakes are also utilized by sockeye salmon for spawning and rearing.

In addition to sockeye salmon, resident fish in the Buskin Lake drainage include pink salmon, coho salmon, chum salmon (*O. keta*), rainbow trout (anadromous and non-anadromous), Dolly Varden, threespine stickleback (*Gasterosteus aculeatus*), and coastrange sculpin (*Cottus aleuticus*). Chinook salmon (*O. tshawytscha*) have also been occasionally observed in the Buskin River, but do not appear to represent a viable population.

METHODS

Screened weirs and traps, located at both the Buskin Lake outlet stream and the Louise-Catherine lakes outlet stream, were installed and operated from late April through 30 June in order to estimate total annual sockeye salmon smolt emigration. A lower Buskin River trap was also installed downstream of the Louise-Catherine tributary to capture and sample smolt encountered during the study period. After installation, it was quickly determined that the original weir design at the Buskin Lake outlet would be ineffective at both capturing smolt and counting adult salmon for reasons having to do with site characteristics and trap design. Consequently, it was not possible to census sockeye smolt emigrating from Buskin Lake; this objective was replaced by efforts to obtain mark–recapture estimates of smolt abundance. As a result of this study design modification, the Buskin Lake outlet trap was only used to capture sockeye salmon smolt for age-weight-length (AWL) estimates and for mark–recapture experiments. The Louise-Catherine lakes tributary weir, however, was used to census the smolt migrating from that system as well as a platform to conduct sampling for smolt AWL estimates and for marking smolt used in mark–recapture estimates.

Two marking methods, based on a modified Peterson mark–recapture estimator, were used to estimate the number of sockeye salmon smolt emigrating from the Buskin River watershed: 1) a genetic mark using Louise-Catherine lakes smolt as the marked component, and 2) a dye mark of Buskin Lake smolt using techniques described by Carlson et al. (1998). Recaptures of marked smolt were made using the trap operated in the lower Buskin River downstream of its confluence with the Louise-Catherine lakes tributary stream. The downstream trap was used to estimate the marked fraction associated with each of the marking schemes described in 1) and 2) above. An estimate of the marked fractions of Louise-Catherine lakes smolt in the total population of smolt emigrating from the watershed was made from tissue samples taken from smolt captured in the lower trap. Estimates of the marked fractions of dye-marked smolt were made by visual inspection of the smolt captured in the lower trap. Recapture results were used to estimate trap efficiency and total smolt abundance.

SMOLT CAPTURE LOCATIONS AND TECHNIQUES

Louise-Catherine Lakes Tributary

Year 2010

For 2010, an inclined plane–design trap (Figures 3 and 4) (Todd 1994) was placed in the outflow creek approximately 450 m downstream of Lake Louise. The trap was connected to a cross-creek barrier utilizing the superstructure of a traditional adult salmon counting weir. Perforated, 1/8″ thickness aluminum sheets (1.2 m width × 3.0 m length), supported by aluminum weir panels, were placed across the face of the weir and integrated with the trap entryway to help direct water flow. Strips of Mirafi[1] construction fabric (1 m × 4.8 m) were placed between the panels and

[1] Product names used in this publication are included for completeness but do not constitute product endorsement.

perforated aluminum across the front of the weir to further direct flow. Mirafi fabric was also positioned along the creek bottom to complete a cross-creek barricade and prevent scouring. Sandbags were placed on top of the fabric following the river bottom contour. A trap entrance consisted of perforated and framed 2.4 m × 1.2 m aluminum sheeting angling downstream lengthwise from the center of weir structure in order to divert flow over the inclined plane and into the trap live box. A hinged 'apron' of perforated aluminum was attached to the bottom of the inclined plane to increase surface area and enhance trap performance by preventing smolt from escaping under the trap entrance.

A capture or "live" box (1.2 m × 1.2 m × 0.5 m) was attached to the distal end of the trap below the top end of the inclined plane. Captured smolt were shielded from turbulent flow in the live box by a custom baffle plate, where the bottom edge of the baffle had a gap under which smolt could pass into the live box. The entire trapping device was suspended by cable winches attached to an aluminum pipe A-frame that allowed for adjustments in response to changing water levels.

Year 2011

For 2011, the inclined plane–design trap was replaced with a Canadian fan trap (Figures 5 and 6) (Ginetz 1977). The new design had a 1.52 m × 1.52 m opening, the bottom of which was flush with the creek bottom, and a runnel ramp of perforated aluminum leading to a 0.91 m × 0.91 m × 0.61 m hinged live box. This trap was also connected to a cross-creek barrier, and the live box was suspended in a way similar to that of the 2010 trap design.

During both years of the study, trapping conditions were initially adequate until stream flow and water levels decreased, which decreased the volume and velocity of water entering the trap. This was mitigated by placing either solid vinyl sheeting or Mirafi fabric along the bottom of the traps and Mirafi fabric over the perforated aluminum sheets comprising the trap entrance. During periods of increased flow, the Mirafi covering was removed.

Buskin Lake Outlet

Year 2010

In order to census total sockeye salmon smolt emigration from Buskin Lake, a trap configuration similar in design to that on the Louise-Catherine lakes tributary was originally constructed across Buskin River at the lake outlet. An integrated cross-river barrier and incline plane trap were installed in early May but were removed 4 days later, after it was determined this design would be ineffective for capturing smolt. A free-standing inclined plane trap was subsequently installed to capture smolt for AWL estimates and mark–recapture experiments approximately 230 m below the outlet of Buskin Lake (Figures 4 and 7). The incline plane trap was positioned in the middle of the river where water velocity was sufficient to minimize fish avoidance.

The Buskin Lake outlet trap design was similar to that used for the Louise-Catherine lakes tributary trap. The trap and live box were suspended by cable winches from an aluminum pipe frame to allow for adjustments based on water level fluctuations. Perforated aluminum sheeting (1.2 m × 2.4 m), supported by a rigid frame, was placed lengthwise on end leading away from the trap entrance in a "V" configuration to divert smolt into the live box.

Year 2011

In 2011, the Buskin Lake outlet inclined plane trap was replaced with a Canadian fan trap design (Figure 5) with a 1.8 m × 1.8 m entrance, runnel ramp of perforated aluminum sheeting, and a

0.91 m × 0.91 m × 0.61 m live box. This trap was positioned in approximately the same location as the inclined plane trap used in 2010 (Figure 8). Depending on water flow, either 3.05 m or 6.1 m long spans of perforated aluminum sheeting (1.2 m × 2.4 m), supported by a rigid frame, were placed leading way from the trap entrance in a "V" configuration to increase water velocity and flow into the trap.

Lower Buskin River

Year 2010

In order to sample Buskin River smolt emigration downstream of both Buskin Lake outlet and the Louise-Catherine lakes tributary, a semi-floating inclined plane trap was installed on 12 May at a location beneath a defunct vehicle bridge where the river forks into 2 channels, approximately 2 km above the stream terminus (Figure 9). The trap was placed in the channel that accounted for approximately 60% of the total stream flow. The trap design included a ramp of perforated aluminum runnels leading into the live box, supported by pontoons tethered to the shore with adjustable lines. A 1.2 m × 1.2 m × 0.5 m live box, and the remainder of the trapping device, were suspended by cable winches to the bridge deck and pilings. To divert smolt into the live box during low water conditions, perforated aluminum sheeting (1.2 m × 2.4 m), supported by a rigid frame, was placed lengthwise on end leading away from the entrance of the trap in a "V" configuration.

Year 2011

The trap configuration used in 2011 was nearly identical to the previous year's configuration, except that the trap was suspended from the overhead bridge without floatation and had adjustable guidelines attached to the front of the trap that ran to pulleys approximately 18 m upriver in the river channel (Figure 9). The guidelines were used as needed to align the trap with prevailing flow direction within the river channel.

SMOLT ENUMERATION

The traps at the 2 lake outlets and the lower Buskin River were used to enumerate emigrating smolt between 28 April and 30 June 2010 and between 25 April and 30 June 2011. At each trap site, captured smolt were held in a live box until counted. From evening to morning (2130 to 0730 hours), live boxes were checked every 1 to 2 hours depending on observed catch rates. During the day (0731 to 2129 hours), live boxes were checked every 3 to 4 hours. Trap catches were removed from each live box with a dip net and identified by species. All salmonids were counted, and all captured sockeye salmon smolt were either subsequently released downstream of the trap or moved to an instream holding box for sampling. Occasionally, when catch rates were low, numbers of fish were estimated and left in the attached live box for sampling later that day. Salmonid species identification was made by visual examination of external characteristics (Pollard et al. 1997). All data, including mortalities, were entered on a reporting form each time the trap was checked. After the project had concluded for the season, a back cast–time series based estimate of smolt passage was calculated for periods when a trap was not operational, usually due to high water flows. The estimate was calculated utilizing a Systat ARIMA model and the ITSM time series software package (Brockwell and Davis 2002; SYSTAT 2011; ITSM 2005).

We were able to count all smolt emigrating from the Louise-Catherine lakes system in each year while the trap was operational, and total sockeye smolt emigration (N_L) was calculated as the summation of trap counts:

$$N_L = \sum_{v=1}^{V} C_v \tag{1}$$

where

V = total number of trap loads for which abundance is censused, and

C_v = number of sockeye smolt counted in census of v^{th} trap load.

AGE, WEIGHT, AND LENGTH SAMPLING

The sampling goal for AWL measurements was a weekly sample of 120 sockeye salmon smolt from the Louise-Catherine and Buskin lakes outlet traps. This sample size is based on methods for estimating multinomial proportions (Thompson 1987) and would allow each age class proportion to be estimated within 5 percentage points of the true values 95% of the time. To reach the weekly total, daily samples of 40 sockeye salmon smolt were collected on 3 days within each statistical week. Smolt were randomly collected from those retained in the live box and sampled to obtain AWL data. Typically smolt were collected during the night and held in the instream live box. After sampling, all smolt were released downstream from the trap.

Tricaine methanesulfonate (MS-222) was used to anesthetize smolt prior to sampling. Fork lengths were measured to the nearest 1 mm, and weights were recorded to the nearest 0.1 g. Scales were removed from the preferred area (INPFC 1963) and mounted on a microscope slide for age determination. After sampling, smolt were held in aerated water until they recovered from the anesthetic, and subsequently released downstream from the trap. Age was estimated from scales using a microfiche reader (EYECOM 3000) under 60× magnification, and recorded in European notation (Koo 1962).

For Louise-Catherine lakes, estimates of age composition were stratified using weekly stratum smolt counts from the Louise-Catherine lakes outlet trap as appropriate weights. The proportion of sampled smolt in stratum *i* of age class *j* was estimated as a binomial proportion:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \tag{2}$$

where

n_{ij} = the number of sampled smolt in stratum *i* that were in age class *j*,

n_i = the number of smolt sampled that were aged in stratum *i*, and

The variance of $\hat{p}_{ij}$ was estimated as follows:

$$\text{var}(\hat{p}_{ij}) = \left(\frac{N_{Li} - n_i}{N_{Li}}\right)\left(\frac{\hat{p}_{ij}\left(1 - \hat{p}_{ij}\right)}{n_i - 1}\right), \tag{3}$$

where

N_{Li} = the total number of Louise-Catherine lakes smolt counted in stratum *i*.

The total number of smolt in stratum *i* of age class *j* was estimated as follows:

$$\hat{N}_{Lij} = N_{Li}\,\hat{p}_{ij}, \tag{4}$$

and its variance by

$$\mathrm{var}(\hat{N}_{Lij}) = \hat{N}_{Li}^{2}\,\mathrm{var}(\hat{p}_{ij}). \tag{5}$$

The total number of smolt of age class *j* for the season ($\hat{N}_{Lj}$) was estimated by summing the stratum estimates $\hat{N}_{Lij}$ over *i* and likewise for the variance ($\mathrm{var}(\hat{N}_{Lj})$) by summing $\mathrm{var}(\hat{N}_{Lij})$ over *i*. The overall proportion of smolt of age class *j* was calculated as follows:

$$\hat{p}_{j} = \sum_{i=1}^{I}\frac{N_{Li}}{N_{L}}\,\hat{p}_{ij} \tag{6}$$

where

I = total number of weekly strata (10 by design),

and its variance was estimated as

$$\mathrm{var}(\hat{p}_{j}) = \sum_{i=1}^{I}\left(\frac{N_{Li}}{N_{L}}\right)^{2}\mathrm{var}(\hat{p}_{ji}). \tag{7}$$

For the Buskin Lake trap, where there was no census of the emigration, Equations 2, 3 (without the finite population correction factor), 6, and 7 were used. Trap catches were used as stratum weights.

Condition factor, a quantitative measure of overall growth that may influence migratory behavior (Bagenal and Tesch 1978), was determined for each smolt as

$$K = \frac{W}{L^{3}}10^{5} \tag{8}$$

where

W = weight in grams,

L = FL in millimeters.

GENETIC TISSUE SAMPLING

During the summers of 2005 and 2010, baseline samples were collected for genetic analyses from spawning populations of Buskin River drainage (Buskin and Louise-Catherine lakes) sockeye salmon. The Buskin and Louise-Catherine lakes stocks have been shown to be genetically very different (C. Habicht, Fisheries Geneticist, ADF&G, Anchorage, personal communication) such that individual assignments to stock of origin are possible with a high degree of certainty. Target sample size for baseline collections was 95 individuals to achieve acceptable precision for estimating allele frequencies (Allendorf and Phelps 1981; Waples 1990) and to accommodate the ADF&G genotyping platform.

Baseline samples from 2005 and 2010 and smolt samples collected in 2010 and 2011 were genotyped for 96 single nucleotide polymorphisms (SNPs) following the methods of Dann et al. (2009). The genotypes were imported and archived in the Gene Conservation Laboratory Oracle database, LOKI. A quality control analysis (QC) was conducted to identify laboratory errors and to measure the background discrepancy rate of our genotyping process. The genotypes were retrieved from LOKI and imported into *R* (R Development Core Team 2010). The quality of the data was confirmed by identifying and removing the following: invariant SNP markers, individuals that were missing substantial genotypic data (80% rule; Dann et al. 2009), and duplicate individuals. Common population genetic assumptions (Hardy-Weinberg and linkage equilibrium) were validated, and collections were pooled to obtain better estimates of allele frequencies when appropriate. The baseline for mixed stock analysis (MSA) was evaluated by assessing the accuracy of the identified reporting groups. Reporting groups for this project were the 2 lake systems in the Buskin River drainage: Buskin and Louise-Catherine lakes. Following the methods of Dann et al. (2009), "100% proof tests" were conducted to examine model performance. The stock composition of the 2010 Buskin River smolt sample was estimated following these same methods. For the 2011 sample, we estimated the probability of assignment to each reporting group for each individual using the same parameters used for the other estimates.

Sample procedures to estimate the respective proportions of smolt catches originating from Buskin and Louise-Catherine lakes each week included collection of caudal fin tissues from smolt 65 mm or larger. For sockeye salmon smolt less than 65 mm, it was necessary to retain the whole fish as a sample. Labeled samples were shipped to the ADF&G Gene Conservation Laboratory for storage and processing.

TRAP EFFICIENCY AND POPULATION ESTIMATES

Completely stratified mark–recapture experiments were performed to estimate smolt abundance (Carlson et al. 1998) for both 2010 and 2011. The following assumptions were used in a simulation of these mark–recapture experiments in order to determine relative precision of the estimates:

1) Carlson et al. (1998) estimated about 200,000 smolt emigrate from Akalura Lake, which has escapement levels in the range of those seen at Buskin Lake. Furthermore, adult escapement into Louise Lake has been about 20% of that of Buskin Lake. Based on these, it was assumed that 200,000 smolt emigrate from Buskin Lake and 40,000 smolt emigrate from Louise-Cathrine lakes for a total migration of 240,000 smolt.
2) It was also assumed that smolt migration follows a normal distribution, peaking at the middle of a 10 migration-week period. A negligible number of smolt are assumed to migrate before or after the 10 week period.
3) It was assumed that 500 smolt would be marked (dyed) and released per week.
4) The lower Buskin River trap efficiency was assumed to be 5%; Carlson el al. (1998) estimated their trap efficiency ranged from 6% to 20%, while King et al. (unpublished sockeye salmon smolt study on the Russian River, ADF&G, Kenai Peninsula, AK) reported a trap efficiency range from 2% to 40% over time.

A stratified Petersen estimator of the total abundance (see Data Analysis section below) was simulated under the above assumptions. The simulated 95% relative precision for the total abundance estimate was found to be 15%, meeting objective criteria, while that for individual weeks was found to be about 40%.

Total smolt emigration was estimated by summing weekly abundance estimates from the mark–recapture experiments. To achieve the desired relative error for population estimates, weekly trap efficiency estimates were obtained by releasing 500 marked (dyed) smolt from the outlet of Buskin Lake (and Louise-Catherine lakes if needed) at the start of each week. Additionally, another 200 smolt (100 dyed and 100 as a control) were held overnight to monitor delayed mortality.

Smolt were collected from the trap live box by dip net, placed in groups of up to 100 each into a semi-rigid, mesh fabric Bait Tamer bucket liner, and held in the Buskin Lake outlet or Louise-Catherine lakes tributary live box until the desired number was obtained for the mark–recapture first event (500) and delayed mortality test (200). Smolt were collected over the course of 1 or 2 days and held in the Bait Tamers for up to 2 nights when attempting to obtain the desired numbers.

Dying procedures began by placing Bait Tamers containing smolt in an aerated 100-gallon water-filled tank that was transported via a truck to a release site approximately 1,200 m upstream of the lower Buskin River trap. A diluted solution of dye was made by mixing 2.85 g of Bismark Brown Y dye with a 33-gallon container of river water. After a transport recovery period of 30 minutes, each Bait Tamer containing smolt was placed into an individual aerated bucket filled with 4 gallons of the dye solution. Smolt were held in the dye solution for 30 minutes, after which they were returned to the aerated 100-gallon tank to recover for a minimum of 1 hour.

After recovery, dyed smolt were counted and released across the width of the stream between 2100 and 2300 hours. Dyed smolt that displayed unusual behavior (i.e., rolling, difficulty swimming, moribund) were not released. All dyed smolt subsequently recaptured at the lower Buskin River trap site were counted and assigned to a mark recovery period (hereafter referred to as a stratum).

For each week (h) of the I weeks (I = 10, by design) covering the smolt emigration period, total smolt abundance (Buskin plus Louise-Catherine lakes smolt) was estimated as follows:

$$\hat{N}_{Th} = \frac{(n_h + 1)(M_h + 1)}{m_h + 1} - 1 \qquad (9)$$

where

M_h = total number of fish marked and alive in the first event sample during week h,

n_h = number of fish caught in the second event in the lower trap during week h, and

m_h = number of marks found in n_h in lower trap during week h.

An approximately unbiased estimate of the variance of $\hat{N}_{Th}$ was calculated as

$$\text{var}(\hat{N}_{Th}) = \frac{(n_h + 1)(M_h + 1)(M_h - m_h)(n_h - m_h)}{(m_h + 1)^2 (m_h + 2)}. \qquad (10)$$

Trap efficiency for each stratum (h) was calculated as

$$u_h = \frac{m_h}{M_h}. \tag{11}$$

The total smolt population estimate over the season was calculated as follows:

$$\hat{N}_T = \sum_{h=1}^{I} \hat{N}_{Th} \tag{12}$$

and the variance of the estimate was calculated as

$$\text{var}(\hat{N}_T) = \sum_{h=1}^{I} \text{var}(\hat{N}_{Th}). \tag{13}$$

An estimate of the number of Buskin lake smolt migrating from the drainage was calculated as the difference in the total emigration and the Louise–Catherine lakes census count:

$$\hat{N}_B = \hat{N}_T - N_L \tag{14}$$

with variance estimated as var($\hat{N}_T$).

The null hypothesis of constant capture probability by the lower Buskin River trap over all sampling periods was examined using a χ-square test of homogeneity. The test consisted of an *I* by 2 contingency table:

Week	Recaptured	Not Recaptured
1	m_1	M_1-m_1
2	m_2	M_2-m_2
…	…	…
I	m_I	M_I-m_I

If the test was not significant (P > 0.05), strata were pooled (Carlson et al. 1998).

Recently, Sagalkin and Honnold (2003) assessed potential sources of error and bias in the estimates generated from a smolt enumeration project employing mark–recapture methods. Sources of error investigated were related to mortality caused by marking, handling, and trapping. Biases related to capture associated with smolt size and behavior were also examined. Sagalkin and Honnold (2003) judged these sources of error and bias to have negligible effects upon smolt estimates. Consequently, the results of the delayed mortality tests conducted during the dye-test experiments conducted in both study years were not used to adjust the number of released marks.

ESTIMATION OF PROPORTION OF BUSKIN LAKE SMOLT

Proportions of the total smolt population migrating past the lower Buskin River inclined trap site comprised of Buskin and Louise-Catherine lakes stock components were estimated from genetics samples collected from the trap catch. DNA was extracted from fish collected for this purpose and was genotyped by the ADF&G Gene Conservation Laboratory in Anchorage. Single nucleotide polymorphisms (SNPs) were used to estimate the stock composition of mixture samples using laboratory methods described by Dann et al (2009).

ESTIMATION OF BUSKIN LAKE SMOLT ABUNDANCE FROM DYE-BASED MARK-RECAPTURE EXPERIMENTS AND GENETIC DATA

In addition to estimating Buskin Lake smolt abundance as the difference between the total mark–recapture emigration estimate and the Louise-Catherine lakes census count, Buskin Lake smolt population abundance was estimated as the product of the total mark–recapture estimate based on the recovery of dye-marked smolt and the genetics-based estimate of the proportion of the emigration comprised of Buskin Lake smolt:

$$\hat{N}_{BG} = \hat{p}_B \hat{N}_T \qquad (15)$$

with variance (Goodman 1960) estimated as

$$\text{var}(\hat{N}_{BG}) = \hat{p}_B^2 \,\text{var}(\hat{N}_T) + \hat{N}_T^2 \,\text{var}(\hat{p}_B) - \text{var}(\hat{N}_T)\,\text{var}(\hat{p}_B). \qquad (16)$$

The proportion of Buskin Lake stock in the migration past the lower trap, $\hat{p}_B$, and its variance were estimated as in Equations 6–7, with weights calculated using trap catches for the 2 strata.

ESTIMATION OF TOTAL BUSKIN RIVER DRAINAGE SMOLT ABUNDANCE USING LOUISE-CATHERINE LAKES TRAP COUNT AND GENETIC DATA FROM LOWER BUSKIN RIVER TRAP

The total smolt emigration (Buskin Lake plus Louise-Catherine lakes) past the lower Buskin River trap was estimated from a 2-event mark–recapture analysis using Louise-Catherine lakes smolt as the marked component based on their genetic distinction from Buskin Lake smolt. The total smolt emigration, using the trap count at Louise-Catherine lakes tributary as the first event sample (the total number of marked smolt; N_L), the catch at the lower trap as the second event sample (n), and the number of smolt of Louise-Catherine lakes origin recaptured during the second event ($\hat{m}_L$) based on results of genetic analyses, was estimated as follows:

$$\hat{N}_{TG} = \frac{(N_L + 1)(n + 1)}{\hat{m}_L} \qquad (17)$$

where

n = lower Buskin River trap catch

$\hat{m}_L$ = estimated number of Louise-Catherine lakes smolt in n

and where

$$\hat{m}_L = n(1 - \hat{p}_B). \tag{18}$$

An approximate variance for $\hat{N}_{TG}$ is as follows (delta method):

$$\text{var}(\hat{N}_{TG}) = \frac{(N_L + 1)^2 (n+1)^2}{n^2 (1 - \hat{p}_B)^4} \text{var}(\hat{p}_B). \tag{19}$$

RESULTS

YEAR 2010

Smolt Enumeration and Sampling

Louise-Catherine lakes tributary smolt trapping was conducted a total of 64 days from 28 April to 30 June 2010. With the exception of a total period of approximately 10 hours occurring over 4 separate high water events, the trap was operated continuously with an assumed 100% capture rate. A total of 9,389 sockeye salmon smolt were caught and counted. Of these, 191 smolt died due to handling and 744 died due to turbulent water in the live box. The largest daily sockeye salmon smolt catch occurred on 2 June when 1,486 smolt were captured (Table 2 and Figure 10). During the trapping period, AWL data were obtained from a total 582 smolt.

Buskin Lake smolt trapping was conducted 39 days out of a possible total of 44 days during 5 May to 30 June. The original trap configuration was operated for 5 days (5 May–9 May), while the modified incline plane trap was operated for 34 days (23–29 May and 5–30 June). During this latter period, there was a 6-day interruption (30 May–4 June) due to flood conditions. A total of 5,561 sockeye salmon smolt were counted and estimated. Of these, 47 died due to handling. The largest daily catch occurred on 11 June when 1,858 smolt were captured (Table 2 and Figure 11). During the trapping period, a total 373 smolt were collected for sampling purposes, and AWL data were obtained from 368 of these.

Lower Buskin River smolt trapping was conducted a total of 49 days from 12 May to 30 June. The trap was intermittently inoperable on 11 days during this period due to flood conditions. A total of 1,240 sockeye salmon smolt were captured and enumerated, with the largest daily catch on 6 June when 247 smolt were captured (Table 2 and Figure 12). No estimate was generated for the periods of time when the trap was not fishing. During the trapping period, a total of 129 genetic samples were collected from the lower Buskin River trap between 24 May and 25 June.

Age, Weight, and Length

Louise-Catherine Lakes Tributary Trap

Age composition changed appreciably over the emigration. Freshwater-age-2 was the dominant age class in samples obtained from the Louise-Catherine lakes tributary trap from 17 May through 13 June, representing 100% of samples during 17–30 May and 71% during 31 May–13 June (Table 3 and Figure 13). After 13 June, freshwater-age-1 was the dominant age class, representing 53% of samples from 14 to 20 June and at least 84% during the remainder of the study period. Three freshwater-age-3 smolt were sampled between 31 May and 13 June. The stratified age composition (Equations 6 and 7) was 32% (SE 2.4%) freshwater-age-1, 67% (SE 0.024) freshwater-age-2, and 1% (SE 0.6%) freshwater-age-3 smolt.

Sampled freshwater-age-1 smolt had a mean weight of 11.5 g (range 7.2 g to 16.9 g), a mean length of 106 mm (range 92 mm to 120 mm), and a mean condition factor of 0.96 (range 0.65 to 1.69) (Table 4 and Appendix A1). Freshwater-age-2 smolt had a mean weight of 12.0 g (range 4.1 g to 17.0 g), a mean length of 109 mm (range 92 mm to 123 mm), and a mean condition factor of 0.93 (range 0.42 to 1.25). Freshwater-age-3 smolt weights ranged from 12.4 g to 15.5 g; lengths ranged from 114 mm to 121 mm; and condition factors ranged from 0.79 to 0.89.

An estimated 6,304 freshwater-age-2, 2,981 freshwater-age-1, and 104 freshwater-age-3 sockeye salmon smolt emigrated from the Louise-Catherine lakes during 2010 (Table 5).

Buskin Lake Outlet Trap

Age composition changed appreciably over the emigration. Freshwater-age-2 was the dominant age class in samples obtained from the Buskin Lake outlet trap during 24 May to 13 June, representing 93.8% of samples taken from 24 May to 6 June and 59.2% from 7 to 13 June (Table 3 and Figure 14). After 13 June, freshwater-age-1 was the dominant age class, representing 71.4% or more of samples taken during the remainder of the study period. Five freshwater-age-3 smolt were sampled between 31 May and 13 June. The stratified age composition (based on trap catches, not weir counts) was 31% (SE 2.6%) freshwater-age-1, 68% (SE 2.7%) freshwater-age-2, and 1% (SE 0.4%) freshwater-age-3 smolt.

Sampled freshwater-age-1 smolt had a mean weight of 4.5 g (range 2.9 g to 9.4 g), a mean length of 78 mm (range 64 mm to 100 mm), and a mean condition factor of 0.95 (range 0.66 to 1.62) (Table 4 and Appendix A1). Freshwater-age-2 smolt had a mean weight of 6.7 g (range 3.2 g to 10.3 g), a mean length of 87 mm (range 71 mm to 103 mm), and a mean condition factor of 1.00 (range 0.73 to 1.40). Freshwater-age-3 smolt weights ranged from 5.4 g to 11.9 g; lengths ranged from 79 mm to 101 mm; and condition factors ranged from 0.99 to 1.19.

Genetic Samples

Tissue Collections

Genetic tissue samples were collected from a total of 129 sockeye salmon smolt captured in the lower Buskin River trap between 24 May and 25 June. Unfortunately, due to apparent confusion over sampling protocol by the project field crew, the greatest percentage of genetic sampling did not coincide temporally with peak smolt emigration (Figure 15).

Analysis of Genetic Structure

The 2010 samples of sockeye salmon smolt were genotyped with a process that produced an error rate of 0.14%, if equal error rates in the original and QC genotyping process are assumed.

During quality control verification, a total of 9 samples were removed from further analyses: 6 individuals were missing genotypes from greater than 20% of the loci (19 SNPs), and 3 baseline individuals were identified as duplicate individuals. Two SNPs were invariant.

Baseline evaluation for mixed stock analysis (MSA) proof tests indicated that the 2 Buskin River reporting groups (Buskin and Louise-Catherine lakes) were very distinct; both had a correct allocation of 0.99 (Table 6).

A total of 120 Buskin River smolt samples from the lower Buskin River trap were used in MSA. Stock composition estimates of the sample indicated that 99.6% of the smolt originated from

Buskin Lake. The 90% credibility intervals were 0.98 to 1.00 for Buskin Lake and 0.00 to 0.02 for Louise-Catherine lakes (Table 7).

Trap Efficiency and Population Estimates

In between repeated flood events, a total of 4 weekly mark–recapture experiments were attempted in 2010, but only 1 partial and 1 successful experiment were conducted. During the first attempt to dye-mark smolt on 31 May, 62% of the smolt died from apparent stress before the dye was administered, and the remaining 126 smolt were released to avoid additional mortality. The second dye experiment was attempted on 7 June, but 75% of the smolt died during or immediately following the dye application due to a lethal dye concentration.

During the third dye experiment on the evening of 16 June, a total of 126 marked smolt were dyed and released. Two of these were subsequently recaptured, resulting in a trap efficiency estimate of 1.59%. During the fourth dye experiment on 21 June, a total of 529 smolt were marked and released. Eight of these were recaptured in the lower Buskin River trap during the subsequent 3-day period, resulting in a trap efficiency estimate of 1.51%.

No smolt abundance estimates were made for any releases due to the low number of recaptures, which would have resulted in high variability estimates, and the low utility of a partial season smolt emigration estimate.

YEAR 2011

Smolt Enumeration and Sampling

Louise-Catherine lakes tributary smolt trapping was conducted a total of 66 days from 25 April to 30 June, 2011. With the exception of a total period of approximately 48 hours occurring over 2 separate high water events, the trap was operated continuously with an assumed 100% capture rate. A total of 44,960 sockeye salmon smolt were counted emigrating from Louise-Catherine lakes. Of these, 595 smolt died due to handling. An additional 861 smolt were estimated to have emigrated while the trap was inoperable, which increased the total emigration estimate to 45,821 smolt. The largest daily sockeye salmon smolt catch occurred on 21 June when 2,457 smolt were captured (Table 8 and Figure 10). During the trapping period, AWL data were obtained from a total of 928 smolt.

Buskin Lake smolt trapping was conducted 54 of 63 possible days during 28 April to 30 June. The trap was fished continuously, except for 10 consecutive days of severe flood conditions (17–26 May). A total of 42,257 sockeye salmon smolt were counted emigrating from Buskin Lake. Of these, 705 smolt died due to handling. An additional estimated 2,500 smolt emigrated while the trap was inoperable. The largest daily catch occurred on 14 June when 4,792 smolt were captured (Table 8 and Figure 11). During the trapping period AWL data were obtained from a total of 614 smolt.

Lower Buskin River smolt trapping was conducted 45 of 58 possible days during 3 May to 30 June. Trapping operations were interrupted for 13 consecutive days (16–29 May) due to flood conditions. A total of 20,436 sockeye salmon smolt were captured and enumerated. An estimated 6,177 smolt emigrated while the trap was inoperable, which increased the total emigration estimate to 26,613 smolt. The largest daily catch occurred on 4 June when 2,995 smolt were captured (Table 8 and Figure 12). During the trapping period, a total of 400 genetic samples were obtained between 11 May and 26 June.

Age, Weight, Length and Condition

Louise-Catherine Lakes Tributary Trap

Freshwater-age-1 was the dominant age class during every sampling stratum for the Louise-Catherine lakes tributary trap (Table 9 and Figure 16). Percentages ranged from 67.5% during the first sampling period (3–9 May) to 100% during 14–20 June. Freshwater-age-2 smolt contributions ranged from 32.5%, during the first sampling stratum, to 0% during a later stratum (14–20 June). Four freshwater-age-3 smolt were sampled between 17 May and 6 June. The stratified age composition was 89% (SE 1%) freshwater-age-1, 10.5% (SE 1%) freshwater-age-2, and 0.5% (SE 0.3%) freshwater-age-3 smolt.

The sample of freshwater-age-1 smolt had a mean weight of 4.0 g (range 1.4 g to 20.7 g), mean length of 79 mm (range 61 mm to 132 mm), and mean condition factor of 0.78 (range 0.43 to 1.63) (Table 10 and Appendix A2). Freshwater-age-2 smolt had a mean weight of 12.9 g (range 2.9 g to 24.5 g), mean length of 116 mm (range 74 mm to 151 mm), and mean condition factor of 0.79 (range 0.43 to 1.38). Freshwater-age-3 smolt had weights ranging from 17.7 g to 17.9 g, lengths ranging from 129 mm to 136 mm, and mean condition factors ranging from 0.71 to 0.83.

A total of 54 samples, considered outliers due to extremely low or high condition factors (condition factors < 0.4225 or > 2.0; personal communication, Heather Finkle, ADF&G fisheries biologist, Kodiak, Alaska), were omitted from mean weight, length, and condition factor calculations.

An estimated 40,706 freshwater-age-1, 4,870 freshwater-age-2, and 245 freshwater-age-3 sockeye salmon smolt emigrated from the Louise-Catherine lakes during 2011 (Table 5).

Buskin Lake Outlet Trap

Freshwater-age-1 was the dominant age class in samples obtained from the Buskin Lake outlet trap (Table 9 and Figure 17). Percentages ranged from 55.0% during the period 24–30 May to 92.5% during 28–30 June. Freshwater-age-2 contributions ranged from 45% during 24–30 May to 7.5% during the last stratum. A total of 4 freshwater-age-3 smolt were sampled during 31 May–13 June. The stratified age composition (based on trap catches, not weir counts) was 72% (SE 2%) freshwater-age-1, 27% (SE 2%) freshwater-age-2, and 1.0% (SE 0.2%) freshwater-age-3 smolt.

The sample of freshwater-age-1 smolt had a mean weight of 4.6 g (range 2.3 g to 20.1 g), mean length of 81 mm (range 63 mm to 130 mm), and mean condition factor of 0.84 (range 0.47 to 1.29) (Table 10 and Appendix A2). Freshwater-age-2 smolt had a mean weight of 9.1 g (range 3.2 g to 24.2 g), mean length of 100 mm (range 72 mm to 136 mm), and mean condition factor of 0.85 (range 0.61 to 1.26). Freshwater-age-3 smolt had weights ranging from 12.3 g to 18.4 g, lengths ranging from 116 mm to 131 mm, and condition factors ranging from 0.61 to 0.91.

A total of 8 samples, considered outliers due to extremely low or high condition factors (individual condition factor < 0.4225 or > 2.0; personal communication, Heather Finkle, ADF&G fisheries biologist, Kodiak, Alaska), were omitted from mean weight, length, and condition factor calculations.

Genetics

Tissue Collections

Genetic tissue samples were collected from 400 smolt captured in the lower Buskin River trap between 11 May and 26 June, but 127 samples were subsequently omitted from the data set due to species misidentification. The greatest percentage of genetic sampling did not coincide temporally with peak smolt emigration (Figure 18).

Analysis of genetic structure

Genotypes were obtained for 390 individuals collected during 2011 for 96 SNPs. Of these, 127 individuals were not sockeye salmon, 2 individuals were missing genotypes from greater than 20% of the loci (19 SNPs), and 2 individuals were identified as duplicate individuals. All of these 131 individuals were removed from further analyses. The process used for this collection produced genotypes with an error rate of 0.25%, if equal error rates in the original and QC genotyping process are assumed.

Analysis of the remaining 259 Buskin River sockeye smolt samples collected from the lower Buskin River trap showed that 3 could not be definitively assigned to either population due to intermediate probabilities (P = 0.54 to 0.69), while 151 individuals were assigned to Buskin Lake and 105 individuals were assigned to Louise-Catherine lakes (Table 11). Stock composition estimates of the sample, based on 2 temporal strata (before 14 June and after 14 June) indicated that 63.0% (SE 4%) of the smolt originated from Buskin Lake.

Trap Efficiency and Population Estimates

Five 2-event mark–recapture experiments were performed to estimate smolt abundance. During each of the first 4 experiments, all released smolt from each marking event were assumed to have passed the lower Buskin River trap before each subsequent dye-test release. This allowed mark–recapture estimates from each experiment to be summed in order to obtain a total smolt population estimate. The first mark–recapture experiment occurred 31 May, and each subsequent experiment, except for the fifth one, was conducted for a 1-week period, with marking done at the start of each week, through the end of the project. The fifth experiment was only conducted for 3 days at the end of the study period. An additional experiment was planned prior to 31 May, but was cancelled due to a 2-week high water event

Trap efficiencies ranged from 11% and 29%, and the average was 21%. The lowest efficiency occurred during the last incomplete experiment, which lasted only 3 days. Based on recovery patterns of the 4 fully sampled mark–recapture experiments, it was likely that about 8 (ranging from 2 to 20) more recaptures would have occurred, if the experiment continued for the entire week.

Estimation of total smolt emigration from dye-test experiments

The 2011 total population dye-based estimate for the Buskin drainage emigration was 118,377 (SE 5,868) sockeye salmon smolt.

It is noted that significant species misidentification occurred during genetics sampling, with up to 65% of the sampled fish being non-sockeye species. The non-sockeye species were likely coho salmon, and all mark–recapture samples are potentially affected by the misidentification, with the result that the value of the mark–recapture estimates is questionable at best. We attempted to correct for the species identification problem at the lower Buskin River trap (only) by reducing the number examined during each dye experiment (n_h in Equation 9) according to the proportion of coho salmon determined from the genetics analysis of the lower trap catches; the derived estimates were nonsensical (i.e., estimates were lower than actual catch) and the adjustments were abandoned.

Estimation of Buskin Lake smolt emigration from dye-test experiments and genetics data

The total Buskin Lake smolt emigration estimated using the dye-based estimate of total smolt abundance and the genetics-based estimate of the proportion of the lower river trap catch comprised of Buskin Lake smolt was 74,613 (SE 6,323).

Estimation of total Buskin River drainage smolt emigration from Louise-Catherine lakes trap count and genetics data

The total smolt emigration (Buskin plus Louise-Catherine lakes) past the lower Buskin River trap estimated from a mark–recapture analysis using the live fish trap count at Louise-Catherine lakes tributary as the first sample (mark) event, the catch at the lower Buskin River trap as the second sample (capture) event, and the genetics-based estimate of the number of smolt of Louise-Catherine lakes origin caught in the lower Buskin River trap as recaptures, resulted in a total smolt emigration estimate of 122,326 (SE 14,353) smolt. This estimate is independent of the dye-based estimate, but may potentially be biased as a result of species misidentification in the lower trap catches.

DISCUSSION

The first year of this feasibility study, 2010, produced mixed results. Initial unsuccessful trapping methods combined with persistent flood conditions during the period of peak smolt emigration prevented attainment of the primary study objective, which was to estimate total Buskin River drainage sockeye salmon smolt abundance.

Early in the 2010 field season, when it became apparent that a census of the Buskin Lake component of the smolt population was not feasible, the study design was modified to use mark–recapture experiments as the primary means to determine total smolt abundance. The subsequently planned series of experiments were largely unsuccessful due to unexpectedly high mortality incidents during marking events, which produced inadequate samples sizes, and severe spring flooding of the Buskin River drainage through much of the 2010 study period, which compromised effective recapture of smolt at the lower Buskin River trapping site. This problem was aggravated by general operation difficulties with the lower river trap configuration due to a deployment technique that was poorly adapted to elevated water levels. As a result, overall smolt capture rates were deemed too variable for estimating catches during periods of interrupted operation due to flooding, and the low trap efficiency rates obtained from the mark–recapture experiments were well outside the target study parameters. The combined consequences of these problems did not allow an estimate of total sockeye salmon smolt abundance to be derived from the collected data.

In contrast, efforts to enumerate the 2010 Louise-Catherine lakes smolt run were largely successful. Over a 61 day period, continuous trapping operations were interrupted for just 10 hours, due to high water conditions. Consequently, the total sockeye salmon smolt count for this component of the drainage-wide emigration during the study period closely approximated a census. However, captured Louise-Catherine lakes smolt experienced a large handling mortality (~9%) due to a poor trap design and deployment technique.

In 2011, less persistent flooding combined with substantial improvements to the design of each smolt trap and to deployment techniques produced very different study results in comparison to the previous year. Due to less severe flood conditions, trap operations began 26 days earlier than in 2010 at Buskin Lake outlet, 3 days earlier at Louise-Catherine lakes tributary, and 10 days earlier at the lower Buskin River trap site. This allowed for better temporal coverage and sampling of the 2011 Buskin drainage sockeye salmon emigration. The Canadian fan trap design used in 2011 was more effective in capturing smolt than the traps used in 2010 because it had a larger trap entrance that was flush with the river bottom. Additionally, because the ramp was less steep than before, smolt inside the live-box were in better condition and had greater survival. The Louise-Catherine lakes tributary trap handling mortality decreased to 1%. The earlier deployment of each trap along with the improved trap design was probably responsible for the much larger catches of smolt in 2011, with over 7 times more sockeye smolt counted than in 2010.

In 2010, the study period probably overlapped most of the sockeye salmon smolt emigration in time. The final daily counts at the 3 trap sites ranged between 0 and 50 smolt, which generally met the condition, set at the beginning of the study for identifying the tail end of the run, of capturing less than 50 smolt daily for 3 consecutive days.

However, the study period in 2011 did not appear to temporally coincide with the entire smolt run, as the pre-study condition of dissipating catch rates was not met by the date trapping operations ended. Between the 3 sites, the final 3 consecutive-day counts ranged between 61 and 1,301 smolt. Emigration past the Buskin Lake outlet trap was nearing its end, but this did not appear to be true for either the Louise-Catherine lakes run, because the last day's count was over 1,300 smolt, or the lower Buskin River trap, which was consistently catching over 200 smolt per day during its last week of operation.

Emigration timing, based on daily cumulative trap catches, was quite variable between Buskin Lake and the Louise-Catherine lakes, even though in both years the cumulative catch percentages for each run eventually coincided. During 2010, approximately 29% of Buskin Lake smolt had emigrated past the Buskin Lake trap site by the week ending on 30 May, while only 6% of Louise-Catherine lakes smolt had passed the Louise-Catherine lakes trap site during this time period. In 2011, the percentages were reversed: 33% of smolt from Louise-Catherine lakes passed the trap site by 30 May compared to only 11% of smolt from Buskin Lake during this time period. In both years, by 13 June, the emigration timing for both runs converged. In 2010, 84% of Buskin Lake smolt and 86% of Louise-Catherine lakes smolt had passed the trap sites by 13 June. In 2011, 60% of Buskin Lake smolt and 65% of Louise-Catherine lakes smolt had passed the trap sites by 13 June.

The relatively high percentage of freshwater-age-1 smolt in 2011 (stratified estimates were 89% for Louise-Catherine lakes and 72% for Buskin Lake) versus freshwater-age-2 smolt (11% and 27%, respectively) suggests that rearing numbers did not excessively strain the carrying capacity of the Buskin River drainage during that year, because larger cohorts of younger fish typically indicate favorable freshwater habitat conditions (Honnold and Schrof 2004). Conversely, increased freshwater residence of sockeye salmon suggests rearing capacity of the system may be exceeded. The large percentage of freshwater-age-2 smolt during 2010 (stratified estimates were 67% for Louise-Catherine lakes and 68% for Buskin Lake) implies that recent rearing conditions prior to 2011 were less than optimal. Evidence of poor freshwater survival of Louise-Catherine lakes sockeye salmon may also be reflected by recent record-low adult returns, which included only 360 adults counted in 2011 (Tiernan 2011).

Most smolt captured for marking died before being released during the first (62%) and second (75%) marking events, and resulting trap efficiency estimates (1.59% and 1.51%) were much too low to use to estimate smolt abundance with any degree of useful precision.

The 2011 dye-based mark–recapture experiments were more successful than those in 2010 in part because smolt mortalities were much lower. Of the 5 experiments conducted, the lower Buskin River trap efficiencies were never less than 11%. However, little confidence can be given to the total Buskin drainage sockeye salmon abundances calculated using the mark–recapture experiments. The dye-based point estimate for total population in the Buskin drainage was 118,377 smolt, which indicates an unexpectedly high Buskin Lake outlet trap efficiency of about 61%. During low water levels, the lake outlet trap configuration spanned a large portion of the river channel, which could have resulted in relatively high trap efficiency rates. However, these intervals occurred well outside peak emigration periods and cannot account for a high overall efficiency. Most often, the trap configuration spanned substantially less than 50% of the river width at the capture site, and by flow volume, would account for an even smaller portion of the total available migratory pathway for smolt. Given these circumstances, it is unlikely that trap efficiency was very high, and it seems more likely the total abundance estimate based only on dye-based mark–recapture experiments was too low.

The dye-based mark–recapture estimate probably underestimated total smolt abundance due to inaccurate interpolation of the lower Buskin River trap catches during high water events. During the month of May, daily trap catches for 13 days (a total of 6,177 smolt) had to be interpolated as a result of flooding. These interpolated values represent 43% of the total trap catch (14,162 smolt) used to calculate efficiency for the first mark–capture experiment, conducted between 31 May and 5 June, and nearly 68% of the total monthly trap catch leading up to the experiment (3–30 May). Because trap efficiency from the first mark–recapture experiment (28%), used to estimate total smolt abundance from 31 May to 5 June, was applied to the total lower river trap catch during this period, an underestimation of interpolated catches would result in underestimation of total abundance. This error could substantially affect the estimate of the total 2011 smolt run because estimated total abundance via the first mark–recapture experiment (49,824 smolt) represented 42% of the estimated total run (118,377 smolt).

Unequal mixing of marked and unmarked smolt during the dye-based mark–recapture experiments may have biased estimates of total smolt abundance by skewing estimated trap efficiency rates. However, an effort was made to determine whether this had occurred. The fundamental assumption that all migrating fish are equally subject to capture by the lower trap prescribes that marked fish randomly mix with unmarked fish migrating at the same time and that the lower trap fishes consistently within an experiment (consistent trap operation was part of the sampling protocol). The effects of uneven mixing across the river within the mark–release time frame would have been exacerbated by the fact that only 1 of 2 flowing channels at the lower Buskin River capture site was sampled with a trap. If the same proportion of marked and unmarked smolt did not occur within both channels, trap efficiency estimates would have been different for each channel, and neither channel would have provided an unbiased estimate. Mixing of marked and unmarked fish across the river at any given time was, however, considered a reasonable assumption because the marked fish were scattered from bank to bank during release. It is noted that complete mixing of marked and all unmarked fish within an experiment will not have occurred because marked fish were released all at once at the beginning of the experiment.

Finally, errors in species identification may also have affected mark–recapture estimates. The presence of non-sockeye salmon species in genetic samples suggests that misidentification could also have occurred when enumerating and marking smolt. The mix of sockeye and non-sockeye salmon smolt was probably not constant during the season, and the study was not designed to determine how misidentification errors varied among samples and through time.

The very low contribution of Louise-Catherine lakes sockeye salmon smolt stock in genetics samples obtained in 2010 from the lower Buskin River capture site (0% to 2%) was likely due to deviation from the prescribed sampling strategy. While smolt catches from the lower river trap were supposed to be randomly sampled throughout the run, the relatively compressed timing of tissue collections for genetic analysis combined with a small overall sample size may have biased test results. Based on adult sockeye salmon escapements into Buskin River drainage, the Louise-Catherine lakes proportion of the drainage-wide smolt population is presumed to be small in comparison to that of Buskin Lake, but the cumulative count of more than 9,300 smolt leaving Louise-Catherine lakes in 2010 suggests that analysis of randomly collected tissues from smolt captured at the lower river trap should have shown a larger contribution from this genotype.

The relatively large presence (37%) of Louise-Catherine lakes origin stock found in the 2011 genetic results was also unexpected, not only due to the known small returns of adult sockeye salmon to the Louise-Catherine lakes system, but also because a similar number of sockeye smolt were trapped in sample catches at the Buskin Lake outlet (44,757) as the census catch of Louise-Catherine lakes (45,821) smolt. Even though the lake outlet trap captured an unknown proportion of the total Buskin Lake emigration, the overall magnitude suggests that these should have comprised a larger percentage of the smolt emigration past the lower trap site.

The large presence of non-sockeye salmonid species (likely coho salmon) in the 2011 genetic samples raised questions about the validity of the daily and cumulative trap counts. However, of the approximate 1,550 scale samples collected from the Buskin Lake outlet and Louise-Catherine lakes tributary traps, only 2 were identified as non-sockeye salmon. This species determination was based on Mosher (1969), which states sockeye salmon scales generally have no more than 6 complete circuli below the focus. Questions still exist, however, regarding the validity of the trap counts at the lower river sampling site, where the misidentified samples were taken. Furthermore, Mosher’s (1969) technique for identification should perhaps be reevaluated with genetic analysis. For this study, all mark–recapture and dye-test samples are potentially affected by species misidentification, which raises questions on the validity of mark–recapture estimates presented here. Attempts to correct for the proportion of non-sockeye species yielded unrealistic results (i.e., reducing the trap count based on a stratified proportion of non–sockeye salmon smolt resulted in an estimate of the Buskin Lake smolt population that was smaller than the number counted at the Buskin Lake outlet trap).

Finally, the 2011 genetics-based mark–recapture estimate and the dye-based estimate were similar. The genetics-based estimate was not subject to the potential errors and bias from the dye-induced effects described previously. However, the estimate was susceptible to problems associated with interpolation, mixing (Louise-Catherine lakes origin and Buskin Lake origin smolt), disproportionate sampling that failed to randomly encompass the run, and the assumption of consistent lower trap operation for the entire emigration (unlike the dye-based estimate, where consistent capture is only required within each experiment).

CONCLUSIONS

1) A Canadian fan trap integrated into a traditional adult weir was found to be an effective capture method to census the Louise-Catherine lakes smolt population.
2) A Canadian fan trap located below the Buskin Lake outlet was an effective capture method for biological data collection and enumeration of smolt.
3) The lower Buskin River smolt trap suspension and tethering system employed in 2011 resulted in high trap efficiencies and worked well in changing water levels and velocities.
4) Genetic mark–recapture techniques are a feasible method to estimate the proportion of sockeye salmon smolt emigrating from Buskin and Louise-Catherine lakes at a lower river trapping site when sampling protocols are observed.

RECOMMENDATIONS

If this project were to continue, the Louise-Catherine lakes population census should be counted using a Canadian fan trap integrated into a traditional adult weir. In order to estimate the Buskin Lake smolt population, a single Canadian fan trap located below the Buskin Lake outlet should be used to enumerate smolt, collect biological data, and conduct mark-recapture experiments, which in turn could be used to produce Buskin drainage sockeye salmon abundance estimates. A traditional dye-based mark–recapture experiment should not be used for several reasons, including sensitivity of smolt to dye, the possibility of unequal mixing, and because of concerns about the proximity of the Buskin Lake outlet trap to Buskin Lake, possibly resulting in the prolonged temporal dispersion of marked smolt into the lake, confounding recapture rates and associated estimates of trap efficiency. Rather, the use of coded-wire tags as a marking technique, described in Macdonald and Smith (1980), should be investigated as a method to release marked sockeye salmon fingerlings into Buskin Lake for subsequent recapture as emigrating smolt. This technique would allow mixing and little concern about loss of marks. With the incorporation of the above changes, it may be feasible to annually estimate the total seaward emigration of Buskin drainage sockeye salmon smolt. Time series of smolt abundance estimates could be used to forecast adult returns and refine the biological escapement goal.

ACKNOWLEDGEMENTS

The author appreciates the efforts of the field crew Amanda Bowers, Brandi Giroux, Danielle Ringer, Raye Ann Neustel, Kate Kimmel, and Scott Wandersee; the support, genetic analysis of smolt samples, and creation of tables by Tyler Dann of the ADF&G Gene Conservation Laboratory in Anchorage, Alaska; and the technical advice and support of Donn Tracy and Tyler Polum. The U.S. Fish and Wildlife Service, Office of Subsistence Management, provided $209,891 in funding support for this project through the Fisheries Resource Monitoring Program, under agreement number 70181-AJ036.

REFERENCES CITED

Allendorf, F. W., and S. R. Phelps. 1981. Use of allelic frequencies to describe population structure. Canadian Journal of Fisheries and Aquatic Sciences 38:1507-1514.

Bagenal, T. B., and F. W. Tesch. 1978. Age and growth. Pp. 101-136 [*In*] T. Bagenal, editor. Methods for assessment of fish production in fresh waters. IBP Handbook No. 3, Third edition. Blackwell Scientific Publications, London.

Brockwell, P. J., and R. A. Davis. 2002. Introduction to time series and forecasting. Springer Science + Business Media, New York, NY.

Carlson, S. R., L. G. Coggins, Jr., and C. O. Swanton. 1998. A simple stratified design for mark-recapture estimation of salmon smolt abundance. Alaska Fishery Research Bulletin 5(2):88-102. http://www.adfg.alaska.gov/FedAidpdfs/AFRB.05.2.088-102.pdf

Dann, T. H., C. Habicht, J. R. Jasper, H. A. Hoyt, A. W. Barclay, W. D. Templin, T. T. Baker, F. W. West, and L. F. Fair. 2009. Genetic stock composition of the commercial harvest of sockeye salmon in Bristol Bay, Alaska, 2006-2008. Alaska Department of Fish and Game, Fishery Manuscript Series No. 09-06, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/FMS09-06.pdf

Ginetz, R. M. J. 1977. A review of the Babine Lake development project 1961-1976. Environment Canada, Fish and Marine Service Technical Report Pac-T-77-6.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association 55:708-713.

Honnold, S. G., and S. Schrof. 2004. Stock assessment and restoration of the Afognak Lake sockeye salmon run. Fisheries Resource Monitoring Program. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fishery Information, Services Division, Final Report No. FIS 03-047, Anchorage.

INPFC (International North Pacific Fisheries Commission). 1963. Annual report, 1961. International North Pacific Fisheries Commission, Vancouver, British Columbia.

ITSM. 2005. ITSM, Professional version 7.3. B and D Enterprises, Inc. Northern California.

Jennings, G. B., K. Sundet, and A. E. Bingham. 2007. Participation, catch, and harvest in Alaska sport fisheries during 2004. Alaska Department of Fish and Game, Fishery Data Series No. 07-40, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds07-40.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2009a. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2005. Alaska Department of Fish and Game, Fishery Data Series No. 09-47, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/FDS09-47.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2009b. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2006. Alaska Department of Fish and Game, Fishery Data Series No. 09-54, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/FDS09-54.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2010a. 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. http://www.sf.adfg.state.ak.us/FedAidpdfs/Fds10-02.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2010b. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2008. Alaska Department of Fish and Game, Fishery Data Series No. 10-22, Anchorage. http://www.sf.adfg.state.ak.us/FedAidpdfs/FDS10-22.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2011a. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2009. Alaska Department of Fish and Game, Fishery Data Series No. 11-45, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FDS11-45

Jennings, G. B., K. Sundet, and A. E. Bingham. 2011b. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2010. Alaska Department of Fish and Game, Fishery Data Series No. 11-60, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FDS11-60

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. 2004. Participation, catch, and harvest in Alaska sport fisheries during 2001. Alaska Department of Fish and Game, Fishery Data Series No. 04-11, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-11.pdf

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. 2006a. Participation, catch, and harvest in Alaska sport fisheries during 2002. Alaska Department of Fish and Game, Fishery Data Series No. 06-34, Anchorage. http://www.sf.adfg.state.ak.us/FedAidpdfs/fds06-34.pdf

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. 2006b. Participation, catch, and harvest in Alaska sport fisheries during 2003. Alaska Department of Fish and Game, Fishery Data Series No. 06-44, Anchorage. http://www.sf.adfg.state.ak.us/FedAidpdfs/fds06-44.pdf

REFERENCES CITED (Continued)

Koenings, J. P., J. A. Edmundson, J. M. Edmundson, and G. B. Kyle. 1987. Limnology field and laboratory manual: methods for assessing aquatic production. Alaska Department of Fish and Game, Fisheries Rehabilitation, Enhancement, and Development Division Report 71 (available from: Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau).

Koo, T. S. Y. 1962. Studies of Alaska red salmon. University of Washington Press, Seattle.

Macdonald, P.D.M., and H.D. Smith. 1980. Mark-recapture estimation of salmon smolt runs. Biometrics 36:401-417.

Mosher, K. H. 1969. Identification of Pacific salmon and steelhead trout by scale characteristics. U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Circular 317.

Pollard, W. R., G. F. Hartman, C. Groot, and P. Edgell. 1997. Field identification of coastal juvenile salmonids. Harbour Publishing for the Federal Department of Fisheries and Oceans and Weyerhaeuser Ltd., Madeira Park, BC Canada.

Sagalkin, N. H., and S. G. Honnold. 2003. Evaluation of sockeye salmon smolt population estimate bias from single-site mark recapture experiments. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K03-40, Kodiak. http://www.sf.adfg.state.ak.us/FedAidPDFs/rir.4k.2003.40.pdf

Schmidt, J. S., and D. Evans. 2010. Stock assessment of sockeye salmon in the Buskin River, 2007-2009. Alaska Department of Fish and Game, Fishery Data Series No. 10-29, Anchorage. http://www.sf.adfg.state.ak.us/FedAidpdfs/FDS10-29.pdf

SYSTAT. 2011. MYSTAT for Windows, Version 12.2. SYSTAT Software Inc. Richmond, CA

Thompson, S. K. 1987. Sample size for estimating multinomial proportions. The American Statistician 41(1):42-46.

Tiernan, A. R. 2011. Kodiak Management Area weir descriptions and salmon escapement report, 2011. Alaska Department of Fish and Game, Fishery Management Report No. 11-73, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FMR11-72

Todd, G. L. 1994. A lightweight, inclined-plane trap for sampling salmon smolts in rivers. Alaska Fishery Research Bulletin 1(2):168-175. http://www.adfg.alaska.gov/FedAidpdfs/AFRB.01.2.168-175.pdf

Waples, R. S. 1990. Conservation genetics of Pacific salmon. III. Estimating effective population size. Journal of Heredity 81(4):277-289.

TABLES

Table 1.–Buskin River drainage sockeye salmon estimated escapements, harvests, and total runs, 2001–2011.

	Escapement		Harvest				
Year	Buskin Lake	Louise-Catherine	Commerical[a]	Subsistence[b]	Sport[c]	Total	Total Run
2001	20,552		0	10,260	866	11,126	31,678
2002	16,479	3,581	0	13,333	1,903	15,236	35,296
2003	23,870	4,488	6	10,651	3,017	13,674	42,032
2004	22,023	2,086	1,098	9,421	1,379	11,898	36,007
2005	15,468	2,028	0	8,239	1,540	9,779	27,275
2006	17,734	4,586	6	7,577	1,577	9,160	31,480
2007	16,502	1,676	30	11,151	1,509	12,690	30,868
2008	5,900	833	0	2,664	1,160	3,824	10,557
2009	7,757	992	45	1,883	687	2,615	11,364
2010	9,800	421	0	1,514	332	1,846	13,581
2011	11,982	360	38	1,764	na	na	14,144
Average 2001–2009	16,254	2,534	132	8,353	1,515	10,000	28,506

[a] Data from ADF&G, Division of Commerical Fisheries, Kodiak, Statistical fishing sections 259-22 and 259-26 (Buskin River Section).

[b] Data from ADF&G, Division of Commerical Fisheries, Kodiak, subsistence catch database. Data for 2011 are preliminary.

[c] Data from ADF&G, Statewide Harvest Survey.

Table 2.–Sockeye salmon smolt counts (daily and cumulative), numbers of age-weight-length samples, and mark–recapture (genetic sample) counts from trapping on the Buskin River drainage, 2010.

	Louise-Catherine lakes trap			Buskin Lake trap[a]			Lower Buskin River trap		
	Count		AWL sample	Count		AWL sample	Count		Genetic sample
Date	Daily	Cum.	cum.	Daily	Cum.	cum.	Daily	Cum.	cum.
28 Apr	2	2	0						
29 Apr	0	2	0						
30 Apr	0	2	0						
1 May	0	2	0						
2 May	0	2	0						
3 May	0	2	0						
4 May	0	2	0						
5 May	1	3	0	0	0	0			
6 May	0	3	0	0	0	0			
7 May	0	3	0	0	0	0			
8 May	0	3	0	0	0	0			
9 May	0	3	0	0	0	0			
10 May	0	3	0						
11 May	0	3	0						
12 May	0	3	0				0	0	0
13 May	0	3	0				0	0	0
14 May	0	3	0				0	0	0
15 May	5	8	0				0	0	0
16 May	4	12	0				0	0	0
17 May	10	22	10				0	0	0
18 May	4	26	14				0	0	0
19 May	17	43	27				0	0	0
20 May	9	52	35				0	0	0
21 May	1	53	35				0	0	0
22 May	0	53	35				0	0	0
23 May	4	57	36	0	0	0	0	0	0
24 May	3	60	36	0	0	0	1	1	1
25 May	19	79	45	0	0	0	6	7	5
26 May	6	85	51	1	1	0	52	59	25
27 May	92	177	101	65	66	0	65	124	48
28 May	54	231	128	206	272	40	54	178	63
29 May	161	392	128	1,290	1,562	40	141	319	63
30 May	164	556	128	153	1,715	40	0	319	63

-continued-

Table 2.–Part 2 of 2.

	Louise-Catherine lakes trap			Buskin Lake trap[a]			Lower Buskin River trap		
	Count		AWL sample	Count		AWL sample	Count		Genetic sample
Date	Daily	Cum.	cum.	Daily	Cum.	cum.	Daily	Cum.	cum.
31 May	165	721	151	4	1,719	80	39	358	63
1 Jun	598	1,319	151	45	1,764	80	13	371	64
2 Jun	1,486	2,805	191	13	1,777	80	4	375	64
3 Jun	263	3,068	191	4	1,781	80	61	436	65
4 Jun	231	3,299	227	1	1,782	80	172	608	75
5 Jun	473	3,772	227	272	2,054	80	120	728	75
6 Jun	208	3,980	227	127	2,181	80	247	975	75
7 Jun	578	4,558	267	47	2,228	80	25	1,000	75
8 Jun	270	4,828	267	0	2,228	80	2	1,002	75
9 Jun	944	5,772	305	228	2,456	120	41	1,043	77
10 Jun	330	6,102	305	55	2,511	120	0	1,043	77
11 Jun	822	6,924	305	1,858	4,369	160	76	1,119	78
12 Jun	449	7,373	345	207	4,576	160	15	1,134	78
13 Jun	678	8,051	345	152	4,728	160	12	1,146	78
14 Jun	176	8,227	385	40	4,768	200	27	1,173	81
15 Jun	25	8,252	385	131	4,899	200	8	1,181	89
16 Jun	13	8,265	385	14	4,913	200	4	1,185	90
17 Jun	242	8,507	418	82	4,995	240	9	1,194	97
18 Jun	33	8,540	451	44	5,039	265	8	1,202	105
19 Jun	81	8,621	451	120	5,159	265	0	1,202	105
20 Jun	230	8,851	451	99	5,258	265	0	1,202	105
21 Jun	132	8,983	451	133	5,391	265	15	1,217	117
22 Jun	140	9,123	491	6	5,397	265	9	1,226	120
23 Jun	21	9,144	491	43	5,440	305	5	1,231	124
24 Jun	13	9,157	502	6	5,446	305	0	1,231	124
25 Jun	178	9,335	542	43	5,489	345	5	1,236	129
26 Jun	0	9,335	542	21	5,510	345	1	1,237	129
27 Jun	0	9,335	542	10	5,520	345	0	1,237	129
28 Jun	50	9,385	582	13	5,533	373	0	1,237	129
29 Jun	4	9,389	582	28	5,561	373	3	1,240	129

[a] Lower Buskin Lake trap inoperable due to high water 25May and from 30 May–4 June; values were estimated.

Table 3.–Sample age composition of Buskin and Louise-Catherine lakes sockeye salmon smolt sampled in each statistical week, 2010.

		Buskin Lake outlet trap								Louise-Catherine lakes outlet trap							
			Freshwater age								Freshwater age						
			1		2		3				1		2		3		
Sample week	Calendar dates	Number sampled	No.	%	No.	%	No.	%	Total aged	Number sampled	No.	%	No.	%	No.	%	Total aged
21	17–23 May	0	-	-	-	-	-	-	-	36	0	0.0	36	100.0	0	0.0	36
22	24–30 May	40	0	0.0	40	100.0	0	0.0	40	92	0	0.0	91	100.0	0	0.0	91
23	31 May–6 June	40	0	0.0	35	87.5	5	12.5	40	99	15	15.2	82	82.8	2	2.0	99
24	7–13 June	80	31	40.8	45	59.2	0	0.0	76	118	46	39.0	71	60.2	1	0.8	118
25	14–20 June	105	75	71.4	30	28.6	0	0.0	105	106	56	52.8	50	47.2	0	0.0	106
26	21–27 June	80	76	96.2	3	3.8	0	0.0	79	91	76	96.2	15	19.0	0	0.0	91
27	28 –30 June	28	28	100.0	0	0.0	0	0.0	28	40	36	90.0	4	10.0	0	0.0	40

Table 4.–Mean weight, length, and condition factor of Buskin and Louise-Catherine lakes sockeye salmon smolt samples by freshwater age, 2010.

Age	Sample location[a]	Sample size	Weight (g) Mean	Weight (g) Standard error	Length (mm) Mean	Length (mm) Standard error	Condition (K) Mean	Condition (K) Standard error
1	Buskin	210	4.5	0.07	77.6	0.41	0.95	0.009
	Louise	229	11.5	0.12	106.1	0.41	0.96	0.055
2	Buskin	153	6.7	0.10	87.4	0.49	1.00	0.011
	Louise	349	12.0	0.11	108.9	0.32	0.93	0.007
3	Buskin	5	8.7	1.03	91.2	3.64	1.12	0.036
	Louise	3	13.7	0.93	117.0	2.08	0.85	0.030

[a] "Buskin" = Buskin Lake trap; "Louise" = Louise-Cathrine lakes trap.

Table 5.–Louise-Catherine lakes sockeye salmon smolt emigration estimated age composition based on percents by freshwater age class, 2010 and 2011.

Statistical Week	Calender dates	2010 Age 1	2010 Age 2	2010 Age 3	2010 Total	2011 Age 1	2011 Age 2	2011 Age 3	2011 Total
18	26 Apr–2 May	0	2	0	2	3	1	0	4
19	3 May–9 May	0	1	0	1	181	87	0	268
20	10 May–16 May	0	9	0	9	1,897	286	0	2,183
21	17 May–23 May	0	45	0	45	4,885	2,050	181	7,116
22	24 May–30 May	0	499	0	499	4,812	706	0	5,518
23	31 May– 6 Jun	519	2,836	69	3,424	6,704	894	64	7,662
24	7–13 Jun	1,587	2,450	35	4,071	4,304	523	0	4,827
25	14 Jun–20 Jun	423	377	0	800	8,100	0	0	8,100
26	21 Jun–27 Jun	404	80	0	484	8,076	278	0	8,354
27	28 Jun–30 Jun	49	5	0	54	1,744	45	0	1,789
	Total	2,981	6,304	104	9,389	40,706	4,870	245	45,821

Table 6.–Estimates of stock composition, 90% credibility intervals, and standard deviations for mixtures of 95 known-origin smolt removed from the Buskin River baseline populations of sockeye salmon that comprise each reporting group (i.e., 100% proof tests) using the program *BAYES* with a flat prior. Correct allocations are in bold.

		Reporting Group	
Reporting Group		Buskin Lake	Louise-Catherine lakes
Buskin Lake			
	Proportion	**0.99**	0.01
	Lower 90% CI	0.98	0
	Upper 90% CI	1	0.02
	SD	0.01	0.01
Louise-Catherine lakes			
	Proportion	0.01	**0.99**
	Lower 90% CI	0	0.97
	Upper 90% CI	0.04	1
	SD	0.01	0.01

Table 7.–Estimates of stock composition, 90% credibility intervals, standard deviations, and sample size for a sample of Buskin River smolt using the program BAYES with a flat prior, 2010.

		Reporting Group	
Sample[a]		Buskin Lake	Louise-Catherine lakes
Lower Buskin River smolt	Proportion	1	0
	Lower 90% CI	0.98	0
	Upper 90% CI	1	0.02
	SD	0.01	0.01

[a] *n* = 119.

Table 8.–Sockeye salmon smolt counts (daily and cumulative), number of age-weight-length samples, and mark–recapture (genetic sample) counts from trapping on the Buskin River drainage, 2011.

	Louise-Catherine lakes trap[a]			Buskin Lake trap[b]			Lower Buskin River trap[c]		
	Count		AWL Sample	Count		AWL Sample	Count		Genetic Sample
Date	Daily	Cum.	Cum.	Daily	Cum.	Cum.	Daily	Cum.	Cum.
25 Apr	0	0	0						
26 Apr	1	1	0						
27 Apr	0	1	0						
28 Apr	0	1	0	0	0	0			
29 Apr	1	2	0	0	0	0			
30 Apr	1	3	0	5	5	0			
1 May	0	3	0	1	6	0			
2 May	1	4	0	0	6	0			
3 May	1	5	0	0	6	0	0	0	0
4 May	6	11	0	0	6	0	0	0	0
5 May	4	15	0	0	6	0	0	0	0
6 May	8	23	0	0	6	0	0	0	0
7 May	30	53	0	0	6	0	0	0	0
8 May	43	96	0	0	6	0	9	9	0
9 May	176	272	40	4	10	0	2	11	0
10 May	184	456	40	7	17	0	4	15	0
11 May	189	645	80	14	31	0	10	25	5
12 May	163	808	80	9	40	0	11	36	5
13 May	125	933	120	3	43	0	7	43	12
14 May	283	1,216	143	65	108	0	34	77	12
15 May	549	1,765	185	17	125	0	17	94	12
16 May	690	2,455	185	25	150	30	73	167	12
17 May	1,308	3,763	185	32	182	30	94	261	12
18 May	673	4,436	225	46	228	30	119	380	12
19 May	678	5,114	225	66	294	30	153	533	12
20 May	688	5,802	265	93	387	30	196	729	12
21 May	1,738	7,540	265	132	519	30	251	980	12
22 May	1,170	8,710	305	187	706	30	321	1,301	12
23 May	861	9,571	305	266	972	30	410	1,711	12
24 May	1,247	10,818	350	378	1,350	30	525	2,236	12
25 May	547	11,365	350	537	1,887	30	671	2,907	12
26 May	635	12,000	350	763	2,650	30	859	3,766	12
27 May	723	12,723	390	155	2,805	50	1,099	4,865	12
28 May	666	13,389	390	1,302	4,107	50	1,406	6,271	12
29 May	503	13,892	430	375	4,482	90	1,799	8,070	17
30 May	1,197	15,089	430	535	5,017	90	945	9,015	27

-continued-

Table 8.–Part 2 of 2.

	Louise-Catherine lakes trap[a]			Buskin Lake trap[b]			Lower Buskin River trap[c]		
	Count		AWL Sample	Count		AWL Sample	Count		Genetic Sample
Date	Daily	Cum.	Cum.	Daily	Cum.	Cum.	Daily	Cum.	Cum.
31 May	1,714	16,803	430	743	5,760	90	91	9,106	37
1 Jun	1,313	18,116	470	1,566	7,326	135	631	9,737	37
2 Jun	1,742	19,858	470	700	8,026	135	118	9,855	37
3 Jun	584	20,442	510	1,095	9,121	175	107	9,962	37
4 Jun	1,031	21,473	510	3,856	12,977	175	2,995	12,957	46
5 Jun	615	22,088	550	4,035	17,012	215	1,205	14,162	52
6 Jun	663	22,751	550	256	17,268	215	157	14,319	52
7 Jun	971	23,722	550	1,432	18,700	215	320	14,639	52
8 Jun	356	24,078	590	2,009	20,709	255	813	15,452	52
9 Jun	528	24,606	590	942	21,651	255	1,314	16,766	62
10 Jun	498	25,104	625	1,416	23,067	295	616	17,382	71
11 Jun	628	25,732	625	1,651	24,718	295	161	17,543	71
12 Jun	579	26,311	670	1,559	26,277	335	132	17,675	71
13 Jun	1,267	27,578	670	2,690	28,967	335	66	17,741	71
14 Jun	1,731	29,309	670	4,792	33,759	335	1,159	18,900	130
15 Jun	1,541	30,850	710	525	34,284	374	896	19,796	178
16 Jun	925	31,775	710	592	34,876	374	235	20,031	189
17 Jun	474	32,249	710	2,091	36,967	414	312	20,343	200
18 Jun	1,613	33,862	710	1,262	38,229	414	666	21,009	240
19 Jun	616	34,478	770	1,513	39,742	454	510	21,519	275
20 Jun	1,200	35,678	770	1,083	40,825	454	491	22,010	307
21 Jun	2,457	38,135	770	1,564	42,389	454	675	22,685	342
22 Jun	1,535	39,670	810	964	43,353	494	487	23,172	377
23 Jun	466	40,136	810	470	43,823	494	666	23,838	387
24 Jun	1,287	41,423	850	306	44,129	534	574	24,412	395
25 Jun	756	42,179	850	59	44,188	534	281	24,693	397
26 Jun	1,464	43,643	890	98	44,286	574	480	25,173	400
27 Jun	389	44,032	890	251	44,537	574	765	25,938	400
28 Jun	488	44,520	890	159	44,696	574	461	26,399	400
29 Jun	1,301	45,821	930	61	44,757	614	214	26,613	400

[a] Trap inoperable due to high water from 0800 hours on 23 May to 2200 on 24 May. Values are estimated for this time period.

[b] Trap inoperable due to high water from 0100 on 17 May to 2220 on 26 May; values estimated.

[c] Trap inoperable due to high water from 1700 on 16 May to 2250 on 29 May; values estimated.

Table 9.–Sample age composition of Buskin and Louise-Catherine lakes sockeye salmon smolt sampled in each statistical week, 2011.

		Buskin River trap								Louise-Catherine lakes trap							
			Freshwater age								Freshwater age						
			1		2		3				1		2		3		
Sample week	Calendar dates	Number sampled	No.	%	No.	%	No.	%	Total aged	Number sampled	No.	%	No.	%	No.	%	Total aged
19	3–9 May	0	-	-	-	-	-	-	-	40	27	67.5	13	32.5	0	0.0	40
20	10–16 May	30	17	56.7	13	43.3	0	0.0	30	145	126	86.9	19	13.1	0	0.0	145
21	17–23 May	0	-	-	-	-	-	-	-	120	81	68.6	34	28.8	3	2.5	118
22	24–30 May	60	33	55.0	27	45.0	0	0.0	60	125	109	87.2	16	12.8	0	0.0	125
23	31 May–6 June	125	78	62.4	46	36.8	1	0.8	125	120	105	87.5	14	11.7	1	0.8	120
24	7–13 June	120	83	69.2	34	28.3	3	2.5	120	120	107	89.2	13	10.8	0	0.0	120
25	14–20 June	119	99	83.2	20	16.8	0	0.0	119	100	100	100.0	0	0.0	0	0.0	100
26	21–27 June	120	103	85.8	17	14.2	0	0.0	120	120	116	96.7	4	3.3	0	0.0	120
27	28– 30 June	40	37	92.5	3	7.5	0	0.0	40	40	39	97.5	1	2.5	0	0.0	40

Table 10.–Mean weight, length, and condition factor of Buskin and Louise-Catherine lakes sockeye salmon smolt samples by freshwater age, 2011.

			Weight (g)		Length (mm)		Condition (K)	
Age	Sample Location[a]	Sample Size	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
1	Buskin	449	4.6	0.07	81.2	0.31	0.84	0.005
	Louise	766	4.0	0.07	79.2	0.31	0.78	0.005
2	Buskin	153	9.1	0.74	99.7	1.28	0.85	0.007
	Louise	104	12.9	0.51	115.9	1.47	0.79	0.017
3	Buskin	4	15.0	1.30	123.0	3.39	0.81	0.067
	Louise	3	17.8	0.06	131.7	2.19	0.79	0.038

[a] "Buskin" = Buskin Lake trap; "Louise" = Louise-Cathrine lakes trap.

Table 11.–Numbers of individuals assigned, average assignment probabilities, and range of assignment probabilities for the 2011 sample of Buskin River smolt using the program BAYES with a flat prior.

		Reporting Group	
Sample[a]		Buskin Lake	Louise-Catherine lakes
2011 smolt	Number of individuals assigned	151	105
	Average assignment probabilities	0.99	0.99
	Range of assignment probabilities	0.85–1	0.84–1

[a] $n = 256$.

FIGURES

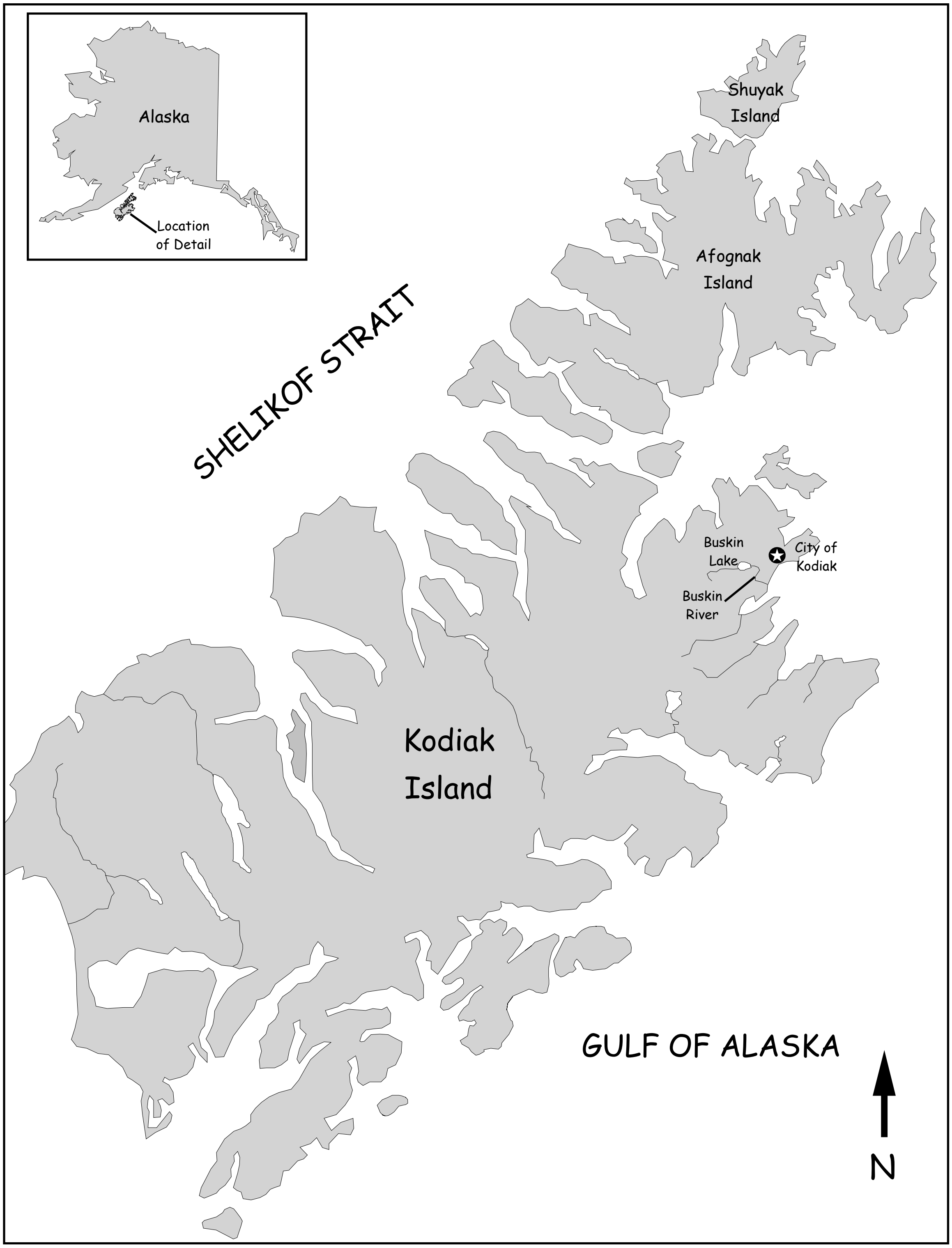

Figure 1.–Map of Kodiak Island showing the Buskin River drainage.

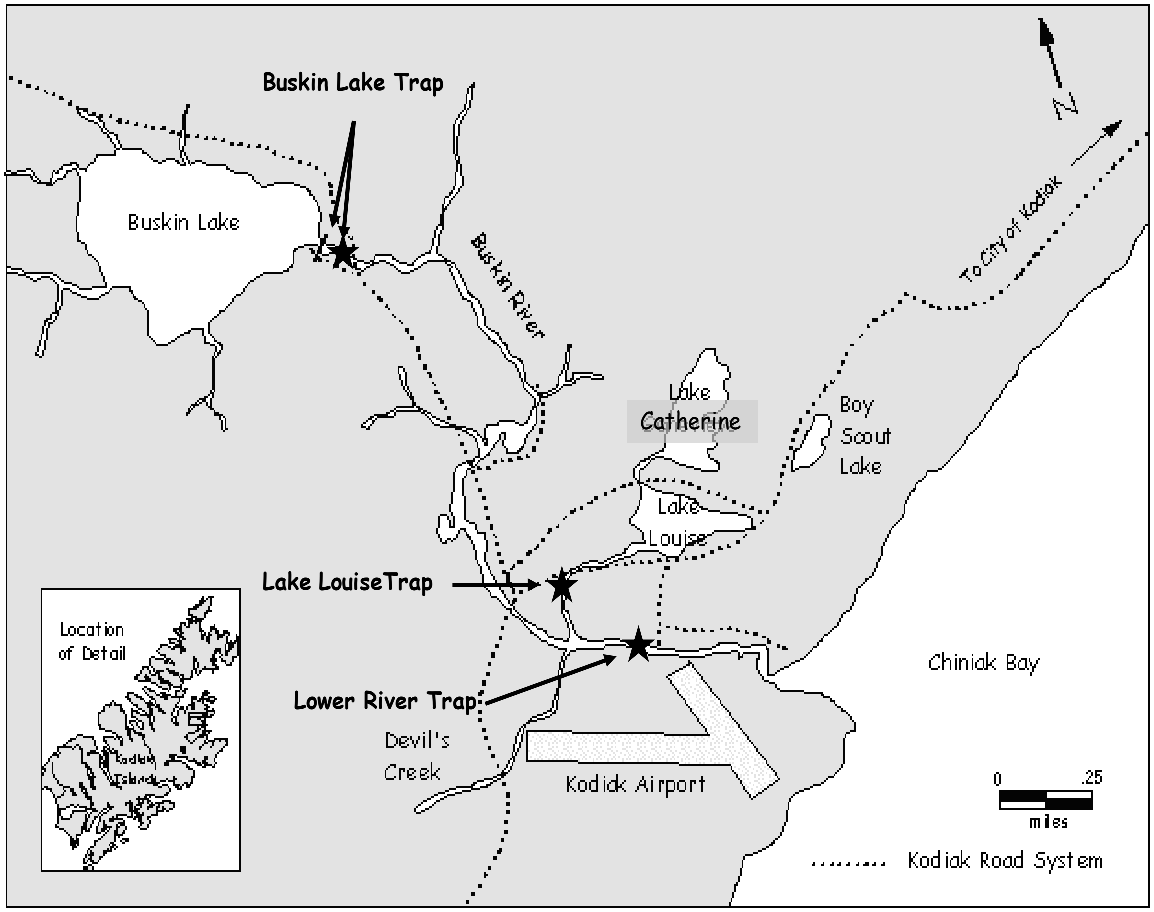

Figure 2.–Locations of Buskin Lake outlet, Louise-Catherine lakes tributary (Lake Louise) and lower Buskin River (Lower River) smolt traps on the Buskin River drainage, 2010–2011.

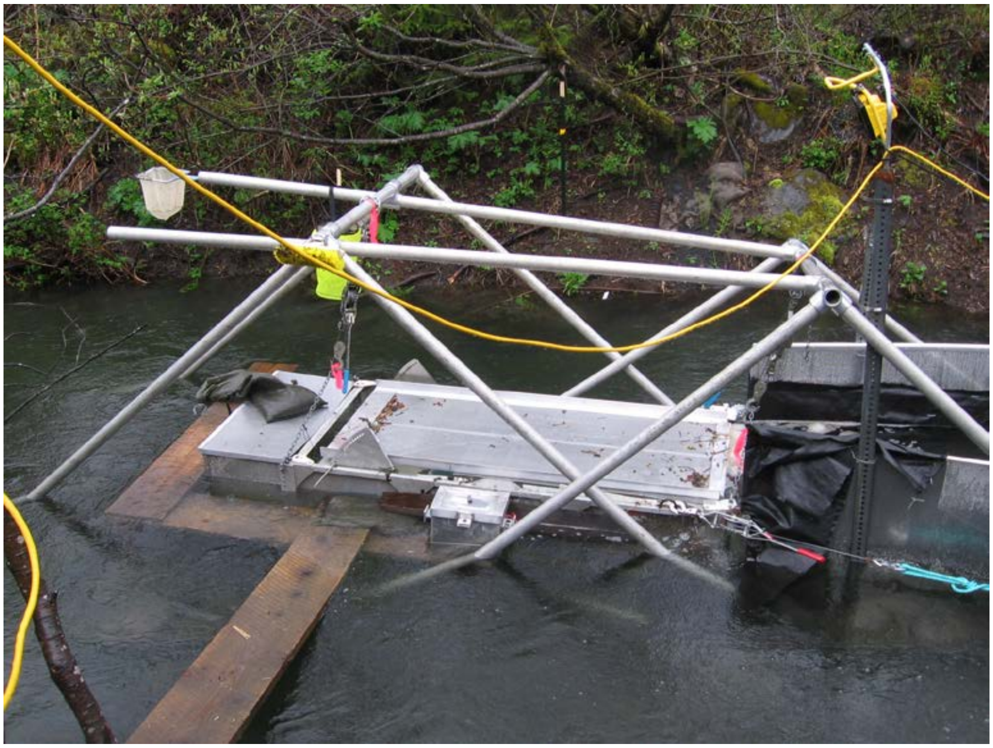

Figure 3.–Louise-Catherine lakes tributary inclined plane trap integrated into weir structure, 2010.

Figure 4.–Incline plane trap design with apron and attached live box, used for Louise-Catherine lakes tributary and Buskin Lake outlet, 2010.

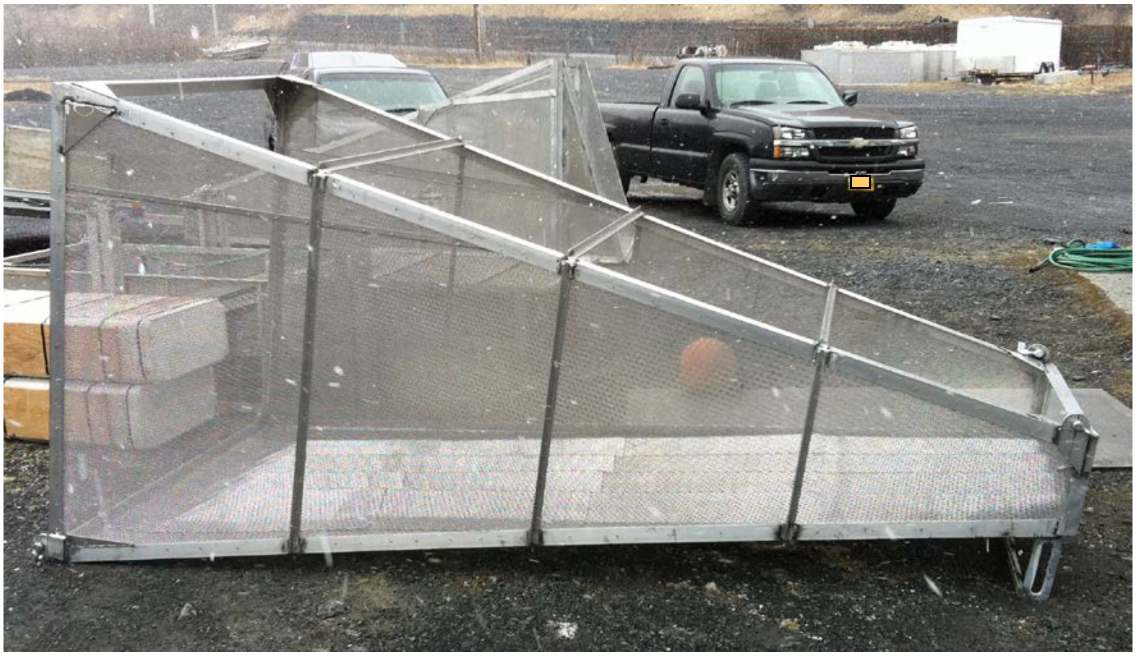

Figure 5.–Canadian fan trap design installed at Buskin Lake outlet and Louise-Catherine lakes tributary, 2011.

Figure 6.–Installation of Canadian fan trap in Louise-Catherine lakes tributary, with live box on far river bank, 2011.

Figure 7.–Buskin Lake outlet reconfigured trap design and location during high water, 2010.

Figure 8.–Buskin Lake outlet trap submerged during high water, note holding live box in forefront, 2011.

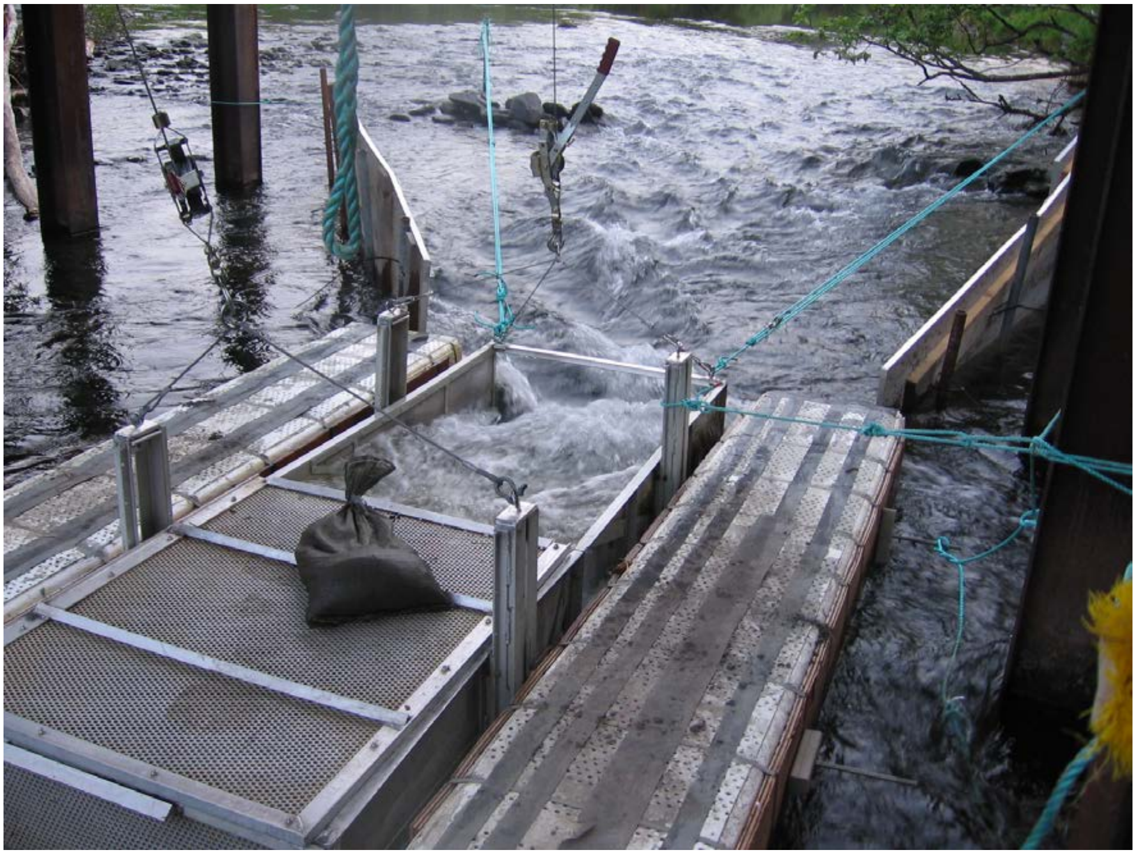

Figure 9.–Lower Buskin River trap, 2011. A very similar design was utilized in 2010.

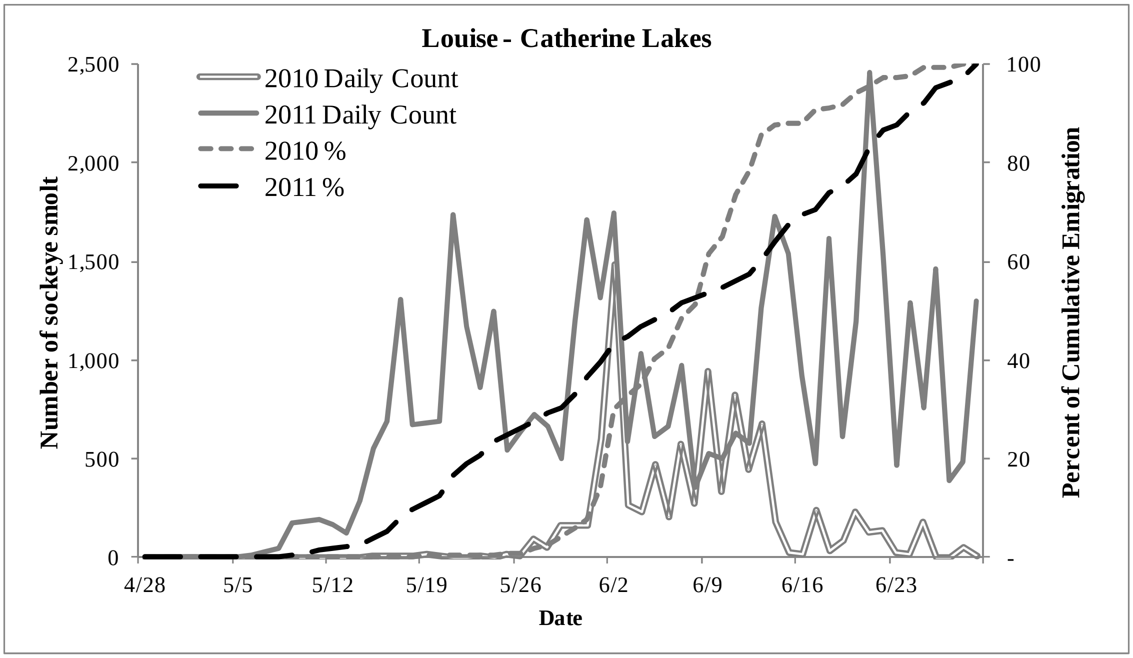

Figure 10.–Daily and cumulative counts by day of sockeye salmon smolt, Louise-Catherine lakes tributary trap, 2010 and 2011.

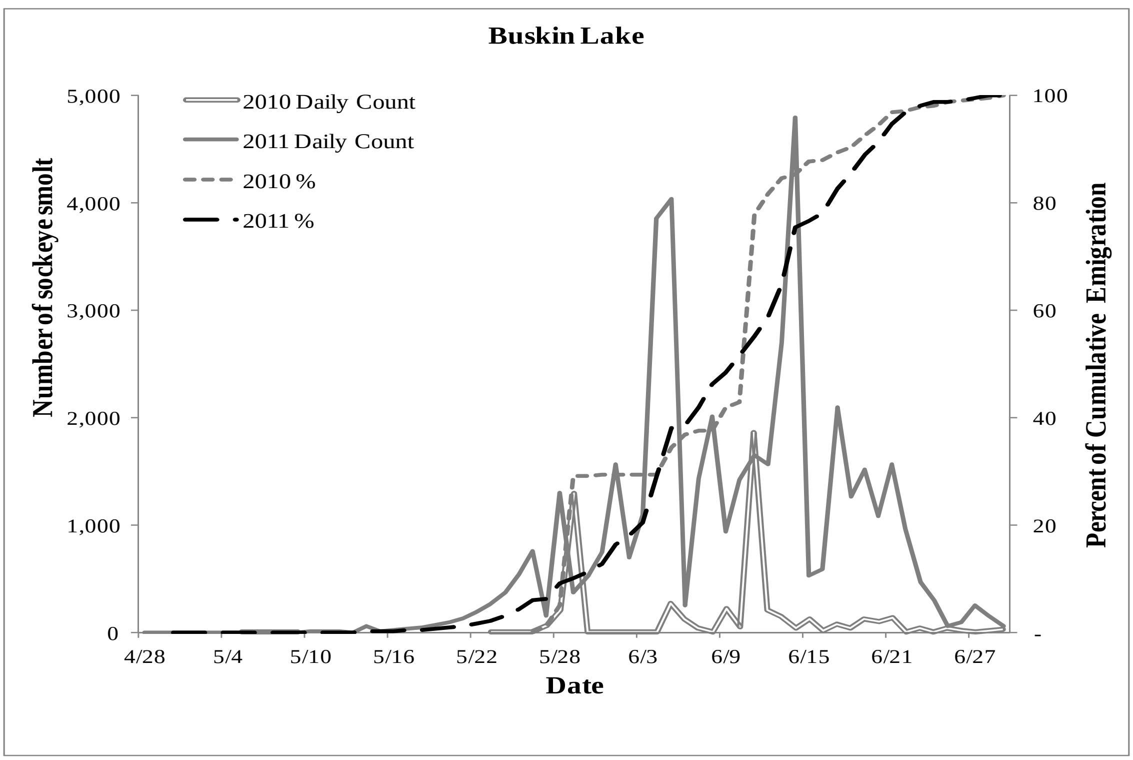

Figure 11.–Daily and cumulative counts by day of sockeye salmon smolt, Buskin Lake outlet trap, 2010 and 2011.

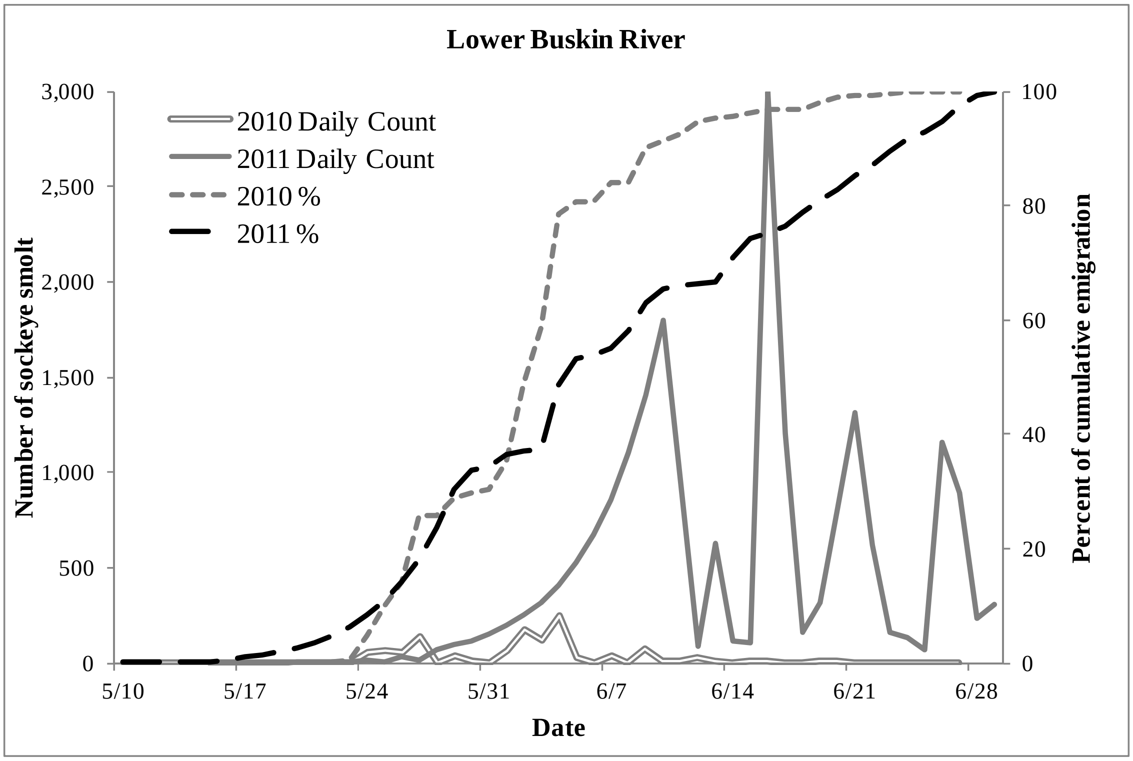

Figure 12.–Daily and cumulative counts by day of sockeye salmon smolt, lower Buskin River trap, 2010 and 2011

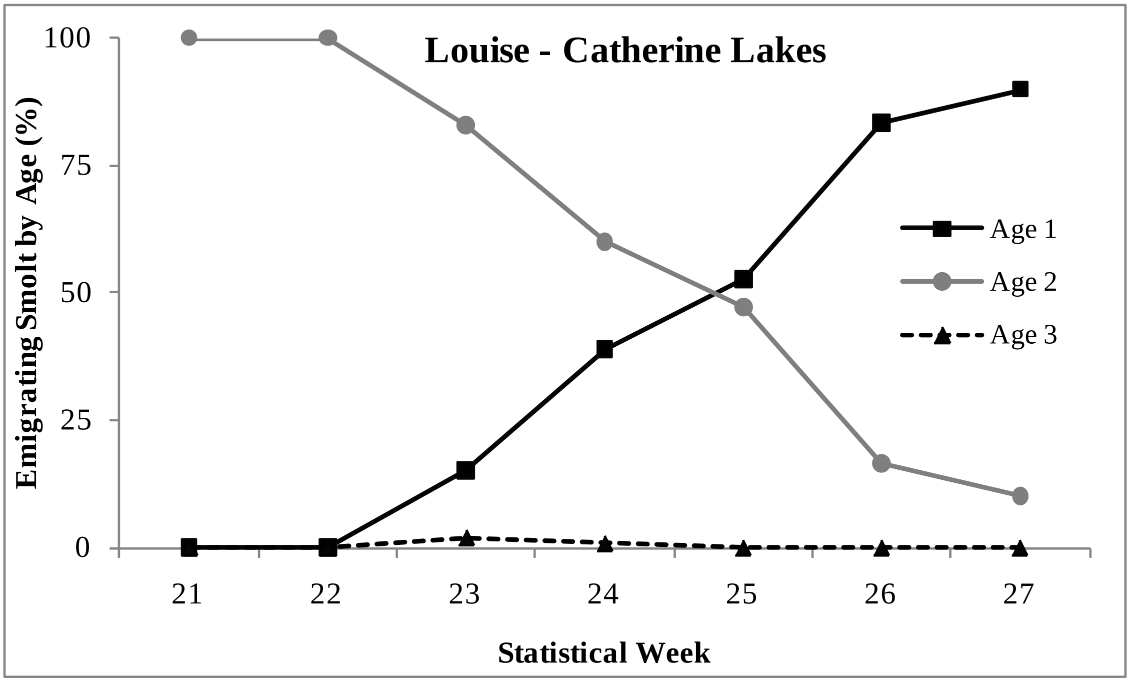

Figure 13.–Louise-Catherine lakes sockeye salmon smolt emigration by age class and statistical week, 2010.

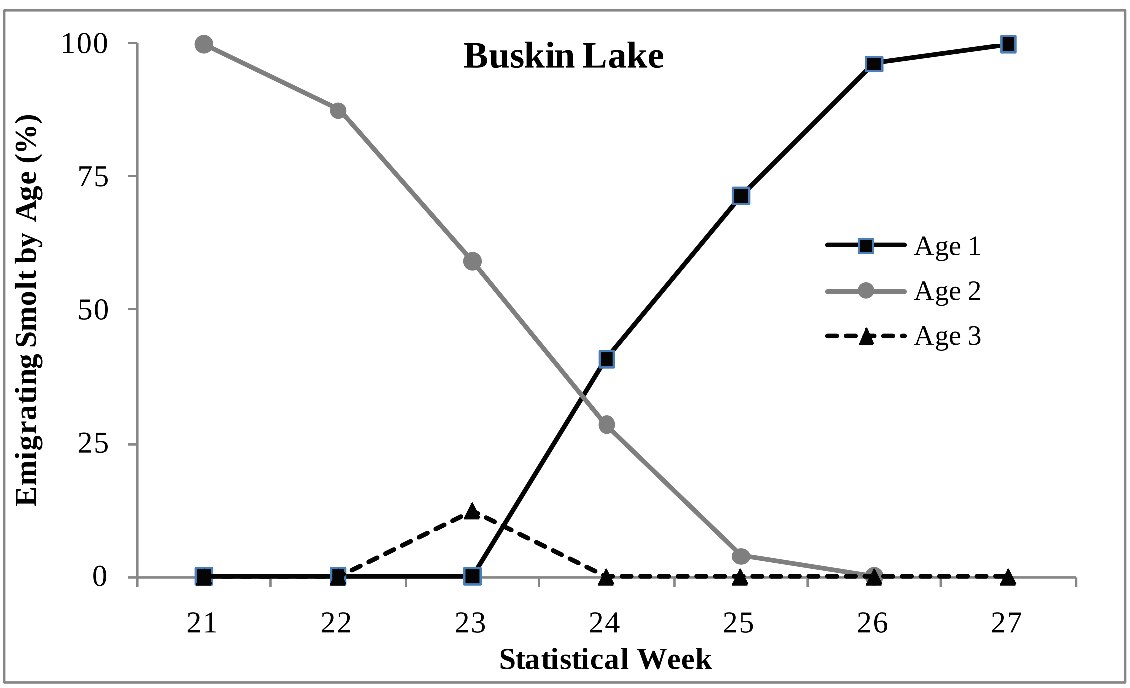

Figure 14.–Buskin Lake sockeye salmon smolt emigration by age class and statistical week, 2010.

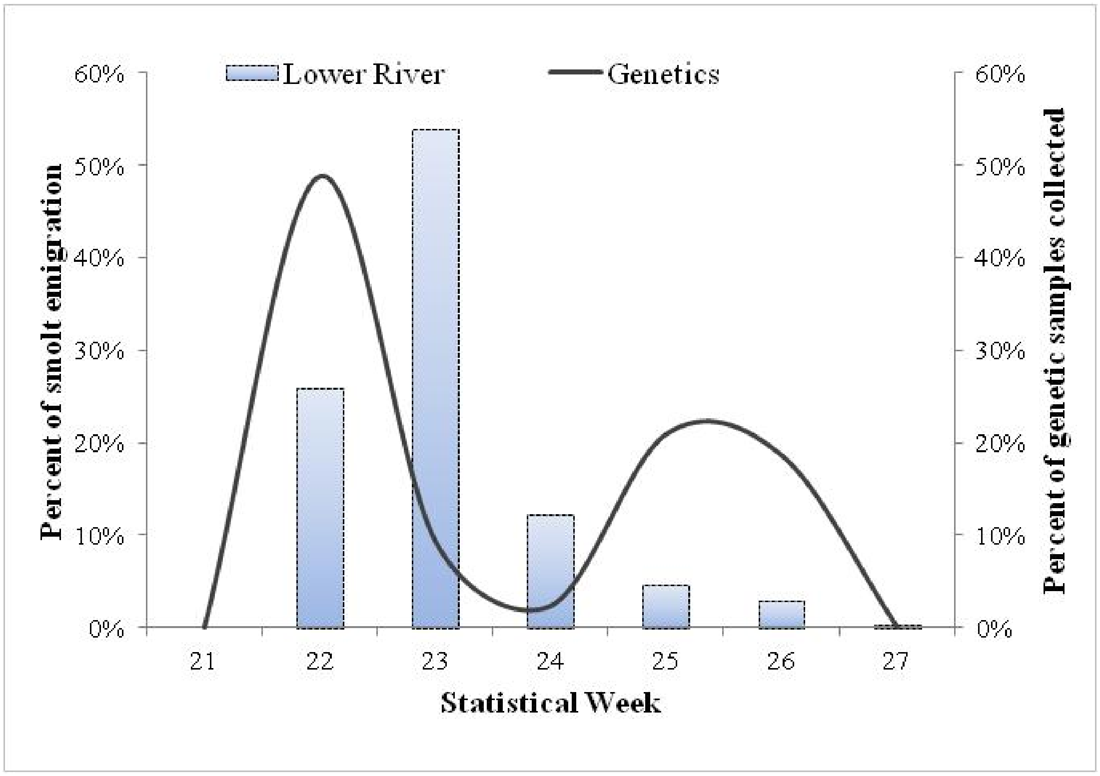

Figure 15.–Percent of smolt emigration estimated for the lower Buskin River trap by statistical week compared to percent of genetic samples collected by statistical week, 2010.

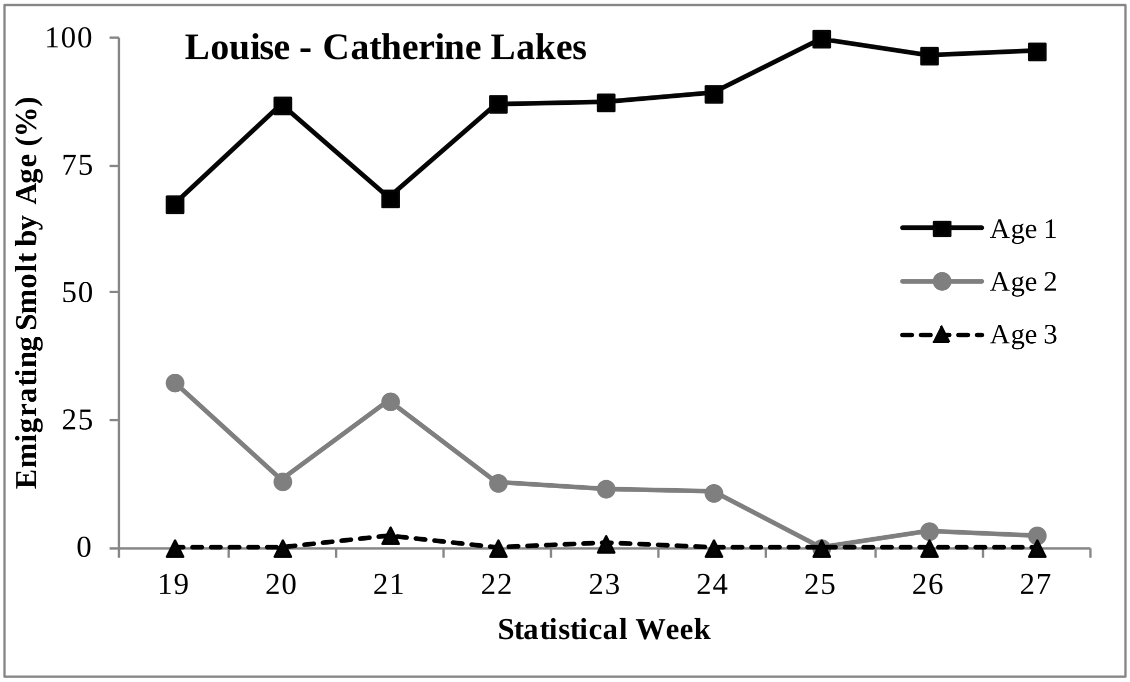

Figure 16.–Louise-Catherine lakes sockeye salmon smolt emigration by age class and statistical week, 2011.

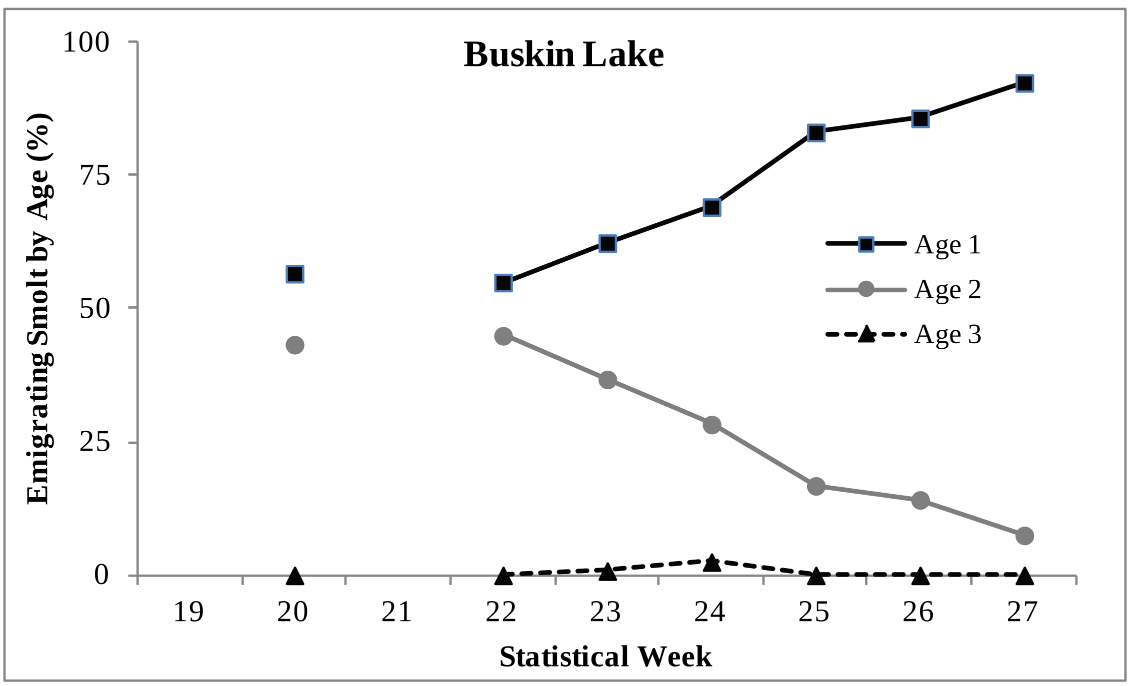

Figure 17.–Buskin Lake sockeye salmon smolt emigration estimated for the lower Buskin River trap by age class and statistical week, 2011.

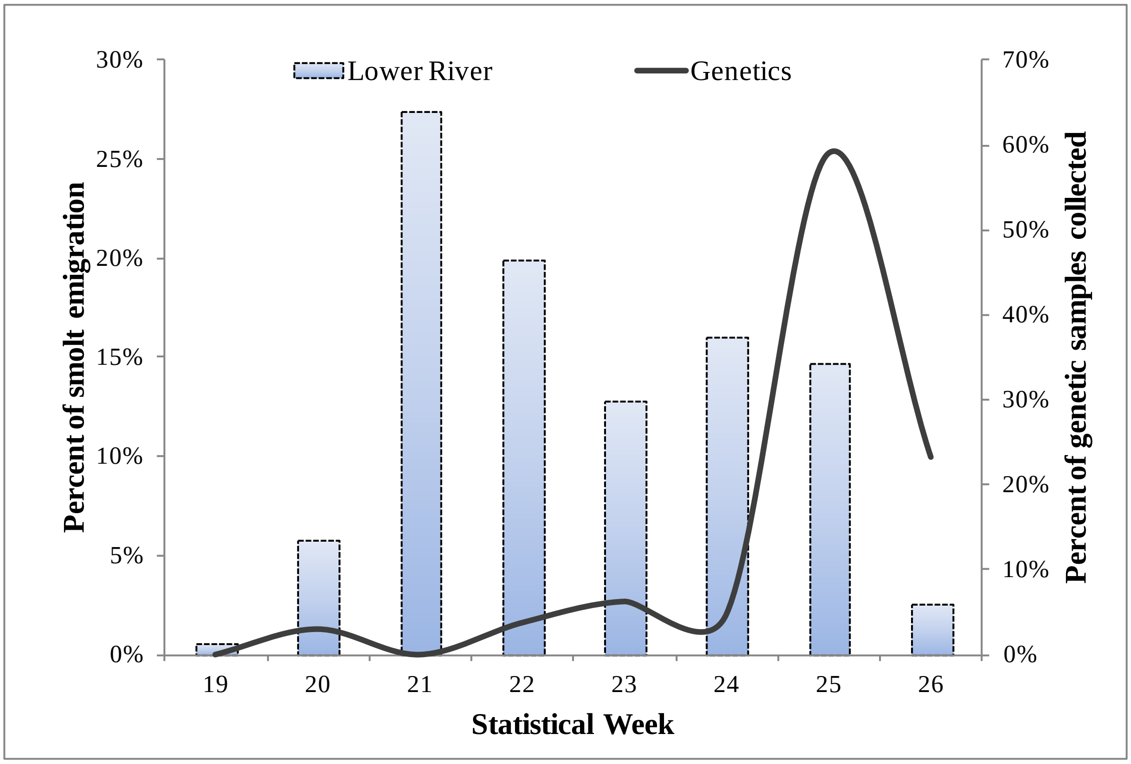

Figure 18.–Percent of smolt emigration by statistical week compared to percent of genetic samples collected by statistical week, 2011.

APPENDIX A: WEIGHT, LENGTH, AND CONDITION AT AGE FOR BUSKIN LAKE OUTLET AND LOUISE-CATHERINE LAKES TRIBUTARY SMOLT

Appendix A1.–Mean weight, length, and condition factor of Buskin and Louise-Catherine lakes sockeye salmon smolt samples by freshwater age and statistical week, 2010.

				Weight (g)		Length (mm)		Condition (K)	
Age	Statistical week	Sample location	Sample size	Mean	Standard error	Mean	Standard error	Mean	Standard error
1	21	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
1	22	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
1	23	Buskin	0	-	-	-	-	-	-
		Louise	15	10.4	0.42	102.3	1.44	0.96	0.020
1	24	Buskin	31	4.3	0.30	75.8	1.48	0.97	0.028
		Louise	46	11.1	0.19	104.1	0.64	0.98	0.009
1	25	Buskin	75	4.2	0.10	74.4	0.54	1.02	0.013
		Louise	56	10.9	0.23	103.8	0.95	0.97	0.013
1	26	Buskin	76	4.8	0.08	79.7	0.48	0.87	0.032
		Louise	76	11.8	0.21	107.3	0.65	0.96	0.015
1	27	Buskin	28	4.5	0.05	82.4	0.81	0.80	0.022
		Louise	36	12.8	0.28	111.5	0.71	0.09	0.015
	Age 1 total	Buskin	210	4.5	0.07	77.6	0.41	0.95	0.009
		Louise	229	11.5	0.12	106.1	0.41	0.96	0.007
2	21	Buskin	0	-	-	-	-	-	-
		Louise	36	9.7	0.31	110.1	1.04	0.73	0.020
2	22	Buskin	40	6.6	0.15	90.1	0.87	0.90	0.013
		Louise	91	13.3	0.17	112.4	0.44	0.93	0.008
2	23	Buskin	35	7.4	0.21	86.2	0.94	1.16	0.015
		Louise	82	12.4	0.26	108.8	0.67	0.96	0.015
2	24	Buskin	45	6.4	0.21	87.4	0.91	0.95	0.017
		Louise	71	11.2	0.17	105.2	0.60	0.96	0.010
2	25	Buskin	30	6.3	0.22	85.0	1.15	1.03	0.021
		Louise	50	11.1	0.15	105.7	0.66	0.95	0.013
2	26	Buskin	3	6.4	0.15	90.0	1.15	0.87	0.032
		Louise	15	13.6	0.45	112.2	0.62	0.96	0.031
2	27	Buskin	0	-	-	-	-	-	-
		Louise	4	14.2	0.79	113.5	1.32	0.97	0.027
	Age 2 total	Buskin	153	6.7	0.10	87.4	0.49	1.00	0.011
		Louise	349	12.0	0.11	108.9	0.32	0.93	0.007

-continued-

Appendix A1.–Part 2 of 2.

Age	Statistical week	Sample location	Sample size	Weight (g) Mean	Weight (g) Standard error	Length (mm) Mean	Length (mm) Standard error	Condition (K) Mean	Condition (K) Standard error
3	21	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
3	22	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
3	23	Buskin	5	8.7	1.03	91.2	3.64	1.12	0.036
		Louise	2	12.8	0.40	115.0	1.00	0.84	0.048
3	24	Buskin	0	-	-	-	-	-	-
		Louise	1	15.5	0.00	121.0	0.00	0.87	0.000
3	25	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
3	26	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
3	27	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
	Age 3 total	Buskin	5	8.7	1.03	91.2	3.64	1.12	0.036
		Louise	3	13.7	0.93	117.0	2.08	0.85	0.030

Appendix A2.–Mean weight, length, and condition factor of Buskin and Louise-Catherine lakes sockeye salmon smolt samples by freshwater age and statistical week, 2011.

				Weight (g)		Length (mm)		Condition (K)	
Age	Statistical Week	Sample location	Sample size	Mean	Standard error	Mean	Standard error	Mean	Standard error
1	19	Buskin	0	-	-	-	-	-	-
		Louise	27	5.1	0.24	88.3	1.47	0.74	0.030
1	20	Buskin	17	3.9	0.13	76.8	1.10	0.86	0.028
		Louise	105	4.8	0.15	85.1	0.67	0.77	0.017
1	21	Buskin	0	-	-	-	-	-	-
		Louise	62	3.6	0.13	82.8	0.68	0.62	0.015
1	22	Buskin	33	3.8	0.11	77.1	0.83	0.82	0.020
		Louise	109	4.1	0.14	80.2	0.76	0.78	0.134
1	23	Buskin	78	4.0	0.10	79.4	0.58	0.80	0.015
		Louise	105	3.5	0.98	76.9	0.58	0.76	0.011
1	24	Buskin	82	4.2	0.21	79.0	0.76	0.84	0.009
		Louise	104	4.5	0.37	79.6	1.41	0.78	0.010
1	25	Buskin	99	4.4	0.15	80.4	0.58	0.84	0.008
		Louise	99	3.6	0.12	75.4	0.53	0.82	0.008
1	26	Buskin	103	5.3	0.14	84.8	0.58	0.86	0.009
		Louise	116	3.7	0.09	75.2	0.47	0.86	0.010
1	27	Buskin	37	6.0	0.24	87.5	0.99	0.88	0.010
		Louise	39	3.9	0.17	76.2	0.79	0.88	0.016
	Total	Buskin	449	4.6	0.07	81.2	0.31	0.84	0.005
		Louise	766	4.0	0.07	79.2	0.31	0.78	0.005
2	19	Buskin	0	-	-	-	-	-	-
		Louise	13	11.0	0.84	115.2	4.59	0.74	0.06
2	20	Buskin	7	9.1	1.61	100.3	4.89	0.86	0.034
		Louise	15	12.1	0.93	115.5	3.17	0.77	0.028
2	21	Buskin	0	-	-	-	-	-	-
		Louise	30	10.0	0.97	111.4	2.83	0.68	0.034
2	22	Buskin	26	7.0	0.28	93.5	1.31	0.85	0.018
		Louise	14	16.7	1.42	122.4	3.69	0.87	0.025
2	23	Buskin	46	7.5	0.60	94.8	2.13	0.83	0.012
		Louise	14	16.5	0.70	121.5	2.01	0.91	0.016
2	24	Buskin	34	8.9	0.84	98.4	3.17	0.85	0.015
		Louise	13	14.4	1.62	116.4	5.23	0.84	0.033
2	25	Buskin	20	10.9	1.06	105.4	3.77	0.87	0.020
		Louise	0	-	-	-	-	-	-
2	26	Buskin	17	14.2	1.04	115.6	2.73	0.90	0.025
		Louise	4	16.3	1.11	119.0	2.92	0.96	0.008
2	27	Buskin	3	13.8	1.60	113.7	3.67	0.93	0.017
		Louise	1	4.3		77.0		0.94	
	Total	Buskin	153	9.1	0.74	99.7	1.28	0.85	0.007
		Louise	104	12.9	0.51	115.9	1.47	0.79	0.017

-continued-

Appendix A2.–Part 2 of 2.

Age	Statistical week	Sample location	Sample size	Weight (g) Mean	Weight (g) Standard error	Length (mm) Mean	Length (mm) Standard error	Condition (K) Mean	Condition (K) Standard error
3	19	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
3	20	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
3	21	Buskin	0	-	-	-	-	-	-
		Louise	2	17.9	0.05	132.5	3.50	0.77	0.063
3	22	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
3	23	Buskin	1	12.3	1.00	126.0	1.00	0.61	1.000
		Louise	1	17.7	1.00	130.0	1.00	0.81	1.000
3	24	Buskin	3	15.9	1.33	122.0	4.58	0.87	0.027
		Louise	0	-	-	-	-	-	-
3	25	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
3	26	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
3	27	Buskin	0	-	-	-	-	-	-
		Louise	0	-	-	-	-	-	-
	Total	Buskin	4	15.0	1.30	123.0	3.39	0.81	0.067
		Louise	3	17.8	0.06	131.7	2.19	0.79	0.038